



EL MOLINO AND SAN MATÍAS HYDROELECTRIC PROJECTS

ENVIRONMENTAL IMPACT STUDY VOLUME II OF V CHAPTER 3

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3. ENVIRONMENTAL CHARACTERIZATION

3.1 AREAS OF STUDY AND AREAS OF INFLUENCE

The influence area of the El Molino hydroelectric project is the middle and low side basin of the San Matias River, the natural boundary between the municipalities of Cocorná and Granada, both belonging to the eastern sub region of the department of Antioquia (see Photo 3-1 and Photo 3-2). The first municipality is located in the forests area and the second in the reservoirs area, according to the established division by the Corporación Autónoma Regional of the basin of the Rionegro and Nare Valleys - CORNARE.



Photo 3-1. Panoramic view of the urban area of Cocorná from Vereda (Political and administrative division of the municipality located in the rural area) San Juan



Photo 3-2. Aerial photo of the bedside of Granada.

Source: Vereda (Political and administrative division of the municipality located in the rural area) Atlas, Government of Antioquia

The Forest Area, in addition to Cocorná, is conformed by the municipalities of San Luis and San Francisco. It is an area rich in natural resources, which combines the peasant and extractive activities of the forest, with the informal trade around the road axis of Medellin - Bogota. Highway.

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For its part, the municipality of Granada is located in the Area of Waters or Reservoirs, conformed by the El Peñol, Guatapé, San Carlos, San Rafael, Concepcion and Alejandria. Their dynamics have undergone severe changes product of the construction of reservoirs, where agricultural land suitable to produce were flooded, declined the agricultural activity type peasant smallholdings, altered the socio-economic relations of the communities and to a large extent, tourism became the main activity, although with reverse in the last few decades due to the armed conflict¹.

3.2.1 DIRECT INFLUENCE AREA(DIA)

In accordance with the defined in the Terms of Reference of the Ministry of Environment, Housing and Territorial Development, for Studies of Environmental Impact, Energy sector, Construction and operation of power plants, hydroelectric generating plants I-B-1-01, " *The direct project influence area, is the one where there are the environmental impacts generated by the activities of construction and operation; it is related to the project site and its associated infrastructure.*"

For the Physical Environment and biotic environment, the area of direct influence is composed of the areas to be occupied by the facilities of the project: Collection, House of engines, workshops, industrial squares, camp, access roads, and reservoir zones. The area to be occupied by the facilities is 30.71 ha.

In addition, it includes those areas adjacent to the San Matias River, between the collection area and the waters discharge, where there will be a reduction in flow rates.

The area of direct influence of the socio-economic environment, covers the municipal territories affected by the project facilities and the flow reduction of the San Matias River, comprising the following Vereda (Political and administrative division of the municipality located in the rural area): Quebradona Abajo and Las Faldas of the municipality of Granada, affected by the flow reduction of the San Matias River; and El Molino of the flow rate (see Cartography 2148-04-EV-DW-032)., Campo Alegre, Los Mangos, La Immaculada and San Lorenzo, affected by the facilities and by flow reduction.

3.2.2 AREA OF INDIRECT INFLUENCE (AII)

The area of indirect influence is defined in the Terms of Reference of the Ministry of Environment, Housing and Territorial Development for hydroelectric projects where it is stated that: " *The area where the environmental impacts transcend the physical space of the project and its associated infrastructure, i.e. the area outside the area of direct influence and extends up to where such impacts are manifested* ".

It was established that for the impacts of Physical and Biotic Media may be manifested in the fringe, of the watershed between the San Matias and Cocorná Rivers, in the right margin of the San Matias River; and in the left margin, a band defined by existing roads on the Vereda (Political and administrative division of the municipality located in the rural area)of

¹ Government of Antioquia. Strategic Plan of the Department of Antioquia PLANEA Profile of the subregional East of Antioquia.

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Quebradona Abajo and Las Faldas, up to where it can reach the decrease effect in San Matias River flow (see Cartography 2148-04-EV-DW-032).

For the socio-economic environment, the All corresponds to the territory comprised by the municipalities of Cocorná and Granada, since they are the administrative centers and socio-cultural units around the El Molino hydroelectric project (see Cartography 2148-04-EV-DW-032).

3.2 PHYSICAL ENVIRONMENT

3.2.1 GEOLOGY²

The project area is framed in a mountainous landscape, located between the elevation of 1,480 meters above sea level, where the highest part is found, dividing the cutting edge of water that separates the Cocorná and San Matias Rivers, and the elevation of 750 meters above sea level, in the vicinity of the outfall of the San Matias and Cocorná Rivers, close to the house of engines facilities of the San Matias hydroelectric project, which is currently in the stage of licensing before CORNARE.

For this study were analyzed aerial photographs taken by aero studios in 2009, shown in Table 3-1 which is complemented by field surveys and with secondary information of the area.

Table 3-1. Index of aerial photographs of the influence area of the project

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| 12 | 717-719 |
| 14 | 726-728 |

Field studies were based on geological mapping at a scale of 1:100,000 (Ignominies, 1970) and the descriptions are based on studies by various authors (Feininger et al. 1972; Feininger and Botero, 1982; INGEOMINAS, 1999; INGEOMINAS1999 to; INGEOMINAS, 2001; INGEOMINAS, 2002).

3.2.1.1 Regional geology

The project area is directly influenced by the Batholithic Antioqueño, which is embedded in the more ancient Paleozoic metamorphic rocks of the Central mountain range.

- Verde River GNEISS' (ni)

² For the study of environmental impact of the El Molino hydroelectric project were used the same geological and geomorphological information of the Environmental Assessment of the alternatives of the hydroelectric development of the San Matias river - El Molino, because these studies had a scope at the level of feasibility of the project, stage in which it currently is. This is why this numeral, is equal to the study previously mentioned.

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The Verde River GNEISS' is located within the group of the syntectonic intrusive gneiss' sintectonics (Feininger et al, 1972), which are also known as ortoneises (INGEOMINAS, 2001; 2002).

The Verde River GNEISS' is an elongated body of approximate orientation N20 °E-30 °E, length of the body is 26 km, a maximum width of 5 km, which gets narrowed to less than 2 km in its north and south ends, and an extension of 75 km². It extends from the Cocorná River north side to near the El Coco Creek, some 12 km northwest of the municipality of Argelia in the Department of Antioquia (INGEOMINAS, 2002) to the south. This short GNEISS' amphibolites, sericitics schists and quartzite, and at the same time it is cut by the San Francisco hornblendic gabbros and derived from granitic rocks Antioqueño and, toward the south, is truncated by the Batholithic of Sonson (Feininger et al, 1972).

The predominant rocks are characterized at the level of outcrop by a gneissic structure, defined by the orientation of sheets of biotype and muscovite, although in the fine-grained rocks this structure is not so clear and the rock is similar to a granitic rock that varies, in general terms, of nearly massive to schistose and from fine to coarse-granular and in many areas presents intense folding that distort the original structure and give auger structures.

Essential minerals are quartz (30-35 %), potassium feldspar (2-30 %), plagioclase (20-40 %); accessory minerals are biotype (5-25 %) and Moscow (2-10 %); in addition are garnets (0-1 %), opaque (0.5 -1 %) and other (1-2 %) (Feininger et al, 1972); the modal classification varies from quartz monzonite to tonalite. The texture is idioplasmic to hipidioblastic commonly distorted, that gives auger textures or mortar.

The granite composition with an abundance of quartz and feldspar and the nature of the contacts indicate that these bodies were originated by dynamo-thermal metamorphism syntectonic granitic bodies, stationed at the top of the sequence quartz-sericitics amphibolies shale at the Cajamarca Complex (INGEOMINAS 2001).

The protoplasmic textures observed in some of these bodies were acquired, probably, during the intrusion, when the magma was partially crystallized and could had behaved in a semi-plastic state and therefore must be regarded as intrusive syntectonic with structures of the Cajamarca Complex, although locally may be discordant and show digitations and migmatitic areas of variable thickness (INGEOMINAS, 2002).

It appears that from the field study that the Verde River GNEISS' is the oldest rock outcropping in the project area and is assigned two ranges of possible age, very previous to the site of the batholiths Antioqueño: one around 350 Ma during the Late Devonian Acadian Orogeny and another of 240 Ma could be associated with the Laramide orogeny of Hercinica Permo-Tri/Triassic (INGEOMINAS, 2002).

Emphasis is placed on the presence of the inferred GNEISS' with outcrops above the elevation of 1,000 meters above sea level, which allows to some 180-200 m of maximum thickness of "roof of rock", counted on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino from the highest peak point of the dividing line between the San Matias and Cocorná Rivers.

- Antioquia Batholiths (Kqd)

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Upper Cretaceous Antioquia Batholiths of superior age (58 to 83 M.A.), outcrops in the central region of Antioquia, in the axial part of the Central mountain range, this body is elongated and present a trapezoidal shape, with its larger dimension north -south, where it reaches a length of 110 km and a maximum width of 80 km along the railroad line Medellín-Puerto Berrio. It has an area of 7,800 km², without including the satellites bodies separated from the main body by metamorphic rocks, which occupy an area of 322 km² in the center and eastern part of the department (INGEOMINAS, 1999 a).

The batholiths have intruded the metamorphic wall rocks of the poly-metamorphic complex in Central Andes. Its contacts with the wall rocks are discordant, with development generally intrusive of contact aureoles with very variable extent and magnitude (Feininger, 1982).

The composition of the batholiths is characterized by its petro graphic and petrochemical. Homogeneity. Its lithology is composed mainly of tonalites-granodiorites (97% of its total land area), which is the normal facies (INGEOMINAS, 1999 a) and in less percentage are felsic facies (2.8 % of the area) and gabbroidal (0.2 % of the area). Sometimes presents gabbros (mafic inclusions), lenticular to ovoid shape, without predominant orientation, fine grain, massifs, dark gray, with mega-crystals of plagioclase-hornblende, that contrast in color and composition with the rock theologies; its composition is similar to the normal rock, except for the content of quartz and the enrichment of mafics (Feininger, 1982; Ingeominas, 1999 a).

The rock of the normal facies prevails in the vicinity of Cocorná, where it is seen as an igneous rock, plutonic, isotropic, equigranular, and faneritic, with medium to thick grain, mottled, average color index of 21, salt and pepper with hipidiomorfic granular texture and tonalite composition to granodiorite, rarely cuarzomonzonite (Ingeominas, 1999a) and only occasionally shows some degree of anisotropy, expressed with felsic intrusion of more acidic dikes, poor in ferromagnesian and clearer color; at the local level there are some flow structures. There are usually sharp boundaries between the derived from granitic rocks and the dams; it is of fresh nature and without weathering, in the beds of rivers and streams.

The rock of the felsic facies is well exposed in the Santo Domingo -Nare river road, in the La Doncella Creek to the east of Maceo and on the way Maceo-La Susana; displays higher alteration than the other facies of the batholiths and generally occurs as scattered blocks; it is characterized by its cream color to light gray, solid, medium-grained to coarse and composition granodiorite to quartz-monzonite. This facies is richer in quartz and potassic feldspar with respect to the normal facies and also has more sodium plagioclase with a lower index color.

The rock of the gabbroid facie prevails between San Jose del Nus and Cristales; it is gradational with the normal facies and it is defined by an increase in the content of mafics, pyroxene and olivine at the expense of the decrease in the content of quartz and feldspars, and becomes, in addition, more calcium plagioclase. The rock characteristic of this facies is black to dark gray-green color, medium-grained to coarse texture and hipidiomorfic to equigranular texture. Its mineralogical composition is variable between pyroxenes and hornblendic gabbros the most mafic rocks are cooler than the gabbros, since the increase of the calcium plagioclase content shows saturation and the pyroxene is replaced by fibrous amphibole (Feininger, 1982; Ingeominas, 1999 a).

The Batholiths is cut by numerous dikes with thicknesses between 2 cm and 1 m (occasionally reach 800 m) (Feininger, 1982). These dykes are of two types: apophasis

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dykes of the batholiths, intruding wall rocks, and dikes post - batholiths, which cut (intruding) rocks of the batholiths, whose composition, extension and form vary widely with predominance of andesitic, felsites and alaskites (leucocratic granite). The dyke's spinout processes vary very little with regard to the composition of the normal facies of the batholiths (Ingeominas, 1999 a).

The contacts of the batholiths with the adjacent rocks are discordant, even where the direction of contact of the batholiths and the foliation of the wall rock coincides (Feininger et al. 1972).

Excluding the failures of intrusion, very little deformation can be attributed to the intrusion of the Antioquia batholiths and, in addition, the regional folds in the meshing rock are rather truncated than deflected.

The quartz-diorite derived from granitic rocks of the batholiths rises in great part of the Project area and was observed in various states of weathering in the journeys made during the field work.

3.2.1.2 Local Geology

The lithologic units directly involved in the study area are the Verde River GNEISS', the Antioquia Batholiths, slope deposits and alluvial deposits (see Cartography 2148-04-EV-DW-026).

- GNEISS' of Verde River (ni)

This GNEISS' emerges as an elongated body in the southwestern portion of the area, where it reaches a length of 3.3 km measured in the north-south direction and a width of 0.95 km in the middle part, although it narrows a bit toward the southern limit of the study area, where it reaches 0.65 km wide, measured in the west-east direction.

Their best outcrops are located close to the birth of the El Coco Creek, in the limit of the two reliefs that are evident throughout the way that joins Vereda (Political and administrative division of the municipality located in the rural area) El Choco and El Molino as well: the first relief, modeling in weathering traces derived from granitic rocks, contains a watershed of peaks convex, oblong, moderately broad; and the second relief contains a narrow edge, tall, of convex peaks and steep slopes (40 °). Within the limits of these two reliefs is the contact between the derived from granitic rocks and GNEISS'. It is worth noting that in the project area the outcrops of this body are located above the elevation of 1,000 meters above sea level, close to the watershed between the San Matias and Cocorná Rivers.

During the tours on the ground, there were no GNEISS' fresh outcrops on the spot. In very few occasions it was noted the weathering profile of GNEISS' and examples are cited in the observations made in the surrounding area of La Fonda, Campo Alegre of Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino and in the immediate vicinity of the school La Inmaculada, where it showed residual sandy and clayey soils, rich in quartz and mica, cream- reddish colored, with occasional GNEISS' balls.

- Antioquia Batholiths (Kqd)

The Batholiths occupies the area of Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo and Las Faldas, until the confluence

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of the San Matias and Cocorná Rivers, on the left bank of the San Matias River, municipality of Granada, and a sector of the small Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco and part of Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino by the right margin, municipality of Cocorná.

The weathering profile of this rock presents a strong evolution in the tops of the hills and in the watershed of the San Matias and Cocorná Rivers, as showed in the field trail between the El Choco and El Molino Vereda (*Political and administrative division of the municipality located in the rural area*)s. However, in some sectors of the slope toward the San Matias River, presents a moderate evolution corresponding to Grus, which is showed in the outcrop of medium to thick sands that preserves the thick granular texture of the original rock and its color.

During the field trips it was found quartz-diorite derived from weathered granitic rocks with weathering well-developed profiles (Deere and Patton, 1971), with the following general features:

The horizon **I**, with thicknesses observed in the range of 1 m to 2 m, is, often, with development of (IB) yellow, (IB) reddish horizons, consisting of sandy silt, with angular quartz grains up to 1 mm in diameter, low to medium plasticity.

The horizon **IC** corresponds to the underlying coprolite and is located in boundary with the gradual IB reddish horizon; this is formed by silt loam soils with gradation toward thick sand type grus; mottled colors of yellow, white, red and black; preserves the faneritic granular texture derived from granitic rocks; the quartz grains remain intact to the crushed material between the fingers and reach a maximum rate of 25 %, according to the modal analysis; the orientation of minerals observed in some sites is due to the protoclasia caused by magma movements before its complete crystallization. Common is the presence of nucleus derived from granitic rocks with spherical weathering, inside of the saprolite, with very different diameters between 0.2 m and 2 m, usually weathered on the outside edge and with production of sands by hitting the hammer.

The grus is a particular type of saprolite, which has been formed by the weathering in situ of the materials, where granular disintegration prevail with the development of micro cracking, alteration of the feldspars and hydration of the biotype with expansion, and it is associated mainly with the granitic igneous rocks and similar, but can also be found associated with other rocks (Griffing, 2005). Its color is generally pale, salty sandy texture, with particles of quartz in a matrix of feldspar with something of kaolinite. Its top can be completely altered, but in its bottom there are rounded nuclei and small rock.

In general the grus derived from granitic rocks in the area of the projects are characterized by the low vertical differentiation and low presence of rock balls, which can reach diameters of 10 m, although the most common size is in the range of 1 m to 3 m. The ball size depends on the cracks spacing in the original rocky substrate. The matrix that surrounds the balls can be saprolite or Grus. The clay content is very low and is usually less than 2 %, which indicates an extremely limited chemical action (Migon and Lidmar-Bergström , 2002).

Due to the formation conditions, the grus has low cohesion; on very few occasions is preserved the surface of the ground to form edaphic soils; it is not associated with layers of

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humus that provide materials that link to the particles, therefore does not develop aggregate or structures, being very susceptible to the action of the drop of rain, allowing, generally, an intense rainfall erosion; it is also a high porosity and permeability material, which favor the water infiltration; they are also very susceptible to denuding and erosion, and the hedges of grasses and debris, determined by earth use, don't protect the soil adequately.

The thickness of the horizon I (IB+CI) is not known in the vicinity of the project, but is presumed very variable, with depths of the order of 30 m to 60 m at the top of the hills and close to the watershed of the San Matias and Cocorná Rivers, in the vicinity of the road that joins the Vereda (Political and administrative division of the municipality located in the rural area) El Choco and El Molino. In the bottom of the valley of the San Matias River these horizons have been eroded completely.

The horizon **IIA** can only be observed near the San Matias river-bed, covered in the high part by slope deposits. Corresponds to a horizon moderately weathered, with development of rock balls between 0.5m to 2m diameter average, embedded in a saprolite which preserves the granular faneritic texture derived from granitic rocks, of very similar colors to those of the fresh rock, with ferruginous pints in the middle bands of weathering. Presents joints, occasionally open up to 1 cm, filled with sandy loam with oxidation; some of these joints revealed the presence of slicken sides as a result of shear. The thickness of this horizon is variable and can reach up to 30 m - 40 m thick.

The horizon **IIB** can only be seen in the bed of the San Matias River, as partially weathered rock, with presence of open joints up to 1 cm and filled with sand silt loam material, of light gray to white color, oxidized. Some of the fractures observed in this horizon show slight signs of shear with development of slicken sides; the thickness of that horizon is presumed between 5 m and 15 m.

The horizon **III**, rock completely fresh, is only visible in the parts where the valley of the San Matias River fits heavily toward the sector of the waterfalls. Presents spaced joints of decompression, According to the field morphological characteristics and the presence of a thick weathering edge and highly evolved of the quartz diorite derived from granitic rocks, this horizon of fresh rock is located at depths exceeding 60 m on the mountain slopes of the edge where the project is located.

- Slope deposits (Qv)

The slope deposits are originated by removal processes through erosion and mass movements that have occurred in the upper and middle parts of the slopes of steep slope in such a way as to form destabilized areas that produce areas of reservoir by gravity flows of mud and debris. It is also common to find coluvial deposits in the bottom of the slopes with moderate inclination.

- Coluvial-alluvial deposits (qcal)

In the left margin of the San Matias River is present a thick coverage of these deposits of sand, brown color, with presence of blocks of fresh rock from the top of the hill.

- Alluvial deposits (Qal)

The alluvial deposits are presented in the valley of the San Matias River toward the northern boundary of the project area, where it has a low gradient and amplitudes greater than 150 m,

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which allows the accumulation of landslides in a section of approximately 1,500 m, between the upstream site of the sand removal, until the confluence with the Tafetanes River; these alluviums are presented as barrier islands, and bed deposits and terraces; the islands reach lengths of 400 m and amplitudes up to 100 m; in these floods are quartz-diorite blocks derived from fresh granitic rocks, sub rounded to rounded, heterometrics, with sizes between 2 cm and 80 cm in diameter, occasionally higher, embedded in little quantity of sands, scattered across the alluvial plain; when rock outcrops are found on both sides, these limit the width of the river to ranges between 20 m and 50 m.

The alluvial terraces are often mixed with beach sands torrential deposits, overflow silts and A-edaphic horizons, up to 20 cm thick, with salty sand consistency.

3.2.1.3 Structural Geology

- Geological faults

In the project area there were no faults detected. The system closest to the project corresponds to the Miraflores fault, which occurs between the western part of the municipality of Santo Domingo and the middle of Cocorná (Ingeominas, 1999), and reaches the confluence of the San Matias and Tafetanes Rivers; possesses a length close to 50 km and has a course that ranges between N10°E to N20°W.

- Joints

Table 3-2 presents the joints that are identified in the study area of the project, where there are grouped secondary geological structures, such as joints, slicken sides, sheet joint, dikes and arrangement of the plate in the intrusive GNEISS'.

For all practical purposes it is considered in this study that the joints, slicken sides and dykes keep the same behavior, although it is obvious the difference between them, given that the slicken sides present traces of shearing with friction mirrors formation that show the displacement of both lips of the fracture, but due to its magnitude, for engineering work, assimilates its behavior to a semicircle and not to a fault.

The dykes observed are usually welded contacts and in the same way assimilates its behavior to that described for the joints. In the intrusive Verde River GNEISS' were only found a platy data, which was associated with a joints family, and both had the same structural arrangement.

The existence of the joint sheet are associated with the processes of weathering-remove vs. relaxation of effort, so that as the denuding of the surface material happens, there is a loss of charge pressure in the inferior materials and they spontaneously develop, by weathering, from the outer surface of a rocky outcrop toward its interior and parallel to the surface of the ground, concentric slabs with thicknesses ranging from less than 1 cm up to several meters; as it increases the depth, there is a greater thickness of the slabs and could reach depths greater than 100 m (Holzhausen, 1989). When the rivers incise deeply in the massive rocks, develop the joint sheet parallel to the walls of the canyon (Ahnert, 1998). The presence of these structures of relaxation of efforts is shown mainly along the rocky outcrops close to the San Matias River, which allows to anticipate its presence in a broader manner throughout the valley, where are characterized primarily by its low tilt angle and in addition are generally open and empty.

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According to the characteristics of the joints encountered in the study area, were identified four families of structural discontinuities, two major and two secondary:

– Main Families

- N3°E/80N. In this group of fractures orientations were found in the range N10 °W-N20 °E; the variable dips are located between 60° and 90° directed both to the north and to the south, reaches the spacing between 0.7 m and 2 m, with moderate to massive joints (Wickham and Tiedemann, 1972); contains long, continuous and closed fractures, although some are occasionally open, of rough and wavy walls. In this range it is located the only data of the intrusive GNEISS' banding and a system of parallel joints to the banding, which presents in the horizon CI weathering edge, a system of closely spaced fractures (0.05 m-0.07m). They are considered vertical, because of the magnitude of their dip (Wickham and Tiedemann, 1972) and are classified as plodding joints (Chica, 1979), because they make an angle between 0° and 30° in the orientation of the tunnel.

Table 3-2. Secondary geological structures in the canyon of the San Matias River

| Structural Data | | | | Type | a | EC | L | Co | R | LS | O | V | RLL |
|-----------------|--------------|-----|------------------|-------|---|----|---|----|---|----|---|---|-----|
| Station | Structure | No. | Space (m) | | | | | | | | | | |
| M3 | N20°E/ 86 °E | 3 | 0.5-0.8 | D | | X | X | | X | | X | | |
| M9 | N75°E/ 47°S | | | Slick | | X | X | | | X | | | |
| | N25°E/ 40°E | | | D | | X | X | | | X | | | |
| | NS/ 75°E | | | D | | X | X | | | X | | | |
| M11 | N80°E/ 74°S | 2 | 3 | | | | X | | X | | X | | |
| | N75°E/ 88°S | 1 | | | | X | X | | X | | X | | |
| | N75°W/ 7°S | | 0.3 | D | | X | X | | | | | | |
| | N15°E/ 66°E | | (0.02) | D | X | | | | X | | X | | |
| | N60°E/ 84°S | 3 | 0.8 -1.5 (0.01) | D | X | | | | | | | | |
| | NS/ 18°W | | | D | X | | X | | X | | X | | |
| | EW/ 85°N | | | D | | | | | | | | | |
| | N20°E/ 8° W | 5 | 0.5-0.75 | D | X | | X | | | X | X | | |
| | EW/90° | | E=0.75 | D | | | | | | | | | |
| M16 | N5°E/ 60°W | 3 | 0.05-0.07 | B | | X | X | | X | | | | |
| | N70°W/ 86°N | 2 | 0.15 , (0,001) | D | X | | | | X | | | | X |
| M23 | N10°W/90° | | E=0.4 | D | | | | | | | | | |
| M30 | N85°E/ 84°E | 2 | 1.0 , (0,01) | D | X | | X | | X | | X | | |
| | N10°E/ 12°E | 3 | 1.5 -2.0 (0.05) | D | X | | | | X | | X | | |
| M32 | N40°E/90° | 6 | 0.2 -0.5 (0.01) | D | X | | X | | X | | X | | |
| | N60°W/ 7°NE | 3 | 0.3-0.5 | Sh | X | | | | | | | | |
| | EW/ 68°S | 5 | (0.1) | D | X | | X | | | X | X | | |
| | N70°W/ 85°S | 2 | 2.0 | D | X | | X | | | X | X | | |
| | N40°W/ 47°NE | 4 | 0.3 | D | | X | X | | | X | X | | |
| | EW/ 82°S | 4 | | D | | X | X | | | X | X | | |
| | N85°E/ 84°S | 6 | | | | X | | X | | X | X | | |
| | N30°E/ 70°W | 2 | | | | X | X | | | X | X | | |
| | N50°W/ 63°S | 4 | | | | X | X | | | X | | | |
| | N4°W/ 70 °N | 6 | 0.4 (,0,01) | D | X | | X | | | X | | | |
| | N60°W/ 60°SW | 5 | | Sh | | | X | | | X | | | |
| M33 | N20°E/ 78°S | 2 | 2.0 | D | | X | X | | | X | X | | |
| | N50°E/ 75°IS | 3 | 0.7 | D | | X | X | | | X | X | | |
| | N85°W/90° | 7 | 1.0 | D | | X | X | | | X | | | |
| | N10°E/ 7°E | 2 | 0.02-0.05 | D | | | | | | | | | |
| | N50°E/ 28°W | 4 | | | X | | X | | | X | X | | |

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| Structural Data | | | | Type | a | EC | L | Co | R | LS | O | V | RLL |
|-----------------|-------------|-----|-------------|-------|---|----|---|----|---|----|---|---|-----|
| Station | Structure | No. | Space (m) | | | | | | | | | | |
| | N30°E/ 81°E | 5 | 0.3-0.6 | Slick | | X | X | | | X | X | | |
| M35 | N5°E/ 76°N | 2 | 0.7 (0.05) | D | X | | X | | X | | | | |
| | N40°E/ 22°S | 2 | | Sh | X | | X | | | X | X | | |
| | N50°E/ 80°W | 2 | | D | | X | | | X | | X | | |
| | N60°W/ 80°E | 3 | 1.0-3.0 | D | | | X | | X | | | | |

Note: d=fissure; D=dam; slick=slickenside; a=open; ec=closed; l=long; co=short; r=rough; v=empty; Rll=filled out; e= 75cm; b=platy; or=wavy; ls=Lisa; (0.03)=opening the joints; sh=sheet joint.

➤ N85°E/ 80°SE. In this family there were found orientations between N75 °E and E-W; the variable dips found range between 70° and 90 °, both north and south and its spacing reaches up to 3 m. These fractures are long, continuous, flat, rough, closed walls, occasionally open up to 1 cm, empty; on one occasion there was found one of these fissure with an aperture of 10 cm crossed by roots; there are dikes with welded walls, of the same composition of quartz diorite derived from granitic rocks, although more fine-grained, up to 75 cm thick; this family of fissures, makes an angle between 30° and 60° in the tunnel orientation. By their spacing with the development of massive blocks and the size of its domes are considered vertical (Wickham and Tiedemann, 1972) and are classified as normal pitch fissures (Chica, 1979).

• Secondary Families

Classified as slow step fractures because they make an angle between 0° and 30° in the tunnel direction

– N56 W/ 55°W. In this family there were evidenced orientations in the range between N40°-60° W, with variable dips between 47° and 63° north and south. These fractures, moderately spaced -30cm- (Wickham and Tiedemann, 1972), are found in groups of four long fractures, closed, of smooth and wavy walls.

– N55°W/ 80°W. In this family there were found orientations in the range N40 ° -70 °W with variable dips between 70 ° -90° north and south. These fissures have spacing between moderate and massive (Wickham and Tiedemann, 1972), with magnitudes between 0.4 m-1 m; they are in groups of up to seven fractures long, continuous, closed, of smooth and wavy wall.

In addition we found the following families:

• N46°E/ 80°W. With orientation between N30° -60°E and variable dips between 75 ° -90° to the north and south and with average spacing between 30 cm and 70 cm, named as moderate to blocks development (Wickham and Tiedemann, 1972), although occasionally reaches up to 1.5 m. This family is constituted of quick step fractures, because they make an angle between 60° and 90° with the tunnel axis

• Sheet joint. These fractures have very soft dip, usually less than 10 °, although occasionally can coincide with the tilt of the walls of the valley bottom; these structures are very common in the rocky outcrops directly related to the course of the San Matias River; usually occurs near the surface of the ground and disappear toward the interior of the rock massif; in general are long, continuous, open and some of them have smooth walls.

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3.2.2 GEOMORPHOLOGY³

The geomorphologic information was collected through photo interpretation and confirmation of field work, as in the study area it was not found detailed work describing the morphology of this sector.

3.2.2.1 Regional Framework

The project is located between the river basins of the San Matias and Cocorná Rivers, which are characterized by a relief of mountainous character, clipped and deep valleys, and long slopes of moderate and high slopes, with the presence of narrow channels and with frequent slopes disruptions, giving rise to waterfalls up to 150 m in height (waterfalls). This mountainous terrain makes part of the erosive advance front of the main tributaries of the Magdalena River, on the eastern slope of the Central mountain range, which have been ascending denuded the eastern edge of the plateau of Rionegro, leaving a mountainous terrain of deep valleys, which contrasts with the relatively low relief of the hilly plateau.

3.2.2.2 Local Geomorphology

The direct influence area of the El Molino hydroelectric project is part of a relief of mountainous character, composed of a basal edge section of wide, long strands, with development toward the bottom of the cutting edge, hilly slopes and escarpments in sectors where the valley of the San Matias River sweeps through.

Due to the morphological characteristics of a valley in "V" and very deep seated of the San Matias River, flat surfaces of sediment accumulation in the bottom are minimal.

The following describes each of the relief units present in the influence area of the El Molino hydroelectric project (see Cartography 2148-04-EV-DW-027).

- Mountainous edge (Fm)

Corresponds to the prominent relief of the study area, which is distinguished by edged mountain slopes, where the conduction tunnel of the water of the San Matias River crosses toward the house of engines. It is morphologically differentiated by the two main sections in the edge.

- Mountain edge of wide top (FMCA)

Corresponds to the first section of the edge that can be seen from the mountainous slopes, from the sector of the El Choco Creek, located between the San Matias River and the La Trinidad Creek. It is characterized for being a cutting edge in the orientation N45 °W; asymmetric, basal section close to the top, which is gradually expanding downstream, where the strands that go toward the La Trinidad Creek and the Cocorná River are increasingly long (600 m -1,500 m in length) and going to the San Matías River is shorter (600 m-800 m); both of concave convex form; also, the height is greater toward the slope that goes toward the Cocorná River(250 m - 400 m) and less toward the San Matias River (180 m - 200 m).

³ This numeral, like that of Geology, was extracted from the information presented in the Environmental Assessment of the alternatives of the hydroelectric development of the San Matias River, since for these studies, these topics were worked from a feasibility level, stage, during which the project is being presented with this Environmental Impact Study.

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The slopes are generally moderate tilt, ranging between 20° and 30°, with frequent slopes disruption by the accumulation of slope deposits on the hillside and by the irregular field denuding.

The summit presents an irregular shape by both sides denuding, with the presence of small cavities in the middle, with heights ranging from 1,430 meters above sea level and 1,480 Meters above sea level, convex and wide shape, modeled in horizons IB and IC weathering profile of the quartz diorite derived from granitic rocks of the batholiths Antioqueño.

Dissection in the slopes of this edge is moderate, with valley formation in small "V", and configuration of secondary edges of convex forms modeled in weathering profile.

The slopes of the mountain edge are modeled in materials of the Antioquia batholiths, with a dense cover of slope deposits. The batholiths are composed mainly of quartz diorite derived from granitic rocks, heavily weathered, distributed as follows:

- Residual soil horizons of IB yellow and IB reddish, up to 2 m thick, especially toward the top of the cutting edge, texture of silt loam to sandy clay loam.
- Horizon IC saprolite, up to 10 m thick visible, texture of loamy sand to sandy. It can reach up to 40 m-50 m thick in the watershed, including the Grus sandy horizon. The presence of this horizon is so common that is located near the rocky bed of the river, sometimes from 1.5 m to 2 m above the level of the water in the river under normal conditions.

The horizons of rock weathering (IIA, IIB and III) are only visible toward the river bed of the San Matias River.

The active morpho dynamic process more recurrent in the slopes of this edge is the laminar erosion by action of the rainfall and the exploitation of the soil, in particular of cattle rising. Erosive focus are observed in areas used by overgrazing and land with use of clean crops; the mass movements are minimal, there are only landslides in the right margin of the San Matias River associated with lateral undermining of the river, and superficial twist in the gutters of the roads from the small Vereda (Political and administrative division of the municipality located in the rural area)s. In the field there are frequently traces of old landslides and gullies, currently inactive, and colonized by debris.

Although the evidence of active focus is minimal, it is notorious that the slopes of these edges modeled in developed soils in the weathering profile derived from granitic rocks with slope deposits coverage, are highly susceptible to laminar erosion and mass movement's landslides type.

The slopes of this edge are characterized by the high coverage of slope deposits, in particular flow of mud and debris, accommodated as a film that masks the greater part of the horizons of residual soil and saprolite derived from granitic rocks; it is also common the presence of rock balls on the slope, of varying sizes (0.5m - 2m in diameter), which was a product of the spherical weathering derived from granitic rocks, which are located on the slope as blocks "in situ", by discovery on the surface by erosion of the weathered material that surrounds them, or well placed and organelles toward the bottom of the slopes.

- Mountain edge of narrow summit (Fmce)

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Corresponds to the adjacent section to the southern edge of the previous; it presents a orientation of N15 °W, symmetrical, basal section of very wide, long strands (1,500 m - 2,000 m), high grades in the high part (30° - 40 °), and moderate toward the lower middle (20-30 °), height between 400 and 500 m.

The top of the cutting edge is convex and narrow shaped, modeled in horizons IB and IC weathering profile of GNEISS'.

Dissection in the slopes of this edge is moderate to low, with valleys formation in small "V", of usually temporary flows.

They are modeled toward the high side, above the elevation of 1,000 meters above sea level, in materials of intrusive GNEISS', which develops profiles of weathering of moderate thickness, ranging from 20 m - 30 m, horizons IB, and IC, and toward the bottom of the strands, modeled in weathering profile derived from granitic rocks of Batholiths Antioqueño. Both weathering profiles are, usually, coated by deposits of heterometric slopes, of variable thickness between 4 m and 10 m.

The more relevant erosive process in this segment is on the eastern slope: a severe active gully that removes the slope deposits of (flows of mud and debris of low cohesion), which is crossed by the access road to the house of engines.. There are also occasional active landslides toward the bed of the river, associated to undermining side. There are frequent traces of gullies and crowns of inactive landslides colonized by debris.

Like the previous edge, they are covered with slope deposits, in particular flow deposits of mud and debris, accommodated as a film that masks the greater part of the horizons of residual soil and saprolite of GNEISS' and derived from granitic rocks. In the lower part are common blocks of rock boulders of 0.4 m to 3 m in diameter, composed mainly of GNEISS'.

- Hilly gradients of mountainous slopes (Vcpvm)

Corresponds to the lower part of the edge and the mountainous slopes, that because of the incision of the major creeks, give rise to a relief of hilly slopes, of moderate inclination (20° - 25 °), concave convex forms, modeled in weathering profile derived from granitic rocks, but the majority are covered by slope deposits (flows of mud, rubble and rock blocks), which smoothed the surface of this area. This type of relief occurs on both sides of the valley of the San Matias River.

- Low Hills (Cb)

They are located toward the confluence of the San Matias and Cocorná Rivers, characterized by a set of low hills to a very low (15 m - 30 m) in height, short slopes, convex, smooth slopes, plane-convex peaks. Modeled in horizons IB and IC weathering profile derived from granitic rocks. There are focused processes of laminar erosion product of runoff in the horizon IB yellow.

- Steep slope Segment (SVE)

Corresponds to the section in the San Matias River valley very enbedded, which is configured, in both margins by a relief of rugged slopes usually in fresh rock, with presence of waterfalls and a very narrow and deep river channel. Close to this segment of steep slope, it is proposed the location of the house of engines of the El Molino hydroelectric project .

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- Surfaces of accumulation of alluvial sediments (Spal)

By the morphological characteristics of a valley in "V" very enclosed of the San Matias River, flat surfaces of sediments accumulation are minimal; only, toward the part of the sand removal, presents a wide area of sediment accumulation; downstream, the large segments of the river bed are minimal; only small barrier islands and thin and short floodplains, usually composed of stone blocks, in its majority, of direct fall from the slope as organelles.

Alluvial terraces (Tal): Corresponds to a narrow strip of flat surface, slightly tilted toward the south, made up of materials of heterometric blocks of rock of various sizes, mixed with medium to coarse sand. It is located 2 m above the river, with problems of severe active side undermining.

Barrier Island (ISB): Thick accumulation of sediments, with a predominance of rock blocks in a variety of sizes, 0.2m - 1m in diameter, corresponding to alluvium – torrential events accumulated in large areas of the river bed, or accumulation of rock sub rounded blocks, product of the spherical weathering, which fall as rounded boulders of the slope and are accommodated as organelles toward the river channel.

Cone of inflows (Abal): Cone of inflows are composed of rock blocks reaching up to 1.5 m in diameter, mainly associated with phenomenon of mass removal from the middle-high of the slope, with clumps of rock blocks embedded in materials of the residual soil and the saprolite of the upper horizons of weathering of the GNEISS' and derived from granitic rocks.

- Flat Surfaces slightly inclined of sediment accumulation colluviums alluvial (Spical)

They are located in the middle of some concavities of the relief. Corresponds to the accumulations of fine granular sediments, with predominance of sands and occasional rock blocks.

- Channel of the San Matias River

Corresponds to a channel that goes through the middle of a narrow valley, with some narrow sections, modeled in fresh rock derived from granitic rocks. The influence area was subdivided into three channel sections as well:

Section "CIIB". Takes place in the horizon IIB derived from quartz diorite; usually, with the horizons IIA and IC weathering trace above the water stream, between 2 m and 3 m. There is present accumulation of alluvial deposits between sectors. High presence of rock blocks from rounded to sub rounded derived from granitic rocks and GNEISS' splayed on the channel as organelles.

Section "CIIR". Canyoned river channel, which takes place in the horizon III of fresh rock derived from quartz diorite. Presents rounded rock blocks derived from quartz diorite, accommodated on the river channel as organelles.

Section "CIIRC". Sector of the channeled river, which takes place in the horizon III of fresh rock, with presence of cascade hops in different levels.

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3.2.2.3 Morphodynamic processes

The dynamics of the mountain edges slopes where the project is located, consists of a set of removal processes as mass movements, surface or concentrated erosion and processes of sediment accumulation (alluvial or slope).

In the mountainous slopes can be determined a very active paleo-dynamic and a current dynamic of low activity; the first refers to the set of processes that have shaped the relief under natural conditions, leaving a high density of footsteps on the slope; the current dynamic corresponds to the set of active processes associated with natural conditions or punctuated by the anthropogenic intervention as the instability of slopes on paths or roads.

- Paleodynamic

The paleodynamic mountainous slope is reflected by a dense cover of traces of landslides and erosion in gullies; most of them are currently colonized by hedges of low to high plant debris.. The high number of footsteps on the ground is an indicator that the relief has presented a significant erosive behavior in the past, joined to the materials of the mountain slopes, which are very susceptible to landslides.

- Current Dynamics

Morphodynamic processes of greater relevance in the slopes of the project are landslides and gullies; landslides are mainly related to the undermining whole side of the San Matias River, and involve the horizons of residual soil and saprolite derived from quartz diorite.

The active gullies, although they are few in the study area, are frequently related to landslides, due to the concentrated erosion toward the active crowns, as occurs in one of the most severe outbreaks located toward the Vereda (*Political and administrative division of the municipality located in the rural area*) of Los Mangos, where two years ago, a phenomenon of sudden mass movement concentrated as a flow of mud and debris by one of the creek tributaries of the San Matias River, leaving a footprint on the ground, with ascendant erosion of considerable size, which is activated with greater efficiency during periods of high rainfall. The erosion generated a combined system between landslides, surface rends and concentrated erosion in gullies. This gully can affect the crossing of the proposed path to the house of engines of the El Molino hydroelectric project .

Other active processes, but of lesser impact, are the undermining side in some of the terraces of the San Matias River, caused by lateral movements of the flow of water and by laminar erosion, frequent in land deprived of vegetation, in use for cattle raising and clean crops.

The production and sediment contribution from the mountain slopes to the main current of the San Matias River is low, with high gradient sites protected with thick vegetative covers.

3.2.3 SOILS⁴

In accordance with the general study of soils in Antioquia, in the influence area of the El Molino hydroelectric project there are seven associations, which were presented in

⁴ This numeral is based on the General Study of soils and land zoning of the department of Antioquia. Geografic Institute Agustin Codazzi, Government of Antioquia. 2007

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Cartography 2148-04-EV-DW-029. Table 3-3 shows delineated units its physiographic position and the area occupied by these in the study area.

Table 3-3. Soils in the study area

| Physiographic Position Great Landscape | Association/Consociation/Complex | Area (Has) | Phase | |
|---|----------------------------------|---------------|----------|---------|
| | | | Gradient | Erosion |
| Mountain | Calderas | 46.23 | B | |
| | Yarumal | 664.47 | F | 2 |
| | Yarumal | 2.81 | E | 1 |
| | Zaragoza | 5.89 | F | 1 |
| | Girardota | 21.78 | B | |
| | Poblanco | 5.26 | C | |

3.2.3.1 Co-association Calderas (CL)

The soils have developed on the basis of mixed colluvial deposits on gravel and basalts; they are well drained, moderately thick textures to fine ones; deep surface limited by stoniness and by fragments of rock in the trace.

Corresponds to the mountain scenery and the type of colluvial glacia reliefs and colluvial removal, from embossed slightly flat to heavily corrugated, with slopes from 1 to 25% (see Cartography 2148-04-EV-DW-028), laminar erosion and in light furrows, mass quartz diorite movements, and located cow leg. Some sectors are affected by abundant stoniness surface (15% - 20 %).

3.2.3.2 Yarumal Association (YA)

In this association, which was located in the greater part of the influence area, soils have been formed mainly of igneous rocks, quartz diorites and granites with deposits of volcanic ash. They have medium and fine textures, well drained, deep, limited in some inclusions by physical factors (stones or gravel in the embossed); present erosion by runoff diffuse, terraces, cow leg, mass movements and small landslides.

Includes the mountains in relief types of rows and beams, with small Valleys and not mappable collusions; the relief is moderately inclined to strongly steeped, slopes in their majority between 50% and 75% (see Cartography 2148-04-EV-DW-028).

On the soil surface can be present stones, rocks and rock outcrops, sometimes of great size; in the dry seasons appear low and depth amplitude cracks

3.2.3.3 Zaragoza Association (ZC)

This unit is located on the banks of the San Matias River, near the area where it crosses the path of the house of engines. They are soils that have been developed from metamorphic rocks, Migmatic GNEISS' and paragneiss, with inclusions of limestone, marble, quartzite and schist; are deep or moderately deep, limited by gravel, stones or by rock; well-drained.

The texture of the soil varies from moderately fine to fine; the colors are dark on the surface and clear in the subsurface horizons, from extreme to strongly acidic, with high saturation of aluminum, low in total bases and low fertility.

It is part of the mountain scenery, conformed by the relief types of rows and beams. The terrain varies from moderately undulated to moderately steeped, with slopes of different gradients, lengths and shapes; some are long, medium and short, convex and rectilinear, in a

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range of 12% to 75 %. Presents moderate to strong dissection, of different breadth and depth, slight to moderate erosion and moderate to frequent mass movements (cow leg). Some soils can submit gravel, stone chips and stones on the surface and in the embossed.

3.2.3.4 Girardota Complex (GS)

In the collection area of the project this complex is identified, it is located in the colluvial alluvial small valleys between 1,000 meters and 2,000 meters above sea level, where there can be found small terraces, meadows, dike and colluviums. The terrain is flat to undulating, with slopes of up to 12% (see Cartography 2148-04-EV-DW-028).

The soils have developed from recent mixed heterogeneous sediment colluvial alluvial of different sizes; they are shallow to moderately deep, limited by physical and chemical factors (prelatic level, rock fragments in the embossed and aluminum toxicity). The natural drainage is poor to good; the majority is soils of very low to moderate pedogenetic evolution, presented structural development in the upper horizons; the textures are moderately fine to coarse and low to high fertility.

3.2.3.5 Poblano Association (PO)

In the left margin of the San Matias River, in the collection area, it is identified the Poblano association, which is located in the mountain scenery, in type of embossed glacia and colluvial removal; it is lightly to heavily corrugated, with slopes up to 25 %; in some sectors there is erosion or mass movements, in addition, different sizes stones on the surface.

The soils have developed on the basis of heterometric material deposits mixed with colluvial and colluvial alluvial materials; they are moderately deep to deep, limited by the presence of rock fragments such as gravel, stone chips and stones in the embossed; with natural drainage well-drained, fine textures to moderately thick, some soils have a high saturation of aluminum which produces toxicity to the majority of the plants. The soils of this unit are from very low to very high pedogenetic evolution, with structure especially in the upper horizons and very low to high fertility.

3.2.4 POTENTIAL USES

In Table 3-4 and in Cartography 2148-04-EV-DW-030 presents the potential uses of the soil of the study area, based on the General Study of soils and zoning of land from the department of Antioquia⁵

Table 3-4. Potential uses of the soil

| Class | Subclass | Potential Use |
|-------|----------|--|
| 3 | S-2 | <p>They have limitations due to moderate effective depth, and of chemical character as strong acidity, high aluminum content and low fertility, complemented by the low content of phosphorus and organic matter.</p> <p>Suitable for:</p> <ul style="list-style-type: none"> • Agriculture with crops that require applying fertilizer and adding organic matter and amendments. • Semi-intensive farming, with proper handling of the pasture and cattle, applying |

⁵ Ibid.

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| Class | Subclass | Potential Use |
|-------|----------|---|
| | | practices that include rotational grazing, avoiding the overhead of cattle and overgrazing. |
| | PS-7 | Limited by moderately inclined slopes, depth effectively limited by the presence of rock fragments and the presence of cow leg or cattle trails. Present strong acidic reaction, moderate saturation of aluminum, a low content of calcium, magnesium, and phosphorus and low fertility. Suitable for the cultivation of coffee, bananas, cassava, citrus, avocado, guava, passion fruit and mango; in addition to semi intensive and intensive cattle raising, using improved pastures |
| | S-7 | The soils have originated from colluvial-alluvial materials; they are deep and moderately deep; limited by rock fragments, well-drained soils of very strong reaction to moderately acidic, medium saturation of aluminum and low to moderate fertility. Suitable for agriculture with root crops moderately deep, adapted to the climatic conditions, and for semi intensive or intensive cattle raising. Require fertilizer application in accordance with the availability of nutrients in the soil and the requirements of the crops, incorporation of organic matter, preparatory work on surroundings. In regard to the management of pastures and cattle, they must be kept free of pasture weeds, applying fertilizer, planting trees for the cattle bleak, avoid overgrazing. |
| 6 | P-7 | Limited by slightly inclined slopes, high susceptibility to erosion and mass movements (cow trail), strong acidity and high saturation of aluminum; low content of calcium, magnesium, potassium, phosphorus and organic matter. Suitable for forest plantations (protector-producer forest), cattle raising with improved grasses or semi forest (coffee and cocoa with bleak) or for fruit trees and citrus fruits. |
| 7 | P-5 | Its limitations are the steep slopes, excessive rainfall in some areas, the current moderate erosion, the high susceptibility to erosion, strong acidity, and the high aluminum saturation, the deficiency of calcium, magnesium, potassium, phosphorus and organic matter. These soils have an aptitude for forest plantations only. |
| | P-7 | Limited by moderate to strong steeped, moderate erosion, high susceptibility to erosion and mass movements (cow leg), strong acidity and high aluminum saturation, low content of calcium, magnesium, potassium, phosphorus and organic matter. Have an aptitude for forest plantations (protector-producer forest) and crops of semi forest (coffee with bleak), applying conservation practices such as planting in level curves or transverse to the slopes, implement fertilization programs in accordance with nutrients availability in the soil and the requirements of the crops. |

3.2.5 HYDROLOGY

The El Molino hydroelectric project is located in the basin of the San Matias River, a tributary of the Cocorná River, which in turn download its waters in the Calderas River. The main tributary of the San Matías River is the Tafetanes River that pours its waters 1,000 m before the siege of collection.

For the estimation of the flow rate 34 rainfall stations were identified belonging to the IDEAM, EPM and CHEC, located in the basins of the Cocorná, San Matias, Tafetanes, Calderas, and Santo Domingo rivers (see

Table 3-5); and four seasons of flows on the Cocorná, San Matias, Calderas and Santo Domingo rivers, belonging to the first three Public Companies of Medellin and the last to the IDEAM (see

Table 3-6). From the last ones. it was only able to be used the IDEAM (Pailania), because by internal politics, Public Enterprises did not supply the series of flows.

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Table 3-5. Rainfall stations identified in the area

| Code | Type | Name | Sub basin | Municipality | Coordinates | Lift | Entity | Installation Date |
|---------|------|----------------------|---------------|----------------------|----------------|------|--------|-------------------|
| 2305501 | ME | Argelia | Samana | Argelia | 0546N 7510W | 2500 | CHEC | 1977 |
| 2305507 | ME | Argelia | Samana south | Argelia | 0544N 7509W | 1700 | IDEAM | 1977 |
| 2308027 | PG | Rionegro La Macarena | Negro | Rionegro | 0609N 7522W | 2070 | EPM | 1949 |
| 2308030 | PM | El Carmen | Negro | El Carmen de Viboral | 0605N 7520W | 2180 | EPM | 1959 |
| 2308035 | PM | Santuario | Negro | El Santuario | 0608N 7516W | 2150 | EPM | 1959 |
| 2308037 | PM | Guatape | Nare | Guatape | 0614N 7510W | 1900 | EPM | 1959 |
| 2308044 | PG | Corrientes | Nare | San Vicente | 0619N 7516W | 1980 | EPM | 1967 |
| 2308046 | PG | La Pradera | Guatape | San Rafael | 0617N 7459W | 1100 | EPM | 1967 |
| 2308052 | PM | Cocorna | North Samana | Cocorna | 0604N 7511W | 1210 | EPM | 1968 |
| 2308054 | PM | Granada | North Samana | Granada | 0609N 7511W | 2050 | EPM | 1968 |
| 2308055 | PM | San Luis | North Samana | San Luis | 0603N 7500W | 1080 | EPM | 1968 |
| 2308061 | PG | El Bizcocho | Guatape | San Rafael | 0619N 7505W | 1040 | EPM | 1968 |
| 2308064 | PM | Marinilla | Negro | Marinilla | 0611N 7520W | 2100 | IDEAM | 1973 |
| 2308065 | PM | Campoalegre | Cimarrona | El Carmen de Viboral | 0605N 7520W | 2150 | IDEAM | 1973 |
| 2308067 | PM | La Araña | Guatape | San Rafael | 0617N 7506W | 1260 | EPM | 1977 |
| 2308070 | PG | Calderas | Calderas | Granada | 0610N 7506W | 2070 | EPM | 1974 |
| 2308075 | PM | Cocorna | Cocorna | Cocorna | 0604N 7511W | 1280 | IDEAM | 1975 |
| 2308079 | PG | La Linda | Santo Domingo | El Carmen de Viboral | 0557N 7517W | 2620 | IDEAM | 1982 |
| 2308082 | PG | Tafetanes | North Samana | Granada | 0609N 7508W | 1950 | IDEAM | 1983 |
| 2308083 | PM | La Rapida | Guatape | San Rafael | 0614N 7503W | 1380 | EPM | 1987 |
| 2308085 | PM | La Cascada | Guatape | San Rafael | 0615N 7505W | 1700 | EPM | 1987 |
| 2308086 | PG | Samaria | Guatape | San Rafael | 0616N 7507W | 1350 | EPM | 1988 |
| 2308090 | PG | La Honda | North Samana | San Francisco | 0553N 7500W | 1000 | EPM | 1989 |
| 2308091 | PG | Los Medios | Calderas | Granada | 0608N 7505W | 1630 | IDEAM | 1991 |
| 2308092 | PG | Santuario | Rionegro | El Santuario | 0608N 7517W | 2180 | IDEAM | 1992 |

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| Code | Type | Name | Sub basin | Municipality | Coordinates | Lift | Entity | Installation Date |
|---------|------|---------------|--------------|--------------|----------------|------|--------|-------------------|
| 2308499 | PM | Santa Ana | Nare | San Rafael | 0615N 7808W | 2225 | EPM | 2003 |
| 2308505 | CP | Santa Rita | Nare | Alejandria | 0619N 7510W | 1875 | EPM | 1958 |
| 2308511 | CO | El Peñol | Rionegro | El Peñol | 0613N 7515W | 2075 | IDEAM | 1973 |
| 2308514 | CO | San Francisco | Calderas | Cocorna | 0558N 7506W | 1300 | IDEAM | 1973 |
| 2308517 | CP | El Peñol | Nare | Peñol | 0614N7513W | 1880 | EPM | 195911 |
| 2308522 | CP | San Carlos | North Samana | San Carlos | 0610N7501W | 1132 | IDEAM | 198305 |
| 2618008 | PG | Mesopotamia | Buey | La Union | 0548N7519W | 2415 | EPM | 195812 |
| 2618010 | PM | La Union | Piedras | La Union | 0559 N7522W | 2500 | EPM | 195901 |
| 2618018 | PG | Sonson | Sonson | Sonson | 0543N7518W | 2530 | IDEAM | 197006 |

Notes: **CP** : Main weather; **CO** : Ordinary Climatology; **ME** : Meteorology; **PG** : Pluviograph; **PM** : Pluviometric

Table 3-6. Flows stations identified in the area

| Code | Type | Name | Sub basin | Municipality | Coordinates | Elevation | Entity | Installation date |
|---------|------|-----------------|------------------------|--------------|-----------------|-----------|--------|-------------------|
| 2308720 | LG | Pailania | Santo Domingo | Cocorná | 0559 N 7507W | 980 | IDEAM | 1973 |
| 2308734 | LG | Calderas PSN-3 | Calderas | Cocorná | 0559 N 7504W | 650 | EPM | 1981 |
| 2308735 | LG | El Ocho PSN-2 | Cocorna | Cocorna | 0601N 7509W | 925 | EPM | 1980 |
| 2308741 | LG | El Molino PSN-1 | San Matias - Tafetanes | Cocorna | 0603N 7509W | 1256 | EPM | 1980 |

Notes: LG: Limnigraphic

In general, the information of precipitation and stream flow covers at least the past 30 years, registering extreme behavior recognized in technical literature as Los Niños of 1953, 1957, 1965, 1969, 1972, 1976, 1982, 1991, 1994, 1997 and 2002; and Las Niñas of 1954, 1964, 1970, 1973, 1975, 1988, 1998 and 2000.

Table 3-7 shows the average rainfall for each of the stations and Figure 3-1 presents the isohyets of average annual precipitation in the San Matias River basin.

Table 3-7. Average station rainfall

| Code | Name | Precipitation (MM) |
|---------|----------------------|--------------------|
| 2305501 | Argelia | 5,367 |
| 2305507 | Argelia | 4,864 |
| 2308027 | Rionegro la macarena | 1,889 |
| 2308030 | El Carmen | 2,733 |
| 2308035 | Santuario | 2,803 |
| 2308037 | Guatape | 3,702 |
| 2308044 | Flows | 2,526 |

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| Code | Name | Precipitation (MM) |
|-------------|---------------|-------------------------------|
| 2308046 | La Pradera | 3,491 |
| 2308052 | Cocorna | 4,671 |
| 2308054 | Granada | 3,292 |
| 2308055 | San Luis | 4,927 |
| 2308061 | El Bizcocho | 4,501 |
| 2308064 | Marinilla | 2,065 |
| 2308065 | Campoalegre | 2,614 |
| 2308067 | La Araña | 5,720 |
| 2308070 | Caldera | 4,283 |
| 2308075 | Cocorna | 4,554 |
| 2308079 | La Linda | 4,565 |
| 2308082 | Tafetanes | 4,437 |
| 2308083 | La Rapida | 4,498 |
| 2308085 | La cascada | 5,464 |
| 2308086 | Samaria | 6,069 |
| 2308090 | La Honda | 4,304 |
| 2308091 | Los Medios | 4,545 |
| 2308092 | Santuario | 2,540 |
| 2308499 | Santa Ana | 5,430 |
| 2308505 | Santa Rita | 5,550 |
| 2308511 | El Peñol | 2,473 |
| 2308514 | San Francisco | 4,884 |
| 2308517 | El Peñol | 2,529 |
| 2308522 | San Carlos | 4,312 |
| 2618008 | Mesopotamia | 3,164 |
| 2618010 | La Union | 2,418 |
| 2618018 | Sonson | 2,302 |

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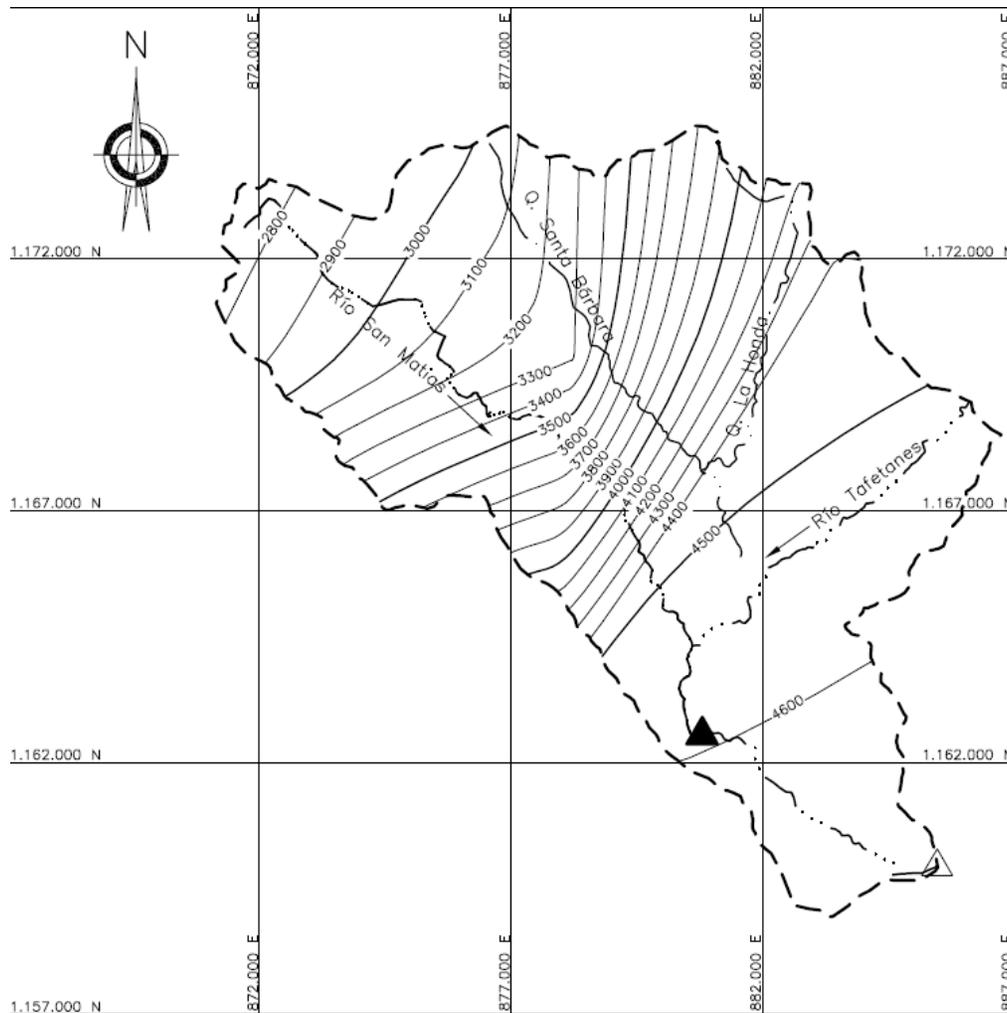


Figure 3-1. Isohyets Precipitation

3.2.5.1 Medium flows

On the basis of the flow information of the Pailania station, the isohyets of precipitation, the afferent areas to these stations and interest site proceeded to determine the flow rates by means of the relationship Average Flow-Area-Precipitation.

- Relationships average flow-area-precipitation

To determine the average flow at any site within the study area, it was considered using the balance equation:

$$Q_{\text{medium}} = c * A * P/T$$

Where:

Q_{Medium} : Average monthly multi annual flow of the interest site in m^3 /s

TO: Basin Area to the interest site in km^2

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P: medium precipitation of the basin to the interest site in mm

C: Runoff multi annual coefficient that depends on the type of soil, the average slope of the field, the plant cover. This coefficient indicates what percentage of the precipitation becomes flow, which implies that deducts to multi annual scale other abstractions such as infiltration and vapor transpiration.

T: Time, in this case 1 year

Table 3-8 shows the flow, the area, the precipitation and the performance until the station Pailania.

Table 3-8. Characteristics of the flows station

| Code | Type | Station | Flow (m ³ /s) | Area (Km ²) | Precipitation (mm) | Performance (l/s/km ²) |
|---------|------|----------|--------------------------|-------------------------|--------------------|------------------------------------|
| 2308720 | LG | Pailania | 25.81 | 196.5 | 4583 | 131 |

Been defined the characteristics of the Pailania Station there was obtained a runoff coefficient c for the basin of 0.90, very high value compared to other coefficients of other basins in Antioquia determined by HMV ENGINEERS. In addition, for its calculation, it was only taken into account rainfall, and not the actual precipitation that is equal to the precipitation minus evaporation.

To check the consistency of the runoff coefficient, applied the balance equation involving the actual evaporation E:

$$Q_{\text{medium}} = c_1 * A * (P-E) / t$$

From the Turk equation and average rainfall in the basin, it was determined that the current evaporation of the basin is 1,007 mm, resulting in a runoff coefficient c 1 11585. A value totally illogical, since this should not be greater than one.

When investigating a possible cause of this phenomenon, it was observed that the Santo Domingo River basin is located in the lower section of the precipitation station 238514 San Francisco, there is no precipitation stations on the top, only by reaching, some of them very far away, toward the south of the river basin, as stations 2350501 Argelia, 2350507 Argelia, 2350890 La Honda and 2618018 Sonson.

Given that there are doubts about the current precipitation in the basin of the Rio Santo Domingo River and not overestimating the flow rates for the San Matias River it was decided that, from runoff coefficients c, determined by HMV ENGINEERS in other basins, to assume for the basin of the Santo Domingo River a runoff coefficient c₁ equal to 0.90 (for the effective precipitation P-E). From this coefficient, it is determined the medium real precipitation and evaporation of the basin of the Santo Domingo River until Pailania, station which were 5.652 mm and 1,014 mm, respectively.

It was defined to work with 5,650 mm of precipitation.

From the precipitation, it is obtained a coefficient c equal to 0.7333, obtaining the next balance equation for the Santo Domingo River:

$$Q_{\text{medium}} = 2.3253 * 10^{-5} * A * P$$

| | | | |
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From the previous equation it is determined the multi annual monthly flow in the collection and discharge site of the central.

- Average multi-annual monthly Flow

To determine the average flow in the collection and discharge sites, it was not only taken into account the area of the basin of the Tafetanes River and the average annual rainfall in the sites, but also the subtraction of the basin area of river Tafetanes River exploited by ISAGEN for deviation of the latter river to Calderas River. Table 3-9 presents medium flows in the diversion of the Tafetanes, River collection and discharge.

Table 3-9. Medium flows in the sites of interest

| Site of interest | Area (km ²) | Precipitation (mm) | Flow (M ³ /s) | Performance (l/s/km ²) |
|---------------------------------------|-------------------------|--------------------|--------------------------|------------------------------------|
| River Tafetanes - Deviation Tafetanes | 19.49 | 4,250 | 1.93 | 99 |
| San Matias River - Collection * | 107.29 | 3,822 | 9.54 | 89 |
| San Matias River - Discharge * | 124.72 | 3,934 | 11.41 | 91 |

* Does not include the area of the diversion of the river Tafetanes

To check the determined medium flow, using the following equation, developed by Integral S. A. in 1980 for the study of the Calderas and Tafetanes projects of ISA:

$$Q_{\text{medium}} = \text{EXP} (-5.78329 + 0.99455 * \text{Ln}A + 1.4468 * \text{Ln} P), \text{ where}$$

Q_{Medium} : Average monthly multi annual flow of the site of interest in m³ /s

TO: Basin Area to the site of interest in km²

P: Average precipitation of the basin to the site of interest in mm/day

It was obtained as a result:

Collection Site: 9.63 M³ /s

Discharge Site: 11.66 M³ /s

Tafetanes River - Deviation Tafetanes: 2.06 M³ /s

As it is noticed, the results for the two procedures are virtually equal, presenting minor differences of 2 %, so the determined flows with the equation of balance are adopted.

Once the annual medium multi flow was obtained, the distribution of the flow rate to monthly multi annual for the site was determined for the El Molino hydroelectric project, taking as a pivot the Pailania station.

$$Q_{i,j} = \frac{A_i * P_{i,j}}{A_p * P_{p,i}} * Q_{p,j}, \text{ where}$$

$Q_{i,j}$: Medium multi annual monthly flow of site i to the month j.

A: Average monthly multi annual rainfall until the site i to the month j.

$P_{i,j}$: Average monthly multi annual rainfall until the site i to the month j.

$Q_{p,j}$: Average monthly multi annual flow of the pivot station in month j.

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AP : Area of the basin until the pivot station

P_{p,j}: Medium monthly multi annual rainfall of the pivot station in month j.

The precipitation and the average monthly multi annual flow for the station Pailania and the site of collection of the El Molino hydroelectric project, are presented in Table 3-10 and Table 3-11

Table 3-10. Medium monthly multi annual rainfall (mm)

| Month | Pailania Station | Collection |
|-----------|------------------|------------|
| January | 287 | 166 |
| February | 319 | 195 |
| March | 424 | 273 |
| April | 559 | 392 |
| May | 570 | 443 |
| June | 460 | 319 |
| July | 415 | 291 |
| August | 543 | 377 |
| September | 642 | 457 |
| October | 571 | 305 |
| November | 487 | 337 |
| December | 373 | 266 |
| Total | 5,650 | 3,822 |

Table 3-11. Medium monthly multi annual flow (m³ /s)

| Month | Pailania Station | Collection |
|-----------|------------------|------------|
| January | 23.63 | 7.51 |
| February | 24.48 | 8.26 |
| March | 23.90 | 8.46 |
| April | 29.97 | 11.56 |
| May | 29.82 | 12.74 |
| June | 22.88 | 8.75 |
| July | 17.49 | 6.74 |
| August | 20.64 | 7.88 |
| September | 28.16 | 11.05 |
| October | 30.91 | 9.09 |
| November | 30.73 | 11.71 |
| December | 27.14 | 10.68 |
| Average | 25.81 | 9.54 |

- Series of flow rates at a daily level

The obtained flow monthly multi annual level to collection site distributions, based on the series of flow rates at daily level of the Pailania Station, identified the daily flow rates by means of the following equation:

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$$Q_{i,j,k} = \frac{Q_j}{Q_{P,j}} * Q_{P,i,j,k}, \text{ where}$$

$Q_{i,j,k}$: Daily volume of flow at the site of interest in the day i, of month j, of year k.

Q_j : Medium monthly multi annual flow in the site of interest of month j.

$Q_{P,j}$: Medium monthly multi annual flow of the Pailania station in month j.

$Q_{P,i,j,k}$: Daily flow at the Pailania station on day i, of month j, of year k.

3.2.5.2 Minimum Flows

Based on the series of flows to daily level, it is estimated the minimum flows in the collection site, which are presented in Table 3-12 .

Table 3-12. Minimum flows, Collection site

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|-------------|------|------|------|------|-------|------|------|------|------|------|-------|------|
| 1974 | 5.20 | 5.52 | 2.71 | 6.34 | 6.33 | 6.59 | 3.08 | 5.54 | 6.96 | 6.91 | 10.33 | 5.43 |
| 1975 | 4.15 | 5.87 | 5.43 | 6.26 | 11.04 | 4.40 | 4.91 | 5.06 | 9.57 | 6.94 | 9.92 | 7.77 |
| 1976 | 4.61 | 6.14 | 6.45 | 7.02 | 7.77 | 2.68 | 1.54 | 1.53 | 2.32 | 3.61 | 4.34 | 3.66 |
| 1977 | 4.32 | 3.14 | 2.37 | 3.16 | 4.44 | 3.06 | 2.66 | 3.05 | 1.84 | 4.58 | 6.59 | 4.45 |
| 1978 | 3.16 | 2.70 | 2.99 | 7.70 | 7.38 | 4.87 | 4.86 | 3.05 | 4.77 | 4.53 | 7.44 | 7.59 |
| 1979 | 3.02 | 2.70 | 3.72 | 4.40 | 4.78 | 3.06 | 1.97 | 1.68 | 5.49 | 3.09 | 5.07 | 3.74 |
| 1980 | 3.34 | 2.77 | 2.16 | 2.12 | 4.14 | 3.52 | 1.73 | 3.13 | 3.53 | 3.79 | 4.92 | 5.51 |
| 1981 | 2.54 | 6.24 | 2.83 | 4.98 | 5.98 | 4.01 | 2.51 | 2.10 | 3.14 | 4.11 | 6.52 | 5.51 |
| 1982 | 2.35 | 4.72 | 3.72 | 5.40 | 5.98 | 3.06 | 1.46 | 0.76 | 0.78 | 4.76 | 3.05 | 2.16 |
| 1983 | 1.11 | 0.91 | 1.42 | 3.09 | 4.87 | 2.56 | 2.12 | 1.34 | 5.49 | 2.35 | 5.34 | 4.80 |
| 1984 | 2.73 | 4.72 | 2.62 | 5.67 | 4.48 | 4.01 | 3.08 | 3.28 | 3.14 | 5.20 | 6.63 | 5.94 |
| 1985 | 2.54 | 2.70 | 2.83 | 5.40 | 2.86 | 1.15 | 0.69 | 2.82 | 5.49 | 3.35 | 2.32 | 3.82 |
| 1986 | 2.99 | 2.70 | 2.83 | 2.12 | 4.23 | 3.29 | 1.00 | 0.76 | 3.14 | 4.11 | 5.34 | 4.13 |
| 1987 | 2.92 | 3.54 | 1.95 | 2.12 | 5.98 | 2.10 | 1.23 | 1.53 | 4.12 | 7.26 | 9.47 | 7.14 |
| 1988 | 1.75 | 1.86 | 2.83 | 4.44 | 4.48 | 3.06 | 1.77 | 5.34 | 4.40 | 3.29 | 5.34 | 4.41 |
| 1989 | 4.45 | 4.18 | 3.22 | 4.17 | 3.42 | 3.06 | 1.35 | 2.10 | 4.12 | 4.76 | 4.12 | 3.15 |
| 1990 | 2.58 | 1.86 | 1.66 | 3.09 | 1.37 | 1.34 | 1.30 | 1.18 | 2.85 | 4.11 | 4.00 | 2.46 |
| 1991 | 2.70 | 2.66 | 3.01 | 3.38 | 6.15 | 3.54 | 2.49 | 2.10 | 2.07 | 2.68 | 7.25 | 6.09 |
| 1992 | 2.74 | 2.72 | 2.48 | 2.87 | 7.26 | 3.25 | 2.24 | 2.55 | 4.55 | 3.23 | 5.28 | 4.13 |
| 1993 | 3.88 | 3.37 | 2.76 | 4.86 | 5.51 | 2.68 | 2.70 | 2.33 | 5.61 | 4.11 | 5.34 | 6.06 |
| 1994 | 3.75 | 4.35 | 3.93 | 5.86 | 7.09 | 3.82 | 2.85 | 3.05 | 3.06 | 3.59 | 6.86 | 3.90 |
| 1995 | 1.91 | 2.06 | 3.10 | 4.59 | 5.98 | 5.35 | 4.82 | 5.34 | 3.34 | 5.34 | 3.91 | 3.84 |
| 1996 | 3.59 | 3.50 | 4.00 | 6.27 | 6.58 | 5.07 | 3.04 | 2.84 | 4.32 | 4.70 | 4.19 | 7.39 |
| 1997 | 2.78 | 3.16 | 3.01 | 5.40 | 3.84 | 3.78 | 2.27 | 2.25 | 2.66 | 3.23 | 5.34 | 3.34 |
| 1998 | 1.88 | 2.87 | 2.48 | 6.94 | 3.63 | 3.25 | 2.70 | 4.20 | 5.49 | 4.11 | 6.86 | 7.08 |
| 1999 | 4.45 | 6.68 | 6.38 | 4.24 | 4.70 | 5.35 | 2.85 | 2.75 | 7.06 | 4.70 | 5.34 | 5.82 |
| 2000 | 3.59 | 3.71 | 6.38 | 6.94 | 7.69 | 6.88 | 6.01 | 3.24 | 8.75 | 5.29 | 5.34 | 4.33 |
| 2001 | 3.50 | 2.36 | 5.53 | 4.82 | 5.98 | 3.25 | 2.70 | 2.25 | 3.34 | 5.29 | 6.86 | 7.08 |
| 2002 | 4.45 | 4.72 | 5.67 | 6.94 | 2.99 | 3.25 | 2.27 | 2.25 | 7.06 | 4.11 | 6.86 | 5.51 |

| | | | | |
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| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|----------------|------|------|------|------|------|------|------|------|------|------|------|------|
| Minimum | 1.11 | 0.91 | 1.42 | 2.12 | 1.37 | 1.15 | 0.69 | 0.76 | 0.78 | 2.35 | 2.32 | 2.16 |

3.2.5.3 Maximum Flow Rates

For the collection and discharge sizing there was determined the maximum flow of the San Matias River in those two sites.

The hydrological design methods for the calculation of growing flows in a basin are connected to the type of available information such as the records of flow rates, precipitation, and land use, among others. In this case a direct measurement of flow rates is not available, so it was necessary the application of different methods such as the models of the rational equation and rainfall-runoff to determine the maximum flow rates.

For the minor currents, it was used the rational equation with coefficients proposed by Chow (1994), in order to not underestimate the maximum flow rates, which presents higher results for minor basins than the other methods described throughout this document.

- Rainfall-torrents models

The rainfall-torrents models not only provide information of the maximum flow rates, but also after the convolution of the rain with the design of the unitary hydrographs of the basins, allows the learning about the distribution of the resulting hydrographs in time.

For modeling there were used four models of unitary hydrographs; three of them were ran under program HEC-HMS 3.0.0: The hydrograph of the Soil Conservation Service (SCS), Snyder and Clark. In addition it was built the unitary synthetic hydrograph of Williams and Hann.

The Model HEC-HMS is a program of the computational modeling of hydrological system of the Corps of Engineers of the Navy of the United States of America, which allows simulating the historical rain runoff, by means of a system that integrates different hydrological methods, concentrated or distributed for the flow rates transit. The parameters used by this model are the initial losses, the transformation of rainfall runoff and the method of base flow.

The HEC-HMS has several methods for the losses rate calculation, which are:

- The model of initial loss and constant rate loss
- The deficit model and constant rate
- Exponential loss rates
- Loss function of Green and Ampt
- The curve model number of the SCS.

For the present work it is used the curve number method of SCS, now that the remaining require a calibration parameters that require a lot of information on the basin soils.

- Rational Method

The rational method is possibly the most commonly used method for the determination of water raising in small basins, less than 250 km². The rational equation used in this study,

| | | | |
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with their respective coefficients, was proposed by Chow (1994) ⁶, which it is expressed as follows:

$$Q = z * C * I * A, \text{ where}$$

Q: Peak Flow for a return period Tr.

I: Intensity of the precipitation, corresponding to the time of concentration Tc, for a return period Tr. In general the intensity is obtained from the curves Intensity-Duration - Frequency (IDF).

TO: Area of the basin.

C: Torrent coefficient, which depends on the type of soil and return period Tr.

Z: Coefficient depends on the units of the above parameters. For the calculation of the maximum flow of the San Matias River, it was given a value of 1.

Torrent coefficients C proposed by Chow are presented in Table 3-13, which must be corrected for the department of Antioquia, dividing by 1.4, to avoid overestimating the flows.

Table 3-13. Runoff coefficients. Chow (1994)

| Characteristics of the surface | Return Period (years) | | | | | | |
|--------------------------------|-----------------------|------|------|------|------|------|------|
| | 2 | 5 | 10 | 25 | 50 | 100 | 500 |
| Undeveloped Areas | | | | | | | |
| Crop Area | | | | | | | |
| Plan, 0-2% | 0.31 | 0.34 | 0.36 | 0.4 | 0.43 | 0.47 | 0.57 |
| Average, 2-7% | 0.35 | 0.38 | 0.41 | 0.44 | 0.48 | 0.51 | 0.60 |
| Slope greater than 7% | 0.39 | 0.42 | 0.44 | 0.48 | 0.51 | 0.54 | 0.61 |
| Pasture | | | | | | | |
| Plan, 0-2% | 0.25 | 0.28 | 0.3 | 0.34 | 0.37 | 0.41 | 0.53 |
| Average, 2-7% | 0.33 | 0.36 | 0.38 | 0.42 | 0.45 | 0.49 | 0.58 |
| Slope greater than 7% | 0.37 | 0.4 | 0.42 | 0.46 | 0.49 | 0.53 | 0.6 |
| Forests | | | | | | | |
| Plan 0-2% | 0.22 | 0.25 | 0.28 | 0.31 | 0.35 | 0.39 | 0.48 |
| Average, 2-7% | 0.33 | 0.36 | 0.38 | 0.42 | 0.45 | 0.49 | 0.58 |
| Slope greater than 7% | 0.37 | 0.4 | 0.42 | 0.46 | 0.49 | 0.53 | 0.60 |

For the calculation of the coefficients of runoff is assumed an average slope between 2% and 7% for collection facilities and more than 7% for the discharge. The distribution of the land uses shown in Table 3-14.

Table 3-14. Land Uses

| Crops (%) | Pasture (%) | Forests (%) | Total (%) |
|-----------|-------------|-------------|-----------|
| 10 | 60 | 30 | 100 |

- Characterization of the precipitation

Once briefly described the methodology used for the calculation of water raisings, follows the procedure implemented for the calculation of the precipitation of design.

⁶ CHOW, V. T. ; MAIDMENT, D. R. ; MAYS, L. W. (1994). Applied Hydrology. MacGrow-Hill . Santafé de Bogotá

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- Spatial distribution of rainfall

From Thiessen polygons for the two precipitation stations that are located near to the study area, it was estimated the area and the percentage of influence of each of the stations in the basins of the interest sites (see Table 3-15).

Table 3-15. Areas of influence of the stations

| Stations | Collection El Molino | | Discharge El Molino | |
|-----------|-------------------------|----|-------------------------|----|
| | Area (km ²) | % | Area (km ²) | % |
| Santuario | 26.57 | 21 | 26.57 | 18 |
| Cocorná | 42.45 | 33 | 59.88 | 42 |
| Calderas | 57.76 | 46 | 57.76 | 40 |

- Distribution of precipitation in time

For the distribution of precipitation in time, which it is used in the methods of SCS, Snyder and Clark, it was used the distribution curve of temporary rain in station Calderas, presented in the hydrology of Antioquia⁷, with a probability of occurrence of that distribution of rain in the time of the 50% (see Table 3-16).

Table 3-16. Distribution of precipitation in time

| % Time | % Precipitation to sites of interest |
|--------|--------------------------------------|
| 13 | 14 |
| 26 | 29 |
| 39 | 44 |
| 52 | 60 |
| 65 | 74 |
| 78 | 87 |
| 91 | 96 |
| 100 | 100 |

- Intensity of the precipitation

The station Calderas is the only station that has IDF curve, which equation is:

$$I = \frac{381.544 \times T^{0.185}}{(0.250 + d)^{0.519}}$$

For the other four stations of precipitation, it was used the methodology proposed by Vargas (1998) to determine the intensity of precipitation for a specific return period, depending on the maximum precipitation in 24 hours, the number of days with rain per year and the average annual rainfall, which is expressed by the following equation:

$$I = a \times \frac{T^b}{t^c} \times M^d \times N^e \times PT^f, \text{ where}$$

I: Intensity (mm/h).

⁷ Hydrology of Antioquia. Department of Antioquia. Secretariat of Public Works. Universidad Nacional de Colombia. Faculty of mines. Postgraduate in utilization of water resources. 1997

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M: Average value of the annual maximum daily precipitation (mm).

N: Average number of days with rain per year.

PT: Average annual precipitation (mm).

TR: Return Period (years).

T: Time of concentration (h).

The coefficients a, b, c, d, e, f vary according to the area of the country where it is been worked, and for this case there were used the proposed for the Andean zone, which are presented on Table 3-17 . The values of M, N and PT for each station are presented in Table 3-18 .

Table 3-17. Coefficients for the Andean region

| a | B | c | D | e | f |
|------|------|------|------|-------|------|
| 1.61 | 0.19 | 0.65 | 0.75 | -0.15 | 0.08 |

Table 3-18. Values of precipitation for each station

| Station | M | N | Pt (mm) |
|-----------|----|-----|---------|
| Cocorná | 99 | 224 | 4,554 |
| Santuario | 67 | 243 | 2,540 |

– Morph metric parameters of the basin

To determine the variables that allow the calculation of the maximum flow rates in the sites of interest, the obtained morph metric parameters are presented in Table 3-19 . For the minor river basins of the project, there were obtained the morph metric parameters shown in . Table 3-20

Table 3-19. Morphometric parameters of the basin

| Basin | Area (Km ²) | Main channel length (km) | Length. mainstream until dividing (km) | Dividing elevation (Meters above sea level) | Elevation birth channel (Meters above sea level) | Elevation site of interest (Meters above sea level) | Slope mainstream (%) | Slope mainstream until dividing (%) |
|----------------------|-------------------------|--------------------------|--|---|--|---|----------------------|-------------------------------------|
| El Molino collection | 126.8 | 16.99 | 17.49 | 2,380 | 2,350 | 1,270 | 6.36 | 6.35 |
| El Molino discharge | 144.2 | 23.43 | 23.94 | 2,380 | 2,350 | 750 | 6.83 | 6.81 |

Table 3-20. Morphometric parameters of the minor river basins

| Basin | Area (Km ²) | L. mainstream (km) | L. mainstream until dividing (km) | Dividing elevation (Meters above sea level) | Elevation birth channel | Elevation site of interest (Meters above sea level) | Mainstream slope (%) | Mainstream slope until dividing (%) |
|-------------|-------------------------|--------------------|-----------------------------------|---|-------------------------|---|----------------------|-------------------------------------|
| El Molino 1 | 0.66 | 1.62 | 1.82 | 1,460 | 1,380 | 860 | 32.1 | 33.0 |
| El Molino 2 | 0.02 | 0.14 | 0.25 | 1,005 | 960 | 882 | 57.2 | 49.6 |

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| Basin | Area (Km ²) | L. mainstream (km) | L. mainstream until dividing (km) | Dividing elevation (Meters above sea level) | Elevation birth channel | Elevation site of interest (Meters above sea level) | Mainstream slope (%) | Mainstream slope until dividing (%) |
|--------------|-------------------------|--------------------|-----------------------------------|---|-------------------------|---|----------------------|-------------------------------------|
| El Molino 3 | 0.34 | 0.82 | 1.01 | 1,460 | 1,160 | 896 | 32.2 | 55.6 |
| El Molino 4 | 0.22 | 1.08 | 1.11 | 1,460 | 1,402 | 953 | 41.7 | 45.7 |
| El Molino 5 | 0.26 | 0.70 | 0.88 | 1,460 | 1,310 | 1,028 | 40.4 | 48.9 |
| El Molino 6A | 0.03 | 0.20 | 0.28 | 1,420 | 1,360 | 1,282 | 39.6 | 49.8 |
| El Molino 6B | 0.03 | 0.23 | 0.31 | 1,420 | 1,360 | 1,267 | 41.3 | 50.0 |
| El Molino 6C | 0.03 | 0.26 | 0.34 | 1,420 | 1,360 | 1,254 | 41.5 | 49.4 |
| El Molino 7 | 0.04 | 0.26 | 0.32 | 1,356 | 1,336 | 1,266 | 27.0 | 27.9 |
| El Molino 8 | 0.02 | 0.30 | 0.38 | 1,143 | 1,103 | 1,006 | 31.9 | 35.8 |

– Time of concentration

The critical duration time for the precipitation is that one corresponding the time of concentration t_c , which is defined from a physical point of view, as the time it takes for a raindrop to reach the remotest parts of the basins at the interest site. It is clear then the dependence of this parameter with morphometric variables such as the area, slope of the mainstream, slope of the mainstream until the divisory line, length of the main channel and length of the mainstream until the dividing line.

Table 3-21 shows the concentration time of the obtained from each of the formulations, which are presented in the hydrology of Antioquia. The time of final concentration is selected as the average of the values that presented the same trend.

Table 3-21. Times of concentration

| Basin | Temez | Kirpich | California culverts Practice | S,C,S, - Ramser | Ventura-Heron | T average |
|----------------------|-------|---------|------------------------------|-----------------|---------------|-----------|
| El Molino collection | 1.77 | 1.73 | 1.68 | 1.11 | 1.77 | 1.61 |
| El Molino discharge | 2.23 | 2.14 | 2.10 | 1.37 | 2.23 | 2.01 |

The times of concentration for small river basins are presented in Table 3-22. In the case that the time of concentration is minor than 5 minutes, it was worked out with a time of concentration equal to 5 minutes, 0.083 h, due to the fact that this is the minimum time for measuring a pluviograph, from which are deducted the IDF curves.

Table 3-22. Times of concentration for the minor river basins

| Basin | Temez | Kirpich | California culverts Practice | S. C. S. Ramser | Ventura Heron | Tc average | Tc selected |
|-----------|-------|---------|------------------------------|-----------------|---------------|------------|-------------|
| Molino 1 | 0.22 | 0.16 | 0.14 | 0.11 | 0.22 | 0.17 | 0.17 |
| Molino 2 | 0.03 | 0.03 | 0.01 | 0.02 | 0.03 | 0.03 | 0.08 |
| Molino 3 | 0.13 | 0.10 | 0.07 | 0.07 | 0.13 | 0.10 | 0.10 |
| Molino 4 | 0.16 | 0.10 | 0.09 | 0.06 | 0.16 | 0.11 | 0.11 |
| Molino 5 | 0.11 | 0.09 | 0.06 | 0.06 | 0.11 | 0.09 | 0.09 |
| Molino 6A | 0.04 | 0.04 | 0.02 | 0.03 | 0.04 | 0.03 | 0.08 |
| Molino 6B | 0.05 | 0.04 | 0.02 | 0.03 | 0.05 | 0.04 | 0.08 |
| Molino 6C | 0.05 | 0.04 | 0.03 | 0.03 | 0.05 | 0.04 | 0.08 |
| Molino 7 | 0.06 | 0.05 | 0.04 | 0.03 | 0.06 | 0.05 | 0.08 |

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| Basin | Temez | Kirpich | California culverts Practice | S. C. S. Ramser | Ventura Heron | Tc average | Tc selected |
|----------|-------|---------|------------------------------|-----------------|---------------|------------|-------------|
| Molino 8 | 0.06 | 0.05 | 0.04 | 0.03 | 0.06 | 0.05 | 0.08 |

– Reduction Factor in the area.

The reduction of precipitation in the area for the basin of the El Molino hydroelectric project was performed, given that the drainage area is greater than 50 km², which means that the factors for reduction were used for precipitation in the area that are presented in Table 3-23, obtained from the curve area-precipitation - Duration of Chow (1994).

Table 3-23. Reduction factors of the precipitation in the area

| Basin | % Reduction |
|----------------------|-------------|
| El Molino Collection | 0.88 |
| El Molino discharge | 0.89 |

– Intensity and precipitation

The results of the currents and rainfall are observed in Table 3-24. The precipitation is obtained by multiplying the time of concentration by the intensity.

Table 3-24. Values of intensity and precipitation obtained for the basins

| Basin | Return Period Tr (Years) | Intensity I (mm/h) | Total precipitation P (mm) |
|----------------------|--------------------------|--------------------|----------------------------|
| El Molino collection | 2.33 | 32.58 | 52.45 |
| | 5 | 37.59 | 60.52 |
| | 10 | 42.81 | 68.92 |
| | 25 | 50.83 | 81.84 |
| | 50 | 57.88 | 93.19 |
| | 100 | 65.92 | 106.12 |
| El Molino discharge | 2.33 | 29.13 | 58.56 |
| | 5 | 33.62 | 67.58 |
| | 10 | 38.30 | 76.97 |
| | 25 | 45.48 | 91.42 |
| | 50 | 51.81 | 104.13 |
| | 100 | 59.01 | 118.60 |

Table 3-25 shows the values for the intensity and precipitation in the basin of the lower El Molino hydroelectric project.

Table 3-25. Values of intensity and precipitation for the minor river basins

| Basin | Return Period Tr (years) | Intensity mm/h | Precipitation (MM) |
|------------|--------------------------|----------------|--------------------|
| El Molino1 | 2.33 | 162.28 | 27.92 |
| | 5 | 187.62 | 32.28 |
| | 10 | 214.03 | 36.83 |
| | 25 | 254.73 | 43.83 |
| | 50 | 290.59 | 50.00 |
| | 100 | 331.50 | 57.04 |
| El Molino2 | 2.33 | 259.99 | 21.67 |
| | 5 | 300.59 | 25.05 |

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| Basin | Return Period Tr (years) | Intensity mm/h | Precipitation (MM) |
|-------------|-----------------------------|----------------|-----------------------|
| | 10 | 342.90 | 28.57 |
| | 25 | 408.11 | 34.01 |
| | 50 | 465.55 | 38.79 |
| | 100 | 531.09 | 44.26 |
| | 2.33 | 227.86 | 23.26 |
| El Molino 3 | 5 | 263.44 | 26.89 |
| | 10 | 300.52 | 30.68 |
| | 25 | 357.67 | 36.51 |
| | 50 | 408.02 | 41.65 |
| | 100 | 465.45 | 47.51 |
| El Molino 4 | 2.33 | 211.25 | 24.23 |
| | 5 | 244.24 | 28.01 |
| | 10 | 278.62 | 31.95 |
| | 25 | 331.60 | 38.03 |
| | 50 | 378.28 | 43.38 |
| El Molino 5 | 100 | 431.52 | 49.49 |
| | 2.33 | 253.14 | 21.98 |
| | 5 | 292.66 | 25.41 |
| | 10 | 333.86 | 28.99 |
| | 25 | 397.35 | 34.50 |
| Molino 6A | 50 | 453.28 | 39.36 |
| | 100 | 517.09 | 44.90 |
| | 2.33 | 259.99 | 21.67 |
| | 5 | 300.59 | 25.05 |
| | 10 | 342.90 | 28.57 |
| Molino 6B | 25 | 408.11 | 34.01 |
| | 50 | 465.55 | 38.79 |
| | 100 | 531.09 | 44.26 |
| | 2.33 | 259.99 | 21.67 |
| | 5 | 300.59 | 25.05 |
| Molino 6C | 10 | 342.90 | 28.57 |
| | 25 | 408.11 | 34.01 |
| | 50 | 465.55 | 38.79 |
| | 100 | 531.09 | 44.26 |
| | 2.33 | 259.99 | 21.67 |
| Molino 7 | 5 | 300.59 | 25.05 |
| | 10 | 342.90 | 28.57 |
| | 25 | 408.11 | 34.01 |
| | 50 | 465.55 | 38.79 |
| | 100 | 531.09 | 44.26 |
| Molino 8 | 2.33 | 259.99 | 21.67 |
| | 5 | 300.59 | 25.05 |
| | 10 | 342.90 | 28.57 |
| | 25 | 408.11 | 34.01 |
| | 50 | 465.55 | 38.79 |
| | 100 | 531.09 | 44.26 |

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- Study of losses

For the calculation of the effective precipitation on the basin, we use the SCS method to determine the part of the total precipitation that becomes runoff, which is calculated using the following expressions:

$$P_e = \frac{(P - I_a)^2}{P - I_a + S}$$

$$S = \left(\frac{1000}{CN} - 10 \right)$$

$$I_a = 0.2 * S$$

Where,

P_e : Excess precipitation,

P: Total precipitation

I_a : Initial Abstraction

S: Maximum Retention potent

CN: Curve Number

The number of torrent curve CN of SCS, was developed as an index that represents the combination of the hydrological soil groups, the use and the kind of treatment of the soil.

Empirical analysis led to infer that the CN is a function of three factors: land use, hydrology group of soil and moisture history, which are related to the amount of rain fall in the basin during the five days preceding, to which there were established three states: dry soils (AMCI), intermediate soils (AMC II) and wet soil (AMCIII).

The considerations for the selection of the NC in the basins of eastern Antioquia are as the follows:

- The surface condition of the hydrographic basin is reflected in the use of the soil and the types of treatment. Land use is associated with the forest and vegetation cover of the basin as are the types of vegetation, agricultural practices, and land in rest, impermeable surfaces and urban areas. The distribution of use of the soil used is the presented in Table 3-14 .
- Hydrological SCS classified more than 4,000 soils based on their potential for torrent, from which were the grouped into four hydrologic soil groups, which are identified with the letters A, B, C and D. In accordance with what it is seen in the field, these basins were defined as soil type B, which are soils with infiltration capacities higher than average, after it has been completely soaked.
- The antecedent moisture takes into account the precipitation of the five days prior to the storm. For the basins was established the condition of average antecedent moisture (AMCII), which has a potential for medium runoff.

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The values obtained are summarized in Table 3-26 , which were taken from the book Design of small dams⁸ .

Table 3-26. Final values for the CN

| LAND USES | | Percentage in relation to the total area (%) | Curve number CN |
|------------------------------|--------------------------------|--|-----------------|
| Crops | Without Conservation Treatment | 10 | 88 |
| | With Conservation Treatment | 0 | 85 |
| Pasture | In poor conditions | 0 | 86 |
| | In regular conditions | 60 | 79 |
| | In optimal conditions | 0 | 74 |
| Natural forests | Thin logs. Poor Cover | 0 | 77 |
| | Regular Cover | 30 | 73 |
| | Good Cover | 0 | 70 |
| Curve Number selected | | | 78 |

- Duration of the effective rainfall

For choosing the duration of the effective rainfall du , the criteria adopted was the SCS, whereby $du=0,133 * T_c$. The results are shown in Table

Table 3-27. Values of du

| Basin | Du (minutes) |
|----------------------|--------------|
| El Molino collection | 12.87 |
| El Molino discharge | 16.07 |

- Flow rates obtained for the interest sites

Due to the experience that HMV engineers has had in the design of hydraulic facilities in their hydroelectric projects, where it has been selected the SCS methodology for the calculation of high water rising and with the object of not underestimating or overestimating maximum flow rates, it was decided to select the flow rates obtained by this method. The maximum flow rate selected for the El Molino hydroelectric project are shown in . Table 3-28

Table 3-29 presents the maximum flow rates for different periods of return in small river basins of the El Molino hydroelectric project , and in Figure 3-2 , are graphically displayed the maximum flow rates in the creeks and sections of them.

Table 3-28. Maximum flow rates in the interest sites

| Basin | Tr | SCS |
|----------------------|------|-------|
| El Molino collection | 2.33 | 329 |
| | 5 | 447 |
| | 10 | 580 |
| | 25 | 799 |
| | 50 | 1,003 |
| | 100 | 1,246 |
| El Molino discharge | 2.33 | 347 |

⁸ DESIGN OF SMALL DAMS. U. S. Department of the Interior. Bureau of Reclamation. Continental Publishing Company. Mexico. 1979

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| Basin | Tr | SCS |
|-------|-----|-------|
| | 5 | 467 |
| | 10 | 602 |
| | 25 | 822 |
| | 50 | 1,026 |
| | 100 | 1,268 |

Table 3-29. Maximum flow rates in the interest sites for small river basins

| Basin | Return Period (years) | | | | | |
|--------------|-----------------------|------|-------|-------|-------|-------|
| | 2.33 | 5 | 10 | 25 | 50 | 100 |
| El Molino 1 | 6.97 | 8.78 | 10.60 | 13.90 | 17.02 | 21.09 |
| El Molino 2 | 0.26 | 0.33 | 0.40 | 0.52 | 0.64 | 0.79 |
| El Molino 3 | 5.09 | 6.42 | 7.75 | 10.16 | 12.44 | 15.41 |
| El Molino 4 | 3.02 | 3.81 | 4.59 | 6.02 | 7.37 | 9.14 |
| El Molino 5 | 4.24 | 5.35 | 6.45 | 8.46 | 10.36 | 12.84 |
| El Molino 6a | 0.44 | 0.55 | 0.67 | 0.87 | 1.07 | 1.33 |
| Molino 6b | 0.46 | 0.58 | 0.70 | 0.92 | 1.13 | 1.40 |
| Molino 6C | 0.50 | 0.63 | 0.77 | 1.00 | 1.23 | 1.52 |
| Molino 7 | 0.68 | 0.85 | 1.03 | 1.35 | 1.65 | 2.05 |
| Molino 8 | 0.34 | 0.43 | 0.52 | 0.68 | 0.84 | 1.04 |

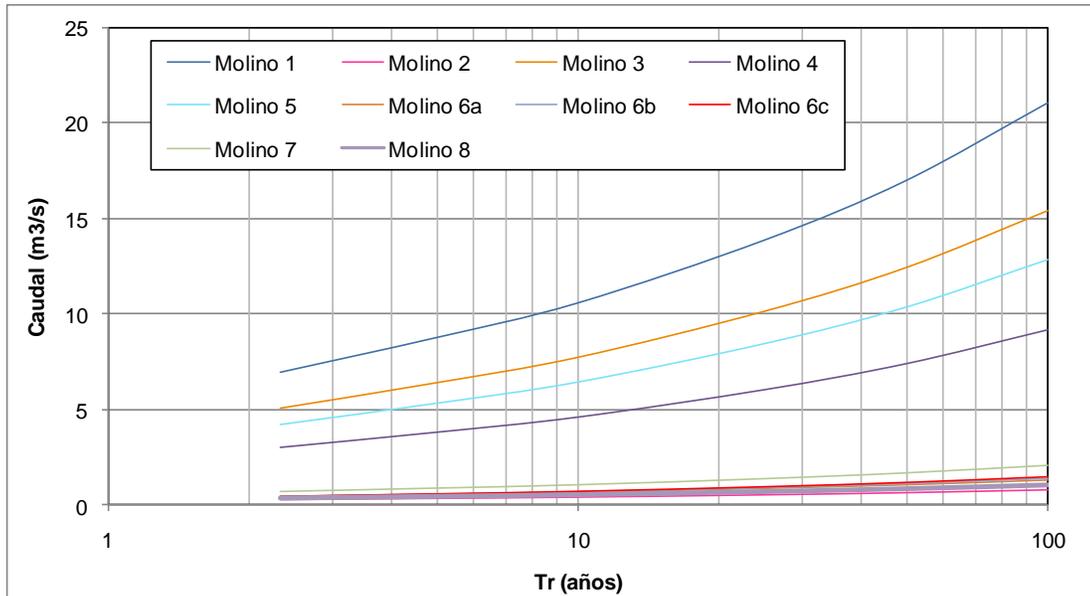


Figure 3-2. Maximum Flow Rates - minor river basins

3.2.5.4 Sediment transport

The quantification and characterization of the sediments is of great importance from a technical and environmental point of view in the construction of hydroelectric projects that have dam regulation, by the implications for the useful dam life and the effects on the pluvial dynamics upstream and downstream.

In the case of the El Molino hydroelectric project , it will not count with a regulation reservoir, only a small pondage formed by the construction of the weir at 4 m, which will not comply with

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any regulatory role and whose mode of operation will allow the continuous cleaning of sediments, thus avoiding the little accumulation behind the weir.

- Methodology and results

For the determination of sediment transport, was provided with the information of the total transport of suspended sediment of the Samana North River in the station La Garrucha, supplied by IDEAM, which covers the period between 1983 and 1999.

In accordance with the information of the IDEAM, the transport of suspended sediment of the Samana North River is 938 kt/year, for a solid unitary performance of 575 /year/km².

The indicated transport only refers to the suspended sediment sampled, but skipping the suspension sediment not sampled and the transport of the bottom sediment. Based on the experience in several rivers in Antioquia, it might be assumed that the load not sampled and the sediment in the bottom represents approximately 40 % of the sampled sediment. According to this, the total average load of sediment would be 1.313 kt/year, approximately.

This transport would mean a rate of denuding average of 0.50 mm/year. Considering that the uses of the soil, the geomorphology and the climate system of the Samana North basin of the river, including the San Matias River, are equal, you can apply the solid unitary performance to determine the transport in suspension of the San Matias River in the collection site. With the case above, the contribution of suspended sediments of the San Matias River in the collection site would be of 102 kt/year.

- Downstream and upstream effects of the weir

In the case of the El Molino hydroelectric project , the process of degradation that commonly occurs in the construction of dams has no influence, already that the retention of fine sediments in the pondage is minimal and the procedure of opening of the gate during the water raising, guarantees the drag of these toward the river bed.

Also, the process of gradation by the formation of the delta sediments by the small poundage that is formed, would not be significant, since the opening of the gate during water raising, facilitates this drag, given the high slope that the river presents in the sector and under the weir.

3.2.6 USES OF WATER

Using ex officio 47308 of December 12 of 2011, it is requested before CORNARE information on the uses of the water existing in the influence area of the El Molino hydroelectric project , which was replied by ex officio 134-0241 from 21 December 2011, and in which the entity reported that their databases are not water concessions granted in the basin and its drainages, as can be seen in Annex 4 .

3.2.6.1 Identification of water sources and their respective owners

In order to carry out the inventory and quantification of the uses and users of the drains located in the direct project influence area, carried out a field reconnaissance, in which were identified the small tributaries that supply the San Matias River, which eventually will be seen altered by the execution of the project.

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For the direct project influence area were identified a total of 25 flows of water and 5 births, which supply 30 dwellings and three untimed units producing panela and cattle raising use, for a total of 34 users (see FigureFigure3-3). In this way the main uses identified were domestic and agriculture.

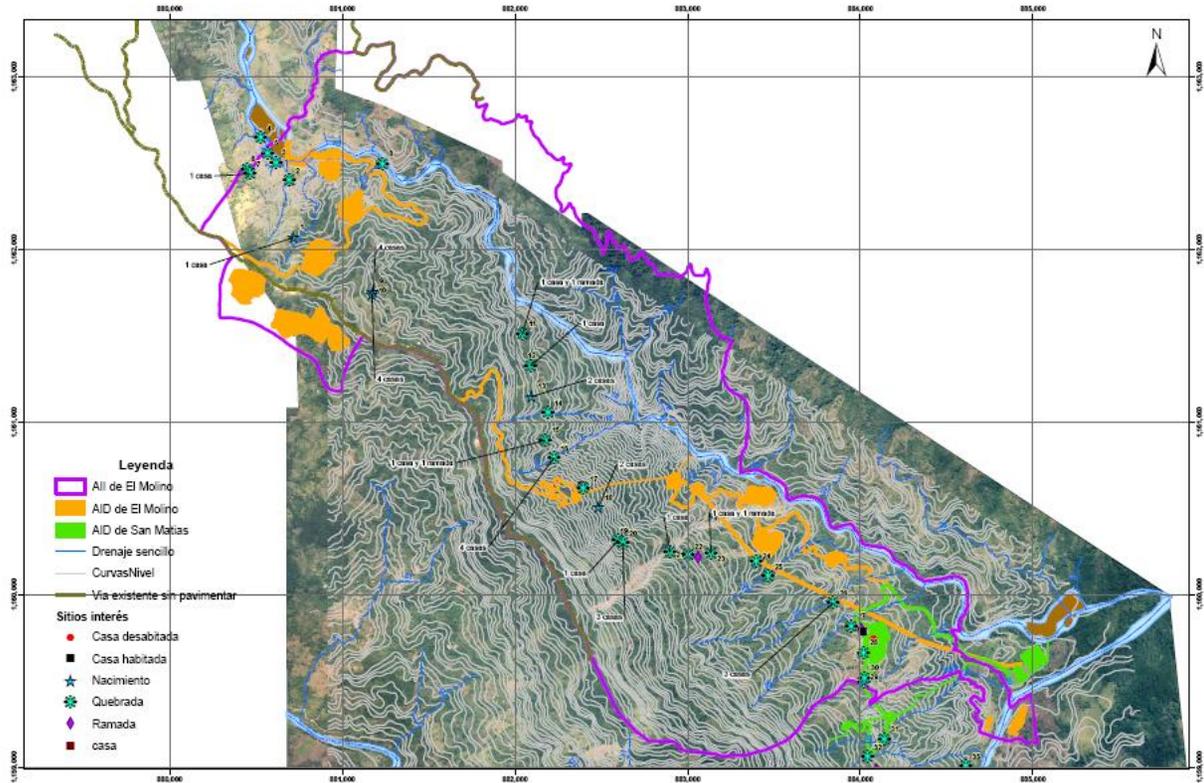


Figure3-3. Water sources identified in the area of direct influence of the El Molino hydroelectric project

In Table 3-30 you can observe the spatial localization of the water source with its respective coordinates, Vereda (Political and administrative division of the municipality located in the rural area) and their respective users and in some of the creeks identified; in the Annex 5 presents the complete photographic record of the field visit carried out.

Table 3-30. Location of water sources direct influence area of the El Molino hydroelectric project

| Source N° | Coordinates | | Meters above sea level | Vereda (Political and administrative division of the municipality located in the rural area) | Users identified | Comments |
|-----------|-------------|---------|------------------------|--|------------------|----------|
| 1 | 880719 | 1162075 | 1374 | El Molino | 1 House | Birth |
| 2 | 880689 | 1162408 | 1301 | El Molino | Without users | Creek |
| 3 | 880609 | 1162509 | 1291 | El Molino | Without users | Creek |
| 4 | 880529 | 1162652 | 1291 | El Molino | Without users | Creek |
| 5 | 880568 | 1162569 | 1290 | El Molino | Without users | Creek |
| 6 | 880450 | 1162464 | | El Molino | Without users | Creek |
| 7 | 880467 | 1162443 | 1320 | El Molino | 1 House | Creek |

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| Source N° | Coordinates | | Meters above sea level | Vereda (Political and administrative division of the municipality located in the rural area) | Users identified | Comments |
|-----------|-------------|---------|------------------------|--|--|----------|
| 8 | 881241 | 1162488 | | | Without users | Creek |
| 9 | 881181 | 1161761 | 1419 | El Molino | 4 Houses | Birth |
| 10 | 881173 | 1161747 | 1423 | El Molino | 4 Houses | Birth |
| 11 | 882044 | 1161515 | 1257 | Campo Alegre | 1 House 1 Vereda (Political and administrative division of the municipality located in the rural area) | Creek |
| 12 | 882093 | 1161332 | 1251 | Campo Alegre | 1 House | Creek |
| 13 | 882097 | 1161153 | 1279 | Campo Alegre | 2 Houses | Birth |
| 14 | 882196 | 1161045 | 1235 | Campo Alegre | Without users | Creek |
| 15 | 882178 | 1160900 | 1242 | Campo Alegre | 1 House 1 Vereda (Political and administrative division of the municipality located in the rural area) | Creek |
| 16 | 882228 | 1160797 | 1234 | Campo Alegre | 4 Houses | Creek |
| 17 | 882397 | 1160619 | | Los Mangos | Without users | Creek |
| 18 | 882487 | 1160517 | 1201 | Los Mangos | 2 Houses | Birth |
| 19 | 882598 | 1160321 | 1187 | Los Mangos | 1 House | Creek |
| 20 | 882626 | 1160304 | 1184 | Los Mangos | 3 Houses | Creek |
| 21 | 882900 | 1160254 | 1139 | Los Mangos | 1 House | Creek |
| 22 | 883006 | 1160236 | 1129 | Los Mangos | Without users | Creek |
| 23 | 883137 | 1160247 | 1092 | Los Mangos | 1 House 1 Vereda (Political and administrative division of the municipality located in the rural area) | Creek |
| 24 | 883398 | 1160201 | 1032 | Los Mangos | Without users | Creek |
| 25 | 883467 | 1160116 | 1005 | Los Mangos | Without users | Creek |
| 26 | 883843 | 1159963 | 944 | The Mangos | 3 Houses | Creek |
| 27 | 883949 | 1159827 | 928 | Los Mangos | Without users | Creek |
| 28 | 884020 | 1159670 | 935 | Los Mangos | Without users | Creek |
| 29 | 884025 | 1159515 | 933 | Los Mangos | 1 User, cattle raising | Creek |
| 30 | 884025 | 1159514 | | Los Mangos | Without users | Creek |

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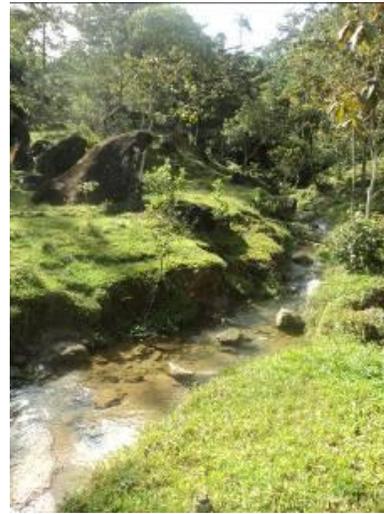


Photo 3-3. Water sources identified

In addition to the above drains, identified the multi Vereda (*Political and administrative division of the municipality located in the rural area*) aqueduct El Choco - Molino-Campo Alegre , which according to the interviews, supplies only the homes located in the road margins that leads from the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco to Campo Alegre; the rest of the population, are supplied with the surface currents in the sector. The aqueduct takes its waters currently in water sources that do not meet the required demand; through a program funded by Social Action within the strategy Return is Live, improvement and reconstruction facilities of the aqueduct that will take the waters of creek Hawk are taking place.

3.2.6.2 Potential conflicts

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The implementation of the project may enhance conflicts with the uses of water and its existing users in the direct project influence area; some of the possible conflicts identified are:

- The loss of the diversity of aquatic ecosystems: caused by the decrease of oxygen present in water that is generated by various factors such as the bad management of the solid and liquid waste that leads to the improper disposal of these directly in the water sources; the sediments generated by erosive processes; the pollution of water by chemical agents.
- Diseases to humans and animals: caused by the pollution of water by biological agents, metals such as lead and mercury, detergents, pesticides.
- Water Shortage: caused by the pollution of the existing water sources, or to the diversion of the river.

According to the conditions of the water sources identified and possible damages, formulate the management plans, which include the necessary preventive activities, mitigate and correct potential impacts that may be enhanced on these sources.

3.2.7 WATER QUALITY

The aim of this immunological evaluation IWRA, is to characterize the assemblages of periphyton, benthic macro-invertebrates and fish, and twenty variables (physical, chemical and microbiological) water quality that allow to perform ecological inferences about interventions to bypass flow rates in royalties of hydro-energy utilization.

Were carried out two surveys, that considered two climatic periods, dry season and rainy season, in the months of February 2009 (sampling done for the Environmental Assessment of the Alternatives of the Hydroelectric Development of the San Matias River – El Molino) September 2011, respectively. In both sampling was carried out a characterization of water quality from the health point of view, according to current legislation and environmental quality index as IFSN (NSF-WQI) and the ICA (HOW, ICOMI, ICOTRO, ICOSUS) of Viña and Ramirez (1998). These are supported with interpretations of biotic index of water quality (BMWP).

The hydro biological characterization of these studies is contextualized in the need to specify the habitat modification of sections of the river that could receive impact for the alteration of the variability of the frequencies, magnitudes and durations of the historical flow rates, and its effect on the availability of habitat and structural arrangement of the populations of benthic microalgae, aquatic saprophytes, macro invertebrates, fish, that take advantage of these stages and their hydrological and hydraulic characteristics.

Lotic ecosystems (streams and creeks) integrate interactions between the terrestrial and aquatic environments, where the materials are transported and processed in different ways (Dent, 1999). These systems are heterogeneous and routed by spatial scales, which are closely related from a macro to microhabitat dimension (O' Neill et al. 1979; Frissell et al. 1986, Hawkins et al. 2000 Griffith et al. 2002).

In these systems one of the most important biotic components is the periphyton, mainly constituted by fungi, bacteria and algae that live attached to substrates inert or live that vary in abundance according to the physical characteristics of the system (Allan 1995). In

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particular the epiphytic algae fulfill the producer role or photosensitizing within the community and the system, and for this reason is a component of special importance in the study of aquatic communities of current systems.

Functionally, the periphyton is a microcosm where the internal processes (autotrophic and heterotrophic) occur simultaneously and where the processes of exchange with the environment can be studied. Its spatial and temporal dynamics can be used as a model for understanding the problems related to ecological theory, such as species diversity and stability, ecological succession, spatial competition and the herbivores' (Wetzel 1983).

By its position in the substrate - water interface, periphyton plays a fundamental role in some biogeochemical cycles and ecosystem dynamics (Amblart et al. 1990, Hansson 1990 in Masseret et al. 1998). Since the epiphytic forms are sessile, its composition and abundance reflect the environmental conditions of the recent past and consequently can be used as indicators of water quality (Wetzel 1979 in Masseret et al. 1998). In addition, the ecological habitat of the epiphytic algae can be characterized through the viability and stability of the substrate, the concentration of nutrients, the chemical and physical characteristics of the water, morphometric, hydrology and hydrodynamics of the system and other associated biota (Wetzel 1983, Viviane et al. 2000).

In general terms, the aquatic biota changed its structure and operation when modified the environmental conditions of their natural habitats, so that it is possible to use some features or structural and functional properties of the different levels of biological organization to evaluate in a comparative form its state, which condition is a reflection of the ecological state of the body of water. The plankton, fish and invertebrates groups have been used in the studies of Bio indication, and inside of them highlighting the benthic macro invertebrates that inhabit the bottom of aquatic ecosystems, at least in some stage of their life cycle, and that are collected in net facilities with a pore opening equal to or less than the 500 μm (Giannina Segnini 2003).

The preference for this group is due to several reasons, which are identified by Reece & Richardson (1999):

- They are relatively sedentary and therefore representative of the area where they are collected.
- Their life cycles are relatively short compared to the fish, and reflect more quickly the alterations of the environment, through changes in the structure of their populations and communities.
- They live and feed in or on the sediments where tend to accumulate toxins, which are incorporated into the trophic food chain through them.
- They are sensitive to disturbance factors and response to the polluting substances, present in both water and sediment,
- They are primary source of food for many fish and participate in an important manner in the degradation of the organic matter and nutrient cycling.

The simplest protocols of sampling are used to determine the abundance of indicator species in disturbed sites and compare it with the abundance of sites less impacted (Karr and Chu 1997).

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The index of saprobiety and diversity takes into account the composition and adaptability of the taxa, essential aspects when trying to determine the tolerance of different groups of organisms to the disturbance factors, and are based on the presence or absence of a taxa or its abundance weighted average, according to the sensitivity that submits to the disturbance factor wanted for evaluation (Giannina Segnini 2003).

With the recognition that the structure and functioning of the lotic systems is intimately associated with the geology, the vegetation type and other factors that operate at the level of the landscape (Vannote et al. 1980), that the river basin is the geographic and hydrological unit of integration of the different processes that affect the ecological condition of these ecosystems (Naiman 1992), and that the effects of changes in the regional level may be more damaging to the rivers that the effects of organic or chemical pollution (Hughes et al. 1990, Roth et al. 1996, Lammert & Allan 1999, Karwan et al. 2001, Allan et al. 2002 And Wright & Flecker 2004), The assessment methods based in a few properties or in some particular processes of biological communities lose force

The new action strategy is the valuation of the biotic integrity of the rivers, which in its most common form is understood as " *the capacity of an aquatic ecosystem to support and maintain a community of organisms adaptable, balanced and integrated with a species composition, diversity and functional organization comparable to the community of natural ecosystems within the same region* " (Karr & Dudley 1981).

A more operational conception of the biotic integrity is considered as the end of a gradient of biological conditions, that extends between one end formed by sites where there are no conditions suitable for life, severely disturbed and an opposite end of sites, with little or no intervention that maintain a biota that is the result of evolutionary processes and biogeography. This is an optimal biological condition that is associated with the concept of biotic integrity. According to this view, the biological condition of a body of water is measured by comparing elements representative of the biota of impacted sites with the same elements present in the biota of referential undisturbed sites.

3.2.7.1 Description of sampling sites

In

Table 3-31 and Cartography 2148-04-EV-DW-025 gives the location of sampling points located on the San Matias River, and its location with respect to the basin.

- Site 1- Collection (CAP)

Located in the elevation 1,290 Meters above sea level, located in the middle - high part of the basin of the San Matias River, approximately 2,000 m downstream of the confluence of the San Matias and Tafetanes Rivers and the bridge that existed in the spoolable El Choco - Las Playas (Cocorná) - Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo (Granada). It is a section with low slope (1 %), in an area with slopes in high stubble and paddocks. The channel presents large stones ($\varnothing \approx 1.0$ m), pools and puddles of 3 m - 10 m in length and 0.3 m - 2.0 m depth. The water was clean, the speed of the current moderate, the depth of the thawed between 0.50 m and 2.0 m and the bed formed by rocks, stones, pebbles, gravel and sand. Exposure to the sun is 90% (see Photo 3-4).

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Table 3-31. Location of the sampling sites

| Site/Section (Meters above sea level) | San Matias river sites | | Coordinates | | Height meters a.s.l. |
|---|------------------------|--|-----------------|-----------------|----------------------------|
| | Code | Reference | Latitude | Length | |
| High | CAP | 2,000 M downstream of the spoolable bridge of El Chocó - Las playas (Cocorná) - small Vereda (Political and administrative division of the municipality located in the rural area) Quebradona Abajo (Granada), on the confluence of the rivers San Matias and Tafetanes... | 06 ° 03'56.5 " | 75 ° 09 ' 5" | 1,290 |
| Medium 1 | MED | The waterfalls of the San Matias River | 06 ° 03 '20.0 " | 75 ° 08 '23.7 " | 1,100 |
| Medium 2 * | MED 2 | Discharge area of the project El Molino I. | 06 ° 02 '57.4 " | 75 ° 07 '58.7 " | 1,010 |
| Low | DES | 1,000 M upstream of the confluence of the San Matias River to the Cocorná. | 06 ° 02 '25.2 " | 75 ° 07 '04.9 " | 790 |

*: This was sampled only in environmental assessment of the alternatives of the hydroelectric development of the San Matias River - El Molino



Photo 3-4. Site1, CAP, in the middle-high basin of the San Matias River

- Site 2 - medium section (MED1)

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Located in the middle part of the basin of the San Matias River (1,100 Meters above sea level). It is a section of steep medium and high (6% -100 %), where are presented with quick short pools, and vertical jumps of 5 m - 30 m, in an area with covered slopes with pastures used for cattle raising, and strongholds of secondary forest and high secondary vegetation in the abrupt riverbanks (see Photo 3-5).



Photo 3-5. Site 2- medium Section

It is a section with 50% of exposure to the sun. The channel presents rocks and large stones ($\varnothing \approx 3.0$ m), pools and puddles of 1m - 3m length and 0.5m - 2.0m in depth, with bed rock and pebbles. The water was clean, the speed of the current high, the overall flow turbulent.

- Site 3 - middle section (MED2)

Located in the middle - low part of the basin of the San Matias River (1,010 Meters above sea level). It is a section of average gradient (6% - 15 %), where there are present quick short pools, vertical jumps of 1m - 5m, in an area with slopes covered with pastures used for cattle raising; there's also sugarcane and redoubts of secondary forests, located on the shores of creeks (see Photo 3-6).

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Photo 3-6. Site 3 - middle Section

It is a section with a 60% exposure to the sun. The channel presents rocks and large stones ($\varnothing \approx 3.0$ m), pools and puddles of 1m - 3m length and 0.5m - 2.0m in depth, with bed rock and pebbles. The water was clean, the speed of the current high, the overall flow turbulent.

- Site 4 - Lower section (DES)

Located in the low part of the basin of the San Matias River (970 Meters above sea level), 1,000 m upstream of the confluence of the San Matias River with the Cocorná River. It is a section with medium - low gradient (2 %), in an area with slopes covered in low stubble, with pastures for cattle raising. Exposure to the sun is 70 %. The channel presents rocks and large stones ($\varnothing \approx 2.0$ m), pools and puddles of 1m - 6m in length and 0.3 m - 2.0 m in depth, with bedrock, gravel, pebbles and sand. The water was clean, the speed of the average flow, turbulent flow and sub-critical, with hops between 0.4 and 1.0 m (see Photo 3-7).



Photo 3-7. Site 4 - Lower Section

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3.2.7.2 Methodology

- Sanitary water quality
 - Physical, chemical and bacteriological characterization

At each sampling site some variables were measured in situ, and water samples were collected to analyze in the laboratory. In the same were sampled simultaneously hydro biological and benthic microalgae variables, saprophytes, aquatic macro-invertebrates and fish.

For the characterization of the physical, chemical and bacteriological, the following methodology was used:

- In situ was measured the air temperature at the beginning of the assessment in each sampling site, the temperature of the water 15 cm below the current surface, the electrical conductivity (EC), dissolved oxygen (DO), percentage of oxygen saturation (%OS) and the potential of Hydrogen ions (pH) (see Photo 3-8)



Photo 3-8. Sampling in-situ

- Water samples were taken for laboratory analysis of the variables: Total Alkalinity (TA), COD, BOD₅, orthophosphates (PO₄), Total Phosphorus (TP), nitrates (N-NO₃), ammoniac nitrogen (N-NH₄), total nitrogen (NTK), Total Iron (FET), Total Hardness (DT), sulfates (OS₄), total solids (TS), total suspended solids (TSS), sedimentary solids (SS), turbidity (Tu), detergents (of), total coliforms (TC) and fecal (CF).

The samples for the physical and chemical variables were retained and assessed in accordance with the protocols of the Environmental Quality Laboratory CORANTIOQUIA (Medellín), which are presented in Table 3-32 .

Table 3-32. Methodology for the analysis of the physical and chemical variables of water

| Variable | Unit | Method or material |
|-------------------------|-------------------------|---------------------------------------|
| Temperature of the air | °C | Mercury thermometer |
| Water temperature | °C | Thermistor YSI 52 |
| Altitude | M ASL | Summit /Altitech Altimeter |
| Electrical conductivity | µS/cm | Electrometric Conduct meter WTW LF330 |
| Dissolved Oxygen | mg O ₂ /l | Electrometric Oximeter YSI 52 |
| Oxygen Saturation | % | * Electrometric Oximeter YSI 52 |
| PH | Units | Potentiometric, ph-meter WTW320 |
| Total Alkalinity | Mg CaCO ₃ /l | Titulometric |
| Total DQO | MG O ₂ /l | Colorimetric of closed reflux |

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| Variable | Unit | Method or material |
|-------------------------|-------------------------------------|---------------------------------|
| DBO ₅ total | mg O ₂ /l | BOD Test 5 days |
| Soluble BOD5 | MG O ₂ /l | BOD Test 5 days |
| Orthophosphate | Mg PO ₄ ³⁻ /l | Ascorbic Acid |
| Total Phosphorus | Mg P/l | Ascorbic Acid |
| Organic phosphorus | Mg P/l | Ascorbic Acid |
| Nitrates | Mg N-NO ₃ /l | * Electrometric selective ion |
| Ammoniac nitrogen | Mg N-NH ₃ /l | Titulometric |
| Total Kjeldahl nitrogen | Mg N/l | Titulometric |
| Total Iron | Mg Fe/l | Phenanthroline |
| Total Hardness | Mg/l CaCO ₃ | Titulometric of EDTA, spectrode |
| Sulphates | Mg OS ₄ ²⁻ /l | Turbid metric |
| Total Solids | Mg/l | Gravimetric |
| Total Suspended Solids | Mg/l | Gravimetric |
| Sedimentary Solids | ML/l | Volumetric |
| Turbidity | NTU | Nephelometric |
| Detergents | Mg SAAM/l | Anionic surfactants as SAAM |
| Total Coliforms | MPN/100 ml | Multiple Tubes, incubator |
| Fetal Coliforms | MPN/100 ml | Multiple Tubes, incubator |

Taken from the List of Parameters and tariffs CORANTIOQUIA (Resolution 10080 2008)

- Index of sanitary water quality

The considerations of waters quality ranges, for physical and chemical variables, are based on the criteria presented in Table 3-33 and Table 3-34.

Table 3-33. Criteria for the characterization of atrophic status and the quality of water

| Variable | N-NO ₃ ¹ | N-NH ₃ ¹ | Orthophosphates ² | Total Phosphorus ² | DBO ₅ ⁴ |
|----------------------|--------------------------------|--------------------------------|------------------------------|-------------------------------|-------------------------------|
| Quality | Mg/l | Mg/l | Mg/l | Mg/l | Mg/l |
| Oligotrophy | 0.0 - 1.0 | 0.0 - 0.3 | 0.0 - 0.0073 | <0.027 | <2.0 |
| Mesotrophy Condition | 1.0 - 5.0 | 0.3 - 2.0 | 0.0074 - 0.013 | 0.028-0.051 | 2.0 - 12.5 |
| Eutrophy | 5.0 - 50.0 | 2.0 - 15.0 | <0.014 | <0.052 | <12.5 |

Table 3-34. Criteria for the characterization of atrophic status and the quality of water

| Variable | Dissolved Oxygen ⁶ | Total Coliforms | Fecal Coliforms | Dissolved Solids | Sulphates | Electrical conductivity | Total Alkalinity |
|-------------------------------|-------------------------------|--------------------|--------------------|--------------------|---------------------|-------------------------|------------------------|
| Quality or Use | MG/L | MPN/100 ml | MPN/100 ml | Mg/l | Mg/l | µS/cm | Mg/l |
| Lower Basin | | | | | | 150 - 200 ⁴ | 150 - 200 ⁴ |
| Good | | <2400 ⁴ | | | | | |
| Pollution | | >6000 ⁴ | | | | 200 - 275 ⁴ | >200 ⁴ |
| Fauna and Flora | >4 | <5000 ⁴ | | | | >40.0 ³ | |
| Recreation and fishing | SatO >70 % ₂ | <1000 ⁶ | <200 ⁶ | | | | |
| Agricultural use | | <5000 ⁶ | <1000 ⁶ | | | | |
| Human Supply | | <1000 ⁶ | <2000 ⁶ | <1000 ⁵ | <250 ^{5,7} | <1000 ⁷ | <200 ⁷ |
| Irrigation of livestock crops | | | | <450 ⁵ | | | |
| Pisciculture | | | | 2000 ⁵ | | | |
| Industrial | | | | | | | |
| Transport, | | | | | | | |

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| Dilution | | | | | | | |
|----------|--|--|--|--|--|--|--|

1. *Atrophic Classification of Vollenweider (1968) for tropical areas. Ramirez and Viña, 1998.*
2. *Atrophic Classification of Toledo et al. , for tropical areas. Ramirez and Viña, 1998.*
3. *Minimum condition for wildlife preservation. Ministry of Health, 1984.*
4. *Curve for index of natural waters quality (Ramirez and Vineyard 1998). For DBO means the scale in terms of saprobiedad (oligo, meso, eu): Eusaprobia (contaminated).*
5. *Condition for human consumption and urban re- use. Romero, 2002.*
6. *Decree 1541 of 1978, Quality Criteria for the use of water.*
7. *Resolution 2115 of 2007, water quality criteria for human consumption*

– Bio - indicators of water quality:

To correlate the water quality with the aquatic populations of macro invertebrates, applied the BMWP index for Colombia. The scores assigned to the various families in the BMWP index and its meaning, are presented in Table 3-35 and Table 3-36 .

Table 3-35. Classification of taxa for the biotic index BMWP amended and updated of Zamora (2007) and Alvarez (2005)

| Families | Score |
|---|-------|
| Perlidae, Oligoneuriidae, Euthyplocidae, Polymitarcyidae, Odontoceridae, Glossosomatidae, Rhyacophilidae, Calamoceratidae, Hydroptilidae, Anomalopsychidae, Atriplectididae, Psephenidae, Ptilodactylidae, Lampyridae, Polythoridae. | 10 |
| Blepharoceridae, Unionidae, Lymnessiidae, Hydridae, Leptophlebiidae, Ephemeridae, Hydrbiosidae, Philopotamidae, Xiphocentronidae, Gyrinidae, Scirtidae, Gomphidae, Megapodagrionidae, Coenagrionidae, Simuliidae, Gordidae, Chordodidae | 9 |
| Pyalidae, Ampullariidae, Hirudinae, Baetidae, Caenidae, Hydropsychidae, Leptoceridae, Helicopsychidae, Dytiscidae, Dryopidae, Lestidae, Calopterygidae, | 8 |
| Pleidae, Saldidae, Gerridae, Veliidae, Hebridae, Dixidae, Palaemonidae Pseudothelphusidae, Chilinnidae, Tricorythidae, Leptohiphidae, Polycentropodidae) larvae, Elmidae, Staphylinidae, Aeshnidae, Naucoridae, Notonectidae, Mesoveliidae, Corixidae. Psychodidae. | 7 |
| Psychodidae, Ancyliidae, Planorbiidae, Melaniidae, Hydrobiidae, Nertidae, Dolichopodidae) that breed. Libellulidae, Limnichidae, Lutrochidae. | 6 |
| Corydalidae, Sialidae, Atyidae, Hyalellidae, Planariidae, Dugesidae, Chrysomelidae, Haliplidae, Curculionidae, Tabanidae, Stratiomyidae, Empididae, Thiaridae. Belostomatidae, Gelastocoridae, Nepidae. | 5 |
| Hydrophilidae, Noteridae, Hydraenidae, Tipulidae) larvae, Ceratopogonidae. Lymnaeidae, Hydrometridae. | 4 |
| Limnaeidae, Sphaeridae, Culicidae, Muscidae, Sciomyzidae, Physidae, | 3 |
| Glossiphoniidae, Cyclobdellidae, Cylicobdellidae, Chironomidae, Ephydriidae, Syrphidae, all except the Haplotaenidae Tubifex | 2 |
| Tubificidae | 1 |

Table 3-36. Classes of quality, value and environmental meaning of index BMWP (Zamora 2007)

| BMWP Score | Meaning | Class | Quality |
|------------|----------------------------|-------|---------------|
| >121 | Very clean waters | I | Very Good |
| 101-120 | Clean Waters | II | Good |
| 61-100 | Moderately polluted waters | III | Acceptable |
| 36-60 | Polluted water | IV | Doubtful |
| 16-35 | Highly contaminated water | V | Critical |
| <15 | Heavily polluted waters | VI | Very critical |

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- Hydro biological Characterization
 - Benthic microalgae (Ficoperiliton)

To collect the samples in the field, carried out a removal paralytic material acceded to rocky substrates immersed or exposed to current flow, using plastic brushes and knife. As an area unit is used by 234 cm² per section (six replicas of 39 cm²). The samples were fixed with a logo solution to the 10% (0.5 ml per 100 ml sample) and transported in opaque plastic containers properly labeled (see Photo 3-9).



Photo 3-9. Aspects of the sampling of benthic microalgae in rocky substrate (epileptic)

For the observation of the samples of paralytic microalgae was used an inverted microscope. For mounting the sample, we used the count camera Sedgwick-Rafter of 1 ml capacity, as suggested by Wetzel & liken (1990). To make valid comparisons between the quantitative analysis, it took into consideration the volume of the samples, which for the initial phase of observation and counting was shaken in a plastic container top-down 40 times in order to homogenize the sample and to count through the provision of 1 milliliter of sample in the observation camera.

To make the count, 30 fields were selected for observation, according to a system of random sampling, and getting the density of algae per volume unit (in/ml), which was also related to the referred sampling area to (234 cm²) (Uehlinger 1964). The counting was done with a total magnification of 400X.

The taxonomic determination was based on the work of BOURRELLY (1966, 1968, 1985); PRESCOTT et al. (1982); HRSG. HUBER-Pestalozzi (1938): Teil 1 Band XVI Blaualgen (1938), Band XVI Teil 2, 1. Hälfte Chrysophyceae (1976), Band XVI Teil 4 Euglenophyceae (1955), Band XVI Teil 5 Chlorophyceae (1961), Band XVI Teil 7, 1. Hälfte Chlorophyceae

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(1983); Sußwasserflora von Mitteleuropa) (ETTL et al. HRSG. 1983, 1985a, 1985b, 1984, 1988, 1990, 1991a, 1991b, 1997a, 1997b) and Ramirez (2000).

– Aquatic Macro invertebrates (MIA)

For obtaining the field samples of aquatic macro-invertebrates, in each section of interest, benthic samples were taken with screen network in an area of 1.5 m x 1.5 m; marginally was collected, with triangular network where you will find greenery and in addition, manually, by lifting stones, sticks and submersed leaves for the capture of these organisms. The capture effort by section was 30 minutes in total. The samples were placed in plastic bags and preserved with alcohol at 70% (by separating the samples of edges and the center), and transported to the laboratory for taxonomic determination.

In the laboratory the biological material collected was separated from other accompanying materials (organic and inorganic). The separate organisms were stored in plastic containers with alcohol at 70% and the determination was made to the maximum possible taxonomic level extent For the determination of the individuals were used taxonomic keys of Usinger (1956), Edmonson (1959), Edmunds (1976), Pennak (1978), Roland (1988), Merrit & Cummins (1996) and Posada & Roldán (2003).

The organisms were quantified to estimate their relative density by site and time of sampling, and the parameters of structure of the population arrangements were estimated through the diversity index of Shannon and Weaver (1949), Equity of Pielou (1969), species richness and dominance of Simpson (1949).

3.2.7.3 Results

- Characterization of the water quality of the
 - Physical, chemical and bacteriological quality

The sampling and measurements in the field were conducted in the month of February 2009 and September 2011, which results are shown in. Table 3-37

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Table 3-37. Values obtained for the physical and chemical water variables

| Variable | Sampling Site San Matias River | | | | | | |
|--|--------------------------------|-----------------|-----------------------|-----------------|-----------------------|-----------------------|-----------------|
| | Site 1 - CAP | | Site 2 - MED1 | | Site 3 - MED 2 | Site 4 - DES | |
| | Summer Sampling | Winter Sampling | Summer Sampling | Winter Sampling | Summer Sampling | Summer Sampling | Winter Sampling |
| Air Temperature (°C) | 24.00 | | 25.00 | | 26.00 | 25.00 | |
| Water temperature (°C) | 22.70 | 22.50 | 22.00 | 22.00 | 22.40 | 21.40 | 20.20 |
| Electrical conductivity (μ S/cm) | 43.90 | 33.80 | 45.00 | 28.00 | 45.00 | 38.70 | 43.90 |
| Turbidity (NTU) | 2.50 | 96.90 | 2.21 | 315.00 | 2.30 | 24.70 | 27.00 |
| Total solids (mg/l) | 56.00 | 154.00 | 57.00 | 512.00 | 52.00 | 76.00 | 88.00 |
| Suspended solids (mg/l) | <7 | 111.00 | <7 | 477.00 | <7 | 34.00 | 39.00 |
| Sedimentary solids (ml/l) | <0.1 | 43.00 | <0.1 | 35.00 | <0.1 | 0.10 | 49.00 |
| Saturation % OD | 89.50 | 67.03 | 92.00 | 70.95 | 94.00 | 95.20 | 81.74 |
| Dissolved oxygen (DO) (mg OR ₂ /l) | 7.69 | 5.90 | 8.40 | 6.30 | 8.10 | 8.42 | 7.50 |
| PH | 7.65 | 7.23 | 7.40 | 7.32 | 7.42 | 7.35 | 7.26 |
| Total Phosphorus (mg P/l) | <0.020 | <0.015 | <0.020 | 0.71 | <0.020 | 0.05 | <0.015 |
| Organic phosphorus (mg P/l) | <0.020 | | <0.020 | | <0.020 | 0.020 | |
| Orthophosphates totals (mg PO ₄ ³⁻ /l) | <0.150 | 0.30 | <0.150 | 0.30 | <0.150 | <0.150 | 0.09 |
| Ammonia Nitrogen (mg N-NH ₃ /l) | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| Nitrates (mg N-NH ₃ /l) | <1.50 | <0.9 | <1.50 | <0.9 | <1.50 | <1.50 | <0.9 |
| Kjeldahl nitrogen (mg/l) | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 | <1.00 |
| Sulphates (SO ₄ mg ²⁻ /l) | <3.00 | 5.00 | <3.00 | 5.00 | <3.00 | <3.00 | 9.00 |
| Total Iron (mg Fe/l) | 0.22 | 3.13 | 0.19 | 1.64 | 0.23 | 1.24 | 1.40 |
| Total Alkalinity (mg CaCO ₃ /l) | 21.00 | 26.00 | 21.40 | 23.00 | 22.70 | 20.50 | 27.00 |
| Total Hardness (mg/l CaCO ₃) | 14.40 | 24.00 | 14.50 | 16.00 | 15.70 | 16.30 | 20.00 |
| DBO ₅ total (mg OR ₂ /l) | <4.00 | <2.43 | <4.00 | <2.43 | <4.00 | <4.00 | <2.43 |
| Soluble DBO 5 (mg OR ₂ /l) | <4.00 | | <4.00 | | <4.00 | <4.00 | |
| Total COD (mg OR ₂ /l) | <12.0 | <12.9 | <12.0 | 17.00 | <12.0 | <12.0 | <12.9 |
| Coliforms (MPN/100 ml) | 60 X 10 ³ | >2419.6 | 25 X 10 ⁴ | >2419.6 | 160 X 10 ³ | 14 X 10 ⁴ | >2419.6 |
| Fecal Coliforms (MPN/100 ml) | 3.5 X 10 ² | >2419.6 | 1.3 X 10 ² | 866.40 | 2 X 10 ² | 0.2 X 10 ⁴ | 648.80 |
| Detergents (SAAM mg/l) | <0.100 | 0.34 | <0.100 | 0.41 | <0.100 | <0.100 | 0.11 |

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It should be borne in mind that the concept of water quality is subjective to use, as you can see in Table 3-38 , where conditions are present for the water to be used in different activities, in accordance with the Decree 1594 of 1984 of the Ministry of Health.

Table 3-38. Physical - chemicals parameters in the water, Decree 1594 of 1984

| Variable | Units | Flora and Fauna | Agricultural use | Livestock Use | Recreational use | | Residual Water |
|--------------------------------|------------|-----------------|------------------|---------------|------------------|-----------|----------------|
| | | | | | Primary | Secondary | |
| Dissolved Oxygen | Mg/l | 5 | | | | | |
| Percentage of saturation of OD | % | | | | >70 | >70 | |
| PH | U, pH | 6.5-9.0 | 4.5-9.0 | | 5.0-9.0 | 5.0-9.0 | |
| Electrical conductivity | μS/cm | | <750 | | | | |
| Total Solids | Mg/l | | | <3000 | | | |
| Sedimentary Solids | ML/l | | | | | | 10 |
| Coliforms | MPN/100 ml | | | | | | |
| Fecal Coliforms | MPN/100 ml | | <5000 | | <1000 | <5000 | |
| Total Iron | Mg/l | | 5 | | | | |
| Detergents | MG/L SAAM | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |

➤ Dissolved Oxygen, saturation percentage of dissolved oxygen and temperature

Figure 3-4 shows values of dissolved oxygen (DO) and the percentage of dissolved oxygen saturation (%OD) for the sites sampled in the two periods were analyzed; it also presents the required minimum value of OD for use and preservation of flora and fauna and the %OD minimum for primary contact waters according to articles 45 and 42 of decree 1594 of 1984.

In the sampling conducted in the summer season (ISU), the values of dissolved oxygen are very high for all the stages evaluated (8.15 mg/l on average). The lowest concentration (7.69 mg/l) was found at site 1 - collection, which is still high to sustain higher biotic populations. The lowest recorded in site 4 - discharge (8.42 mg/l). While the difference between the maximum and minimum value is almost 1 mg/l, this variation may be assumed as little significant, since the two conditions may provide environments that are conducive to any type of aerobic life. The percentages of dissolved oxygen saturation are very high (92.7 % on average). This fact reflects that the current runs turbulent (see Photo 3-10), in the rocky bed of moderately high slope, where the generated bosses are conducive to an efficient injection of atmospheric oxygen.

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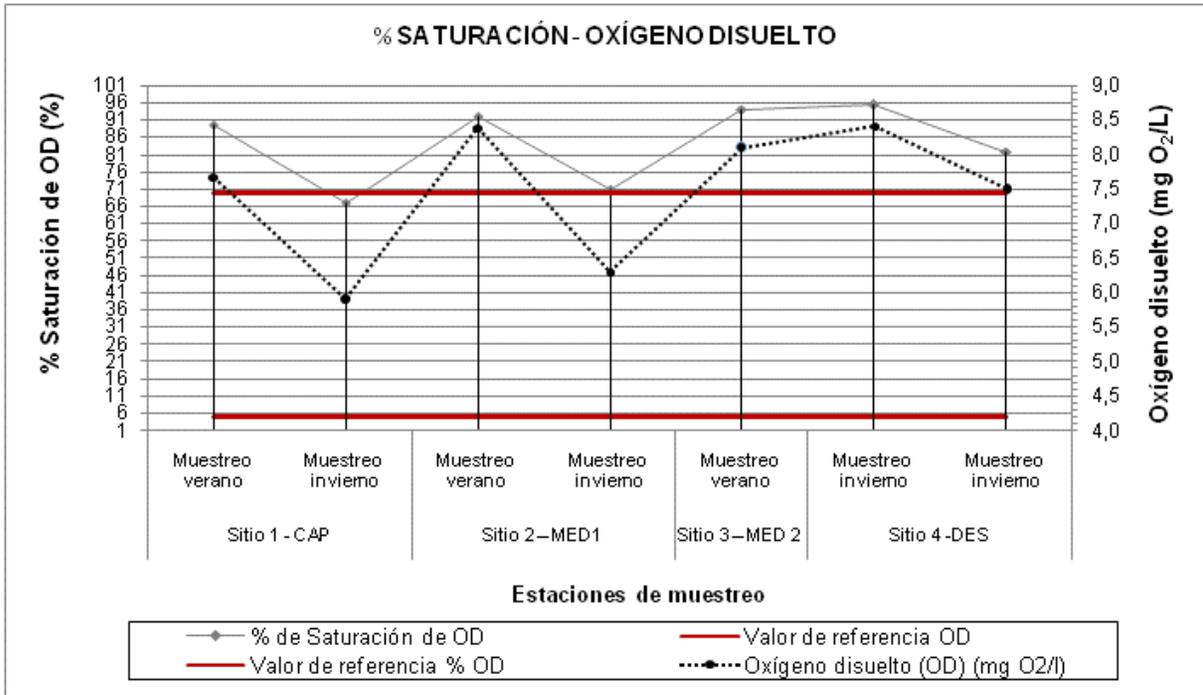


Figure 3-4. Values of Dissolved Oxygen and % of Oxygen Saturation

Note. The reference lines are the minimum concentration of OD required for preservation (OD preservation) and saturation percentage of dissolved oxygen minimum to waters used for primary contact (% Contact).



Photo 3-10. San Matias River, middle section

In this first sampling, all values of OD and %OD exceed what is required by the decree 1594 of 1984 for contact waters (minimum 70% saturation) and the flora and fauna preservation (at least 5 mg/l). That is, in terms of the dissolved oxygen, it can be concluded that the

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evaluated sections present a good sanitary water quality. The values of temperature, average 22.2 °C, are normal for the water flows, and only presented variations associated with sampling times.

In the sampling carried out in the winter (EIA), the values of dissolved oxygen were relatively moderate for all the sections evaluated (6.6 mg/l on average). The lowest concentration (5.9 mg/l) was found at site 1 (CAP), and the higher (7.5 mg/l) was recorded in the discharge sections (site 4, DES). The difference between the minimum and the maximum value is 1.6 mg/l, and this variation can be assumed as significant, since the value in CAP, is close to the inadequate conditions, although it offers possibilities to any type of aerobic life. All the recorded values exceed the minimum margin required (minimum of 5 mg/l) by Decree 1594 of 1984 for waters of preservation of flora and fauna. So, in terms of dissolved oxygen, it may be concluded that the evaluated periods presented a good sanitary quality of water.

The quantified values of temperature (average: 21.6 °C) are normal for the current waters and only presented variations associated with sampling times.

➤ PH and electrical conductivity

The values of electrical conductivity (EC) are relatively low in the section evaluated of the San Matias River. EC values above 270 S/cm μ indicate a high contamination by mineralization (Ramirez and Viña, 1998).

In the samplings for the climatic seasons of winter and summer, it was found that the average of values of electrical conductivity is 39.76 μ S/cm, which is well below the value that indicates the mineral contamination. There are no significant differences between the sites evaluated. The low values of electrical conductivity reflect effects of its own in the basin of the San Matias River and correlate with low concentrations of solids.

The pH values are in general slightly basic (above 7 pH units) and do not exhibit significant spatial variation between tranches evaluated. These slightly basic values of water are associated with high concentrations of dissolved oxygen, as this inhibits the dilution of the carbon dioxide, which is responsible for the presence of acids of the carbonate system. Any pH value is on the outside of the minimum limits (5 pH units) and maximum (9 pH units) established by the rules for the primary contact. For this reason, it is considered that, in terms of the values of electrical conductivity and pH, the San Matias River presented a good sanitary water quality (see Figure 3-5 and Figure 3-6).

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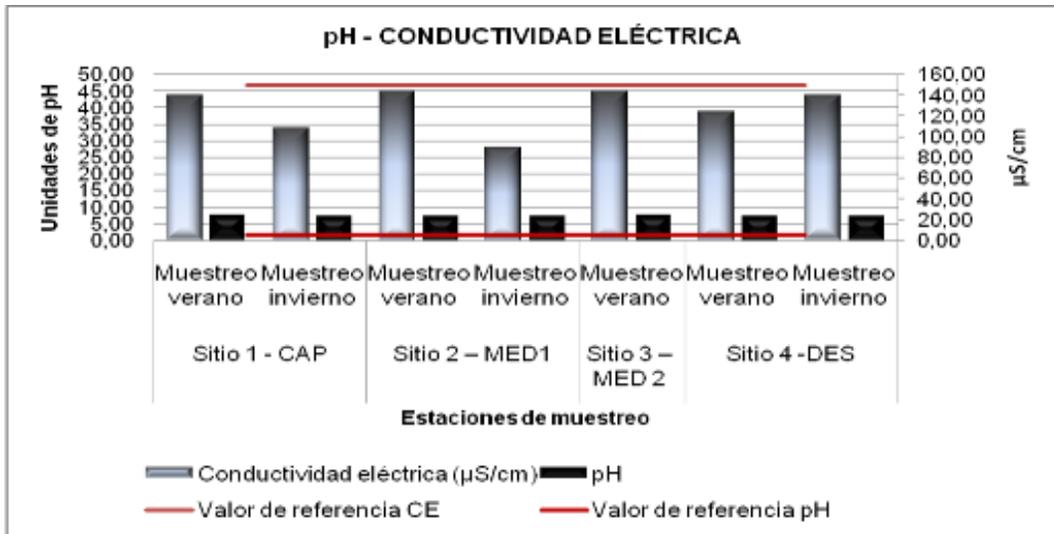


Figure 3-5. Values of electrical conductivity and pH in four sites of the San Matias River

Note: The reference lines indicate maximum and minimum values of pH for primary contact in accordance with Decree 1594 of 1984.

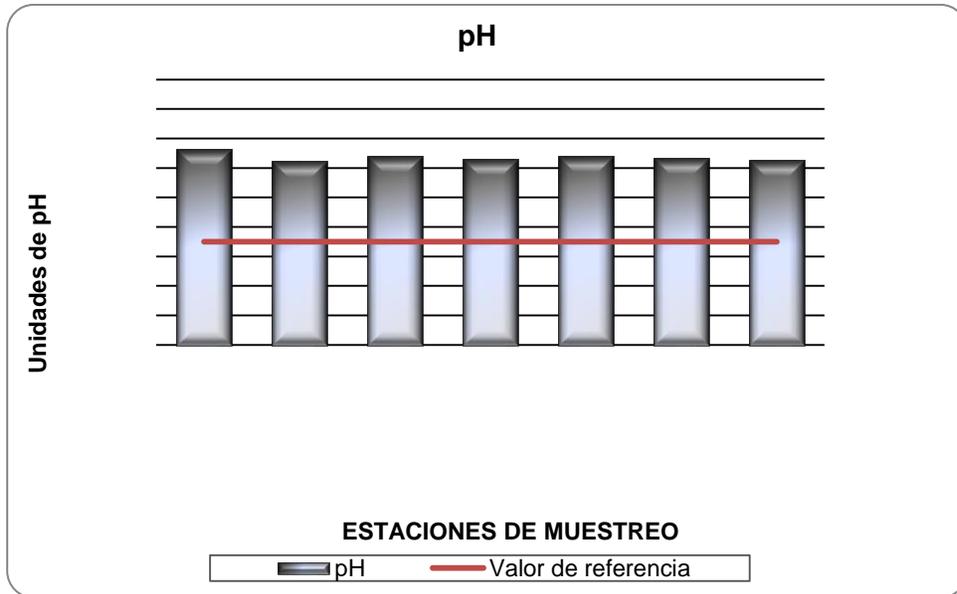


Figure 3-6. pH Values

Note: The reference lines indicate the minimum and maximum values required for preservation of flora and fauna (Decree 1594 of 1984).

➤ Solids and Turbidity

The San Matias River has a low concentration of total solids (average 142.14 mg/l), being the lowest in the MED site 2 -Sampling summer- (52 mg/l) and the largest in MED1 -Sampling winter - (average 512 mg/l) (see Figure 3-7).

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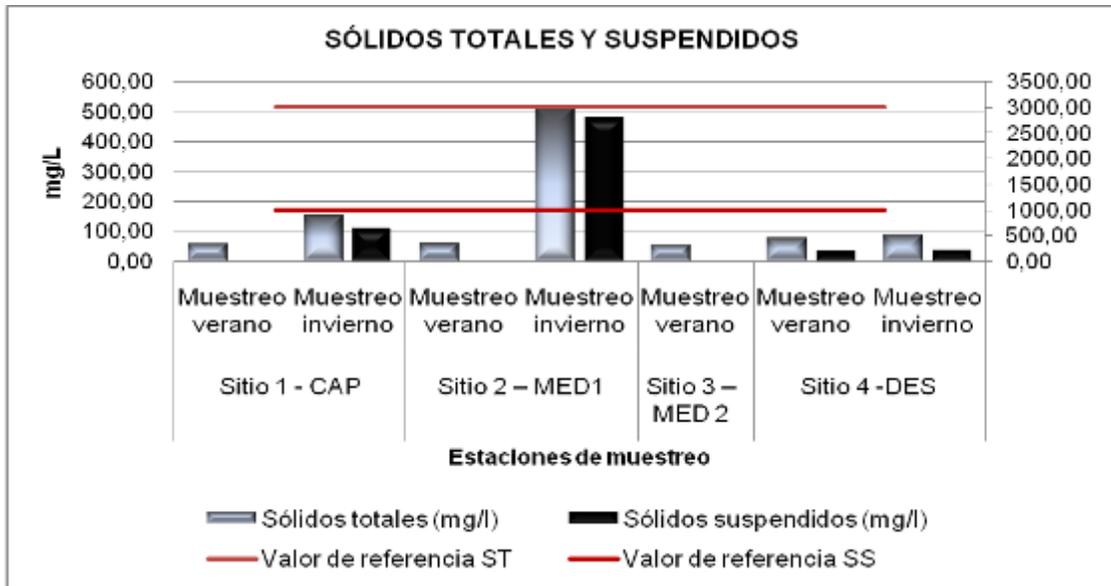


Figure 3-7. Values of total solids concentration and sedimentary solids

Note: The reference lines indicate the maximum value of sedimentary solids in waste water according to the decree 1594 of 1984.

The difference between the minimum and the maximum value is small, which is due to the fact that at the time of sampling, were still active the effects of a night of rainfall over the upper watershed, the same that had already completed in the afternoon when we took samples from the other sites. The fact of finding moments with high concentrations, represents a watershed with significant erosive processes along the river.

However, the concentrations of total solids, of all the evaluated sites, were below the requirements of the regulations (3000 mg/l) for water used for livestock (Decree 1594 of 1984).

In the sampling of the summer season it was found that the concentrations of suspended solids in all the sites were below the minimum detection limit of the method (7 mg/l), with the exception of Site 4 - discharge, which was 34 mg/l; the latter value is explained by the heavy precipitation that fell the previous day of sampling. For the sampling of the winter season in the DES section, the concentration of suspended solids was below the threshold for waters of mediocre quality (Ramirez and Viña 1998), while in CAP and MED was presented in such a category. For both samples the spatial variation of suspended solids is not significant.

In concordance with the values of concentration of suspended solids, turbidity values were also very low in localized sites in the collection and in the middle section, average 2.34 NTU for the sampling of the summer season; while for the winter due to the high concentration of suspended solids, turbidity values were also very high (average 146.3 NTU) (see Figure 3-8).

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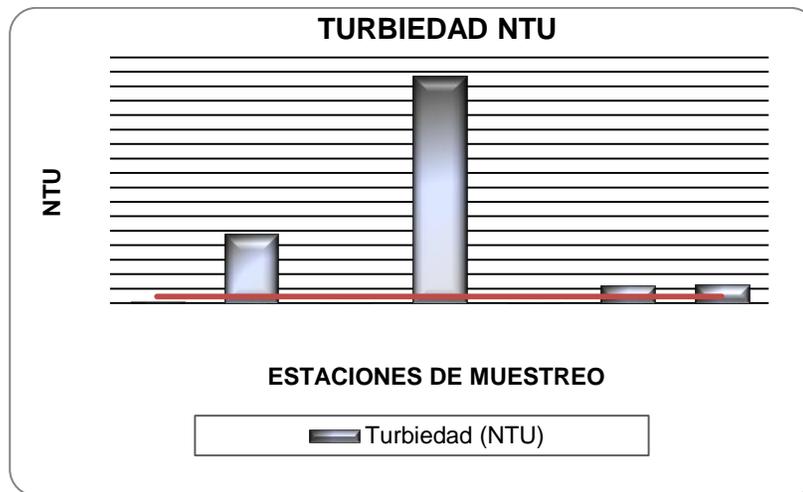


Figure 3-8. Turbidity Values and concentration of total suspended solids

Note: The reference line indicates the value admitted (10NTU) for domestic water use without treatment (Decree 1594 of 1984).

In winter sampling were observed organoleptic characteristics of the river in the regular tranches CAP and DES, and very bad in the MED section, as a result of unique events at each time of sampling, as can be seen in Photo 3-11 .



Photo 3-11. Aspects of the visual water quality of the San Matias River.

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➤ Oxygen Demand

In all the sampled sites, for the two climatic periods evaluated, the values obtained for the parameters COD and BOD₅ total, concentrations are below the minimum detection limits of the method (12.0 mg/l and 4.0 mg/l respectively).

The fact of finding low concentrations of the oxygen demand along the river may indicate that in its route receives small pollutants organic loads; or that the river, due to the hydromorphology, the tread bars and high concentrations of dissolved oxygen, has the ability to oxidize quickly the organic loads it receives; or a combination of the two previous ones.

If the BOD is interpreted as an indicator of biodegradable organic matter found mainly in domestic discharges, we can infer that the domestic discharges to this river are not significant compared to the flow it presents. On the other hand, if the COD is interpreted as coming from organic matter difficult to degrade, found mainly in industrial discharge, it is concluded that the San Matias River receives no affluent with significant features of industrial discharge.

The absence of demanding organic matter of oxygen is important at a time when the river is intervened and increase the hydraulic retention times and flow rates decrease, since it is unlikely that there would be any conditions of hypoxia or anoxia that reduce the physical and chemical quality of the water.

According to Ramirez and Viña (1998), a body of water with DBO₅ concentration above 30 mg/l has a high concentration of organic matter. All the values of the San Matias River are well below this value, which allows us to conclude that in terms of the demands for oxygen, the river presents good sanitary quality of water (see Photo 3-9).

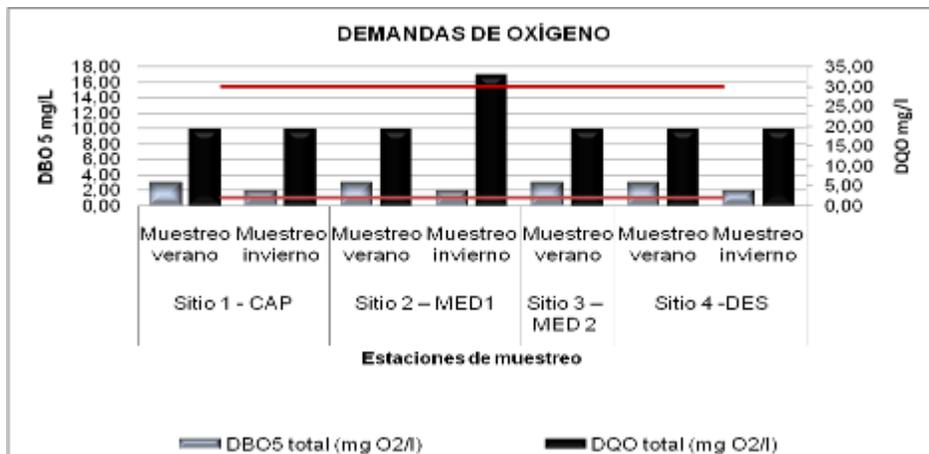


Figure 3-9. Values of oxygen demand (BOD and COD) for three sections of the San Matias River (Cocorná - Granada, Antioquia) sector PCH Molinos. SAG S.A.

Note: The reference lines indicate the maximum value (2ppm BOD) for oligo-saprobe waters, and the value (30ppm BOD) from which there are high levels of air pollution by organic matter (Ramirez and Viña1998).

➤ Coliforms

The presence of total coliforms and fecal in all the sites evaluated, was above the regulatory requirements (Decree 1594 of 1984). The increased presence of fecal coliforms were found in the collection site- winter sampling - (>2419.6 MPN/100 ml), whereas the lowest section in

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the MED1 - Summer sampling - (1.3×10^2 MPN/100 ml) (see Figure 3-10). The high value observed in the collection may be related to the closeness of the Vereda (*Political and administrative division of the municipality located in the rural area*) in the sector of Las Playas, upstream of the collection site.

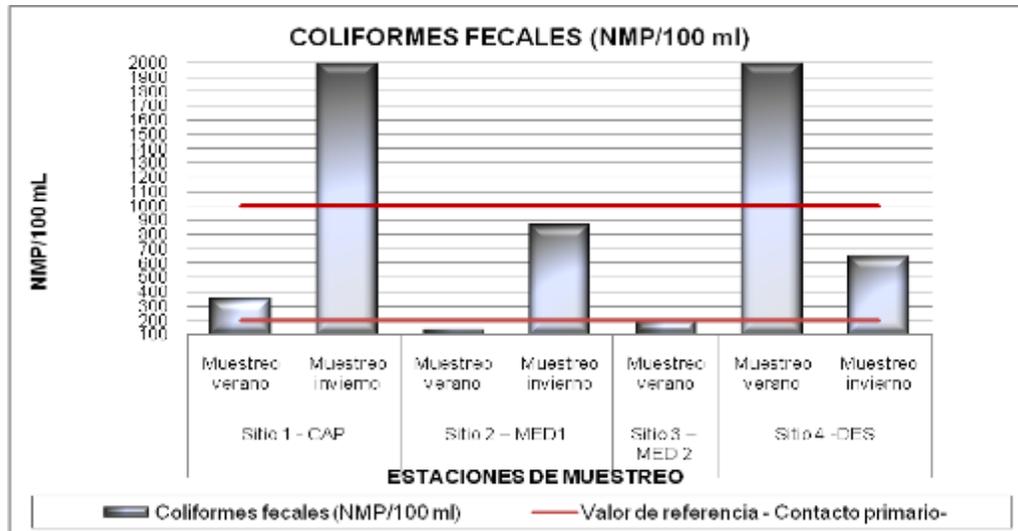


Figure 3-10. Values of fecal coliforms in three sections of the San Matias River (Cocorná - Granada, Antioquia) sector PCH Mills. SAG S.A.

Note: The reference lines indicate the maximum value (200MPN/100 mL) admitted to waters of primary contact, and the maximum allowed value (1000MPN/100 ml) of water for agricultural use (Decree 1594 of 1984).

In all the stages, the presence of total coliforms was greater than the maximum allowed by the Decree 1594 of 1984 (1000 as MPN/100 ml, in the waters that will be used for primary contact). While this would not use that would be given to the body of water of the San Matias River, is a good variable of comparing to infer that the waters of this river are contaminated with potentially pathogenic microorganisms (see Figure 3-11).

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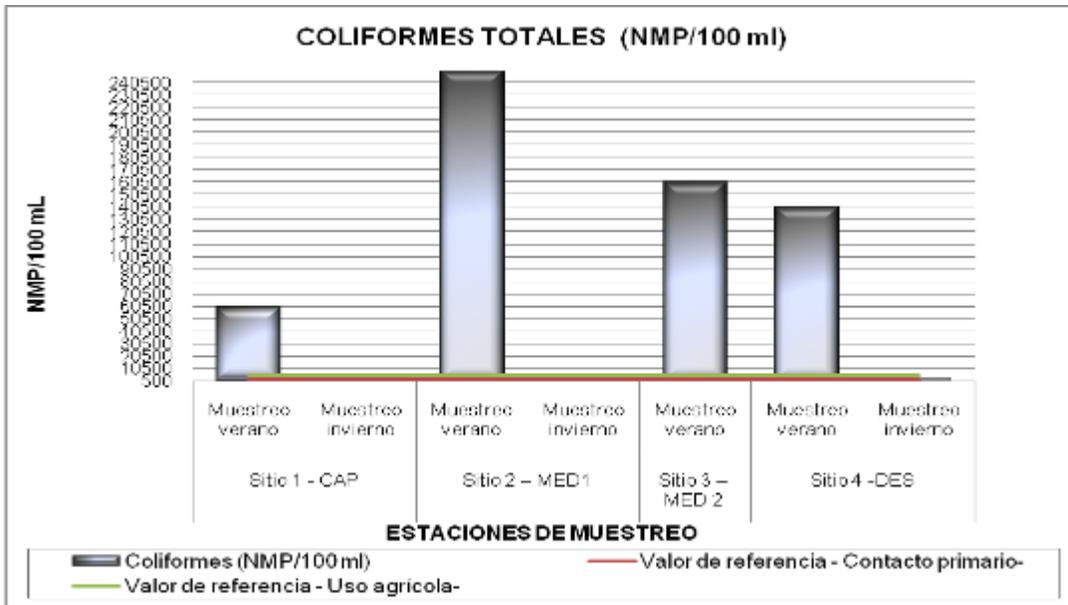


Figure 3-11. Values of total coliforms in three sections of the San Matias River (Cocorná - Granada, Antioquia) sector PCH Molinos. SAG S.A.

Note: The reference lines indicate the maximum value (1000MPN/100 mL) admitted to waters of primary contact, and the maximum allowed value (5000MPN/100 ml) of water for agricultural use (Decree 1594 of 1984).

Initially it might be thought that this result does not match with what was analyzed in the previous paragraph (oxygen demand); on the contrary, it induces a clearest inference. The San Matias River receives few discharges of domestic wastewater (presence of coliforms), but the organic matter vulnerable to biological degradation is oxidized rapidly (low BOD).

On the other hand, the presence of fecal coliforms, which are lower than the total, are above the range allowed by the Decree 1594 of 1984 (maximum 200MPN/100 ml) for use by primary contact. The presence of fecal coliforms in all the stages indicates recent contamination of anthropoid type (discharges of domestic untreated wastewater), more noticeable in the collection section.

➤ Nitrogen and Phosphorus

The behavior of the concentrations of total phosphorus is shown in. Figure 3-12 for the sampling done in the summer season there are no concentrations of orthophosphates or organic phosphorus, as in all the sites were below the detection limit of the method 0.150 mg/l, 0.020 mg/l respectively.

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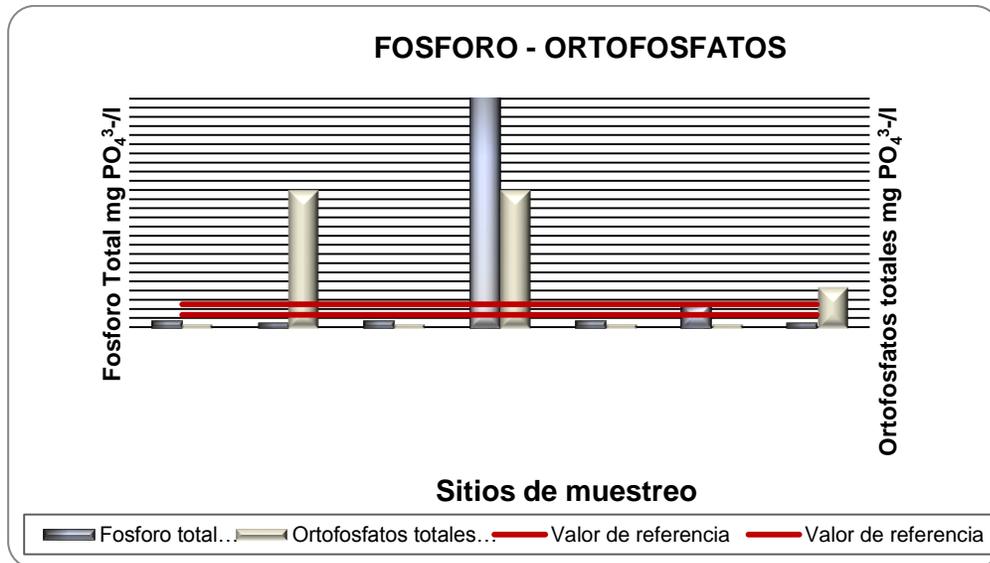


Figure 3-12. Concentrations values of total phosphorus

Note: The reference lines indicate the maximum value (0.027 mg P/L) range of the oligotrophic waters, and the threshold value (0.05 mg P/L) range of eutrophic (Ramirez and Viña 1998).

For the sampling done in the winter time, the total phosphorus presented concentrations between 1.5 times (in CAP and DES) and 14 times (MED) the lower limit (>0.05 mg P/L) of eutrophicated waters; equally, the concentrations of ortho-phosphate with values 6 (DES), 21 (CAP) and 68 (DES) times higher than the lower limit (>0.014 mg PO₄³⁻ /L) for atrophy condition According to Ramirez and Viña (1998), it is considered that there is eutrophication in the bodies of water when the concentration of total phosphorus is greater than 0.027 mg/L (or 0.014 mg PO₄³⁻ /L). In this sampling all the reported values are greater than these reference values, and in the MED site nine times higher (total P) to the other sites, for which it is believed that the water of the San Matias River during the winter water raising presents eutrophication by phosphorus, as a response to the contributions by runoff from the watershed.

The behavior for the forms of nitrogen analyzed can be seen in Figure 3-13 ; for sampling at summer time they do not present the concentrations of nitrate, ammonia nitrogen and total Kjeldahl nitrogen, since all the sites were below the detection limit of the method (1.50 mg/l, 1.00 mg/l and 1.00 mg/l respectively). In the case of the sampling of the winter season, the concentrations of total nitrogen and ammonia were below the detection limit of the method (<1.0 mg/L) in all the sampling sites, and the nitrate presented concentrations below the limit of oligotrophic condition (1mg/L), with values well below the limit of the regulations (10mg/L) of water for domestic use without treatment.

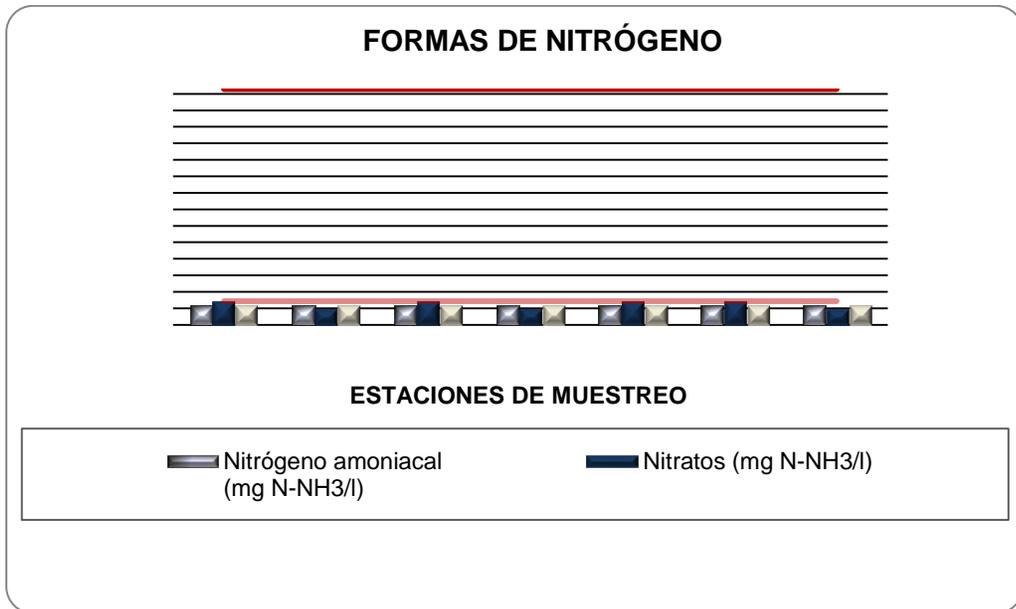


Figure 3-13. Values of total nitrogen, ammonia and nitrates

Note: The reference lines indicate the maximum value (1mg NO³ /L) of the range of oligotrophic waters (Ramirez and Viña 1998), and the maximum allowed value (10mg NO³ /L) of water for domestic use without treatment (Decree 1594 of 1984).

➤ Total hardness and total alkalinity

According to Ramirez and Viña (1998), in the current waters presents high mineral pollution when the concentrations of total hardness are greater than 110 mg/l; with the low values obtained from total hardness in all the sites evaluated (see figure 3 14 Figure 3-14), can be considered that San Matias River presents soft waters, since the values were below 75 mg/l. The greatest value of this variable is observed in the collection section (24mg CaCO₃/l) and the average of the three sites was 17.27 mg CaCO₃/l, indicating an irrelevant spatial variation. It is inferred that, according to data obtained from hardness, in the San Matias River is no contamination of mineral type.

Equally, the concentrations of total alkalinity are low in all the sampled sites (average of 23.09 mg/l). There has been no significant spatial variation for this parameter. According to Ramirez and Viña (1998), in the current waters there is high pollution when the mineral concentrations of alkalinity are greater than 250 mg/l.

The values of these two variables are small because they are much lower than those of the reference values for high mineral contamination. Therefore, it is considered that, in terms of total hardness and alkalinity, the San Matias River presents waters in good quality of sanitary conditions. The Decree 1594 of 1984 sets no limit value for concentrations of hardness and alkalinity for none of the uses (see Figure 3-14).

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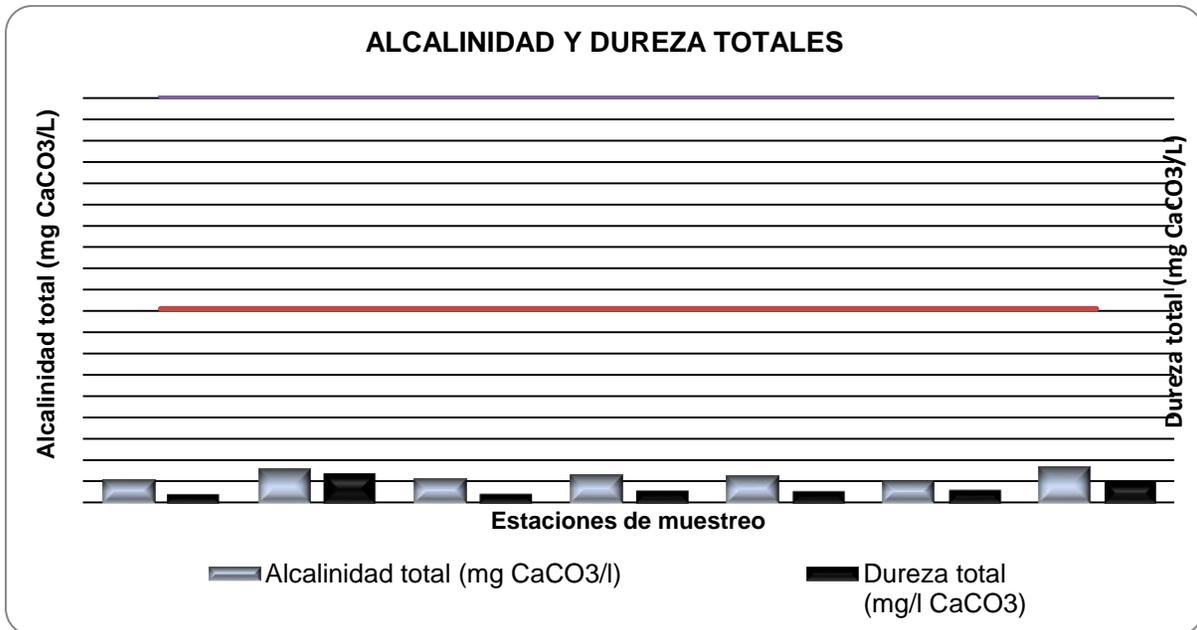


Figure 3-14. Concentration values of total hardness and total alkalinity

Note: The horizontal line indicates the maximum values of hardness and alkalinity from which there are high levels of air pollution by mineralization.

➤ **Total Iron and sulfates**

Although there are variations in the concentration of total iron between the sampled sites, the higher value was found in site 1 - collection - winter sampling- (3.13 mg/l) and the lowest in site 2 -Summer sampling - (0.19 mg/l), as can be seen in Figure 3-15 ; the magnitude of these is not representative, considering that the Decree 1594 of 1984 stipulates that the maximum allowed value of water for agricultural use is 5 mg/l of total iron, although Romero (1996) notes that water for purification with iron concentrations above 0.3 mg/l will require treatment for its removal.

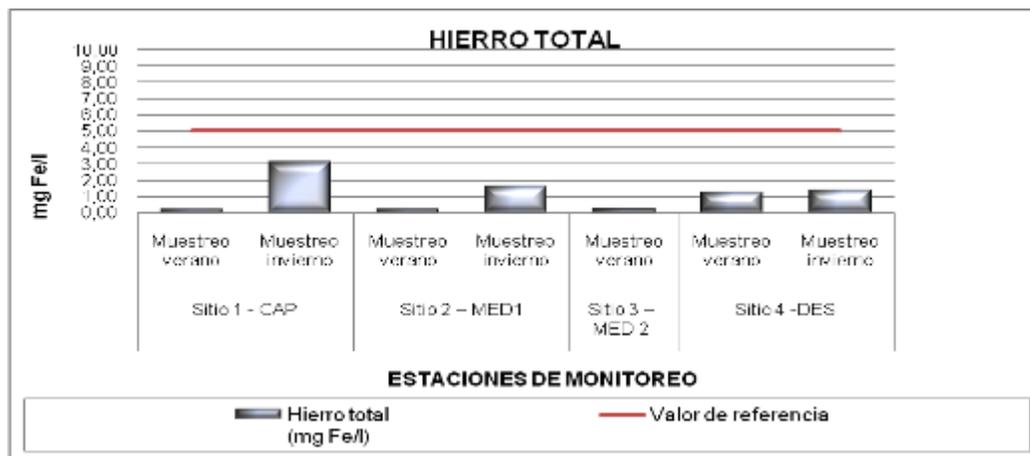


Figure 3-15. Concentrations values of total iron

On the other hand, decree 1594 of 1984 allows waters up to a maximum of 400 mg/l of sulfate to be treated without removal of them (only chlorination). The foregoing indicates that, since the concentrations of sulfides are less than 5.0 mg/l, the presence of sulphates in the water is so low that it would not harm or for home use.

➤ Detergents

All concentrations of detergents were below the minimum detection limit of the analytical method (0.100 mg/l), showing that the presence of detergents is minimal in the waters of the San Matias River. If it is understood that the detergents come mainly from domestic sewage, the current situation indicates the small impact that are generating potential discharge of this type (see Figure 3-16).

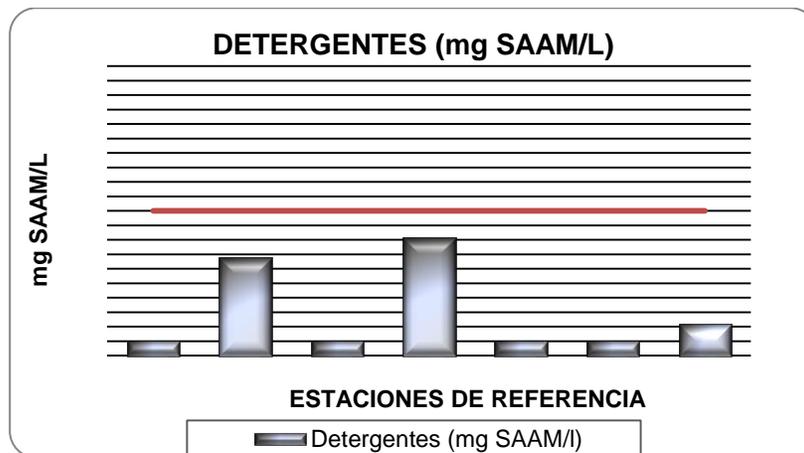


Figure 3-16. Concentrations values of detergents

Note: The reference line indicates the maximum value allowed s (0.5 ppm) for all the uses of water (Decree 1594 of 1984).

The decree 1594 of 1984 requires a maximum limit value of 0.5 mg/l of detergents (expressed as active substances to the methylene blue) for all uses of the body of water. As all the values were below this limit, it appears little contamination by this group of organic compounds in the San Matias River. For this reason, it is considered that, in terms of concentrations of detergents, the San Matias River features a very good water quality.

- Index of sanitary water quality
 - NSF Index - WQI (National Sanitary Foundation-Water Quality Index)

This index evaluates the concentrations of dissolved oxygen, biochemical oxygen demand, phosphorus, nitrates and total solids, the presence of coliforms, the values of turbidity and pH, and the changes in temperature. The index values close to 100 represent good water quality, while the opposite means values close to zero (see Table 3-39).

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Table 3-39. Water quality classification

| Value | Color | Water Quality |
|--------|-------|---------------|
| 91-100 | | Excellent |
| 71-90 | | Good |
| 51-70 | | Regular |
| 26-50 | | Bad |
| 0-25 | | Appalling |

In the variables and sections in which the concentrations were below the minimum detection limit of the method, the index was calculated with the value of limit. Therefore, the results obtained of the index are expressed as greater than those calculated. Table 3-40 show the values of each variable, the weight over the total and the index NSF - WQI. For the calculation of this index, it was assumed that the water did not present temperature changes between consecutive measurements.

In general terms, it can be said that the sector evaluated of the San Matias River presents a good sanitary quality of water (category 4 of 5). It was noted that 71% of the interest variables, presented high levels (>80), except for coliform which present low values in all the sites evaluated. Highlights the high values for OD, pH, T and nitrates, all these important features in the health of a healthy river, with the capacity to sustain a diverse aquatic biota.

Table 3-40. Calculation of the index NSF - WQ for the San Matias River

| Variable | Weight | Site 1 - Collection | | Site 2 - middle section1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|------------------|--------|---------------------|-----------|--------------------------|-----------|---------------------------|--------------------|-----------|
| | | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Dissolved Oxygen | 0.17 | 95 | 87 | 97 | 91 | 98 | 98 | 93 |
| Coliforms | 0.16 | 32 | 17 | 41 | 23 | 37 | 18 | 26 |
| PH | 0.11 | 92 | 92 | 93 | 93 | 93 | 93 | 93 |
| BOD | 0.11 | >61 | 93 | >61 | 93 | >61 | >61 | 93 |
| Temperature | 0.1 | 93 | 85 | 93 | 80 | 93 | 93 | 85 |
| Orthophosphates | 0.1 | >94 | 81 | >94 | 42 | >94 | >94 | 96 |
| Nitrates | 0.1 | >96 | 97 | >96 | 96 | >96 | >96 | 97 |
| Turbidity | 0.08 | 92 | 19 | 92 | 5 | 92 | 57 | 55 |
| Solids | 0.07 | 87 | 78 | 87 | 20 | 87 | 85 | 84 |
| NFS-WQI | | >79.85 | 71 | >81.74 | 63 | 63 | >75.29 | 78 |

– Bio - indicators (BMWP Index)

In Table 3-41 observed value of the index BMWP (Zamora 2007) assigned to each family collected, which depends on its sensitivity to environmental changes. The sum gives the value of biological quality of the water.

Table 3-41. BMWP for families of aquatic macro invertebrates found

| Family | Site 1 - Collection | | Site 2 - middle section1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|-----------------|---------------------|--------|--------------------------|--------|---------------------------|--------------------|--------|
| | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Baetidae | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Leptophlebiidae | 1 | | | | | 9 | 9 |
| Leptohyphidae | 7 | | 7 | 7 | 7 | 7 | |
| Oligoneuridae | | | 10 | | 10 | 10 | |
| Libellulidae | 6 | 6 | | | 6 | 6 | 6 |

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| Family | Site 1- Collection | | Site 2 - middle section1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|-------------------|--------------------|--------|--------------------------|--------|---------------------------|--------------------|--------|
| | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Perlidae | | | | | 10 | 10 | 10 |
| Corydalidae | | 6 | | 6 | | 6 | 6 |
| Naucoridae | 7 | 7 | | | 7 | 7 | 7 |
| Veliidae | | | | | | 8 | |
| Chrysomelidae | | | | | | 4 | |
| Dryopidae | | | | | | 7 | |
| Elmidae | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| Hydrophilidae | | | | | | 3 | |
| Psephenidae | | | | | | 10 | |
| Staphylinidae | | 6 | | | | 6 | |
| Glossosomatidae | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| Hydrobiosidae | | | | 9 | 9 | 9 | 9 |
| Hydropsychidae | 7 | | | | 7 | 7 | 7 |
| Leptoceridae | 8 | | | 8 | 8 | 8 | 8 |
| Pyralidae | 5 | | | | | 5 | |
| Blepharoceridae | 10 | 10 | 10 | | 10 | 10 | 10 |
| Chironomiidae | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Empididae | | | | 4 | | 3 | 4 |
| Simuliidae | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| Tipulidae) Larvae | | 3 | | | 3 | 3 | |
| Hydroptilidae | | 7 | | 7 | | | |
| Syrphidae | | | | 1 | | | |
| BMWP | 81 | 75 | 57 | 72 | 107 | 168 | 106 |

In sites 1 and 2 (Collection and middle section 1), for both climatic seasons sampled, the BMWP value classifies the water with an acceptable quality, with the exception of Site 2 in the summer season, where it was a dubious quality, indicative of polluted waters.

In sites 3 and 4 (middle section 2 and discharge), the BMWP value qualifies with good quality indicative of clean waters (see Table 3-42).

Table 3-42. Results of the index application BMWP

| Site/Section/Season | BMWP | Meaning | Class | Quality |
|---------------------|------|----------------------------|-------|------------|
| 1 Summer | 81 | Moderately polluted waters | III | Acceptable |
| 1 Winter | 75 | Moderately polluted waters | III | Acceptable |
| 2 Summer | 57 | Polluted water | IV | Doubtful |
| 2 Winter | 72 | Moderately polluted waters | III | Acceptable |
| 3 Summer | 107 | Clean Waters | II | Good |
| 4 Summer | 168 | Very clean waters | I | Very Good |
| 4 Winter | 106 | Clean Waters | II | Good |

Unlike the Quality Index of Water NSFI, which responds with snapshot valuations on the degree of contamination of a site, the BMWP is based on the rating of the tolerance of individuals of different species that live permanently exposed to the quality of the environment, then it is a more reliable option on the determination of the water quality from a natural flow.

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However, the use of the average tolerance per family, as is the case with the BMWP system, may cause false results. According to Fernandez and Dominguez (2001)⁹, many genres or families of aquatic invertebrates have broad geographical distributions, such as for example Helicopsyche, Hydroptila - Trichoptera; Thraulodes, Baetodes, Tricorythodes - Ephemeroptera, among others, that can present major ecological tolerance differences between the species.

On the other hand, although the variables analyzed from the point of view of physical and chemical quality of the water will lead to

Values that indicate deterioration of natural waters, it may occur that its nature has not been affected anthropogenically (Fernandez *et al.* . 2002) And, in consequence, the shortage of benthic organisms forges a value of the index that does not reflect changes that come from pollution, but by natural hydraulic stress of the section, or the time of the biological cycles of insects.

3.2.7.4 Hydro biological Characterization

- Benthic Microalgae

In Table 3-43 you can see the number of individuals registered by gender in the sampling sites evaluated in the two climatic seasons in the San Matias River.

Table 3-43. Taxonomic registration and densities (Ind/cm²) recorded in the quantitative analysis of the paralytic algae

| Taxa | Individuals/cm ² | | | | | | |
|--------------------|-----------------------------|----------|--------------------------|--------|---------------------------|--------------------|--------|
| | Site 1- Collection | | Site 2 - middle section1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
| | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Chlorophyta | | | | | | | |
| Oedogonium | 236.82 | 260.4 | 680.32 | 95.3 | 61.72 | 1,083.99 | 1150.8 |
| Characium | 796.58 | 850.5 | 34.45 | | 185.15 | 38.03 | 45.5 |
| Cladophora | | | 8.61 | | 349.73 | | |
| Ulothrix | | | 61.72 | | | | |
| Chlorococcum | | | | | 34.45 | | |
| Mougeotia | | | | | 31.22 | | |
| Cosmarium | 21.53 | 11.2 | | | | | |
| Actinastrum | | | | | 10.41 | | |
| Spirogyra | | | | | 10.41 | | |
| Netrium | | | | | 8.61 | | |
| Cryptomonas | | 21 | | | | | |
| Fragilaria | 6,200.40 | 6,555.00 | 757.83 | 55.8 | 8,722.66 | 3,898.57 | 3535 |
| Achnanthes | 2,971.03 | 2,550.40 | 1,257.30 | 235.70 | 1,152.05 | 627.58 | 627.3 |
| Navicula | 2,497.38 | 2,235.00 | 378.91 | 515 | 1,501.78 | 1,407.29 | 1678 |
| Nitzschia | 968.81 | 880 | 335.86 | 400 | 2900.7 | 608.56 | 712 |
| Cymbella | 409.05 | 510.3 | 172.23 | 43.2 | 473.16 | 2,167.99 | 2345.5 |
| Synedra | 344.47 | 442 | 103.34 | 88 | 1,296.06 | 152.14 | 175.6 |
| Melosira | 516.7 | 512 | 77.51 | 44 | 781.75 | 19.02 | 19 |

⁹ Sylvie Tomanova & Paul A. Tedesco. 2007. Body Size, ecological tolerance and potential Bioindication of water quality from Anacroneuria spp. (Plecoptera: Perlidae) in South America. *Rev. Biol. Trop. (Int. J. Trop. Biol. ISSN-0034-7744) Vol. 55 (1): 67-81*, March 2007.

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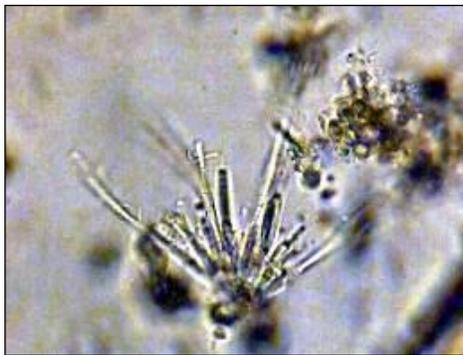
| Taxa | Individuals/cm ² | | | | | | |
|--|-----------------------------|------------------|--------------------------|-----------------|---------------------------|--------------------|------------------|
| | Site 1- Collection | | Site 2 - middle section1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
| | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Chlorophyta | | | | | | | |
| Gomphonema | 322.94 | 389.5 | 172.23 | 23 | 288.01 | 171.16 | 186 |
| Anomooneis | 107.65 | 115.6 | 51.67 | 21.3 | 102.86 | 361.33 | 333.5 |
| Cyclotella | 107.65 | 88.7 | 43.06 | | 329.16 | 133.12 | 140.6 |
| Pinnularia | 279.88 | 312 | 20.81 | | 226.3 | 38.03 | 20 |
| Inflata Achnanthes aff | 193.76 | 193.8 | 17.22 | | 123.43 | 133.12 | 133.1 |
| Frustulia | 172.23 | 189 | 8.61 | | 82.29 | 38.03 | 29.5 |
| Cocconeis | 21.53 | 25.3 | 17.22 | | 102.86 | 152.14 | 165.9 |
| Amphora | 172.23 | | 17.22 | | 61.72 | | |
| Aff Nitzschia acicularis | | | 20.81 | | 144.01 | | |
| Pseudozoya flocculosa Tabellaria aff | 21.53 | 66.3 | 25.84 | 20.1 | 41.14 | 38.03 | 55.7 |
| Stauroneis | | | 20.81 | | 20.57 | | |
| Synura | | | | | 25.84 | | |
| Cryptomonas | 21.53 | | | | 8.61 | | |
| Lyngbya | 14,144.67 | 10,765.00 | 6,837.67 | 880.50 | 9,298.69 | 760.7 | 550 |
| Chamaesiphon | 5,156.24 | 1,010.00 | 1,674.97 | 650.00 | 8,876.96 | 5,667.20 | 4640 |
| Oscillatoria | 688.93 | 590 | 51.67 | | 781.75 | 133.12 | 110.5 |
| Cf Stigonema | 473.64 | 450 | 155.01 | 67.5 | 987.47 | | |
| Planktolynbya | 64.59 | 35 | 17.22 | | 144.01 | 399.37 | 289 |
| Pseudanabaena | 129.18 | 99.8 | 43.06 | | 102.86 | | |
| Coelosphaerium | 64.59 | 64.6 | | | 17.22 | 95.09 | 80 |
| Anabaena | | | | | | 76.07 | 76.1 |
| Microcystis | | | | | 20.57 | | |
| Euglenophyta | | | | | | | |
| Trachelomonas aff volvocina | 43.06 | 43.1 | 17.22 | | 41.14 | 19.02 | 19 |
| Cf Colacium | | | | | | 38.03 | |
| Trachelomonas | | | | | 17.22 | 19.02 | 19 |
| Euglena | | | 20.57 | | | | |
| Individuals/cm² | 37,148.60 | 29,265.50 | 13,100.97 | 3,139.40 | 39,364.55 | 18,275.75 | 17,136.60 |
| Number of taxa | 28 | 27 | 30 | 14 | 38 | 26 | 25 |

For the sampling of summer, in general terms, the list of taxa meets the representation of 40 genuses, belonging to five algal divisions, distributed in the following form, a representative of Cryptophytes, three of Euglenophyta, nine cyanoficeas or cyan bacteria, 10 green algae or chlorophyta, and the division with the highest number of representatives was Bacillariophyta or diatoms with 17 different taxa (see Table 3-43).

In the winter sampling, the list of taxa meets the representation of 27 genuses belonging to five algal divisions, distributed in the following form, a representative of Cryptophytes, two of Euglenophyta, eight Cyanophyta/cyan bacteria, three green algae or Chlorophyta, and division (class) with greater number of representatives was Bacillariophyta or diatoms with 15 different taxa (see Table 3-43).

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In both samples (summer and winter), it was found that the majority of the algae found belong to the division Bacillariophyta, known as "diatoms", what is common, as this type of algae are common components of the periphyton of running water. These algae can be unicellular, colonial or filamentous, and are regularly used in the study of water quality of lotic systems or flows, because their cells are included in a cell wall surrounded by silicon, which gives them more weight and as a result, adaptation to colonize firm substrates, immersed in the exposed flows to the speed of the flow. As agencies belonging to the first level of the trophic food chain in the aquatic environment of a lotic system, and because of their frequent presence, diatoms are a key component as a group and producer in the photosynthetic system (Bold & Wynne 1985) (see Photo 3-12 and Photo 3-13).



Lyngbya sp



Chamaesiphon sp



Fragillaria sp



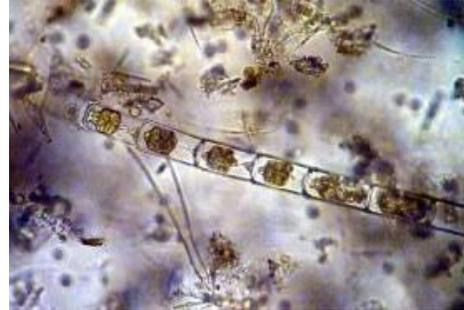
Navicula sp

Photo 3-12. Some of the dominant benthic microalgae, collected in the section of assessment

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Cymbella sp



Oedogonium sp

Photo 3-13. Some of the dominant benthic microalgae, collected in the section of assessment



Synedra sp



Cf. *Stigonema*

Photo 3-13. Some of the dominant benthic microalgae, collected in the section of assessment. (Continued)

For the summer sampling the population structure of the sector evaluated, it is noteworthy that 24 of the 40 taxa reported were recorded in the four stages of evaluation and 11 taxa were exclusive to the middle section, although they are of broad biogeography distribution. In the sampling of winter it is noteworthy that of the taxa recorded, only 38% are reported to the three stages of evaluation, and none was strictly exclusive of the Middle section

To observe the pattern of distribution of the different genuses, in both sampling, highlights the frequency and abundance of cyan bacteria *Lyngbya* sp, *Chamaesiphon* sp, *Oscillatoria* sp and cf. *Stigonema*, diatoms *Fragilaria* sp, *Achnanthes* sp, *Navicula* sp, *Nitzschia* sp, *Cymbella* sp, *Synedra* sp, *Melosira* sp, and green algae *Characium* *Oedogonium* sp and sp (see Figure 3-17). These records indicate environmental conditions favorable for the special settlement of these taxa, as they significantly outperform their density in relation to other organisms.

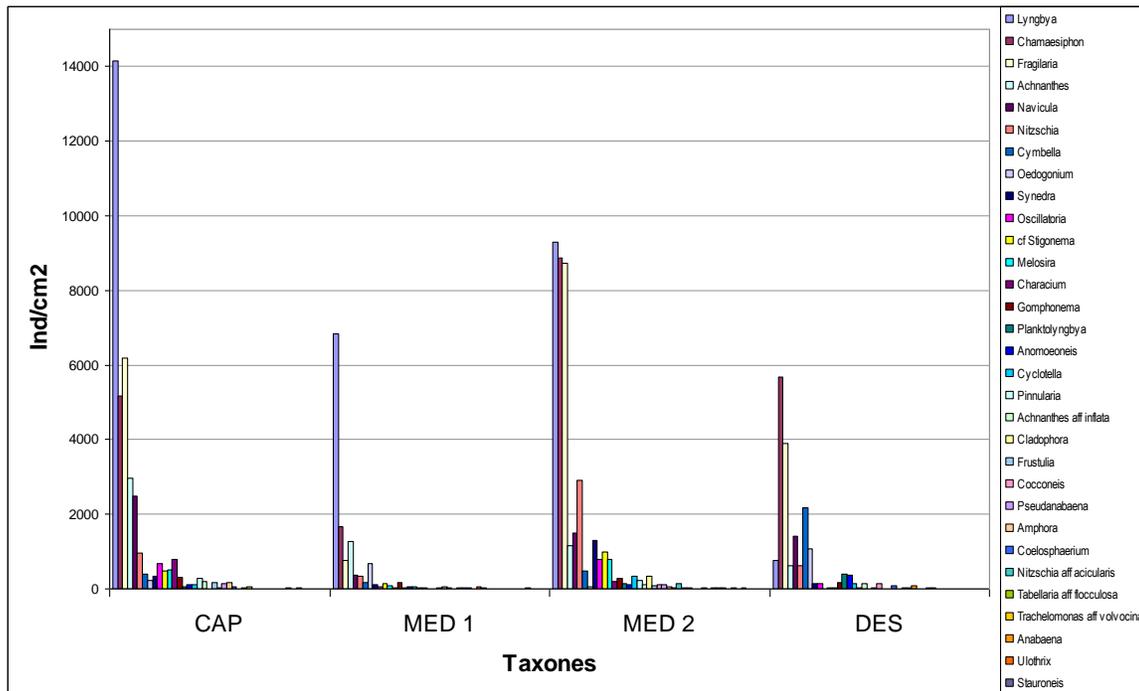
Some ecological aspects relevant of these taxa are:

The cyan bacterium *Lyngbya* sp belongs to a gender of common presence in environments with good availability of organic matter and their filamentous structure is favored by low to intermediate speeds of the current. And the *Oscillatoria* sp can clog filters, reproduced in

ENVIRONMENTAL IMPACT STUDY

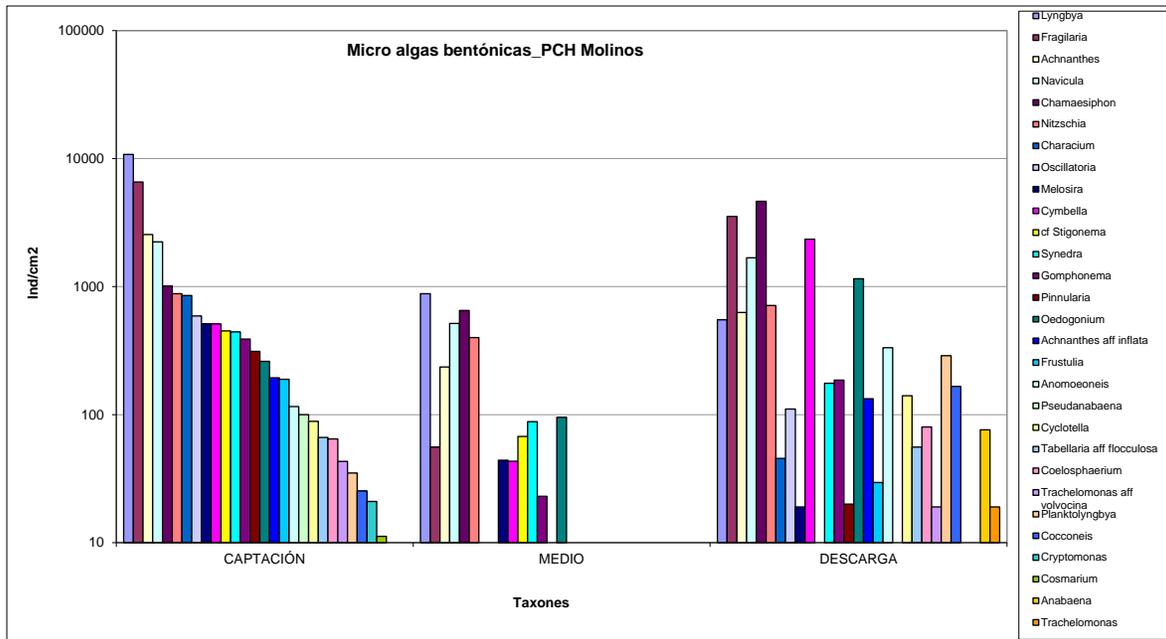
high quantities and indicate presence of wastes associated with paper industries or saline pollution (Branco 1986).

With regard to gender *Fragillaria*, these taxa are formed by united cells from side to side and can form permanent or fluctuating colonies. It is highly adaptable to lotic systems, so that its presence is common in epiphytic communities of mountain streams, from the upper parts of the basin until floodplains, and many of its species are indicators of water with good oxidation states and active decomposition of organic matter (Branco 1986).



Summer Sampling

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Winter Sampling

Figure 3-17. Distribution of abundance (org/cm²) of the gender recorded

Of *Oedognium* sp it is important to mention that it is composed of green filaments formed of long cylindrical cells, which in its youth state lives in the bottom of large pools, and later rise to the surface where they can build important agglomerated or carpets, may indicate low pH or water from marshy areas (Branco 1986).

Finally, by looking at the records of numerical wealth that are presented in Table 343 Table 3-43, for the summer sampling are remarkable similarities between the sites (from 26 up to 38 species); the section MED 1 presented the lowest density of organisms per unit area (ind/cm²), in contrast with the CAP and DES tranches result, which could be associated with ecological conditions unfavorable for the colonization of the rocky substrate exposed to the high flow rates submitted by the bed, in the steep slopes of this section.

For the sampling of winter, the records of taxonomic richness (from 12 up to 25 taxa), show a remarkable similarity between the CAP and DES tranches, which share 79% of the taxa, although with obvious differences in the density values of the various taxa; this result might be associated with ecological conditions relatively less favorable for colonization of the rocky substrate exposed to higher flow rates presented in the Discharge section, and that apparently were much more restrictive in section 1 MED, where there were only 14 taxa, with a total density that only reaches 10% of the documented in the section CAP.

Then it's possible that the speed of the current in section 1 MED, especially toward the center, in conjunction with the availability of substrates and the submerged light penetration restrict a greater density of organisms.

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- Aquatic Macro invertebrates

For the summer sampling were found in total 2,568 individuals from 42 taxa in total in the four sampling sites (see Table 3-44), where *Simulium* was the taxon that presented the greatest abundance in the high tranches (CAP) and low (DES), while in the middle section (MED 2) were *Baetodes* and *Smicridea*.

In the sampling campaign carried out in the winter season, there were 1,901 individuals from 33 taxa in total, in the three stages of sampling, the taxon *Camelobaetidius* presented the most abundant (1,321 individuals) in the three stages, and representing 79.9 % of the total number of individuals of the Middle section (MED 1) (see Table 3-44).

In the summer sampling in section 1 (CAP) were collected a total of 873 individuals, represented in 21 taxa, of which were determined 13 families and 7 orders, where *Simulium* sp was the most abundant taxon, reaching 70.6 % (see Table 3-44 and Figure 3-18).

In winter, in section 1 (CAP) were collected a total of 544 individuals represented in 19 taxa, of which were determined 13 families and 7 orders, where *Camelobaetidius* was the most abundant taxon, representing 59.4 %, followed by *Baetodes* with 18.2 % (see Table 3-44 and Figure 3-18).

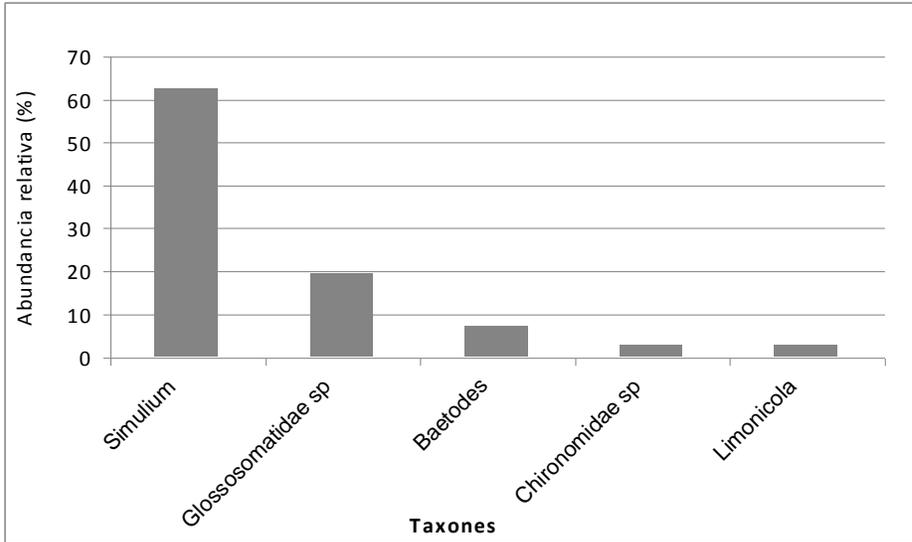
Table 3-44. Taxonomic and numeric composition of aquatic macro invertebrates collected

| Order | Family | Gender | Site 1- Collection | | Site 2 - middle section 1 | | Site 3 - middle section 2 | Site 4 - Discharge | | |
|----------------------|-----------------|------------------------|--------------------|--------|---------------------------|--------|---------------------------|--------------------|--------|---|
| | | | Summer | Winter | Summer | Winter | Summer | Summer | Winter | |
| EPHEMEROPTERA | BAETIDAE | SD . | 2 | 12 | | 6 | 5 | 46 | 14 | |
| | | <i>Baetodes</i> | 61 | 99 | 22 | 57 | 40 | 51 | 40 | |
| | | <i>Camelobaetidius</i> | 11 | 323 | | 664 | 15 | 69 | 334 | |
| | LEPTOPHLEBIIDAE | <i>Thraulodes</i> | 1 | | | | | 1 | 1 | |
| | LEPTOHYPHIIDAE | <i>Leptohyphes</i> | 3 | | 6 | | 14 | 22 | | |
| | | <i>Tricorythodes</i> | | | | 11 | | | | |
| | OLIGONEURIDAE | <i>Lachlania</i> | | | 1 | | 1 | 1 | | |
| Odonata | LIBELLULIDAE | <i>Brechnoroga</i> | 1 | | | | 2 | 1 | | |
| | | <i>Sympetrum</i> | 14 | | | | | | | |
| | | <i>Brechmorhoga</i> | | 1 | | | | | 1 | |
| PLECOPTERA | PERLIDAE | <i>Anacroneuria</i> | | | | 3 | 3 | 1 | | |
| MEGALOPTER | CORYDALIDAE | <i>Corydalus</i> | | 1 | | 1 | 8 | 4 | | |
| HEMIPTERA | NAUCORIDAE | <i>Limnocois</i> | 1 | 3 | | | 2 | 1 | 1 | |
| | VELIIDAE | <i>Rhagovelia</i> | | | | | | 3 | | |
| COLEOPTER | CHRYSOMELIDAE | SD . | | | | | | 1 | | |
| | CUCURLIONIDAE | SD. | | 1 | | | | | | |
| | DRYOPIDAE | <i>Pelonomus</i> | | | | | | 1 | | |
| | ELMIDAE | <i>Austrolimnius</i> | | | | | | | | 1 |
| | | <i>Cylloepus</i> | 4 | 3 | | | 4 | | 2 | |
| | | <i>Disersus</i> | | | | 1 | | | | |
| | | <i>Heterelmis</i> | | 1 | | | | 5 | 1 | |
| <i>Hexacylloepus</i> | | | | | | | 1 | | | |
| <i>Macrelmis</i> | 1 | 1 | | | | 2 | 5 | | | |

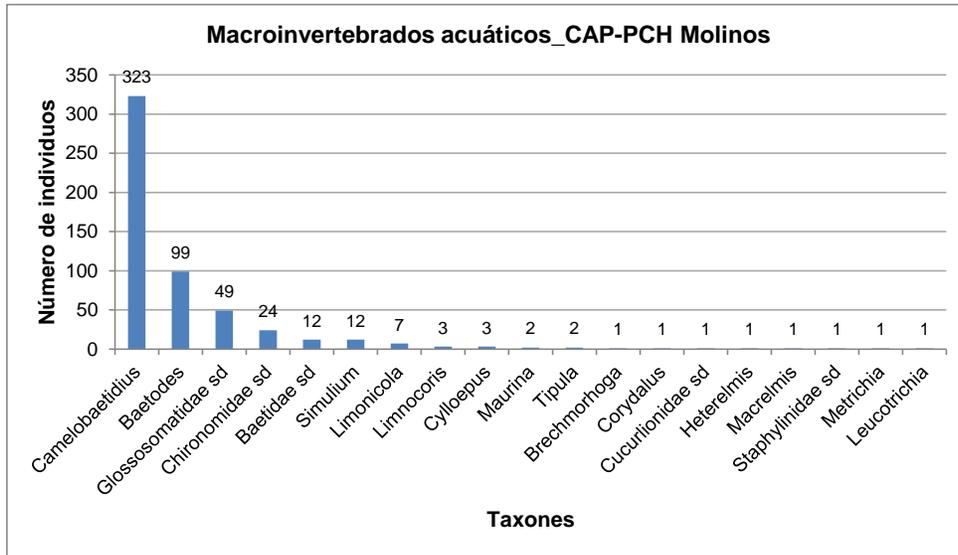
ENVIRONMENTAL IMPACT STUDY

| Order | Family | Gender | Site 1- Collection | | Site 2 - middle section 1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|------------------------------------|-------------------|-----------------------|-----------------------|------------|------------------------------|------------|------------------------------------|-----------------------|------------|
| | | | Summ er | Winter | Sum mer | Winter | Summe r | Sum mer | Winter |
| | | <i>Mycrocylloepus</i> | 1 | | 1 | 4 | 1 | | 1 |
| | | <i>Notelmis</i> | | | | | | 3 | |
| | | <i>Neoelmis</i> | | | | | | | 1 |
| | | <i>Phanocerus</i> | | | | | 1 | 2 | |
| | | <i>Pseudodisersus</i> | | | | | | 1 | |
| | | <i>Pseudosisersus</i> | | | | | | 2 | |
| | | <i>Xenelmis</i> | | | | | | 1 | |
| | HYDROPHILIDAE | SD . | | | | | | 1 | |
| | PSEPHENIDAE | <i>Y Psephenops</i> | | | | | | 1 | |
| | STAPHYLINIDAE | SD. | | 1 | | | | 7 | |
| Trichoptera | GLOSSOSOMATIDAE | SD. | 169 | 49 | 2 | 1 | 3 | 19 | 64 |
| | HYDROBIOSIDAE | <i>Atopsyche</i> | | | | 2 | 12 | 20 | 4 |
| | HYDROPSYCHIDAE | <i>Leptonema</i> | 1 | | | | | 3 | 3 |
| | | <i>Smicridea</i> | 8 | | | | 37 | 15 | 7 |
| | HYDROPTILIDAE | <i>Metrichia were</i> | | 1 | | 4 | | | |
| | | <i>Leucotrichia</i> | | 1 | | 2 | | | |
| | LEPTOCERIDAE | <i>Grumichella</i> | 1 | | | 2 | 2 | 2 | 1 |
| | | <i>Neptosyche</i> | 1 | | | | 1 | 14 | 1 |
| LEPIDOPTERA | PYRALIDAE | SD. | 2 | | | | | 1 | |
| DIPTERA | BLEPHAROCERIDAE | <i>Limonicola</i> | 23 | 7 | | | 4 | 22 | |
| | | <i>Maurina</i> | 1 | 2 | 7 | | 1 | | 2 |
| | CHIRONOMIIDAE | SD. | 24 | 24 | 8 | 70 | 13 | 8 | 5 |
| | EMPIDIDAE | <i>Chelifera</i> | | | | | | 1 | |
| | | <i>Hemerodromia</i> | | | | 1 | | | 1 |
| | SIMULIIDAE | <i>Simulium</i> | 543 | 12 | 4 | 4 | 3 | 1178 | 31 |
| | SYRPHIDAE | <i>S. D</i> | | | | 1 | | | |
| | Tipulidae) LARVAE | <i>Limonia</i> | | | | | 11 | | |
| | | <i>Molophilus</i> | | | | | | 1 | |
| <i>Allows</i> | | | 2 | | | | 2 | | |
| Total number of individuals | | | 873 | 544 | 51 | 831 | 175 | 1,520 | 526 |
| Total Number taxa | | | 21 | 19 | 8 | 16 | 21 | 37 | 24 |

| Order | Family | Gender | Site 1- Collection | | Site 2 - middle section 1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|-------|--------|--------|-----------------------|--------|------------------------------|--------|------------------------------------|-----------------------|--------|
| | | | Summ er | Winter | Sum mer | Winter | Summe r | Sum mer | Winter |



Summer Sampling

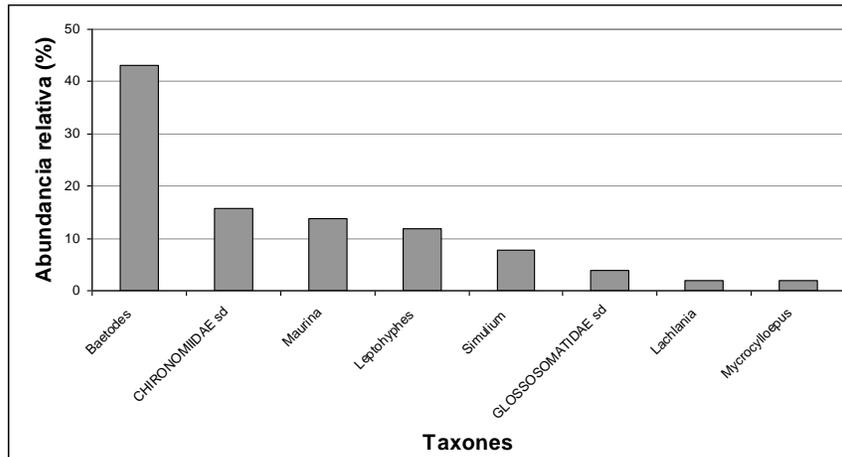


Winter Sampling

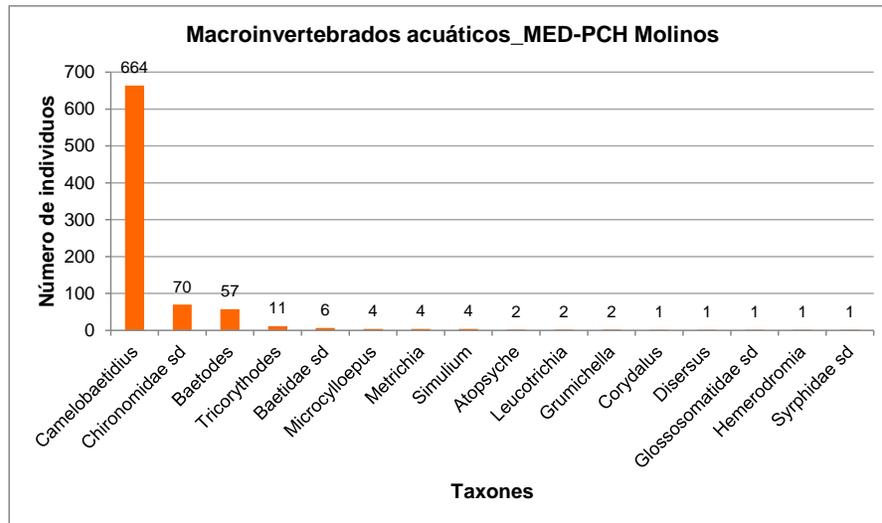
Figure 3-18. Relative abundance of taxa of dominant aquatic macro invertebrates collected in section 1 (CAP)

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In summer at site 2 (MED 1) were collected a total of 51 individuals, represented in 8 families of 4 orders. Gender *Chironomidae* and *Baetodes sd* were the most abundant taxa, with the 42.14 % and 15.6 %, respectively. On the other side in winter, this same section, collected a total of 831 individuals represented in 13 families of 5 orders. The taxon *Camelobaetidius* was the most abundant with the 79.9 % of the total of the individuals collected in this installment. *Chironomidae sd* (8.4 %) and *Baetodes* (6.6 %) were the other important taxa in abundance (see Table 3-44 and Figure 3-19).



Summer sampling



Winter Sampling

Figure 3-19. Relative abundance of the taxa of dominant aquatic macro invertebrates collected in section 2

In site 3 (MED 2), in the summer sampling, were collected a total of 175 individuals, represented in 15 families of 7 orders. Genuses *Smicridea* and *Baetodes* taxa were the most abundant, with 22.9 % and 21.1 % respectively (see Table 3-44 and Figure 3-20).

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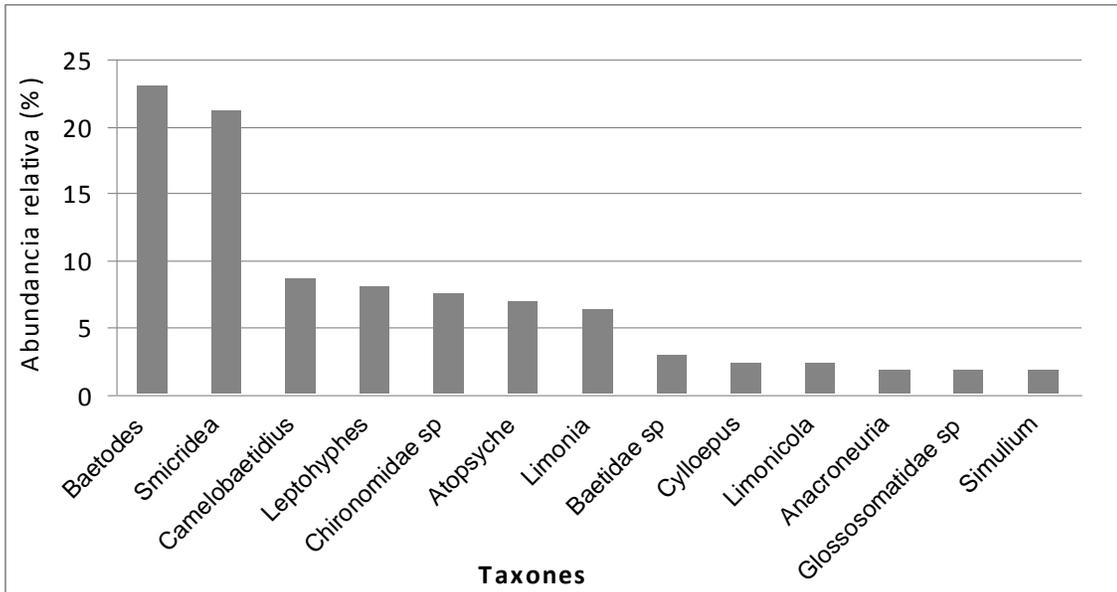
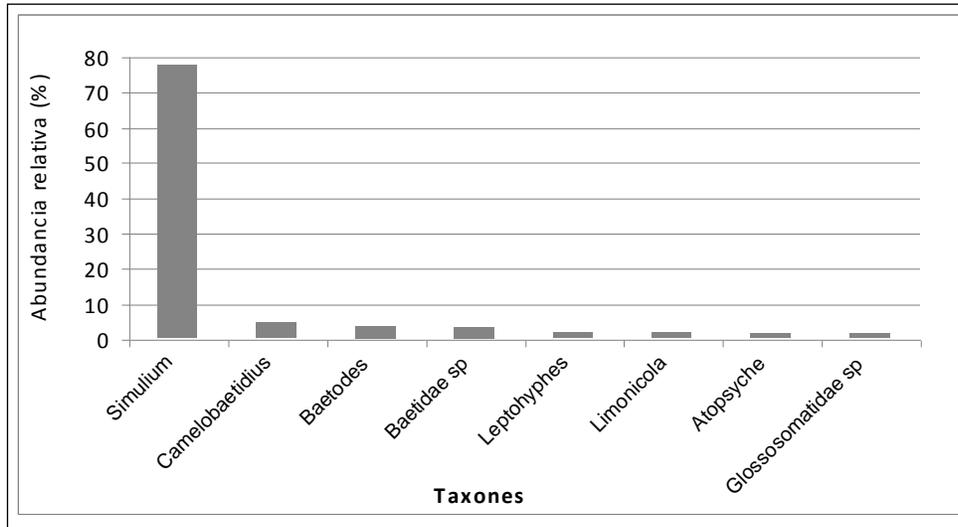


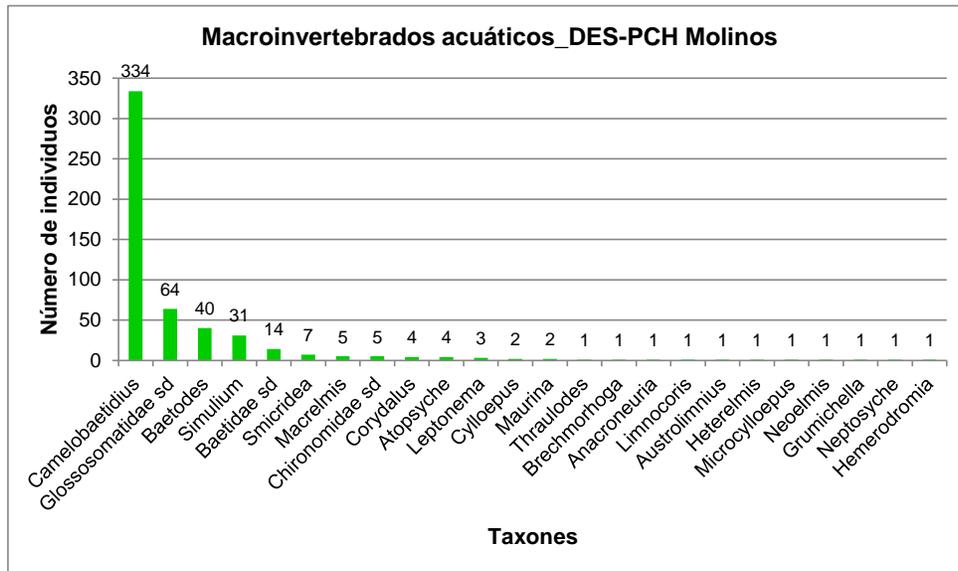
Figure 3-20. Relative abundance of the taxa of dominant aquatic macro invertebrates collected in site 3

In summer on the sampling site 4 (DES), were collected a total of 1,520 individuals, represented in 37 taxa, of which were determined 25 families and 9 orders. Just like in site 1, the gender *Simulium* taxon was the most abundant taxa, representing 77.5 % of the total aquatic macro invertebrates found. Figure 3-21 shows 93.9 % of the dominant taxa in this section. In the case of winter sampling, were collected a total of 526 individuals represented in 24 taxa, of which 14 families were identified and eight orders. As in the two previous stages, *Camelobaetidius* was the most abundant taxon with 63.5 % of the total of the individuals collected in this section. *Glossosomatidae* sd (12.2 %) and *Baetodes* (7.6 %) were the other important taxa in abundance (see Table 3-44 and Figure 3-21).

ENVIRONMENTAL IMPACT STUDY



Summer Sampling



Winter Sampling

Figure 3-21. Relative abundance of the taxa of dominant aquatic macro invertebrates in site 4

The main ecological characteristics of the most abundant organisms in the different sampling sites are:

- The Simulium larvae (see Photo 3-14 a) can measure from 8 mm to 12 mm; they are filtering, they are usually found in high densities in different altitudinal floors, in clean waters or in moderately polluted waters; in the latter case, there are formed large densities in the rocks in areas of high current (Vane and Ospina 2007).

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- The larvae of *Baetodes* (see photo), are found in rivers and streams in the areas of greatest current, attached to the well-oxygenated rocks. They are scrapers, feeding on algae (Lievano and Ospina 2007).
- The gender *Smicridea* (see Photo 3-14c) live mainly in the center of the bodies of water, where there is strong current. They are generalists, found in several height floors, in waters from clean to moderately contaminated (Lievano and Ospina 2007).
- *Camelobaetidius* gender (see Photo 314 Photo 3-14d) is characterized by living in bodies of oxygenated water, with current and little organic pollution (Dominguez *et al.* . 2009). According to Perry (2005), commonly occurs a direct relationship between the abundance of this gender and filamentous algae in the summer season and packages of litter immersed in winter, a fact that was able to corroborate in this assessment.

Within the sector evaluated genres *Leucotrichia* and *Neelmis* (see Photo 3-14 e and f) can be named as "rare" taxa, because they are rare in the collections of aquatic macro-invertebrates. These genres may show a vulnerable or endangered state within the ecosystem due to different causes, the main one being the direct destruction of the habitat.

The ecological index of diversity presented low values for the summer sampling in site 1- CAP and 4 - DES, as a result of the high dominance of *Simulium* . In site 2, in spite of lower values of taxonomic richness, there are high values for diversity and equity (see Table 3-45).

Also for the winter sampling, the diversity of ecological index presented low values in the three sites evaluated, as a result of the high dominance (between 59 and 80% of the abundances of *Camelobaetidius*) and the low species richness, very probably induced by the events that characterize the rainy season (ascent of flow rates, increased sediment with abrasive capacity, reduction of brightness).



(a)



(b)



(c)

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(d)



(e)



(f)

Photo 3-14. Aquatic Macro invertebrates of greater abundance: a. *Simulium sp* , b. *Baetodes sp* , c. *Smicridea sp* , d. *Camelobaetidius*, e. *Neelmis* and f. *Leucotrichia*

Table 3-45. Ecological index for the stages of assessment in the San Matias River - El Molino (Cocorná - Granada, Antioquia).

| Ecological Index | TraSite 1- Collection | | Site 2 - middle section 1 | | Site 3 - middle section 2 | Site 4 - Discharge | |
|---------------------------------|--------------------------|--------|------------------------------|--------|---------------------------------|--------------------|--------|
| | Summer | Winter | Summer | Winter | Summer | Summer | Winter |
| Total number of individuals (N) | 873 | 544 | 51 | 831 | 175 | 1,520 | 526 |
| Species richness (S') | 21 | 19 | 8 | 16 | 21 | 37 | 24 |
| Equity of Pielou (J') | 0.43 | 0.47 | 0.84 | 0.30 | 0.79 | 0.32 | 0.45 |
| Dominance of Simpson (D') | 0.43 | 0.40 | 0.21 | 0.65 | 0.13 | 0.61 | 0.43 |
| Shannon diversity (H') | 1.30 | 1.39 | 1.76 | 0.83 | 2.41 | 1.14 | 1.43 |

3.2.8 SEISMICITY

The study area was located in an area of medium seismicity, as noted in Figure 3-8 ; this factor, coupled with the presence of slope deposits, consisting of collations of flows of mud and rubble in areas of high rainfall, make it very susceptible to mass movements (Gomez, 1999).

The seismic hazard is defined as the probability that a parameter such as acceleration, velocity or displacement of the field produced by an earthquake, exceeds or equals a reference level (Ingeominas, 2004), as follows:

Area of Low Seismic Hazard. Defined for those regions whose earthquake design does not exceed effective peak acceleration (A_a) of 0.10g.

Area of Intermediate Seismic Hazard. Regions where there is the probability of achieving effective peak acceleration values greater than 0.10g and less than or equal to 0.20g.

Area of High Seismic Hazard. Those areas where one would expect very strong tremors, with values of effective peak acceleration greater than 0.20g.

ENVIRONMENTAL IMPACT STUDY

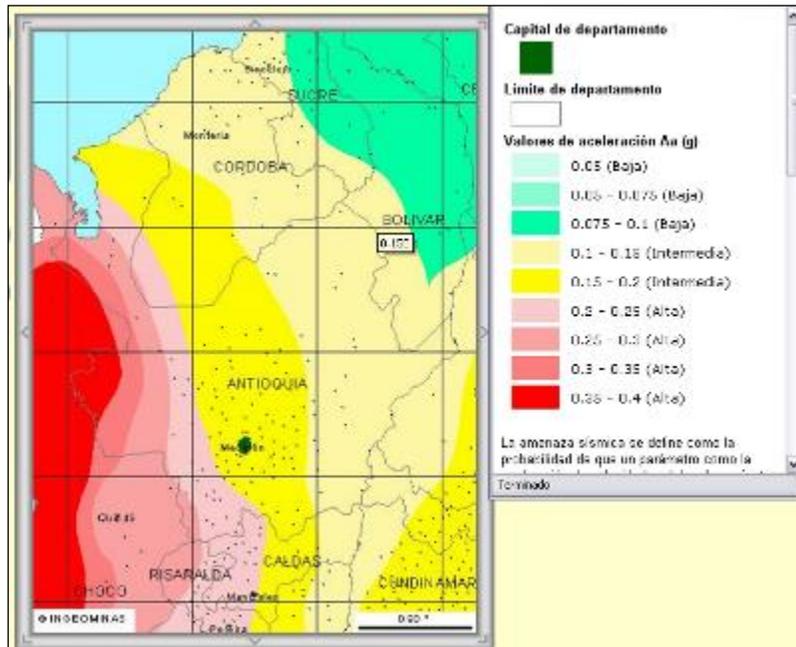


Figure 3-22. Map of seismic hazard and values of Aa of Colombia (Ingeominas, 2004)

3.2.9 ATMOSPHERE

3.2.9.1 Climate

Below are described the climatic conditions for the project influence area, recorded by the weather station, installed during the sampling done in the period from September 27 until October 13 of 2011.

- Temperature

During the sampling period, the average hourly temperature is between 17.9 °C and 23.9 °C (see Figure 3-23); the lowest average daily temperature was submitted the day October 04 (18.8 °C) and the day August 27 was presented the greater average daily temperature equivalent (22.7 °C) (see Figure 3-24)

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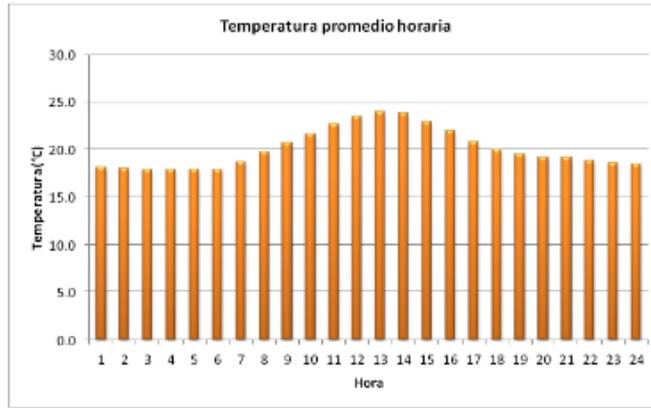


Figure 3-23. Average hourly temperature

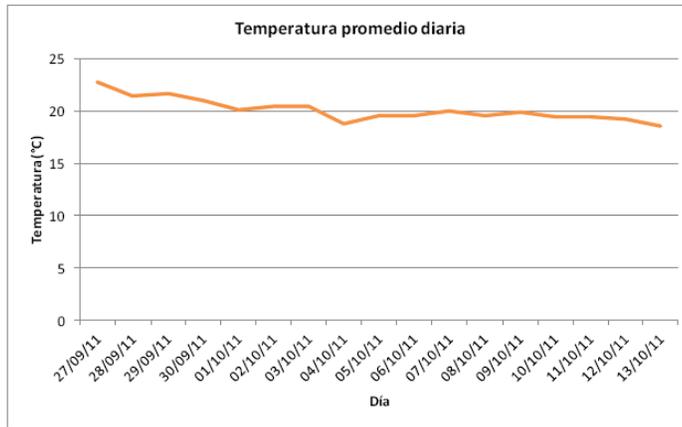


Figure 3-24. Average daily temperature

In addition to the results of the sampling presented above, Figure 3-25 are presented the temperature records in San Francisco and Cocorná stations, which are located near to the area of study. As you can see, the temperature is constant throughout the year, with average temperatures between 21 °C and 22 °C, with maximum and minimum ranging between 15 °C and 30 °C, the greatest values were recorded in the San Francisco station.

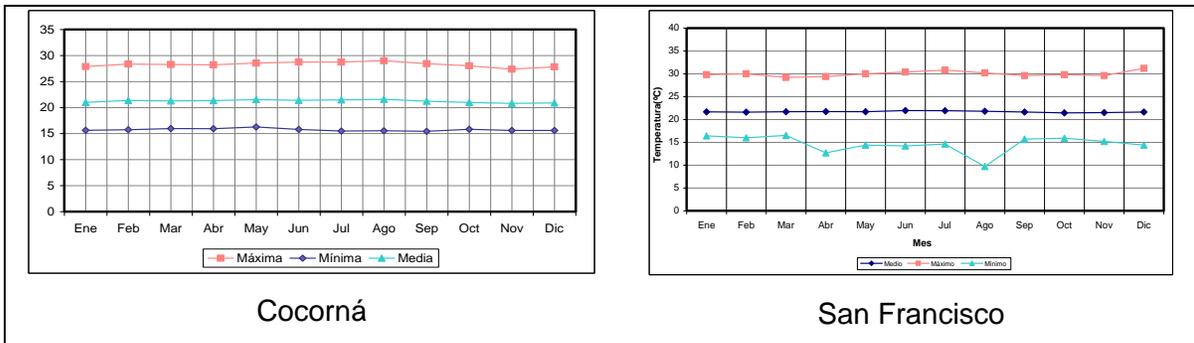


Figure 3-25. Temperature stations in San Francisco and Cocorná

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- Precipitation

In Figure 3-26 can be seen the accumulated precipitation during each of the monitoring days of the study of air quality. Accumulated precipitation during the monitored period was 263.6 mm, presenting rain on most of the days of the monitoring, being the days of maximum precipitation on October 6 and 7, 2011.

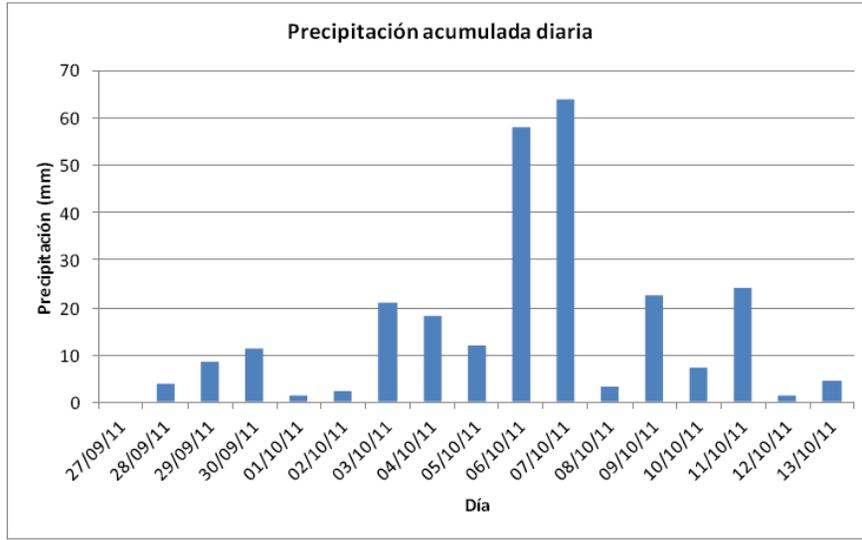


Figure 3-26. Accumulated daily precipitation.

During the sampling period, the rainfall is presented between 10:00 PM and 7:00 am, as can be seen in Figure 3-27.

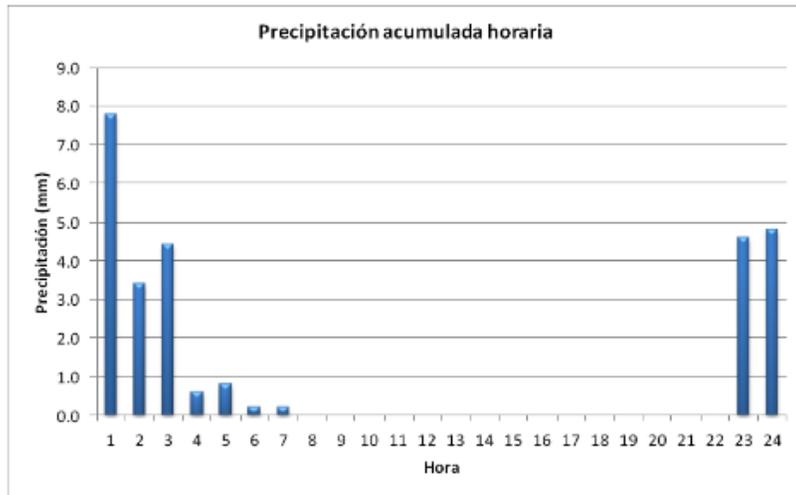


Figure 3-27. Hourly accumulated precipitation

Figure 3-28 shows the results of medium rainfall consulted in the nearest stations to areas of the project.

ENVIRONMENTAL IMPACT STUDY

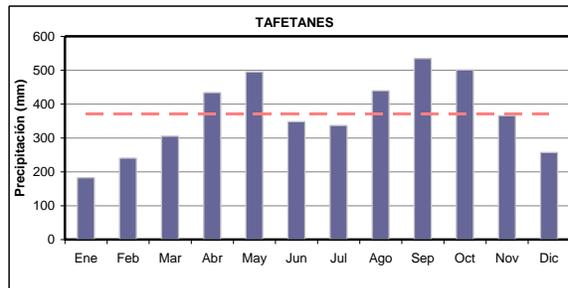
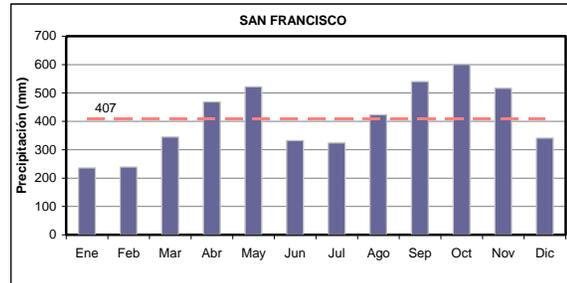
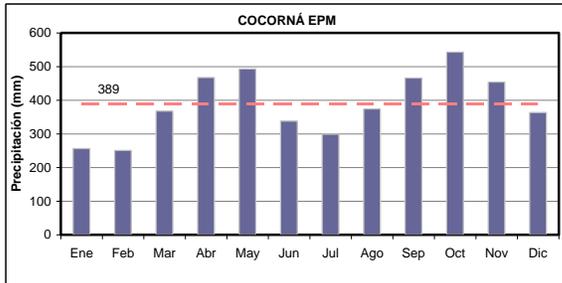


Figure 3-28. Average monthly rainfall

As you can see in Figure 3-28 , the annual rainfall in the area is high (Cocorná 4,671 mm, San Francisco 4,884 mm, 4,437 mm Tafetanes), if compared with the annual rainfall in the Andean zone, which ranges from 1,000 mm and 2,500 mm.

The rainfall regime presents a bimodal behavior, whose dry periods occur between the periods of December - March and June - August.

- Barometric Pressure

In Figure 3-29 you can see the average barometric pressure for each monitoring day the survey of air quality registered in the weather station installed; the minimum value is reported on September 29 and October 07 and October 08, days that correspond to the highest rainfall in the area.

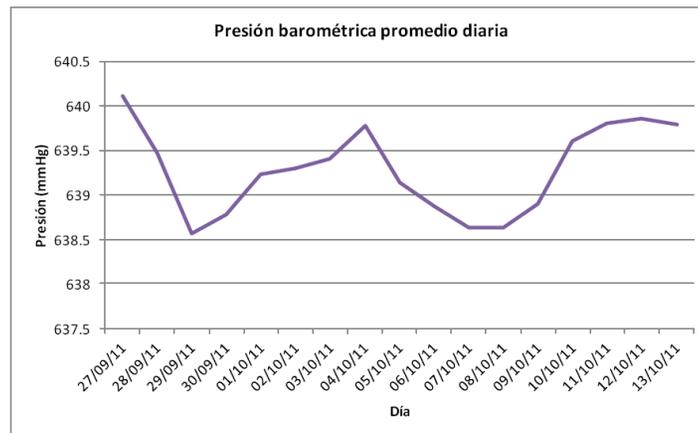


Figure 3-29. Daily average barometric pressure

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In Figure 3-30 you can observe the behavior of the average barometric pressure for different hours of the day in the area of measurement; noted a rise in the values of pressure toward the mid-morning and late night; it also presents a significant decline by mid afternoon, near to 4:00 pm, which does not match the hours of precipitation of the section.

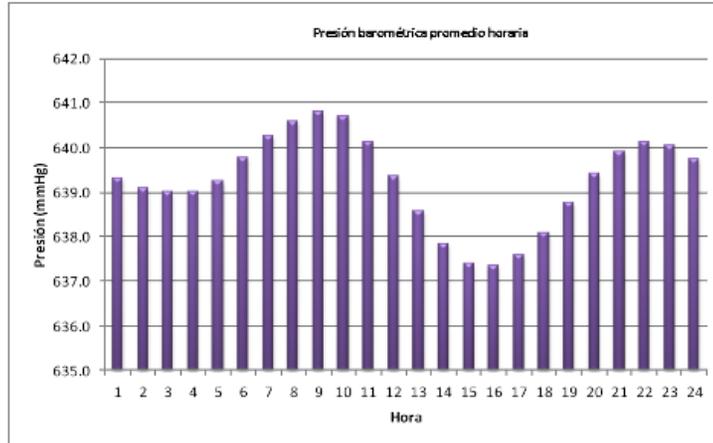


Figure 3-30. Hourly barometric pressure

- Relative Humidity

The average monthly relative humidity in the San Francisco and Cocorná stations ranges between 82% and 89 %, and as can be observed in Figure 3-31 , there are no significant variations in average moisture during the year.

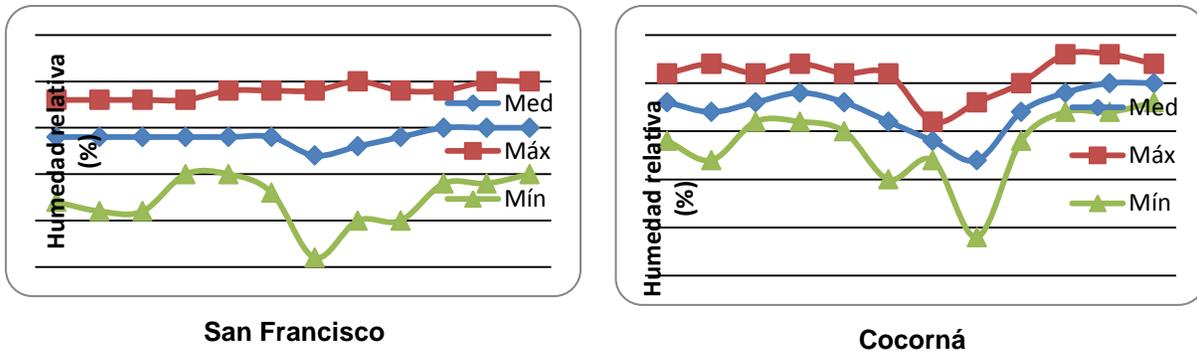


Figure 3-31. Monthly moisture average.

- Wind
 - Speed

In Figure 3-32 you can see the average wind speed for each monitoring day and in Figure 3-33 you can observe the behavior of the average wind speed for different hours of the day, where you can observe that wind speed tends to remain constant in the course of the day, presenting the greatest values in the afternoon.

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Figure 3-32. Daily wind speed average



Figure 3-33. Hourly wind speed average

– Direction

In Figure 3-34 it is seen the winds rose recorded in the weather station, where it is seen that there is predominance of the winds coming from the Eastern-Northwest (Jan), which is characterized by the presence of average speed of less than 1 m/s in the time interval of 30 min, which was set up at the station, the calm periods represent a 6.7 %.

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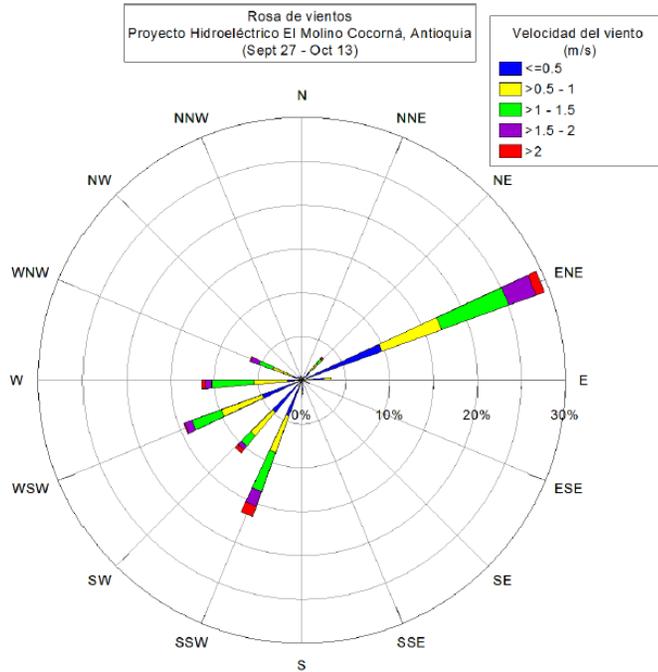


Figure 3-34. Wind rose

- Hydric Balance

The hydra balance corresponds to a comparison between the variables of precipitation and evaporation and water availability in the soil, in order to determine the deficit or surplus of water in the area.

Table 3-46 and Figure 3-35 show the hydra balance in the area, based on the average records of the San Francisco station. As you can see, there is never water shortage in the area.

Table 3-46. Hydric Balance, San Francisco station

| | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan |
|----------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|-------|
| ETP potential (mm) | 84.0 | 84.8 | 84.8 | 84.8 | 87.0 | 89.4 | 87.1 | 84.0 | 81.0 | 81.8 | 82.5 | 84.8 |
| Precipitation (mm) | 230.0 | 330.0 | 460.0 | 510.0 | 315.0 | 310.0 | 415.0 | 530.0 | 600.0 | 505.0 | 340.0 | 220.0 |
| P-etp | 146.0 | 245.2 | 375.2 | 425.2 | 228.0 | 220.6 | 327.9 | 446.0 | 519.0 | 423.2 | 257.5 | 135.2 |
| Variation in the reservoir | 146.0 | -46.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 423.2 | -323.2 | 0.0 |
| Reservoir | 146.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Deficit | 0.0 | | | | | | | | | | | |
| Water excess | 0.0 | 291.2 | 375.2 | 425.2 | 228.0 | 220.6 | 327.9 | 446.0 | 519.0 | 423.2 | 257.5 | 135.2 |
| Runoff | 0.0 | 145.6 | 260.4 | 342.8 | 285.4 | 253.0 | 290.5 | 368.2 | 443.6 | 423.2 | 340.4 | 237.8 |

Notes: The calculation starts with the wettest month, considering that it achieves the maximum reservoir in the soil, which is 100. The ETP potential was calculated using the formula of García Benavides, J and Lopez Diaz J.

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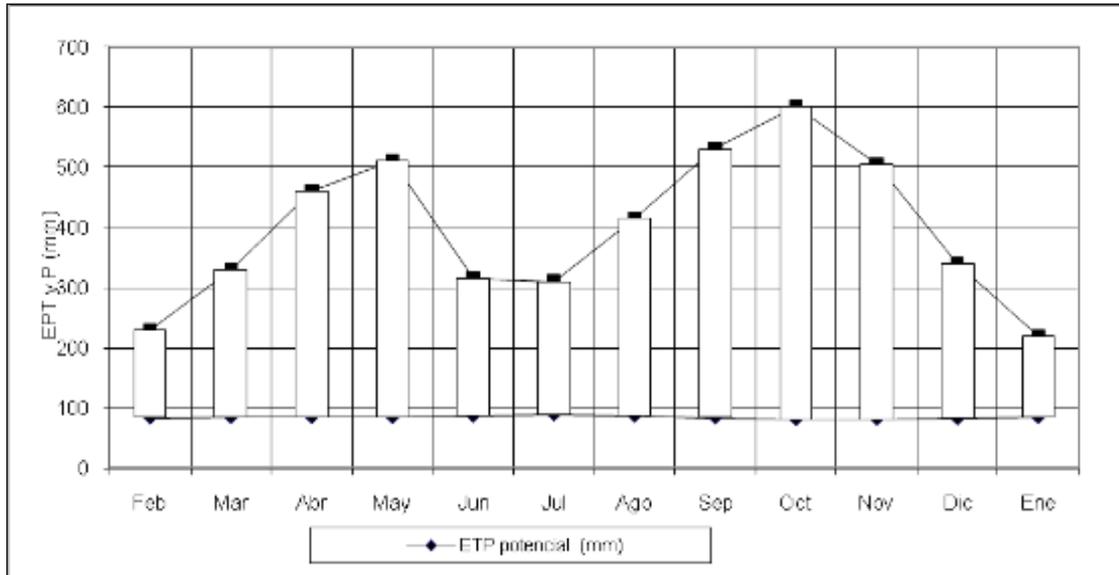


Figure 3-35. Hydric Balance, San Francisco station

3.2.9.2 Air Quality

The study of the Monitoring of Air Quality for the El Molino hydroelectric project , took place from September 26 to October 14 of 2011, for which were used the methods of sampling and calculation recommended by the Environmental Protection Agency (US EPA) of the United States of America and endorsed by Colombian law. What follows is a comparison of the measurements results, with the current standard for air quality, the Resolution 610 of 24 March 2010 the MAVDT. Annex 6 shows the full report of the study of air quality conducted by the firm K2 Engineering.

There were placed four monitoring stations located in the Vereda (*Political and administrative division of the municipality located in the rural area*) Los mangos, Campo Alegre, Las Playas and El Molino, whose location is presented in Table 3-47 and Figure 3-36 .

The obtained results were compared with the maximum allowable levels for contaminants, criteria established in Article 4 of Resolution 610 of 2010 (see Table 3-48).

Table 3-47. Sampling stations for air quality

| Sampling Station | Description | |
|---|---|--|
| Station 01 - Vereda Los Mangos | Coordinates | N 06 ° 02 '49.6 " W 75 ° 07 '54.1 " |
| | Altitude | 998 Meters a.s.l. |
| | Equipments | Hi-Vol HRV PM10, RAC, NDIR. |
| | Description of the environment and the emission sources | Station located in rural areas, where vegetation predominates, located on the slopes of the river and in the vicinity of houses where they cook with wood and close to a "trapiche", where handmade panela is done |
| Station 02 - Vereda Campo Alegre | Coordinates | N 06 ° 03 '08.1 " W 75 ° 08 '25.8 " |
| | Altitude | 1,191 m.a.s.l. |

| | | | |
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| Sampling Station | Description | |
|---|---|--|
| Station 03 - Vereda (Political and administrative division of the municipality located in the rural area) Las Playas | Equipments | Hi-Vol HRV PM10, RAC, NDIR. |
| | Description of the environment and the emission sources | Station located in a rural area, where vegetation prevail, located in the vicinity of houses where they cook with wood |
| | Coordinates | N 06 ° 04 '49.5 " W 75 ° 09 '28.9 " |
| | Altitude | 1,328 m.a.s.l. |
| Station 04 - Vereda (Political and administrative division of the municipality located in the rural area) El Molino | Equipments | Hi-Vol HRV PM10, RAC, NDIR. |
| | Description of the environment and the emission sources | Station located in a rural area, where vegetation prevail, located in the vicinity of houses where they cook with wood |
| | Coordinates | N 06 ° 03 '31.9 " W 75 ° 09 '23.2 " |
| | Altitude | 1,452 m.a.s.l. |
| | Equipments | Hi-Vol HRV PM10, RAC, NDIR, Vantage Weather Station |
| | Description of the environment and the emission sources | Station located in rural areas, where vegetation prevail, located in the vicinity of houses where they cook with wood. |

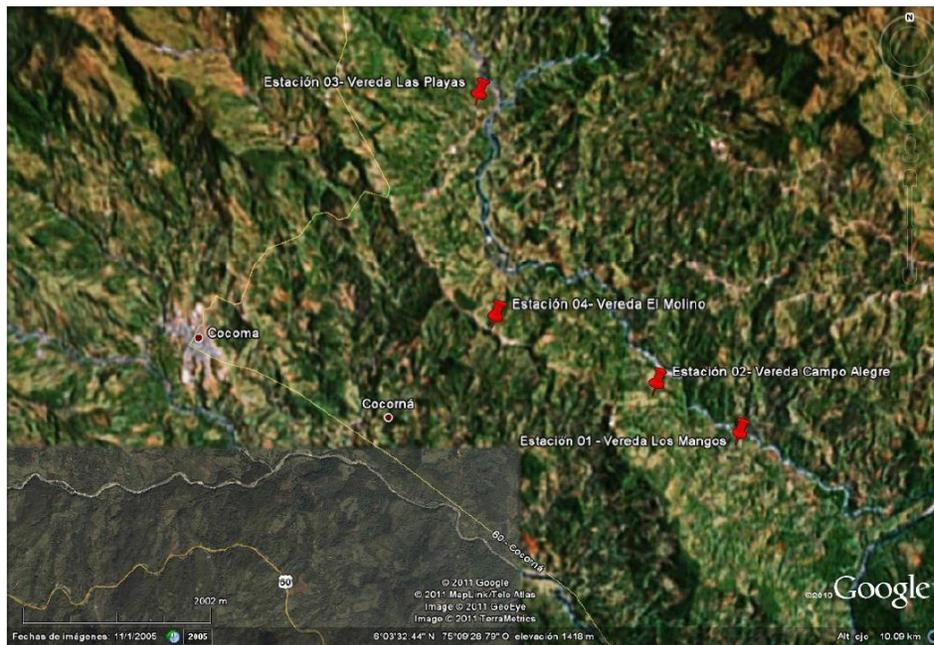


Figure 3-36. Location of each station for measuring air quality

Table 3-48. Maximum permissible levels for criteria pollutants

| Pollutant | Maximum allowable level ($\mu\text{g}/\text{m}^3$) | Exposure Time |
|---------------|--|---------------|
| PST | 100 | Annual |
| | 300 | 24 Hours |
| PM10 | 50 | Annual |
| | 100 | 24 Hours |
| PM 2.5 | 25 | Annual |

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| Pollutant | Maximum allowable level ($\mu\text{g}/\text{m}^3$) | Exposure Time |
|-----------------|--|---------------|
| SO ₂ | 50 | 24 Hours |
| | 80 | Annual |
| | 250 | 24 Hours |
| | 750 | 3 Hours |
| NO ₂ | 100 | Annual |
| | 150 | 24 Hours |
| | 200 | 1 Hour |
| O ₃ | 80 | 8 Hours |
| | 120 | 1 Hour |
| CO | 10,000 | 8 Hours |
| | 40,000 | 1 Hour |

Based on the results obtained, it can be concluded that in the influence area of the El Molino hydroelectric project, it complies with the requirements of the legislation for the parameters PM₁₀, SO₂, NO₂ and CO, and therefore do not represent any problem for people's health.

- PM₁₀ Particular matter less than 10 micron

Table 3-49 shows the comparison of the average value (arithmetic mean) of concentration of PM₁₀, corresponding to the 18 days of sampling, obtained at each station, with the daily standard Indicative and a comparison with the annual norm.

Table 3-49. Consolidated results PM₁₀

| Station | Average ($\mu\text{g}/\text{m}^3$) | Daily Standard ($\mu\text{g}/\text{m}^3$) | Annual Norm ($\mu\text{g}/\text{m}^3$) | Compliance |
|---|--------------------------------------|---|--|------------|
| Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos | 15.79 | 100 | 50 | Complies |
| Vereda (Political and administrative division of the municipality located in the rural area) Campo Alegre | 12.54 | 100 | 50 | Complies |
| Vereda (Political and administrative division of the municipality located in the rural area) Las Playas | 17.27 | 100 | 50 | Complies |
| Vereda (Political and administrative division of the municipality located in the rural area) El Molino | 9.8 | 100 | 50 | Complies |

In Table 3-37 you can observe the daily measurements results of PM₁₀ obtained in each of the stations, during the monitoring period.

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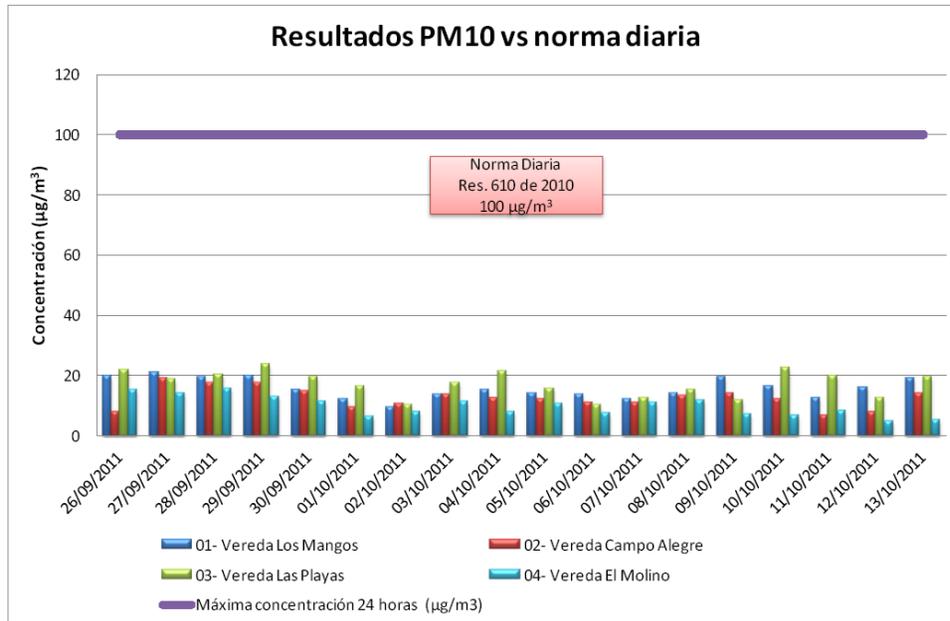


Figure 3-37. Results of PM 10 vs. daily standard

During the monitoring days were not recorded values of concentration of PM₁₀ higher than the maximum limit of 100 µg/m³ for 24 hours, given by Resolution 610 of 2010 the MAVDT. The highest value of PM₁₀ found in this study was 23.70 µg/m³ (Sample 4 - Station Vereda (Political and administrative division of the municipality located in the rural area) Las Playas, which represents a 23.70 % of the value of the daily norm. The highest values for the Station Vereda (Political and administrative division of the municipality located in the rural area) Las Playas (20.8 µg/m³), Vereda (Political and administrative division of the municipality located in the rural area) Station Campo Alegre (19.5 µg/m³) and the station Vereda (Political and administrative division of the municipality located in the rural area) El Molino (15.56 µg/m³) represent a 20.98 %, 19.5 % and 15.56 % of the value of the daily standard, respectively.

In general, the stations were identified as emission sources, the anthropogenic rural activities, given that it is common in the area the cooking with firewood, the step of beasts of burden, the farming and production jobs of artisanal panela.

Precipitation levels measured in the area during the monitoring, favor a low concentration of particular matter PM₁₀.

- OS₂ Sulfur dioxide

During monitoring days were not recorded concentration values of sulfur dioxide (SO₂) exceeding the maximum limit of 250 µg/m³ for 24 hours, established by resolution 610 of 2010 the MAVDT. Only a single information, the corresponding to October 3, in the Station Las Playas, reports a greater value than the detection limit of the method (24.97 µg/m³).¹⁰

- NO₂ Nitrogen dioxide

¹⁰ The method used to assess the OS₂, have as minimum detectable value 0.77 µg/10 ml of solution

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During the monitoring days, there were no concentration values of nitrogen dioxide (NO₂) exceeding the limits set by Resolution 610 of 2010 the MAVDT for 24 hours, 150 µg/m³. The highest value of NO₂ found in the study was of 29.46 µg/m³ recorded in the Station Las Playas, value that represents less than 20% of the daily norm.

During the monitoring period, were found only five records above the value of the detectable equipment¹¹; apart of the maximum value mentioned in the previous paragraph, there are two records in the Station Los Mangos (8.26 µg/m³ and 16.07 µg/m³, on October 2 and 4, respectively), a register in the station El Molino (11.92 µg/m³, the 3rd. of October) and another in the Station Las Playas (13.81 µg/m³, October 1st.)

- CO Carbon Monoxide

The results of carbon monoxide (CO) were obtained from the automated gas sensor analyzer with non-dispersive infrared device (NDIR). The automatic equipment reports the average hourly values of CO concentration in ppm, these values are converted to µg/m³ and corrected to reference conditions of 25 °C and 760 mmHg; the team was initially installed in the Station of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos where it registered values between September 26 and 30, it was then transferred to the Station of the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, operating from September 30 to October 4, it was then transferred to the Station of the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Playas, and monitored from the October 4 to 9 and finally the equipment was taken to the Station Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino where it was operating between October 9 and 14.

During the monitoring days were not recorded concentration values of carbon monoxide (CO) exceeding the maximum limit for 1 hour given by Resolution 610 of 2010, 40,000 µg/m³ (see Figure 3-38); the average hours of concentration represent less than 0.5 % of the standard value

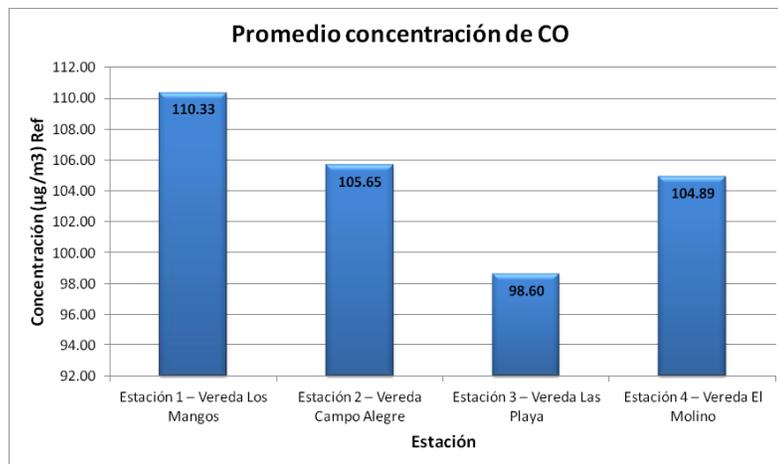


Figure 3-38. Average concentration of CO in the stations evaluated

¹¹ The method used to assess the NO₂, have as minimum detectable value 0.03 µg/ml of solution

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The moving average of CO concentration calculated for eight hours, presented an oscillatory behavior around the 100 µg/m³ with a periodicity of about 20 hours; the eight hours moving average values for the contaminant CO did not exceed 2% of the value of the standard (see Figure 3-39).

The above figure shows that the average mobile presents a cycle of rise and fall approximately every 20 hours.

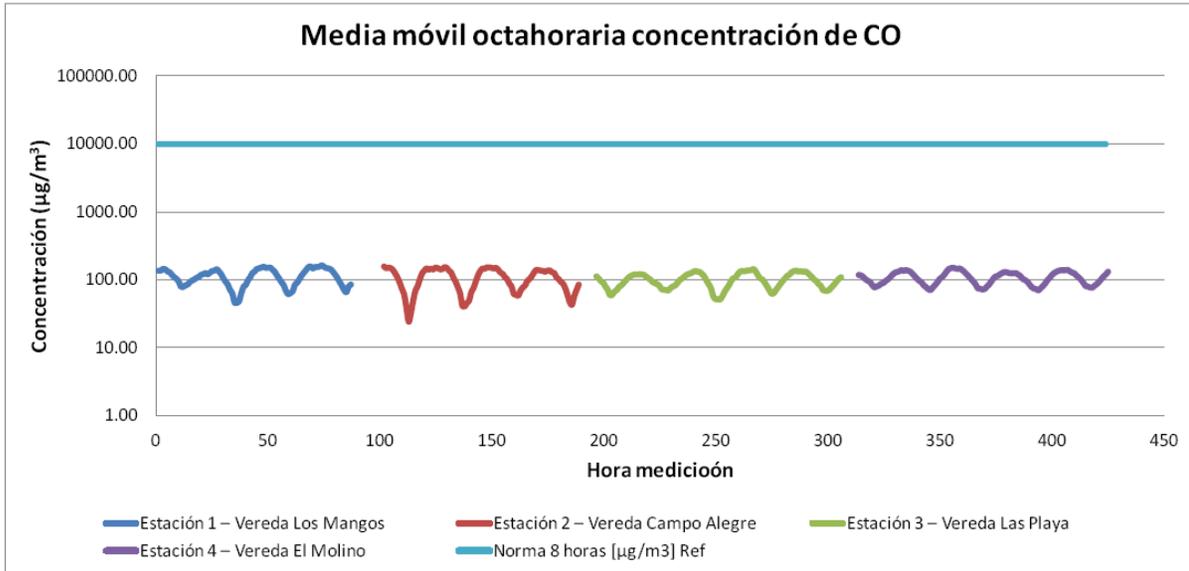


Figure 3-39. Eight-hours moving average concentration of CO

3.2.9.3 Noise

Annex 7 presents the results of the noise monitoring made by FIMA K2 Engineering, in the project influence area. The study of environmental noise was held in the same places where we assessed the air quality, conducting a total of 16 measurements distributed in the future construction area of the El Molino hydroelectric project. The measurements were conducted on 29 September (ordinary day) and October 9 of 2011 (public holiday)

In accordance with the provisions of Resolution 627 of 2006, the project influence area is classified as Sector D: Suburban or rural area of tranquility and moderate noise, where there are sub-rural areas inhabited, intended to farming.

Table 3-50 presents the prevailing noise generating sources in each monitoring point, in addition to allowable levels according to the environmental regulations in force for the sector and sub sector in day and night hours

All measurements were taken in thirds of octaves for 15 minutes each, with frequent weightings A, and temporary weightings F (Fast). With respect to adjustments, the measurements were corrected by tone (KT) and impulse (KL) adjustments were made from 3 to 6 dB in the various measurements.

| | | | |
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Table 3-50. Ld of sources and permissible limits

| Measuring point | Daytime limit | Nighttime limit | Dominant sources identified |
|--|---------------|-----------------|--|
| Station 01 - Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos | 55 | 45 | Noise of wild and domestic animals, noise on pasturage activities, music in neighboring houses, noise from the flow of the San Matias River. |
| Station 02 - Vereda (Political and administrative division of the municipality located in the rural area) Campo Alegre | 55 | 45 | Over flight of aircraft and helicopters, noise of wild and domestic animals, noise on pasturage activities, music in neighboring houses, noise from the San Matias River flow |
| Station 03 - Vereda (Political and administrative division of the municipality located in the rural area) Las Playas | 55 | 45 | Noise of wild and domestic animals, noise on pasturage activities, music in neighboring houses, noise from the near creek floor, noise from cars on track nearby. |
| Station 04 - Vereda (Political and administrative division of the municipality located in the rural area) El Molino | 55 | 45 | Noise on pasturage activities, noise of the San Matias River current, noise of vehicles in route of entry to the Vereda (Political and administrative division of the municipality located in the rural area). |

The results were not corrected for low frequencies (facilities of ventilation and air conditioning) by the nature of the sources identified and were not corrected by schedule, since the calculated value of the Leq was conducted for daytime and nighttime independently and not as a single value of Leq for day and night.

During the measurement days, the average temperature was 21.7 °C and 19.4 °C. The speed of the prevailing winds reached an average of 0, .9 m/s from the west-south -West for an ordinary day, and East-North-East for the holiday. The barometric average pressure was 638.6 mmHg and 639.6 mmHg. In addition there was a register of 83.3 % and 93.1 % of relative humidity on average.

In Figure 3-40 and Figure 3-41 are plotted the results obtained for environmental noise in daytime and nighttime respectively.

Through an analysis of the results, is determined for each monitoring period the following:

- Ordinary daytime period Points 1, 2 and 3 exceed the limits established by resolution 627 of 06; in point 4 it complies with regulations, but the difference with the standard is only 2.64 dB.
- Festive daytime period Points 1 and 3 exceed the norm, while the values recorded in points 2 and 4 are located in a very close level to the stipulated by the standard, as is recorded a value of 52.98 and 48.98 dBA, being 55 dBA the allowable limit for this point of monitoring.

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- Ordinary nighttime period. Each of the points exceed the limits established by resolution 627 of 2006, highlighting point 2 which presents the greatest surpassed with respect to the standard.

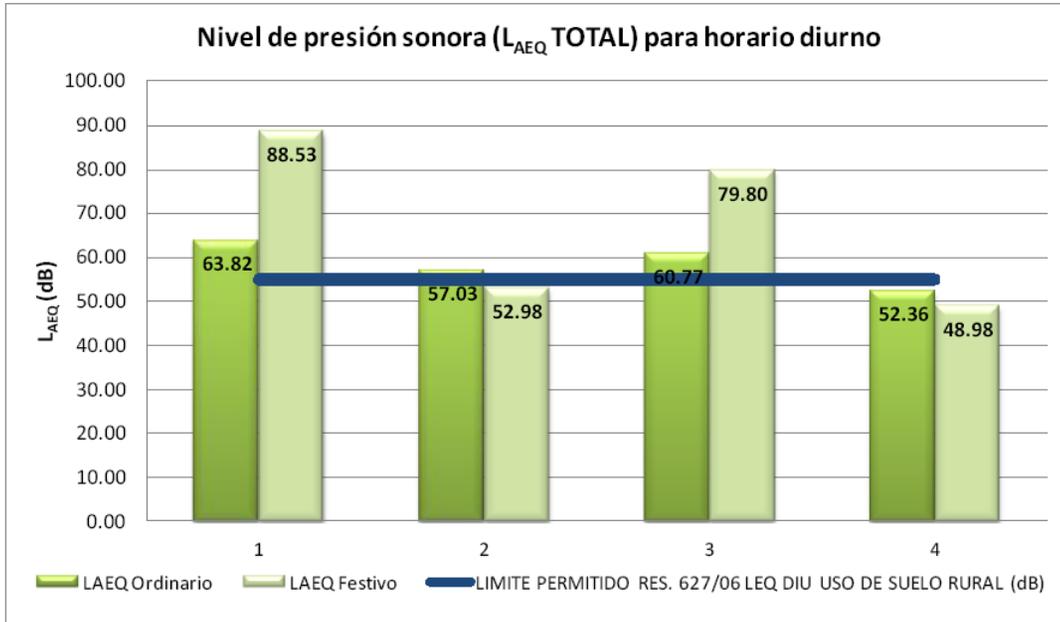


Figure 3-40. Result obtained for environmental noise in the daytime

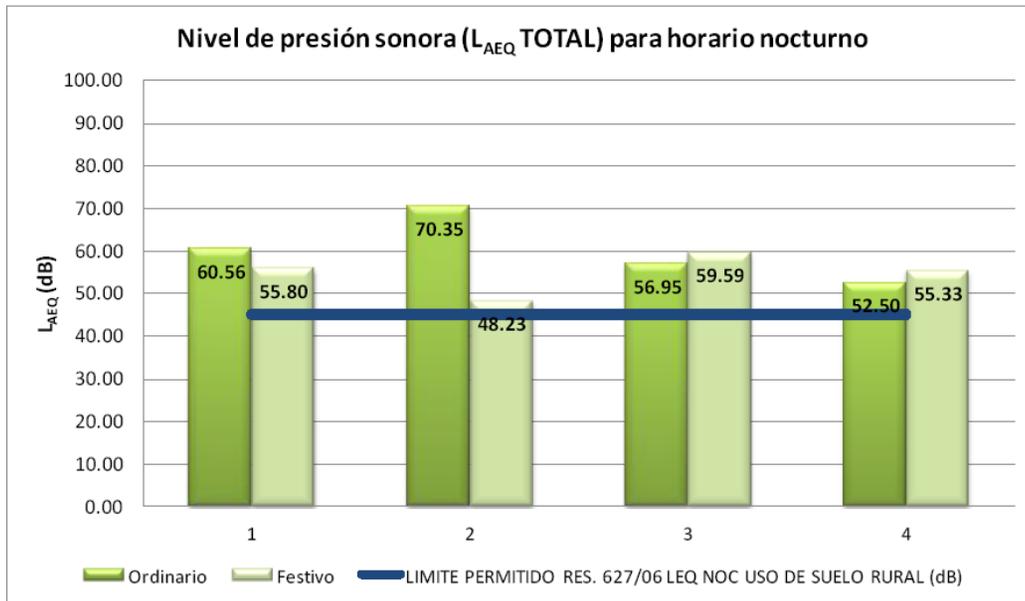


Figure 3-41. Results obtained for environmental noise at night

- Festive night period. Each of the points exceed the limits established by resolution 627 of 2006, highlighting the point 2 that shows the greatest surpass from the norm.

| | | | |
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The noise levels and the values described above the standard, are due to anthropogenic activities in the sector identified in Table 3-50 and to the noise of wild creature's insects, the flow of the San Matias River and other creeks present in the area. This is evidenced by the values obtained in the Station of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, where there is no access road, and real roads should be used.

It is noted that only points 2 and 4 show a reduction in the noise registration on the festive day with regard to the ordinary day in the daytime, while for points 1 and 3 presents the opposite case, increase in the recorded levels of noise on the festive day with regard to the ordinary day.

In general, the influence area of the El Molino hydroelectric project presents the areas of non-compliance with the permissible standards required by environmental regulations in force for all the points in the nighttime, but in the daytime, compliance is presented in points 2 and 4 only during the holidays; the above is, for the most part, to the presence of sources that generate tones at high frequencies and impulses by increasing the LAeq end by 6dB.

3.2.10 LANDSCAPE

The characterization of the surrounding landscape is part of the concept issued by Etter, A (1990), which explains the landscape as " *a portion of the geographical space, homogenous in terms of its physiognomy and composition, with pattern of temporary stability resulting from the complex interaction of the climate, the rocks, water, soil, flora, fauna and human activities, recognizable and distinguishable from other neighboring in accordance with a level of spatial-temporal analysis (resolution)* ", and of the methodology proposed by Villota (1992) to the physiographic classification, which considers the geomorphologic environment (relief and rocks), the parent material, weather and climate factors as formers of the landscapes and associated soils to these.

Taking into account these two concepts the following categories are defined to describe the landscape:

3.2.10.1 Physiographic Province

Corresponds to a natural or morphological region in which prevails one or more climate units and consists of relevant genetic sets units with relationships of geological, topographical and spatial kinship (Villota, 1997)

3.2.10.2 Climatic Region

Corresponds to the union of the climatic unit categories or climatic region and climate province proposed by Villota (1997). Includes the land which average annual temperature and the available humidity are sufficiently homogeneous to be reflected in a specific genesis of the soil, in the structure and plant species and in the occupation of the geographical space through the current land use (CCE, 2007).

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3.2.10.3 Great landscape

Corresponds in Geomorphologic terms, to the genetic units highlighted. According to the classification system proposed by Villota (1997) includes associations or complex landscape with kinship relationships of climatic, gamogenetic, lithological and topographic type.

3.2.10.4 Landscape

Corresponds to tridimensional portions of the earth's surface, resulting from a same geogenesis which can be described in terms of the same climatic and morphological characteristics, lithologic material and of age, within which you can expect high pedagogical homogeneity, as well as a plant cover or a similar land use (Villota 1997; CE, 2007)

For purposes of this study were taken as landscape units the over embossments described in geomorphology (see Cartography 2148-04-EV-DW-027) and were associated with vegetative covers.

Table 3-51 Show the categories described above

Table 3-51. Landscapes categories

| Physiographic Province | Climatic Region | Climatic Province | Great landscape | Landscape | Associated coverage |
|---|-----------------|-------------------|-------------------------|--|---------------------------|
| Eastern flank of the Central mountain range | Medium | Rainy | Mountainous edge (Fm) | Mountainous edge of narrow peak (Fmce) | Open Forest |
| | | | | | Dense Forest |
| | | | | | Dense Forest of Guadua |
| | | | | | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Weeded grass |
| | | | | | Clean Grass |
| | | | | | Wooded pasture |
| | | | | | Crop |
| | | | | | Rivers |
| Eastern flank of the Central mountain range | Medium | Rainy | Mountainous edge (Fm) | Mountainous edge of ample peak (FMCA) | High secondary vegetation |
| | | | | | Low secondary vegetation |
| Eastern flank of the Central mountain range | Medium | Rainy | Mountainous edge (Fm) | Mountainous edge of ample peak (FMCA) | Dense Forest of Guadua |
| | | | | | Wooded pasture |
| | | | | | Weeded pasture |
| | | | | | Crops |
| | | | Rivers | | |
| | | | Discontinuous urban web | | |
| | | | Hilly reliefs (C) | | |
| Dense Forest | | | | | |
| High secondary vegetation | | | | | |

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| Physiographic Province | Climatic Region | Climatic Province | Great landscape | Landscape | Associated coverage |
|---|-----------------|-------------------|-------------------|---------------------------|---------------------------|
| | | | | | Low secondary vegetation |
| | | | | | Dense Forest of Guadua |
| | | | | | Clean Grass |
| | | | | | Wooded pasture |
| | | | | | Crops |
| | | | | | Rivers |
| | | | | | Bare earth |
| | | | | | Discontinuous urban web |
| Eastern flank of the Central mountain range | Medium | Rainy | Hilly reliefs (C) | Low hills (Cb) | Open Forest |
| | | | | | Dense Forest |
| | | | | | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Dense Forest of Guadua |
| | | | | | Clean pasture |
| | | | | | Wooded pasture |
| | | | | | Crops |
| | | | | | Rivers |
| | | | | | Discontinuous urban web |
| Eastern flank of the Central mountain range | Medium | Rainy | Escarpment (E) | Steep slope Segment (SVE) | Open Forest |
| | | | | | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Dense forest of Guadua |
| Eastern flank of the Central mountain range | Medium | Rainy | Escarpment (E) | Steep slope Segment (SVE) | Wooded pasture |
| | | | | | Weeded pasture |
| | | | | | Rivers |
| | | | | Alluvial Terrace (Tal) | Open Forest |
| | | | | | Dense forest of Guadua |
| | | | | | Wooded pasture |
| | | | | | Weeded pasture |
| | | | | | Rivers |
| | | | | Barrier Island (ISB) | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Guadua |
| | | | | | Weeded pasture |
| | | | | Alluvial fan (Abal) | Open Forest |
| | | | | | High secondary vegetation |
| | | | | | Low secondary vegetation |

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| Physiographic Province | Climatic Region | Climatic Province | Great landscape | Landscape | Associated coverage |
|--|-----------------|-------------------|---------------------------------|-----------------------------|---------------------------|
| | | | | | Weeded pasture |
| | | | | | Crops |
| | | | | | Bare Soil |
| | | | | Colluvial alluvial (Spical) | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Wooded pasture |
| | | | | | Weeded pasture |
| | | | | | Crops |
| | | | | | Rivers |
| | | | | | Infrastructure |
| | | | | | |
| Eastern flank of the Central mountain range | Medium | Rainy | Channel of the San Matias River | Section "CIIB" | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Guadua |
| Eastern flank of the Central mountain range | Medium | Rainy | Channel of the San Matias River | Section "CIIB" | Wooded pasture |
| | | | | | Weeded pasture |
| | | | | | Rivers |
| | | | | Bare Soil | |
| | | | | Section "CIIR" | Open Forest |
| | | | | | High secondary vegetation |
| | | | | | Low secondary vegetation |
| | | | | | Wooded pasture |
| | | | | | Weeded pasture |
| | | | River | | |
| | | | Section "CIIRca" | Open Forest | |
| | | | | High secondary vegetation | |
| | | | | Low secondary Vegetation | |
| | | | River | | |
| | | | Individual Geo forms | | |
| Low secondary vegetation | | | | | |
| Wooded pasture | | | | | |
| Weeded pasture | | | | | |
| Crop | | | | | |
| Infrastructure | | | | | |
| Flourishing of rock weathering horizon IIB (ArIIB) | Rivers | | | | |

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3.3 BIOTIC ENVIRONMENT

3.3.1 TERRESTRIAL ECOSYSTEMS

3.3.1.1 Flora

Ecosystems have been recently defined as more than geographical units, such as functional systems with inputs and outputs and with natural or arbitrary limits; its size can be determined by the complexity degree of its components and generally the boundaries between units are gradual; therefore, an ecosystem contains some heterogeneity in their biotic and Physical Environment stresses (Josse *et al.* . 2003; Quoted by Rodriguez *et al.* . 2004).

For its part, the biomes correspond to a set of related ecosystems by their structural and functional characteristics, which differ mainly in the traits of the associated vegetation.

The information regarding the ecosystems and existing biomes in the influence area of the project, comes from the map of continental, coastal and marine ecosystems of Colombia/ IDEAM, IGAC, IAvH, INVEMAR, I. Sinchi and IIAP. 2007, The general procedure for the delimitation of continental ecosystems consisted in integrating information from geopedologic, climatic zones and soil coverage, through processes of spatial analysis and geographic information systems; in the case of the Andean region is located the area of study, information on soil coverage was generated by the Biological Resources Research Institute Alexander Von Humboldt (IAvH).

- Indirect influence area (IIAS)

To delimit the indirect influence area is considered the sub-basins of the San Matias River, and on the dividing line of these was staked out to both sides of the river, the area that is seen in Cartography 2148-04-EV-DW-025.

- Life areas

The life zones are vegetal associations within a natural climate division, which, taking into account the soil conditions and the stages of succession, have a similar appearance in any part of the world (Holdridge, 1978). The basic factors that are taken into account in order to classify a region are the annual average values of bio temperature, rain and potential vapor transpiration (Spinal, 1992).

Also, there is an equivalence between the altitudinal floors proposed for the life areas with the common name of the zones or thermal floors, which, together with certain temperature limits, make up the determinations of thermal floors in the department and in the country. In this regard, to the influence area of the El Molino hydroelectric project, given that it is below the 2,000 meters above sea level, the altitudinal levels in which it is framed are the tropical (warm) and the premountain (warm soil or coffee producer); the first characterized by an elevation range between 0 meters and 1,000 meters above sea level and an average annual temperature above 24° C and the second by a range between 1,000 meters and 2,000 meters above sea level and an average temperature between 18 °C and 24°C.

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According to the classification system of life zones (Holdridge, 1978), the project and its associated facilities are located in the life zone very humid tropical forests (Bmh-T) and premountain pluvial forest (bp-PM), which are characterized by the following bioclimatic limits:

➤ Very Humid tropical forests (Bmh-T)

This formation applies to zones with a bio temperature above 24 °C and an average annual rainfall between 4,000 mm and 8,000 mm.

In the department of Antioquia, the Bmh-T appears mainly in two areas on the western slope of the Western mountain range (from Dabeiba, Serrania de Abibe until Chigorodo) and on the eastern slopes of the central mountain ranges descend toward the Magdalena River (Cocorná, San Luis, and San Francisco). Due to its high rainfall, are not very suitable for the establishment of annual crops by the constant washing of soil nutrients and the susceptibility to erosion (Espinal, 1992).

Espinal (1991) ensures that under natural conditions or low-intervention, is one of the more complex by its high diversity of flora, with emergent trees of more than 50 meters in height. Their microenvironments of high temperature and humidity make the existence of large numbers of epiphytes on the branches and trunks (ferns, mosses, bromeliads, lichens and Araceae).

Some of the most representative species of natural forests in this life area are *Euterpe precatoria* (Palm-kernel oil), *Goethalsia meiantha* (Combo), *Pourouma hirsutipetiolata* (Cirpo), *Miconia trinervia* (IFOR), white, among others.

➤ Premountain pluvial forest (bp-PM)

The general climatic limits for this formation, also known as ground coffee producer super moist land, are: a bio temperature between 18 °C and 24 °C, and an average annual rainfall of over 4,000 mm.

The bp-PM in Antioquia is located on the western slope of the Western mountain range, that is to say, in the influence area of the Pacific, in the slopes of the Moor of Frontino, on the slopes of the Serranía de Abibe that slope down to the Leon River, in the region of Ventanas near Valdivia and on the slopes of the Magdalena River in the municipalities of Cocorná and San Luis.

According to Espinal (1992), generally corresponds to a very hilly topography and slope, soils low in nutrients, covered with debris, forests in the process of destruction, pastures and some crops of maize, plantain, cassava, and coffee.

– Ecosystems

According to the ecosystem map, the area of the project is part of the Great biome Tropical Humid Forest, within which is the biome low Orobioma of the Andes, which according to the study of the IDEAM, has an area of 809.4 has, as can be seen in Table 3-52 .

Table 3-52. Inland ecosystems present in the influence area of the project. Source IDEAM et al 2007.

| Great Biome | Biome | Soil coverage | Has | % |
|----------------|---------------------------|---------------------------|-------|------|
| Humid Tropical | Low Orobioma of the Andes | Annual or transient crops | 280.1 | 34.6 |
| | | Pasture | 44.2 | 5.5 |

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| Great Biome | Biome | Soil coverage | Has | % |
|--------------|-------|----------------------|--------------|------------|
| Forest | | Secondary Vegetation | 485.1 | 59.9 |
| Total | | | 809.4 | 100 |

The following is a definition and characterization of the biome and orobioma of the study area:

➤ Great Biome humid tropical forest

This great biome covers a total area of 105,632,472 has. in Colombia and is characterized by areas in which there are essentially two types of weather: warm and humid (37 %) and very wet warm (37 %). The rest of the area has a diversity of climates, such as warm rain, mild humid and very wet, cold, wet and very wet and very cold, wet and very wet, with areas and features of orobiomes and pedobiomes. The average annual rainfall is greater than 2,000 mm, and the approximate altitude is between 0 and 1,800 m. There is no shortage of water for the plants throughout the year or this is very low. The vegetation in this great biome, is equivalent to the tropical rain forest, tropical moist forests, very humid and rainforests of low-floor, low montane and pre-montane of Holdridge (1967), subtropical of Chapman (1917) and the rain forest Ombrophylus montane and sub-montane to the Unesco classification (1973) (Hernandez and Sanchez, 1992).

➤ Low Orobiome of the Andes

This orobiome has an extension of 14,035,898 has. and is characterized by having mainly dry and temperate climates (25 %), humid temperate (22 %), very damp mild (20 %) and, in some sectors, warm, humid climates (14 %), warm and very humid (10 %). It is located approximately 500 meters above sea level and 1,800 Meters above sea level, where temperatures are above 18 degrees. The 51% of the orobiome is located on the geomorphologic unity of the pluvio gravitational mountain and 47% on erosion Structural Mountain. In the project influence area is submitted for this orobiome the secondary vegetation covererage, annual crops or transient and pastures.

– Vegetation coverage

For the characterization of the flora in the study area, first was defined a land cover map in the influence area of the project, based on aerial photography to scale 1:20, year 2008, complemented with the coverage reported in the EOT of the municipality of Granada (2002) and the regional system of protected areas to the southeast of Antioquia (Sanchez, 2003) and its subsequent corroboration in field. The coverage were interpreted following the methodology *Corine Land Cover*, taken from the study adapted to Colombia by IDEAM, 2010.

The existing coverage in the area of study on which were the estimation of biomass were the open and dense woodland (BA, BD), the secondary high and low vegetation (VSA, VSB) and the wooded pastures, clean and weeded (PA, PL and PE). Other coverage identified in the area were: Permanent and transient crops (CPH, CT), dense forest of Guadua (BDG), rivers (R), bare and degraded land (TDD) and discontinuous urban web (TUD).

In the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, Quebradona Abajo, and Campo Alegre is observed that the coverage is dominated by clean pasture (see Cartography 2148-04-EV-DW-031), as a result is the most representative of the project coverage area supported by the low secondary vegetation (LSV); in subsequent positions are the high secondary vegetation (HSV) and the wooded

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pastures (WP). The presence of these coverage probably attributable to the social and economic conditions in the area, as well as to the location of the Vereda (Political and administrative division of the municipality located in the rural area). In the first three, the land use has traditionally been agriculture and livestock, in fact El Molino and Campo Alegre have been considered as part of the territory of the agricultural pantry of Cocorná; additionally, the easy access favors the establishment of agricultural activities. On the other hand, after the armed conflict, the families of the three Vereda (*Political and administrative division of the municipality located in the rural area*) returned earlier, if compared with the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, where the return began more recently. In this last project area, there is a greater predominance of areas in the process of vegetation succession (see Cartography 2148-04-EV-DW-031). In the Vereda (*Political and administrative division of the municipality located in the rural area*) prevail the cultivation of sugarcane with respect to other activities and the number of inhabitants is less. Figure 3-42 shows the categories of coverage identified and its coverage in hectares in the project indirect influence area.

The following describes the coverage found in the indirect influence area according to the IDEAM, 2010

➤ Dense Forest (3.1.1)

Plant community dominated by typically tree elements, which form a stratum of cups (canopy) more or less continuous, which wooded coverage area represents more than 70% of the total unit area, and height of the canopy greater than five meters. These plant formations have not been supervised or its intervention has been selective and has not altered its original structure and the functional characteristics (IGAC, 1999) (see Photo 3-15). For the influence area was only observed a fragment with this coverage, located on the Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada of the municipality of Cocorná. The most common tree species for this fragment were the white tuno (*Miconia trinervia*) and the combo (*Goethalsia meiantha*), the latter with considerable diameters. This coverage covers 3.4 hectares, which is equivalent to 0.4 % of the IIA.

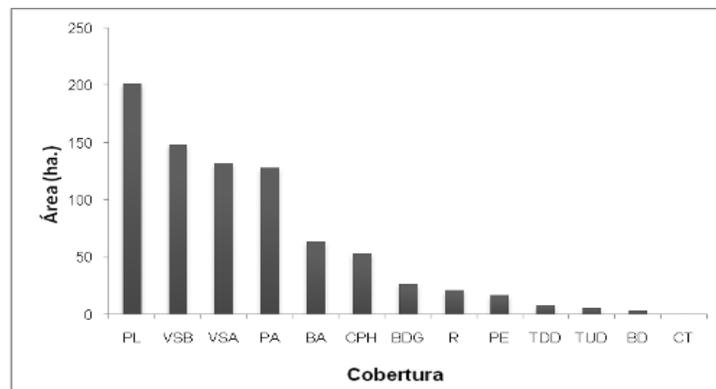


Figure 3-42. Coverage present in the area of indirect influence of the project.

BA: Open Forest, BD: Dense Forest, BDG: Dense Forest of *Guadua bamboo*, VSA: High Secondary Vegetation, VSB: Low Secondary Vegetation, PL: Clean pasture, PA: Wooded pasture PE: Weeded pasture CPH: Herbaceous perennial crop, CT: Transitional Crop, R: Rivers, TDD: Bare and degraded lands, TUD: Discontinuous urban web.

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Photo 3-15. Coverage of dense forest in the project influence area.

➤ Dense Forest of Guadua (3.1.1)

This coverage is composed, almost exclusively, by the graminea species *Guadua angustifolia* (Guadua), which is propagated vegetatively, forming stands that contribute to the water protection and it also has great potential for its use and development (see Photo 3-16). In the IIA of the project cover about 26.7 ha, corresponding to 3.3 % of the total area.



Photo 3-16. Coverage of dense forest of Guadua bamboo in the project influence area

➤ Open Forest (3.1.2)

Coverage consists of a plant community dominated by elements typically arboreal, regularly distributed, which form a discontinuous stratum of cups (canopy), with canopy height greater than five meters and whose area of arboreal cover represents between 30% and 70% of the total area of the unit. These plant formations have not been intervened or its intervention has been selective and has not altered its original structure and the functional characteristics (see Photo 3-17).

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Photo 3-17. Coverage of open forest in the project influence area.

Although there are few areas occupied by this coverage, even small fragments are scattered in the area and usually associated with water sources. Some species that dominate this coverage are the palm-kernel oil (*Euterpe precatória*), the silbasilba (*Hedyosmum racemosum*) and the cirpo (*Pourouma hirsutipetiolata*). The open forest occupies 63.9 ha of the All, which is equivalent to 7.9 % of the total area.

➤ **Secondary Vegetation (3.2.3)**

Comprise that vegetation coverage originated by the process of succession of natural vegetation that occurs after the intervention or by the destruction of the primary vegetation. In the study area was development in areas where by the occurrence of natural events, the natural vegetation was destroyed and in areas of abandoned pastures and crops. In accordance with the height and the structural complexity of the areas found, were differentiated two categories:

Low Secondary Vegetation (3.2.3.2)

Areas covered by vegetation mainly herbaceous and shrub canopy with irregular and occasional presence of trees and creepers, which corresponds to the initial stages of plant succession.

Communities are composed of shrubs and herbaceous formed by many species The secondary vegetation commonly corresponds to a type of herbaceous shrub vegetation of short cycle, with heights that do not exceed the five meters and dense coverage (see Photo 3-18).

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Photo 3-18. Coverage of low secondary vegetation in the project influence area

This was one of the coverage with greater surface area in the IIA (148.2 - 18.3 %), surpassed only by clean pastures, and is dispersed in the study area and usually adjacent to houses, in abandoned pastures or crops, where it began the process of natural regeneration. The most common species were the mantequilla (*Campania cinerea*) and several species of *Vismia*.

High Secondary Vegetation (3.2.3.1)

Are areas covered by vegetation mainly arboreal with irregular dosel and occasional presence of shrubs, palms and creepers, which corresponds to the intermediate stages of plant succession (see Photo 3-19).



Photo 3-19. Coverage of high secondary vegetation in the project influence area

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This coverage is 16.3 % of the All, corresponding to 131.7 has. and is scattered by the study area, usually associated to high slope areas and water sources. The most common species were the cirpo (*Pourouma hirsutipetiolata*), the black rubber (*Castilla elastic*) and silbo silbo (*Hedyosmum racemosum*).

➤ Pasture (2.3)

Includes the land area covered with dense grass, floristic composition dominated mainly by the Phocaea family, dedicated to permanent pasture and the later management done to them. For its classification were considered the following pastures units.

Clean pasture (2.3.1)

This coverage includes the lands occupied by clean pasture with a percentage of coverage greater than 70 %; the implementation of management practices (cleaning, liming or fertilization) and the technology level used, preventing the presence or development of other coverage. This coverage is ranked first in extension in the IIA (201.7 ha. - 24.9 %), found dispersed over the entire study area (see Photo 3-20 and Cartography 2148-04-EV-DW-031).



Photo 3-20. Coverage of clean grass in the project influence area

Wooded pasture (2.3.2)

Coverage that includes the land area covered with pastures, in which have been structured paddocks with presence of trees from a height in excess of five meters, distributed in a disperse fashion. The trees coverage must be greater than 30% and less than 50% of the total area of the pastures unit. It is the fourth category of greater coverage in the IIA (127.9 ha. - 15.8 %) (See Photo 3-21 and Cartography 2148-04-EV-DW-031).

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Photo 3-21. Coverage of wooded pasture in the area of project influence area

Weeded pasture (2.3.3):

Coverage are represented by land with grass and weeds, forming associations of secondary vegetation, mainly due to the realization of scarce management practices or the occurrence of abandonment processes. In general, the height of the secondary vegetation is less than 1.5 m. This coverage is only 16, 5 ha, 2% of the IIAS and is located near the San Matias River, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos (see Photo 3-22 and Cartography 2148-04-EV-DW-031).

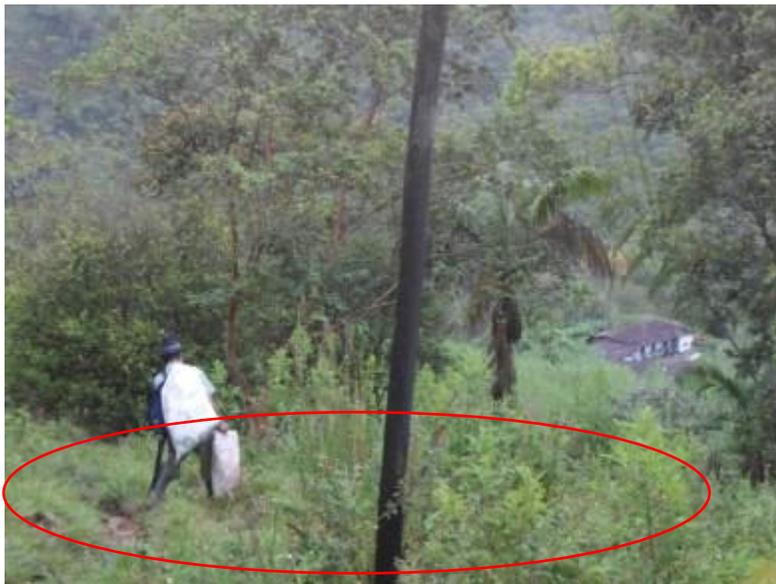


Photo 3-22. Weeded grass coverage in the project influence area

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➤ Bare and degraded land (3.3.3)

Corresponds to the field surfaces devoid of vegetation or with little vegetation, due to the occurrence of processes both natural and anthropic of erosion and degradation. It occupies 1.0 % of the All, corresponding to 7.8 ha of the total area (see Photo 3-23 and Cartography 2148-04-EV-DW-031).



Photo 3-23. Coverage of bare and degraded land in the project influence area

➤ Transient crops (2.1)

Occupied areas with crops whose vegetative cycle is less than a year, and that after harvest is necessary to re-sowing or planting to continue producing. This coverage was the one that occupied a lower surface of the All (0.6 - 0.1 %), with crops of passion fruit, beans, papaya, among others (see Photo 3-24 and Cartography 2148-04-EV-DW-031).



Photo 3-24. Coverage of transitional crop (beans) in the project influence area

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➤ Permanent herbaceous crops (2.2.1)

Includes the territories dedicated to crops whose vegetative cycle is more than a year, producing several crops without need for re-planting. In the IIA, 53.5 ha (6.6 %) are covered by sugarcane (see Photo 3-25 and Cartography 2148-04-EV-DW-031).



Photo 3-25. Coverage of perennial herbaceous (sugarcane) crop in the project influence area

➤ Rivers (5.1.1)

Natural flow of the water that flows continuously, possess a considerable flow and empties into the sea, in a lake or in another river. The San Matias River passes through the project influence area in orientation northwest-southeast and pours its waters into the Cocorná River (see Photo 3-26).



Photo 3-26. San Matias River crossing the project influence area

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➤ Discontinuous urban web (1.1.2)

Are spaces formed by buildings and green areas. The buildings, roads and infrastructure built cover the surface of the ground in a disperse and dashed fashion, as the rest of the area is covered by vegetation. The IIA comprises an area of 5,5 ha, which is equivalent to 0.7 % of the total area.

– Sensitive ecosystems and protected natural areas

In order to identify if in the project influence area there are areas declared as of special handling belonging to different systems of protected areas (SINAP, SIDAP, SIMAP), checks were made in the reports of the IAvH (Alexander von Humboldt Institute), in the map of the ecosystems of the Colombian Andes, in the declarations of special management areas, ecological areas of environmental interest declared by the municipalities, CORNARE protected areas and the EOTs in the municipalities of Cocorná and Granada. It is not identified any reservation or area with special handling declared in the Vereda (*Political and administrative division of the municipality located in the rural area*) of interest or areas of influence.

• Direct influence area(DIA)

The direct influence area corresponds with the zone where the facilities will take place, which are: eight reservoirs, collection, discharge, house of engines, substation, access roads, pipelines, industrial zones, camps, with their respective conditioning areas.

To identify and locate the crops cover that can be affected by the construction of the hydroelectric plant, was the projection of the facilities on the map of plant cover, setting out both categories as the areas occupied by each one of them. Also, were counted and characterized the existing plant covers in the polygons shown in the coverage map. In this area are found the forest coverage (dense with Guadua and open), secondary vegetation (high and low) pastures (wooded, clean and weeded) and permanent crops.

Table 3-53 and Figure 3-43 presents the areas by coverage for AID, where it is noted that the coverage are the dominant clean grass (34.9 %), the wood pasture (24.8 %), the high secondary vegetation (11.2 %) and the low secondary vegetation (10.4 %); the natural coverage, proposals in the inventory, with less area to intervene are forests (dense with Guadua and open), followed by the weeded grass (6.5 %). The low percentage of natural coverage in this area reflects the degree of intervention in this area where prevails the agricultural activity.

Table 3-53. Coverage present in the direct project influence area

| Coverage | Symbol | Area M ² | Area (ha) | Area (%) |
|----------------------------|--------|---------------------|-----------|----------|
| Clean Grass | PL | 107165.4 | 10.72 | 34.90 |
| Wood pasture | PA | 76063.2 | 7.61 | 24.77 |
| High Secondary Vegetation | VSA | 34301.2 | 3.43 | 11.17 |
| Low Secondary Vegetation | VSB | 32061.3 | 3.21 | 10.44 |
| Weeded Grass | PE | 19894.7 | 1.99 | 6.48 |
| Open Forest | BA | 14642.0 | 1.46 | 4.77 |
| Rivers | R | 11646.2 | 1.16 | 3.79 |
| Permanent herbaceous crops | CPH | 4604.3 | 0.46 | 1.50 |
| Dense Forest (Guadua) | BDG | 4063.5 | 0.41 | 1.32 |
| Discontinuous urban web | TUD | 1504.9 | 0.15 | 0.49 |

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| Coverage | Symbol | Area M ² | Area (ha) | Area (%) |
|------------------------|--------|---------------------|--------------|---------------|
| Bare and degraded land | TDD | 1106.1 | 0.11 | 0.36 |
| Overall Total | | 307,052.7 | 30.71 | 100.00 |

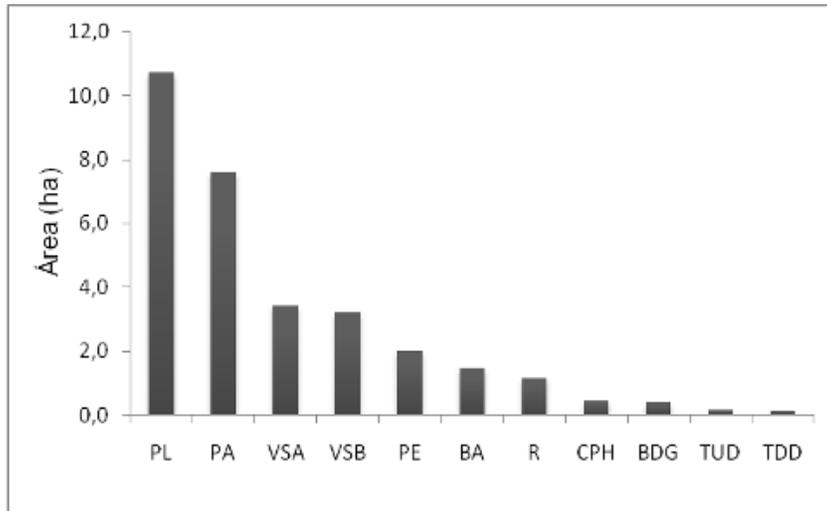


Figure 3-43. Distribution of vegetal covertures (has.) in the project direct influence area

- Methodology for the floristic composition
- Forest Inventory

For the direct influence area were defined the areas where the work will take place, which were overlapped with the map of land cover scale 1:10, built on the basis of aerial photographs of the area and corroboration in field. From this information, we performed a stratified forest inventory at random, with a sampling error of less than 15%.

For this purpose, plots were fitted based on the methodology used by Gentry (1982), called RAP (*Rapid Assessment Plot*) and subsequently amended by the Convention ISA-JAUM (2004). This method consists in the establishment of blocks of 0.1 ha (50 m x 20 m), which are divided into five rectangular plots of 50 m x 4 m (200 m²), inside of which are plotted subplots, one of 5 m x 4 m (20 m²) and a 25 m x 4 m (100 m²), located at the beginning of each plot (see Figure 3-44 and Annex 8).

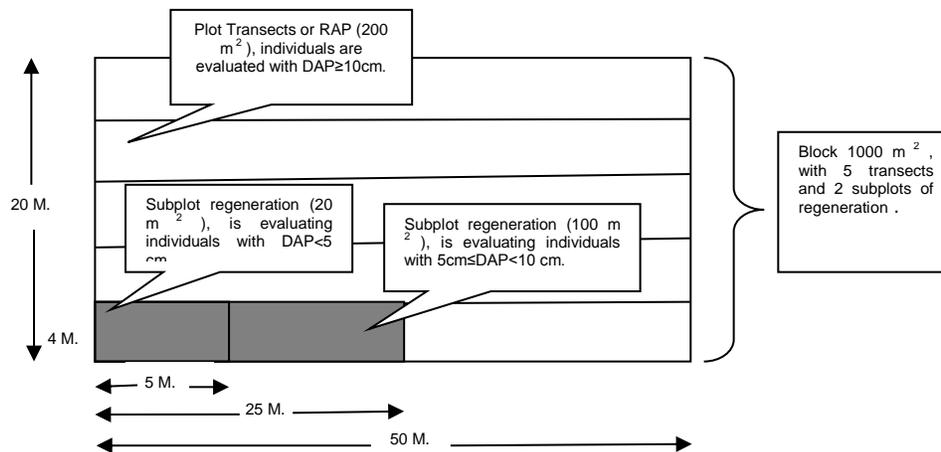


Figure 3-44. The schematic design of the field sampling blocks, which includes the transects (plots) and the regeneration subplots.

In total 90 plots were established in 200 m², 90 subplots of 20 m² and 90 subplots of 100 m². Table 3-54 Table 3-54 records the number of plots of 200 m² laid down and the total area sampled for each coverage type. In annex 8 is recorded the plots location within the study area

Table 3-54. Present coverage and sampled area present in the project influence area

| Converge | Symbol | # Slots | A. simple (m ²) |
|---------------------------|-------------|-----------|-----------------------------|
| Open forest of firm land | BA | 5 | 1,000 |
| Dense Forest of Guadua | BD (Guadua) | 5 | 1,000 |
| High Secondary Vegetation | VSA | 10 | 2,000 |
| Low Secondary Vegetation | VSB | 10 | 2,000 |
| Poded pasture | PA | 20 | 4000 |
| Ceded pasture | PE | 15 | 3,000 |
| Clean Grass | PL | 25 | 5,000 |
| Total | | 90 | 18,000 |

Within the plots of 200 m² were counted and measured all the woody plants whose stem had a diameter at breast height (DBH measured at 1.3 m from the surface of the ground) ≥ 10 cm (stem). In the plots of 100 m², were counted and measured the individuals within the range of 5 cm DBH ≤ <10 cm (saplings) and in the subplots of 20 m² recorded the presence and abundance of plants with < 5 cm DBH saplings).

The surveyed plants in each plot, for the stem category, were marked with asphalt specifying the number of the plot and the consecutive of the tree. For each species was collected a botany sample for later identification in the Herbarium of the National University; in addition there were registered all the morphological characteristics that could disappear in the handling of the botanical collections for a proper identification in the laboratory. The botanical samples collected in the field, were pressed on newspaper sheets previously labeled, were subsequently alcohol zed with alcohol at 70 %, to prevent detachment from the leaves and the attack by insects or organisms (see Photo 3-27)

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(a)



(b)



(c)



(d)



(e)

Photo 3-27. Sampling Process of vegetation present in the project area. (a) measurement (b and c) marking of the individuals surveyed. (d) Collection of plant samples. (e) Pressing of plants collected.

The growth habits were defined following the proposed by Londoño and Alvarez (1997), who considered 20 habits, grouped into five categories: arboreous, shrub, scandent, herbaceous and saprophyte (Table 3-55). The basic criteria for defining the different growth habits were: the presence or absence of woody tissue, the dependence or independence of other plants that give support, and finally, the size.

Table 3-55. Growth Habits registered for the vascular plants surveyed in the influence area of the El Molino hydroelectric project

| Category | Growth Habit | Code |
|-----------|-------------------------------|------|
| Arboreous | Trees | A |
| | Tree ferns | FA |
| | Mono estipitated tree palms | PAM |
| | Tussock tree palms | PAC |
| Shrub | Shrubs | T |
| | Scandent shrub | Ts |
| | Rosulate shrub palm | PTU |
| | Tussock shrub palm | PTC |
| | Mono estipitated shrubby palm | PTM |

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| Category | Growth Habit | Code |
|---------------------------|---|------|
| Scandent | Scandent Herbaceous | SH |
| | Hemiepiphytes Herbaceous | SEH |
| | Scandent ferns | FSH |
| | Scandent Herbaceous | SH |
| | Scandente woody (vines or lianas) | SL |
| | Wooden Hemiepiphytes (e.g. Clusias) | SEL |
| | Scandent palms (Desmoncus) | PSL |
| Herbaceous | Epiphyte | E |
| | Terrestrial Herbs | Ht |
| | Fern Herbaceous terrestrial | FHR |
| Saprophytic and parasitic | That completely dependent on the host (e.g. Loranthaceas) | Pa |

The plant material previously alcoholized was taken to the Herbarium Workshop of the National University, where it was ready to be dissected and where process for taxonomic identification is performed.

For the taxonomic determination of the species were followed the classification system APG (2009), for which was used specialized bibliography, such as keys and species descriptions, with the comparison with the morphological specimens deposited in the Herbarium of the National University (MEDEL), the database of the *Missouri Botanical Garden* (www.mobot.org) and with the collaboration of specialists in some groups or botanical families.

At the end was the botany chip for each of the specimens and were taken to the assembly process, to be included within the reference collection of the herbarium of the National University (MEDEL).

➤ Analysis of the information

To estimate the weight of the ecological plant species, we calculated the importance value index (IVI) for each species, which is the result of the sum of the relative abundance (RA), the relative frequency (FR) and the relative dominance (DoR) (Finol, 1976).

Relative abundance (RA) : number of individuals of a species / total number of individuals x 100

Relative frequency (FR): frequency of a kind / summation of all frequencies x 100

Relative Dominance : basal area per species / basal area for all species x 100

IVI : relative dominance + relative abundance + relative frequency

To evaluate the diversity alpha (α) of the study area, indexes were calculated for Shannon diversity (H'), dominance of Simpson (D) and the ratio of mixture, which are based on the relative abundance of species (Velez and Fresneda, 1992).

The Shannon diversity index measures the heterogeneity of the community; the maximum value is an indication of a situation in which all species are equally abundant (Velez and Fresneda, 1992). Their values are between 0 and 5, and are calculated using the following expression:

$$H' = \sum_i - (f_i \ln f_i), \text{ where}$$

f_i = Proportional abundance of the species i

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The index of dominance of Simpson measured the dominance of the species and assesses the probability that two individuals from an infinitely large community, taken at random, belong to the same species (Velez and Fresneda, 1992). Their values are between 0 and 1; when the value is close to zero, the dominance is smaller and therefore, the greater diversity. Its mathematical expression is:

$$D = \sum f_i^2, \text{ where}$$

f_i : Proportional abundance of the species i

The ratio of mixture (CM) establishes a relationship between the number of species and the total number of individuals, which is estimated by the equation:

$$CM = N / S, \text{ where}$$

N = total number of individuals

S = total number of species

To estimate the floristic similarity between the coverage or the Beta (β) diversity, calculation of the Jaccard index (J), which is based on the presence-absence of species in matched assemblies (Magurran, 2004), and whose equation is as follows:

$$J = C / (A + B) - C, \text{ where}$$

C are the shared species

A and B are the unique species at each site

After calculating the IVI for individuals older than 10 cm DBH, proceeded to calculate the index of Importance expanded (IVIA), which provides additional information about the structure and composition of the vegetation with diameters less than those already mentioned. In this way the IVIA is calculated as follows:

$$IVIA\% = Ab + D\% + Ps\% + Rn\%, \text{ where}$$

$Ab\%$: Relative abundance of individuals with DBH > 10cm.

$F\%$: Relative frequency of individuals with DBH > 10cm.

$D\%$: Relative dominance of the individuals with DBH > 10cm.

$Ps\%$: sociological position relative to all the individuals in the census coverage.

$Rn\%$: natural regeneration relative of all individuals with DAP<10 cm.

The first three components correspond to the IVI to the stem (DBH > 10 cm), while the sociological position relative ($Ps\%$) is found in the categorization of the total height variable of all the individuals surveyed in each category (stem, age stages and saplings) in three percentiles (33, 66 and 100) and subsequently remove the percentage shares.

Natural relative regeneration ($Rn \%$), is expressed as:

$$Rn\% = (Ab\% + Fr\% + Ct \%) / 3, \text{ where}$$

$Ab\%$: Relative abundance of individuals with DAP<10 cm.

$Fr\%$: Relative frequency of individuals with DAP<10 cm.

| | | | |
|---|--|----------------------------|------------|
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Ct%: Relative size category of individuals with DAP<10 cm.

The Ab% and Fr% are calculated in a similar manner to those of the IVI to stem, but only for those censused with DAP<10 cm. The size category is calculated from the data fragmentation in low and high by means of two percentiles (50 and 100), where low corresponds to the first and high to the last.

– Results of the floristic composition

In the sampling conducted for this study, there were 4,300 individuals, distributed in 69 families, 174 genuses and 250 species, of which 240 belong to the group of angiosperms (flowering plants) and 10 to the group of Pteridophytas (ferns). Annex 9 presents the listing with the totality of species recorded for this study. The families of vascular plants with the greatest number of species were Melastomataceae with 25 species, with 21 Rubiaceae, Asteraceae with 18, Fabaceae with 17, 12 and Piperaceae Lauraceae Araceae with 11 and 8 species each (Figure 3-45). These seven families grouped the 44.8 % of the species reported in this sampling; also, the majority of these families have been reported as the richer species for other premontane forests in the neotropics (Gentry, 1995; Giraldo, 1995; Mendoza and Ramirez, 2006, Rangel *et al.*, 1997 and Armenteras and Rodriguez, 2007).

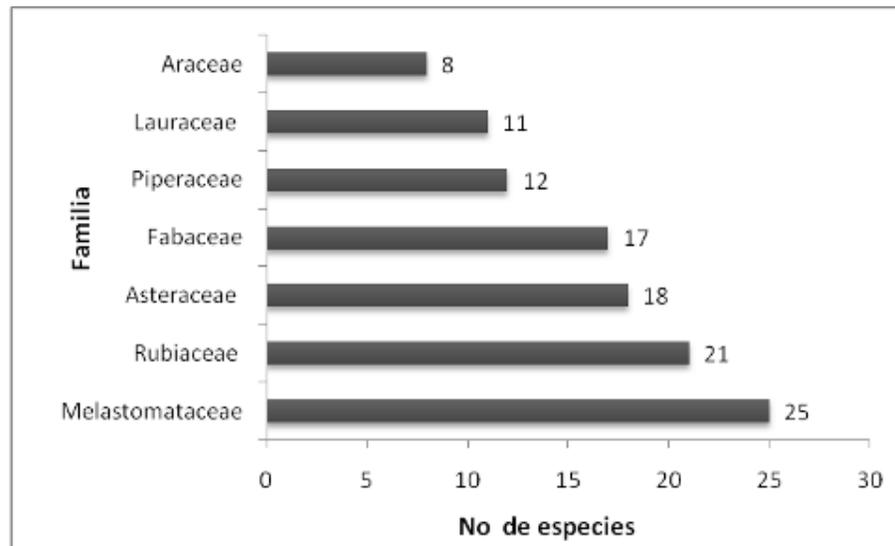


Figure 3-45. Families of vascular plants with the largest number of species in the project influence area

- Analysis of natural regeneration

The regeneration of plants is a dynamic process by which new individuals are incorporated into the breeding population, as others have disappeared as a result of natural mortality (Harper, 1977). In each of the 90 semi-permanent plots, subplots were established from natural regeneration of 5 m x 4 m and 25 m x 4 m. These subplots were distributed in the different areas of coverage recorded for the project influence area. In these were recorded in total 3,796 individuals belonging to the categories of saplings and seedlings, which were distributed in 66 families, 163 genuses and 236 species or morpho species (see Annex 9).

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The coverage with greater species richness were the high secondary vegetation and the weeded grass, with 81 and 76 species respectively, followed by the wood pasture, clean, and the open forest, with 72, 62 and 44 species (see Table 3-56). These results are probably the result of increased availability of light, germplasm and the latent spatial location, which in many cases is an array of vegetation in different succession stages, where in the most advanced competition is highest, while in these coverage less complex, natural regeneration may develop more easily.

Table 3-56. Representativeness of each one of the taxonomic hierarchies in the category of saplings and seedlings, for each of the coverage assessed within the study area.

| Coverage | Category | No. of individuals | No. species | No. Genres | No. Families |
|----------|------------------|--------------------|-------------|------------|--------------|
| BA | Brinzal | 211 | 41 | 33 | 21 |
| | Latizal | 10 | 9 | 8 | 6 |
| | Total BA | 221 | 50 | 41 | 27 |
| BDG | Brinzal | 199 | 16 | 15 | 11 |
| | Latizal | 8 | 6 | 6 | 6 |
| | Total GDB | 207 | 22 | 21 | 17 |
| PA | Brinzal | 666 | 68 | 56 | 30 |
| | Latizal | 6 | 5 | 5 | 4 |
| | Total PA | 672 | 73 | 61 | 34 |
| PE | Brinzal | 962 | 70 | 56 | 27 |
| | Latizal | 34 | 12 | 10 | 8 |
| | Total PE | 996 | 82 | 66 | 35 |
| PL | Brinzal | 779 | 60 | 51 | 31 |
| | Latizal | 4 | 4 | 4 | 4 |
| | Total PL | 783 | 64 | 55 | 35 |
| VSA | Brinzal | 435 | 71 | 54 | 29 |
| | Latizal | 80 | 26 | 25 | 17 |
| | Total VSA | 515 | 97 | 79 | 46 |
| VSB | Brinzal | 389 | 38 | 32 | 22 |
| | Latizal | 13 | 5 | 5 | 4 |
| | Total VSB | 402 | 43 | 37 | 26 |

BA: Open Forest, BDG: Dense Forest of *Guadua bamboo*, PA: Wood pasture, PE: Weeded pasture, PL: Clean Grass, VSA: High Secondary Vegetation, VSB: Low Secondary Vegetation.

In the category of saplings (DAP between 0 cm and 5 cm), there were 3,641 individuals and 220 species, and in the category of age stages (DAP between 5 cm and 9.9 cm), were counted 155 individuals and 50 species. It is important to note that 66.8 % of the individuals registered for the category of saplings are herbaceous of annual growth (2,432), probably due to that the coverage with the greatest number of individuals in this category are the pastures, distinguishing among them the weeded grass (PE) with 992. Seedlings were recorded in addition, young and adult trees and shrub species as *Alchornea cf. acutifolia*, *Alchornea megalophylla*, *Bellucia echinoderms exhibit fivefold*, *Calophyllum brasiliense*, *Casearia arborea*, *Cespedesia spathulata*, area studied. *Chrysochlamys weberbaueri*, among others, indicating an active process of natural regeneration, where one looks at the evolution of the forest with a continuous replacement of individuals and species.

In the categories and age stages saplings, pioneering species were recorded in the family Piperaceae (knitted ribbing), Rubiaceae y Melastomataceae (Mortinos), which in their majority, are bushy habit. In addition there were tree species of intermediate succession stages as *Piptocoma discolor* (Vulture) and *Miconia elata* (mortiño Colorado), *Vismia baccifera* (Punta'e

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Tiller), which present high frequencies and abundances. Jointly timber species were recorded as *Heliocarpus americanus* (white balsum), *Cinnamomum triplinerve* (Laurel Perillo), *Nectandra* spp. , *Jacaranda copaia* (Chingale), Aniba cf. *Muca* (Laurel inciden), *Ficus popayanensis* (salary). There were also found typical forest species preserved as *Cyathea* spp. (Tartar), *Euterpe precatoria* (Palm-kernel oil), *Guatteria boliviana* (Garrapato); this result is a reflection of the wealth of flora in the area and the conservation status of some of their forests.

- Analysis by type of coverage

We now turn to the analysis of the floristic composition for individuals with a DBH \geq 10 cm. (Stem), in each of the coverage sampled, dense forest of Guadua, open forest, high secondary vegetation, low secondary vegetation, wood pasture, weeded grass and clean pasture .

Dense Forest of Guadua

This coverage is presented in small fragments, usually close to water sources. In the area to intervene was located a snippet on the track that will lead to the relief line and collection, and occupies 0.4 has, corresponding to 1.3 % of the area to intervene. In this coverage were established five plots of 200 m², for a total sampled area of 0.1 ha, where there were 151 individuals belonging to nine families and an equal number of species, being the Guadua bamboo (*Guadua angustifolia*), the species of greater importance for this coverage, with 71.4 % of the whole IVI (see Figure 3-46 and Table 3-57).

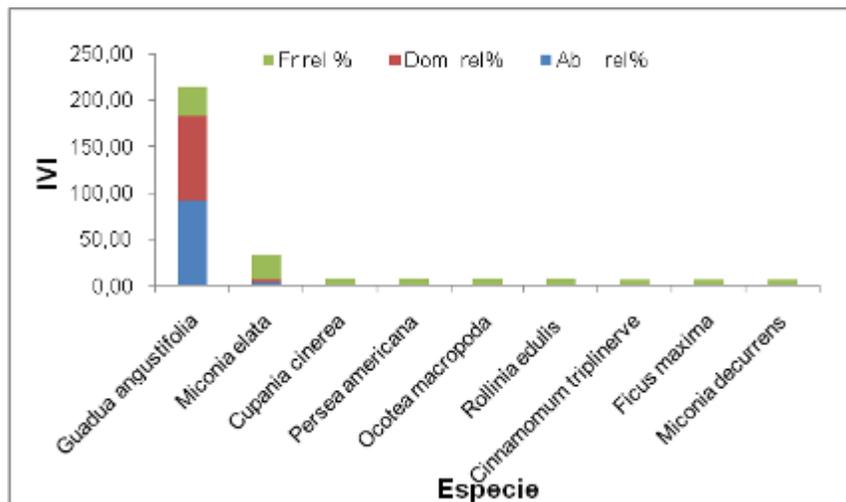


Figure 3-46. Index of Importance value (IVI) of the registered species for the dense forest of Guadua

Table 3-57. Index of Importance value (IVI) of the recorded species for the dense forest of Guadua

| # | Scientific name | Common Name | Family | # Ind. | Ab rel% | Dom rel% | Fr rel % | IVI |
|---|-----------------|-------------|---------|--------|---------|----------|----------|--------|
| 1 | <i>Guadua</i> | Guadua | Poaceae | 138 | 91.39 | 91.70 | 31.25 | 214.34 |

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| # | Scientific name | Common Name | Family | # Ind. | Ab rel% | Dom rel% | Fr rel % | IVI |
|---|-------------------------------|-------------------|-----------------|--------|---------|----------|----------|-------|
| | <i>angustifolia</i> | | | | | | | |
| 2 | <i>Miconia elata</i> | Mortiño Colorado | Melastomataceae | 6 | 3.97 | 3.54 | 25.00 | 32.52 |
| 3 | <i>Cupania cinerea</i> | Cariseco, mestizo | Sapindaceae | 1 | 0.66 | 0.90 | 6.25 | 7.82 |
| 4 | <i>Persea americana</i> | | Lauraceae | 1 | 0.66 | 0.88 | 6.25 | 7.79 |
| 5 | <i>Ocotea macropoda</i> | Laurel | Lauraceae | 1 | 0.66 | 0.83 | 6.25 | 7.74 |
| 6 | <i>Rollinia edulis</i> | Mahoe | Annonaceae | 1 | 0.66 | 0.81 | 6.25 | 7.73 |
| 7 | <i>Cinnamomum triplinerve</i> | Laurel Perillo | Lauraceae | 1 | 0.66 | 0.48 | 6.25 | 7.39 |
| 8 | <i>Ficus maximum</i> | Rubber | Moraceae | 1 | 0.66 | 0.44 | 6.25 | 7.35 |
| 9 | <i>Miconia decurrens</i> | White mortiño | Melastomataceae | 1 | 0.66 | 0.40 | 6.25 | 7.31 |
| | Overall Total | | | 151 | 100 | 100 | 100 | 300 |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance value

Although in this coverage were found, in addition to Guadua bamboo, eight tree species, the ability of the Guadua to reproduce asexually through the rhizomes, its adaptability to different types of soils, its accelerated growth, among others, assigns a higher reproductive success in the other species and in consequence a dominance in the area. This species, known for its great construction value, also performs an important role in the ecosystems dynamics, because its root system ingrained and the presence of abundant rhizomes, contribute greatly to the conservation and recovery of the soil, in addition to participate in the water regulation.

Open Forest

Although there are few areas occupied by this coverage, even small fragments are scattered in the area and usually associated with water sources. In this coverage will be located part of the deposits SM4 and SM2, in addition to being intersected by the transmission line and the way to the house of engines and the collection area, the open forest occupies an area of 1.5 hectares, equivalent to 4.8 % of the area to intervene.

In this coverage, were established five plots of 200 m², for a total area of 0.1 ha sampling, where there were 88 individuals, belonging to 11 families and 15 species. Despite the high intervention by the selective removal of wood, still contains trees of commercial importance as the mantequillo (*Cupania cinerea*), the salary (*Ficus sp.*, 2) and the laurel (*Ocotea macropoda*), which are attractive remnants for the extraction and use of the forest resource.

Figure Figure 3-47 and Table 3-58 registers the importance value index for this coverage, where the Cirpo (*Pourouma hirsutipetiolata*) was the kind with a greater ecological weight, followed by the silbasilba (*Hedyosmum racemosum*), palm-kernel oil (*Euterpe precatoria*), the yarumo (*Cecropia angustifolia*) and the mortiño colorado (*Miconia elata*). For the first kind, the parameter that provided most was the dominance, the highest among the species evaluated, what means that in spite that it occupies secondary places in the other two

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components of the IVI, the diameters of this species were the largest of this coverage (see Photo 3-28).

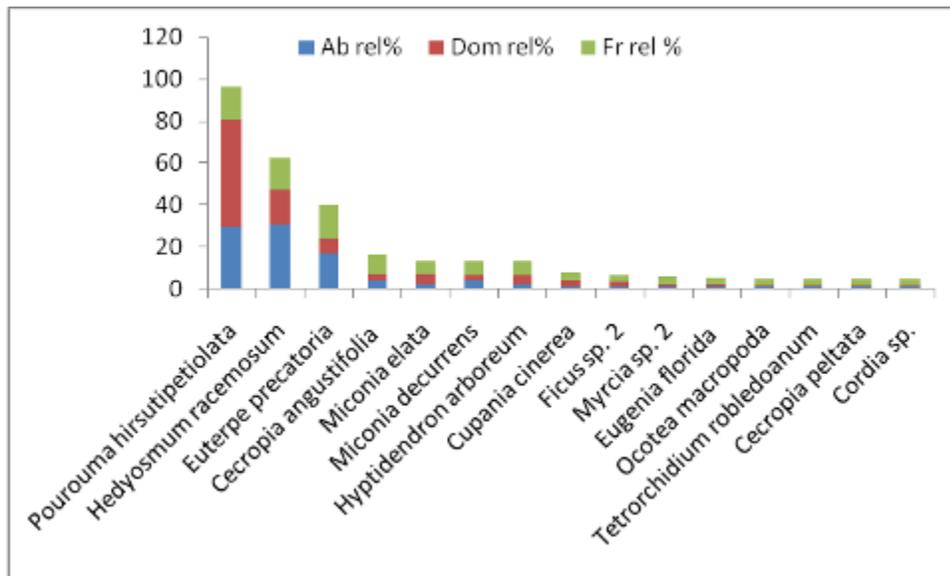


Figure 3-47. Index of Importance value (IVI) of the species recorded for the open forest

Table 3-58. Index of Importance value (IVI) of the species recorded for the open forest

| Scientific name | Family | Common Name | # | Ab rel% | Dom rel% | Fr rel % | IVI |
|---------------------------|-----------------|--|------------|------------|------------|----------|------|
| Pourouma hirsutipetiolata | Urticaceae | Cirpo | 26 | 29.5 | 51.1 | 15.6 | 96.2 |
| Hedyosmum racemosum | Chloranthaceae | Silbasilba, hail | 27 | 30.7 | 16.3 | 15.6 | 62.6 |
| Euterpe precatória | Arecaceae | Palm-kernel oil, macana | 15 | 17.0 | 7.1 | 15.6 | 39.7 |
| Cecropia angustifolia | Urticaceae | Yarumo, Yarumo black | 4 | 4.5 | 2.6 | 9.4 | 16.5 |
| Miconia elata | Melastomataceae | Colorado mortiño | 2 | 2.3 | 4.8 | 6.3 | 13.4 |
| Miconia decurrens | Melastomataceae | White mortiño | 4 | 4.5 | 2.3 | 6.3 | 13.1 |
| Arboretum Hyptidendron | Lamiaceae | Aguanoso, white and black vulture, Borrajo | 2 | 2.3 | 4.5 | 6.3 | 13.1 |
| Cupania cinerea | Sapindaceae | Mantequillo, cariseco, Guacharaco, mestizo | 1 | 1.1 | 3.4 | 3.1 | 7.7 |
| Ficus sp. 2 | Moraceae | Salary | 1 | 1.1 | 2.3 | 3.1 | 6.5 |
| Myrcia sp. 2 | Myrtaceae | | 1 | 1.1 | 1.5 | 3.1 | 5.8 |
| Eugenia florida | Myrtaceae | | 1 | 1.1 | 1.3 | 3.1 | 5.5 |
| Ocotea macropoda | Lauraceae | Laurel | 1 | 1.1 | 0.8 | 3.1 | 5.1 |
| Tetrorchidium robledoanum | Euphorbiaceae | | 1 | 1.1 | 0.7 | 3.1 | 5.0 |
| Cecropia peltata | Urticaceae | Yarumo | 1 | 1.1 | 0.6 | 3.1 | 4.9 |
| Cordia sp. | Boraginaceae | | 1 | 1.1 | 0.6 | 3.1 | 4.9 |
| Total | 88 | 100 | 100 | 100 | 300 | | |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance.

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Photo 3-28. Twig and stipulates the cirpo (*Pourouma hirsutipetiolata*)

When comparing between forested areas sampled (dense forest of Guadua and open forest), the open forest has presented a higher floristic diversity, because in spite of being a more intervened area in relation to the dense forests of Guadua, the rehabilitation of surrounding areas enables the gene flow and the seeds dispersion. In this coverage has been reported the species guanos (*Hyptidendron arboreum*), which has a vulnerable conservation status - National Category- (Garcia, & Galeano, 2006).

High Secondary Vegetation

This is one of the more abundant coverage in the project area and is dispersed and associated generally to areas of high slope and water sources. In the area to be intervened there are 3.4 ha (11.2 % of the project influence area) occupied by this coverage, that will be affected by the relief line and the pathways leading to the relief pipeline, the house of engines and the collection, in addition to deposit 1.

There were established 10 plots of 200 m², for a total evaluated area of 0.2, where 133 individuals were counted, belonging to 20 families and 35 species, being this the evaluated coverage with greatest profusion of flora, an outcome that may be associated primarily with the availability of light, which could generate greater diversity and a greater number of individuals, in addition to the rehabilitation of the surrounding areas enables the colonization and migration of species from other areas. In addition, this coverage was evaluated for the double of the area, if compared to the dense forest of Guadua and the open forest, unique communities in more advanced succession status than this, which is why it is not surpassed in floristic richness in the entire inventory.

Evaluating the IVI for individuals with DAP \geq 10 cm, it was found that the Cirpo (*Pourouma hirsutipetiolata*, see Photo 3-29) it is the species with a greater IVI, by presenting the greatest

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abundance, basal area and frequency (see Figure 3-48 and Table 3-59 and); the other species, including the second (*Hedyosmum racemosum*), exhibit similar values, though declining, in all the components of the IVI.



Photo 3-29. With greater ecological importance to the high secondary vegetation, left: *Pourouma hirsutipetiolata*, Right: *Castille elastic*

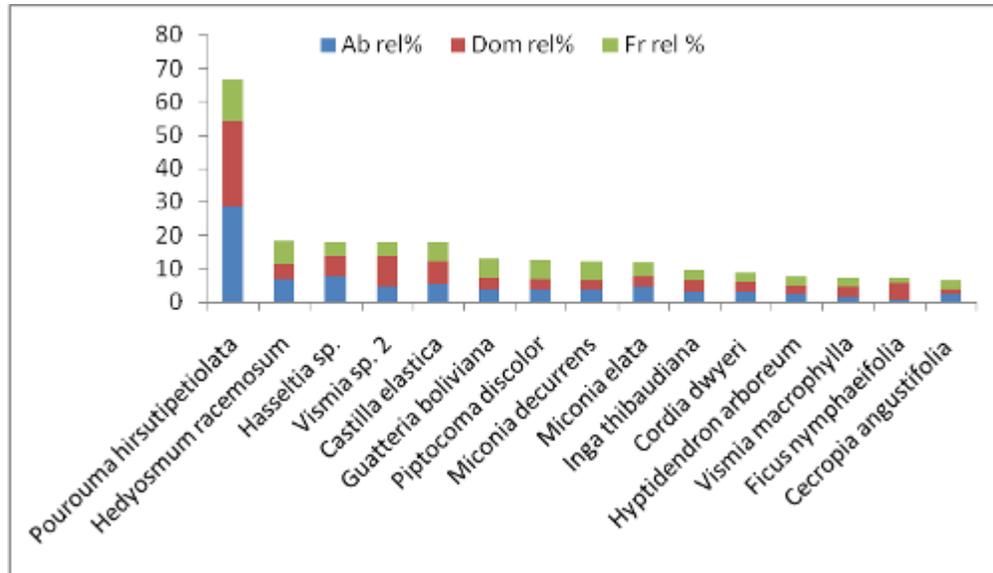


Figure 3-48. Index of Importance value (IVI) of the species recorded for the high secondary vegetation.

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Table 3-59. Index of Importance value (IVI) of the species recorded for the high secondary vegetation

| Scientific name | Family | Common Name | Ab | Ab rel % | Dom rel% | Fr rel % | IVI |
|----------------------------------|-----------------|--|----|----------|----------|----------|------|
| <i>Pourouma hirsutipetiolata</i> | Urticaceae | Cirpo | 38 | 28.6 | 25.5 | 12.7 | 66.8 |
| <i>Hedyosmum racemosum</i> | Chloranthaceae | Silbasilba, hail | 9 | 6.8 | 4.5 | 7.0 | 18.3 |
| <i>Hasseltia sp.</i> | Salicaceae | | 10 | 7.5 | 6.2 | 4.2 | 17.9 |
| <i>Vismia sp. 2</i> | Hypericaceae | Tongue Tip | 6 | 4.5 | 9.1 | 4.2 | 17.8 |
| <i>Castilla elastic</i> | Moraceae | Black Rubber, rubber female | 7 | 5.3 | 6.9 | 5.6 | 17.8 |
| <i>Guatteria bolivian</i> | Annonaceae | Garrapato | 5 | 3.8 | 3.7 | 5.6 | 13.0 |
| <i>Discolor Piptocoma</i> | Asteraceae | Vulture, mulato, pigweed | 5 | 3.8 | 3.2 | 5.6 | 12.6 |
| <i>Miconia decurrens</i> | Melastomataceae | White mortiño | 5 | 3.8 | 2.6 | 5.6 | 12.0 |
| <i>Miconia elata</i> | Melastomataceae | Colorado mortiño | 6 | 4.5 | 3.0 | 4.2 | 11.8 |
| <i>Inga thibaudiana</i> | Fabaceae | | 4 | 3.0 | 3.6 | 2.8 | 9.4 |
| <i>Cordia dwyeri</i> | Boraginaceae | Arm of tiger, hen paw | 4 | 3.0 | 3.0 | 2.8 | 8.8 |
| <i>Arboretum Hyptidendron</i> | Lamiaceae | Aguanoso, white and black vulture, Borrajo | 3 | 2.3 | 2.6 | 2.8 | 7.7 |
| <i>Vismia macrophylla</i> | Hypericaceae | Seven hides | 2 | 1.5 | 2.9 | 2.8 | 7.3 |
| <i>Ficus nymphaeifolia</i> | Moraceae | Rubber | 1 | 0.8 | 5.0 | 1.4 | 7.2 |
| <i>Cecropia angustifolia</i> | Urticaceae | Yarumo, Yarumo black | 3 | 2.3 | 1.4 | 2.8 | 6.5 |
| <i>Gloeospermum sp.</i> | Violaceae | | 2 | 1.5 | 1.1 | 2.8 | 5.4 |
| <i>Guadua angustifolia</i> | Poaceae | Guadua | 3 | 2.3 | 1.4 | 1.4 | 5.0 |
| <i>Vismia baccifera</i> | Hypericaceae | Carate, sealing wax | 2 | 1.5 | 1.6 | 1.4 | 4.5 |
| <i>Nectandra sp. 1</i> | Lauraceae | | 1 | 0.8 | 2.1 | 1.4 | 4.2 |
| <i>Cinnamomum triplinerve</i> | Lauraceae | Laurel Perillo, laurel, aguacatillo | 2 | 1.5 | 1.3 | 1.4 | 4.2 |
| <i>Rollinia edulis</i> | Annonaceae | Mahoe | 1 | 0.8 | 1.5 | 1.4 | 3.7 |
| <i>Unonopsis sp.</i> | Annonaceae | | 1 | 0.8 | 1.2 | 1.4 | 3.4 |
| <i>Indet. 2</i> | Indet. 2 | | 1 | 0.8 | 0.9 | 1.4 | 3.0 |
| <i>Inga alba</i> | Fabaceae | Churimo | 1 | 0.8 | 0.7 | 1.4 | 2.9 |

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| Scientific name | Family | Common Name | Ab | Ab rel % | Dom rel% | Fr rel % | IVI |
|--|-----------------|---|-----------|-----------|------------|------------|------------|
| <i>Echinoderms exhibit fivefold Bellucia</i> | Melastomataceae | Coronillo, guava of pava, guava of Monte, guava from mico | 1 | 0.8 | 0.6 | 1.4 | 2.8 |
| <i>Regia Welfia</i> | Arecaceae | Thousand pesos, San Juan | 1 | 0.8 | 0.6 | 1.4 | 2.8 |
| <i>Miconia dolichorrhyncha</i> | Melastomataceae | White mortiño | 1 | 0.8 | 0.5 | 1.4 | 2.7 |
| <i>Ocotea macropoda</i> | Lauraceae | Laurel | 1 | 0.8 | 0.5 | 1.4 | 2.7 |
| <i>Hieronyma sp.</i> | Phyllanthaceae | Leno | 1 | 0.8 | 0.4 | 1.4 | 2.6 |
| <i>Alchornea megalophylla</i> | Euphorbiaceae | | 1 | 0.8 | 0.4 | 1.4 | 2.6 |
| <i>Casearia arborea</i> | Salicaceae | Niguito, Escobo, Espadero | 1 | 0.8 | 0.4 | 1.4 | 2.6 |
| <i>Inga sp. 8</i> | Fabaceae | | 1 | 0.8 | 0.4 | 1.4 | 2.6 |
| <i>Erythroxylum citrifolium</i> | Erythroxylaceae | Coca | 1 | 0.8 | 0.4 | 1.4 | 2.5 |
| <i>Euterpe precatória</i> | Arecaceae | Palm-kernel oil, macana | 1 | 0.8 | 0.3 | 1.4 | 2.5 |
| <i>Lacistema aggregatum than</i> | Lacistemataceae | Coffee of Mt. | 1 | 0.8 | 0.3 | 1.4 | 2.5 |
| Total | | | 13 | 10 | 100 | 100 | 300 |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance value

Although this coverage contains pioneer species as *Vismia sp.2* and *Cecropia angustifolia*, the majority of species found are associated with intermediate stages of the natural succession, demonstrating that although it is still a young ecosystem, has been enriched with typical species of the forest through the process of dispersion, giving continuity to the process of natural succession and the consequent increase of forest cover.

Low Secondary Vegetation

This coverage applies to initial stages of plant succession, once the disturbance has ceased. Are characterized primarily by the presence of heliophilous invasive species highly competitive with high populations, homogeneous floristic composition, and fast-growing species, with a predominance of individuals of herbaceous mien The intervention area for the project occupies an area of 3.2 ha and is found mainly in the areas where the conduction line and the path to the relief pipeline will be located.

It is divided into 10 plots of 200 m² for a total evaluated area of 0.2 ha, where 26 individuals were counted belonging to 5 families, with 6 species, with a proportion of pioneer species that favor an environment suitable for colonization of succession stages of more advanced species; from them stand out the sietecueros (*Vismia macrophylla*) and -carat stone (*Vismia baccifera*), mixed with other more advanced succession stages as the mantequillo (*Cupania cinerea*) and the espadero (*Myrsine pellucidopunctata*). In this coverage, the vulture (*Piptocoma discolor*), the Carate (*Vismia baccifera*) and the mortiño colorado (*Miconia elata*),

were the species with greater ecological importance, contributing 81.9 % of the IVI for this coverage (see Figure 3-49 ,Photo 3-30 and Table 3-60).

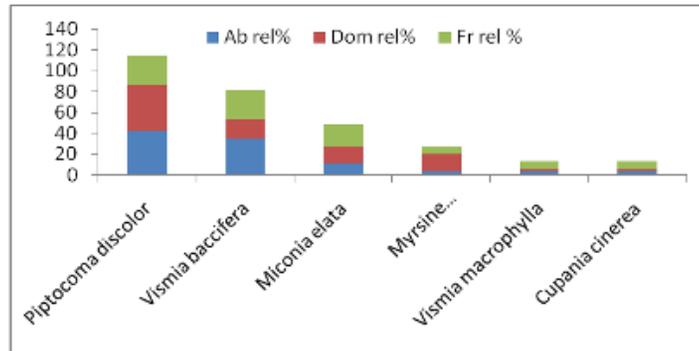


Figure 3-49. Index of Importance value (IVI) of the species recorded for the low secondary vegetation

Table 3-60. Index of Importance value (IVI) of the species recorded for the low secondary vegetation

| Scientific name | Family | Common Name | # Ind | Ab rel% | Dom rel% | Fr rel % | IVI |
|----------------------------------|-----------------|--|-----------|------------|------------|------------|------------|
| <i>Discolor Piptocoma</i> | Asteraceae | Vulture, mulato, pigweed | 11 | 42.3 | 44.1 | 28.6 | 115.0 |
| <i>Vismia baccifera</i> | Hypericaceae | Carate, sealing wax | 9 | 34.6 | 18.9 | 28.6 | 82.0 |
| <i>Miconia elata</i> | Melastomataceae | Colorado mortiño | 3 | 11.5 | 15.7 | 21.4 | 48.7 |
| <i>Myrsine pellucidopunctata</i> | Primulaceae | Espadero | 1 | 3.8 | 16.6 | 7.1 | 27.6 |
| <i>Vismia macrophylla</i> | Hypericaceae | Seven hides | 1 | 3.8 | 2.5 | 7.1 | 13.5 |
| <i>Cupania cinerea</i> | Sapindaceae | Mantequillo, cariseco, Guacharaco, mestizo | 1 | 3.8 | 2.3 | 7.1 | 13.2 |
| Total | | | 26 | 100 | 100 | 100 | 300 |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance value



(a)



(b)

Photo 3-30. Some of the plant species recorded for the sampling in the low secondary vegetation. (A) *Piptocoma discolor*, (b) *Vismia baccifera*.

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Clean Grass

The clean pasture correspond to an array of grazing, in which are dispersed tree or shrub elements, without reaching more than 30% of the array. The direct influence area is distributed throughout the zone, where it covers 10.7 ha. Being the largest area to be intervened (34.9 %). This plant coverage intercepts with the substation, the house of engines, the discharge of the house of engines, the transmission line, the area of deposits 1 and SM4 relief and pressure line, and tracks to the relief pipeline, the house of engines and collection area.

We sampled 0.5 has, equivalent to 25 plots of 200 m² each, and where were counted 19 individuals belonging to nine families and 11 species, being the mortiño colorado (*Miconia elata*), the guava (*Psidium guajava*) and the carob tree (*Hymenaea courbaril*), species with greater ecological importance. The mortiño colorado obtained the highest records in all components of the IVI, while El Guayabo took second place in the relative abundance and relative frequency, only surpassed by the carob tree in the relative dominance (see Figure 3-50 and Table 3-61); the rest of species were reported only once.

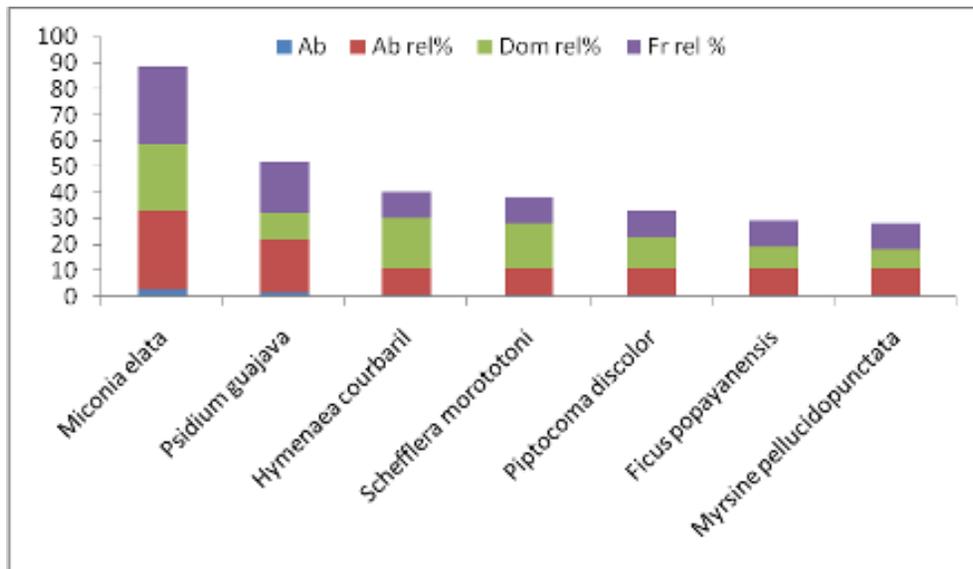


Figure 3-50. Index of Importance value (IVI) of the species recorded for the clean pastures

Table 3-61. Index of Importance value (IVI) of the species recorded for the clean pastures.

| Scientific name | Family | Common Name | # Ind | Ab rel% | Dom rel% | Fr rel % | IVI |
|------------------------------|-----------------|------------------------------|-------|---------|----------|----------|------|
| <i>Miconia elata</i> | Melastomataceae | Colorado mortiño | 3 | 30 | 25.6 | 30 | 85.6 |
| <i>Psidium guajava</i> | Myrtaceae | Guayabo | 2 | 20 | 10.0 | 20 | 50.0 |
| <i>Hymenaea courbaril</i> | Fabaceae | Algarrobo, pecueca, almohada | 1 | 10 | 19.2 | 10 | 39.2 |
| <i>Schefflera morototoni</i> | Araliaceae | Arracacho | 1 | 10 | 17.2 | 10 | 37.2 |
| <i>Discolor Piptocoma</i> | Asteraceae | Vulture, mulato, pigweed | 1 | 10 | 12.2 | 10 | 32.2 |

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| Scientific name | Family | Common Name | # Ind | Ab rel% | Dom rel% | Fr rel % | IVI |
|----------------------------------|-------------|-------------|-----------|------------|------------|------------|------------|
| <i>Ficus popayanensis</i> | Moraceae | Salary | 1 | 10 | 8.3 | 10 | 28.3 |
| <i>Myrsine pellucidopunctata</i> | Primulaceae | Espadero | 1 | 10 | 7.4 | 10 | 27.4 |
| Total | | | 10 | 100 | 100 | 100 | 300 |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance value.

All individuals present in the clean pasture are distributed randomly, presenting three or fewer individuals per species and have remained, either because they are used for cattle sombre, by its location or its wood quality as is the case of the carob tree (*H. courbaril*), the sueldo (*Ficus popayanensis*) and arracacho (*Schefflera morototoni*).

Wooded pasture

With the same economic purposes of clean grass, the wooded pasture is a coverage dedicated mainly for grazing cattle. The area to be intervened occupies 7.6 has, corresponding to 24.8 per cent of the area to intervene, where will be located part of deposits 3, 5 and SM4, collection, sand remover, the transmission line, and the way to the relief pipeline, the house of engines and collection, among other facilities.

20 Plots of 200 m² were established, corresponding to 0.4 ha, where we recorded 70 individuals belonging to nine families and 12 species, with *Piptocoma discolor* as the species with higher ecological weight, with more than half of the IVI (51 %) (See Figure 3-51 and Table 3-62); this tree is one of the most abundant for the entire study area, which suggests a high adaptability to the area conditions. As in the clean pasture, in this coverage there is no uniformity in the characteristics of the species that inhabit, since species are observed as pioneering *P. discolor*, *Psidium guajava* and *Vismia macrophylla*, but there are also species of more advanced succession stages as *Myrsine pellucidopunctata*, *Hymenaea courbaril*, *Nectandra cuspidata* and *Rhodostemonodaphne kunthiana*, which is explained by the uses or features that these species deliver to the communities of the area, including the considered beneficial for this type of coverage.

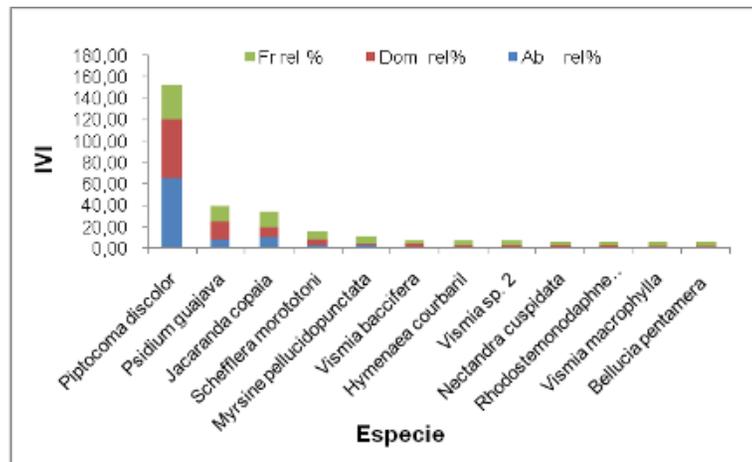


Figure 3-51. Index of Importance value (IVI) of the species recorded for the wooded pasture

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Table 3-62. Index of Importance value (IVI) of the species recorded for the wooded pasture

| # | Scientific name | Common Name | Family | # Ind | Ab rel% | Dom rel% | Fr rel % | IVI |
|----------------------|--|-------------------------|-----------------|-----------|---------------|---------------|---------------|---------------|
| 1 | <i>Discolor Piptocoma</i> | Turkey Vulture | Asteraceae | 46 | 65.71 | 55.07 | 32.14 | 152.93 |
| 2 | <i>Psidium guajava</i> | Guayabo | Myrtaceae | 6 | 8.57 | 16.46 | 14.29 | 39.32 |
| 3 | <i>Jacaranda copaia</i> | Chingale | Bignoniaceae | 7 | 10.00 | 9.91 | 14.29 | 34.20 |
| 4 | <i>Schefflera morototoni</i> | Arracacho | Araliaceae | 2 | 2.86 | 5.59 | 7.14 | 15.59 |
| 5 | <i>Myrsine pellucidopunctata</i> | Espadero | Primulaceae | 2 | 2.86 | 1.50 | 7.14 | 11.50 |
| 6 | <i>Vismia baccifera</i> | Carate | Hypericaceae | 1 | 1.43 | 2.29 | 3.57 | 7.29 |
| 7 | <i>Hymenaea courbaril</i> | Algarrobo | Fabaceae | 1 | 1.43 | 1.99 | 3.57 | 6.99 |
| 8 | <i>Vismia sp. 2</i> | Punta del Este'e tiller | Hypericaceae | 1 | 1.43 | 1.99 | 3.57 | 6.99 |
| 9 | <i>Nectandra cuspidata</i> | Laurel pavito | Lauraceae | 1 | 1.43 | 1.63 | 3.57 | 6.63 |
| 10 | <i>Rhodostemonodaphne kunthiana</i> | | Lauraceae | 1 | 1.43 | 1.63 | 3.57 | 6.63 |
| 11 | <i>Vismia macrophylla</i> | Siete cueros | Hypericaceae | 1 | 1.43 | 1.13 | 3.57 | 6.13 |
| 12 | <i>Echinoderms fivefold Bellucia</i> exhibit | Guayabo IMCO | Melastomataceae | 1 | 1.43 | 0.80 | 3.57 | 5.80 |
| Overall Total | | | | 70 | 100.00 | 100.00 | 100.00 | 300.00 |

Ind: Number of individuals. Ab rel%: Relative abundance. Fr rel%: Relative frequency. Dom rel%: Relative dominance. IVI: Index of Importance value

Weeded Grass

This coverage is represented by lands that are occupied with grass and weeds, forming associations of secondary vegetation. In areas where the facilities will be built, the weeded grass occupies an area of 2.0 ha, where will be built part of deposits SM2, 4 and 5, the house of engines, the weir, pondage and tracks to the house of engines and collection. This area corresponds to a 6.5 % of the total built-up area.

This coverage was evaluated in 15 plots of 200 m², which is equivalent to 7.8 % of the total area of weeded grass in the AID. There were 26 individuals belonging to 9 botanical families and 13 species (see Figure 3-52 and Table 3-63).

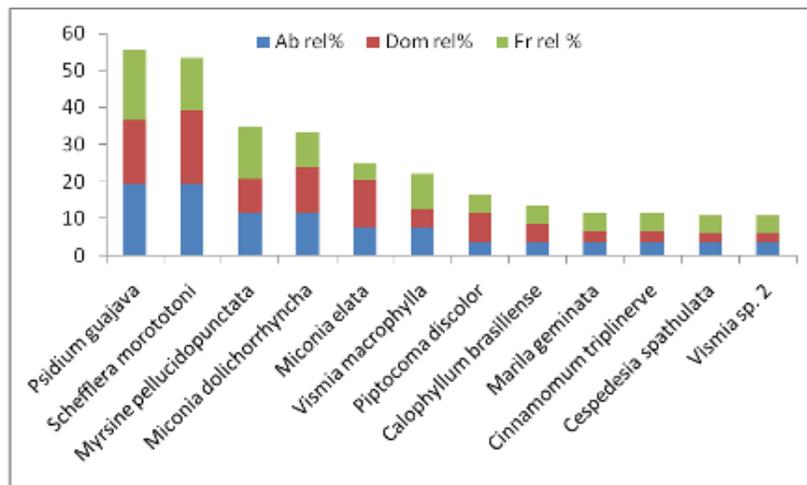


Figure 3-52. Index of Importance value (IVI) of the species recorded for the weeded pastures.

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Table 3-63. Index of Importance value (IVI) of the species recorded for the weeded pastures.

| Scientific name | Common Name | Family | # Ind | Ab rel% | Dom rel% | Fr rel % | IVI |
|----------------------------------|--|-----------------|-----------|--------------|--------------|--------------|--------------|
| <i>Psidium guajava</i> | Guayabo | Myrtaceae | 5 | 19.2 | 17.5 | 19.0 | 55.8 |
| <i>Schefflera morototoni</i> | Arracacho | Araliaceae | 5 | 19.2 | 20.0 | 14.3 | 53.5 |
| <i>Myrsine pellucidopunctata</i> | Espadero | Primulaceae | 3 | 11.5 | 9.2 | 14.3 | 35.0 |
| <i>Miconia dolichorrhyncha</i> | White mortiño | Melastomataceae | 3 | 11.5 | 12.5 | 9.5 | 33.6 |
| <i>Miconia elata</i> | Colorado mortiño | Melastomataceae | 2 | 7.7 | 12.7 | 4.8 | 25.2 |
| <i>Vismia macrophylla</i> | Siete cueros | Hypericaceae | 2 | 7.7 | 5.1 | 9.5 | 22.3 |
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | Asteraceae | 1 | 3.8 | 7.8 | 4.8 | 16.4 |
| <i>Calophyllum brasiliense</i> | Oil, Oil mary, barcino | Calophyllaceae | 1 | 3.8 | 4.9 | 4.8 | 13.5 |
| <i>Marila geminata</i> | | Calophyllaceae | 1 | 3.8 | 2.8 | 4.8 | 11.4 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | Lauraceae | 1 | 3.8 | 2.8 | 4.8 | 11.4 |
| <i>Cespedesia spathulata</i> | Paco, Pedro boys read, Alejandro, language cow leg | Ochnaceae | 1 | 3.8 | 2.3 | 4.8 | 11.0 |
| <i>Vismia sp. 2</i> | Punta de lanza | Hypericaceae | 1 | 3.8 | 2.3 | 4.8 | 10.9 |
| Total | | | 26 | 100.0 | 100.0 | 100.0 | 300.0 |

The guava (*Psidium guajava*) is the species with the highest ecological importance of this coverage, because it has the highest values in two of the three components of the importance value index (IVI), exceeded only in the component by the relative dominance of the arracacho (*S. morototoni*), which occupies the second place; these two species account for more than a third of the IVI total. In summary, all the species recorded in this coverage have in common that they are heliophytes that can be at free exposure in all its stages and by the parasol shaped form of its canopies are well seen by the locals as trees or timber of bleak, as is the case of oil (*Calophyllum brasiliense*) and arracacho (*S. morototoni*).

➤ Index of Importance value extended

This analysis provides additional information for each of the coverage analyzed and provides a full look of present vegetation in the study area.

Dense Forest of Guadua

Given its clumping character, is clear that the dominant species in this coverage is the Guadua bamboo (*Guadua angustifolia*). This Poaceae represents nearly 48% of the total IVIA, which dominates in almost all of its components, except for the sociological component of Position, where it was relieved by the ajenjillo (*Renealmia* sp. see Photo Photo 3-31).

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Photo 3-31. Renealmia Species sp., one of the few species that compete with Guadua bamboo in the dense forest idem.

In summary, in spite of the superiority of the *G. angustifolia* (see Figure 3-53 and Table 3-64), the first five positions of the IVIA are clearly marked and ensure its presence in the future, since all were recorded in the regeneration evaluation.

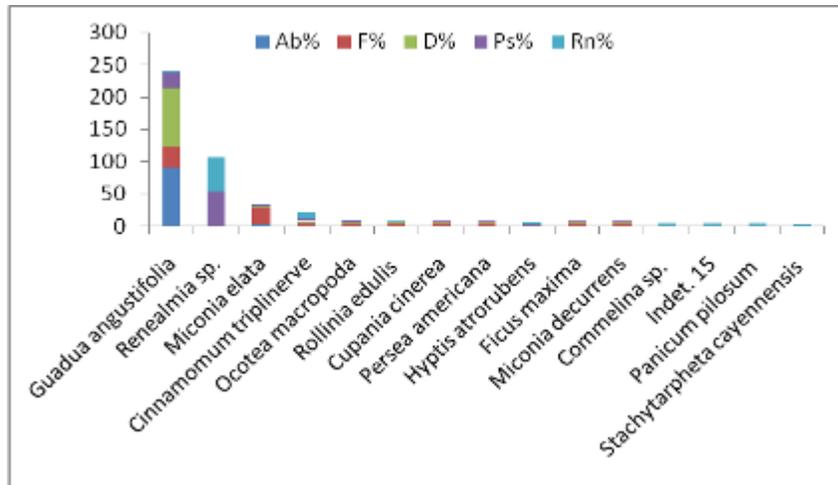


Figure 3-53. Index of Importance value expanded (IVIA) of the species recorded for the dense forest of Guadua.

Table 3-64. Index of Importance value expanded (IVIA) of the species recorded for the dense forest of Guadua

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|-------------------------------|-------------------------------------|---------|---------|----------|------|------|-------|
| <i>Guadua angustifolia</i> | Guadua | 91.4 | 31.3 | 91.7 | 23.9 | 1.4 | 239.6 |
| <i>Renealmia sp.</i> | Ajenjillo | | | | 54.4 | 53.5 | 107.8 |
| <i>Miconia elata</i> | Colorado mortiño | 4.0 | 25.0 | 3.5 | 0.7 | 1.3 | 34.5 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | 0.7 | 6.3 | 0.5 | 5.6 | 9.4 | 22.4 |
| <i>Ocotea macropoda</i> | Laurel | 0.7 | 6.3 | 0.8 | 0.5 | 1.4 | 9.7 |
| <i>Rollinia edulis</i> | Mahoe | 0.7 | 6.3 | 0.8 | 0.2 | 1.3 | 9.2 |

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| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|-----------------------------------|--|---------|---------|----------|-----|-----|------|
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | 0.7 | 6.3 | 0.9 | 0.1 | | 7.9 |
| <i>Persea americana</i> | | 0.7 | 6.3 | 0.9 | 0.1 | | 7.9 |
| <i>Hyptis atrorubens</i> | Buttonwood, Cartagena, mastranto | | | | 3.0 | 4.8 | 7.8 |
| <i>Ficus maximum</i> | Rubber, dairy and lechudo | 0.7 | 6.3 | 0.4 | 0.1 | | 7.5 |
| <i>Miconia decurrens</i> | White mortiño | 0.7 | 6.3 | 0.4 | 0.1 | | 7.4 |
| <i>Commelina sp.</i> | Always alive | | | | 2.2 | 3.1 | 5.3 |
| <i>Indet. 15</i> | Kingras | | | | 1.9 | 2.8 | 4.6 |
| <i>Panicum pilosum</i> | | | | | 1.9 | 2.8 | 4.6 |
| <i>Stachytarpheta cayennensis</i> | Chilca, verbena negra, cola de armadillo | | | | 0.7 | 2.9 | 3.6 |
| <i>Ageratum houstonianum</i> | | | | | 1.1 | 2.1 | 3.2 |
| <i>Clidemia bullosa</i> | | | | | 0.7 | 1.8 | 2.5 |
| <i>Patens Vernonanthura</i> | Salvion | | | | 0.7 | 1.8 | 2.5 |
| <i>Crotalaria nitens</i> | Cascabelito | | | | 0.4 | 1.4 | 1.8 |
| <i>Diplazium sp.</i> | | | | | 0.4 | 1.4 | 1.8 |
| <i>Ficus popayanensis</i> | Sueldo | | | | 0.4 | 1.4 | 1.8 |
| <i>Hyptis obtusiflora</i> | | | | | 0.4 | 1.4 | 1.8 |
| <i>Spermacoceae sp. 3</i> | | | | | 0.4 | 1.4 | 1.8 |
| <i>Clibadium surinamense</i> | Salvia, language of cow, mastranto | | | | 0.1 | 1.3 | 1.4 |
| <i>Protium colombianum</i> | | | | | 0.1 | 1.3 | 1.4 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological relative Position r, Rn%: Natural relative regeneration

Open Forest

This coverage is poorly represented in the study area, primarily by the removal of timber species.

The dominant species is the cirpo (*Pourouma hirsutipetiolata*), followed closely by the silbasilba (*Hedyosmum racemosum*), which together represent more than 40% of the total value of the IVIA (see Figure 3-54 and Table 3-65). In spite of the fact that the cirpo is reported in the regeneration with a 2.9 %, its middle-term position in the IVIA is threatened by the silbasilba, which is the best represented in this component with the 11.9 % of the natural regeneration evaluated. The first seven species of the IVI coincide with those of the IVIA, however, the species that occupies the eight position of IVI (*Campania camera*), was relegated in the IVIA until the thirteenth position, by species that were reported for two of the five components of this index expanded. In this way the future of the *Campania camera*, in case the present conditions persist, will be to occupy secondary positions of the IVI or even disappear from the coverage, by absence in the lower sections of the forest.

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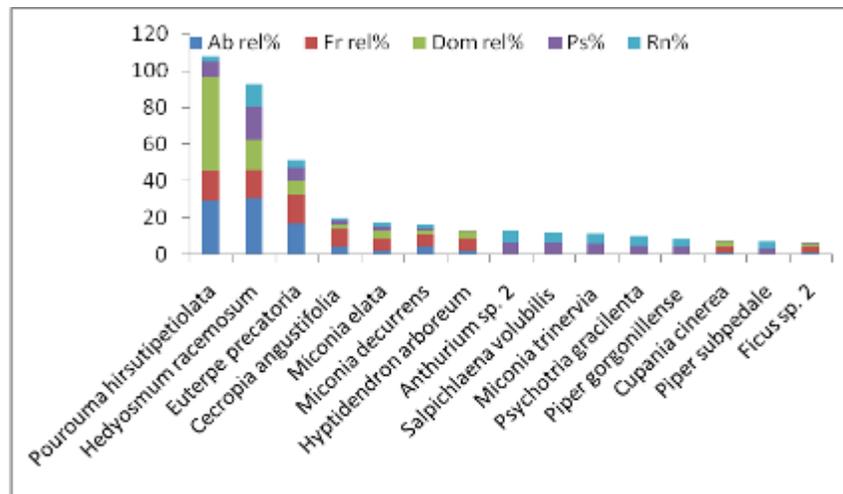


Figure 3-54. Index of Importance value expanded (IVIA) of the species recorded for the open forest

Table 3-65. Index of Importance value expanded (IVIA) of the species recorded for the open forest

| Científica name | Como name | Ab real % | Fr real % | Don real% | Psi% | Rn% | IVIA |
|--------------------------------|--|-----------|-----------|-----------|------|------|-------|
| <i>Puruña hirsutipetiolata</i> | Cirpo | 29.5 | 15.6 | 51.1 | 8.5 | 2.9 | 107.7 |
| <i>Hedyosmum racemosum</i> | Silbasilba, hail | 30.7 | 15.6 | 16.3 | 18.0 | 11.9 | 92.5 |
| <i>Euterpe precatória</i> | Palm-kernel oil, macana | 17.0 | 15.6 | 7.1 | 7.3 | 4.4 | 51.4 |
| <i>Cecropia angustifolia</i> | Yarumo, Yarumo black | 4.5 | 9.4 | 2.6 | 2.3 | 1.4 | 20.3 |
| <i>Miconia elata</i> | Colorado mortiño | 2.3 | 6.3 | 4.8 | 1.7 | 2.5 | 17.5 |
| <i>Miconia decurrens</i> | White mortiño | 4.5 | 6.3 | 2.3 | 1.5 | 1.6 | 16.1 |
| <i>Arboretum Hyptidendron</i> | Aguanoso, white and black vulture, Borrajo | 2.3 | 6.3 | 4.5 | 0.5 | | 13.6 |
| <i>Anthurium sp. 2</i> | Sheet heart | | | | 6.8 | 6.7 | 13.5 |
| <i>Volubilis Salpichlaena</i> | | | | | 6.4 | 5.9 | 12.3 |
| <i>Miconia trinervia</i> | Inciden white | | | | 5.8 | 5.5 | 11.3 |
| <i>Psychotria gracilenta</i> | | | | | 4.8 | 5.7 | 10.5 |
| <i>Piper gorgonillense</i> | | | | | 4.3 | 4.2 | 8.5 |
| <i>Cupania cinerea</i> | Mantequillo, Guacharaco, mestizo cariseco, | 1.1 | 3.1 | 3.4 | 0.3 | | 7.9 |
| <i>Piper subpedale</i> | | | | | 3.4 | 4.0 | 7.4 |
| <i>Ficus sp. 2</i> | Sueldo | 1.1 | 3.1 | 2.3 | 0.3 | | 6.8 |
| <i>Ocotea macropoda</i> | Laurel | 1.1 | 3.1 | 0.8 | 0.7 | 0.8 | 6.5 |
| <i>Myrcia sp. 2</i> | | 1.1 | 3.1 | 1.5 | 0.3 | | 6.0 |
| <i>Eugenia florida</i> | | 1.1 | 3.1 | 1.3 | 0.3 | | 5.8 |
| <i>Costus Lasius</i> | Canaguatè | | | | 3.0 | 2.8 | 5.8 |
| <i>Thelypteris sp. 3</i> | | | | | 3.0 | 2.8 | 5.8 |
| <i>Cecropia peltata</i> | Yarumo | 1.1 | 3.1 | 0.6 | 0.3 | | 5.2 |
| <i>Cordia sp.</i> | | 1.1 | 3.1 | 0.6 | 0.3 | | 5.2 |

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| Científica name | Como name | Ab real % | Fr real % | Don real% | Psi% | Rn% | IVIA |
|--|-------------------------------------|-----------|-----------|-----------|------|-----|------|
| <i>Tetrorchidium robledoanum</i> | | 1.1 | 3.1 | 0.7 | 0.2 | | 5.2 |
| <i>Diplazium sp.</i> | | | | | 2.6 | 2.4 | 5.0 |
| <i>Paniculata Coussarea</i> | | | | | 1.4 | 2.7 | 4.1 |
| <i>Indet. 12</i> | | | | | 1.7 | 1.8 | 3.5 |
| <i>Piper obrutum</i> | | | | | 1.7 | 1.8 | 3.5 |
| <i>Psychotria longirostris</i> | Coffee Tree of Mt. | | | | 0.9 | 2.4 | 3.3 |
| <i>Guatteria bolivian</i> | Garrapato | | | | 0.6 | 2.2 | 2.9 |
| <i>Piper arboreum</i> | Ribbing | | | | 1.0 | 1.8 | 2.8 |
| <i>Piper munchanum</i> | | | | | 1.0 | 1.8 | 2.8 |
| <i>Bicolor Pourouma</i> | Cirpo, cirpo male | | | | 0.8 | 1.7 | 2.5 |
| <i>Asplundia sp. 1</i> | | | | | 0.9 | 1.6 | 2.4 |
| <i>Asterogyne martiana</i> | Panda, panga, rooster tail | | | | 0.9 | 1.6 | 2.4 |
| <i>Marila sp.</i> | | | | | 0.8 | 1.3 | 2.2 |
| <i>Calophyllum brasiliense</i> | Oil, Oil mary, barcino | | | | 0.6 | 1.6 | 2.1 |
| <i>Clidemia bullosa</i> | | | | | 0.9 | 1.1 | 2.0 |
| <i>Purpurea Sciaphila</i> | | | | | 0.9 | 1.1 | 2.0 |
| <i>Ficus macbridei</i> | | | | | 0.3 | 0.9 | 1.2 |
| <i>Miconia sp.</i> | | | | | 0.4 | 0.8 | 1.2 |
| <i>Myrcia sp. 1</i> | | | | | 0.4 | 0.8 | 1.2 |
| <i>Nectandra sp. 1</i> | | | | | 0.4 | 0.8 | 1.2 |
| <i>Piper crassinervium</i> | Ribbing | | | | 0.4 | 0.8 | 1.2 |
| <i>Renealmia cf. thyrsoides</i> | Platanillo, Berber | | | | 0.4 | 0.8 | 1.2 |
| <i>Bactris gasipaes Bactris setulosa are found cf.</i> | | | | | 0.3 | 0.7 | 0.9 |
| <i>Cf. Oxandra sp.</i> | | | | | 0.2 | 0.7 | 0.8 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | | | | 0.2 | 0.7 | 0.8 |
| <i>Cyathea molederana</i> | | | | | 0.2 | 0.7 | 0.8 |
| <i>Indet. 1</i> | | | | | 0.2 | 0.7 | 0.8 |
| <i>Inga thibaudiana</i> | | | | | 0.2 | 0.7 | 0.8 |
| <i>Marila geminata</i> | | | | | 0.2 | 0.7 | 0.8 |
| <i>Palicourea cf. garciae</i> | | | | | 0.2 | 0.7 | 0.8 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological Position relative, Rn%: Natural regeneration relative.

High Secondary Vegetation

In this coverage, the intermediate succession status, notes that, as the IVI, the cirpo (*Pourouma hirsutipetiolata*) is the species with the highest value of the IVIA and this was justified given that in almost all of its components is first, which is a permanence guarantee in time in this coverage. This species represents 16.4 % of the IVIA, followed by the silbasilba (*Hedyosmum racemosum*), with only 4.7 % of the idem.

It is noticeable that the punta de lanza (*Vismia sp.2*) passed from the fourth place in the IVI until the seventh in the IVIA, which is justified because it was not reported in the regeneration, while the preceding were; for example, the black rubber (*Castilla elastic*), although it has a

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0.3 per cent of this component, in addition to the fact that the value of the sociological position is also slightly higher than the punta de lanza, it was barely enough to overcome it. While the mortiños colorado (*Miconia elata*) and white (*Miconia decurrens*) moved the *Vismia* sp2, due that they are clearly greater in the components of natural regeneration and sociological position than the first. However, these high values were not enough to overcome the black rubber (*elastic C.*) of the fourth place in the IVIA (see Figure 3-55 and Table 3-66).

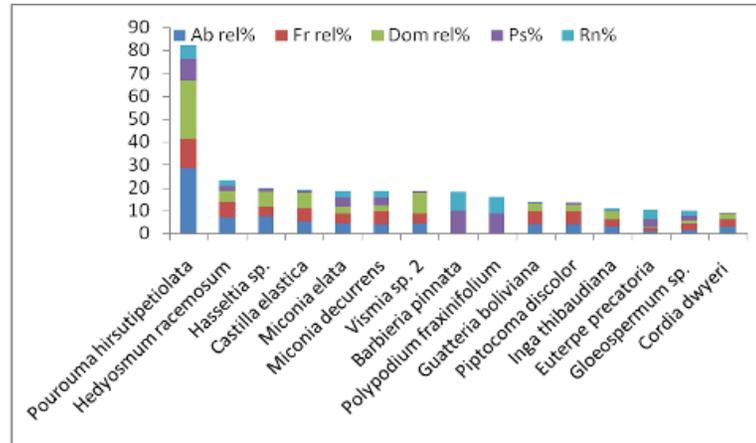


Figure 3-55. Index of Importance value expanded (IVIA) of the species recorded for the high secondary vegetation.

Table 3-66. Index of Importance value expanded (IVIA) of the species recorded for the high secondary vegetation.

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|----------------------------------|--|---------|---------|----------|------|-----|------|
| <i>Pourouma hirsutipetiolata</i> | Cirpo | 28.6 | 12.7 | 25.5 | 9.5 | 5.9 | 82.2 |
| <i>Hedyosmum racemosum</i> | Silbasilba, hail | 6.8 | 7.0 | 4.5 | 2.3 | 2.7 | 23.3 |
| <i>Hasseltia sp.</i> | | 7.5 | 4.2 | 6.2 | 1.2 | 0.6 | 19.8 |
| <i>Castilla elastica</i> | Black Rubber, rubber female | 5.3 | 5.6 | 6.9 | 0.8 | 0.3 | 18.9 |
| <i>Miconia elata</i> | Colorado mortiño | 4.5 | 4.2 | 3.0 | 3.6 | 3.3 | 18.7 |
| <i>Miconia decurrens</i> | White mortiño | 3.8 | 5.6 | 2.6 | 3.4 | 3.0 | 18.5 |
| <i>Vismia sp. 2</i> | Punta lanza | 4.5 | 4.2 | 9.1 | 0.6 | | 18.4 |
| <i>Pinnata Barbieria</i> | | | | | 10.1 | 8.0 | 18.1 |
| <i>Polypodium fraxinifolium</i> | | | | | 8.7 | 7.0 | 15.8 |
| <i>Guatteria boliviana</i> | Garrapato | 3.8 | 5.6 | 3.7 | 0.6 | 0.3 | 14.0 |
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | 3.8 | 5.6 | 3.2 | 0.5 | | 13.1 |
| <i>Inga thibaudiana</i> | | 3.0 | 2.8 | 3.6 | 0.7 | 0.4 | 10.6 |
| <i>Euterpe precatoria</i> | Palm-kernel oil, macana | 0.8 | 1.4 | 0.3 | 3.6 | 4.1 | 10.2 |
| <i>Gloeospermum sp.</i> | | 1.5 | 2.8 | 1.1 | 2.3 | 2.2 | 9.9 |
| <i>Cordia dwyeri</i> | Arm of tiger, hen paw | 3.0 | 2.8 | 3.0 | 0.4 | | 9.2 |
| <i>Guadua angustifolia</i> | Guadua | 2.3 | 1.4 | 1.4 | 1.5 | 1.6 | 8.1 |
| <i>Arboretum Hyptidendron</i> | Aguanoso, white and black vulture, Borrajo | 2.3 | 2.8 | 2.6 | 0.3 | | 8.0 |
| <i>Vismia macrophylla</i> | Siete cueros | 1.5 | 2.8 | 2.9 | 0.4 | 0.4 | 8.0 |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|--|--|---------|---------|----------|-----|-----|------|
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | 1.5 | 1.4 | 1.3 | 1.9 | 1.9 | 8.0 |
| <i>Cecropia angustifolia</i> | Yarumo, Yarumo black | 2.3 | 2.8 | 1.4 | 0.6 | 0.7 | 7.8 |
| <i>Ficus nymphaeifolia</i> | Rubber | 0.8 | 1.4 | 5.0 | 0.1 | | 7.3 |
| <i>Tococa lancifolia</i> <i>guianensis</i> | Anthill | | | | 3.7 | 3.6 | 7.3 |
| <i>Thelypteris sp. 1</i> | | | | | 3.5 | 3.2 | 6.7 |
| <i>Volubilis Salpichlaena</i> | | | | | 3.5 | 2.8 | 6.3 |
| <i>Regia Welfia</i> | Thousand pesos, San Juan | 0.8 | 1.4 | 0.6 | 1.4 | 1.6 | 5.7 |
| <i>Inga sp. 8</i> | | 0.8 | 1.4 | 0.4 | 1.5 | 1.6 | 5.7 |
| <i>Anthurium sp. 1</i> | Sheet heart | | | | 2.7 | 2.4 | 5.1 |
| <i>Vismia baccifera</i> | Carate, sealing wax | 1.5 | 1.4 | 1.6 | 0.2 | | 4.7 |
| <i>Erythroxylum citrifolium</i> | Coca | 0.8 | 1.4 | 0.4 | 0.6 | 1.5 | 4.6 |
| <i>Nectandra sp. 1</i> | | 0.8 | 1.4 | 2.1 | 0.1 | | 4.4 |
| <i>Casearia arborea</i> | Niguito, Escobo, Espadero | 0.8 | 1.4 | 0.4 | 0.5 | 1.0 | 4.0 |
| <i>Alchornea megalophylla</i> | | 0.8 | 1.4 | 0.4 | 0.4 | 0.9 | 3.8 |
| <i>Rollinia edulis</i> | Mahoe | 0.8 | 1.4 | 1.5 | 0.1 | | 3.8 |
| <i>Unonopsis sp.</i> | | 0.8 | 1.4 | 1.2 | 0.1 | | 3.5 |
| <i>Inga alba</i> | Churimo | 0.8 | 1.4 | 0.7 | 0.2 | 0.3 | 3.4 |
| <i>Mendoncia sp.</i> | Surmulletts (= Redmulletts) Castaneta Brazilian sandperches | | | | 1.7 | 1.5 | 3.2 |
| <i>Monopyle macrocarpa</i> | | | | | 1.7 | 1.5 | 3.2 |
| <i>Indet. 2</i> | | 0.8 | 1.4 | 0.9 | 0.1 | | 3.1 |
| <i>Lacistema aggregatum</i> <i>than</i> | Coffee of Mt. | 0.8 | 1.4 | 0.3 | 0.1 | 0.4 | 3.0 |
| <i>Piper sp. 1</i> | | | | | 1.6 | 1.4 | 2.9 |
| <i>Clidemia crenulata</i> | | | | | 1.4 | 1.5 | 2.9 |
| <i>Echinoderms exhibit</i> <i>fivefold Bellucia</i> | Coronillo, guava of pava, guava trees of Monte, guava from mico | 0.8 | 1.4 | 0.6 | 0.1 | | 2.9 |
| <i>Miconia dolichorrhyncha</i> | White mortiño | 0.8 | 1.4 | 0.5 | 0.1 | | 2.8 |
| <i>Piper seducentifolium</i> | | | | | 1.4 | 1.4 | 2.8 |
| <i>Ocotea macropoda</i> | Laurel | 0.8 | 1.4 | 0.5 | 0.1 | | 2.8 |
| <i>Hieronyma sp.</i> | Leno | 0.8 | 1.4 | 0.4 | 0.1 | | 2.7 |
| <i>Miconia dodecandra</i> | | | | | 1.4 | 1.2 | 2.6 |
| <i>Piper sp. Nov! 2</i> | | | | | 1.2 | 1.4 | 2.6 |
| <i>Lindsaea lancea</i> | | | | | 1.2 | 1.1 | 2.2 |
| <i>Piper aduncum</i> | Ribbing | | | | 1.2 | 1.1 | 2.2 |
| <i>Myrcia fallax</i> | Arrayán | | | | 0.8 | 1.5 | 2.2 |
| <i>Cyathea andina</i> | Tree Fern | | | | 0.3 | 1.7 | 2.0 |
| <i>Anthurium formosum</i> | | | | | 1.0 | 0.9 | 1.9 |
| <i>Piper obrutum</i> | | | | | 1.0 | 0.9 | 1.9 |
| <i>Anthurium sp. 2</i> | Sheet heart | | | | 0.8 | 1.0 | 1.8 |
| <i>Renealmia cernua</i> | | | | | 0.8 | 1.0 | 1.8 |
| <i>Psychotria gracilenta</i> | | | | | 0.4 | 1.2 | 1.6 |
| <i>Paullinia sp. 2</i> | | | | | 0.8 | 0.8 | 1.6 |
| <i>Psychotria deflexa</i> | | | | | 0.8 | 0.8 | 1.6 |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|--|--|---------|---------|----------|------|-----|------|
| <i>Persea sp.</i> | | | | | 0.2 | 1.1 | 1.4 |
| <i>Thelypteris falcata</i> | | | | | 0.3 | 1.1 | 1.3 |
| <i>Ageratina sp. 1</i> | Chilca | | | | 0.6 | 0.6 | 1.2 |
| <i>Anthurium sp. 4</i> | | | | | 0.6 | 0.6 | 1.2 |
| <i>Nectandra sp. 2</i> | | | | | 0.6 | 0.6 | 1.2 |
| <i>Piper sp. Nov! 1</i> | Guayaquil | | | | 0.6 | 0.6 | 1.2 |
| <i>Bactris gasipaes Bactris setulosa are found cf.</i> | | | | | 0.3 | 0.9 | 1.2 |
| <i>Asplundia sp. 2</i> | | | | | 0.3 | 0.7 | 1.1 |
| <i>Tovomita weddelliana are excluded</i> | Carate | | | | 0.3 | 0.7 | 1.0 |
| <i>Indet. 7</i> | Palma | | | | 0.4 | 0.5 | 0.9 |
| <i>Mikania micrantha</i> | | | | | 0.4 | 0.5 | 0.9 |
| <i>Myrcia sp. 3</i> | Arrayán | | | | 0.4 | 0.5 | 0.9 |
| <i>Piper subpedale</i> | | | | | 0.4 | 0.5 | 0.9 |
| <i>Tibouchina paratropica kingii</i> | | | | | 0.4 | 0.5 | 0.9 |
| <i>Vismia sp. 1</i> | Punta lanza | | | | 0.2 | 0.4 | 0.6 |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | | | | 0.2 | 0.4 | 0.6 |
| <i>Desmodium adscenden</i> | Amorseco, pegapega, Cadillo | | | | 0.2 | 0.4 | 0.6 |
| <i>Indet. 11</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Indet. 6</i> | Palma | | | | 0.2 | 0.4 | 0.6 |
| <i>Paullinia sp. 1</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Peperomia versicolor</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Philodendron sp. 1</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Piper muncanum</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Rhynchosia minima sp.</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Senna sp.</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Aniba cf. Muca</i> | Inciden Laurel | | | | 0.1 | 0.3 | 0.4 |
| <i>Indet. 14</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Palicourea sp. 1</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Philodendron sp. 3</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Rhodostemonodaphne kunthiana</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Senna bacillaris</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Aciotis indecora</i> | Yuyito | | | | 0.02 | 0.3 | 0.3 |
| <i>Miconia pulvinata</i> | | | | | 0.02 | 0.3 | 0.3 |
| <i>Myrsine pellucidopunctata</i> | Espadero | | | | 0.02 | 0.3 | 0.3 |
| <i>Piper gorgonillense</i> | | | | | 0.02 | 0.3 | 0.3 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological Position relative, Rn%: Natural regeneration relative.

ENVIRONMENTAL IMPACT STUDY

Photo 3-32. Flowers of *Barbieria pinnata***Low Secondary Vegetation**

The first two positions of the IVIA for low secondary vegetation coincide with those of the IVI; however, the *Lycopodiella cernua* scale up to the third position, which is justified by the high values obtained in the sociological position components and natural regeneration where for these occupied the first place.

In Figure 3-56 (Figure 3-56 and Table 3-67 (Table 3-67)) it is noted that all species reported in the low secondary vegetation have a value for the natural regeneration component (Rn%), except the turkey vulture (*Piptocoma discolor*), which surprisingly currently occupies the first place of the IVIA; consequently, it can be assumed that in the event that the current conditions of this coverage remain stable over time, the *P. discolor* is doomed to be relegated and may even disappear from this coverage in the medium term.

ENVIRONMENTAL IMPACT STUDY

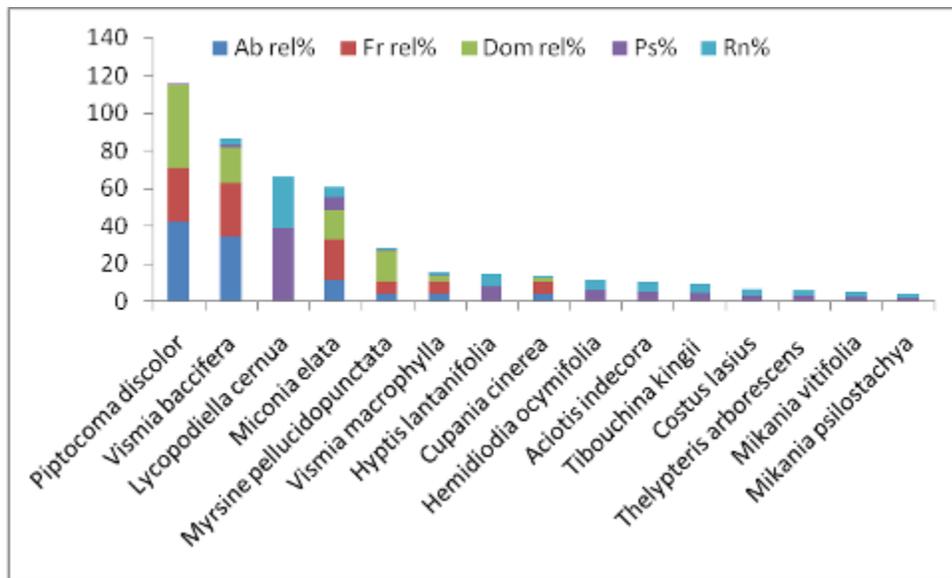


Figure 3-56. Index of Importance value expanded (IVIA) of the species recorded for the low secondary vegetation.

Table 3-67. Index of Importance value (IVI) of the species recorded for the low secondary vegetation.

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|--------------------------------------|--|---------|---------|----------|------|------|-------|
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | 42.3 | 28.6 | 44.1 | 0.5 | | 115.4 |
| <i>Vismia baccifera</i> | Carate, lacre | 34.6 | 28.6 | 18.9 | 1.4 | 2.8 | 86.3 |
| <i>Lycopodiella cernua</i> | Mattress of poor | | | | 39.4 | 27.0 | 66.5 |
| <i>Miconia elata</i> | Colorado mortiño | 11.5 | 21.4 | 15.7 | 6.5 | 5.4 | 60.6 |
| <i>Myrsine pellucidopunctata</i> | Espadero | 3.8 | 7.1 | 16.6 | 0.1 | 0.5 | 28.2 |
| <i>Vismia macrophylla</i> | Siete cueros | 3.8 | 7.1 | 2.5 | 0.6 | 1.2 | 15.2 |
| <i>Hyptis lantanifolia</i> | White Manrubio | | | | 7.9 | 6.9 | 14.9 |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | 3.8 | 7.1 | 2.3 | 0.1 | 0.5 | 13.9 |
| <i>Hemidiodia ocymifolia</i> | Sarboleta | | | | 6.1 | 5.3 | 11.4 |
| <i>Aciotis indecora</i> | Yuyito | | | | 5.3 | 5.6 | 10.9 |
| <i>Tibouchina paratropica kingii</i> | | | | | 4.7 | 5.0 | 9.7 |
| <i>Costus Lasius</i> | Canaguante | | | | 3.4 | 3.1 | 6.6 |
| <i>Thelypteris arborescens</i> | | | | | 3.2 | 2.9 | 6.1 |
| <i>Mikania vitifolia</i> | | | | | 2.5 | 3.1 | 5.6 |
| <i>Mikania psilostachya</i> | | | | | 2.1 | 2.2 | 4.4 |
| <i>Coccocypselum hirsutum</i> | Food culebra | | | | 1.9 | 2.1 | 3.9 |
| <i>Spermacoceae sp. 2</i> | | | | | 1.9 | 2.1 | 3.9 |
| <i>Psidium guajava</i> | Guayabo | | | | 0.7 | 3.0 | 3.7 |
| <i>Clidemia crenulata</i> | | | | | 1.3 | 1.3 | 2.6 |
| <i>Davilla kunthii</i> | Lambe ox | | | | 1.1 | 1.6 | 2.6 |
| <i>Spermacoceae sp. 3</i> | | | | | 1.1 | 1.6 | 2.6 |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|------------------------------|-----------------------------|---------|---------|----------|-----|-----|------|
| <i>Spina Gleichenia</i> | | | | | 1.1 | 1.1 | 2.2 |
| <i>Cuphea carthagenensis</i> | Moradita | | | | 0.8 | 1.4 | 2.2 |
| <i>Rhynchospora radicans</i> | | | | | 0.8 | 1.0 | 1.7 |
| <i>Siparuna sessiliflora</i> | Lemon grass | | | | 0.8 | 1.0 | 1.7 |
| <i>Hedyosmum racemosum</i> | Silbasilba, hail | | | | 0.5 | 1.2 | 1.7 |
| <i>Rubus urticifolius</i> | | | | | 0.4 | 1.3 | 1.7 |
| <i>Miconia resima</i> | Niguito | | | | 0.3 | 1.1 | 1.4 |
| <i>Oxandra sp.</i> | | | | | 0.5 | 0.8 | 1.3 |
| <i>Spermacoceae sp. 1</i> | | | | | 0.5 | 0.8 | 1.3 |
| <i>Miconia theaezans</i> | Inciden white, niguito | | | | 0.1 | 1.0 | 1.1 |
| <i>Ageratina sp. 1</i> | Chilca | | | | 0.3 | 0.6 | 0.9 |
| <i>Ageratina sp. 2</i> | | | | | 0.3 | 0.6 | 0.9 |
| <i>Anthurium sp. 2</i> | Sheet heart | | | | 0.3 | 0.6 | 0.9 |
| <i>Baccharis trinervis</i> | Maruchinga, chilco, machuco | | | | 0.3 | 0.6 | 0.9 |
| <i>Clidemia capitellata</i> | | | | | 0.3 | 0.6 | 0.9 |
| <i>Melochia villosa</i> | Malvilla | | | | 0.3 | 0.6 | 0.9 |
| <i>Panicum polygonatum</i> | | | | | 0.3 | 0.6 | 0.9 |
| <i>Piper munchanum</i> | | | | | 0.3 | 0.6 | 0.9 |
| <i>Vismia sp. 2</i> | Tongue Tip | | | | 0.3 | 0.6 | 0.9 |
| <i>Sabicea panamensis</i> | | | | | 0.1 | 0.6 | 0.7 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological Position relative, Rn%: Natural regeneration relative.

Clean Grass

The clean grass is a coverage basically anthropogenic in origin, which is managed and preserved in its current state for economic purposes, mainly for breeding and raising of cattle.

In the same way as in the IVI, the first three positions are repeated for this extended analysis, where the mortiño colorado (*Miconia elata*) dominates with some advantage, supported by the guava (*Psidium guajava*) and the carob tree (*Hymenaea courbaril*) (see Figure 3-57 and Table 3-68). These three species represent 36.7 per cent of the total of the IVIA and given that the first two have values in the five components, it can be inferred that in the event that they retain the conditions and environmental, edaphic, climatic factors, these species will have permanent presence over time in this coverage.

ENVIRONMENTAL IMPACT STUDY

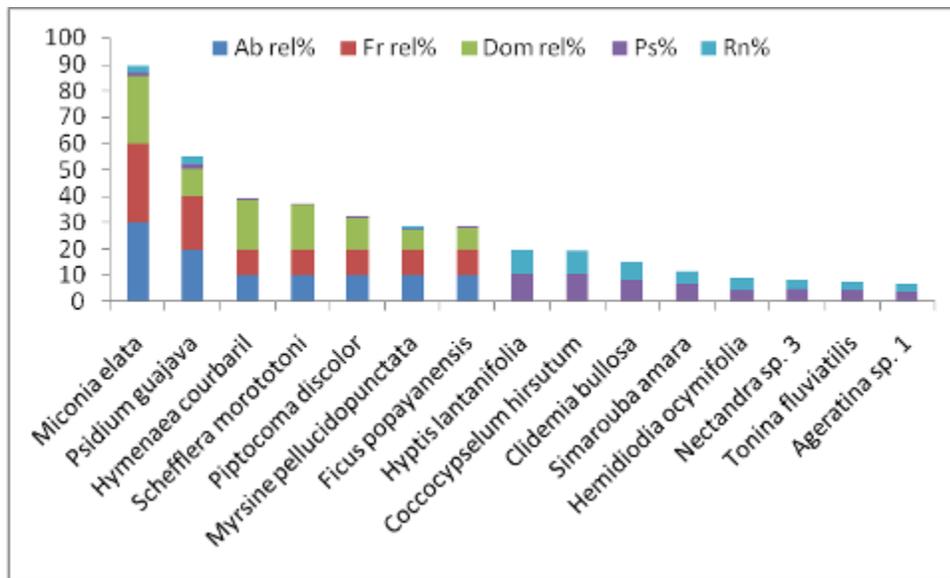


Figure 3-57. Index of Importance value expanded (IVIA) of the species recorded for the clean pastures .

Table 3-68. Index of Importance value expanded (IVIA) of the species recorded for clean pastures.

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|----------------------------------|--|---------|---------|----------|------|-----|------|
| <i>Miconia elata</i> | Colorado mortiño | 30 | 30 | 25.6 | 1.6 | 2.0 | 89.2 |
| <i>Psidium guajava</i> | Guayabo | 20 | 20 | 10.0 | 2.1 | 3.1 | 55.2 |
| <i>Hymenaea courbaril</i> | Algarrobo, pecueca algarroba | 10 | 10 | 19.2 | 0.0 | | 39.2 |
| <i>Schefflera morototoni</i> | Arracacho | 10 | 10 | 17.2 | 0.0 | | 37.2 |
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | 10 | 10 | 12.2 | 0.0 | | 32.2 |
| <i>Myrsine pellucidopunctata</i> | Espadero | 10 | 10 | 7.4 | 0.4 | 0.8 | 28.5 |
| <i>Ficus popayanensis</i> | Sueldo | 10 | 10 | 8.3 | 0.0 | | 28.3 |
| <i>Hyptis lantanifolia</i> | White Manrubio | | | | 10.5 | 9.2 | 19.7 |
| <i>Coccocypselum hirsutum</i> | Food culebra | | | | 10.4 | 8.8 | 19.3 |
| <i>Clidemia bullosa</i> | | | | | 8.2 | 6.9 | 15.1 |
| <i>Simarouba amara</i> | | | | | 6.6 | 5.1 | 11.6 |
| <i>Hemidiodia ocymifolia</i> | Sarboleta | | | | 4.4 | 4.8 | 9.2 |
| <i>Nectandra sp. 3</i> | | | | | 4.6 | 3.6 | 8.2 |
| <i>Tonina fluviatilis</i> | | | | | 4.2 | 3.3 | 7.5 |
| <i>Ageratina sp. 1</i> | Chilca | | | | 3.9 | 2.8 | 6.7 |
| <i>Ageratum conyzoides</i> | Manrubio, fart, herb goat | | | | 3.5 | 3.0 | 6.5 |
| <i>Patens Vernanthura</i> | Salvion | | | | 3.0 | 3.4 | 6.4 |
| <i>Fimbristylis sp.</i> | Guayacana | | | | 3.6 | 2.6 | 6.2 |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | | | | 2.7 | 3.0 | 5.7 |
| <i>Clidemia sericea</i> | Mortiño | | | | 2.4 | 2.6 | 5.0 |
| <i>Pterogastra divaricata</i> | | | | | 2.1 | 2.1 | 4.1 |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|--|--|---------|---------|----------|-----|-----|------|
| <i>Gramineae) melaleuca</i> | Tresfilos, La Cortadera | | | | 2.1 | 2.1 | 4.1 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | | | | 1.7 | 1.6 | 3.3 |
| <i>Hyptis obtusiflora</i> | | | | | 1.3 | 1.6 | 2.9 |
| <i>Miconia aggregata</i> | Niguito | | | | 1.3 | 1.6 | 2.9 |
| <i>Arboretum Hyptidendron</i> | Aguanoso, white and black vulture, Borrajo | | | | 1.3 | 1.3 | 2.6 |
| <i>Melochia villosa</i> | Malvilla | | | | 1.3 | 1.3 | 2.6 |
| <i>Stachytarpheta cayennensis</i> | Chilca, verbena black, armadillo queue | | | | 1.4 | 1.2 | 2.6 |
| <i>Solanum leaves and litter</i> | Raja teta | | | | 0.9 | 1.6 | 2.5 |
| <i>Clidemia capitellata</i> | | | | | 1.2 | 1.2 | 2.4 |
| <i>Ageratina sp. 3</i> | | | | | 1.0 | 1.2 | 2.2 |
| <i>Nectandra cuspidata</i> | Laurel pavito | | | | 1.0 | 1.2 | 2.2 |
| <i>Thelypteris sp. 4</i> | | | | | 0.9 | 1.1 | 2.0 |
| <i>Aciotis indecora</i> | Yuyito | | | | 0.8 | 1.0 | 1.8 |
| <i>Cuphea carthagenensis</i> | Moradita | | | | 0.8 | 0.8 | 1.5 |
| <i>Spermacoceae sp. 2</i> | | | | | 0.4 | 1.0 | 1.4 |
| <i>Davilla kunthii</i> | Lambe ox | | | | 0.6 | 0.7 | 1.3 |
| <i>Justice filibracteolata</i> | | | | | 0.6 | 0.7 | 1.3 |
| <i>Ludwigia octovalvis</i> | Nail swamp, picture of Laguna | | | | 0.6 | 0.7 | 1.3 |
| <i>Spermacoceae sp. 3</i> | | | | | 0.6 | 0.7 | 1.3 |
| <i>Tibouchina paratropica longifolia</i> | | | | | 0.6 | 0.7 | 1.3 |
| <i>Croton Trinitatis</i> | | | | | 0.5 | 0.6 | 1.1 |
| <i>Cyathula prostrata</i> | Cadillo, scorpion | | | | 0.5 | 0.6 | 1.1 |
| <i>Sauvagesia erecta</i> | Simarruga | | | | 0.3 | 0.7 | 0.9 |
| <i>Blechnum polypodioides</i> | | | | | 0.4 | 0.5 | 0.9 |
| <i>Cyperus luzulae</i> | | | | | 0.4 | 0.5 | 0.9 |
| <i>Pavonia mollis</i> | Mauve | | | | 0.4 | 0.5 | 0.9 |
| <i>Aids rhombifolia,</i> | Broom lasts, broom slug | | | | 0.4 | 0.5 | 0.9 |
| <i>Caladium bicolor</i> | Ajenjilla | | | | 0.3 | 0.4 | 0.7 |
| <i>Nectandra cf. microcarpa</i> | Laurel pavito | | | | 0.3 | 0.4 | 0.7 |
| <i>Glomerata Aids</i> | | | | | 0.3 | 0.4 | 0.7 |
| <i>Tococa lancifolia guianensis</i> | Anthill | | | | 0.3 | 0.4 | 0.7 |
| <i>Uniflora Acisanthera</i> | | | | | 0.1 | 0.3 | 0.5 |
| <i>Alchornea cf. acutifolia</i> | Pandequeso | | | | 0.1 | 0.3 | 0.5 |
| <i>Bacopa salzmanni</i> | | | | | 0.1 | 0.3 | 0.5 |
| <i>Desmodium adscenden</i> | Amorseco, pegapega, Cadillo | | | | 0.1 | 0.3 | 0.5 |
| <i>Dioscorea sp.</i> | | | | | 0.1 | 0.3 | 0.5 |
| <i>Hirta Jaegeria</i> | Yellow Button | | | | 0.1 | 0.3 | 0.5 |
| <i>Mimosa sp.</i> | Dormidera | | | | 0.1 | 0.3 | 0.5 |
| <i>Piper gorgonillense</i> | | | | | 0.1 | 0.3 | 0.5 |
| <i>Aids acuta</i> | Broom | | | | 0.1 | 0.3 | 0.5 |
| <i>Urochloa sp.</i> | Brachiaria | | | | 0.1 | 0.3 | 0.5 |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Ab rel% | Fr rel% | Dom rel% | Ps% | Rn% | IVIA |
|---------------------------|---------------|---------|---------|----------|-----------|-----|------|
| <i>Vismia macrophylla</i> | Siete cueros | | | | 0.1 | 0.3 | 0.5 |
| <i>Vismia sp. 2</i> | Tongue Tip | | | | 0.1 | 0.3 | 0.5 |
| <i>Citrus aurantium</i> | Naranja | | | | 0.00 3 | 0.3 | 0.3 |
| <i>Miconia trinervia</i> | Inciden white | | | | 0.00 3 | 0.3 | 0.3 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Relative Sociological Position, Rn%: Natural regeneration relative.

The case of the carob tree is striking, given that only an individual was found in this coverage, which implies that this was planted in order to provide shade and fruit for the cattle. The above is confirmed by assessing the regeneration component, since it was not reported for this stratum.

Wooded pasture

This coverage, like the clean grass, is anthropogenic in origin and is managed with economic purposes, especially livestock. In consequence, it is hard to produce a succession evolution in this type of coverage, which makes an ecological analysis difficult.

As with the previous coverage, the first three species of the IVI repeated for this analysis, where the vulture (*Piptocoma discolor*) is the predominant species in the arboreal pastures, with 30.9 % of the IVIA. In second place and quite far behind is the guava (*Psidium guajava*) and thirdly the chingale (*Jacaranda copaia*), fairly common species in this type of coverage (see Figure 3-58 and Table 3-69).

It is important to point out that the *Melochia villosa* and *Hyptis lantanifolia*, that occupy the fourth and fifth place respectively, are herbaceous species and therefore are not outlined in the IVI, which confirms that the IVIA is a sturdier method to analyze the vegetation than the IVI.

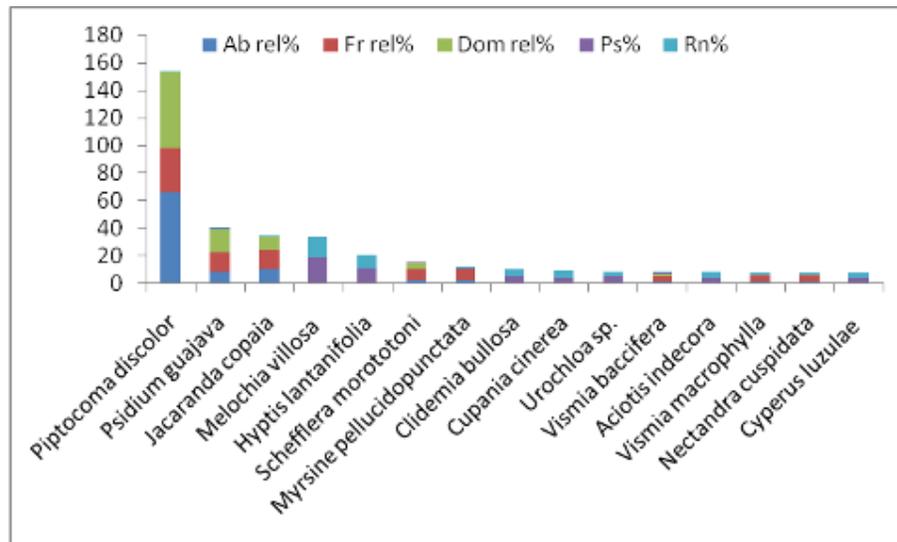


Figure 3-58. Index of Importance value expanded (IVIA) of the species recorded for the wooded pasture

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Table 3-69. Index of Importance value expanded (IVIA) for the recorded wooded pasture species.

| Scientific name | Common Name | Ab rel% | Dom rel% | Fr rel % | Ps% | Rn% | IVIA |
|--|---|---------|----------|----------|------|------|-------|
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | 65.7 | 55.1 | 32.1 | 1.1 | 0.3 | 154.3 |
| <i>Psidium guajava</i> | Guayabo | 8.6 | 16.5 | 14.3 | 0.8 | 0.9 | 41.0 |
| <i>Jacaranda copaia</i> | Chingale | 10.0 | 9.9 | 14.3 | 0.2 | 0.3 | 34.7 |
| <i>Melochia villosa</i> | Malvilla | | | | 18.9 | 14.7 | 33.5 |
| <i>Hyptis lantanifolia</i> | White Manrubio | | | | 11.4 | 9.9 | 21.3 |
| <i>Schefflera morototoni</i> | Arracacho | 2.9 | 5.6 | 7.1 | 0.0 | | 15.6 |
| <i>Myrsine pellucidopunctata</i> | Espadero | 2.9 | 1.5 | 7.1 | 0.2 | 0.3 | 12.0 |
| <i>Clidemia bullosa</i> | | | | | 5.5 | 4.9 | 10.4 |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | | | | 4.7 | 4.8 | 9.5 |
| <i>Róchalo spa.</i> | Vaciaría | | | | 5.2 | 3.9 | 9.1 |
| <i>Visita vocifera</i> | Carate, peeling fax, Punta 'e taller | 1.4 | 2.3 | 3.6 | 0.5 | 0.8 | 8.5 |
| <i>Achiotis indecoro</i> | Puyito | | | | 4.6 | 4.0 | 8.5 |
| <i>Visita macrophylla</i> | Siete cueros | 1.4 | 1.1 | 3.6 | 0.8 | 1.0 | 8.0 |
| <i>Nectandra cuspidata</i> | Laurel pavito | 1.4 | 1.6 | 3.6 | 0.4 | 0.8 | 7.8 |
| <i>Cyperus luzulae</i> | | | | | 4.1 | 3.4 | 7.5 |
| <i>Hymenaea courbaril</i> | Algarrobo, pecueca almohada | 1.4 | 2.0 | 3.6 | 0.0 | | 7.0 |
| <i>Vismia sp. 2</i> | Tongue Tip | 1.4 | 2.0 | 3.6 | 0.0 | | 7.0 |
| <i>Rhodostemonodaphne kunthiana</i> | | 1.4 | 1.6 | 3.6 | 0.0 | | 6.6 |
| <i>Echinoderms exhibit fivefold Bellucia</i> | Coronillo, guava of pava, guava trees of Monte, guava from mico | 1.4 | 0.8 | 3.6 | 0.0 | 0.3 | 6.1 |
| <i>Hemidiodia ocymifolia</i> | Sarboleta | | | | 2.7 | 3.0 | 5.7 |
| <i>Mimosa sp.</i> | Dormidera | | | | 2.7 | 2.8 | 5.5 |
| <i>Desmodium adscenden</i> | Amorseco, pegapega, Cadillo | | | | 2.9 | 2.4 | 5.3 |
| <i>Pourouma hirsutipetiolata</i> | Cirpo | | | | 2.9 | 2.2 | 5.0 |
| <i>Psychotria capitata</i> | | | | | 2.3 | 1.8 | 4.0 |
| <i>Pavonia mollis</i> | Mauve | | | | 2.0 | 2.0 | 4.0 |
| <i>Coccocypselum hirsutum</i> | Food culebra | | | | 1.8 | 1.9 | 3.7 |
| <i>Peltaea sessiliflora</i> | Black Malva | | | | 1.8 | 1.7 | 3.5 |
| <i>Inga alba</i> | Churimo | | | | 1.8 | 1.4 | 3.3 |
| <i>Hirta Jaegeria</i> | Yellow Button | | | | 1.7 | 1.6 | 3.3 |
| <i>Piper aduncum</i> | Ribbing | | | | 1.2 | 1.5 | 2.7 |
| <i>Nectandra sp. 3</i> | | | | | 0.8 | 1.4 | 2.2 |
| <i>Solanum leaves and litter</i> | Raja teta | | | | 0.8 | 1.3 | 2.1 |
| <i>Clidemia sericea</i> | Mortiño | | | | 0.9 | 1.1 | 2.0 |
| <i>Lantana armata</i> | Successful | | | | 0.9 | 1.1 | 2.0 |
| <i>Lacistema aggregatum than</i> | Coffee of Mt. | | | | 0.8 | 1.2 | 2.0 |
| <i>Gramineae) neogranatensis</i> | | | | | 0.9 | 0.8 | 1.8 |
| <i>Psychotria brachiata</i> | | | | | 0.8 | 1.0 | 1.7 |
| <i>Gramineae) melaleuca</i> | Tresfilos, La Cortadera | | | | 0.6 | 1.1 | 1.7 |
| <i>As Hyptis suaveolens</i> | Venturosa | | | | 0.6 | 0.9 | 1.6 |
| <i>Polygala asperuloides</i> | | | | | 0.8 | 0.7 | 1.5 |

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| Scientific name | Common Name | Ab rel% | Dom rel% | Fr rel % | Ps% | Rn% | IVIA |
|------------------------------------|-------------------------------------|---------|----------|----------|-----|-----|------|
| <i>Spermacoceae sp. 2</i> | | | | | 0.8 | 0.7 | 1.5 |
| <i>Stizophyllum inaequilaterum</i> | | | | | 0.8 | 0.7 | 1.5 |
| <i>Siparuna sessiliflora</i> | Lemon grass | | | | 0.6 | 0.9 | 1.5 |
| <i>Rollinia edulis</i> | Mahoe | | | | 0.4 | 1.0 | 1.4 |
| <i>Miconia lacera</i> | | | | | 0.6 | 0.6 | 1.2 |
| <i>Aids rhombifolia,</i> | Broom lasts,broom slug | | | | 0.5 | 0.8 | 1.2 |
| <i>Miconia affinis</i> | Niguito | | | | 0.5 | 0.5 | 1.0 |
| <i>Mikania micrantha</i> | | | | | 0.5 | 0.5 | 1.0 |
| <i>Physalis peruviana</i> | Uchuva | | | | 0.5 | 0.5 | 1.0 |
| <i>Cuphea carthagenensis</i> | Moradita | | | | 0.3 | 0.7 | 1.0 |
| <i>Davilla kunthii</i> | Lambe ox | | | | 0.3 | 0.7 | 1.0 |
| <i>Glomerata Aids</i> | | | | | 0.3 | 0.7 | 1.0 |
| <i>Cyperus sp.</i> | | | | | 0.3 | 0.4 | 0.7 |
| <i>Spiralis Pseudelephantopus</i> | Welded, love dry, Amargón | | | | 0.3 | 0.4 | 0.7 |
| <i>Cane Sabicea</i> | | | | | 0.3 | 0.4 | 0.7 |
| <i>Stylosanthes guianensis</i> | Estilosante | | | | 0.3 | 0.4 | 0.7 |
| <i>Patens Vernonanthura</i> | Salvion | | | | 0.3 | 0.4 | 0.7 |
| <i>Miconia elata</i> | Colorado mortiño | | | | 0.0 | 0.6 | 0.6 |
| <i>Blechnum sp.</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Citrus aurantium</i> | Naranjo | | | | 0.2 | 0.3 | 0.5 |
| <i>Genipa americana</i> | Jagua ink tree, Huito, beach mat | | | | 0.2 | 0.3 | 0.5 |
| <i>Heliocarpus americanus</i> | BALSUM, balsum white, tab of mule | | | | 0.2 | 0.3 | 0.5 |
| <i>Hibiscus verbasciformis</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Indet. 16</i> | Kingras | | | | 0.2 | 0.3 | 0.5 |
| <i>Inga cf. pezizifera</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Mikania vitifolia</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Muntingia calabura</i> | Chiato, chirriador | | | | 0.2 | 0.3 | 0.5 |
| <i>Panicum pilosum</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Piper crassinervium</i> | Ribbing | | | | 0.2 | 0.3 | 0.5 |
| <i>Piper munchanum</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Pterogastra divaricata</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Sauvagesia erecta</i> | Simarruga | | | | 0.2 | 0.3 | 0.5 |
| <i>Solanum cyathophorum</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Spermacoceae sp. 1</i> | | | | | 0.2 | 0.3 | 0.5 |
| <i>Casearia arborea</i> | Escobo, niguito | | | | 0.0 | 0.3 | 0.3 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | | | | 0.0 | 0.3 | 0.3 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological Position relative, Rn%: Natural regeneration relative.

Weeded Grass

In concordance with all the other coverage analyzed, the species that occupies the first place of the IVI coincides with that of the IVIA, although the arracacho (*Schefflera morototoni*) has very similar values and threatens this privileged position (see Figure 3-59 and Table 3-70). In contrast, the food of Culebra (*Coccocypselum hirsutum*) is not represented in the IVI by its herbaceous character, and even so, it is an abundant species in the lower stratum, which

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together with the high value of weighting in the sociological position, occupies the third place in this coverage expanded analysis.

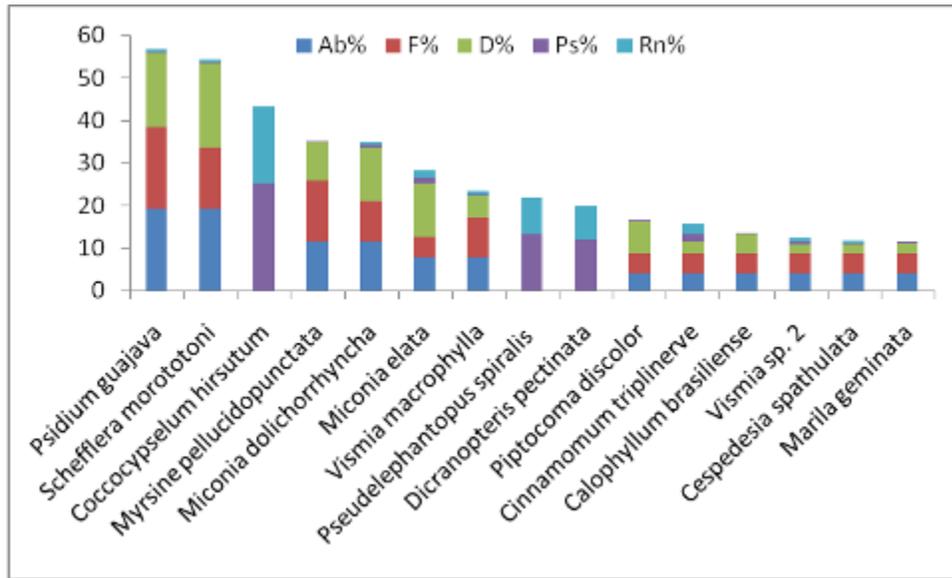


Figure 3-59. Index of Importance value expanded (IVIA) of the species recorded for the weeded pastures.

Table 3-70. Index of Importance value expanded (IVIA) of the species recorded for the weeded pastures.

| Scientific name | Common Name | Ab% | F% | D% | Ps% | Rn% | IVIA |
|-----------------------------------|--|------|------|------|------|------|------|
| <i>Psidium guajava</i> | Guayabo | 19.2 | 19.0 | 17.5 | 0.2 | 0.6 | 56.6 |
| <i>Schefflera morototoni</i> | Arracacho | 19.2 | 14.3 | 20.0 | 0.2 | 0.6 | 54.3 |
| <i>Coccocypselum hirsutum</i> | Food culebra | | | | 25.3 | 18.0 | 43.2 |
| <i>Myrsine pellucidopunctata</i> | Espadero | 11.5 | 14.3 | 9.2 | 0.1 | | 35.1 |
| <i>Miconia dolichorrhyncha</i> | White mortiño | 11.5 | 9.5 | 12.5 | 0.6 | 0.8 | 34.9 |
| <i>Miconia elata</i> | Colorado mortiño | 7.7 | 4.8 | 12.7 | 1.2 | 1.8 | 28.2 |
| <i>Vismia macrophylla</i> | Siete cueros | 7.7 | 9.5 | 5.1 | 0.2 | 0.9 | 23.4 |
| <i>Spiralis Pseudelephantopus</i> | Welded, love dry, Amargón | | | | 13.2 | 8.8 | 22.0 |
| <i>Dicranopteris pectinata</i> | Fern marranero | | | | 11.9 | 8.0 | 19.9 |
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | 3.8 | 4.8 | 7.8 | 0.03 | | 16.4 |
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | 3.8 | 4.8 | 2.8 | 1.9 | 2.2 | 15.5 |
| <i>Calophyllum brasiliense</i> | Oil, Oil mary, barcino | 3.8 | 4.8 | 4.9 | 0.0 | | 13.5 |
| <i>Vismia sp. 2</i> | Tongue Tip | 3.8 | 4.8 | 2.3 | 0.4 | 1.0 | 12.3 |
| <i>Cespedesia spathulata</i> | Paco, Pedro boys read, Alejandro, lengua de vaca | 3.8 | 4.8 | 2.3 | 0.2 | 0.6 | 11.8 |
| <i>Marila geminata</i> | | 3.8 | 4.8 | 2.8 | 0.03 | | 11.5 |
| <i>Hyptis lantanifolia</i> | White Manrubio | | | | 4.2 | 3.9 | 8.0 |
| <i>Sauvagesia erecta</i> | Simarruga | | | | 3.5 | 2.4 | 5.9 |
| <i>Clidemia bullosa</i> | | | | | 3.1 | 2.5 | 5.6 |
| <i>Clidemia ciliata</i> | | | | | 2.3 | 3.3 | 5.6 |

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| Scientific name | Common Name | Ab% | F% | D% | Ps% | Rn% | IVIA |
|--|--|-----|----|----|-----|-----|------|
| <i>Desmodium adscenden</i> | Amorseco, pegapega, Cadillo | | | | 2.7 | 2.2 | 4.8 |
| <i>Baccharis trinervis</i> | Maruchinga, chilco, machuco | | | | 1.8 | 2.8 | 4.6 |
| <i>Hemidiodia ocymifolia</i> | Sarboleta | | | | 2.1 | 2.1 | 4.1 |
| <i>Psychotria brachiata</i> | | | | | 2.1 | 1.8 | 3.9 |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | | | | 1.8 | 1.9 | 3.8 |
| <i>Aciotis indecora</i> | Yuyito | | | | 1.7 | 1.9 | 3.6 |
| <i>Coccocypselum sp. 1</i> | | | | | 1.6 | 1.3 | 2.9 |
| <i>Clidemia capitellata</i> | | | | | 1.0 | 1.2 | 2.2 |
| <i>Anthurium sp. 1</i> | Sheet heart | | | | 0.8 | 1.3 | 2.1 |
| <i>Mimosa sp.</i> | Dormidera | | | | 0.8 | 1.3 | 2.1 |
| <i>Peltaea sessiliflora</i> | Black Malva | | | | 0.9 | 1.1 | 2.0 |
| <i>Solanum leaves and litter</i> | Raja teta | | | | 0.9 | 1.1 | 2.0 |
| <i>Nectandra cuspidata</i> | Laurel pavito | | | | 0.3 | 1.4 | 1.7 |
| <i>Piper aduncum</i> | Ribbing | | | | 0.6 | 1.1 | 1.7 |
| <i>Mikania psilostachya</i> | | | | | 0.5 | 1.0 | 1.5 |
| <i>Siparuna sessiliflora</i> | Lemon grass | | | | 0.4 | 1.1 | 1.5 |
| <i>Clusia sp. 2</i> | Chagualo | | | | 0.7 | 0.7 | 1.4 |
| <i>Miconia aggregata</i> | Niguito | | | | 0.7 | 0.7 | 1.4 |
| <i>Pavonia mollis</i> | Mauve | | | | 0.7 | 0.7 | 1.4 |
| <i>Miconia decurrens</i> | White mortiño | | | | 0.5 | 0.8 | 1.3 |
| <i>Cestrum mariquitense</i> | | | | | 0.4 | 0.8 | 1.2 |
| <i>Clidemia sericea</i> | Mortiño | | | | 0.6 | 0.6 | 1.2 |
| <i>Indet. 13</i> | | | | | 0.6 | 0.6 | 1.2 |
| <i>Psychotria deflexa</i> | | | | | 0.6 | 0.6 | 1.2 |
| <i>Uniflora Acisanthera</i> | | | | | 0.3 | 0.7 | 1.1 |
| <i>Psychotria gracilentia</i> | | | | | 0.5 | 0.5 | 1.0 |
| <i>Spermacoceae sp. 1</i> | | | | | 0.5 | 0.5 | 1.0 |
| <i>Blechnum polypodioides</i> | | | | | 0.3 | 0.5 | 0.8 |
| <i>Lacistema aggregatum than</i> | Coffee of Mt. | | | | 0.3 | 0.5 | 0.8 |
| <i>Miconia lacera</i> | | | | | 0.3 | 0.5 | 0.8 |
| <i>Piper muncanum</i> | | | | | 0.3 | 0.5 | 0.8 |
| <i>Psychotria sp.</i> | | | | | 0.3 | 0.5 | 0.8 |
| <i>Stachytarpheta cayennensis</i> | Chilca, verbena black, armadillo queue | | | | 0.3 | 0.5 | 0.8 |
| <i>Vismia baccifera</i> | Carate, sealing wax | | | | 0.1 | 0.6 | 0.7 |
| <i>Davilla kunthii</i> | Lambe ox | | | | 0.2 | 0.4 | 0.6 |
| <i>Elephantopus mollis</i> | Welded, 'El Totumo', orejemula | | | | 0.2 | 0.4 | 0.6 |
| <i>Indet. 5</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Indet. 9</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Miconia resima</i> | Niguito | | | | 0.2 | 0.4 | 0.6 |
| <i>Nectandra sp. 3</i> | | | | | 0.2 | 0.4 | 0.6 |
| <i>Patens Vernonanthura</i> | Salvion | | | | 0.2 | 0.4 | 0.6 |
| <i>Tovomita weddelliana are excluded</i> | Carate | | | | 0.1 | 0.4 | 0.5 |
| <i>Tococa lancifolia guianensis</i> | Anthill | | | | 0.1 | 0.4 | 0.5 |

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| Scientific name | Common Name | Ab% | F% | D% | Ps% | Rn% | IVIA |
|--|--|-----|----|----|------|-----|------|
| <i>Ageratina sp. 1</i> | Chilca | | | | 0.1 | 0.3 | 0.4 |
| <i>Chelonanthus alatus</i> | Yerba of Adam, canaguete | | | | 0.1 | 0.3 | 0.4 |
| <i>Hypstis atrorubens</i> | Buttonwood, Cartagena, mastranto | | | | 0.1 | 0.3 | 0.4 |
| <i>Indet. 10</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Indet. 8</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Inga sp. 5</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Miconia cf. albicans</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Notopleura macrophylla</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Palicourea sp. 2</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Psychotria racemosa</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Renealmia sp.</i> | Ajenjillo | | | | 0.1 | 0.3 | 0.4 |
| <i>Schefflera sp. 1</i> | | | | | 0.1 | 0.3 | 0.4 |
| <i>Stylosanthes guianensis</i> | Estilosante | | | | 0.1 | 0.3 | 0.4 |
| <i>Acalypha macrostachya</i> | Zanque mule deer, beards of guasco | | | | 0.1 | 0.3 | 0.4 |
| <i>Cyathea andina</i> | Tree Fern | | | | 0.1 | 0.3 | 0.4 |
| <i>Acaciella sp. 1</i> | Pisquin | | | | 0.03 | 0.3 | 0.3 |
| <i>Echinoderms exhibit fivefold Bellucia</i> | Coronillo, guava trees of pava, guava of Mt. | | | | 0.03 | 0.3 | 0.3 |
| <i>Mandevilla hirsuta</i> | | | | | 0.03 | 0.3 | 0.3 |

Ab rel%: Relative abundance, Fr rel%: Relative Frequency, Dom rel%: Relative dominance, IVI: Index of Importance, Ps%: Sociological Position relative, Rn%: Natural regeneration relative.

The espadero (*Myrsine pellucidopuntacta*) is the only one in that is located in the first five places of the IVIA and it was not reported in the evaluation of the regeneration, therefore this species will be relegated or even could disappear in the future, if the current conditions for weeded grass are kept.

– Diversity indexes

Biodiversity and its measurement are important, given that they allow knowing their distribution patterns, both spatially and temporally, and the diversity measures serve, allegedly, as indicators of the ecological balance of ecosystems (Magurran 1988).

In the analysis of richness and diversity were considered the indexes of greater importance used at the international level, as are the alpha and beta indexes, which are commonly used to know the riches at the interior of the analyzed coverage between them.

We calculated the following indexes alpha: number of species, Simpson (D), Shannon - Wiener (H) and the quotient of mixture (CM), which are based on the internal wealth or "diversity intra-habitat" of each coverage. These indexes of diversity are based on the total number of individuals per species and in the number of species in each coverage analyzed (see Figure 3-60). Similarly, are presented in Table 3-71 the results obtained for the different index.

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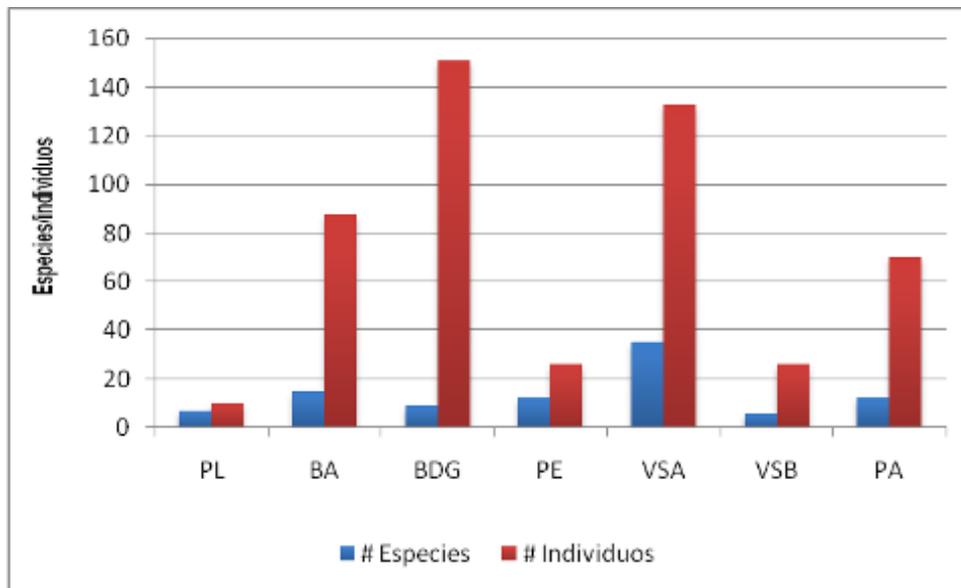


Figure 3-60. Number of species and individuals reported in each coverage.

Table 3-71. Indexes of alpha diversity, species and individuals reported in the different coverage areas.

| Coverage | Ind. | S | Simpson (D) | Shannon (H) | CM | Area (ha.) |
|----------|------|----|-------------|-------------|-------|------------|
| PL | 10 | 7 | 0.18 | 1.83 | 1.43 | 10.72 |
| BA | 88 | 15 | 0.22 | 1.88 | 5.87 | 1.46 |
| BDG | 151 | 9 | 0.84 | 0.44 | 16.78 | 0.41 |
| PE | 26 | 12 | 0.12 | 2.28 | 2.17 | 1.99 |
| VSA | 133 | 35 | 0.11 | 2.88 | 3.8 | 3.43 |
| VSB | 26 | 6 | 0.32 | 1.36 | 4.33 | 3.21 |
| PA | 70 | 12 | 0.45 | 1.34 | 5.83 | 7.61 |

Ind. = Number of individuals; S = number of species; Simpson = alpha diversity index of Simpson (D); Shannon = alpha diversity index of Shannon (H); CM = quotient of mixture (Cm); Area = sampling area in hectares

➤ **Number of species (S).**

One of the most commonly used indexes for the direct measurement of the species richness of a coverage, is the number of species per se (Magurran 1998), which warns against the first instance of the "diversity net" possessed by the fragments of inventoried vegetation, taking into account that this is not considered the number of individuals that represents, or the sampling area where the species were identified (Krebs 1989).

The development of diversity is predictable, the species richness increases as a function of time and manages to keep thanks to the interaction between the different species in the forest; in accordance with the results, the highest species richness was found in the high secondary vegetation (S= 35), by the 10 plots that were established in this coverage, while in other coverage where one would expect higher number of species, such as the open forest, only 5 plots were evaluated, which explains this result. The index "S" describes the coverage of low secondary vegetation as the lowest floristic richness with 6 species, result just obvious by the 10 plots established for this coverage, equivalent to half and 40% of the area assessed

| | | | |
|---|--|----------------------------|------------|
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| | | Rev. No. : 0 | 2012-03-30 |
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in the wooded pastures and clean pastures respectively, which are supposed a priori to be the poorest in species.

➤ Simpson index

This index is calculated using the following mathematical expression:

$$D = \sum (Ni/N)^2, \text{ where:}$$

ni: Number of individuals of the i-nth species

N: Total number of individuals.

The Simpson index (D) determines the possibility that two individuals randomly selected in a population or coverage, belong to the same species; the values vary between zero and one, and more diversity is hoped while is close to zero, and less diversity or greater dominance of some species if it is close to one.

This index gives the highest value in floristic richness to the high secondary vegetation (D=0.11), where there is no clearly dominant species, although some species reported more than nine individuals, such as the cirpo (*Pourouma hirsutipetiolata*) with 38 and the *Hasseltia* sp., with 10 individuals, but the total number of individuals reported for this coverage is 133. This result is predictable since the areas evaluated for VSA are greater than those from the open forest which have, in the coverage of the study area, the greater structural complexity and therefore it would be expected to have the greatest wealth of flora.

In contrast, the dense forest coverage of Guadua (0.84) and wooden pasture (0.45) are clearly dominant species; for the first the Guadua bamboo (*Guadua angustifolia*), which gives the name to the coverage and for the latter, the vulture (*Piptocoma discolor*) that is, with advantage, the most abundant coverage species.

➤ Shannon-Wiener index.

The mathematical expression is as follows:

$$H = - \sum (ni/N) * \ln (ni/N), \text{ where}$$

ni: Number of individuals of the i-nth species

N: Total number of individuals.

The Shannon index (H) is used to measure the proportional abundance of species; takes values between zero, when there is only one species, and the logarithm of the total number of species, when all species are represented by the same number of individuals.

In the analyzed coverage, the highest values of diversity also presented by the high secondary vegetation (H=2.88), which together with weeded grass are the only ones to obtain values greater than 2.00 ; third place was for the open forest, which has values close to the clean pasture. In contrast, the dense forest coverage of Guadua bamboo, wooded pasture and low secondary vegetation has the lowest value, since they are relatively homogeneous coverage, given their intrinsic characteristics.

The indexes of alpha diversity calculated (D and H) for the coverage identified are influenced by the high degree of intervention by the census fragments, the sampling area in each

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coverage and the use of the soil of the region, factors that clearly affect the results of any sampling.

➤ **Mixing Quotient.**

This index is calculated using the following expression:

$$C_m = N / S, \text{ where}$$

N: Total number of individuals in the coverage.

S: Total number of species in the coverage.

Assuming that the values of the C_m show the average amount of individuals per species, there is a more equitable distribution for the clean grass ($C_m=1.43$), where only 10 individuals were surveyed, belonging to 7 species; followed relatively close, by weeded grass with $C_m=2.17$, given that only 26 individuals belonging to 12 species were registered. The coverage clearly less equitable was the dense forest of Guadua ($C_m=16.78$), which is explained by the large number of individuals of this species in the coverage.

➤ **Diversity beta (β) indexes**

Beta diversity represents the replacement or the difference in floristic composition as you move from one place to another; therefore, its measurement is based on establishing proportions or differences. Its evaluation allows to see the similarity or difference between the compared coverage; to evaluate them, it is most commonly used the Jaccard index by its broad applicability, which facilitates the process. This index is based on the number of species of each coverage and in the shared or common species among them (see Table 3-72).

Table 3-72. Number of common species among the compared communities.

| COB | PL | BA | BDG | PE | VSA | VSB | PA |
|-----|----|----|-----|----|-----|-----|----|
| PL | 7 | | | | | | |
| BA | 1 | 15 | | | | | |
| BDG | 1 | 4 | 9 | | | | |
| PE | 5 | 1 | 2 | 12 | | | |
| VSA | 2 | 8 | 6 | 6 | 35 | | |
| VSB | 3 | 2 | 2 | 4 | 4 | 6 | |
| PA | 5 | 0 | 0 | 6 | 5 | 4 | 12 |

COB= coverage; BA= open forest; GDB= dense forest of gradual bamboo; VSA= high secondary vegetation; VSB= low secondary vegetation; PL= clean grass; PA= wooded pasture; PE= weeded grass.

Table 3-73 shows the values of the Jaccard index to analyze the similarity between the proposed coverage. The coverage for wooded pasture and weeded grass, in addition to clean grass and wooded pasture, are the ones that have the highest degree of similarity (0.36), in this way, they share the 25% and 26.3 % of the species recorded for these coverage. In summary, the coverage with more degree of similarity with the other are wooded pasture and clean grass, since the higher values of this index are related to them.

The only coverage that does not have some degree of similarity between them are the dense forest of Guadua bamboo and wooded pasture, in addition to the open forest and wooded pasture, relevant fact, given that wooded pasture is one of the coverage that shares more with the species of other evaluated communities.

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Table 3-73. Beta diversity index coverage analyzed.

| COB | PL | BA | BDG | PE | VSA | VSB |
|-----|-------------|------|-------------|-------------|-------------|-------------|
| PL | 1.00 | | | | | |
| BA | 0.05 | 1.00 | | | | |
| BDG | 0.07 | 0.20 | 1.00 | | | |
| PE | 0.36 | 0.04 | 0.11 | 1.00 | | |
| VSA | 0.05 | 0.19 | 0.16 | 0.15 | 1.00 | |
| VSB | 0.30 | 0.11 | 0.15 | 0.29 | 0.11 | 1.00 |
| PA | 0.36 | 0.00 | 0.00 | 0.33 | 0.12 | 0.29 |

– Diameter Distributions

The diameter distributions are the relationships between the diameter and their respective frequency in a forest or stand, referring to a specific area and generally attends the grouping by diameter classes (Lema, 2002). Its importance lies in the fact that the diameter is a variable that is correlated in a satisfactory manner with the majority of the parameters susceptible of quantification of the trees as height, volume and biomass among others.

For the coverage object of study, once completed the database with the respective clusters in diameter classes, several models were tested in the program Statgraphics Centurion XV- Version 1.15.02 among the most important are: Normal, lognormal, lognormal (3-parameter), largest Extreme Value, Logistic, Loglogistic, Exponential, Exponential (2-parameter), Birnbaum-Saunders , Gamma, Beta, Poisson and Negative Binomial, Weibull, Weibull (3-parameter), among others. After testing the models for each coverage, their statistical arrangements were analyzed in order to ensure that the selected model for each distribution was the most appropriate or to submit a better adjustment.

The selected models for the different coverage, by submitting good statistical adjustments in its diametric distribution, were: the Weibull (3-parameter) (P-value=0.729158 > 0.05) for the open forest, the Beta 4-parameter (P-value=0.906247 > 0.05) in the dense forest of Guadua, *Loglogistic3-parameter* (P-value=0.528729 > 0.05) in wooded pasture, the *Exponential distribution2-parameter* for the weeded grass (P-value=0.509554 > 0.05), for the high secondary vegetation (P-value=0.396001 > 0.05) adjusted the lognormal 3-parameter and the *largest Extreme Value distribution* for the low secondary vegetation. In the case of the clean grass, due to the scarcity of data, it was not possible to adjust a model, therefore presents a histogram with the data.

When analyzing the histogram, it is obvious that almost all the coverage have the tendency to behave like disetaneous forests, i.e. , to be distributed in the form of reversed "J" (see Figure 3-61 to Figure3-67), except for the dense forest of gradual bamboo, where there are few individuals with greater diameters due to intense competition and the substitution of native species, increasing then the number of individuals in accordance with decreases in the DAP, until reaching a high density in lower diameter categories. All the adjustments were made with the goodness-of-fit test Kolmogorov-Smirnov.

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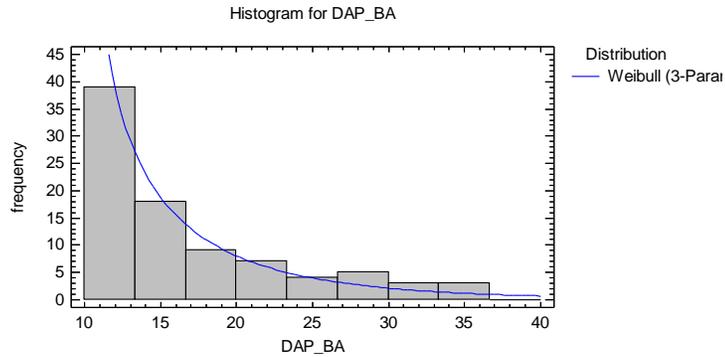


Figure 3-61. Diametric Distribution and distribution line of individuals in the open forest.

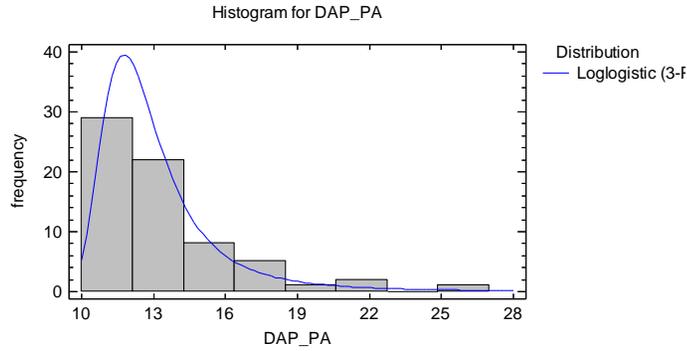


Figure 3-62. Diametric Distribution of individuals in wooded pastures.

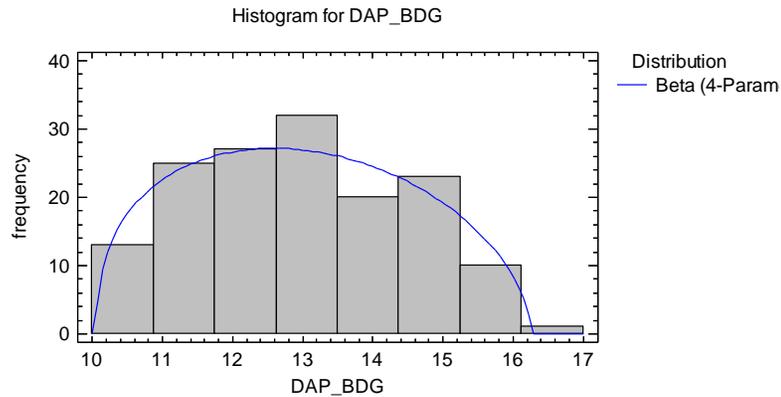


Figure 3-63. Diametric Distribution of individuals in dense forest of Guadua.

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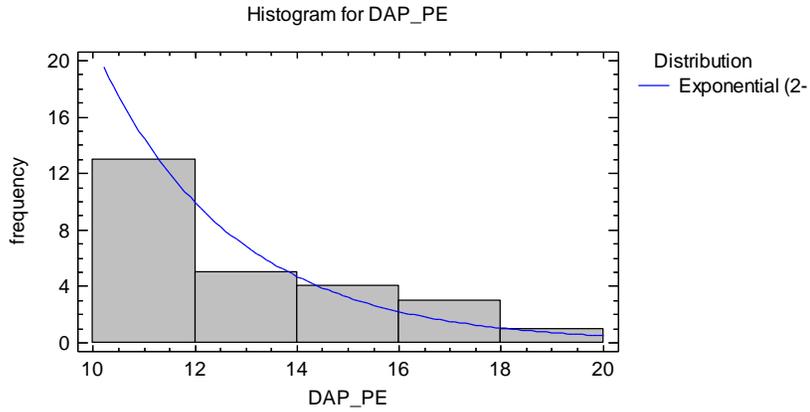


Figure 3-64. Diametric distribution line and adjustment of individuals in weeded grass.

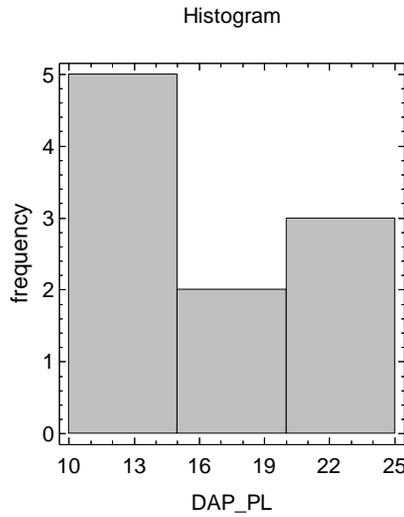


Figure 3-65. Diametric Distribution of individuals in clean pasture.

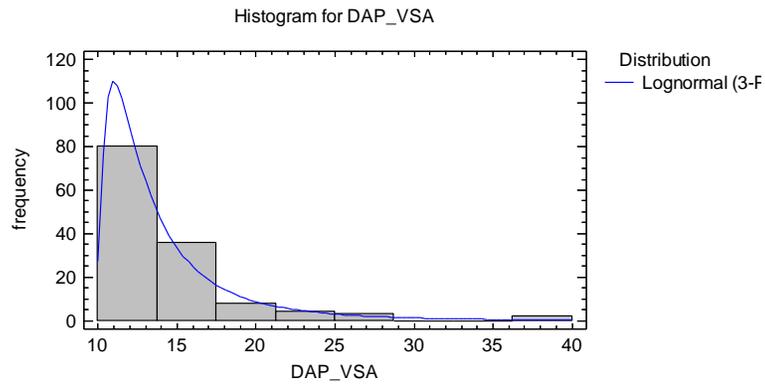


Figure 3-66. Diametric Distribution of individuals in high secondary vegetation.

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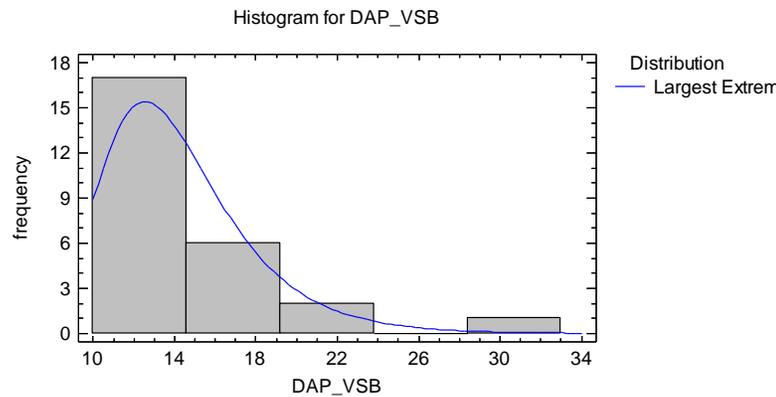


Figure3-67. Diametric Distribution of individuals in low secondary vegetation.

Table 3-74 shows how a test performed by the *Weibull model (3-parameter)*, properly determines the distribution of the diametric individuals with commercial diameters of the coverage BA. Also, the Kolmogorov-Smirnov test ensures a higher level of trust higher than 95 %, that the maximum absolute distance between the accumulations of observed and expected frequencies in no case exceed the DN. In this way, for this particular case, the greater absolute distance above is $DPLUS=0.0633635$ while the greater absolute distance below is $DMINU=0.0734673$, values that do not exceed the $DN=0.0734673$. Accordingly, it can be said, with a 95% of statistical certainty, that the open forest is distributed by the *Weibull model (3-parameter)*.

Table 3-74. Parameters of the Weibull distribution (3-parameters) for open forest.

| | <i>Weibull (3-parameter)</i> |
|---------|------------------------------|
| DPLUS | 0.0633635 |
| DMINUS | 0.0734673 |
| DN | 0.0734673 |
| P-value | 0.729158 |

Unfigured most of the data are skewed to the left; in the first two diameter classes focuses almost 65% of the data, where the first doubles the amount of individuals of the second. In contrast, in the greater diametric class (32.5 cm - 37.5 cm) barely exceeds the 3% of the total data, represented in three cirpos (*Pourouma hirsutipetiolata*), common in this type of coverage.

The beta distribution (4-parameters) is a model for data with upper and lower thresholds; in this case, the lower threshold is given to all individuals with $DAP \geq 10$ cm, while the upper threshold is given by the highest recorded DAP (16.2 cm). This distribution was the one that best adjusted after applying the Kolmogorov-Smirnov goodness-of-fit test for the database of the dense forest of Guadua (see Table 3-75).

Table 3-75. Parameters of the Beta distribution (4-parameters) for dense forest of Guadua.

| | <i>Beta (4-parameter)</i> |
|---------|---------------------------|
| DPLUS | 0.0319294 |
| DMINUS | 0.0460318 |
| DN | 0.0460318 |
| P-value | 0.906247 |

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The result obtained for this coverage is predictable since the predominant species is a Poaceae that by ontogeny presents no secondary growth (diameter), along with its gregarious character, which inhibits the competition from other species. In Figure 3-63 is noticed that in the diametric intermediate class are concentrated the largest number of individuals, while in the queues are the lowest values.

In a similar way to what happened in the open forest coverage, in wooded pastures is a trend of the data to a reversed "J" (see Figure 3-62); although it is a coverage clearly anthropogenic in origin, it can be theorized that the registered individuals are disetaneous. Although more than half belong to the first two diameter classes, the rest are decreasingly distributed around the rest of the class marks.

In Table 3-76 are observed absolute maximum distances above (DPLUS) and below (DMINUS) of the frequencies distribution; these values should in no case exceed the DN.

Table 3-76. Parameters of the logistic distribution 3-parameters for grass trees.

| | <i>Loglogistic (3-parameter)</i> |
|---------|----------------------------------|
| DPLUS | 0.0978106 |
| DMINUS | 0.0789963 |
| DN | 0.0978106 |
| P-value | 0.528729 |

The exponential distribution 2-parameters are adjusted to the data belonging to the weeded grass coverage (see Figure 3-64 and Table). In the histogram is noticed that more than two-thirds of the data are among the 10 cm and 14 cm and only one individual represents the diametric last class, the vulture (*Piptocoma discolor*), and a native species that grows commonly in this type of coverage. These results are barely obvious in a coverage where there is full light availability and abundant germplasm.

Table 3-77. Parameters of the Exponential distribution 2-parameters for weeded grass.

| | <i>Exponential (2-parameter)</i> |
|---------|----------------------------------|
| DPLUS | 0.162634 |
| DMINUS | 0.132717 |
| DN | 0.162634 |
| P-value | 0.509554 |

In accordance with what have been seen in Figure 3-65 , the distribution of the diametric clean pastures is pretty simple, since there were only ten individuals belonging to three diameter classes, where the first is the 50% of the data, while at the second class mark appear only two individuals.

Although three individuals are in the last class mark, the carob tree (*Hymenaea courbaril*) was the individual with the highest value recorded for this coverage. That native species can reach large dimensions and are usually seen isolated in pastures, and open spaces such as clean pasture.

The high secondary vegetation is a coverage that is primary in succession stages in the forest and although it has a vertical structure clearly differentiable, still receives light in all directions. In this way, this coverage is possibly the most disetaneous of all evaluated, due to the fact that there are still early heliophytes species, with late heliophytes and begin to appear

| | | | |
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species of early secondary successions. This series of events are reflected in the histogram of the Figure3-67

Table 3-78. Parameters of the Log normal distribution (3-parameters) for the high secondary vegetation.

| | <i>Lognormal (3-parameter)</i> |
|---------|--------------------------------|
| DPLUS | 0.0439329 |
| DMINUS | 0.0531146 |
| DN | 0.0531146 |
| P-value | 0.847245 |

Figure3-67 shows the histogram of the low secondary vegetation; although the trend is descendant as it progresses in the class marks, this change is gradual and more homogeneous than in coverage such as weeded grass, high secondary vegetation and open forest.

The diameters reported for the low secondary vegetation were adjusted to the distribution curve with larger extreme value, which is a continuous distribution that prioritizes the maximum values of a data series. The P-value calculated for this setting was found after applying the Kolmogorov-Smirnov test, whose estimated parameters can be viewed in Table 3-79 .

Table 3-79. Parameters of the distribution of larger extreme value, for the low secondary vegetation.

| | <i>Largest Extreme Value</i> |
|---------|------------------------------|
| DPLUS | 0.151767 |
| DMINUS | 0.10264 |
| DN | 0.151767 |
| P-value | 0.587191 |

In summary, the diameter distributions observed were represented through six mathematical models that exhibit a generalized modal form, with bias in the lower diameter categories, except for the dense forest of Guadua bamboo, becoming more asymmetrical (resembling an inverted "J"), as diameters increase, indicating lower abundance of arborous individuals in the upper classes.

– Volumes to remove in the project intervention area

With the purpose of carrying out precise estimates of the basal area (BA) and the volumes by coverage throughout the area of project intervention, it took into account the estimates per hectare calculated from the results obtained from the plots. Also, for the estimates of the total volume (VT) and commercial (VC) in the different categories, in addition to the use of the parameters DAP, total height, commercial height and area, used a form or morphed factor (F=0.65), which corrects the volume, given the conical or neiloide shape of the tree (Lema, 2002).

Figure3-68 show the estimates of trade volumes, in cubic meters, to remove all the coverage susceptible to intervention. In it excels almost exclusively the open forest, because it is the only coverage sufficiently developed to possess significant commercial volume.

In Table 3-80 coverage with greatest amount of volume of wood are susceptible to remove the open forest and high secondary vegetation, where the first represents a little more than

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48.5 % of the total volume to remove. The coverage with less volume rendering is the clean grass, followed by the weeded grass, low secondary vegetation and wooded pasture respectively, expected results in accordance with the structure of these coverage.

It is reiterated that these estimates, the calculated values of basal area and volume, include all individuals with diameters greater than or equal to 10 cm DBH.

In summary, the 12.43 m³ which can be affected by the execution of the facilities to carry out the project, arise from estimating a clearance or complete removal of the vegetation in the facilities area.

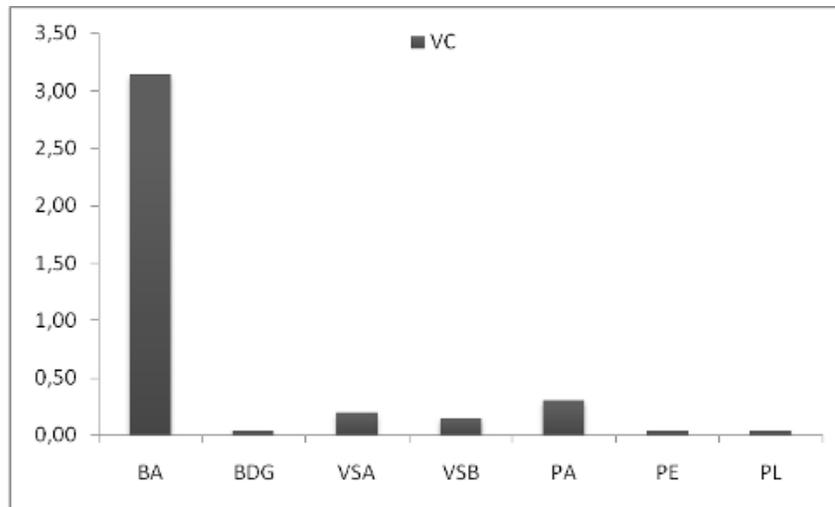


Figure 3-68. Estimate of trade volumes with possible exploitation.

Table 3-80. Estimates of basal area and volume of coverage in the area of project intervention.

| Coverage | AID | Inventory Values | | | | Per-hectare values | | | Values to Remove | | |
|---------------------------|--------------|------------------|-------------|-------------|-------------|--------------------|-------------|-------------|------------------|-------------|-------------|
| | | AIM | VT | VC | AB | VT | VC | AB | VT | VC | AB |
| Open forest of firm land | 1.46 | 0.10 | 0.41 | 0.21 | 0.04 | 4.12 | 2.15 | 0.45 | 6.04 | 3.14 | 0.65 |
| Dense Forest of Guadua | 0.41 | 0.10 | 0.42 | 0.01 | 0.04 | 4.21 | 0.11 | 0.41 | 1.71 | 0.05 | 0.17 |
| High Secondary Vegetation | 3.43 | 0.20 | 0.20 | 0.01 | 0.02 | 0.98 | 0.06 | 0.12 | 3.38 | 0.20 | 0.41 |
| Low Secondary Vegetation | 3.21 | 0.20 | 0.03 | 0.01 | 0.005 | 0.15 | 0.05 | 0.02 | 0.47 | 0.15 | 0.08 |
| Wooded pasture | 7.61 | 0.40 | 0.03 | 0.02 | 0.005 | 0.08 | 0.04 | 0.01 | 0.63 | 0.31 | 0.10 |
| Weeded Grass | 1.99 | 0.30 | 0.01 | 0.01 | 0.002 | 0.05 | 0.02 | 0.01 | 0.09 | 0.04 | 0.02 |
| Clean Grass | 10.72 | 0.50 | 0.01 | 0.002 | 0.001 | 0.01 | 0.00 | 0.00 | 0.11 | 0.04 | 0.02 |
| Total | 28.82 | 1.80 | 1.11 | 0.27 | 0.12 | 9.61 | 2.43 | 1.02 | 12.43 | 3.93 | 1.44 |

Where: AID: area to affect in has, AIM: area inventoried in the sample in has, AB= basal area expressed in square meters; VC= trade volume in cubic meters; VT= total volume in cubic meters.

- Species with importance

In the inventory that species were reported by various factors highlighted by its importance to men and the environment in general. Table 3-81 show a listing, where species are discriminated in accordance with the economic importance (food, commercial value, ornamental), ecological (wildlife food), scientific (scientific value, category of threat, CITES Appendix, endemic, medicinal value) and cultural (cultural value).

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Table 3-81. List of species with some importance found in El Molino

| Scientific name | Common Name | Animals food | Human food | Scientific Value | Medicinal Value | Commercial Value | Cultural Value | Ornamental | Ban | Cat. Threat | CITES Appendix | Endemic |
|--|---|--------------|------------|------------------|-----------------|------------------|----------------|------------|-----|-------------|----------------|---------|
| <i>Ageratum conyzoides</i> | Manrubio, ventosidad, goat herb | | | | X | | | | | | | |
| <i>Alchornea cf. acutifolia</i> | Pandequeso | | | | | | X | | | | | |
| <i>Alchornea megalophylla</i> | | | | | | | X | | | | | |
| <i>Anthurium formosum</i> | | | | | | | | X | | | | |
| <i>Asterogyne martiana</i> | Panda, panga, rooster tail | | | | | | X | X | | LC | | |
| <i>Baccharis trinervis</i> | Maruchinga, chilco, machuco | | X | | X | | | | | | | |
| <i>Bactris gasipaes</i> <i>Bactris setulosa</i> are found cf. | | | | | | | X | | | | | |
| <i>Echinoderms exhibit fivefold</i> <i>Bellucia</i> | Coronillo, guava trees of pava, guava of Mt. | | X | | | | X | X | | | | |
| <i>Caladium bicolor</i> | Ajenjilla | | | | | | | X | | | | |
| <i>Calathea crotalifera</i> | Bihao, mantagorda | | | | | X | X | X | | | | |
| <i>Calophyllum brasiliense</i> | Oil, Oil mary, barcino | | | | X | | | | | | | |
| <i>Casearia arborea</i> | Escobo, niguito | | | | | X | X | | | | | |
| <i>Casearia mariquitensis</i> | | | | | | X | X | | | | | |
| <i>Casearia silvestris</i> | | | | | | X | X | X | | | | |
| <i>Castilla elastic</i> | Black Rubber, rubber female | | | | | | X | | | | | |
| <i>Cecropia angustifolia</i> | Yarumo, Yarumo black | | | | | | X | X | | | | |
| <i>Cespedesia spathulata</i> | Paco, Pedro boys read, Alejandro, language e' cow | | | | | X | X | | | | | |
| <i>Cestrum cf. schlehtendahli</i> | | | | | | | X | | | | | |
| <i>Cestrum mariquitense</i> | | | | | | | X | | | | | |

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| Scientific name | Common Name | Animals food | Human food | Scientific Value | Medicinal Value | Commercial Value | Cultural Value | Ornamental | Ban | Cat. Threat | CITES Appendix | Endemic |
|--|--|--------------|------------|------------------|-----------------|------------------|----------------|------------|-----|-------------|----------------|---------|
| <i>Cinnamomum triplinerve</i> | Laurel Perillo, laurel, aguacatillo | | | | | X | X | | | | | |
| <i>Citrus aurantium</i> | Naranja | | | | X | X | X | | | | | |
| <i>Clibadium surinamense</i> | Salvia, language of cow, mastranto | | X | | X | | | | | | | |
| <i>Horrida;</i> | | | | | | | | | X | | | |
| <i>Cordia dwyeri</i> | Arm of tiger, hen paw | | | | | | X | | | | | |
| <i>Cordia nodosa</i> | Tumbatoro, turmetoro, balls of jack | | | | | | X | | | | | |
| <i>Cordia sp.</i> | | | | | | | X | | | | | |
| <i>Costus allenii</i> | Canaguante | | | | X | | X | X | | | | |
| <i>Costus Lasius</i> | Canaguante | | | | X | | X | | | | | |
| <i>Crotalaria nitens</i> | Cascabelito | | | | | | X | | | | | |
| <i>Croton Trinitatis</i> | | | | | X | | X | | | | | |
| <i>Cupania cinerea</i> | Mantequillo, cariseco, Guacharaco, mestizo | | | | | | X | | | | | |
| <i>Cyathea andina</i> | Tree Fern | | | | | | X | X | X | | Appendix II | |
| <i>Cyathea molederana</i> | | | | | | | X | | X | | Appendix II | |
| <i>Click image for caption and other Dendropanax</i> | Platero | | | | | | X | | | | | |
| <i>Desmodium adscenden</i> | Amorseco, pegapega, Cadillo | | | | X | | X | | | | | |
| <i>Erythrina rubrinervia</i> | Chocho | | | | X | X | | X | | | | |
| <i>Eugenia florida</i> | | | | | X | | X | | | | | |
| <i>Euterpe precatória</i> | Palm-kernel oil, macana | | X | | X | | X | | | LC | | |
| <i>Ficus maximum</i> | Rubber, dairy and lechudo | | | | | | X | | | | | |
| <i>Genipa americana</i> | Jagua ink tree, Huito, beach mat | | X | | X | X | X | X | | | | |
| <i>Gloeospermum sphaerocarpum</i> | Monte Guayabito | | | X | | X | X | | | | | |

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| Scientific name | Common Name | Animals food | Human food | Scientific Value | Medicinal Value | Commercial Value | Cultural Value | Ornamental | Ban | Cat. Threat | CITES Appendix | Endemic |
|--------------------------------|--|--------------|------------|------------------|-----------------|------------------|----------------|------------|-----|-------------|----------------|---------|
| <i>Graffenrieda galeottii</i> | White Niguito | | | | | | X | | | | | |
| <i>Guadua angustifolia</i> | Guadua | | | | | X | X | X | | | | |
| <i>Guarea guidonia</i> | El Trompillo cedrillo, cocoa of Mt. | | | | | X | X | X | | | | |
| <i>Guatteria bolivian</i> | Garrapato | | | | | | X | | | | | |
| <i>Guatteria sp.</i> | Garrapato | | | | | | X | | | | | |
| <i>Hedyosmum racemosum</i> | Silbasilba, hail | | | | | | X | | | | | |
| <i>Heliocarpus americanus</i> | BALSUM, balsum white, tab of mule | | | | | | X | | | | | |
| <i>Hibiscus verbasciformis</i> | | | | | | | | X | | | | |
| <i>Hieronyma sp.</i> | Leno | | | | | | X | | | | | |
| <i>Hymenaea courbaril</i> | Algarrobo, pecueca almohada | | X | | | X | X | | | NT | | |
| <i>Arboretum Hyptidendron</i> | Aguanoso, white and black vulture, Borrajo | | | | | | X | | | VU | B1ab(iii) | |
| <i>Hyptis atrorubens</i> | Buttonwood, Cartagena, mastranto | | X | | | | | | | | | |
| <i>Indet. 6</i> | Palma | | | | | | | X | | | | |
| <i>Indet. 7</i> | Palma | | | | | | | X | | | | |
| <i>Inga cf. pezizifera</i> | | | X | | | | X | | | | | |
| <i>Inga cf. samanensis</i> | | | X | | | | X | | | | | |
| <i>Inga alba</i> | Churimo | | X | | | | X | | | | | |
| <i>Inga sp. 1</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 2</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 3</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 4</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 5</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 6</i> | | | X | | | | X | | | | | |
| <i>Inga sp. 8</i> | | | X | | | | X | | | | | |
| <i>Inga thibaudiana</i> | | | X | | | | X | | | | | |
| <i>Jacaranda copaia</i> | Chingale, escobillo, pavito | | | | X | | | | | | | |
| <i>Justice filibracteolata</i> | | | | | X | | | | | | | |

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| Scientific name | Common Name | Animals food | Human food | Scientific Value | Medicinal Value | Commercial Value | Cultural Value | Ornamental | Ban | Cat. Threat | CITES Appendix | Endemic |
|--|------------------------|--------------|------------|------------------|-----------------|------------------|----------------|------------|-----|-------------|----------------|---------|
| <i>Lacistema aggregatum</i> than | Coffee of Mt. | | | | | X | X | | | | | |
| <i>Lantana armata</i> | Successful | | | | | | | X | | | | |
| <i>Miconia affinis</i> | Niguito | | | | | | X | | | | | |
| <i>Miconia dodecandra</i> | | | | | | | X | | | | | |
| <i>Miconia elata</i> | Colorado mortiño | | | | | X | X | | | | | |
| <i>Miconia theaezans</i> | Inciden white, niguito | | | | | | X | | | | | |
| <i>Myrcia fallax</i> | Arrayán | | X | | | X | X | X | | | | |
| <i>Myrcia sp. 1</i> | | | X | | | X | X | X | | | | |
| <i>Myrcia sp. 2</i> | | | X | | | X | X | X | | | | |
| <i>Myrcia sp. 3</i> | Arrayán | | X | | | X | X | X | | | | |
| <i>Myrsine pellucidopunctata</i> | Espadero | | | | | | X | | | | | |
| <i>Nectandra cf. microcarpa</i> | Laurel pavito | | | | | | X | | | | | |
| <i>Nectandra cuspidata</i> | Laurel pavito | | | | | | X | X | | | | |
| <i>Nectandra sp. 1</i> | | | | | | | X | | | | | |
| <i>Nectandra sp. 2</i> | | | | | | | X | | | | | |
| <i>Nectandra sp. 3</i> | | | | | | | X | | | | | |
| <i>Nectandra sp. 4</i> | | | | | | | X | | | | | |
| <i>Ocotea macropoda</i> | Laurel | | | | | X | X | | | | | |
| <i>Palicourea sp. 1</i> | | | | | | X | X | | | | | |
| <i>Palicourea sp. 2</i> | | | | | | X | X | | | | | |
| <i>Palicourea cf. garciae</i> | | | | | | X | X | | | | | |
| <i>Panicum pilosum</i> | | | | | X | | | | | | | |
| <i>Peltaea sessiliflora</i> | Black Malva | | | | | | X | | | | | |
| <i>Persea americana</i> | | | X | | | X | X | | | | | |
| <i>Persea sp.</i> | | | | | | | X | | | | | |
| <i>Philodendron cf. inaequilaterum</i> | | | | | | | X | X | | | | |
| <i>Philodendron sp. 1</i> | | | | | | | X | X | | | | |
| <i>Philodendron sp. 2</i> | | | | | | | X | X | | | | |
| <i>Philodendron sp. 3</i> | | | | | | | X | X | | | | |
| <i>Philodendron sp. 4</i> | | | | | | | X | X | | | | |
| <i>Picramnia antidesma</i> | | | | | | X | | | | | | |
| <i>Piper aduncum</i> | Ribbing | | | | X | | X | | | | | |
| <i>Piper arboreum</i> | Ribbing | | | | X | | X | | | | | |
| <i>Piper crassinervium</i> | Ribbing | | | | | | X | | | | | |
| <i>Piper sp. Nov! 1</i> | Guayaquil | | | X | | | | | | | | |

ENVIRONMENTAL IMPACT STUDY

| Scientific name | Common Name | Animals food | Human food | Scientific Value | Medicinal Value | Commercial Value | Cultural Value | Ornamental | Ban | Cat. Threat | CITES Appendix | Endemic |
|--|--------------------------------|--------------|------------|------------------|-----------------|------------------|----------------|------------|-----|-------------|----------------|---------|
| <i>Piper sp. Nov! 2</i> | | | | X | | | | | | | | |
| <i>Discolor Piptocoma</i> | Vulture, mulato, pigweed | | X | | | X | X | X | | | | |
| <i>Bicolor Pourouma</i> | Cirpo, cirpo male | | X | | | | X | | | | | |
| <i>Spiralis Pseudelephantopus</i> | Welded, love dry, Amargón | | | | X | | | | | | | |
| <i>Psidium guajava</i> | Guayabo | | X | | | X | | | | | | |
| <i>Psychotria brachiata</i> | | | | | | | | X | | | | |
| <i>Renealmia cf. thyrsoidea</i> | Platanillo, Berber | | | | X | X | X | X | | | | |
| <i>Rhodostemonodaphne kunthiana</i> | | | | X | | X | X | | | | | |
| <i>Rubus urticifolius</i> | | | | | | | | | | NT | Crit. V 3.1 ii | |
| <i>Schefflera morototoni</i> | Arracacho | | | | | X | | X | | | | |
| <i>Senna bacillaris</i> | | | | | | | X | X | | | | |
| <i>Aids rhombifolia,</i> | Broom lasts, broom slug | | | | X | | | X | | | | |
| <i>Simarouba amara</i> | | | | | X | X | X | | | | | |
| <i>Tapirira guianensis</i> | Cedrillo, shrubs, palo balsudo | | X | | | X | X | X | | | | |
| <i>Tovomita weddelliana are excluded</i> | Carate | | | | | | X | X | | | | |
| <i>Tovomita weddelliana are excluded</i> | Carate | | | | | | X | X | | | | |
| <i>Trichilia pallida</i> | Guacharaca, wolf | | | | X | | X | | | | | |
| <i>Virola sebifera</i> | Soto, blood toro | | | | | X | X | | | | | |
| <i>Vismia baccifera</i> | Carate, sealing wax | | | | X | | X | | | | | |
| <i>Vismia macrophylla</i> | Siete cueros | | | | | | X | | | | | |
| <i>Vismia sp. 1</i> | Tongue Tip | | | | | | X | | | | | |
| <i>Vismia sp. 2</i> | Tongue Tip | | | | | | X | | | | | |
| <i>Vochysia sp.</i> | | | | | | X | X | | | | | |
| <i>Regia Welfia</i> | Thousand pesos, San Juan | | | | | X | X | | | LC | | |

As you can see in the Table , it was found that the species are closed: *Horrida*, *Cyathea andina*, *Cyathea molederana*, at the national level. Similarly, was assigned a *status* of threat,

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NT -almost threatened - for *Hymenia courbaril* and *Rubus urticifolius* and VU-vulnerable - for *Hyptidendron arboreum*.

Finally, add the information, by adding the proposed species in Appendix II of CITES and which were recorded in the inventory; these were: *Rubus urticifolius* with status Crit. V 3.1 ii; e *Hyptidendron arboretum* with status B1ab (iii), as for the species *Cyathea andina* and *Cyathea molederana* its marketing is prohibited.

3.3.1.2 Fauna

- Mammals

- Area of indirect influence

The study area, which in general is of mountainous topography, creeks and with strong slopes, high and steep, and with good water sources, has been highly intervened, although still presents some remnants or different sizes patches of open forest and high secondary vegetation (see Photo 3-33). In the study area is presented cane crops for milling, crops of Granadilla, tomato and fruit trees like mango, orange, lemon, in addition to bananas, plantain, cassava; also pastures are located. Throughout the course of the San Matias River, are protective forests and some areas with erosive processes.



Photo 3-33. View of the San Matias River

According to Hernandez-Camacho *et al.* . . . (1992), the study area is located in the Andean region, Nechi in the districts of Nechi, the biogeographically Province Choco-Magdalena, the district of Tolima, the biogeographically Norandean Province.

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➤ Nechi District.

This is a unit of humid Magdalena jungles, between the right margin of the low Cauca, including the valley of the Nechi River in Antioquia, and extends up to the Magdalena River, involving the hills of San Lucas, and continues down the right flank of the Magdalena River until reaching the vicinity of La Dorada, and a little more to the south, taking the lower foothills of the Andes, to the vicinity of Mariquita.

The biological elements in this area have clear affinities with those of the sector of the Alto Sinu, Alto San Jorge and with those of the Chocó. It is also an area for exchange of elements of the Magdalena high valley. In the area is presented an appreciable degree of endemic species, being one of the most characteristic elements of this area the species *Saguinus leucopus* (titi gray), whose actual distribution area coincides essentially with the district.

➤ Tolima District

The norandean province includes districts heavily transformed. Specifically for the Tolima District, low sustainability is reported by the present conditions of their ecosystems. However, Márquez notes that the Andean forests are found in better condition when compared with the sub Andean (www.virtual.unal.edu.co/cursos/IDEA/2010615/lecciones/estad_actual_trans/estado_act_trans4.html).

It is possible that the entire biota belonging to the region of the Magdalena middle and high valley (District Glory = V. 17, District Lebrija= V. 18, Carare = V. District 19, District Canon Chicamocha = IX.6 and District Tolima = IX.11), to have its limit in the south at the level of the Cambao region (Department of Cundinamarca) or in the vicinity of this (Halffter, 1992)

Of *Saguinus* Tran-Andean taxa are reported, widely separated from the main area of distribution of the gender, Alto Amazonas. These probably were able to reach the upper Magdalena valley by the depression of La Uribe during the season of high temperatures, and from there continued their dispersion (Defler, 2010). For *Saguinus leucopus* it is reported as part of its distribution area the Tolima District.

– Direct influence area

➤ Methodology

For the mammals inventory tours were conducted by the edge and the inside of the coverage of secondary vegetation and forests, seeking to explore the edges of creeks and the San Matias River being these the best preserved sectors. Table 3-82 present the sectors where the mammals sampling which were located in areas adjacent to similar coverage to those that were sampled for flora.

Table 3-82. Sectors of mammals sampling

| Vereda (Political and administrative division of the municipality located in the rural area) | Site | Sector | Habitat |
|--|------------------|-----------|---------------------------|
| El Molino | Forest road | Deposit 4 | Open Forest |
| Beaches | San Matias River | Deposit 2 | High Secondary Vegetation |

| | | | |
|---|--|----------------------------|------------|
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| Vereda (Political and administrative division of the municipality located in the rural area) | Site | Sector | Habitat |
|--|-------------------------|--------------|--|
| Campo Alegre | Aguas Claras | Planned Road | Dense Forest (Guadua), low secondary vegetation, clean grass |
| Los Mangos | San Matias River Sector | Deposit SM4 | High secondary vegetation, weeded grass |
| La Inmaculada | San Matias River Sector | Deposit SM2 | High Secondary Vegetation, open Forest |

In the different sampling sites were indirect records: hearing evidence, fingerprints, and marks in the bark of the trees, trails, rooting, feces, food waste, burrows and caves. There were also direct recordings as: sightings, installed mist nets to capture bats, and type Sherman sounds traps far-fetched for the live capture of small terrestrial mammals such as rodents and marsupials.

Flying Mammals (Bats)

The bats sampling was performed with two mist nets type (mist-nets), with mesh eye of 3x3 cm and 4x3 cm (see Photo 3-34). The nets were placed in foraging facilities and activity areas as edges and clear forest with florid vegetation or fructificated areas with water bodies. The nets were installed in the afternoon (5:00 pm) and were left open until the following day (Muñoz, 2001, Voss et al., 1996, Wilson et al, 1996). The determination and taxonomic classification of the recorded species were based on Cuartas-Calle and Munoz, 2003a, b; Muñoz et al. , 2003; Cuartas-Calle et al, 2001; Muñoz, 2001; Alberico et al. , 2000; Emmons and FEER, 1999; Wilson and Reeder, 1992; Eisenberg, 1990.



Photo 3-34. Bat captured in fog network

Small non-volant mammals

For the capture of small non-volant mammals (PMNV), Sherman traps were installed of 9x9x28 cm and 25x25x45 cm. In total 10 traps were installed, which were located at strategic sites and microhabitats as fallen logs, base of trees, trees branches, palms base and foliage, cavities formed by the roots, burrows, in edges of stones and in paths (Wilson et al, (1996) and Aranda-Sanchez (1981)).

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All the traps were examined daily in the morning hours, to verify the presence of catches and change lures. For traps are used as bait a mixture of oats in flakes, corn, bananas, peanuts, and essences of vanilla and banana. The determination and taxonomic classification of the registered species have been based on Cuartas-Calle , 2005; Morales-Jimenez et al. , 2004; Cuartas-Calle and Munoz, 2003a, b; Defler, 2003; Alberico et al. , 2000; Emmons and FEER, 1999; Wilson and Reeder, 1992; Eisenberg, 1990.

Capture Camera

It was Installed a capture camera type Cudde digital back, brand Capture IR, that has a photo receiver that is triggered with the body heat of an animal that is near. The camera was left at night close to footpaths, for the registration of the nocturnal animals. It is worth noting that it is very helpful, since it allows to photograph several nocturnal animals, for which in daytime the recording is difficult.

Sightings

Day hikes are conducted to obtain records of mammals of greater, middle and small size, which were obtained by direct observation or indirect evidence. In addition, photographic records were obtained when the observing conditions permitted (see Photo 3-35); also used surveys and reports from the area inhabitants for investigating the presence of mammals in the area.



***Oryzomys talamancae* (mountain mouse) in trap**



Traces of *Didelphis marsupialis*



Traces of *Cerdocyon thous*



Traces of *Procyon cancrivorus*

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Traces of *Lontra longicaudis*



Traces of *Eira barbara*



***Leopardus weidii* Footprint**



Traces of *Cuniculus paca*

Photo 3-35. Registration of mammals in the San Matias project influence area

The system of classification for the mammal species is given by the appearance order of each taxon at evolutionary level, from order, family, and kind, based on Mammal Species of the World, 2004. Mammalian species reported by the settlers of the area are included in the taxonomic list, but are not taken into account for the results of the Alpha diversity. For the endemic species and the most vulnerable consulted the preliminary list of Colombians mammals with some extinction risk (Rodriguez, J. V. 1998).

➤ Results

The mammals community recorded in the study area (200 individuals), is represented by eight orders, 19 families and 45 species (see Table 3-83).

Table 3-83. Taxonomic Determination, local names and diet of the recorded mammals in the study area

| Taxa | Common and local name | No. indiv. | Reports | Diet |
|------------------------------|--------------------------|------------|---------|------|
| CLASS: MAMMALIA | | | | |
| ORDER: DIDELPHIMORPHIA | | | | |
| FAMILY: DIDELPHIDAE | | | | |
| <i>Didelphis marsupialis</i> | Common Chucha | 9 | | O |
| FAMILY: MARMOSIDAE | | | | |
| <i>Marmosa robinsoni</i> | Mapurito, chuchita churn | 1 | | O |

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| Taxa | Common and local name | No. indiv. | Reports | Diet |
|----------------------------------|----------------------------------|------------|---------|------|
| ORDER HAIRY | | | | |
| FAMILY BRADYPODIDAE | | | | |
| <i>Bradypus variegatus</i> | Lazy. Parakeet lightweight | | X | Ff |
| ORDER: CINGULATA | | | | |
| FAMILY: Dasypodidae | | | | |
| <i>Centralis Cabassous</i> | Armadillo coletropo | 1 | | O |
| <i>Dasybus novemcinctus</i> | Armadillo, gurre | 13 | | O |
| ORDER: VERMILINGUA | | | | |
| FAMILY:MYRMECOPHAGIDAE | | | | |
| <i>Tamandua mexicana</i> | Anteater | | X | I |
| ORDER: CHIROPTERA | | | | |
| FAMILY: Phyllostomidae | | | | |
| <i>Micronycteris schmidtorum</i> | Bat | 1 | | F |
| <i>Discolor Phyllostomus</i> | Bat | 1 | | OR |
| <i>Anoura cultrata</i> | Bat | 1 | | P/N |
| <i>Glossophaga soricina</i> | Bat | 1 | | P/N |
| <i>Carollia colombiana</i> | Bat | 9 | | F |
| <i>Carollia sowelli</i> | Bat | 2 | | F |
| <i>Carollia perspicillata</i> | Bat | 9 | | F |
| <i>Artibeus gnomus</i> | Bat | 1 | | F |
| <i>Artibeus jamaicensis</i> | Bat | 5 | | F |
| <i>Artibeus lituratus</i> | Bat | 6 | | F |
| <i>Artibeus phaeotis</i> | Bat | 1 | | F |
| ORDER: CHIROPTERA | | | | |
| FAMILY: Phyllostomidae | | | | |
| <i>Platyrrhinus helleri</i> | Bat | 1 | | F |
| <i>Lilium Sturnira</i> | Bat | 3 | | F |
| <i>Ludovici Sturnira</i> | Bat | 2 | | F |
| <i>Uroderma bilobatum</i> | Bat | 1 | | F |
| <i>Vampyressa pusilla</i> | Bat | 1 | | F |
| FAMILY: VESPERTILIONIDAE | | | | |
| <i>Myotis nigricans</i> | Bat | 8 | | I |
| FAMILY: MOLOSSIDAE | | | | |
| <i>Molossus molossus</i> | Bat | 7 | | I |
| ORDER: PRIMATES | | | | |
| CALLITRICHIDAE FAMILY | | | | |
| <i>Saguinus leucopus</i> | Mico tistis | 46 | | O |
| FAMILY: AOTIDAE | | | | |
| <i>Aotus lemurinus</i> | Marteja | 2 | | F |
| ORDER: CARNIVORA | | | | |
| FAMILY: CANIDAE | | | | |
| <i>Cerdocyon thous</i> | Zorro dog. Dog city center Marno | 11 | | C |
| FAMILY: PROCYONIDAE | | | | |
| <i>Nasua nasua</i> | Cusumbo | 6 | | O |
| <i>Procyon cancrivorus</i> | Patemuchacho. Zorra patona | 3 | | C |
| (<i>Potos flavus</i> | Mount Dog | 2 | | F |
| FAMILY: MUSTELIDAE | | | | |
| <i>Mustela frenata</i> | Weasel | 1 | | C |
| <i>Eira barbara</i> | Ulama. Wolf | 2 | | C |
| <i>Lontra longicaudis</i> | Otter | 1 | | |
| FAMILY: Felidae | | | | |
| <i>Leopardus wiedii</i> | Margay | 1 | | C |
| ORDER: Rodentia | | | | |

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| Taxa | Common and local name | No. indiv. | Reports | Diet |
|--|-----------------------|------------|---------|------|
| FAMILY: SCIURIDAE | | | | |
| <i>Sciurus granatensis</i> | Squirrel alazana | 18 | | F |
| <i>Santanderensis Microsciurus flaviventer and mixed-species</i> | Ardillita rabicana | 4 | | F |
| FAMILY: MURIDAE | | | | |
| <i>Melanomys caliginosus</i> | Mountain Mouse | 2 | | O |
| <i>Nectomys melonius</i> | Water Mouse | 1 | | O |
| <i>Oryzomys alfaroi</i> | Mountain Mouse | 1 | | O |
| <i>Oryzomys talamancae</i> | Mountain Mouse | 1 | | O |
| <i>Reithrodontomys mexicanus</i> | Mouse | 1 | | O |
| FAMILY: ERETHIZONTIDAE | | | | |
| <i>Coendou prehensilis</i> | Hedgehog | | X | Ff |
| FAMILY: DASYPROCTIDAE | | | | |
| <i>Dasyprocta punctata</i> | Rabbit, trogon | 9 | | F |
| FAMILY: CUNICULIDAE | | | | |
| <i>Cuniculus paca</i> | Lapa, guagua | 3 | | F |
| FAMILY: Drainages | | | | |
| <i>Proechimys magdalenae</i> | Mouse spina bifida | 1 | | OR |
| Species Total 45 | | 200 | | |

Conventions: OR: omnivorous, C: carnivore, I: insectivore, F: frugivorous, Ff: frugivorous-folivoro, P/N: Polinivoro/Nectarivore.

The 45 species of mammals recorded in this study represent 9.81 % of the total proven for Colombia (465 species).

The order Chiroptera is the most diverse, with 18 species, followed by the order Rodentia with 11 species, Carnivora with eight species, and the Cingulata orders, Primates and Didelphimorphia with two species each; the other orders are represented by one species (see Table 3-83, Figure3-69 and Photo 3-36).

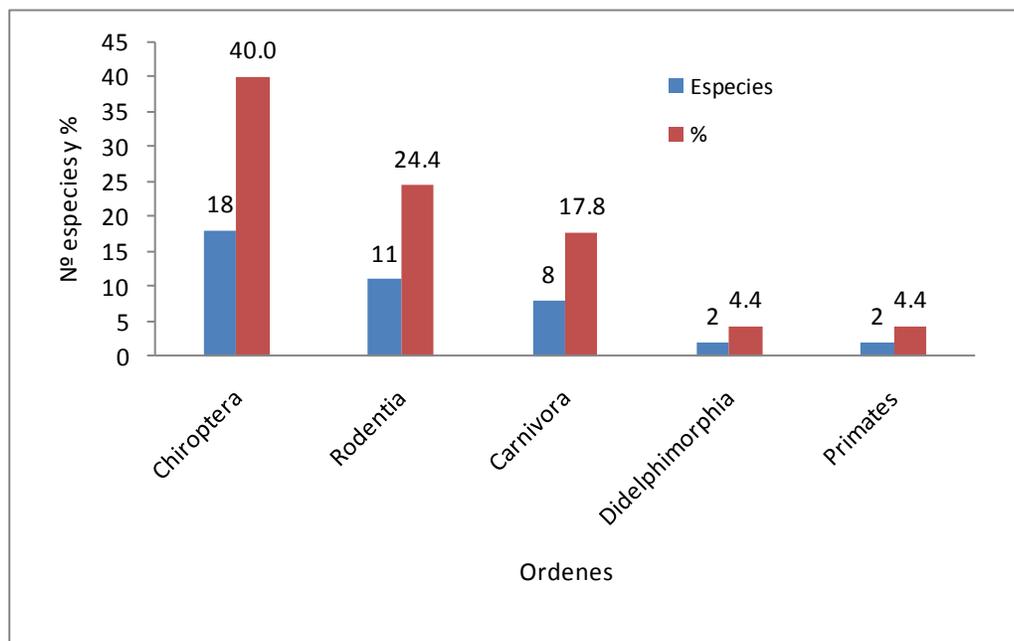


Figure3-69. Taxonomic structure (Orders) based on the recorded species in the study area

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Carollia colombiana



Artibeus gnomus



Artibeus lituratus



Liliom Sturnira

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Ludovici Sturnira



Uroderma bilobatum



Vampyressa pusilla



Nectomys melonius



Melanomys caliginosus



Oryzomys alfaroi

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Oryzomys talamancae

Photo 3-36. Species recorded in the influence area of the El Molino hydroelectric project

The seven orders accounted for 53.8 % of total non-aquatic mammals orders registered in Colombia (13 orders).

The most representative families, based on the recorded species, are: With 16 species Phyllostomidae, Muridae with five, Procyonidae and) with three, and Dasypodidae with two species, as can be seen in Table 3-83 and Figure 3-70 . The other families are represented by one species. The 19 families registered represent 45.2 % of the total number of families of non-aquatic mammals registered in Colombia (42 families).

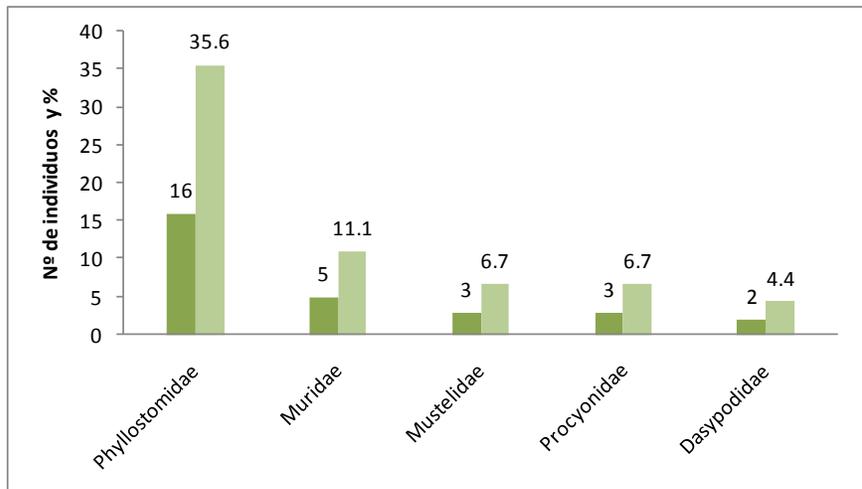


Figure 3-70. Taxonomic structure (families) based on the recorded species in the study area.

The hierarchical structure, composed of the orders, families and mammals species recorded in the study area indicates a great deal of richness, and shows that the area has a high representativeness of the mammals fauna that is present in the Colombian territory; it is also a good indicator of the conservation of the forested areas in the study area.

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➤ Ecological Indicators

Alpha diversity

A community is more complex while greater the number of species that conform it, as there are more avenues of energy flow in the food chain, and presents a high equity and a lesser dominance of a group with respect to the others.

The ecological indexes registered for this inventory give a value for Shannon-Wiener index of 4.4, the dominance of Simpson ($1-D = 0.06$), showing that there is no dominance of a group or species of mammals on another. The value of the equity ($E1= 0.83$) shows that the distribution of individuals within a species is uniform and does not get any dominance of one group over another. Presents a richness of 45 species and 200 individuals.

The mammals diversity that present the inventory plant coverage, is given by the extension of some forest patches, the flora composition, the refuge sites, the water and food supply that the coverages offered, and the ecology that each mammal species presents. There are species that are very demanding and specialists of the habitat they occupy, so in degraded areas or very altered, with missing water bodies of water, the presence of this fauna is low or null.

The availability of the trophic resources also influence the presence or absence of certain mammal species in the vegetation coverages, as well the different phenological stages of the plants (flowering or fruiting).

➤ Diet

Trophic structure (diet) is based on the preference for each species food, which is expressed through the relative importance values, that is to say, the proportion of each category within the total trophic species recorded.

The trophic structure of the species recorded in the study area is represented by six diets (see Figure 3-71). It was found that there is a greater dominance by frugivorous species with 19, followed by the omnivore with 13, the carnivorous with five, the wrens with three, the folivoras/avian frugivores and polinivoras/nectarivorous with two species.

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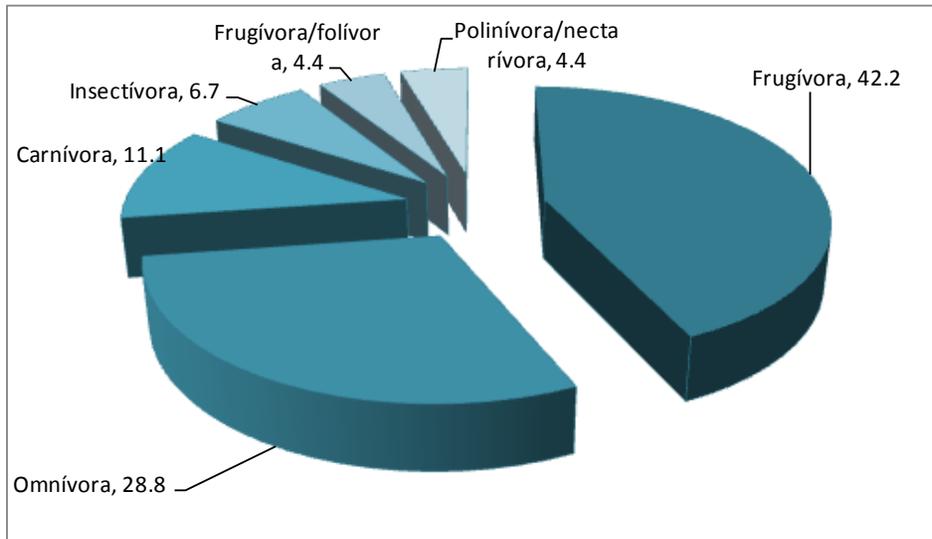


Figure 3-71. Trophic structure of the mammal species recorded in the study area.

The species, because of their diet, are a good resource in the forests, indicating the dependence on such species to the forest cover, since in them they find their food and shelters. The trophic structure presents a greater number of consumers of first order (frugívoros, frugívoros-folívoros), followed by the second-order consumers (carnívoros, insectívoros); and hence, omnívoros that are consumers of first and second order.

Based on the orders, families, and in the different trophic categories of the mammal species recorded, you can say that the community in the influence area is very diverse. Trophic structure shows that the food availability in the area is good, and indicates that the forest and the habitats are still well preserved.

The vegetation coverage of secondary vegetation high and open forest are of preference for the mammals, which is due to the fact that in this type of forest they find good shelter, protection against predators, food and nesting sites; in addition, based on the ecology and behavior of this fauna, this was to be expected. The species *Nectomys melonius* (water rat) and *Lontra longicaudis* (otter) are very dependent on water sources (near water bodies), given the diet and shelters they use. Other species utilize the edges of creeks, and rivers for water consumption, such as routes of displacement, and food achievement, as for example the species *Cerdocyon thous* and *Procyon cancrivorus*, which are used for consumption of crabs, and other arthropods.

➤ Curve of the cumulative number of species

We used the method of records in general, where it was assessed how complete is the list of resulting species, through the analysis of graphs that represent the cumulative number of species found in an area, in relation to the time that was used during the recognition.

In Figure 3-72 are observed the species accumulation curve for all coverages sampled

ENVIRONMENTAL IMPACT STUDY

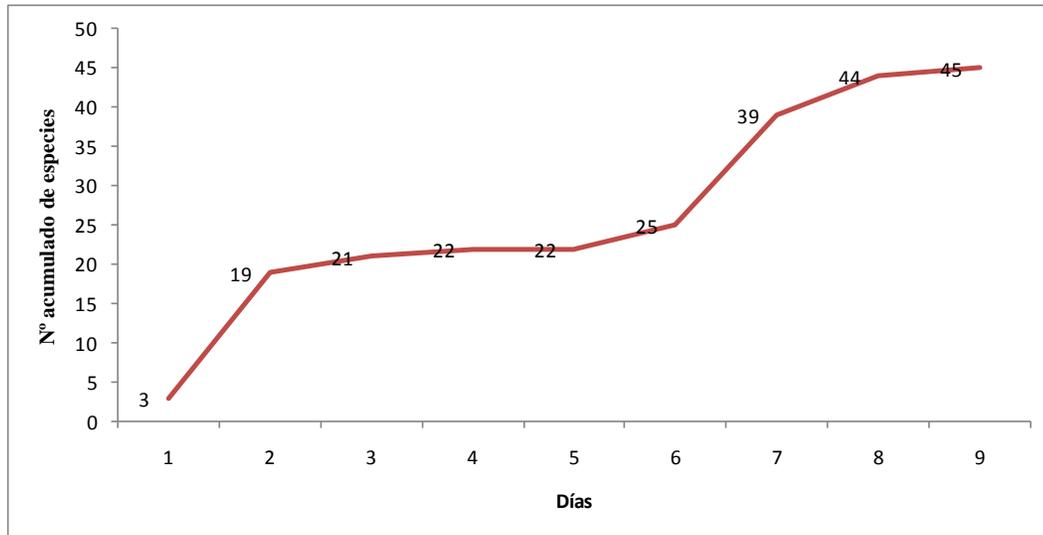


Figure 3-72. Curve of the cumulative number of mammal species recorded in the study area.

The remarkable increase of the curves in day two is explained because they are the first records that are obtained in the inventory. It would be expected that by increasing the days of sampling there would be variations and the asymptote of the curve would fall until stabilizing in N days of sampling; there would be few new records, and would be repetitions in the species observed or captured.

From day sixth to the ninth, the asymptote of the curve increases again, since the sites sampled correspond to new forests in localized areas in the warm thermal soil.

➤ Endemism and endangered species

Based on the listings of threatened mammals in Colombia (International Union for the Conservation of Nature IUCN, 2010, Rodríguez-Mahecha et al, 2006; Ministry of the Environment and Housing, 2005, Alexander von Humboldt Institute IAvH, 1998), presents the list of vulnerable species, in danger, in critical condition and near threatened (see Table 3-84).

Table 3-84. Mammalian species with some risk recorded in the study area.

| Species | IUCN (2010) | Ministry of Environment and Housing (2005) | IAvH (1998) |
|---------------------------|----------------------|--|-----------------|
| <i>Saguinus leucopus</i> | Endangered (EN) | Vulnerable (VU) | Vulnerable (VU) |
| <i>Aotus lemurinus</i> | Vulnerable (VU) | Vulnerable (VU) | Vulnerable (VU) |
| <i>Lontra longicaudis</i> | | Vulnerable (VU) | Vulnerable (VU) |
| <i>Leopardus wiedii</i> | Near Threatened (NT) | | Vulnerable (VU) |

| Especies | Nombre común | Cat. amenaza a nivel nacional | | | Cat. amenaza a nivel global http://www.iucnredlist.org |
|---------------------------|--------------|-------------------------------|-----------------|-----------------|--|
| | | Res. 383 de 2010 | Res 192 de 2014 | Libro rojo | |
| <i>Capito hypoleucus</i> | | EN (En Peligro) | EN (En peligro) | EN (En peligro) | VU (C2a) (Vulnerable) |
| <i>Ortalis columbiana</i> | Guacharaca | | | | LC (Preocupación menor) |

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| Especies | Nombre común | Cat. amenaza a nivel nacional | | | Cat. amenaza a nivel global http://www.iucnredlist.org |
|-------------------------|---------------|-------------------------------|-----------------|---------------------|--|
| | | Res. 383 de 2010 | Res 192 de 2014 | Libro rojo | |
| <i>Habia gutturalis</i> | Habia ahumada | | | NT (Casi amenazada) | NT (casi amenazada) |

There were recorded three endemic species: *Saguinus leucopus* (titi gray), whose distribution is very restricted, while found in the north and center of Colombia, between the Cauca and Magdalena Rivers, in Antioquia, Bolívar, Caldas up to the department of Tolima, (Cuartas-Calle , 2001, Defler, 2003, Morales-Jimenez et al, 2004); groups have been observed in the right margin of the Magdalena River in Barrancabermeja Vereda (*Political and administrative division of the municipality located in the rural area*) of San Rafael de Chucurí, Cimitarra - Santander (personal observation).

The *santanderienses* *Microsciurus flaviventer* and *mixed-species* (squirrel rabicana), whose distribution is restricted between the valley of the Magdalena River and the Eastern mountain range, in Antioquia, Bolívar, Caldas, Guajira, Santander, (Koprowski and Roth, 2008). AND *Proechimys magdalenae* (spiny rat), which is distributed to the west of the middle valley of the Magdalena River, in Antioquia, (Tirira et al, 2008).

The vulnerable species (VU) are *Saguinus leucopus* (titi gray), *Aotus lemurinus* (marteja), *Lontra longicaudis* (otter) and *Leopardus wiedii* (ocelot). These species are found in this category due to the fact that many wild populations have disappeared by the indiscriminate hunting, and by the sale of pups as pets, as well as by the destruction and degradation of their habitats.

The species endangered (EN) are the *Saguinus leucopus* (titi gray) and the Near Threatened (CT) is *Leopard wiedii* (margay), that are in this category because of the indiscriminate hunting they are subject to having them as pets and for the destruction and degradation of their habitats.

It must be borne in mind that the species *Saguinus leucopus* appears in three categories (endemic, vulnerable and endangered), given its distribution in the Colombian territory and its fragility to the deterioration of their natural habitats. The *Leopard species wiedii* appears in two categories (Vulnerable and almost threatened), due to the indiscriminate hunting to which is subjected and to their habitat deterioration.

The results highlight the ecological importance of the study area for the protection of terrestrial mammals, in particular by the species that were recorded and are cataloged as endemic, vulnerable, endangered, critically Endangered, and almost endangered, which reaffirms the importance of the study area in the protection of the mammalian fauna of special interest at national level.

– Conclusions

The existence in the study area of natural corridors between the forests of the sampled sites, ecosystems of the micro-watersheds depository of the San Matias River, are of great importance for the protection of the animal populations that inhabit the area, due that these corridors facilitate the exchange of genetic flow between individuals of the same species present there.

| | | | |
|---|--|----------------------------|------------|
|  | EL MOLINO AND SAN MATÍAS HYDROELECTRIC PROJECTS | Doc.: 2148-04-EV-ST-020-03 | |
| | | Rev. No. : 0 | 2012-03-30 |
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It is of the utmost importance the conservation and protection of the forested study areas, since these have registered three endemic species *Saguinus leucopus* (Titi gray), *Proechimys magdalenae* (spiny rat) and *santanderiensis Microsciurus flaviventer and mixed-species* (ardita cusca). Three species are vulnerable *Saguinus leucopus* (Titi gray), *Aotus lemurinus* (marteja or mico at night) *Lontra longicaudis* (Otter) and *Leopardus wiedii* (Ocelot).

Wildlife populations are part of the various ecosystems, and conservation or protection to ensure the permanence of the species, ecosystems and biotic diversity in general, it should be emphasized mainly in the endemic and threatened. Some species are more prone to degrade and become extinct than others; such is the case of the rare species, especially the geographical distribution or ecological very restricted, and especially the endemic as: *Saguinus leucopus* (Titi gray) and *Proechimys magdalenae* (Mouse thorny).

As registered to date shows that the most important danger for wildlife mammals species recorded, is the deterioration and disappearance of their original habitats, as a result of colonization, the establishment of land for grazing, the expansion of the agricultural frontier, the logging that is observed in the study area.

- Birds

The total land area where birds monitoring took place, is composed of open forest, high and low secondary vegetation bordering the banks of the San Matias River (see Photo 3-37).

These areas are being used particularly for the agricultural and livestock exploitation at small and medium-scale, mainly from sugar cane for the production of brown sugar, and some fruits such as bananas, passion fruit, orange and lemon. The area that has a better plant coverage, according to those observed during the field trips, is located in the sectors of the middle part of the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, Campoalegre and Los Magos, which have births and water sources, moderately protected by the different forest systems.

The characteristics of the fragments evaluated as the estimated size, vegetation types, the existence of paths that communicate with smaller fragments, facilitate the exchange of individuals between populations, and their food webs sources are sufficient to sustain the populations encountered and in addition, there are other nearby forest fragments to the monitoring areas that serve as refuge.

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Sugarcane Planting and high secondary vegetation in the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos



Low Secondary Vegetation, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Campoalegre



Open Forest, Vereda (*Political and administrative division of the municipality located in the rural area*) Campoalegre

Photo 3-37. Coverages in the influence area of the El Molino hydroelectric project

The habitats are important factors to be taken into account because they give an idea of the places that are frequented or inhabited by birds. In the different vegetation coverages monitored, could not be found primary forest as such, but areas with open woodland and high secondary vegetation, that are providing shelter, food, rest places and birds nesting. There were four habitats that could be determined: Pasture, high and low secondary vegetation, and open Forest.

– Methodology

The characterization of the avian fauna is conducted in the vicinity of the influence area of the El Molino hydroelectric project and farms with different vegetation coverages (see Table 3-85).

Table 3-85. Location of the sites for birds monitoring.

| Site | Coverage | Relief |
|-------------|--|----------|
| Molino | High secondary vegetation, clean grass | Moderate |
| Los Mangos | Weeded grass, clean grass | Flat |
| Campoalegre | Dense Forest (guadua), low secondary vegetation, clean grass | High |
| Campoalegre | Low Secondary Vegetation | High |
| Molino | High Secondary Vegetation, dense forest (guadua) | Moderate |

Direct observations were conducted, using 10X40 binoculars and capture of specimens with three mist nets, at an approximate distance of 40 m between them and during an average of eight hours a day, for five days. These nets were placed in strategic places such as along roadsides, inside the forest, debris, pastures and along the riverbanks, attempting to ensure birds transit. To those which were captured, were placed in cloth bags (see Photo 3-38), then photograph them (see Photo 3-39) and then be released, since it was not carried out a collection of examples.



Mist Nets



Introduced birds within cloth bags

Photo 3-38. Birds capture in the influence area of the San Matias hydroelectric project .



ENVIRONMENTAL IMPACT STUDY

Jacamar (*Galbula Ortalis ruficauda colirrufo*).



Dendroica fusca (cerulean gorginaranja)



Columbina talpacoti (Tortolita reddish),



Leptotila verreuxi (tortola bar-tailed godwits)



Cathartes aura (Guala cabecirroja)



Coragyps atratus (black vulture)



Buteo magnirostris (sparrowhawk caminero)

Chondrohierax uncinatus (caracolero jungla)

ENVIRONMENTAL IMPACT STUDY



Ortalis columbiana (E) (Colombian guacharaca)



Amazilia franciae (amazilia andino), (♂)



Doryfera ludovicianae (peak of tiller frentiverde)



Ye Phaethornis strigular (hermit dwarf)



Saucerottia saucerrottei (Amazilia deliver such a tool proved more elusive than)



Jacamar (*Galbula Ortalis ruficauda colirrufo*)

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Melanerpes rubricapillus (carpenter habado)



Piaya cayana (cuckoo-common squirrel)



Amazilia tzacatl (amazilia red-tailed hawk)



Tyrannus melancholicus (siriri common)



Machaeropterus Regulus (jumping scratched) (♂)

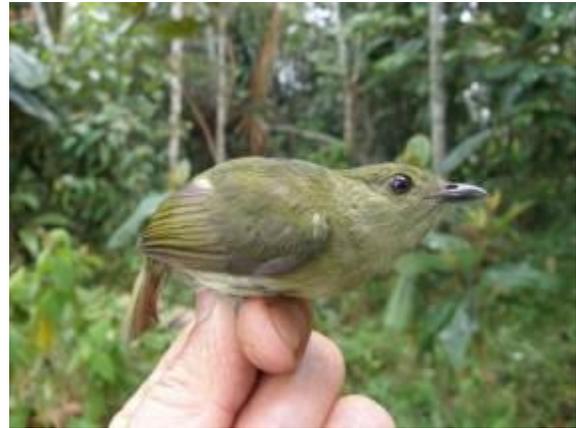


Machaeropterus Regulus (jumping scratched) (♀)

ENVIRONMENTAL IMPACT STUDY



Manacus manacus (Jumping barbiblanco), (♂)



Manacus manacus (Jumping barbiblanco), (♀)



Thraupis palmarum (azulejo palmero)



Thraupis episcopus (common tile)



Flavogaster Elaenia (elaenia elegant-crested tinamou)



Mionectes oleagineus (flycatchers front)

ENVIRONMENTAL IMPACT STUDY



Stelgidopteryx ruficollis (swallow barranquera)



Leptopogon superciliaris (Flycatchers orijinegro)



Turdus Ignobilis (May embarrador)



Catharus ustulatus (el zorzal buchepecoso)



Phaethlypis fulvicauda (coastal aranero)



Basileuterus rufifrons (aranero cabecirrufo)

ENVIRONMENTAL IMPACT STUDY



Ramphocelus dimidiatus (Toche silver peak), (♂)



Ramphocelus dimidiatus (Toche silver peak), (♀)



Rio Piranga rubra (Rio Piranga abejera) (♂)



Saltator maximus (jumper ajicero)



Dendroica fusca (cerulean gorginaranja)

Photo 3-39. Birds sighted in the project influence area.

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It was also carried out the bird count, taking into account the number of individuals per species, both the captured as those observed. Another parameter was the cumulative number of different species that were observed daily.

Sampling was carried out between the 10th. and 14th.of October 2011, to complement the information collected in the Environmental Assessment of alternatives. Bird observation was carried out between 7:30 am until 5:30 PM. For its capture, the mist nets remained roughly nine hours each, for a total of twenty-seven hours daily for the three networks, for a total of 135 hours for the 5 days.

To the systems called high secondary vegetation (see Cartography 2148-04-EV-DW-031), two days were spent, and the other systems took a day, due to greatest difficulties in the capture and observation in the VSA, besides there may be a greater species variety, given the structural complexity of this coverage

– Results

During the five days of sampling were recorded a total of 100 species in 391 individuals belonging to 13 orders and 33 families. The total number of birds recorded corresponds to a 5.4 % of the total existing in Colombia (approximately 1,883 species, see Table 3-86), emphasizing that during these dates, coincided with the permanence of migratory birds (residents of winter, or boreal migration), which have been successful in identifying a total of 11 species (see Table 3-86).

Table 3-86. Taxonomic determination of birds recorded, amount of individuals and diets in the influence area of the El Molino hydroelectric project

| Quantity. | Taxa | Common Name | Sites | | | | | Total | Diet |
|-----------|---|----------------------|-------|---|---|---|---|-------|------|
| | | | 1 | 2 | 3 | 4 | 5 | | |
| I | Birds class | | | | | | | | |
| | I) ORDER TINAMIFORMES | | | | | | | | |
| | 1 TINAMIDAE FAMILY | | | | | | | | |
| 1 | <i>Crypturellus soui</i> | Tinamous chico | | 1 | | | | 1 | F/G |
| | II) Order Falconiformes | | | | | | | | |
| | 2 FAMILY CATHARTIDAE | | | | | | | | |
| 2 | <i>Cathartes aura</i> | Guala cabecirroja | 2 | | 2 | | | 4 | Crr |
| 3 | <i>Coragyps atratus</i> | Black Vulture | 3 | | | 1 | | 4 | Crr |
| | 3 FAMILY ACCIPITRIDAE | | | | | | | | |
| 4 | <i>Sparrow-hawk (buteogallus anthacinus urubitinga)</i> | Great Crab | 1 | | | | | 1 | R |
| 5 | <i>Chondrohierax uncinatus</i> | Jungle caracolero | | 1 | | | | 1 | R |
| | 4 FAMILY FALCONIDAE | | | | | | | | |
| 6 | <i>Buteo magnirostris</i> | Gavilán caminero | 1 | 1 | 1 | 1 | | 4 | R |
| 7 | <i>Buteo swainsoni (M)</i> | Swainson Hawk | 30 | | | | | 30 | R |
| 8 | <i>Falco peregrinus (M)</i> | Peregrine Falcon | 1 | | | | | 1 | R |
| 9 | <i>Milvago chimango chimachima</i> | Gavilán garrapatero | 1 | | | | 1 | 2 | R |
| | III) ORDER GALLIFORMES | | | | | | | | |
| | 5 FAMILY CRACIDAE | | | | | | | | |
| 10 | <i>Ortalis columbiana (E)</i> | Guacharaca colombian | | | | | 3 | 3 | F/G |
| | IV) ORDER COLUMBIFORMES | | | | | | | | |
| | 6 FAMILY COLUMBIDAE | | | | | | | | |
| 11 | <i>Columbina talpacoti</i> | Tortolita reddish | 3 | | | | | 3 | G |

ENVIRONMENTAL IMPACT STUDY

| Quantity. | Taxa | Common Name | Sites | | | | | Total | Diet |
|-----------|--|------------------------------------|--------|---|---|---|---|-------|------|
| | | | 1 | 2 | 3 | 4 | 5 | | |
| 12 | <i>Leptotila verreauxi</i> | Tortola bar-tailed godwits | 2 | | | | | 2 | G |
| | V) Order Psittaciformes | | | | | | | | |
| | 7 FAMILY PSITTACIDAE | | | | | | | | |
| 13 | <i>Forpus xanthops conspicillatus</i> | Spectacled Parrotlet | 4 | | | 4 | | 8 | F/G |
| 14 | <i>Pionus chalcopterus</i> | Corn Belt Parrot | 1 0 | | | | | 10 | F/G |
| | VI) CUCULIFORMES ORDER | | | | | | | | |
| | 8 FAMILY CUCULIDAE | | | | | | | | |
| 15 | <i>Crotophaga ani</i> | A garrapatero common | 6 | | | | | 6 | I |
| 16 | <i>Piaya cayana</i> | Cuckoo-common squirrel | 1 | 1 | 1 | 1 | | 4 | I |
| 17 | <i>Tapera naevia</i> | Without cuckoo-order | | 1 | | 1 | | 2 | I |
| | IX) ORDER APODIFORMES | | | | | | | | |
| | 12 FAMILY TROCHILIDAE | | | | | | | | |
| 18 | <i>Amazilia Francie</i> | Amazilia andean | | | 1 | | | 1 | N |
| 19 | <i>Amazilia tzacatl</i> | Amazilia red-tailed hawks | 2 | | 2 | 1 | | 5 | N |
| 20 | <i>Anthracothorax nigricollis</i> | Handle black-chested fruiteater | | 2 | | | | 2 | N |
| 21 | <i>Chlorostilbon, Chlorostilbon mellisugus</i> | Blue tail Emerald | | | | 1 | | 1 | N |
| 22 | <i>Doryfera ludoviciae</i> | Peak of tiller frentiverde | | | | 1 | | 1 | N |
| 23 | <i>Phaethornis strigularis</i> | Hermit dwarf | | | | 1 | | 1 | N |
| 24 | <i>Phaethornis syrmatorphorus</i> | Hermit griffon | | | 1 | | | 1 | N |
| 25 | <i>Saucerotia saucerottei</i> | Blue tail Amazilia | | | 2 | | | 2 | N |
| | X) CORACIIFORMES | | | | | | | | |
| | 13 MOMOTIDAE FAMILY | | | | | | | | |
| 26 | <i>Baryphthengus Martii</i> | Barranquero Canelo | | | | | 1 | 1 | F/I |
| 27 | <i>Momotus momota</i> | Barranquero coronado | | | | | 1 | 1 | F/I |
| | XI) GALBULIFORMES | | | | | | | | |
| | 14 GALBULIDAE FAMILY | | | | | | | | |
| 28 | <i>Galbula Ortalis ruficauda</i> | Jacamar colirrufo | | | 1 | | | 1 | I |
| | XII) ORDER PICIFORMES | | | | | | | | |
| | 15 FAMILY CAPITONIDAE | | | | | | | | |
| 29 | <i>Capito hypoleucus (E)</i> | Torito capiblanco | 2 | | | 2 | | 4 | F |
| 30 | <i>Eubucco bourcierii</i> | Torito red-capped | 2 | | | 2 | 2 | 6 | F |
| | 17 FAMILY PICIDAE | | | | | | | | |
| 31 | <i>Dryocopus lineatus</i> | Real Carpenter | | | | | 1 | 1 | I/C |
| 32 | <i>Punctigula Colaptes fernandinae)</i> | Carpenter buchepecoso | | 1 | | | | 1 | I/C |

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| Quantity. | Taxa | Common Name | Sites | | | | | Total | Diet |
|-----------|---|---------------------------------|--------|---|---|---|---|-------|------|
| | | | 1 | 2 | 3 | 4 | 5 | | |
| 33 | <i>Melanerpes rubricapillus</i> | Carpenter habado | 2 | | | | | 2 | I/C |
| | XIII) ORDER PASSERIFORMES | | | | | | | | |
| | 18 FAMILY FURNARIIDAE | | | | | | | | |
| 34 | <i>Synallaxis albescens</i> | Pale Rastrojero | | | 1 | | | 1 | I |
| | 19 FAMILY THAMNOPHILIDAE | | | | | | | | |
| 35 | <i>Thamnophilus multistriatus</i> | Batara laugh | | 2 | | 2 | | 4 | I |
| | 20 FAMILY COLLECTION | | | | | | | | |
| 36 | <i>Machaeropterus Regulus</i> | Jumping scratched | | 2 | | 2 | | 4 | F |
| 37 | <i>Manacus manacus</i> | Jumping barbiblanco | | 1 | | | 1 | 2 | F |
| | 21 FAMILY COTINGIDAE | | | | | | | | |
| 38 | <i>Tityra semifasciata</i> | Masked Sandfiy May | | | 2 | | | 2 | F/I |
| | 22 FAMILY TYRANNIDAE | | | | | | | | |
| 39 | <i>Contopus sordinulus (M)</i> | Western Flycatchers | | | 1 | | | 1 | I |
| 40 | <i>Elaenia flavogaster</i> | Elegant-crested tinamou Elaenia | 2 | 2 | | | 2 | 6 | I |
| 41 | <i>Flycatcher trailii (M)</i> | Traill Flycatchers of | | 1 | | | | 1 | I |
| 42 | <i>Legatus leucophaeus</i> | Flytrap pirate | 2 | 1 | | | | 3 | I |
| 43 | <i>Leptopogon superciliaris</i> | Flytrap orijinegro | | | 2 | | | 2 | I |
| 44 | <i>Machetornis rixosa</i> | Flytrap livestock | 2 | | | | | 2 | I |
| 45 | <i>Billed flycatcher commonly builds Megarhynchus</i> | Flytrap weevil | | | | 2 | | 2 | I |
| 46 | <i>Mionectes oleagineus</i> | Flytrap ocraceo | | | 3 | 1 | | 4 | F/I |
| 47 | <i>Myiarchus tuberculifer</i> | Flytrap capinegro | | | 1 | | 1 | 2 | I |
| 48 | <i>Myiodynastes maculatus</i> | Siriri scratched | | 2 | | 2 | 2 | 6 | I |
| 49 | <i>Myiozetetes cayanensis</i> | Welded crestinegra | 2 | 2 | | | 2 | 6 | I |
| 50 | <i>Oncostoma olivaceum</i> | Olive Piquitorcido | | 1 | | 1 | | 2 | I |
| 51 | <i>Pitangus sulfuratus</i> | Bichofue | | 2 | | | | 2 | I |
| 52 | <i>Sayornis nigricans</i> | Flytrap cuidapuentes | | 2 | | | | 2 | I |
| 53 | <i>Isolated from Pleurothyrium cinereum Todirostrum</i> | Common Espatulilla | 2 | | | | | 2 | I |
| 54 | <i>Tyrannus melancholicus</i> | Siriri common | 2 | 3 | | 2 | 2 | 9 | I |
| 55 | <i>Zimmerius chrysops</i> | Tiranuelo matapalos | 1 | | | | | 1 | I |
| | 23 FAMILY HIRUNDINIDAE | | | | | | | | |
| 56 | <i>Pygochelidon cyanoleuca</i> | Blue-white swallow | 1 0 | | | | | 10 | I |
| 57 | <i>Stelgidopterix ruficollis</i> | Barranquera swallow | 8 | 9 | 6 | 8 | | 31 | I |
| | 24 FAMILY CORVIDAE | | | | | | | | |

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| Quantity. | Taxa | Common Name | Sites | | | | | Total | Diet |
|-----------|---------------------------------|------------------------------|-------|---|---|---|---|-------|------|
| | | | 1 | 2 | 3 | 4 | 5 | | |
| 58 | <i>Cyanocorax affinis</i> | Carriqui pechiblanco | | | 3 | | 3 | 6 | F/I |
| | 25 FAMILY TROGLODYTIDAE | | | | | | | | |
| 59 | <i>Henicorhina leucosticta</i> | Cucarachero pechiblanco | 2 | 2 | | 1 | | 5 | I |
| 60 | <i>Spadix Pheugopedius</i> | Cucarachero cabecinegro | | | 1 | | 1 | 2 | I |
| 61 | <i>Troglodytes aedon</i> | Cucarachero Common | 2 | 2 | | | | 4 | I |
| | 26 FAMILY TURDIDAE | | | | | | | | |
| 62 | <i>Catharus ustulatus</i> | Zorzal buchepecoso | | | 2 | | | 2 | F/I |
| 63 | <i>Turdus Ignobilis</i> | May embarrador | 2 | 2 | | | | 4 | F/I |
| | 27 VIREONIDAE FAMILY | | | | | | | | |
| 64 | <i>Cyclarys gujanensis</i> | Verderon cejirrufo | | | 2 | | | 2 | I |
| 65 | <i>Vireo leucophrys</i> | Mountaineer Verderon | 1 | | | | | 1 | I |
| | 28 FAMILY ICTERIDAE | | | | | | | | |
| 66 | <i>Icterus chrysater</i> | Mountaineer cowled blackbird | | 2 | | | | 2 | F |
| 67 | <i>Molothrus bonariensis</i> | Chamonmaicero | 4 | | | | | 4 | G |
| 68 | <i>Molothrus oryzivora</i> | Chamon giant | | | 8 | | | 8 | F/G |
| 69 | <i>Decumanus Psarocolius</i> | Golden Oriole crested | | | | | 1 | 1 | |
| | 29 (Parulidae FAMILY | | | | | | | | |
| 70 | <i>Basileuterus rufifrons</i> | Arañero cabecirrufo | | | 2 | | | 2 | I |
| 71 | <i>Dendroica aestiva (M)</i> | Golden reinita | 1 | | | | | 1 | I |
| 72 | <i>Dendroica fusca (M)</i> | Cerulean gorginaranja | | | 2 | 1 | | 3 | I |
| 73 | <i>Dendrica virens (M)</i> | Cerulean verdinegra | | | | 1 | | 1 | I |
| 74 | <i>Pilgrim Leiothlypes (M)</i> | Cerulean verderona | | | | 1 | | 1 | I |
| 75 | <i>Mniotilta varies (M)</i> | Cerulean climber | | | 1 | | | 1 | I |
| 76 | <i>Phaeothlypis fulvicauda</i> | Coastal Arañero | | 2 | | | | 2 | I |
| 77 | <i>Wilsonia canadensis (M)</i> | Canada reinita | | | 2 | | | 2 | I |
| | THRAUPIDAE FAMILY 30 | | | | | | | | |
| 78 | <i>Coereva flaveola</i> | Common Bee | 6 | | 3 | 4 | | 13 | F/N |
| 79 | <i>Dacnis cayana</i> | Blue Bee | | | | 2 | | 2 | F/N |
| 80 | <i>Rufus Tachyphonus</i> | Parlotero malcasado | | | | 2 | | 2 | F |
| 81 | <i>Ramphocelus dimidiatus</i> | Silver Peak Toche | 2 | | 4 | 3 | 3 | 12 | F |
| 82 | <i>Ramphocelus icteronotus</i> | Toche culiamarillo | 4 | | | 2 | | 6 | F |
| 83 | <i>Viridis Tersina</i> | Azulejo swallow | 3 | 2 | | | | 5 | F |
| 84 | <i>Hemithraupis flavicollis</i> | Pitasilgo culiamarillo | 2 | | | | | 2 | F |
| 85 | <i>Saltator ability</i> | Bouncing papayero | 2 | | | | | 2 | F/G |

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| Quantity. | Taxa | Common Name | Sites | | | | | Total | Diet |
|-----------|-------------------------------|----------------------------------|------------|-----------|-----------|-----------|-----------|------------|------|
| | | | 1 | 2 | 3 | 4 | 5 | | |
| 86 | <i>Saltator maximus</i> | Pouncing ajicero | | 3 | 2 | 2 | | 7 | F/G |
| 87 | <i>Saltator striatipectus</i> | Saltator pius jew | | 2 | | | | 2 | F/G |
| 88 | <i>Tiaris olivaceus</i> | Semillero cariamarillo | 2 | | | | | 2 | G |
| 89 | <i>Tangara cyanicollis</i> | Tangara real | 2 | | | 2 | 2 | 6 | F |
| 90 | <i>Tangara inornata</i> | Tangara cinderella | | 3 | 2 | | 1 | 6 | F |
| 91 | <i>Tangara vitriolina</i> | Tangara rastrojera | 6 | | 2 | 2 | | 10 | F |
| 92 | <i>Thraupis episcopus</i> | Common Tile | 4 | | 3 | | | 7 | F |
| 93 | <i>Thraupis palmarum</i> | Azulejo palmero | 3 | 2 | 2 | 3 | 2 | 12 | F |
| | 31 FAMILY CARDINALIDAE | | | | | | | | |
| 94 | <i>Piranga rubra (M)</i> | Piranga abejera | | | | 1 | | 1 | F/I |
| | 32 FAMILY EMBERIZIDAE | | | | | | | | |
| 95 | <i>Arremonops conirostris</i> | Pinzón conirostro | | | 1 | | | 1 | F/G |
| 96 | <i>Sicalis flaveola</i> | Canario Coronado | 2 | | | | | 2 | G |
| 97 | <i>Sporophila nigricollis</i> | Several Australian cappuccino | 2 | | | | | 2 | G |
| 98 | <i>Oryzoborus funereus</i> | Arrocero piquigruoso | | | | 1 | | 1 | G |
| | 33 FAMILY FRINGILLIDAE | | | | | | | | |
| 99 | <i>Euphonia laniirostris</i> | Eufonia gorgiamarilla | 4 | | 2 | | 2 | 8 | F |
| 100 | <i>Carduelis psaltria</i> | Jilguero aliblanco | 2 | | | | | 2 | G |
| | | | 162 | 60 | 71 | 64 | 34 | 391 | |
| | | | 47 | 30 | 34 | 34 | 20 | 100 | |

Conventions: **R** (rapacious); **rrc** (Scavengers); **F/G** (granivorous frugivorous); **F/I** (frugivorous insectivorous); **F/N** (frugivorous nectarivorous); **F** (frugivorous); **G** (Granivorous); **I/C** (Insectivore bark); **I** (insectivorous); **N** (nectarivorous); **M** (migratory); **and** (endemic).

Of the different sampling sites, the first was the one who had a greater number of species, with a total of 47, 162 individuals, which can be explained because this site corresponds to high secondary vegetation, which gives the birds good food webs and shelter sources; it was followed to this site, the three and four with 34 species with 71 and 62 individuals, respectively, site 2 with 30 and finally site five with 20 species and 33 individuals (see Table 3-87). The values found are also explained by the low activity presented by the birds, due to the heavy rains that occurred during the sampling days

Table 3-87. Cumulative number of species and individuals per site in the influence area of the El Molino hydroelectric project

| Sites | 1 | 2 | 3 | 4 | 5 |
|------------------------------|-----|----|----|----|-----|
| Number of individuals | 162 | 60 | 71 | 62 | 33 |
| Species accumulated | 47 | 65 | 85 | 95 | 100 |
| Number of determined species | 47 | 30 | 34 | 34 | 20 |

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Site 1: Vereda (Political and administrative division of the municipality located in the rural area) Molinos High Secondary Vegetation; Site 2: Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos. Weeded grass and clean grass; Site 3: Vereda (Political and administrative division of the municipality located in the rural area) Campo Alegre. Dense Forest (guadua), low secondary vegetation and clean grass; Site 4: Vereda (Political and administrative division of the municipality located in the rural area) Campo Alegre. Low Secondary Vegetation; Site 5: Dense Forest (guadua)

The family that had the greatest number of species is the Tyrannidae family (Flycatchers, siriries), with a total of 17 species (17.0 % of the total birds certain), followed by the Thraupidae family (tiles tanagers, orchard), with 16 species (16.0 % of the total certain birds), the Trochilidae (Hummingbirds or chupaflores) and with eight species (Parulidae (8% of the total certain birds) (see Table 3-86).

The kind that presented the greatest number of individuals was the *Stelgidopteryx ruficollis* (swallow barranquera) with 31 individuals (7.9 % of the total of the individuals), followed by *Buteo swainsoni* (Swainson hawk) with 30 individuals (7.6 % of the total of the individuals), accounted for *flaveola* (bee common) with 13 individuals (3.3 % of the total of the individuals), with 12 individuals and species *Ramphocelus dimidiatus* (Toche silver peak) and *T. hrapuis palmarum* (azulejo palmero) (3.0 % of the total of the individuals) .

There are reported in the study zone two endemic species to Colombia, *Ortalis columbiana* (Colombian guacharaca) and *Habia gutturalis* (smoked Habia), the second one is recorded in the "Red Book", birds of Colombia, in category Near threatened (NT), due to the deterioration of the habitat and indiscriminate hunting for the wild fauna trade (Toro and Cuervo 2002), (Renjifo L. M. , Mary Frank, David Amaya, Gustavo Catan, and Barnabas Lopez-Lanus . 2002), (McMullan et al 2010).

– Cumulative number of species

For the cumulative number of birds species, was the daily birds record from the first observation day until the end of the monitoring, recording a total of 100 species (see Table 3-88 and Figure 3-73).

Table 3-88. Quantity of species accumulated during the monitoring of wildlife in the influence area of the El Molino hydroelectric project

| N° day | Date | Number of species observed | Numbers of new species | Cumulative number of species |
|--------|-----------------|----------------------------|------------------------|------------------------------|
| 1 | October 10/2011 | 47 | 47 | 47 |
| 2 | October 11/2011 | 30 | 18 | 65 |
| 3 | October 12/2011 | 34 | 20 | 85 |
| 4 | October 13/2011 | 34 | 10 | 95 |
| 5 | October 14/2011 | 20 | 5 | 100 |

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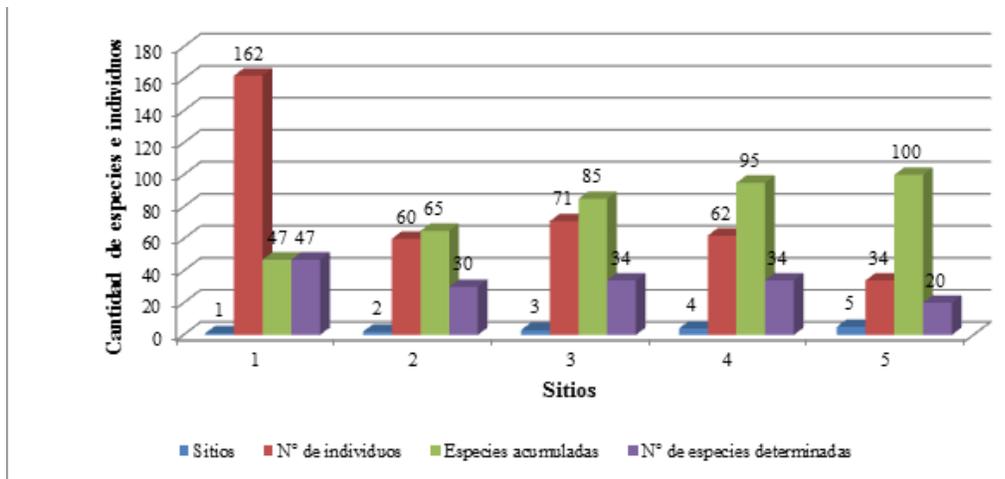


Figure 3-73. Cumulative number of species of birds and individuals in the different monitoring sites in the influence area of the El Molino hydroelectric project

The species accumulation curve shows how new species continue to appear to increase the sampling days (see Figure 3-74).

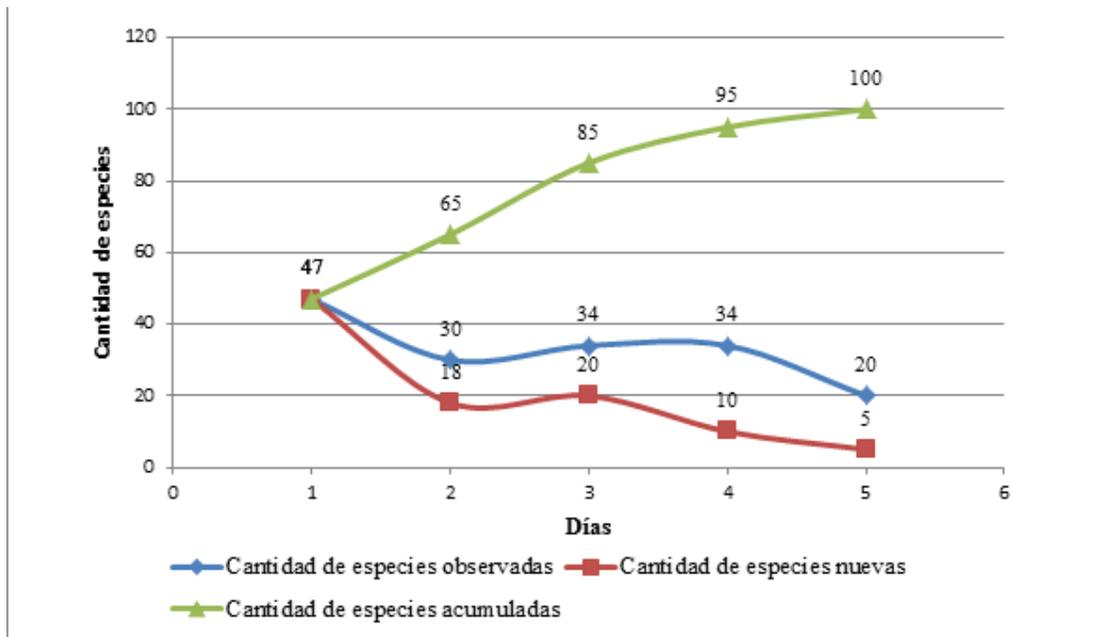


Figure 3-74. Cumulative number of species during five field days in the influence area of the El Molino hydroelectric project

– Relative Abundance

Figure 3-75 Presents the bird species with more than six individuals registered in the influence area of the project; the kind that presented the greatest number of individuals was *Stelgidopteryx ruficollis* (Swallow barranquera) with 31 individuals (8.0 % of the total of the individuals), followed by *Buteo swainsoni* (Swainson Hawk) with 30 individuals (7.8 %);

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flaveola accounted for with 13 individuals (3.42 %), *Ramphocelus dimidiatus* (Toche silver peak) and *Thraupis palmarum* (Azulejo palmero) with 12 individuals (3.1 %), followed *Pionus chalcopterus* (parrot corn belt), *Pigochelidon Cyanoleuca* (Swallow blue-white) and *vitriolina Tanager* (tangara rastrojera) with 10 individuals (2.6 %); *Tyrannus melancholicus* (siriri common) with nine individuals (2.3 %); eight individuals (2.1 %), the species *Forpus xanthops conspicillatus* (Parrotlet eyeglasses), *Molothrus oryzivorus* (chamon giant) and *laniirostris Euphonia* (Euphonia en gorgiamarilla), and finally *Thraupis episcopus* (common tile), with seven individuals (1.8 %).

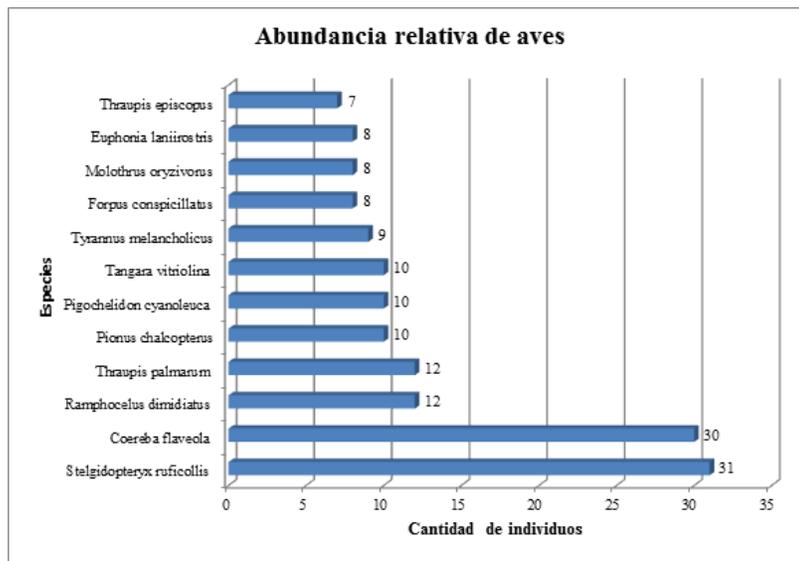


Figure 3-75. Most representative species and individual numbers of birds, registered in the influence area of the El Molino hydroelectric project

– Ecological Indicators

The difference between communities, in terms of their richness, is an aspect of great interest. It is considered that a community is more complex, the greater the number of species composition, because it presents a greater energy flow in food chains, is more stable and less dominant, by one or few species with respect to the other. To determine the diversity indexes and the ecological variables, we used the program Krebs /WIN version 0.9 (this is a freeware), based on the book Ecological Metodolgy Krebs (1989).

For ecological parameters were identified the following indicators:

- **Alpha diversity:** Indicators that combine the relative wealth (index of Shanon-Wiener, Simpson dominance index, Pielou equitability index). To estimate them the following expressions were used:

Diversity (H'):

We used the function (H') Shannon - Wiener, which is given by the following equation:

$$H' = - \sum ni/Ln ni/n, \text{ where}$$

H'= Diversity

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Ni= number of individuals per species

N = total number of individuals.

Equity (J'):

We used the function (J') of Pielou (1966-1967), defined by the equation.

$$J' = H' / H'_{max}, \text{ where}$$

H'= diversity.

H' max = Ln S

S= number of species recorded

Simpson Dominance (Ds):

We used the function (DS) Simpson (1949), which is calculated using the following expression:

$$DS = \frac{1}{N(N-1)} \sum ni(ni-1), \text{ where}$$

N = total number of individuals.

Ni= number of individuals per species.

➤ **Beta diversity.** For this indicator was used the Sorensen index, which correlates the similarity of faunal species between sites, and that is estimated through the following expression:

$$C = \frac{2C}{S1 + S2}, \text{ where}$$

C = number of species in both communities.

S1= number of species in community 1.

S2 = number of species in community 2.

Table 3-89 show the values of ecological indicators for the influence area of the El Molino hydroelectric project.

Table 3-89. Ecological indicators of the birds recorded in the influence area of the El Molino hydroelectric project

| Diversity indexes | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|---------------------------|--------|--------|--------|--------|--------|
| Species (S) | 47 | 30 | 34 | 34 | 20 |
| Number of individuals (N) | 162 | 60 | 71 | 62 | 34 |
| Dominance (DS) | 0.051 | 0.034 | 0.31 | 0.029 | 0.03 |
| Shannon (H') | 5.55 | 4.91 | 4.79 | 5.09 | 4.2 |
| Equity (E) | 0.889 | 0.95 | 0.985 | 0.947 | 0.971 |

Conventions: Number of species, **N** = number of individuals, **Ds:** Simpson dominance (1-D), **E:** Equity, **H':** Index of Shannon-Wiener diversity.

The greatest diversity is presented in site one H'= 5.55, followed by site four, H'= 5.09. On the location map of sampling sites of fauna and flora it is noted that these two sampling sites are located, the first, in high secondary vegetation and the second, in low secondary vegetation.

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The latter forms a patch with wide area that connects to the San Matias River, with an open forest and high secondary vegetation (see Table 3-89).

Sites one and four show the least uniformity, $E=0.889$ and $E = 0.947$. This is due to the fact that in them is greater clustering between individuals of the same species. For the remaining three sites the uniformity is similar and its value is greater.

The greater Simpson dominance is presented in the system of site one ($D_s=0.051$), and the lowest occurs at site four ($D_s=0.029$). This is due to the fact that site one presents dominance of some particular species, but its probability is not very high, since their values are not greater than or equal to 0.7. In general terms, in any of the sites was presented the probability of submitted dominance by one species, which means that all the sites in the diversity of community birds is high (see Table 3-89).

The Sorensen index of similarity shows that between site one and site four, is the highest similarity, with 39.5 %; followed by sites two and four, with a 37.5 % and the lowest similarity is located between sites four and five with a 22.2 %. This is probably due to the fact that in the sites listed above can be determine species that are using similar food and habitat offers in a given time, but also in their displacements become different species of birds, clearly determined where the similarity between these is little (see Table 3-90).

Table 3-90. Values of the Sorensen index for the different sites in the influence area of the El Molino hydroelectric project .

| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 |
|--------|--------|--------|--------|--------|--------|
| Site 1 | 1.000 | | | | |
| Site 2 | 0.312 | 1.000 | | | |
| Site 3 | 0.275 | 0.19 | 1.000 | | |
| Site 4 | 0.395 | 0.375 | 0.328 | 1.000 | |
| Site 5 | 0.269 | 0.28 | 0.264 | 0.222 | 1.000 |

– Diet

By means of these groups, it will identify the different species of birds according to the guilds or food used by these. For the study purposes, the birds have been grouped into guilds or groups of species that exploit similarly the same range of food resources. The species of the same guild interact among themselves, but more weakly with species of other guilds. Land Granivorous birds, for example, have developed strategies to avoid competition between them, as long as its relationship with the birds of prey is distant. Various criteria can help to define a guild, as the type of food, the stratum of vegetation frequented, and the strategy for achieving the food among others.

Classify a species within a guild do not excludes it from being able to belong to others. With few exceptions, no species of birds is restricted to a single type of food, but in most cases, the anatomy and behavior of a species is a reflection of its predilection toward a given food, which facilitates its inclusion in the guild.

During field work for the El Molino hydroelectric project , has been successful in identifying a total of 10 food guilds, which are described below: (James R. Karr, Douglas W. Schemske, Nicolas V. L. Brokaw 1990) (see Table 3-86 , Table 3-91 and Figure 3-76).

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Table 3-91. Number of species of birds according to their feeding type, registered in the influence area of the El Molino hydroelectric project .

| Feeding Type | Species | % |
|-----------------------------------|------------|------------|
| 1. Rapacious (R) | 6 | 6 |
| 2 Scavengers (Crr) | 2 | 2 |
| 3 Granivorous frugivorous (F/G) | 9 | 9 |
| 4 Frugivorous insectivorous (F/I) | 8 | 8 |
| 5 Frugivorous nectarivorous (F/N) | 2 | 2 |
| 6 Frugivores (F) | 17 | 17 |
| 7 Granivorous (G) | 9 | 9 |
| 8 Insectivore crust (I/C) | 8 | 8 |
| 9 Insectivorous (I) | 37 | 37 |
| 10 Nectarivorous (N) | 8 | 8 |
| Total | 100 | 100 |

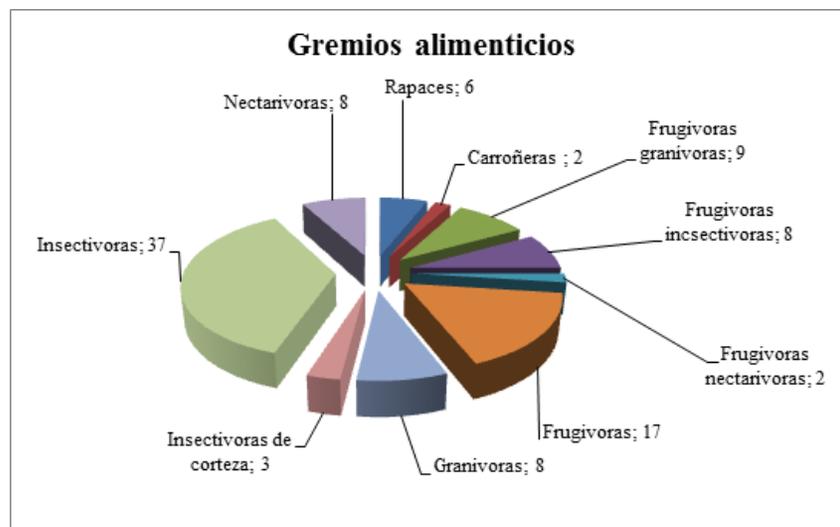


Figure 3-76. Groups of birds according to their feeding type, registered in the influence area of the El Molino hydroelectric project

- **Rapacious (R).** Are the birds of prey (eagles, falcons, hawks, owls, barn owls and some herons and storks, etc.), that generally feed of vertebrates and insects that they capture and kill. To these belong the family *Strigidae* (owls, barn owls), and the order Falconiforms, except the *Cathartidae* family(vultures), which feed on carrion. This guild has been successful in identifying a total of six species, corresponding to a 6% of the certain total of the (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Scavengers (Crr).** Are birds, whose diet is based primarily on decaying organic matter; in this guild are birds such as the turkey vultures, king of the vultures, vultures and condors. It was possible to determine a total of two species, corresponding to a 2% of the total birds (see Table 3-86 and Table 3-91 and Figure 3-76).

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- **Granivorous frugivorous (F/G)** . Are the birds, whose feeding is based, primarily from fruits, grains and seeds that sifted through in the low parts, grounds and pastures? Among the representatives of this guild are the banshees, partridges, parrots, parakeets, doves of which were observed a total of nine species, corresponding to a 9% of the total birds observed (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Granivorous (G)**. Are birds, whose feeding is made from seeds and grains that sifted through in the low parts, grounds and pastures. Among the representatives of this guild are, seedbeds, scullions, canaries and some wild turtledoves, of which there were observed a total of eight species, corresponding to 8% of the total number of birds sighted (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Insectivorous crust (I/C)**. Birds that feed on small dams and insects, that sifted through in the crust and within this, and among the most characteristic representatives are the carpenters and species of the Furnariidae family . This guild has been successful in identifying a total of three species, corresponding to 3% of the total (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Insectivorous (I)**. Birds that usually protrude in branches and high parts, from where they fly to catch their prey, usually returning to the place from where they flew. In this guild mainly belong the flytrap or the Tyrannidae family, can also be included within this guild those of the *Caprimulgidae* family where are the gallinaciegas, trogons and other birds that catch their prey in flight, but in a continuous basis, as the swifts and swallows. This guild has been successful in identifying a total of 37 species, accounting for 37% of the total (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Nectarivorous (N)**. Birds, whose diet is from the nectar, that slurp of the flowers, without damaging them, being large pollinators; in addition they alternate their food, generally, of small insects that capture at flight. Among the representatives of this guild is the Trochilidae family (hummingbirds or chupaflores), of which were identified a total of eight species, corresponding to 8% of the total (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Frugivorous insectivorous (F/I)**. Birds that generally feed on fruit and insects that sifted through in the underwood. The most characteristic representatives are in the *Ramphastidae* family (Toucans), *Cotiginae* family, some species in the *Turdidae* family (Mayos, blackbirds), some of the *Icteridae* family, which is where you find the jays, *Thraupidae* family, where the tiles, tanagers, appear. This guild has been successful in identifying a total of eight species, corresponding to 8% of the total determined (see Table 3-86 and Table 3-91 and Figure 3-76).
- **Frugivores (F)**. Are those birds, whose diet is based mainly on fruits that they look for in the trees, among them are some of the *Thraupidae* family where the tiles appear,

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tanagers, springs. This guild has been successful in identifying a total of 16 species, corresponding to 16% of the total (see Table 3-86 and

- Table 3-91 and Figure 3-76).
- **Frugivorous nectarivorous (F/N).** Birds that feed mainly on nectar, which is taken by breaking the corolla of the flower with its particular hooked bill down, not making the pollination, and alternating this diet with fruit. Among these are the mieleras and some species of the genus *Coerebidae*) and *Dacnis egregious*. They were able to identify a total of two species, corresponding to a 2.8 % of the total determined (see Table 3-86 and
- Table 3-91 and Figure 3-76).
- Food and shelters

The presence in the study area of high and low secondary vegetation coverage connected with open woodland, favors the presence of birds. The results of the sampling point to the importance of this connectivity for species diversity; the sampling site four which is the most connected, registers a diversity of species similar to site one, despite the fact that the first is located in an earlier successional state (low secondary vegetation) and the second more advanced (high secondary vegetation). It is probable, then, that the supply of food and shelter is better in these two sites, if you compare with two, three and five that have grass and dense forest composed of guadua bamboo and are therefore less structurally complex.

The characteristics of the fragments assessed, as the estimated size, the vegetation types, the existence of paths that communicate with smaller fragments, facilitate the exchange of individuals between populations and their food webs and sources are sufficient to sustain the populations found.

- Birds used as a source of human food

Of the birds recorded in the study area, some are used as a food source although it should be emphasized that the hunters action, is not very frequent. Of them, two families are consumed: As the Tinamus or woodcocks of hill, like the *Crypturelus soui* (La llorona); COLUMBIDAE, such as the turtledoves or pigeons, mainly the *Leptotila verreauxi* (caminaera whitetail, Pacific doves).

- Endemic Birds

In the influence area of the El Molino hydroelectric project , we found the following endemic species:

- *Capito hypoleucus* (El Torito capiblanco), endemic; according to the IUCN is located in the category (endangered), A4c Vu B2 ab (ii, iii) and according to the Alexander von Humboldt Institute in category in C2a, by the deterioration of the habitat and indiscriminate hunting and wildlife trafficking. There have been successfully identified four individuals at the site of Campoalegre (see Photo 3-40).

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Capito hypoleucus (El Torito capiblanco). Photo (file) of Manuel Peña



Ortalis columbiana (Colombian guacharaca)

Photo 3-40. Endemic Species registered in the influence area

- *Ortalis columbiana* (guacharaca Colombian). According to Proaves, 2010 is located in the category (endangered), by the deterioration of the habitat and indiscriminate hunting and wildlife trafficking. There were determined three individuals in site five in Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino (see Photo 3-40).

- Herpetofauna

Colombia is one of the five richest countries in renewable natural resources and with the greatest number of species of vertebrates of the world; is home to nearly 15% of the total of all known terrestrial species. Some authors suggest that such diversity is a response to factors such as the geographical position and the varied topography, dominated by three major mountain ranges and several orographic peripherals systems. The privileged geographic location, in the North of South America, makes the Colombian territory constitute a contact point of the flora and fauna from the north and south of the continent, which have generated a wide range of habitats for the optimal development of this diversity.

Colombia, with 733 species, has the greatest diversity of amphibians in the planet and the third place in reptiles, with an approximate number of 520 species (Acosta-Galvis, 2000; Wheel-A. *ET al.*., 2004). Between 80% and 90% of the amphibian species belong to the frogs and toads and the rest (10% to 20 %) to the salamanders, and caecilians or blind. (Acosta-Galva's, 2000; Apes et al., 2002). For its part, it is estimated that 48% of the reptiles are snakes, lizards, and 45% 7% are turtles, and crocodile's anfisbenidos (Paez et al., 2002). In the department of Antioquia are reported approximately 203 species of amphibians, of which 183 are anurans, 13 caecilidos and seven salamanders. Of the 153 species of reptiles reported for Antioquia, 73 are snakes, 71 lizards, six turtles, two crocodiles and an anphisbenido (Paez et al., 2002; Palacio *et al.*., 2006).

The accelerated destruction and alteration of natural habitats in Colombia and the illegal trafficking of species, has led Colombia to be the country of the world with the largest number of amphibians (217) with some risk of extinction (IUCN, 2011; Rueda-Almonacid *et al.*., 2004). Among the frog, the family Bufonidae presents 53% of the total species categorized

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under some degree of threat. So far, in our country have been reported 16 species of reptiles with some kind of threat.

– Methodology

Table 3-92 show the sampling sites of the herpetofauna. The area of the relief pipeline and its path is one of the most disturbed by the project. The vegetation is mainly by the edges of the roads, with some patches and isolated trees in pastures. The trees can reach heights of up to 10 m and even more, in the most preserved and low parts of the site. In this place are dominated by grasses, shrubs of secondary growth and the crops of passion fruit (see Photo 3-41). The surrounding areas are very steep, with few water bodies. There are several paths that lead to the San Matias River, with a bed composed of medium and large size rocks and in their shores are observed a large number trees.

Table 3-92. Sampling sites in the study area

| Vereda (Political and administrative division of the municipality located in the rural area) | Site | Habitat |
|---|----------------------------------|---|
| Campo Alegre | Planned Road and relief pipeline | High Secondary Vegetation, dense forest of guadua |
| El Molino | Collection | Guaduas Cultivation |
| El Molino | Deposits 4 and 3 | Weeded grass, dense wooded grass; open Forest |
| Los Mangos | House of Engines | Open Forest |



Photo 3-41. Planned Road and relief pipeline

The collection area is characterized by small remnants of riparian vegetation which size varies between 4 m and 8 m in height, with strips of broad sandy sediments, low scrub and grassy vegetation. All of the above surrounded by pastures for livestock, with scattered trees that seemed to give shade to the livestock. In the middle of this site is a small island mainly comprised of Guaduas The beaches of the river are rich in sediments and rocks, and the vegetation is in part on small hills (see Photo 3-42).

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Photo 3-42. Collection, cultivation of guaduas in San Matias River

The sector of the deposits 1 and 2 is a site that borders the road that leads to Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino; the slope, in general, is high and limits with pasture in the lower area. It is a relatively preserved forest, with thinning of fine wood. It has trees with a DBH between 70 cm and 100 cm approximately, where you will find lots of palms. The underground forest is walkable except at the edges, where the grass cutters, known locally as La Cortadera lamedera increase in their abundance. On the floor there is a large quantity of litter in decomposition (see Photo 3-43).



Photo 3-43. Deposits 3 and 4.

The coverage in the area of house of engines is a forest gallery that borders the San Matias River, where predominate trees with an average diameter of 70 cm. The canopy is semi-open with a very clear underground forest, with some plants in juvenile states of individuals in the canopy; in the interior there were a large quantity of ferns, palms and vegetation. Bordering the forest there are large areas of arboreal and sugarcane crops. It is crossed by a stream of approximately two meters wide, with forest fragments of native vegetation on the shore (see Photo 3-44).

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Photo 3-44. Coverage of the house of engines area,

The sampling sites were visited between 8:00 am and 12:00 m, and between 1:00 PM and 5:00 p.m. The methodology used was the method of Visual encounters (VES), which consists in walking through an area or habitat for a predetermined time. The species were searched through detailed tours, by lifting the rocks and vegetations fragments, removing litter and carefully examining the caves and roots, trying to include the greatest possible number of microhabitats (bodies of water, forests and open areas, among others) (see Photo 3-45).



Photo 3-45. Methodology used for the capture of amphibians and reptiles

The captured animals were collected directly by hand, they were later placed in plastic bags or cloth, with wet leaves to avoid dehydration. To make the catch, the sightings or to listen to the vocalizations, recorded data was registered on the location where individuals were captured, such as: municipality, Vereda (*Political and administrative division of the municipality located in the rural area*) coordinates, date, time and time of sampling; in addition, characteristics of the micro habitat occupied with individuals when they were detected and finally information was recorded on the number of individuals per species.

Also hearing samplings were carried out, which consists in trying to hear the songs of the male individuals, being them individual or in chorus, and then follow each song until identifying the source, which allowed, in some occasions, recognize up to the species level of individuals.

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In addition, the individuals encountered were captured, photographed and later released on the same site in which they were found.

The samplings were not sufficient to determine exactly the diversity of species and population levels of the herpetofauna existing in the project influence area, due to public order situations, which did not permit sampling at night; that was why it appealed to the interview with local inhabitants, to learn about the different species existing in the area and the current status of the populations, especially the species with some degree of threat.

For the analysis of these results were used the Shannon-Wiener diversity index (H'), the equity of Shannon (J') and the dominance of Simpson (D). There was Identified the alpha diversity of species as the specific richness and beta diversity with the Jaccard similarity index In addition, the endemism and species with some category of threat were recorded

– Results

➤ Taxonomic diversity

In the group of amphibians is reported a total of 84 individuals belonging to 10 species, of the order Anura (frogs and toads), seven families and eight genuses (see Table 3-93). Of the class Reptilia were recorded 27 individuals belonging to 17 species, grouped in the order Squamata, which includes the suborders of the lizards (Sauria, with 13 species) and snakes (Serpentes, with seven species), distributed among 10 families and 16 genuses (see Table 3-93).

These species represent 1.3 % of the total of the amphibians reported for Colombia (750 species) and more than 4.9 % of the documented to the department of Antioquia (203) (Acosta-Galvis et al. , 2006; Páez et al. , 2002; Rueda-Almonacid et al. , 2004). It also represents an 11.1 per cent of the 153 reptiles reported by Páez et al., 2002, for Antioquia and constitute 3.2 % of the 524 species of reptiles reported by Acosta-Galvis (2000) and Rueda-Almonacid et al. (2004) at national level.

In the collection area six species were observed, *Dendropsophus bogerti* , *Leptodactylus fragilis* and *Hemidactylus brookii* exclusive of the zone. Twelve species were recorded in the house of engines; it can be seen that *Colostethus pratti* , *Gonatodes albogularis* , *added ocellata* and *Cnemidophorus lemniscatus* , is found only in this area (see Table 3-93). While in the deposits were reported seven species and two exclusive records, the lizard *Mabuya mabouya* and frog *Pristimantis penelopus*. Finally, the area of the planned road featured a variety of eight species, with the frogs *Centrolene prosoblepon* *Smilisca phaeota*, reported only in this area (see Table 3-93).

For the influence area of the project, the majority of species are considered unique to some areas. These areas in general, are characterized by having presented a high structural and vegetation complexity, indicating high availability of food, shelter and breeding areas, conditions that provide a high level of survival for these species.

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Table 3-93. Amphibians and Reptiles found in the influence area of the El Molino hydroelectric project

| Class | Order | Suborder | Family | Scientific name | Local or common name | Collection | House of engines | Deposits 3 and 4 | Planned Road to relief pipeline | Total |
|----------|----------|----------|-------------------|---|----------------------|------------|------------------|------------------|---------------------------------|-------|
| Amphibia | Anura | | Bufonidae | <i>Rhinella marina</i> (Linnaeus, 1758) | Toad | 1 | | | 1 | 2 |
| | | | Centrolenidae | <i>Centrolene prosoblepon</i> (Boettger, 1892) | Frog | | | | 10 | 10 |
| | | | Craugastoridae | <i>Craugastor raniformis</i> (Boulenger, 1896) | Frog | | 4 | | 2 | 6 |
| | | | Dendrobatidae | <i>Colostethus pratti</i> (Boulenger, 1899) | Frog | | 5 | | | 5 |
| | | | Hylidae | <i>Dendropsophus bogerti</i> ((Cochran and Goin, 1970) | Frog | 5 | | | | 5 |
| | | | | <i>Smilisca phaeota</i> (Cope, 1862) | Frog | | | | 2 | 2 |
| | | | Leptodactylidae | <i>Leptodactylus fragilis</i> (del Brocchi, 1877) | Frog | 7 | | | | 7 |
| | | | Strabomantidae | <i>Pristimantis penelopus</i> (Lynch and Rueda, 1999) | Frog | | | 3 | | 3 |
| | | | | <i>Pristimantis taeniatus</i> (Boulenger, 1912) | Frog | | 2 | 2 | 1 | 5 |
| | | | | <i>Old Pristimantis</i> (Lynch and Rueda Almonacid, 1999) | Frog | | 6 | 30 | 3 | 39 |
| Reptilia | Squamata | Sauria | Corytophanidae | <i>Basiliscus galeritus</i> (Dumeril 1851) | Chamaleon | 2 | 3 | | | 5 |
| | | | Gekkonidae | <i>Gonatodes albogularis</i> (Dumeril & Bibron, 1836) | Lizard | | 2 | | | 2 |
| | | | | <i>Hemidactylus brookii</i> Gray, 1856 | Salamanqueja | 3 | | | | 3 |
| | | | Gymnophthalmidae | <i>Added ocellata</i> Gray 1845 | Lizard | | 1 | | | 1 |
| | | | Polychrotidae | <i>Anolis tropidogaster</i> Hallowell 1856 | Lizard | | | 1 | 1 | 2 |
| | | | Scincidae | <i>Mabuya mabouya</i> (Lacepede 1788) | Lisa | | | 2 | | 2 |
| | | | Sphaerodactylidae | <i>Lepidoblepharis xanthostigma</i> (Noble, 1916) | Anole Lizard | | 1 | 1 | | 2 |
| | | | Teiidae | <i>Ameiva ameiva</i> (Linnaeus1758) | Lizard | | 2 | 2 | | 4 |
| | | | | <i>Ameiva festiva</i> (Lichenstein y von Martens, 1856) | Lizard, lobito | 2 | 1 | | | 3 |
| | | | | <i>Cnemidophorus lemniscatus</i> (Linnaeus 1758) | Lizard | | 1 | | | 1 |

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| Class | Order | Suborder | Family | Scientific name | Local or common name | Collection | House of engines | Deposits 3 and 4 | Planned Road to relief pipeline | Total |
|-------|-------|----------|--------------|---|----------------------|------------|------------------|------------------|---------------------------------|-------|
| | | Snakes | Colubridae | <i>Clelia Clelia</i> (Daudin, 1803) | Black Hunter | | | | | |
| | | | | <i>Spilotes pullatus</i> (Linnaeus, 1758) | Toche, granadilla | | | | | |
| | | | | <i>Leptophis ahaetulla</i> (Linnaeus, 1758) | Huntress, bejuca | | | | | |
| | | | | <i>Oxybelis aeneus</i> (Wagler, G.A.), 1824 | Bejuquilla, Yaruma | | | | | |
| | | | The Elapidae | <i>Micrurus mipartitus</i> (Dumeril & Bibron Dumeril, 1854) | Rabo de aji, Coral | | | | | |
| | | | Viperidae | <i>Bothrops asper</i> (Garman, 1884) | Equis, mapana | | 1 | | 1 | 2 |
| | | | | <i>Pitviper nasutum</i> (¿zaro Bocourt, 1868) | Patoco | | | | | |
| Total | | | | | | 20 | 29 | 41 | 21 | 111 |

Among the amphibians, the family Strabomantidae was the most diverse with three species, which represent 30% of the total reports in this sample, represented by a single gender: *Pristimantis*. Followed by the Hylidae family with two species of the gender *Dendropsophus* and *Smilisca*. While the other families were represented by a single species (see Figure 3-77).

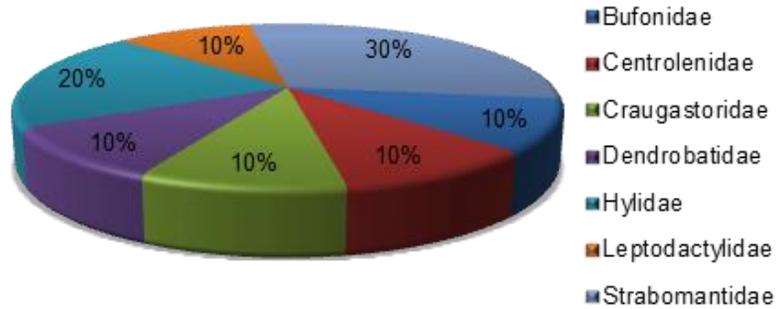


Figure 3-77. Families of amphibians found in the project influence area.

The wealth of the Strabomantidae family is favored with the presence of wet places with presence of leaf litter, as to its direct reproduction does not depend on aquatic ecosystems, features that are adjusted to the forests and tall stubble present in the areas planned for some of the facilities

The Hylidae family is characterized by inhabiting areas with sub humid conditions up to dry, and a vegetation sometimes open and highly intervened, with the presence of a large amount of lentic water bodies, which form a suitable environment for the dispersal of the species that depend on these conditions for their reproduction (Romero-M. et al. , 2008; Lotzkat, 2007). The majority of Hylids were reported in areas intervened, in small lotic bodies of water present in the collection area (85.7 %) (see Photo 3-46).



Pristimantis penelopus



Pristimantis taeniatus

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Smilisca phaeota



Dendropsophus bogerti

Photo 3-46. Amphibian Species of the more representative families in the project influence area

In snakes, the family Colubridae was the most diverse with four species, which represent 23% of the total reports in this sample, with equal number of genres (*Clelia* , *Leptophis* , *Oxybelis* and *Spilotes*), followed by the variety viperish with two species of the genres: *Bothrops* and *Porthidum* . Within the lizards, the Teiidae family (17 %) with two genres (*Ameiva* and *Cnemidophorus*) and three species was the most diverse, continuing the Gekkonidae family with two genres (*Gonatodes* and *Hemidactylus*) with the same number of species (see) Figure 3-78

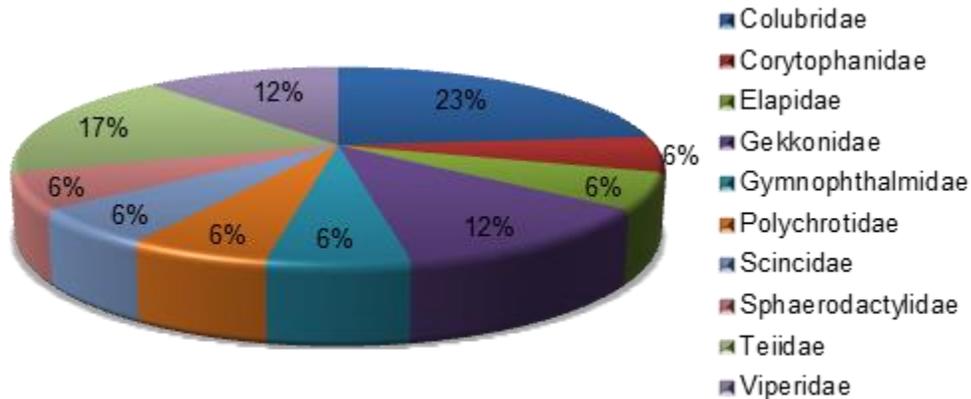


Figure 3-78. Families of reptiles found in the project influence area.

The snake's species of the family Colubridae (snakes) and Viperidae (snakes) were reported in all the studied habitats. Attributing this diversity, over 48% of the reptiles are snakes that make up a cosmopolitan family, which is the most abundant species. Snakes occupy the most diverse environments; many are terrestrial but there are arboreal, aquatic or groundwater species

The lizards of the Teiidae and Gekkonidae families are the most biologically diverse of this group, occupying mainly the area of the house of engines, where were observed bask on the

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rocks or logs from the edge of the San Matias River (see Photo 3-47). The observation of these species could be facilitated by the presence of large rocks in open areas, which serve as a place for the lizards take the sun which allow their survival.



Spilotes pullatus



Bothrops asper



Ameiva ameiva



Cnemidophorus lemniscatus

Photo 3-47. Reptile species of the most representative families of the project area.

➤ Species accumulation Curve

As seen in the species accumulation curve performed, for all areas there is an increase in species richness, without arriving at a stabilization of the asymptote in total time. That is to say, was not obtained the total richness of amphibians and reptiles contained in the different sampling sites (see Figure 3-79).

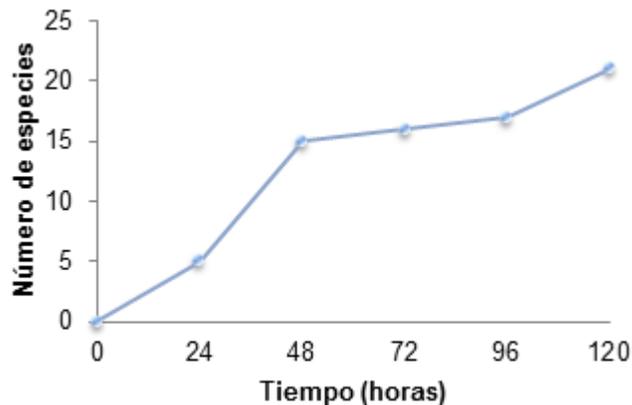
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Figure 3-79. Species accumulation curve.

According to Jiménez and Hortal (2003), at the beginning of a monitoring common species are collected, and the increase in species richness occurs in an accelerated manner; therefore, the slope of the curve starts being high and as the sampling continues, are the rarer species those that grow the inventory, so that the slope of the curve falls and at the time in which this curve reaches the asymptote, would mean that the species richness is partially complete.

For Jimenez and Hortal (2003), a species can expand or reduce its distribution as a function of changes in the environment. In addition, certain species can vary its phenology in function, for example, weather conditions or micro climate, not being able to get to emerge or be detectable all the years and seasons.

In general, the species accumulation curves in the studied areas show a slight sub sampling, by this it would require a little more effort to bring the rare species up to zero. This can be achieved by making specific sampling in micro habitats for some amphibians and reptiles that are not easily observed, such as the nocturnal species, fossorials or arboreal.

➤ Relative Abundance between sampling sites

In general, to the herpetofauna in the entire study area, it was found that the most abundant species were the frogs *Pristimantis old* with 39 individuals (35 %), *Centrolene prosoblepon* with 10 individuals (9 %) and *Leptodactylus fragilis* with seven records (6.3 %) of the total of 111 specimens. On the other hand, the reptiles with lesser abundances, the most representative species were the *Basiliscus lizard's galeritus* and *Ameiva amative* with five and four individuals (4.5 % and 3.6 %, respectively (see Figure 3-80).

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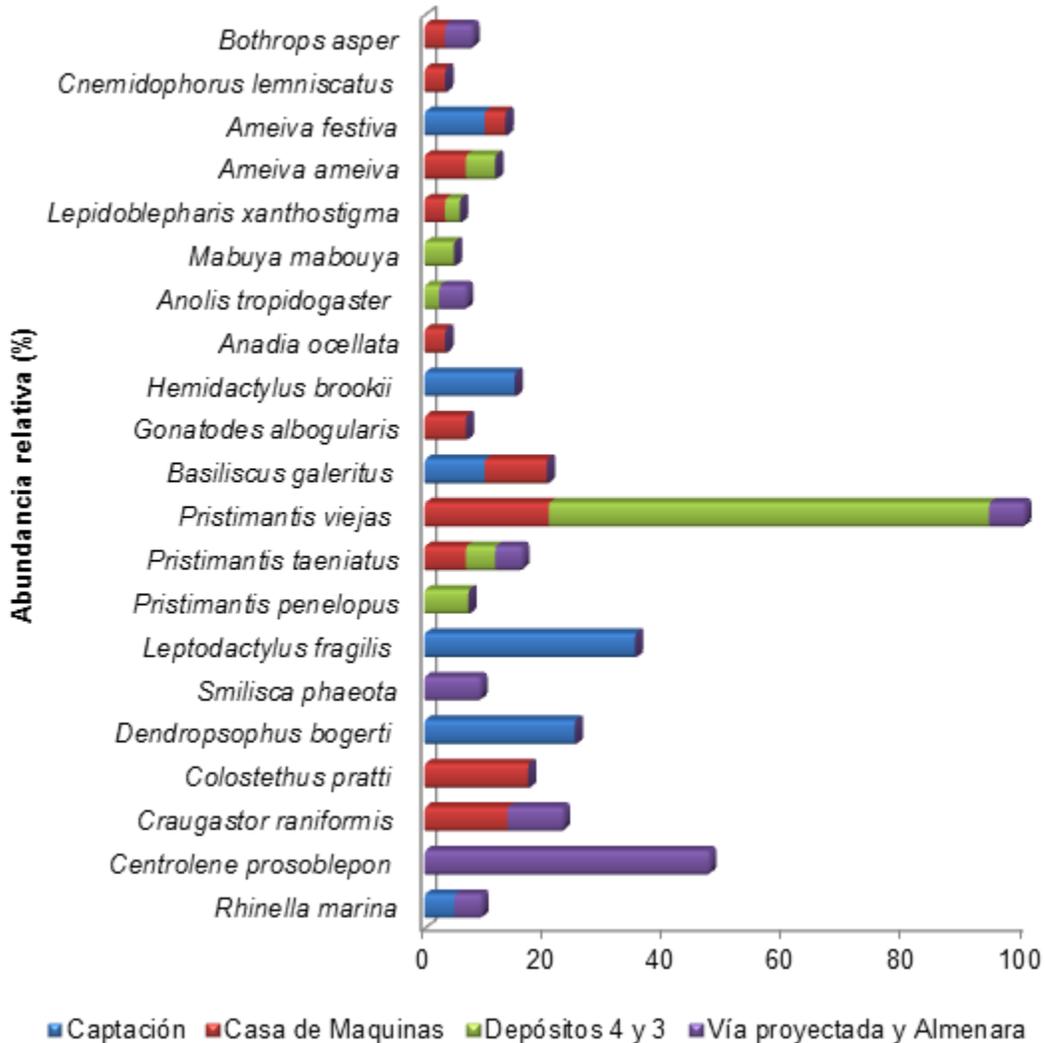


Figure 3-80. Relative abundance of the amphibians and reptiles found in the influence area of the El Molino hydroelectric project

The most abundant species in the collection area was *Leptodactylus fragilis* with seven records, which corresponds to 35 %, with a distribution restricted to aquatic ecosystems in lentic areas intervened. In house of engines and deposits 3 and 4, the frog *Pristimantis old* with six records (21 %), and 30 (71 %), respectively, was the most representative, found on the litter of the forest. While in the planned road, the most abundant species was *Centrolene prosoblepo*, which is found most often in small creeks, where 10 individuals were (48 %) of the total taxon (see Figure 3-80).

Old Pristimantis was most abundant in the project influence area (see Photo 3-48), particularly in the open and dense woodland This may be due to the fact that this frog is very common in this kind of environments or to the applied methodology, which focuses on the

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micro habitats occupied by this frog, like the leaf litter and low vegetation within the forests. During the night move between the litter and environments of greater height on the same site, scrolling vertically in the vegetation, where they actively sing throughout the night.



Old Pristimantis



Leptodactylus fragilis



Amiba Amiba



Basiliscus galeritus

Photo 3-48. Species of abundant amphibians and reptiles in the project area.

One of the most important species in the influence area, by its abundance, was the glass frog *Centrolene prosoblepon* (see Figure 3-80). The frogs of this group prefer the vegetation adjacent to the creeks. There they lay their eggs on the leaves, place in which the larvae develop and subsequently fall to the currents of water. It is possible that the findings of this species have increased due to the fact that the sampling was conducted in the rainy season, reproductive season for this frog, which facilitated listening to the male singing on the leaves.

Leptodactylus fragilis was common in small ponds (see Photo 3-48). This frog shows preferences through the pastures of open areas and is most often associated with the lentic water bodies by their reproductive mode (Renjifo and Lundberg, 1999). Specimens of this species were found vocalizing inside the water bodies, partially immersed, forming aggregates.

Within the reptiles, *galeritus Basiliscus lizard*, which presented the greatest abundance of this group, was found mainly in the margins of San Matias River (see Photo 3-48). According to

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Paez et al., (2002), this species is terrestrial, semi-aquatic and arboreal and is often found along the edges of the rivers. While the lizard *Ameiva Ameiva* (see Photo 3-48), was found at the edges of forests, catching the sun. These lizards are generalists, are often found in high and low debris, forest edges and is moderately common in altitudes below 1000 Meters above sea level (Palace et al. 2006).

– Ecological Indicators

➤ Alpha diversity

Of the 21 species of amphibians and reptiles reported for the project area, in the collection area is reported 57.1 % of the total of the species, in house of engines 45.8 %, in deposits 3 and 4 33.3 % and in the planned road and relief pipeline a 38.1 per cent of the species.

Table 3-94 show the diversity indexes for the different areas. The greatest diversity of species was presented by the area of house of engines, followed by the planned road and relief pipeline, whereas lower diversities are in the sectors of deposits 3 and 4 and collection taking into account the values of this index (1 to 4), sites show a diversity of amphibians from medium to low. When reviewing the dominance data, it is noted that in general, none of the areas showed a marked dominance of any species. In the same way, the high values of equity or uniformity, suggest that the majority of the species are represented by a similar number of individuals in areas, except in the sector of the deposits 3 and 4, which introduced the lowest values of equity and higher of dominance.

Table 3-94. Diversity values for amphibians and reptiles in the El Molino hydroelectric project

| Indexes | Collection | House of engines | Deposits 3 and 4 | Planned Road and relief pipeline | Total |
|-------------------------|------------|------------------|------------------|----------------------------------|-------|
| Species richness | 6 | 12 | 7 | 8 | 21 |
| Number of individuals | 20 | 29 | 41 | 21 | 111 |
| Shannon-Wiener index H' | 1.61 | 2.27 | 1.04 | 1.66 | 2.48 |
| Simpson dominance of D | 0.23 | 0.12 | 0.55 | 0.27 | 0.15 |
| Equity of Shannon J' | 0.90 | 0.91 | 0.54 | 0.80 | 0.81 |

In the influence area, the greatest diversity is introduced in house of engines This may be related to a greater heterogeneity in the vegetation structure; although on this site are large areas of pastures, there is also some forest fragments and debris (shrubs, saplings, grassland, palms and abundant leaf litter), in addition to the presence of rocks, the varied topography and several water sources, make the diversity of micro habitats and resources, to promote a more dynamic vegetation structure and affects an increase in herpetofauna diversity.

While in deposits 3 and 4, the diversity and equity is less due to high dominance of the frog *Pristimantis old*, because of the 41 individuals identified, 73% belong to this species. .

➤ Beta diversity - Jaccard similarity

The information obtained with the implementation of the Jaccard index, shown in the cluster analysis of similarity of the Figure 3-81 . The values of this index range between one when

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both sites are identical in species composition and zero when the listing of species is totally different.

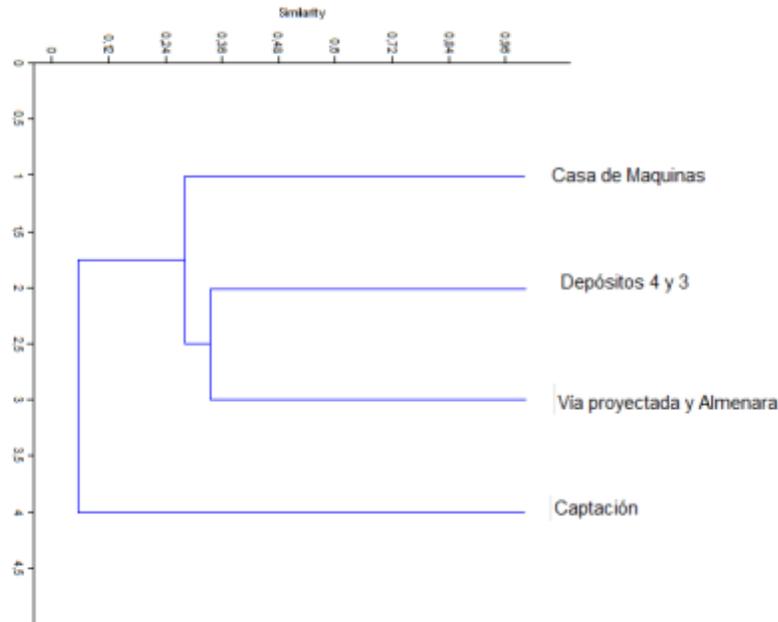


Figure 3-81. Cluster analysis showing the similarity between the sites as to the species of amphibians and reptiles.

In the direct influence area, the index of Jaccard similarity shows a higher value of similarity between the deposit sites 3 and 4 and planned road and relief pipeline. This is because of the seven species of deposits 3 and 4 and the eight of the planned road and relief pipeline, three are shared by both areas with a similarity value of 33% (*Pristimantis taeniatus*, *Pristimantis old* and *Anolis tropidogaster*) (see Figure 3-81).

The greater degree of similarity may be associated with the relationship between the vegetation structure and environmental variables of the micro habitats present in each site, in which the greater coverage of the plant canopy produces a great layer of leaf litter on the soil and more stable ambient temperatures and low to the interior of forests present in both places (Cáceres-A. and Urbina-Cardona, 2009).

Then there are the sites of house of engines and collection. These places gave similar lower values; therefore, it is possible to deduce that there are own community of amphibians and reptiles, in spite of the fact that several species are generalists; this may be due to a set of variables such as altitude, temperature, humidity and aquatic ecosystems characteristic of each site, which may exert selection pressure on these populations.

- Distribution of amphibians and reptiles depending on their habitat preference.

In Figure 3-82 and Table 3-95 can be seen that the total number of species encountered or reported (27), 21 of them (77.8 %) were in the forest, while eight (33.3 %) were present in the

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wooded pasture, while the arboreal habitat of the guadua was the vegetal formation with the lower value of richness of amphibians with only seven species (25.9 %).

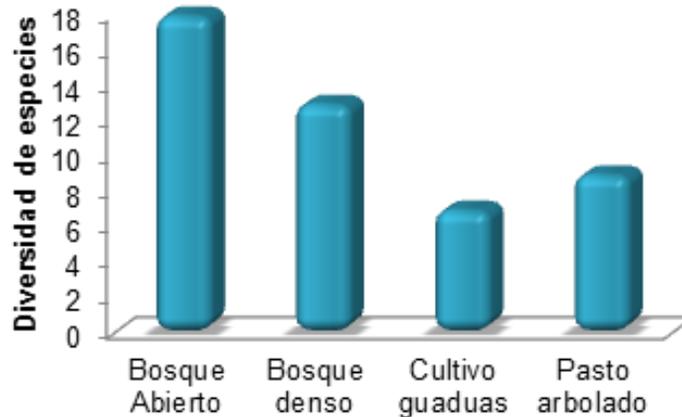


Figure 3-82. Distribution of amphibians and reptiles in the preference of habitats in areas of the El Molino hydroelectric project .

Table 3-95. Distribution of amphibians and reptiles in the preference of habitats in the influence area of the El Molino hydroelectric project

| Scientific name | Open Forest | Dense Forest | Guaduas Cultivation | Wooded pasture |
|-------------------------------------|-------------|--------------|---------------------|----------------|
| <i>Navy Rhinella</i> | | | X | X |
| <i>Centrolene prosoblepon</i> | | | | X |
| <i>Craugastor raniformis</i> | X | | | X |
| <i>Colostethus pratti</i> | X | | | |
| <i>Dendropsophus bogerti</i> | | | X | |
| <i>Smilisca phaeota</i> | | | | X |
| <i>Leptodactylus fragilis</i> | | | X | |
| <i>Pristimantis penelopus</i> | | X | | |
| <i>Pristimantis taeniatus</i> | X | X | | X |
| <i>Old Pristimantis</i> | X | X | | X |
| <i>Basiliscus galeritus</i> | X | | X | |
| <i>Gonatodes albogularis</i> | X | | | |
| <i>Hemidactylus brookii</i> | | | X | |
| <i>Added ocellata</i> | X | | | |
| <i>Anolis tropidogaster</i> | | X | | X |
| <i>Mabuya mabouya</i> | | X | | |
| <i>Lepidoblepharis xanthostigma</i> | X | X | | |
| <i>Available available</i> | X | X | | |
| <i>Festive Ameiva</i> | X | | X | |
| <i>Cnemidophorus lemniscatus</i> | X | | | |
| <i>Clelia Clelia</i> | X | X | | |
| <i>Spilotes pullatus</i> | X | X | | |
| <i>Available Leptophis</i> | X | X | X | X |
| <i>Oxybelis aeneus</i> | X | X | | |
| <i>Micrurus mipartitus</i> | X | X | | |
| <i>Bothrops asper</i> | X | | | X |
| <i>Pitviper nasutum</i> | X | X | | |

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This increased diversity of forests can be associated to the relationship between the vegetation structure and the environmental variables of the habitat, given that the increased canopy cover generates a thick layer of leaf litter on the soil and environments with more stable and lower temperatures than in other habitats. Similarly, the canopy cover helps to reduce the drying out of the organisms, increasing the capacity to hold a greater diversity of species (Cáceres-A. and Urbina-C., 2009).

For its part, the arboreal pastures show extreme ecological features, since they are environments subject to water stress, and with large changes in temperature, which, coupled with the degradation of this kind of environments because of the extensive grazing of livestock, has generated that the existing fauna in these areas present a high degree of tolerance to the changes in their habitat.

The guaduales habitats possess certain physical characteristics which are excluding the majority of species reported here. Among these features can be identified the lesser presence of aquatic ecosystems and support substrate, the highest incidence of the sun and the low environmental humidity that cause the drying of the individuals and their positions. However, the specimens found in this habitat may have a positive influence by the edge effect that is generated between the matrix of the Guaduas and the river.

Among the species reported in this sample, only the serpent *Leptophis available* is reported with a continuous distribution throughout all of the vegetal formations. While the 48.1 % of the species are reported only in the forests, unlike the other habitats where it presented an exclusivity of the 18.5 % of species in each (see Table 3-95).

– Endemic species and in some category of threat

Most of the species are characterized by wide ranges of distribution, mainly corresponding to Central and South America. The only endemic species in Colombia are frogs *Dendropsophus bogerti*, *Pristimantis penelopus* and *Pristimantis old*, representing only 11.1 % of the total number of recorded species for this region.

In reviewing the databases of the IUCN (2011) and CITES (2011), and the listings generated by Rueda-Almonacid (2004) for the amphibians and Colombians reptiles who are nationally under threat, it was found that 96% of the species are in a category of low risk (LC), or those with a wide range of distribution and in addition in an apparent good condition of their populations and only one species is found in the IUCN red list and has been cited in the Appendix II of CITES (see Table 3-96).

Hunter black *Clelia* is cited in appendix II of CITES, 2011) (see Table 3-96 and Photo 3-49). Appendix II lists species that are not necessarily threatened with extinction, but that may become so unless its trade is strictly controlled

Pristimantis penelopus is located in the IUCN Red List as VU (see Table 3-96 and Photo 3-49), due to that its distribution is not greater than the 20,000 km², in turn, the quality and the extension of its habitat (woods) is decreasing rapidly (Castro et al., 2004). This frog is also an endemic species of the departments of Antioquia, Caldas and Tolima, on the eastern flank of the Central mountain range, from 1,180 meters above sea level to 1,500 meters m.a.s.l.

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Table 3-96. Conservation Status of amphibian and reptiles species in the influence areas of the El Molino hydroelectric project .

| Species | IUCN threat category | Category of threat by trade CITES | Endemic Species |
|-------------------------------------|-----------------------------|--|------------------------------|
| <i>Navy Rhinella</i> | LC | | |
| <i>Centrolene prosoblepon</i> | LC | | |
| <i>Craugastor raniformis</i> | LC | | |
| <i>Colostethus pratti</i> | LC | | |
| <i>Dendropsophus bogerti</i> | LC | | Antioquia |
| <i>Smilisca phaeota</i> | LC | | |
| <i>Leptodactylus fragilis</i> | LC | | |
| <i>Pristimantis penelopus</i> | VU | | Antioquia, Caldas and Tolima |
| <i>Pristimantis taeniatus</i> | LC | | |
| <i>Old Pristimantis</i> | LC | | Antioquia, Caldas |
| <i>Basiliscus galeritus</i> | LC | | |
| <i>Gonatodes alboocularis</i> | LC | | |
| <i>Hemidactylus brookii</i> | LC | | |
| <i>Adelpha ocellata</i> | LC | | |
| <i>Anolis tropidogaster</i> | LC | | |
| <i>Mabuya mabouya</i> | LC | | |
| <i>Lepidoblepharis xanthostigma</i> | LC | | |
| <i>Ameiva</i> | LC | | |
| <i>Festive Ameiva</i> | LC | | |
| <i>Cnemidophorus lemniscatus</i> | LC | | |
| <i>Clelia</i> | LC | Appendix II | |
| <i>Spilotes pullatus</i> | LC | | |
| <i>Ahaetulla leptophis</i> | LC | | |
| <i>Oxybelis aeneus</i> | LC | | |
| <i>Micrurus mipartitus</i> | LC | | |
| <i>Bothrops asper</i> | LC | | |
| <i>Porthidium nasutus</i> | LC | | |

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Pristimantis penelopus



Dendropsophus bogerti



Leptodactylus fragilis



Clelia

Photo 3-49. Endemic species in Colombia and listed in the IUCN and CITES

The endemic species of amphibians found in Colombia are unique to the departments of Antioquia, Caldas and Tolima (see Table 3-96 and Photo 3-49). In particular, these species tend to be more sensitive to changes in their habitats due to their dependence on very special conditions, typical of less altered sites these species are characterized by being very sensitive to barriers created during the environment transformation (Left et al., 2000).

3.3.2 AQUATIC ECOSYSTEMS

Another component of the aquatic ecosystem, the fresh water ichthyofauna, is particularly diverse in Colombia, and many of its species have economic and food importance. Paradoxically, this is the least known group of vertebrates in the country (Mojica et al. 2002), and the studies for evaluation of the potential alterations on the structure of fish assemblages, due to actions of man, are scarce and the majority are reduced to inventories, where the ecological approach is short-term, without considering that the dynamics of populations must link observation times to the higher life cycles of the analyzed species. Despite the growing interest relating the distribution of fish, there is little comparison of patterns and large models in the distribution of these. The distribution and abundance of fish are subject to changes

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generated by Physical Environment adverse conditions and to the interaction of a range of biological variables that affect the states from larval and juvenile as competition for resources, susceptibility to disease, predation, dispersion, colonization capacity among others (Brown 1984, Wootton 1992).

3.3.2.1 Methodology

For field work, and following the guidelines of the "General Methodology for the presentation of Environmental Studies" (1503 2010, Ministry of Environment, Housing and Territorial Development - MAVDT), specimens of each section were collected using the method of electro-fishing along transects of 100 m and with nets (with mesh size of 1 cm and 2 m in diameter), while maintaining a constant fishing effort (30 hauls of nets), in order to allow comparisons between the stages and sampling. The electro fishing, is a very appropriate way to the condition of Andean water bodie (flowing and stony) (Maldonado et al. 2005). The sampling sections were chosen trying to assess the greatest amount of meso - habitats (backwaters, rapids, pools) present in the sector (see Photo 3-50). The samplings were punctual and daytime, made during the rainy season the days 12th. and 13th. September 2011.



Photo 3-50. Sampling aspects using electro fishing, in the middle section of the San Matias River

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The collected individuals were measured, weighed, recorded taxonomically in field, photographed and returned to the natural flow. The taxonomic determination was supported by the key proposals by Dahl (1971), Maldonado et al. (2005A) and Nelson (1994).

The information was organized in a matrix where it was recorded the taxonomic listing (scientific and vernacular names), the amount of collected individuals of each species, the weight and the standard length of each specimen, the date and time of sampling, and the type of fishing gear.

- Physical characterization of the section evaluated

Sampling stations are the same as those used for the characterization of the water quality, which can be seen in Cartography 2148-04-EV-DW-025.

In order to describe in the best possible way the habitat and obtain data such as refuge places for the species found in the San Matias River, was carried out a physical description of the Protocol by means of Description of Habitat AusRivAS (*Australian River Assessment System* ; Parsons *et al.* . 2002) Used in lotic ecosystems.

– Section 1 - Collection

It is located in a geomorphology of mountain areas, where the river flows through a shallow valley with steep sides, and the current is cut off by solid rock. The vegetation is distributed in continuous groups on the right bank and consists mainly of native vegetation, while on the left riverside there are two groups of vegetation, covering 50% of the riverside corridor from the section sampled. These two groups of vegetation are trees of more than 5 m in height, while the second group is composed of pastures dedicated to cattle supply (see Photo 3-51).



Photo 3-51. Physical Aspects of the high section, Section 1

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As general feature there are rocky outcrops, which disrupt the normal flow of the water. This type of outcrops determine a lower depth of water, which establish that in the unlikely event of a reduction of the river flow, the isolation of some stages is probable, which reduces the ease of movement of some fish along the river, thus influencing very surely the restriction of particular habitat for some species. In this section is presented a bed with low compaction, where sediments (such as sand, stones and pebbles), are very rounded and easily moved by the currents action.

– Section 2 - middle Section

The valley where the river flow in this area is evenly profound, generating an asymmetric channel, where the greater depth is found in the left riverside. The riversides are covered by woody vegetation more than 5 m high, distributed continuously on both sides (see Photo 3-52).



(a)



(b)



(c)



(d)

Photo 3-52. Coverage in the slopes of the basin in section MED (a), and physical aspect of the Bedform and flow (b and c), of San Matias River

The main characteristic of this stage, is the large size of the substrate, and a slope that generates the presence of streams to the width and length of the entire sampling area (see b, Photo 3-52c). The presence of pools and backwaters are more abundant toward the margins, where the amount of water is less, as well as the flow rate. At the time of sampling the

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transparency was minimal, preventing to observe the substrate until in the shallow shores (depth < 0.10 m). Identified accumulation of fine sand to the right margin (see Photo 3-52) where the water flow was lower, with a greater flow of water to the left and center of the river.

– Section 3 - middle Section

The valley through which the river runs along this section is asymmetric as well as the channel, with the highest height and steepness in the left hillside and the increased depth toward the bank of this same side. The use of the banks is intended for the grazing of cattle. In the first 4 m away from the shore, the vegetation is composed of trees and shrubs, which are distributed continuously. In the slopes of the section, there were no native timber trees in regeneration, since they are intervened environments for livestock and agriculture. Like in MED section, accumulation of sand was detected toward the right bank, which is covered by the shading of the channel, which is 30% approximately, this being generated by arboreal plant cover.

At this stage of sampling, the slope of the channel is less than in section MED, in addition to the decline in the substrate size. In the section it is seeing the formation of streams due to the presence of rocky substrate. Additionally, we can observe the formation of a pond which is a suitable habitat for different species of fish. The presence of pools and streams is less. Approximately 35% of the water sheet is not crimped and presents few disruptions that are generated by substrates that do not reach out to the surface (see Photo 3-53).



Photo 3-53. Physical Aspects of the low section- Discharge

The bed features a moderate compaction, where the substrates of smaller size can be easily dislodged. This substrate is formed by rocks of more than 2 m in diameter in 10 %, stones between 0.3 m and 2.0 m in diameter 40 %, boulders in approximately 15% of bed, the gravel occupies approximately 15% and the remaining 20% is split between the sand and silt.

- Composition, abundance and biomass of the ichthyic association.

– Species composition

In September 2011, in the sampling of San Matias River, were collected only 15 individuals, grouped in two orders, four families and five species. The greatest abundance in number of individuals is presented in the Siluriforms (80.0 %), while the Characiformes presented a very low abundance, which is consistent with what we found in the sampling of February 2009 for the Environmental Assessment of the hydroelectric development of the San Matias River - El

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Molino, when the greatest abundance in number of individuals were also the Siluriformes (92.31 %), as can be seen in Table 3-97 .

Similar behavior is found for biomass, finding a greater contribution to the Siluriforms, 65.5 per cent and 92.67, for the sampling of February 2009 and September 2011.

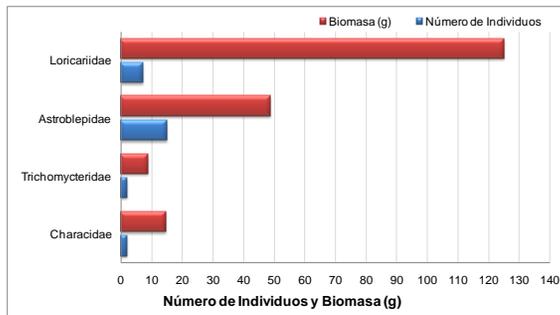
Table 3-97. Abundance, biomass, number of species and fish families recorded

| Order | Number individuals | | Relative abundance (%) | | Biomass (g) | | Relative abundance (%) | | Number Families | | Species Number | |
|---------------|--------------------|-----------|------------------------|---------------|-------------|---------------|------------------------|---------------|-----------------|----------|----------------|----------|
| | Sept | Feb | Sept | Feb | Sept | Feb | Sept | Feb | Sept | Feb | Sept | Feb |
| Characiformes | 3 | 2 | 20 | 7.69 | 20.2 | 14.440 | 34.5 | 7.33 | 1 | 1 | 1 | 1 |
| Siluriforms | 12 | 24 | 80 | 92.31 | 38.4 | 182.660 | 65.5 | 92.67 | 3 | 3 | 4 | 5 |
| Total | 15 | 26 | 100 | 100.00 | 54.6 | 197.00 | 100 | 100.00 | 4 | 4 | 5 | 6 |

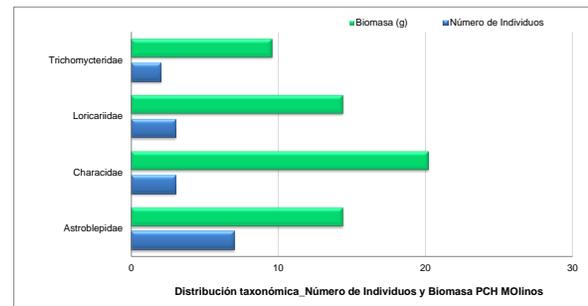
The results, both in terms of the number of individuals as in biomass, maintain the trends of the Neotropics ecosystems, which presents a high abundance of these two fish orders, while others are less abundant (Lowe-Mc Connell 1987).

For the September sampling, the family with the highest number of individuals in the collections was Astroblepidae with seven individuals, followed by Loricariidae and Characidae with three individuals each, while for the Trichomycteridae family only two individuals were collected. However, the biomass for each of the families was higher for the Characidae, of which were collected in total 20.2 g followed by the Loricariidae Astroblepidae and with a contribution of 14.4 g each, while the Trichomycteridae contributed with very low biomass (9.6 g)

In the February sampling, families preserved the same order (Astroblepidae with 15 individuals, followed by Loricariidae with seven, Characidae and Trichomycteridae with two individuals), although the biomass did vary: Was greater for the Loricaridos, of which were collected in total 194.98 g and were followed by the Astroblepidae with a contribution of 48.88 g, whereas the Characidae and Trichomycteridae had a very low input in biomass, due to its low number of individuals (see Figure 3-83)



February



September

Figure 3-83. Number of individuals and biomass collected by family in San Matias River

In general, the number of species found in the two samples is low, six in February and five in September (see Table 3-98 and Photo 3-54), none of them migratory.

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Table 3-98. Orders, families and species registered in San Matias River

| Order | Family | Species | Common Name |
|----------------------------|------------------|--------------------------------|-------------|
| Characiforms | Characidae | <i>Hemibrycon boquiae</i> | Sardine |
| Siluriforms | Trichomycteridae | <i>Trichomycterus caliense</i> | Briola |
| | Astroblepidae | <i>Astroblepus homodon</i> | Captain |
| | Loricariidae | <i>Chaetostoma leucomelas</i> | Cucho |
| | | <i>Chaetostoma milesi</i> * | Cucho |
| <i>Cordylancistrus sp.</i> | | Cucho | |

*: Only species recorded in the February monitoring



Hemibrycon boquiae
(Sardine)

Trichomycterus caliense
(Briola)



Astroblepus homodon
(Captain)

Chaetostoma leucomelas
(Cucho)



Cordylancistrus sp (Cucho)

Photo 3-54. Fish species recorded in September 2011

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The low species richness is a behavior that often occurs in this kind of environments, high mountain ecosystems, in which the strong flows, the rugged topographies, and shortage of native trophic supply are some of the main factors that determine the low diversity. It has also been observed that for the South American basins there is a direct relationship between the size and the number of fish species, this situation may be related to the availability of different environments, which provide a greater diversity of habitat for the species found in these ecosystems. However, the conservation state or habitat disturbance can determine the presence or absence of species in a particular habitat (Paiva 1987).

– Abundance, height and biomass

The species collected that presented the greatest abundance in the two samples were *Astroblepus homodon* (15 individuals in February and 7 September), followed by *Chaetostoma leucomelas* (4 individuals in February, and 5 in September), while the other collected species presented low number of individuals (see Table 3-99 and Table 3-100).

Table 3-99. Number of individuals, frequency of occurrence, standard length and biomass of the registered species, February 2009

| Species | Number Individuals | Frequency Occurrence | Standard Length (mm) | | | | Biomass (g) | | |
|--------------------------------|--------------------|----------------------|----------------------|--------|--------|--------|---------------|-------|-------|
| | | | Med | Min | Max | CV (%) | Total | Min | Max |
| <i>Hemibrycon boquiae</i> | 2 | 0.25 | 75.50 | 74.00 | 77.00 | 2.81 | 14.44 | 6.96 | 7.48 |
| <i>Trichomycterus caliense</i> | 2 | 0.50 | 72.50 | 51.00 | 94.00 | 41.94 | 8.80 | 1.02 | 7.78 |
| <i>Astroblepus homodon</i> | 15 | 0.50 | 46.39 | 19.60 | 81.70 | 43.02 | 48.88 | 0.12 | 10.72 |
| <i>Chaetostoma leucomelas</i> | 4 | 0.50 | 66.60 | 50.00 | 76.00 | 17.87 | 34.00 | 3.41 | 11.73 |
| <i>Chaetostoma milesi</i> | 1 | 0.25 | 140.00 | 140.00 | 140.00 | 0.00 | 82.16 | 82.16 | 82.16 |
| <i>Cordylancistrus sp</i> | 2 | 0.25 | 55.00 | 46.00 | 64.00 | 23.14 | 8.82 | 2.49 | 6.33 |
| Total | 26 | | | | | | 197.10 | | |

Table 3-100. Number of individuals, frequency of occurrence, standard length and biomass of the registered species, September 2011

| Species | Number | Frequency | Standard Length (MM) | | | Biomass (g) | | |
|--------------------------------|-------------|------------|----------------------|------|------|-------------|-----|-----|
| | Individuals | Occurrence | Media | Min | Max | Total | Min | Max |
| <i>Hemibrycon boquiae</i> | 3 | 0.33 | 73.0 | 70.0 | 76.0 | 20.2 | 6.2 | 7.2 |
| <i>Trichomycterus caliense</i> | 2 | 0.67 | 69.0 | 48.0 | 90.0 | 9.6 | 2.3 | 7.3 |
| <i>Astroblepus homodon</i> | 7 | 0.67 | 35.3 | 28.2 | 55.0 | 10.4 | 0.2 | 4.3 |
| <i>Chaetostoma leucomelas</i> | 2 | 0.33 | 55.0 | 50.0 | 60.0 | 11.8 | 3.3 | 8.5 |
| <i>Cordylancistrus sp</i> | 1 | 0.33 | | 48.0 | 48.0 | 2.6 | 2.6 | 2.6 |
| Total | 15 | | | | | 54.6 | | |

All individuals showed very low carvings, fluctuating between 19.6 mm and 140.0 mm in the monitoring of February, and between 28.2 and 70.0 mm in September, being the largest *Chaetostoma milesi* (140 mm) in February, and *Trichomycterus caliense* (90.0 mm) in September. The smaller were the *Astroblepus homodon*, with average sizes 46.39 mm in February and 35.3 mm in September. The biomass of the individuals presented equally low contributions for all the species, which is due to the low height of the individuals (see Table 3-99 and Table 3-100).

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In regard to the occurrence frequency of the species at space level, only the *Astroblepus homodon* was recorded in two of the sampling stages; the rest were collected only in one of the sampling stages, with the exception of *Trichomycterus caliense*, which in the September monitoring was also captured in two sections.

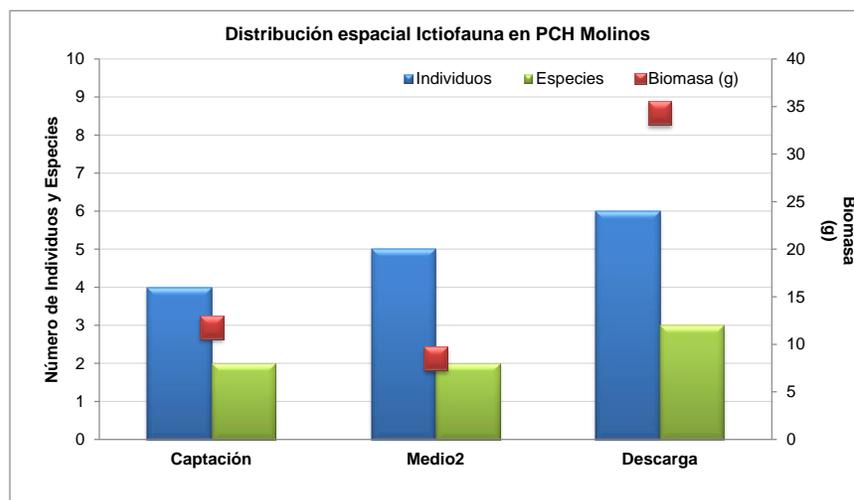
According to Roman - Valencia (1998), the wide spatial distribution of the genera *Hemibrycon*, *Creagrutus*, *Trichomycterus* and *Chaetostoma*, in most of the andean aquatic environments, is a consequence of the ecophysiological characteristics (adaptive) of the species, in relation with the presence of features of favorable habitat for them. So, the apparent absence of these in all the stages evaluated, is due to the limitation imposed by restrictions (high flow rates, high sediment loads, frequent avalanches) emanating from the hydrological assessment time, coupled with the natural restrictions of the sector (jets areas and presence of great height jumps), which are an insurmountable barrier for many species.

– Abundance and biomass by sampling section

When comparing the two monitoring studies, the site that presented the greater number of individuals was the middle section, in February 2009 14 individuals were captured, a number that receded in September 2011, since only four individuals were collected (see Table 3-101 and Figure 3-84).

Table 3-101. Total number of individuals, biomass and number of fish species in the sites, sampling of February 2009

| Species | Section 1 - Collection | | Section 2 - medium | | Section 3 - Discharge | |
|--------------------------------|------------------------|--------------|--------------------|---------------|-----------------------|--------------|
| | Number | Biomass | Number | Biomass | Number | Biomass |
| <i>Hemibrycon boquiae</i> | | | | | 2 | 14.44 |
| <i>Trichomycterus caliense</i> | | | 1 | 7.78 | 1 | 1.02 |
| <i>Astroblepus homodon</i> | 4 | 13.90 | 11 | 34.98 | | |
| <i>Chaetostoma leucomelas</i> | | | 1 | 10.13 | 3 | 23.87 |
| <i>Chaetostoma milesi</i> | | | 1 | 82.16 | | |
| <i>Cordylancistrus sp.</i> | 2 | 8.82 | | | | |
| Total | 6 | 23.72 | 14 | 135.05 | 6 | 39.33 |



| | | | |
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Figure 3-84. Total number of individuals, biomass and fish species in the sampling sites, September 2011

In the discharge section, in the two monitoring studies, six individuals were captured; and in the collection section, the number of individuals vary: six individuals in February 2009 to four individuals in September 2011.

As for the number of individuals, the biomass and the number of species were higher in middle section in the monitoring of February 2009, where it collected 135 g, with four species contribution.

For the discharge section, the biomass had a very similar behavior, 39.3 g for February 2009 and 34.3 g for September 2011, with the same number of species, three.

The low abundance and biomass in the evaluated section of San Matias River, this may be due to the hydro-geomorphological restrictions imposed by the middle section, with a channel confined by large stones and with high speed of the water flow, with the presence of a physiographic insurmountable barrier that limits the movement of species between the different sections of the interest sector.

Oksanen and col. (1995) emphasize that the topography of the terrain in the upper part of the Andean rivers presents homogeneity of habitat and assumes that these environments have autonomous and simple dynamics, a factor that may be a determining factor in the low number of individuals and biomass for San Matias River. In contrast, in the lower part, the heterogeneity is high and often has greater diversity of species and interactions within food webs, with a greater number of species. This means that the conditions of the lotic ecosystems with hilly topographies do not favor a great diversity of habitats and a more equitable distribution of their abundance.

What is usually seen in rivers such as the San Matias, is that as it climbs up the current, the fish diversity as the biomass decrease, due to the size of the water body is reduced, the velocity of the water is more consistent to the slope, which shapes the environment, becoming more restrictive, still inhabited by species of small size with adaptive structures of locomotion and adhesion to substrates.

These changes restrict the distribution of the species in the same river basin, which makes a big difference between the ichtyic diversity of the water bodies, finding over 1,500 meters above sea level, among one to three species; between the 500 meters above sea level and 1,500 Meters above sea level is favored by an increase of eleven to twelve species and below the 500 m can be found more than 78 species (Ramirez and Viña, 1998)).

In most of the fish communities there is an inverse relationship in terms of their distribution, diversity and abundance in relation to the altitude (Margalef 1983). Smith & Smith (2000) found that in other similar lotic systems, increased heterogeneity and diversity of physical structures of the habitat, there are a greater diversity of biological communities that occupy them; however, it should be borne in mind that for San Matías River is presented (possibly due to the slopes and the characteristics of the substrate, among others) a greater habitat homogeneity. In addition, although permanently stated that tropical ecosystems are those which harbor the highest diversity in the world, it is important also to highlight the uniqueness of the high mountain biota that is not as diverse but richer in endemic species compared to other systems (Botero 1989).

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3.4 SOCIO-ECONOMIC ENVIRONMENT

3.4.1 DEMOGRAPHIC DIMENSION

3.4.1.1 Indirect influence area

- Settlement dynamics

In the process of populating the territory now known as Antioquia, intervened aspects linked first, with the adaptive strategy of the population which occupied the geographical space before the arrival of the Spaniards, and in a second time, elements of the emerging process of exploitation of gold and other mineral resources on the part of Europeans.

With the arrival of the Spaniards, Antioquia was populated by various indigenous groups in the north, Nutabes, Tahamies, Yemesies, Moorish, Ituangos, Peques and Ebejicos. In the east, Guamacoes, Punchinaes, Pantagoras and Amanies. In the center, Aburraes Tahamies. In the west Cacios, Nores, Chocoes, Pencos, Carautas, Nutabes and Nitanas. In the northwest Urabaes, Guzuzues, Araques, Cuiscos, Guacas and Tatabes¹².

Subsequently, given the need to feed and supply the population that was concerned and seated around the mining enclaves, the agricultural activity gained relevance, giving rise to the establishment of farms or ranchs. Much later, the need to give new impetus to the Antioquian economy, would open the space for the population of central or peripheral areas such as Medellin, around the industry, already at the end of the nineteenth century and early twentieth century

" The mining activity of the region surrounding Santa Fe de Antioquia, had its greater dynamism between 1575 and 1620, which brought with it an important demographic and colonizer boom; Spanish, slaves and indigenous stick together around the deposits of Buriticá, Cáceres, Zaragoza, remedios and Guamoco. In the following years it is visible the declination in gold production, and in 1625 became fully evident, to see that Cáceres and Zaragoza just produced a third part of the gold obtained at the end of the sixteenth century, this growing crisis, in addition to the gradual deterioration of the profits earned by the mining executives, led to the colonization of other areas of the Province as is the east.

*During the seventeenth century, regions such as the Valley of the Bears, the East of Antioquia and the Valle de Aburrá, acquire importance within the colonizing projects, because of its important gold potential. The plateau of northern Antioquia was sighted by Gaspar de Rodas and Andrew Valdivia in 1541, on its way to the gold of the northeast land and apparently indigenous were still in the region, however, there were just some footprints, because the population groups had disappeared by the XVII and XVIII centuries when the territory was explored "*¹³.

Linked to gold mining, there was all a scaffolding on which rested the activity of gold exploitation, such as the establishment of land for agricultural and livestock production, with

¹² Corantioquia. Socioeconomic and physical-spatial determinants for environmental planning. Jurisdiction of CORANTIOQUIA. S. m.d.

¹³ Corantioquia. Socioeconomic and physical-spatial determinants for environmental planning. Jurisdiction of CORANTIOQUIA. S. m.d.

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the subsequent settlement by entrepreneurs and gangs of slaves. However, this situation was changing, and as is the usual process, when there is a depletion of resources by over-exploitation, the region of Bears, which included land in what is now the municipalities of Santa Rosa de Osos, Yarumal, Don Matías, among others suffered a loss as to the profitability of gold mining, circumstances that had their parallel in Guarne, Rionegro and Piedras Blancas in the seventeenth century.

This mining crisis was the major motivation for the Spaniards to begin looking toward other regions of Antioquia, and thinking about other economic options, which would eliminate this gap, it was then when " *the rich owners were progressively incorporated to the agricultural and livestock production, the big farms trapicheras and herds of cattle, created with the aim to cheaper the maintenance of the slave population, began throughout the XVII century to disperse throughout the province. Herds of cattle and farms engaged in cultivation appeared in the Aburra Valley and in the second half of the century in Marinilla, Rionegro and Guarne, where they operated under the same dynamic or structure of settlement, to establish agricultural sources to meet the nutritional needs inherent in the mining exploitation*"¹⁴ .

Later, in 1740, there is a new gold deployment and expansion of the agricultural and mining frontier in the north, through concessions and grants of land to wealthy homeowners who took advantage of the poor people, who were not paid a salary, to disassembly them and increase its price.

"*The immigration wave in the late eighteenth century and early nineteenth century, whose main representatives were neighbors of Rionegro and Valle de Aburra, helped to set up an entire network and cross-roads in addition to communicating the region from south-north with the Atlantic coast, and from west to east, making it possible to structure a whole food supplier and manufactures of the mining and commercial centers of Antioquia and some municipalities outside the province. This period also marks a change in the mining tradition in the region, to the extent that the new settlers did not only came looking for gold, also "brought seeds and plows"; the new migrants gave rise to the consolidation of small and medium-sized landowners, base of the economy in farms and agricultural allotment of the plateau*"¹⁵ .

As the settlement was closely linked with the gold exploitation, the rhythms of the migration were determined, in large part, by the fall or the rise of the metal exploitation. In this way, the XVIII century presents another decline that leads to the closing of mines, which brought with it, in turn, the manumissions and the gold exploitation on the part of "mazamorreros", who did so independently. This makes new towns to appear in some areas of Antioquia, as San Jerónimo, Sopetran and in Valle de Aburrá, formed by free blacks and mulattos.

" *By the end of the eighteenth century appeared new population centers such as Urrao (1781) in the western Antioquia, Yarumal (1787- San Luis de Gongora), Don Matías (San Antonio of the Infante 1787) and Carolina of Prince in the north (1788), Rionegro (1783) and Marinilla (1787) toward the east, Titiribi (1775), Fake (1788) and Fredonia (1790) in the south; foundations to a great extent linked to the agricultural production needed for the sustenance of the mining centers nearby, and also to the policies proposed by the Bourbon reforms*

¹⁴ Corantioquia. Socioeconomic and physical-space determinants for environmental planning. Jurisdiction of CORANTOQUIA. S. m.d.

¹⁵ Corantioquia. Socioeconomic and physical-spatial determinants for environmental planning. Jurisdiction of CORANTOQUIA. S. m.d.

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carried out in the second half of the XVIII century, which introduced important changes in the settlement and the economy, because they were looking for a greater productive efficiency, agglutinate scattered populations with the order to control them through the civil and ecclesiastical authority and encourage colonizations of empty and unproductive spaces; basically it was looking to promote the spatial and urban organization " ¹⁶ .

The process of setting up in a specific place, resulted in an increase of agricultural production, and with it an improvement in living conditions for those who had worked as slaves or tenant farmers and a decline in indigenous mortality, which was reflected in an increase in the population at that time.

It was then, when" the *trade boom of agricultural and manufacturing products favored the massive circulation of people within and outside the provincial boundaries of Antioquia. At the end of the eighteenth century, Antioquia was inhabited in three regions or districts, one to the north comprised of the nucleus of Caceres, Zaragoza and Nechi, the center of Antioquia and Medellin, and the east Rionegro and Marinilla*" ¹⁷ .

In the forming processes and occupation of the territory it is only logical to produce re-accommodation, centerings and uncentering of the space and places because, as has been said, the territory is built to the extent that it is inhabited and transformed by the socio-economic interactions and is not only a container of natural resources. In this way, at the beginning of the nineteenth century, Santa Fe de Antioquia loses its character of administrative center associated to the usufruct of mineral resource, and it is then when Medellin and Rionegro are experiencing an economic advancement due to the mining and agricultural centers which supplied them are relocated, causing the agglomeration of merchants and landowners, who see in this new space, the opportunity for capital investment accumulated during the previous era.

In sum, " *In the history of settlement can be noted several specific moments of special significance in the current dynamics of subregional configuration from the social, economic, political, cultural and environmental point of view " A first moment considers the period between the XVII and XIX centuries, highlighted as fundamental elements the emergence and consolidation of some of the localities and the subregion, the emergence of Eastern Antioquia in the departmental and national economic scenario - and its role in the national political – administrative dynamic of the era. The second time refers to the period between the first and middle decades of the twentieth century, considering as central issues the economic decline and the new role of an elite that is beginning to consolidate in the immediately preceding period. In the third and last period [...], and the end of the twentieth century [...], what could be termed as a second economic boom, product of the processes of recent industrialization and modernization [...]*"¹⁸

- **Future trend of spatial mobility**

The above outline of the historical process of populating in the East of Antioquia, gives an account of the dynamics that accompany the creation and consolidation of a space that

¹⁶ Corantioquia. Socioeconomic and physical-space determinants for environmental planning. Jurisdiction of CORANTIOQUIA. S. m.d.

¹⁷ Corantioquia. Socioeconomic and physical-spatial determinants for environmental planning. Jurisdiction of CORANTIOQUIA. S. m.d.

¹⁸ Subregional Profile of Eastern Antioquia, 2003.

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ceases to be a deposit for physical-geographic elements, to become a territory. These dynamics implied by this temporary space construction, are reflected today in the dynamics of mobility and composition of the inhabitants in the subregion, in relation to the metropolitan area and other cities like Bogota. Another of the aspects to be taken into account in this landscape, is the phenomenon of forced migration caused by armed conflict, a situation that has been presented so acute in this part of the department and of the country.

Since the beginning of the twentieth century, traces an immigration wave from the eastern of the Department toward the Aburrá Valley, due to the industrialization of Medellín and its neighboring municipalities, labor force that migrated from the east in search of greater stability and better living conditions for family groups.

As always, the construction of new roads and the introduction of new means of transport such as train for the haulage of products such as coffee, spearheaded the development of other regions in the department, leaving the area of the east relegated, arousing in its inhabitants, the need to move to the center of labor and economic movement.

The mobility of the inhabitants of towns such as Guarne, Rionegro, Marinilla and El Carmen, among others, was facilitated by the operation of the electric tram from 1921 onwards, an action which resulted in the settlement of a good part of population that came from the east to the "popular" neighborhoods "in the northeast of the city.

" A fact that had repercussions, both by demographic aspects such as socio-economic and political, was the offer in basic education, high school and college that existed in Medellín by that time Sectors of the elite are moving toward the capital, in search for the offer of "modern" services offered by the city (can also be included in this list, in addition to education, the access to massive public transportation, public services of aqueduct, sewer, electric light, phones, etc. , that were in charge of the Municipal Public Services Company) " ¹⁹ .

We are familiar with the history of clashes between Rionegro and Marinilla for a political and economic supremacy; in the passage of time, these circumstances are not static, having periods in which the relations have been good and others that these became tense. In the era known in the country as "violence", were revived the political struggles between these two populations, which led to a significant migratory cycle to Medellín.

This population mobility brought with it a phenomenon that has been called by some the "descampenización", due that a large peasant population migrated toward the city, some for the purpose of investing accumulated capital in previous years, and others with the aim of making part of the new working population that came to contribute with their labor force in the new industries.

"From 1,955, with the construction of the road from Las Palmas, the communication conditions have improved with Medellín, and the Eastern Antioquia was again a step site toward Bogotá by the road Medellín -La Ceja-Sonson -La Dorada. Also, since 1,957 had started the construction of the Medellín -Bogotá highway, and within a few years, it was able to put into service the section Medellín-El Santuario, with which the distances between Medellín and the municipalities of the plateau were significantly reduced.

¹⁹ Ibid.

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The closeness of Eastern Antioquia with Medellín, the availability of labor force, raw materials and cheap natural resources, suitable land and the fact of being a center located between the markets of Bogotá and Medellín, motivated the business elite of Medellín to project its expansion toward the subregion. After 1,960 shows a "takeoff" of the industry in Eastern Antioquia [...].

The construction of large hydroelectric projects in the area of reservoirs also known as the electrical heart of the country: The El Penol-Guatapé, Las Playas, Santa Rita, Punchina, San Lorenzo and Calderas. The construction of the International Airport Jose Maria Cordova by the 80's.

The dynamism injected to the subregion by road communication and the completion of the Medellín-Bogota Highway at the end of the 70's , made it possible for high and medium socio-economic sectors resident in the Valle de Aburra acquire country homes for rest and recreation, factor that dynamized, the demand for goods and services proper from urbanization"²⁰ .

In this context, it must be remembered the existence of subregions within the region of eastern Antioquia, where we identified two segments of the territory so to speak, which acquired the names of near and far east, between which there are great contrasts in what have to do with the provision of public services, transportation services, existence of a road network in good conditions and the existence of social services.

"The Far East only begins to acquire economic importance from the decade of 1,970 with the construction of the Medellín - Bogota Highway, dams of San Carlos 1 and 2, Jaguars and Calderas and the extension of power transmission lines. The paradox is that these projects have become a source of conflict for the attraction they represent for the armed actors.

Construction of the highway attracted people to be located there, as well as the construction of roads from small towns toward this track, to mobilize the products, the installation of the workshops and restaurants contributed to the peasants leaving their plots and trying luck as restaurant employees and farm butlers in Corcora and San Luis, farmers abandoned the sugar cane cultivation and the sugar cane processing to produce panela and joined as workers of the contractors companies of hydroelectric plants. The construction of the reservoirs of El Penol, San Lorenzo and Las Palmas was the factor that introduced the most profound changes in the east. (National Secretariat for Social Ministry, 2,000)"²¹ .

Similarly, population mobility, and a future trend of this, is framed in a reciprocal relationship of provision and service search, because the urbanization phenomenon and metropolization of the Valle de Aburrá has expanded the radius of influence and demands of the city, toward an offer of environmental and public services, as well as the exploration and exploitation of resources projected for power generation and tourism, for example.

However, "despite being the road and transportation system one of the main advantages for the possibilities of communication they represent for the department at national and international level, the subregion, with one of the highest densities of the department lacks adequate means of communication between several of its municipalities, specifically those of the Far East.

²⁰ Subregional Profile of Eastern Antioquia, 2003.

²¹ Subregional Profile of Eastern Antioquia, 2003.

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The Medellín-Bogotá Highway is the main route in the subregion, which crosses the entire territory from west to east. Begins in the municipality of Guarne, passes by Marinilla, Rionegro, El Santuario, Cocorná and San Francisco, and ends in the municipality of San Luis, and tangentially, in Sonson. Is the main axis of the eastern Antioquia and step site required to communicate the department with the capital of the country”²² .

Another of the ingredients that contribute to the dynamics of mobility in the area and its connection with Medellín, is the educational opportunities in the middle east, given that in the past few years has increased the foundation of several universities in the area. Institutions, such as: University of Antioquia, EAFIT, Universidad Pontificia Bolivariana, College of Public Administration (ESAP-, Politecnico Colombiano Jaime Isaza Cadavid, University Foundation Luis Amigó, Catholic University of the East -UCO-, University Foundation of the East, College of Higher Studies Quirama, National Service of Teaching and Learning - SENA-, Technological Institute Pascual Bravo and Cooperative University of Colombia, among others.

In addition, a fact that cannot be ignored in this context on the dynamics of mobility in the area, is the armed conflict and its direct effect on the displacement of the population; this has resulted in several municipalities which present a total decrease of the population and that in the rural area of several municipalities are evidences of a significant decrease in its population who migrated to the city as a way to safeguard life.

“In the reservoirs area only three municipalities have grown in its population these are Alexandria, El Penol and Guatapé, in the rest the population decreases. In this zone, the municipality which presents the greatest decrease in its population is San Carlos followed by Granada.

The area with the highest population growth is the plateau, all their municipalities grow in its population, this can be explained by various factors, all of them have already been mentioned, such as infrastructure located there, the development of this area in different aspects, its closeness to the area of the Valle de Aburrá, among others. The municipalities with the greatest increase in their population are Rionegro, followed by La Ceja and El Carmen de Viboral.

In the area of forests is present a slight growth in the population of the municipalities of San Francisco and San Luis, but a decrease in the municipality of Cocorná. Situation not very clear, because this area has been hardly hit by the phenomenon of violence, which has generated forced displacement of its inhabitants”²³ .

In addition to the above, the development of hydroelectric projects and tourism in the area, has brought with it floating population flows from the same region and from other places.

On the other hand, " *There is a high mobility of extra population flows and inter subregional, to and from the Greater Metropolitan Area of Aburra Valley, with a stationary and floating character Its importance lies in the pressures of use and the needs for attention in the territory. Mobility however is not referred in the figures of the existing entities, but it proposes some characteristics of these flows identifying the following groups:*

²² Subregional Profile of Eastern Antioquia, 2003.

²³ Subregional Profile of Eastern Antioquia, 2003.

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Working population that circulates and remains in the plateau generally during the working days. Being Rionegro the concentration point of greater number of industries and services (30% of the subregional infrastructure), becomes the main pole of floating population.

Student population enrolled in the various educational centers of primary, secondary, technical, technological and higher education that come from the metropolitan area and neighboring subregions (Middle Magdalena and Northeast). This population group has a tendency to increase in the coming years due to the decentralization and transfer of establishments of higher education of the Metropolitan Area. The increase in the educational activity is reinforced in the already mentioned vision for Eastern Antioquia, 'Educated Eastern Antioquia, will be a world education power in 2020'²⁴.

On the other hand, in the municipalities Cocorná and Granada, as in the rest of the subregion, the mobility is also linked to the livelihood strategies; therefore, this population maintains a few circuits of territoriality confined to the Medellin - Bogota Highway, as has been said.

According to the Bulletin DANE 2005 General Census, Profile Cocorná, Antioquia, the total number of homes in Cocorná, 0.4 % have international emigration experience, the number of people in these households that are permanent residents abroad, the 32.0 % is in Spain, the 28.0 % in Ecuador and the 28.0 % in Venezuela, as can be seen in Figure 3-85 .

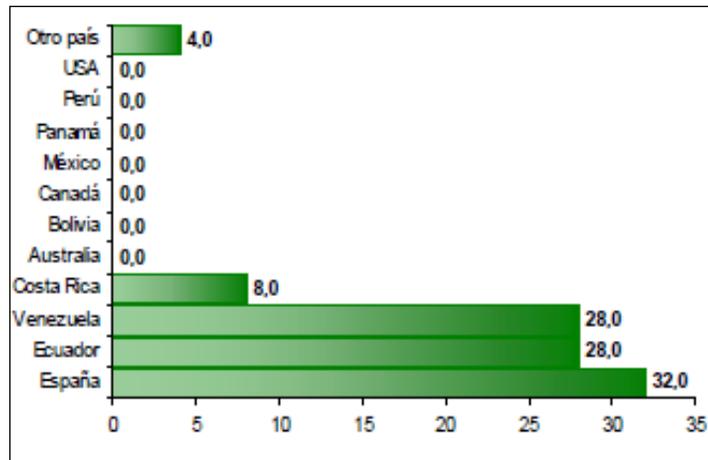


Figure 3-85. People in the municipality of Cocorná, living abroad in year 2005.

Source: DANE Bulletin 2005 General Census, Profile Cocorná, Antioquia

Likewise, with regard to the municipality of Granada, according to the data presented by the DANE Bulletin, 2005 General Census, Profile Granada, Antioquia, from the total number of homes in Granada, 0.7 % have international emigration experience Of the total number of people in these households resides permanently abroad, the 31.6 % is in Venezuela, 21.1 % in Spain and 10.5 % in Panama, as can be seen in Figure 3-86

²⁴ Subregional Profile of Eastern Antioquia, 2003.

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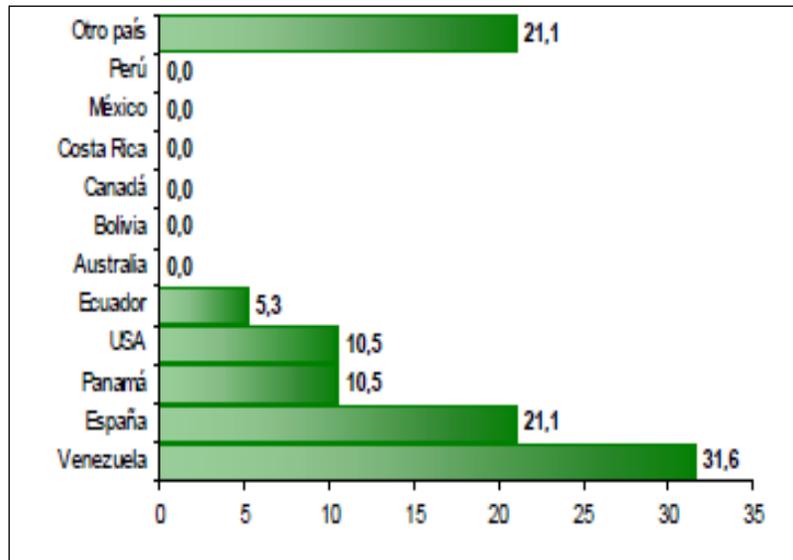


Figure 3-86. People from the municipality of Granada, living abroad in year 2005.

Source: DANE Bulletin 2005 General Census, Profile Granada, Antioquia

As can be seen in Figure 3-85 and Figure 3-86 , although there are two destinations that match, such as Venezuela and Spain, the represented percentages of the population of each municipality in these countries, is different. That is to say, 32% of the inhabitants of Cocorná are in Spain, compared to a 21.1 % of the inhabitants of Granada in the same country. On the other hand, in Venezuela there is a 28 per cent of the population of Cocorná and a 31.6 per cent of the inhabitants of Granada. There is a difference compared to the Panama destination as a residence, because while in Granada, there is a 10.5 % of the population in that country, from Cocorná there is no population; same is true with Ecuador, where there are 28% of the inhabitants outside of Cocorná, and from Granada there is no one.

On the other hand, in regard to the mobility and their motivations, according to the Bulletin DANE 2005 General Census, Profile Cocorná, Antioquia, the 31.7 % of the population of Cocorná that changed their residence in the past five years, did so by threat to their life (see Figure 3-87)

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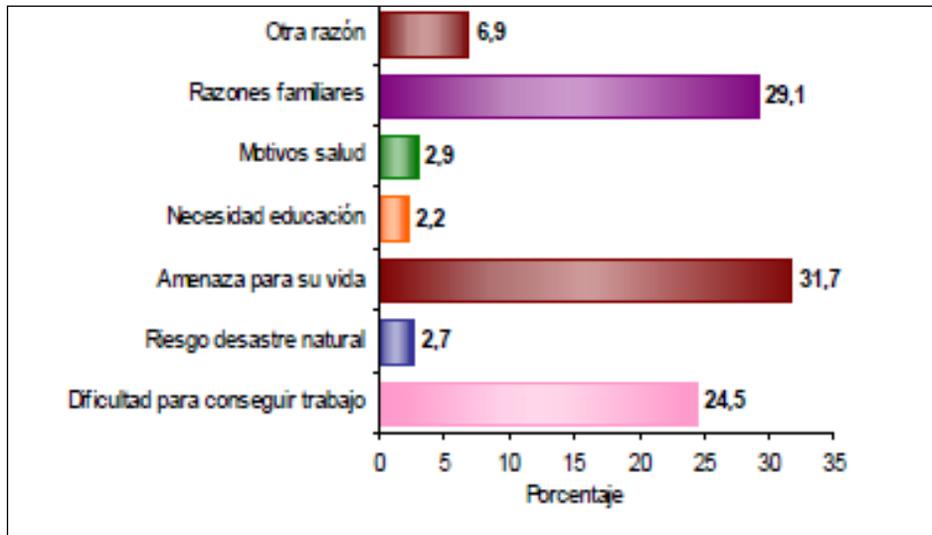


Figure 3-87. Cause of change of residence in the municipality of Cocorná, 2005

Source: DANE Bulletin 2005 General Census, Profile Cocorná, Antioquia

Similarly, as for the reasons of mobility of the population in the municipality of Granada, as stated in the Bulletin DANE 2005 General Census, Profile Granada, Antioquia, 36.2 % of the population of Granada that change of residence in the past five years, made so by threat to their life, the 26.6 % for family reasons and the 16.2 % by difficulty in obtaining work (see Figure 3-88).

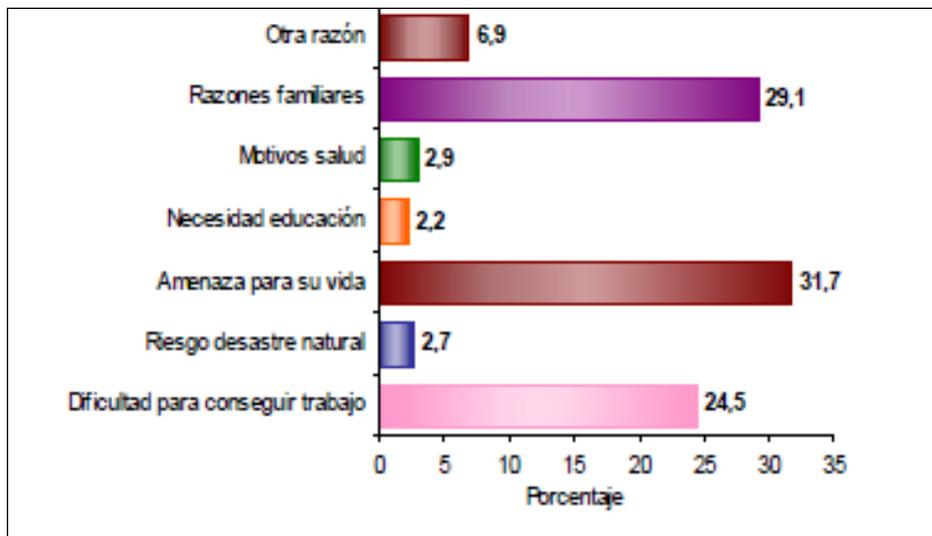


Figure 3-88. Cause of change of residence in the municipality of Granada, 2005.

Source: DANE Bulletin 2005 General Census, Profile Granada, Antioquia

As can be seen in the previous figures, the percentages of emigration by threat to their life in the two municipalities are significant, a fact, that with high probability, is associated with the

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armed conflict, which has been crude in the study area, as will be discussed later, in the political organizational component of the present study.

In sum, today the population of the eastern region of the department of Antioquia and its municipalities, continues in a come and go between its territory and other places, in order to procure improving their living conditions, after the search for basic services such as health and education and sadly by the armed conflict. These dynamics are proper of human populations in their interaction with the territory and strategies developed, for an access to natural resources.

Not in vain, the overseas travel from Europe to the "new" land in America and Oceania, during the XVI and XVIII centuries, have been widely studied as a process of conquest and devastating wildfire of their own culture, but has also been analyzed as a mechanism for social promotion and enrichment of the large number of Spaniards who arrived after being expelled from their country with non-recommendable antecedents. This process, at the beginning, focused to plunder and exploitation of natural resources such as gold, and other elements were brought that then were introduced into the local modus vivendi, and that today are part of a miscegenation culture proper of the inhabitants of the subregions of Antioquia.

On the other hand, right from the first migratory movements in the different regions of the country and from Antioquia until today, in the economic and socio-political context, migratory movements from the countryside to the city have been seen as the movement of the labor force that covers the demand for a rise in industrialization. However, in this case, there is an additional element, as has been said, the internal armed conflict, which has caused more than mobility, exile, the expulsion of a population that has been induced to leave their territory with the sole purpose to save his life.

- Type of population

As a common place to the process of colonization by the Spanish in the country, linked to the exploitation of the mineral resource in a first moment, and then to the establishment of agricultural and livestock activities that reduce costs for the maintenance of workers in mines, trimetric contact was inevitable, since before the arrival of the Spaniards and the African slaves, the indigenous were already in the territory. At the beginning of the exploitation of gold, the eastern region of the department participated in its own dynamics, in this way, with the contact of the three groups, there was a rapid process of miscegenation. However, Rionegro traditionally has been considered more black and mestizo that Marinilla, given that this last Vereda (*Political and administrative division of the municipality located in the rural area*) was more of an agricultural vocation, activity that was exercised in a greater proportion by whites and mestizos, while Rionegro had more black population dedicated to mining.

" As previously noted the political antagonisms of the nineteenth century between Rionegro and Marinilla will be nuanced by the ethnic stigmatization among ones and others, which allowed the marinillos feel 'whites' and the rionegreros "black".

In eastern Antioquia, the side of the large landed farms located in San Antonio, Llano Grande, Tablezo, "chachafruto", and other places, appeared a large population of free blacks, mestizos and mulatto that constituted more than 80% of the population (...). The mestizos and mulattoes did not have the economic conditions that would enable them to exploit the land and have a level of life similar to that of whites, medium and large owners. (...) At the end of

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the eighteenth century and throughout the nineteenth century, the scarcity of land, the increase of the free population and the need of self-sufficiency forced the population to move and colonize places further away from urban centers (Cornare-INNER, 1,987)²⁵ “.

At present time, the vocation of each municipality carries within itself certain elements that are constitutive of a sort of self-identity, an issue that is addressed with the intention of not falling into essentialisms, as has been said, the East is a complex and dynamic region, intercepted by multiple factors, in a process of interaction increasingly close to the city and metropolitan world of Medellín; what is more, in the same region, the municipalities of the plateau make up a node that also influences hegemonically the other municipalities, by the concentration of services and greater road and industrial development.

“In this measure proper localisms of each of the municipalities of Eastern Antioquia express a particular root, which without doubt contributes to set some traits about cultural plurality. The history allows us to understand the way in which from the colony, the boom from mining, created the first differences between the towns of Rionegro and Marinilla. The tri ethnic composition of the population, particularly in Rionegro, suggests the idea of a latent cultural plurality, but limited to the schema of the hegemonic Spanish or creole-white culture

However, if you analyze the weight of this ethnic diversity in the subregion after more than three centuries to the present, it is clear that with the passage of time and the development of new processes, this aspect has been relegated to second place, being replaced by new cultural formations.

It is a clear fact the predominance of the towns of Rionegro and Marinilla in the context compared to other neighboring municipalities. Since the beginning of the colonization, "the two localities (...) marked with its socio-cultural ethos other important populations of Eastern Antioquia: El Retiro, La Ceja, San Vicente, Guarne, in the case of Rionegro and El Penol, Guatapé, Granada, San Carlos, in the case of Marinilla" (CENICS - Cornare. 1988, Took I.).

With the founding of new towns, the arrival of people of different social conditions (large landowners, merchants, humble peasants and "have nothing"), starts to set up the first forms of local authorities, on which were structured traditional forms of social cohesion and social control. With the constitution of the traditional political parties, partisan secondments were formed later in a kind of cultural "magma" homogeneinize attitudes and values, in particular in what had to do with the development of early forms of social identity, but with a marked local character. So to say that the local is in all cases the space of basic reference, the true "homeland", which in many cases makes difficult the realization of projects with subregional and even zonal scope²⁶ .

However, by what has been said above, this connotation of the locality is not monolithic, since the permanent interrelationship of these localities with Medellín, have introduced forms and ways of living more trod; even, consumer habits have changed in all aspects, before the decline of agriculture and the transformation of a peasant way of being. The inhabitants of the municipalities of the plateau and those who have easy access to the Medellín-Bogotá Highway, expand their territoriality among their cities and towns, until broader circuits of interaction and exchange. Likewise, the forced displacement brings with it the uprooting and

²⁵ Subregional Profile of Eastern Antioquia, 2003.

²⁶ Subregional Profile of Eastern Antioquia, 2003.

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detrterritorilization, which involve the acquisition of a new way of living, in spaces that are not their own, and in very precarious conditions. For this reason, a unilinear analysis does not allow to conclude in any way a prototypical definition of the inhabitant of the eastern Antioquia.

" In the area of reservoirs degradation phenomena have resulted in the loss of the peasant vocation, decrease in agricultural food production, sedimentation of the reservoirs and in particular, the type of political conflicts around the exploitation of energy resources.

For the area of forest the analysis of the diagnostics emphasizing aspects as sociopolitical conflict by the exploitation of mineral resources, declining agricultural productivity by migration and forced population displacement, indiscriminate felling of woodland and erosion in areas adjacent to the road infrastructure.

The peasantry as heterogeneous social group present in each of the locations has played a special role in each municipality, the description of this in the polarities allows an overview of its role in the East. In Sonson was a heterogeneous group articulated differently to other social forces, excluded from political life and marked by the inhabitants of the municipal seat²⁷.

Former farmers in the area of reservoirs, formed by the towns of the El Penol, Guatapé, San Carlos, San Rafael, Granada, Concepcion and Alexandria, have been forced to confront a new vocation oriented to tourism, as a product of the dams construction, and in San Rafael and San Carlos is evident an expansion of the agricultural frontier toward the forest, with agricultural and livestock activities diminished. Although, by the cultural weight of being a farmer, maintains a preference for land working.

In the forests areas, highly affected by the construction of the Medellín-Bogotá Highway, and formed by the municipalities of San Luis, Cocorná and San Francisco, there is a predominantly rural population that cultivate cane, coffee, cacao, plantain, cassava, corn, fruits, rice, sesame, mainly for subsistence and also extracts forest resources.

On the other hand, in the area is also a population type known as the holidaymakers, which is constituted by owners and tenants of recreational farms or secondary home. Generally arrive on weekends or holiday season, focusing particularly in Rionegro, El Retiro, La Ceja, Guarne, Marinilla and Guatapé. The floating population are tourists who come to use various infrastructure services for recreation and tourism.

The inhabitants of these two areas have gone through the transformation of their dynamics and life modes, the ones with the construction of reservoirs and the other by the military confrontation and a rooting of the armed conflict in their territory.

On the other hand, in accordance with the General Bulletin DANE Census 2005, Profile Cocorná, Antioquia, 0.2 % of the resident population in Cocorná known as: Raizal , palenquero, black, mulatto, or afro-colombian descendant (see Figure 3-89).

²⁷ Subregional Profile of Eastern Antioquia, 2003.

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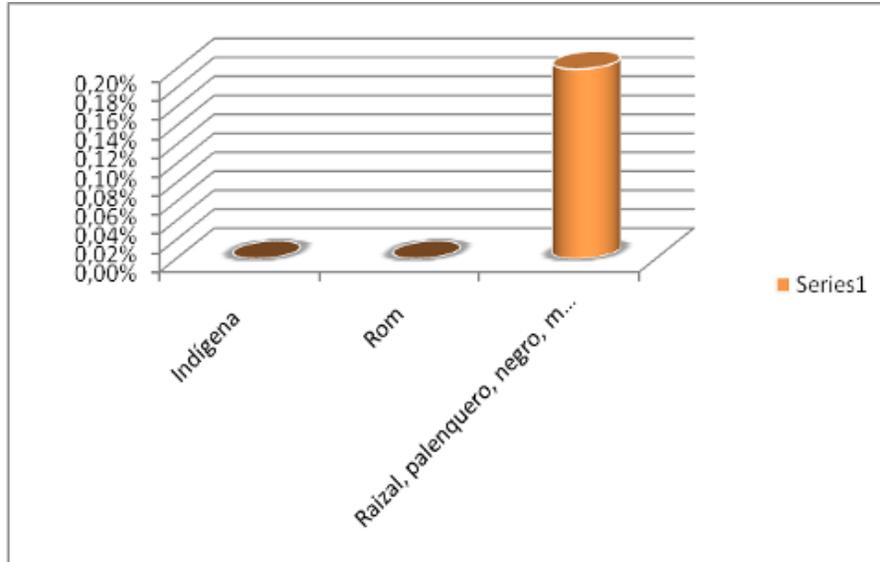


Figure 3-89. Ethnicity in the municipality of Cocorná.

Source: DANE Bulletin 2005 General Census, Profile Cocorná, Antioquia.

Also, according to the Bulletin DANE 2005 General Census, Profile Granada, Antioquia, 0.3 % of the population residing in Granada is known as, palenquero, black, mulatto, or afro-colombian descendant (see Figure 3-90)

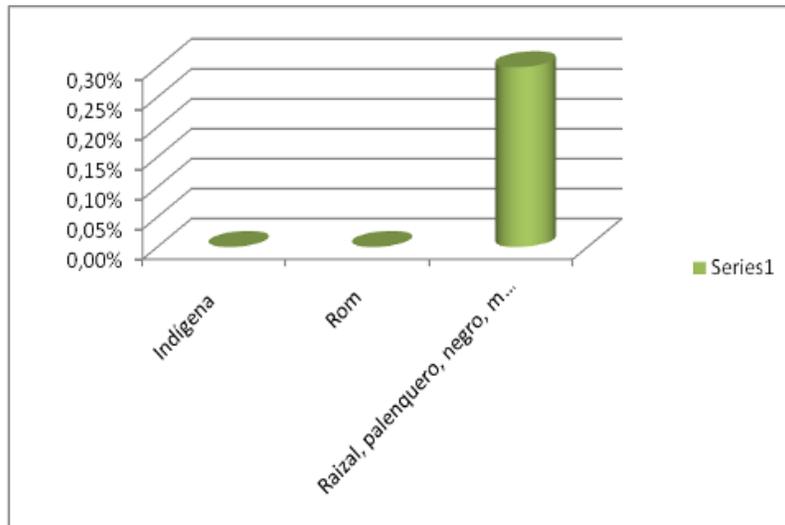


Figure 3-90. Ethnicity in the municipality of Granada.

Source: DANE Bulletin 2005 General Census, Profile Granada, Antioquia.

3.4.1.2 Direct influence area

- Characterization of population groups:

The Vereda (Political and administrative division of the municipality located in the rural area) that are included in the direct influence area of the El Molino hydroelectric project are: the

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municipality of Cocorná, El Molino, Campo Alegre, Los Mangos, La Inmaculada, San Lorenzo, San Juan and El Choco. The municipality of Granada, Quebradona Abajo and Las Faldas.

The Vereda (Political and administrative division of the municipality located in the rural area) in the municipality of Cocorná belong to a zonal center, which was defined by "Agreement 004 of March 6 of 1,999 where were created thirteen (13) zonal centers identified and the Vereda (Political and administrative division of the municipality located in the rural area) they integrate"²⁸. In accordance with the foregoing, the Vereda (Political and administrative division of the municipality located in the rural area) located in the project influence area are found in the zonal centers El Molino, San Juan, El Jordan and La Piñuela, as you can see in Table 3-102.

Table 3-102. Vereda (Political and administrative division of the municipality located in the rural area) in the influence area of the zonal centers of the municipality of Cocorná

| Zonal Center | Vereda (Political and administrative division of the municipality located in the rural area) that conform it |
|--------------|--|
| El Molino | El Molino, Buenos Aires, Viadal, El Choco, Las Playas, Campo Alegre, Los Mangos and Santa Barbara. |
| San Juan | San Juan, La Peña, Montañita, San Antonio, Los Potreros and La Arboleda. |
| La Piñuela | La Piñuela, La Tolda, La Quiebra, Majagual, La veta, Balcones, La Granja, San Lorenzo, Guayabal and Santo Domingo. |
| El Jordán | El Jordán, La Inmaculada, El Coco, and La Aurora. |

Source: Diagnostic Schema Document of Territorial Planning of the Municipality of Cocorná Subregion Forests

Although, according to data from the General Census DANE 2005 and referenced in the previous paragraph, are reported figures that speak of 0.2 % and 0.3 % for the municipalities of Cocorná and Granada, respectively as soon as the membership or ethnic auto recognition, this characterization is presented at the municipality level and not of its Vereda (Political and administrative division of the municipality located in the rural area). On the other hand, according to the memorandum issued by the Ministry of the Interior and the Colombian Rural Development Institute in the influence area of the project there is no presence of ethnic minorities (see Annex 1 and Annex 2).

In any case, despite the dynamic transformation of the territory under the influence of the hydro projects, the Medellin - Bogota Highway and the armed conflict, which has permeated the way of being and the peasant way of conceiving the world of this type of population, a significant number of the population of the Vereda (Political and administrative division of the municipality located in the rural area) saved attachments to traditions related to a production mode based on family labor, in addition, the way of life in general, is based on the maintenance of the social fabric, the religiosity deeply marked by the Catholic Creed, the food and festivity.

However, as has been said, the intention is not to fall into an essentialism rooted in the past, since the picture outlined above gives an account of complex processes of territorial and cultural transformation; therefore, the type of farmers who are still in the different localities, are linked to the relationships and paradoxes of the present. In addition, it is important to remember the marginality degree in which are the peasants in Colombia by factors such as a decline in the resources conditions of the environment, by the armed conflict and by the high

²⁸ Diagnostic Document Schema of Territorial Planning of the Cocorna Municipality Forests Subregion. S. m.d

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costs that imply a productive process, it is not compensated with what is perceived in a marketing, which in most cases is not fair, because the broker gets the most.

As outlined in the Scheme of Management of the municipality of Cocorná, " *With regard to the issue of cultural diversity in the municipality of Cocorná we could say that according to three main climatic zones can be differentiated human staggered groups: the cold zone welcomes peasants who had come from and related to the plateau of Eastern Antioquia: Las Cruces, El Viejo, mainly reflected the influence of the altitudinal higher grounds (almost 2,000 meters high).*

The temperate zone is the great part of the municipality in which coffee, sugar cane and livestock have been central to the development of the town of what is now the municipality. The surrounding Vereda (Political and administrative division of the municipality located in the rural area) the town strategically crossed by the Medellín - Bogota Highway presented dynamic increase in the population density after the enthusiasm of the promise that the road would bring; in general terms is a peasant who aspires to enter livestock in systems that are not compatible with biophysical area conditions. This and the road show us marginal farmers; the eroded area soils that will not provide the necessary means to lead their basic demands, a step economy that leads at critical times to begging and impoverishment.

The warm region has been associated with the Middle Magdalena and with the jurisdiction that there has the Municipality of San Luis. The foregoing reveals a heterogeneity in the characteristics of the human groups, in which were indigenous redoubts, colonists who come from other departments through the Middle Magdalena, and peasant arrivals from the plateau of eastern Antioquia. The main center of logging activities possessed by the Vereda (Political and administrative division of the municipality located in the rural area) of San Francisco, which congregated a major proportion of its inhabitants and its territory, the latter was declared as a municipality in 1987, with which they share affinities as to its identity. Although part of what is today the municipality of Puerto Triunfo made part of Cocorná, cultural differences and of the people auguring that later would translate into the formation of Puerto Triunfo as a municipality, a distant unit and of different composition than Cocorná "²⁹.

For its part, in Granada, which has been delimited by river basins, the type of population is defined by the traditions and shaping of the population at the time of colonization, which converges in some very similar ethnic and cultural characteristics, despite the existent administrative political divisions ³⁰. There prevails a peasant way of life, where the main activity is still agriculture, with livelihood on family labor.

- Population dynamics:

Although the data that are presented below correspond to the year 2006 and are based on the 2005 general census DANE (see Table 3-103), it is important to take into account the characteristics of the armed conflict in the area, which generated forced displacement and the

²⁹ Planning scheme of the Municipality of Cocorná, 2000.

³⁰ For administrative purposes, the municipality has adopted the methodology of grouping a number of paths with similar characteristics, around a territorial unit called basin, five basins were defined in the workshops for the formulation of the development plan 1998-2000, clarifies that the term "basin" should not be understood as a watershed, it refers here only to a territorial unit comprised of numerous Vereda (Political and administrative division of the municipality located in the rural area), villages and a strategic point where the same converge, represented by the municipal seat, the village of Santa Ana, and the three population centers (Los Medios, Galilea and La Quebra).

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depopulation or abandonment of some houses from the Vereda (*Political and administrative division of the municipality located in the rural area*) by its inhabitants.

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Table 3-103. Territorial units affected by the hydroelectric project El Molino in the municipalities of Cocorná and Granada

| Municipality | Vereda (Political and administrative division of the municipality located in the rural area)s | Km ² | Population | Hab/km ² | NBI | | NO. housing | With aqueduct | With sewerage |
|--------------------|---|-----------------|--------------|---------------------|--------------|------------|-------------|---------------|---------------|
| | | | | | In Poverty | In Misery | | | |
| Cocorná | La Inmaculada | 1.83 | 26 | 14.75 | 27 | 2 | 6 | 0 | 0 |
| | San Lorenzo | 10.31 | 488 | 45.78 | 445 | 166 | 96 | 47 | 11 |
| | Campo Alegre | 1.18 | 80 | 0.14 | 80 | 57 | 19 | 3 | 0 |
| | El Chocó | 1.64 | 119 | 72.56 | 117 | 27 | 25 | 8 | 0 |
| | El Molino | 3.06 | 133 | 43.46 | 133 | 73 | 37 | 6 | 0 |
| | San Juan | 2.20 | 205 | 93.18 | 191 | 57 | 51 | 38 | 1 |
| | Los Mangos | 2.93 | 65 | 22.18 | 65 | 47 | 18 | 0 | 0 |
| Total | 7 | 23.15 | 1,101 | ----- | 1,068 | 429 | 252 | 1025 | 12 |
| Granada | Las Faldas | 2.95 | 94 | 31.86 | 94 | 25 | 21 | 0 | 0 |
| | Quebradona Abajo | 2.10 | 95 | 45.23 | 95 | 45 | 27 | 0 | 0 |
| Total | 2 | 5.05 | 189 | --- | 189 | 70 | 48 | 0 | 0 |
| Grand Total | 9 | 28.2 | 1,290 | ---- | 1,247 | 499 | 300 | 102 | 12 |

Source: Government of Antioquia Administrative Planning Department 2007 Vereda (Political and administrative division of the municipality located in the rural area) Atlas Department of Antioquia. Second edition

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In accordance with the data presented in Table 3-103 , there are nine Vereda (*Political and administrative division of the municipality located in the rural area*) in total that will be affected by the project; similarly, the total population are 1,290 people. of which 1,101 are in the municipality of Cocorná, which represent a 7.2 % on the total population of the municipality, which are 15,119 persons. For its part, in the municipality of Granada are 189 people, which corresponds to 1.93 % of the total population of the municipality (9,789). As can be seen in the table above, almost 100% of the population of the Vereda (*Political and administrative division of the municipality located in the rural area*) are located in a state of poverty, which reflects very difficult living conditions. Of the 300 houses, 102 have aqueduct and only 12 with sewage. This percentage represents the 34% and 4% respectively.

- Age/gender composition

In Table 3-104 and Table 3-105 can be seen the main features of the population from the Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area, in terms of the composition by age and gender.

Table 3-104. Composition by age and gender for Vereda (Political and administrative division of the municipality located in the rural area), in the Veredas (Political and administrative division of the municipality located in the rural area) in the influence area of the municipality Cocorná, in year 2007

| Zonal Center | Vereda (Political and administrative division of the municipality located in the rural area) | Population 2007 | Distribution by gender | | |
|--------------|--|-----------------|------------------------|-----------|-------|
| | | | N°. Men | N°. Women | Total |
| El Molino | La Inmaculada | Number | 13 | 13 | 26 |
| | | % | 50 | 50 | 100 |
| | San Lorenzo | Number | 248 | 240 | 488 |
| | | % | 50.82 | 49.18 | 100 |
| | Campo Alegre | Number | 47 | 35 | 82 |
| | | % | 51.08 % | 42.68 % | 100% |
| | Chocó | Number | 74 | 72 | 146 |
| | | % | 50.68 % | 49.32 % | 100% |
| | El Molino | Number | 79 | 68 | 147 |
| | | % | 53.74 % | 46.25 % | 100% |
| | Los Mangos | | 39 | 34 | 73 |
| | | | 53.42 % | 46.57 % | 100% |
| San Juan | San Juan | Number | ND | ND | ND |
| | | % | | | |

Source: Our Municipality. General Information. Territories- Vereda (Political and administrative division of the municipality located in the rural area) Los mangos. Available in <http://cocorna-antioquia.gov.co/municipioinforma.shtml?apc=mtVereda-1-&x=1490543>. Consulted on 2 November 2011

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Table 3-105. Composition by age and sex for Vereda (Political and administrative division of the municipality located in the rural area), in the Veredas (Political and administrative division of the municipality located in the rural area) of the influence area in the municipality of Granada, in year 2007

| Vereda (Political and administrative division of the municipality located in the rural area) | Population 2007 | Distribution by age ranges | | | | | | Distribution by gender | | |
|---|--------------------|----------------------------|------|-------|-------|-------|-------|------------------------|-----------|-------|
| | | < 1 Year | 1-4 | 5-14 | 15-44 | 45-59 | >60 | N°. Men | N°. Women | Total |
| | | | | | | | | | | |
| Las Faldas | Number | 0 | 8 | 20 | 38 | 16 | 10 | 45 | 47 | 92 |
| | % | 0 | 8.69 | 21.73 | 41.30 | 17.39 | 10.86 | 48.91 % | 51.08 % | 100% |
| Quebradona Abajo | Number | 0 | 8 | 24 | 24 | 14 | 11 | 60 | 44 | 104 |
| | % | 0 | 7.69 | 23.07 | 23.07 | 13.46 | 10.57 | 57.69 % | 42.30 % | 100% |
| La Arenosa | Number | ND | ND | ND | ND | ND | ND | ND | ND | ND |
| | % | | | | | | | | | |

Source: Database of Sisben municipality of Granada

In accordance with the data presented in the Table 3-104 , in Vereda (Political and administrative division of the municipality located in the rural area) La Inmaculada is the comparable population of men and women, because respectively each segment of the population by gender represents 50 %, which differed from the situation of the municipality, where the number is higher for women than for men. In accordance with data as reported by the Vereda (Political and administrative division of the municipality located in the rural area) Atlas of the Department of Antioquia, 2006, on the Vereda (Political and administrative division of the municipality located in the rural area) there are two children between 0-5 years. According to information gathered during the field work conducted in the month of December 2011, from the total of the current population, approximately 52 people, there are 18 children from 0 to 14 years and 8 young people from 14 to 20 years.

According to the data expressed in Table 3-104 , in the Vereda (Political and administrative division of the municipality located in the rural area) of San Lorenzo are more men than women, coinciding with the situation of the Vereda (Political and administrative division of the municipality located in the rural area) in this regard. As for the age groups, in the Vereda (Political and administrative division of the municipality located in the rural area) Atlas of the Department of Antioquia, 2006, 38 children are reported between the 0-5 years.

As you can see in Table 3-104 , in the Vereda (Political and administrative division of the municipality located in the rural area) Campo Alegre there is a greater proportion of men with regard to women, showing a different behavior with respect to the municipality, where the total population, 49.6 % are men and 50.4 % women, according to the General Census Data 2005 DANE. With regard to the age group, according to the Vereda (Political and administrative division of the municipality located in the rural area) Atlas of the Department of Antioquia, 2006, on the Vereda (Political and administrative division of the municipality located in the rural area) there are 5 children of 6 years and according to data collected during the field work, carried out in December of 2011, of the approximately 105 people living in this Vereda (Political and administrative division of the municipality located in the rural area), the majority are between 15 and 25 years.

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In the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Chocó, the difference of 1.36 % between the number of men and women is low (see Table 3-104). With regard to the age group, according to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas Department of Antioquia, 2006, on the Vereda (*Political and administrative division of the municipality located in the rural area*) there are 15 children between the ages of 0 and 5 years, in accordance with the field work carried out during December 2011, the population between the ages of 6 and 14 are approximately 30 people.

In Table 3-104 can be seen that, as in the previous Vereda (Political and administrative division of the municipality located in the rural area)s, in El Molino there is a higher percentage of men than women, also showing a different pattern with respect to the total of the municipality where there are more women than men. With respect to the composition of age equality, according to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of the Department of Antioquia, 2006, on the Vereda (*Political and administrative division of the municipality located in the rural area*) there are 16 children between the ages of 0 and 5 years. According to the field work conducted in December of 2011, there are approximately 120 children aged between 0 and 15 years and 35 young people between 15 and 25.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, repeats the behavior in front of the rest of the Veredas (Political and administrative division of the municipality located in the rural area)in the municipality of Cocorná, in terms of the gender composition, it replicates the pattern in relation to the total population of the municipality, where the number is higher for women than for men (see Table 3-104). With regard to the age groups, in accordance with the data of the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of the Department of Antioquia, 2006, in Los Mangos there are 9 children between 0-5 years, and according to the information collected during the field work conducted in December of 2011, there are approximately 8 children from 0 to 12 years; 3 young people from 14 to 18; 62 adults and 3 people from more than 60 years.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Juan not age data are recorded in a formal way. In accordance with the data from the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of the Department of Antioquia, 2006, on the Vereda (*Political and administrative division of the municipality located in the rural area*) there are 12 children between the ages of 0 and 5 years. In accordance with the data collected in December 2011, during the field work carried out, in San Juan there are approximately 8 children from 0-5 years, 30 children between 8-13 years, and 35 adult women.

According to data from the scheme of territorial order of the Municipality of Cocorná, the zonal Center San Juan is one of those with the largest adolescent population. Likewise, the adult population, is representative in this area. In Figure 3-91 can be seen the proportion of the population by age in San Juan with respect to the other zonal centers of the municipality. Note that it is the largest group of people over the age of 18, followed by the population between the 0 and 12 years, being less than the proportion of young people between the ages of 13 and 17.

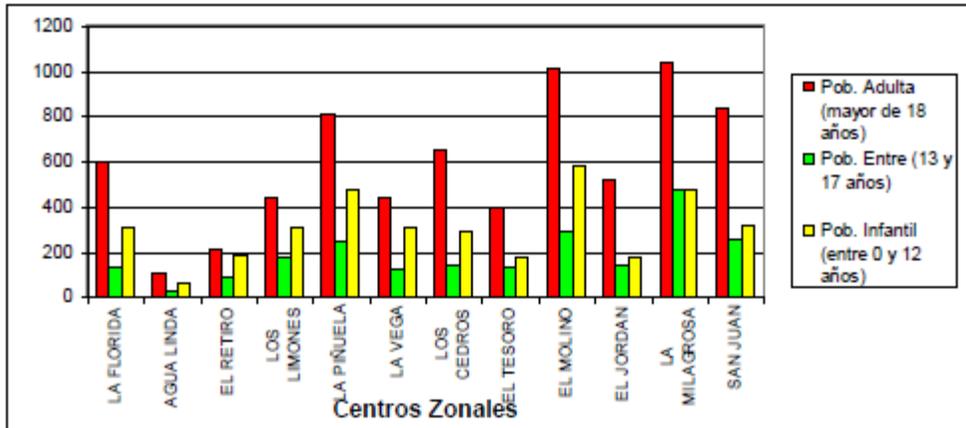


Figure 3-91. Population by age groups of the rural area of the municipality of Cocorná
 Source: Scheme of territorial order of the Municipality of Cocorná, 2000.

According to Table 3-105 , in the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas there is a greater number of women than men, contrary to the pattern shown on the Vereda (*Political and administrative division of the municipality located in the rural area*) already mentioned of the municipality of Cocorná. In regard to age composition, the group between 15-44 years has the greater number with 38 people and the less, the group of people between 1-4 years with 8 children (see Figure 3-92).

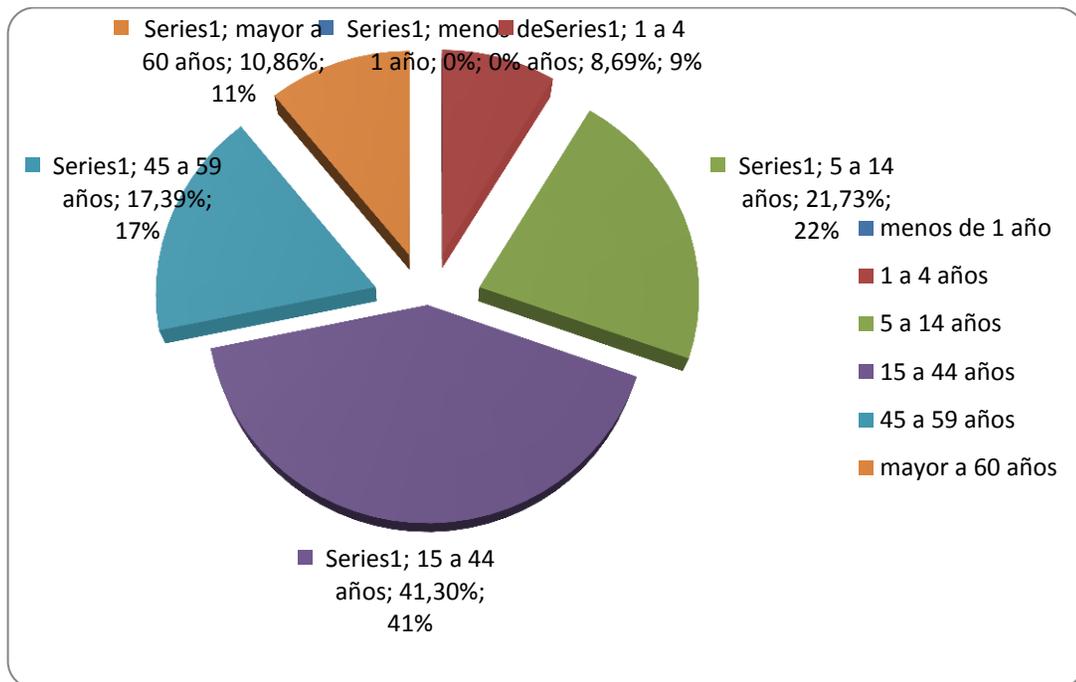


Figure 3-92. Age Composition in %, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas of the municipality of Granada.
 Source: Home processing, social team SAG, based on the data base of Sisben municipality of Granada.

As in the Vereda (*Political and administrative division of the municipality located in the rural area*) in the municipality of Corcorna, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo the percentage of men, is equivalent to a 61.29 %, is higher than the women (see Table 3-105). In relation to the age equality scale it can be said that the most numerous groups are those who are between 5 and 14 and 15 to 44 years, each with 24 people, followed by the group between 45 and 59 years with 14 people, in third place are the people within the group over 60 years old after the group between 1 and 4 years and finally below the age of 1 year (see Figure 3-93).

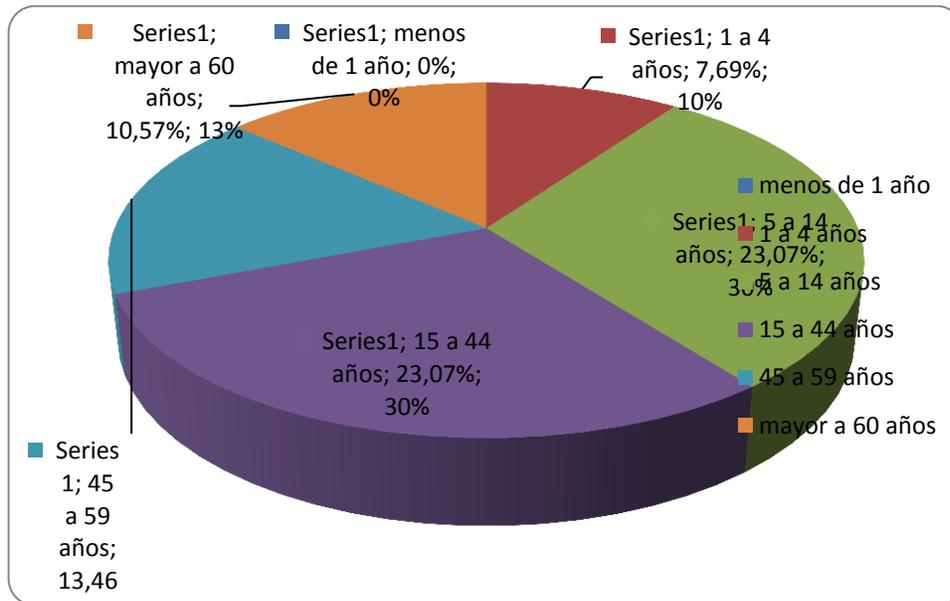


Figure 3-93. Age Composition in %, on Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo of the municipality of Granada.

Source: Home processing, social team SAG, based on the data base of Sisben municipality of Granada.

As can be seen, according to the figures submitted in advance for the municipality of Granada, the age groups with the largest populations are those in the range between 5 to 14 years and 15 to 44 years; this means that the working-age population and children are significant groups, like the group of over 60 years of age.

This fact speaks of aspects as the need to meet a child population in services such as education, health, nutrition and everything that involves a proper growth and development. As the adult population originates demands for social assistance, an important concern for the authorities and financial planners of the state. This in direct relation to the demand for goods and services on the part of this population. In regard to the people of working age, impose the need of thinking in addition to other issues in the supply of labor in this group.

- Trend of population growth

According to data provided by the scheme of territorial order of Cocorná, in the rural area of the municipality, the population density is low, since the Vereda (*Political and administrative division of the municipality located in the rural area*) in the number of families' ranges between 30 and 60. However, in the paths that are located on the Medellin Bogota Highway,

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is evidence of a higher concentration of population, still the case for Los Cedros, El Coco, Santo Domingo, and El Jordan.

In addition there are other Vereda (Political and administrative division of the municipality located in the rural area) such as Las Playas, Caracoli Cruces, San Juan and La Piñuela which are special cases, the families concentration is greater, surpassing the 76 families by Vereda (Political and administrative division of the municipality located in the rural area). In this context, it is important to take into account the dynamics that are generated around the construction of infrastructure projects, since almost always influence the transformation of the existing population density in the concerned territories.

Another important aspect to note, are the effects caused by the armed conflict, given that in the area have been submitted events of forced displacement, which have influenced the population dynamics, with an additional ingredient in the present, the return process conducted by the State.

In direct relationship with the trend of population growth, is the amount of child population in the different Vereda (Political and administrative division of the municipality located in the rural area) or the zonal centers of the municipality. That is why the data schema of Territorial Planning of Cocorná providing information in this regard are retaken

Between the zonal centers of the municipality with the highest number of child population between the ages of 0 and 12 years, are El Molino, La Piñuela and La Milagrosa, the first two are in the project influence area. Other of the Vereda (Political and administrative division of the municipality located in the rural area) that account with a good number of children are San Lorenzo and Los Mangos, which are also part of the project influence area, where the number of children is superior to 100³¹.

With regard to the Vereda (*Political and administrative division of the municipality located in the rural area*) of the municipality of Granada, which is located in the project influence area, Quebradona Abajo and Las Faldas, belonging to the basin San Matías³², the population ranges are the most representative between 5 to 14 and 15 to 44 years, i.e., the growing population, of working age and reproductive stage.

It is important to bear in mind that in Granada are evident the aftermath of the armed conflict, which is reflected in the decrease of the population. According to data of the Development Plan of the Municipality, 2008-2011, *“it is estimated that in the years of the conflict, the population decreased by 64% and that in Granada are now living only 9,800 inhabitants. Granada has a birth rate of 13.69 per 1,000 inhabitants and the mortality rate for 2003 was 10.73 per 1,000 inhabitants however for the past three years this rate is lower due to the municipality breathes an atmosphere of tranquility, improving”*³³.

³¹ Scheme of Territorial Order, 2000. Although during the field work were only found 8 children

³² In the participatory planning process undertaken since the late 90s, Granada community conducted a territorial subdivision which was given the name of Cuenca, for this purpose were identified five basins in the following manner: Basin San Matias, Cuenca Calderas, Cuenca Tafetanes, Cuenca Santa Ana and Cuenca Zona Fría, this last one makes part part of the Urban Area of the municipality, to each one of the cuencas belong several Vereda (Political and administrative division of the municipality located in the rural area)s. Taken from Development Plan of the municipality of Granada, 2008-2011. (Taken from EOT of Granada, 2000)

³³ Development Plan of the municipality of Granada, 2008-2011.

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On the other hand, according to data from the Statistical Yearbook of Antioquia, 2009, the intercensal growth rate of Cocorná and Granada, during the period between 1993 and 2005, was -3, 58 and -5, 43 respectively. According to the Scheme of Management of the municipality of Granada, this negative growth in the population denotes " *The lack of sources of employment, coffee crisis, few incentives of the Government toward the Agro, social phenomena such as violence, lack of education in applicable areas, outside paradigms of that create false expectations especially in the young, high agricultural production costs, marketing difficulties* " ³⁴ .

- Economically active population-PEA-

While the economically active population (EAP) is the portion of the total population that has a stake in the economic production of a country or municipality, for statistical purposes is taken as PEA to those over a certain age, for example 15 years, excluding the retirees, pensioners, housewives and students. This indicator, contrasting with the economically inactive population, facilitates understanding the size of the labor force in direct relation with the age.

In accordance with the Scheme of territorial order of the Municipality of Cocorná, "The age groups between 25 and 69 years of the male population, in its majority, is economically active, almost all of them are occupied. Between the 20 and 24 years is seen a proportion of men in the header which is not occupied, a young population that is not being incorporated into the labor market; the proportion that is found prior to the 20 years is not so relevant given that is associated with population that is in secondary school (by which are considered economically inactive) but it should be a concern about their occupations and future working conditions.

With respect to the men of the rural area from 15 to 64 years we find almost the total of the economically active population occupied, associated especially to rural activities that welcome the majority of labor force in the field. From the age of 15 there is virtually no economically inactive population, in comparison with the bedside, which reveals a population of adolescents that from an early age are incorporated into productive activities.

As for the female population, there is an important proportion of economically inactive females given that domestic activities are not considered paid work that need to be referred to in the category of economically active. In the rural area there is a subtle presence between the 15 and 29 years who could be people associated with activities for community promotion or positions of management of public administration, also people linked to the commercial sector of the rural area that is crossed by the Medellin - Bogota Highway, but mostly we could talk about women enrolled in work of the domestic type. The opposite occurs at the bedside where almost up to the age of 49 years presents a female population that earns wages from activities performed in the commercial sector, services or public administration " ³⁵ .

In relation to the Vereda (Political and administrative division of the municipality located in the rural area) of the influence area of the municipality of Cocorná, La Inmaculada, San Lorenzo, Campo Alegre, El Choco, El Molino, San Juan and Los Mangos, in

³⁴ Scheme of territorial order of the municipality of Granada, 2000.

³⁵ Scheme of Territorial order of the Municipality of Cocorná, 2000.

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correspondence with the modus vivendi and the production mode, the young people and children are incorporated into the economic activities as labor force family; some do it alternately with their attendance at school or college and others do it as the only alternative to the lack of opportunities. On the other hand, adult men over 65 years, still perform field labors, since they are heads of household.

With regard to the municipality of Granada, the largest number of population is concentrated in the ages of 10 to 14 and 15 to 19, being in the second group a portion of the economically active population of the municipality. " To which *the system should respond with policies and strategies for the protection and promotion of their skills in all the senses; full enjoyment of their rights related to the physical and social spaces for participation, the practice of sport, art, the opportunities for resource generation and other; in an attempt to halt the migration trend, expressed [...] and the productive energy serve to the development of the municipality and the consolidation of integral developments for all individuals*". ³⁶

For its part, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas and Quebradona Abajo of Granada, the population of the 15 to 59 years represents the 58.69 %, i.e. more than half of the population, added for these two Veredas (*Political and administrative division of the municipality located in the rural area*), is located in the statistical range considered as PEA.

- Settlement Pattern

In Cocorná, in accordance with the outline of the Legal Municipality, "*The vastness of the territory, forests, steep topography, the absence of considerable holdings of gold, and marginality compared to roads passing through the territory of the municipality from the plateau to the Magdalena framework the pattern of a settlement that, in general terms, has been scattered*"³⁷.

This model in the pattern of settlement predominates in the rural area, where the houses are located so distant from each other, with the exception of part of the Vereda (*Political and administrative division of the municipality located in the rural area*) San Juan, El Choco, El Molino and Campo Alegre, that have homes located in a linear form at both sides of the walkable stub, or of the road that leads to Campo Alegre from El Chocó, where there is a Vereda (*Political and administrative division of the municipality located in the rural area*) or Vereda (*Political and administrative division of the municipality located in the rural area*) center, as well as in the central area of El Molino, where the college, some business and sports infrastructure are located (see Photo 3-55).

³⁶ Scheme of territorial order of the municipality of Granada. Revision. S. m.d.

³⁷ SCHEME OF TERRITORIAL ORDER FORESTS SUBREGION . Covenant Idea -UN - Municipality. DIAGNOSTIC

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Photo 3-55. Vereda (Political and administrative division of the municipality located in the rural area) El Molino nucleated houses at the edge of the branch road.

Source. Field work conducted in November 2011

“Some Vereda (Political and administrative division of the municipality located in the rural area) that are positioned as major centers of its activity and territorial influence are the Vereda (Political and administrative division of the municipality located in the rural area) El Molino and La Piñuela, with more than 500 inhabitants and with acceptable physical and social infrastructure. Have shown a steady growth and shaping a nucleated Vereda (Political and administrative division of the municipality located in the rural area) center in its main populated center”³⁸.

For its part, in the municipality of Granada, the initial conditions of the colonization and settlement, demarcated a dispersed settlement pattern, with a sector in the rural area that operates as a center Vereda (Political and administrative division of the municipality located in the rural area), with an important nucleation. In the Vereda (Political and administrative division of the municipality located in the rural area) in the municipality of Granada that make part of the area of influence, also shows a pattern of dispersed settlement or semi disperse (see Photo 3-56 and Photo 3-58)

³⁸ SCHEME OF TERRITORIAL ORDER FORESTS SUBREGION Covenant Idea - UN - Municipality. DIAGNOSTIC

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Photo 3-56. Garrucha leads toward the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo (dwellings in the background) and the foothills of the municipality of Granada.
Source: field work carried out during February 2012



Photo 3-57. Housing on the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas.
Source: field work conducted in February 2012

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Photo 3-58. Housing at the edge of the road on the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas

Source: field work conducted in February 2012

3.4.2 SPATIAL DIMENSION

3.4.2.1 Area of indirect influence

- **Public Services**

The urban centers of both Cocorná and Granada, have a high percentage in public services coverage (see Photo 3-59); in contrast, in the rural area, the coverage is much lower, which is explained by homes dispersion, which makes it difficult to gain access to the collective services and equipment from the Vereda (*Political and administrative division of the municipality located in the rural area*)s, as explained in the Environmental Assessment of the alternatives (DAA) of hydroelectric development of San Matias River - El Molino ³⁹.

³⁹ Environmental Assessment of the alternatives of the hydroelectric development of San Matias River - El Molino SAG S.A. Itagüí, 2009.

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Photo 3-59. Main Park Cocorná

This phenomenon is known in all the services analyzed, except for the electric power, where the difference between bedside and the rest is not as significant, as can be seen in Table 3-106 .

Table 3-106. Homes with energy service availability and coverage by subregion, area and municipality

| Subregions and municipalities | Homes with service | | | | |
|-------------------------------|--------------------|--------|---------|------------|------|
| | Number | | | Percentage | |
| | Main town | Rest | Total | Main town | Rest |
| East | 94,820 | 93,653 | 188,474 | 99.4 | 94 |
| Reservoirs | 14,377 | 17,720 | 32,096 | 99 | 94 |
| Granada | 2,688 | 5,097 | 7,784 | 98.8 | 88 |
| Forests | 4,237 | 8,348 | 12,584 | 99 | 77 |
| Cocorná | 1,811 | 4,609 | 6,420 | 99.5 | 83 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

In what has to do with the potable water service, the two municipalities show very low percentages of coverage in the rural areas, even compared with the average of the east subregion (see Table 3-107); in this sense highlights the case of Granada, where the difference is almost 600 %, even when their percentage of coverage is higher than the average of the forest area. As for the percentage of Cocorná, this is a little higher than Granada, although significantly lower than the average in the area of reservoirs.

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Table 3-107. Homes with drinking water availability and coverage by subregion, area and municipality

| Subregions and municipalities | Main town | | Rest | |
|-------------------------------|-----------|------|--------|------|
| | Number | % | Number | % |
| East | 92,391 | 96.9 | 17,128 | 17.1 |
| Reservoirs | 14,391 | 99 | 1,624 | 16.1 |
| Granada | 2,699 | 99.2 | 474 | 8.2 |
| Forests | 4,177 | 97.9 | 161 | 0.96 |
| Cocorná | 1,798 | 98.8 | 161 | 2.9 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

The amount of residential phones is notoriously low: in Cocorná there were 615 and 733 in Granada in the residential sector (see Table 3-108).

Table 3-108. Number of telephone subscribers by subregion, area and municipality

| Subregion / municipality | Number of Subscribers | | | | | Public telephones | Wireless Lines | Arrays | Internet |
|--------------------------|-----------------------|------------|------------|-------|---------|-------------------|----------------|--------|----------|
| | Residential | Industrial | Commercial | Other | Total | | | | |
| East | 95,402 | 594 | 13,013 | 2,409 | 111,419 | 1,089 | 178 | 89 | 21,865 |
| Reservoirs | 5644 | 0 | 634 | 273 | 6551 | | | | |
| Granada | 733 | 0 | 53 | 43 | 829 | 21 | 10 | 6 | 147 |
| Forests | 1507 | 0 | 139 | 111 | 1757 | 48 | 42 | 16 | 456 |
| Cocorná | 615 | 0 | 76 | 45 | 736 | 31 | 11 | 7 | 149 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

In what has to do with the sewerage service, the percentages in the urban area of both municipalities are close to 100 %, similar to those in the east as a whole and to the areas of both reservoirs as of forests (see Table 3-109). In rural areas, the percentages of both municipalities are significantly low, even with respect to the East percentage, already low. In fact, the difference between the coverage in Granada and in the east is higher than 200% and in the case of Cocorná, higher than 300 %. In turn, when comparing Granada with the zone of reservoirs, it is found that the difference is greater than 100 %, and to compare Cocorná with the area of forests, the difference is more than 200 %.

However, if the data is analyzed about solid waste collection, it is noted that in Cocorná and Granada the coverage is lower than in the subregion and the forests area (see Table 3-110).

Table 3-109. Homes with sewerage service by subregion, area and municipality

| Subregions, regions and municipalities | Main town | | Rest | |
|--|-----------|------|--------|------|
| | Number | % | Number | % |
| East | 93,781 | 98.3 | 17,644 | 17.7 |
| Reservoirs | 14,283 | 97.9 | 2,378 | 12.4 |
| Granada | 2,685 | 98.7 | 322 | 5.6 |
| Forests | 4,160 | 97.5 | 1,068 | 12.5 |
| Cocorná | 1,800 | 98.9 | 222 | 4 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

Table 3-110. Homes with solid waste service collection and coverage by municipality

| Subregion, areas, municipalities | Number of homes with service | | | Percentage | | |
|----------------------------------|------------------------------|-----------|------|------------|-----------|------|
| | Total | Main town | Rest | Total | Main town | Rest |

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| Subregion, areas, municipalities | Number of homes with service | | | Percentage | | |
|----------------------------------|------------------------------|-----------|--------|------------|-----------|------|
| | Total | Main town | Rest | Total | Main town | Rest |
| East | 120,776 | 94,511 | 26,265 | 61.8 | 99.1 | 26.3 |
| Reservoirs | 16,199 | 14,476 | 1723 | 51.4 | 99.6 | 11 |
| Granada | 3,015 | 2,721 | 295 | 35.5 | 100 | 5.1 |
| Forests | 4,661 | 4,184 | 479 | 32.2 | 97.9 | 5.1 |
| Cocorná | 1,895 | 1,820 | 75 | 25.7 | 100 | 1.3 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

In the municipality of Cocorná, on the other hand, there is not a suitable site for waste disposal. The area of the Sanitary Landfill is approximately 1.5 hectares, and has a projected useful life of 24 years, which expires in 2013 (1989 - 2013) and in addition, its capacity has decreased by various causes among which are the poor compaction and absence of complementary facilities and coexistence by the municipal slaughterhouse, which has as an additional area a wastewater treatment plant, that discharge there the sludge produced in the tank. Complementing this panorama is located the problem of the plaza of fairs, which was built in an area belonging to the sanitary landfill.

In regard to Granada, the final disposal of solid waste in the landfill, which is already in their closure plan monitored by CORNARE; the site, among other things, has a bio-compost heap for the management of organic material. The municipality bought a batch of 12.5 has where in the future will be the final disposal⁴⁰ site.

It should be noted that in Cocorná, allegedly the DAA the hydroelectric development of the San Matias River - El Molino, with the purpose of advancing a coordinated action that impacts the difficult conditions under which are a large part of the rural population, in terms of coverage and public services quality, there have been agreed programs aimed at the coverage expansion in aqueducts, septic tanks, electrification and solid waste management. In the urban area the work is oriented toward achieving full coverage in potable water, sewerage, toilet and electricity and to provide tools to communities through socialization campaigns on the efficient and rational use of natural resources.

One of the efforts agreed upon is the strengthening of the public services company, so the Development Plan speaks of including programs aimed at the expansion of the installed capacity and the human resource, to achieve an efficient service provision and that it would result in social benefits.

In the municipality of Granada, on the other hand, the energy service is provided by public enterprises of Medellín, and the water supply and Sewerage Company by the Public Services of the municipality of Granada E. S. P. G, which also serves the toilet facilities in the rural area and the two population centers, Santa Ana and Los Medios.

All the Granada Veredas (*Political and administrative division of the municipality located in the rural area*) have aqueduct, but only three have water treatment (Las Palmas, Los Medios and Vahitos), although currently are not operating properly. There are no data on the water quality of the rural water supply systems, but the majority of the sources are contaminated with manure from livestock and human, agrochemicals and garbage, which results in not suitable water for human consumption. On the other hand, the administrators

⁴⁰ Development Plan of Grenada. Op cit. 77

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of aqueducts are not properly organized, so there is no guarantee for the service delivery and self-sustainability.

Protrudes the fact that the Vereda (*Political and administrative division of the municipality located in the rural area*) of Santa Ana has sewerage networks in good condition and waste water treatment plant. On the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Medios at the same time, there are some sewage networks, but there is no proper disposal.

The basic sanitation coverage in rural areas is very low, and only 5.6 % of dwellings count with a septic tank suitable for wastewater disposal.

In regard to the communication service in the rural zone of the study area, this is provided through cell phones.

- Health Services

The municipality of Cocorná account with an infrastructure that in general terms offers good access to the services; the population enjoys all the basic amenities of a first level of complexity, within the most important are: emergency care, hospitalization, outpatient clinics, special programs, x-rays, obstetric ultra sonography, pharmacy, clinical laboratory and dentistry.

The municipality has six health posts in the rural area⁴¹, all of which had endowment and basic staff for the attention of both emergency and special programs, as on health promotion and prevention. Each health post has been defined as a focus of attention that gives coverage to approximately 10 Veredas (*Political and administrative division of the municipality located in the rural area*); however, it is important to note that these are not outlined in the Statistical Yearbook of Antioquia.

Finally, the rural promoters supported work in the education field and health promotion and prevention in nearly 24 Veredas (*Political and administrative division of the municipality located in the rural area*). Complementary to this, there is a Primary Health Care program, which was consolidated in the other Vereda (*Political and administrative division of the municipality located in the rural area*) to attend the community on health issues, especially in activities such as promotion and prevention⁴².

The urban area of the municipality of Granada has two IPS, Hospital Father Clemente Giraldo and the medical center of the Social Foundation Coogranada, both in the first level. In addition, it provides its services in the health posts of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Medios and the Vereda (*Political and administrative division of the municipality located in the rural area*) of Santa Ana, as well as the attention services in the health houses and in the extramural brigades. According to data from that institution, the unmet demand is 5%.⁴³

However, in Granada is possible to identify a great ignorance of the communities about the delivery of health services, in particular the top services to the first level of complexity, which is why users do not demand the service. In other cases the absence of demand has to do

⁴¹ DAA Los Molinos. Op cit, 2009

⁴² Municipality of Cocorná Op. Cit 2008

⁴³ DAA Los Molinos. Op cit. P.153

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with the difficulties of freedom of movement and with the lack of resources in order to cancel the copayment of the moderator quote as the case may be.⁴⁴

The foregoing is reaffirmed with the points raised in the Development Plan where it is stated that " *the inhabitants of the municipality are suggesting that the Health Provider Institution must expand the services coverage in such a way that the appointments are not for the next day, but to improve in the promptness; they further requested the extension of the extramural programs in order to provide the possibility of a comprehensive health care, quality and timely*⁴⁵ " .

In accordance with the Development Plan, "The *municipality has 5,180 quotas for the subsidized regime, which are not used in an optimal manner due to the permanent displacement of the population, which makes difficult the timely administration of the system. In regard to the contributory scheme is the coverage of 1,017 affiliates; this is considered low, as a result of the few employment sources that are in the municipality, to which is added the poor insurance culture, tax evasion and the affiliation of independent workers. The remaining population, i.e. approximately 2,589 people are part of the linked exchange rate system, which means that your health care is provided by the Municipality*"⁴⁶ .

Although the average of membership in the municipalities of both the area of reservoirs as of the forest area is higher than average in the east, as well as the departmental average, the population in the municipalities of Cocorná and Granada has lowest rates than the East and the respective areas to which they belong, as you can see in Table 3-111 . The 17.2 % of the population of Cocorná and 14.7 % of Granada are not covered by any of the two health care systems, according to the population projections of the DANE for 2009.

Table 3-111. People affiliated with the contributory and subsidized regimes

| Subregion, region, municipality | Projected population for 2009 | Contributory | | Subsidized | | % Total |
|---------------------------------|-------------------------------|--------------|-------------|------------|------|---------|
| | Number | Number | % | Number | % | |
| Department | 5,988,552 | 2,976,316 | 49.7 | 2,505,234 | 41.8 | 91.5 |
| East | 556872 | 234814 | 42.1 | 253054 | 45.4 | 87.5 |
| Reservoirs | 68,523 | 13640 | 19.9 | 46124 | 67.3 | 97.2 |
| Granada | 9,818 | 1261 | 12.8 | 7124 | 72.5 | 85.3 |
| Forests | 31,994 | 4681 | 14.6 | 24747 | 77.3 | 91.9 |
| Cocorná | 15,068 | 1777 | 11.7 | 10876 | 72.1 | 83.8 |

Source: Government of Antioquia, *Statistical Yearbook Administrative Department of Planning 2009*.

- Education Services

Table 3-112 shows students enrolled for the subregion and the municipalities in the project influence area in 2009. Highlights the fact that in Cocorná the number of students in the rural area is greater than in the town center, contrary to what is happening in both the Department and the subregion, as in Granada. Obviously this has to do with the fact that the rural population in Cocorná is greater than the settled population at the bedside.

Table 3-112. Total number of students enrolled at Departmental level, in the subregion and the municipalities of Cocorná and Granada

⁴⁴ Development Plan of the municipality of Granada. Op cit. P. 60

⁴⁵ Ibid.. P. 61

⁴⁶ Ibid. P. 61

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| Municipalities | Area | Total | Preschool | Basic | | Medium Level |
|----------------|-------|-----------|-----------|---------|-----------|--------------|
| | | | | Primary | Secondary | |
| Department | Rural | 337,658 | 29,237 | 200,060 | 85,306 | 23,055 |
| | Urban | 997,218 | 98,950 | 408,413 | 356,793 | 133,062 |
| | Total | 1,334,876 | 128,187 | 608,473 | 442,099 | 156,117 |
| East | Rural | 49,628 | 3,571 | 27591 | 13,997 | 4,469 |
| | Urban | 81,407 | 6,711 | 30,195 | 31,542 | 12,959 |
| | Total | 131,035 | 10,282 | 57,786 | 45,539 | 17,428 |
| Cocorná | Rural | 2,537 | 184 | 1,397 | 810 | 146 |
| | Urban | 1,386 | 64 | 517 | 571 | 234 |
| | Total | 3,923 | 248 | 1,914 | 1,381 | 380 |
| Granada | Rural | 973 | 85 | 710 | 156 | 22 |
| | Urban | 1,290 | 67 | 445 | 624 | 154 |
| | Total | 2,263 | 152 | 1,155 | 780 | 176 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

If we analyze the schooling rates, it is concluded that the behavior is similar to that shown in all the national territory, where the students percentage is decreasing as it progresses in the school cycle. Both in Cocorná as in Granada, the highest students percentage is located in primary, with rates close to 100% (see Table 3-113 and Photo 3-60) this percentage increases at the secondary level in the town center, and begins to decline significantly in the rural area, to finally fall consistently in both areas and in the two municipalities, for higher levels. In this regard, it is necessary to emphasize that Grenada shows a school enrolment rate slightly higher than Cocorná at all levels, except the top two, that is to say high school and undergraduate students.

Table 3-113. Gross enrolment rate in the subregion and the municipalities in the influence area

| Subregion municipality | Preschool | | | Primary | | | Basic secondary | | | Medium | | | Total | | |
|------------------------|-----------|------|------|---------|-------|-------|-----------------|------|------|--------|------|------|-------|----|----|
| | U | R | T | U | R | T | U | R | T | U | R | T | U | R | T |
| East | 111.9 | 74.2 | 95.2 | 101.1 | 113.8 | 106.8 | 113.5 | 69.4 | 93.8 | 83.4 | 42.1 | 65 | 103.1 | 83 | 94 |
| Granada | 84.8 | 86.7 | 85.8 | 106.9 | 136.2 | 121.5 | 179.8 | 36 | 100 | 88.5 | 10 | 44.7 | 127 | 77 | 99 |
| Cocorná | 85.3 | 95.8 | 92.8 | 118.9 | 121.6 | 120.8 | 123.1 | 87.9 | 97.7 | 97.1 | 31.7 | 49.8 | 114.1 | 92 | 98 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009.

Conventions: **U**: Urban; **R**: Rural; **T**: Total

*: The school enrolment rate is more than 100% due to the calculation of school-age population, the extra age and the displacement of the population

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Photo 3-60. Classroom, Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas.

Below are some elements that establish the education quality in the municipality of Granada, as shown by the Municipal Development Plan⁴⁷ :

- In the municipality of Granada, the Institutional Educational Project (PEI), a document that is of mandatory preparation for the Board of Directors of the institutions or educational centers, appears unfinished in most cases; other times there is no or little applicable and in general, we do not have an operational plan to implement it.
- The institutions have Government School, Student Council, Parents' Association (Council of Parents), Spokesperson Student and restaurant board among others. Many work properly, others not so much and other eventually have a null operation.
- In many institutions in addition, the lack of organizational Table, functions manual and procedures, resulting in the inability to take relevant and timely decisions that has to do with the students welfare.
- The institutions do not have a core information system; institutional assessments are a pure formalism and do not have operational actions plans.
- In terms of adults education, it is important to underline that in 2007, began to give the literacy program with the CAFAM methodology in seven rural educational centers, in response to 120 adults.
- The plant teachers, for the year 2008, is composed of 102 teachers and 6 directors, 54 in the rural area and the rest in the urban areas, where 4 managers work in turn the remaining 2 are employed in the rural area.
- All the establishments have the basic services of aqueduct, sewer and power, although in the rural area the water does not have the required conditions of potability and the energy service is poor.
- 10% of the facilities account at the time with a central library and the other 90% with classroom libraries, these in regular conditions and sometimes outdated.

⁴⁷ Development Plan of the Municipality of Cocorná. Op cit. Ps. 63 And 64

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For the municipality of Cocorná, the indicators used in the Development Plan to define the education quality are the following⁴⁸ :

- There is a municipal average of 24.13 students per teacher
- There is a municipal average of 20 students per classroom.
- The 90% of the classrooms are in good condition.
- There are locative deficiencies in classrooms and laboratory in the educational institution "Eva Tulia Quintero of Toro" of Vereda (*Political and administrative division of the municipality located in the rural area*) la Piñuela (rural area).
- Maintenance and adequacy of some rural schools is required
- Inadequate staffing of the teaching and learning materials in the Rural Education Centers.
- The 65% of the teachers are of recent incorporation and scaled according to the Decree 1278 of 2002.
- Currently the town has the Classroom Support, managed by three educators: One for the urban area and two for the rural area.
- Recreation and sports Services

In Cocorná the recreational sector has been abandoned in the last few years; the holiday programs and youth recreational holiday have been set aside, as well as neighborhood integrations, by sector and rural⁴⁹ . The sport gained great prestige and recognition in the department, but with the onslaught of social conflict, much of the athlete population was forced to leave the Vereda (*Political and administrative division of the municipality located in the rural area*), victims of forced displacement.

There are currently two sports clubs legally constituted but without due recognition, they are chess and soccer; there were sixty rural sports plates and there are sixteen to be build; there is a covered Coliseum in good condition, a sports plate in regular conditions; two urban sports plates, one of them in good condition and the other with some deficiencies; a large dimensions soccer field with technical specifications and an auxiliary soccer field; and there are four health clubs, three urban and one rural, with approximately one hundred and twenty adults and older adults.

The recreational part there has been neglected in recent years, leaving aside the holiday programs and youth recreational holiday, as well as integrations by neighborhood and rural sectors.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) are the following sites for recreation and tourism: Main Park Plaza Bolivar, the dynamic center of the municipality for sporting, religious and political activities; La Guayabal, tourist center with a wide variety of flora, cottages and spas, famous for its great natural

⁴⁸ Development Plan of the Municipality of Cocorná. Op cit. P. 24

⁴⁹ EOT Municipality of Cocorná Op. Cit 2000

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beauty; Villa Rubi, spa in the Guayabal creek; El Ocho and La Trinidad, spas in the Cocorná River, area for camping; Pailania and Vega, spas in the Santo Domingo River; El Marmol, between Sancho and Melcocho Rivers, where there are huge rocks of white marble; cascade Hair of Venus; indigenous rocks with inscriptions, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Sinai; José María Córdoba House Museum; puddles El Brujo, Negro and La Gloria; Cascade The plant or The Leap and the Hermit's cave (see Photo 3-61).⁵⁰



(a)Main Park



(b)Tourist Site

Photo 3-61. Leisure and recreation places in the municipality of Cocorná

In regard to Granada, there are limitations to the recreational and cultural practices, such as the lack of resources to the recruitment of technical staff for the promotion of sports, inadequate staffing of sports equipment and the deficit of sports venues⁵¹.

To this picture adds the fact that, according to a basic survey with the communities, the local health authority and the local hospital have been able to identify among the young population of Granada high levels of sedentary lifestyle, degenerative diseases, high levels of alcoholism and bad life habits, postural problems, difficulties in school learning and low rates of mental health.

The most popular sports in the municipality are basketball, football, jogging, volleyball, chess and table tennis. Currently in the municipality are running several programs and activities that directly benefit children, youth, the adult population and the third age, supported by the educational institutions and cooperatives and COOGRANADA COOCREAFAM among others. Such programs include the following:

- Motility enrichment, targeting children.
- Health and physical activity that include, gym and aerobics for the third age, sports seedbeds for young people and adults.

⁵⁰ Government of Antioquia Department Administrative Statistical Yearbook 2007 Planning

⁵¹ Municipality of Granada Op. Cit 2008

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- Local sporting events, in which highlights: Peasant tournaments, internal tournaments, peasant Olympics, festivals, sports tournaments and inter municipal feting, the national granadine games that take place each year.

In the promotion of recreational and cultural practices, highlighting some limitations, such as a lack of resources for the recruitment of technical staff, the promotion of sports and the expansion of coverage, in addition to the insufficient staff implements and the deficit of sports venues⁵².

In this municipality are the following sites for recreation and tourism: Main Park, which has a monument to Father Clemente Giraldo, a booth at the center and flower; Church of Santa Barbara, located in the park of La Variante, parish of the municipality; community farm Tierra Viva, dedicated to nature enjoyment, which has a swimming pool and ecological path; Tafetanes and Calderas Rivers; spa on the San Matias River, natural bath apt for fishing; house of the Father Clemente Giraldo, declared a national monument; subsidiary Temple, located in the main park and chapel since 1821, declared a national monument; birthplace of Jesus Maria Yepez, national monument; and jumping out of the waterfall, with a waterfall of more than 100 m in height, there was the old power plant for the township.

With regard to sports venues, the municipalities of Cocorná and Granada have for their inhabitants some variety with regard to the practice of sport and recreation, as can be seen in the Table 3-114.

Table 3-114. Sports Venues by department, subregion, and municipalities area

| Subregion, area and municipalities | Sports Venues | | | | | | | | Skating | Fitness Center | Athletic Track | Bicicross |
|------------------------------------|---------------|--------------|---------------|----------------------------------|-----------|-------------|-------------|--------------|---------|----------------|----------------|-----------|
| | Soccer Field | Sports Plate | Swimming Pool | Diamond for baseball or softball | Colosseum | Cover Plate | Sport House | Shuffleboard | | | | |
| East | 242 | 1,010 | 40 | 2 | 23 | 43 | 1 | 43 | 5 | 38 | 11 | 11 |
| Reservoirs | 54 | 237 | 6 | 0 | 7 | 3 | 0 | 7 | 0 | 7 | 3 | 3 |
| Granada | 4 | 42 | 1 | 0 | 1 | 2 | 0 | 1 | 0 | 1 | 0 | 0 |
| Forests | 21 | 96 | 3 | 0 | 1 | 6 | 0 | 3 | 0 | 2 | 0 | 0 |
| Cocorná | 11 | 75 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 |

Source: Government of Antioquia, Statistical Yearbook Administrative Department of Planning 2009

- Tracks

The road length of the municipality of Cocorná is 129 km, of which 40 correspond to primary roads, 35 to 53.5 and secondary roads to tertiary roads (see Photo 3-62 and Photo 3-63). One of the most urgent needs of the Vereda (*Political and administrative division of the municipality located in the rural area*) is the opening of new roads and improving existing ones. Emphasizes the Medellin-Bogotá Highway as primary route, therefore integrates Cocorná with the subregion and the department.

⁵² Development Plan of the municipality of Granada. Op cit. P. 67

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Photo 3-62. Track Cocorná-San Juan-EI Choco



Photo 3-63. Invitation for the construction of rails in the track El Choco - El Molino.



Photo 3-64. Opening of the new track from the highway to La Inmaculada, on the part of the EI Popal hydroelectric project



Photo 3-65. Construction of the new bridge over the Cocorná in Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada, on behalf of the EI Popal hydroelectric project .

The municipality also has several minor roads that communicate with others, such as Santuario, Granada and San Francisco and with a tracks network and tertiary roads suitable for light traffic, pedestrian or moveable (mules, especially), which communicate to the Vereda (Political and administrative division of the municipality located in the rural area) between themselves and with the town center. In any case the scarcity of roads, especially in the south of the Santo Domingo River, dramatically affects the economy in general and the development of rural settlements.

Toward the north of the Santo Domingo River, the municipality has a dynamic road system, composed of three access routes to the bedside that ramifies toward a significant number of

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Veredas (*Political and administrative division of the municipality located in the rural area*) and resulted in a series of complementary bridle paths. These are:

- The access road from the highway to the municipal seat, known as "New Stub".
- The access road to the bedside, by Granada road.
- The San Francisco-Cocorna-La Piñuela way.

The sector of Santo Domingo River toward the sth, has a precarious track system. Access to Vereda (*Political and administrative division of the municipality located in the rural area*) El Roblal, Patio Bonito, Santa Rita, La Secreta, San Martin, El Porvenir, La cuchilla del Rejo" Restaurant-bar El Suspiro and Florida among others, should be done by trails, that highlights the abandonment in which they are kept, the poor specifications and high rainfall that makes them muddy⁵³.

Respect to Granada, it is possible to say that there are a total of 123 km of rural roads, in poor condition almost in its entirety. Maintenance is carried out through treats, where with the support of the municipality, the community gathers together and run the required actions, optimizing the scarce resources available. Tracks do not have the sufficient structures along the road, which makes the deterioration progressive and investing in the maintenance, inefficient, but in this also influence the steep slopes, the soil type and climatic conditions, resulting in the increase in travel times and the gradual deterioration of motor vehicles.⁵⁴

- Social Infrastructure

Regarding social services as a slaughterhouse and plaza of fairs, market square and banking institutions, both municipalities have a precarious supply. Granada, specifically, has only one office of the Agrarian Bank, which is shared by all the inhabitants, and it does not have a market square.

Currently, in regard to the cattle slaughter the facilities are not used in a proper way and the sacrificial system of the slaughterhouse is not the appropriated. Nor do they employ the by-products after the use of meat, such as the viscera, blood, skin, hair, legs or some fat meat. In the infrastructure field is needed in addition to adequate the cattle slaughter plant, to comply with the technical specifications required by the INVIMA.

Trade in agricultural products is performed on Friday, Saturday and Sunday on the main square in the case of the tomato, potato, beans, carrots and other; good part of these products are also sold at El Santuario, where the market takes place every day; the marketing of the panela is performed on Saturdays and Sundays in the town center; the horses are sold on Sundays in the main square and the cattle in the fair every Monday. Coffee, in turn, sold in the Coffee Farmers' Cooperative of Antioquia and when it has good quality, is also purchased by individuals, sometimes dry, sometimes green, getting the buyer in the latter case, a value-added with the drying.

⁵³ Plan for the development of Cocorná. Op cit. P. 37

⁵⁴ [Tracks](http://granada-antioquia.gov.co/index.php?option=com_content&view=article&id=82&Itemid=70) http://granada-antioquia.gov.co/index.php?option=com_content&view=article&id=82&Itemid=70

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In the municipality there are also some facilities for the provision of the services of the economic sector, such as the blackberries collection center and the headquarters of peasants services. The first account with modern facilities and locative structural, which includes a cold room and three wine cellars for storage: The second, is the Office of the UMATA, the UGAM, local health management, a computer room, the Breeders' Association and the ASOCOMUNAL auditorium.

In the rural area some Community Action Boards have their own community house, which served in certain cases as a cellar for the inputs of agricultural products.

3.4.2.2 Direct influence area.

The information presented in this numeral is excerpted from the tab Vereda (*Political and administrative division of the municipality located in the rural area*) elaborated for the study, and presented in Annex 10

- Municipality of Cocorná
- La Inmaculada

The educational center of the Vereda (Political and administrative division of the municipality located in the rural area), which also has the only recreational space of the Vereda (Political and administrative division of the municipality located in the rural area), a sports board, has a coverage from primary until the tenth grade of basic secondary (see Photo 3-66). Most end up the bachelor degree, although there are no professionals. According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia, 2006, there is an illiterate person.



Photo 3-66. Computers Hall, school of La Inmaculada

Health services are provided at the Health Center of La Piñuela; there are also brigades once a year. The people are almost in its entirety in the SISBEN, in level 0 or 1, although some are in level 2. The majority have a displaced letter according to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia, 2006, there are five people without any affiliation to health.

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The water supply is from births, where the people capture the water and carry it up to the housing by means of canoes or hoses. The wastewater are discharged into the open field, although according to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia, 2006, there are four houses with septic tank.

The organic waste is used as fertilizer for crops or to feed animals. Traditionally, the plastic was burned, but the Vereda (*Political and administrative division of the municipality located in the rural area*) is recycling, also with the support of HMV - owner of the El Popal hydroelectric project, currently under construction-, to bring it to CORNARE, where there is a program that gives the Vereda (*Political and administrative division of the municipality located in the rural area*) a few points for quantity, which accumulate and by a certain number, given the resources for a children's playground.

The coverage of electric power is almost complete; only three houses, the most recent to enter the Vereda (*Political and administrative division of the municipality located in the rural area*), that is, those which have been inhabited by people of Medellín, do not have the service.

To access the Vereda (*Political and administrative division of the municipality located in the rural area*) two route are used. The first by a royal road which starts in the sector of El Ocho, Vereda (*Political and administrative division of the municipality located in the rural area*) La Aurora, located in the old track which communicated San Francisco with Corcora (see Photo 3-67). The second route is by the sector of La Mañosa in the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo, which had a path that crossed the Cocorná River through a hanging bridge. However, this route varied by the El Popal hydroelectric project, who built a track that joins the sector of Playa Loca of the Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada with the Medellín - Bogotá Highway



Photo 3-67. Road, Vereda (Political and administrative division of the municipality located in the rural area) La Inmaculada.

– San Lorenzo

Since the construction of the Medellín-Bogotá Highway, this artery was formed as a reference to the territoriality of the inhabitants of San Lorenzo, given that transformed the

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mobility. In this way the inhabitants of San Lorenzo are mobilized to El Santuario, Marinilla, Rionegro and Cocorná...

On Saturday, Sunday, Monday and Friday there are two lines of ladder buses that provide the service at a cost of \$3,000 toward the town center of Cocorná; buses that usually cover the path by the highway charged \$12,000 for the fare.

Another reason for mobility is the study, since the young people who want to pursue a bachelor course must translate to La Piñuela, since on the Vereda (*Political and administrative division of the municipality located in the rural area*) there is only one school with grades of 1° to 5° (see Photo 3-68); this transportation service is co-financed by the municipal administration, the Cooperative Pius XII and the parents.



Photo 3-68. School of San Lorenzo.

In the vicinity of San Lorenzo there are two health centers, one in the farm and another in La Piñuela, where its inhabitants go in case they require first aid services. In each health center remains a nurse for two or three days a week, but in case you require medical care of another type, the inhabitants of San Lorenzo visit the Municipality Hospital

In regard to the recreational spaces, the Vereda (*Political and administrative division of the municipality located in the rural area*) account with a soccer field on the ground plate and a sports center, where basketball panels are in very poor condition (see Photo 3-69). Also sometimes carried out brunch tours to a natural spa known as "La Granja".

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Photo 3-69. Sports center, Vereda (Political and administrative division of the municipality located in the rural area) of San Lorenzo.

Counts with the Vereda (Political and administrative division of the municipality located in the rural area) "San Lorenzo" aqueduct, which has 80 users, and is managed by an administration committee which has established as fees for the provision of the service, \$2,000 per month for residential consumption and \$5,000 for commercial establishments. The system consists of a collection, then it goes on to a sand remover tank then to a storage tank and finally is distributed by PVC piping to the houses, but has no treatment.

For the disposal of sewage, only 20 homes have septic tank, the rest of homes pour their waters into open field.

The majority of homes has energy service, supplied by Public Enterprises of Medellin, only 15 homes are not connected, some of them because they are located in the low part of the Vereda (Political and administrative division of the municipality located in the rural area), near the river, where four years ago there were two events of MAP, and it has not been carried out the interconnection work.

Solid wastes are collected by a dump truck every 15 days on the highway, which is transferred by the people close to the track. In the dwellings away from the same, people bury or burn trash. It is also necessary to mention the existence of an ecological group that performs collection days of organic waste, which are deposited in a hollow; other people re-use organic wastes as fertilizer in home gardens.

- Vereda (Political and administrative division of the municipality located in the rural area) El Molino

To access this Vereda (Political and administrative division of the municipality located in the rural area), using the secondary route that connects the municipalities of Cocorná and Granada, and in center town of Vereda (Political and administrative division of the municipality located in the rural area) El Choco, follows a walkable road toward the Vereda (Political and administrative division of the municipality located in the rural area).

The educational center of the Vereda (Political and administrative division of the municipality located in the rural area) has until ninth grade, with 35 children in primary, 35 secondary and

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12 children in preschool (see Photo 3-70), which has a multifunctional court, and a playground. According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia of 2006, there are 9 people who were illiterate.



Photo 3-70. Rural education center El Molino

The health service is provided at the Health Center of Campo Alegre, about 30 minutes walk away, although there are brigades each month. Since the people can come in ambulance if necessary. According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia of 2006, there are 64 people with no affiliation to health; however, the majority of the people is in the Sisben.

The only public service that is provided in all the Vereda (Political and administrative division of the municipality located in the rural area), with good conditions, is the electricity service. With regard to the aqueduct service, there is one multi- Vereda (Political and administrative division of the municipality located in the rural area), El Choco-Las Playas-El Molino, which covers nine families of the Vereda (Political and administrative division of the municipality located in the rural area), although according to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia in 2006, are 6 (see Photo 3-71 and Photo 3-72); those who are not covered, living in the lower part, from the Vereda (Political and administrative division of the municipality located in the rural area)s, which use existing birth in its sector. It is projecting a treatment plant with the help of Social Action (see Photo 3-73).



Photo 3-71. Washing clothes, Vereda



Photo 3-72. Stone to grind laundry, Vereda

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(Political and administrative division of the municipality located in the rural area) El Molino

(Political and administrative division of the municipality located in the rural area) La Inmaculada



Photo 3-73. Project for the improvement of the aqueduct of the Vereda (Political and administrative division of the municipality located in the rural area) multi-Vereda (Political and administrative division of the municipality located in the rural area) El Chocó, El Molino and Campo Alegre.

For the disposal of the waste water, there are only 11 families with connection to septic tank, according to the Vereda (Political and administrative division of the municipality located in the rural area) Atlas of Antioquia in 2006, the rest is discharge in open-pit.

The organic waste is used to fertilize the land or for animal food; plastic burning and the rest is buried.

- Vereda (Political and administrative division of the municipality located in the rural area) San Juan

The access road to this Vereda (Political and administrative division of the municipality located in the rural area) is the one that joins to the headers of Cocorná and Granada, which is in poor condition; for the displacement of the population, there is a ladder bus that covers the route three times a day. The main causes of displacement are the study (young people who are currently enrolled in the bachelor's degree in the center of the town), the request for medical services and the supply of basic family products.

The CER of the Vereda (Political and administrative division of the municipality located in the rural area), account with 27 pupils and 1 teacher, has implemented the modality of new school, guidance to students in grades from kindergarten up to 5 °. Account with five computers, internet service and school restaurant service. Its facilities have some problems such as humidity and patios in poor condition. In addition, the Vereda (Political and administrative division of the municipality located in the rural area) does not count with recreational spaces since the playground sank.

The inhabitants of the Vereda (Political and administrative division of the municipality located in the rural area) of San Juan are attached in its majority to subsidized health care in levels 1 and 2, and are attended by ECOOPSOS and COMFAMA; however, the population expresses that there is bad attention by these entities and that the POS is insufficient.

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Like on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, on the Vereda (*Political and administrative division of the municipality located in the rural area*) El San Juan, the public service with best quality is electricity, which is provided by public enterprises of Medellin.

The water supply is done via a multi Vereda (*Political and administrative division of the municipality located in the rural area*) aqueduct which brings together three Vereda (*Political and administrative division of the municipality located in the rural area*) of zonal center: San Juan, La Peña, Montañita and La Arboleda, which has a Board for administering the Aqueduct and whose minimum rate is \$4,000 per month. This aqueduct account with a water inlet from where they pass through the water to storage tanks, to be later distributed by PVC piping, without any type of treatment.

For the disposal of wastewater, eight homes have septic tank, which were built by a covenant between CORNARE and the Municipal Administration; others have sump and the rest lead the liquid waste by pipes to open field.

The inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Juan used the organic waste as a fertilizer or as food for animals. Inorganic waste are buried, and a family takes the trash up to the town center of the municipality.

- Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco

Like the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Juan, the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco used the road that connects the headwaters of the municipalities of Cocorná and Granada. The inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) leave to do paperwork in the Vereda (*Political and administrative division of the municipality located in the rural area*), or for medical care; in addition the weekends are mobilized to market in the urban centers of Cocorná and Granada, and usually on Fridays and Saturday the production of panela is carried toward the urban center of Cocorná. The cost of the fare to Cocorná is \$ 2,000 and up to Granada is \$ 2,500.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a school with grades from 1° to 5° of primary, which is headed by a professor who guides 30 students; high school is completed in the urban center of the town. This school has a physical plant in good condition, to which recently were added another lounge (see Photo 3-74); also account with the service of school restaurant, kitchen and a small sports plate center in the school that as a recreational space is completed with a soccer field existing in the Vereda (*Political and administrative division of the municipality located in the rural area*).

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Photo 3-74. Project for the improvement of the school of the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Chocó

The majority of inhabitants are affiliated to the subsidized regime in the level 1 and come to the hospital of the municipality of Cocorná in case of illness.

The energy service is in all the dwellings of the Vereda (*Political and administrative division of the municipality located in the rural area*) for water supply, the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco has a multi Vereda (*Political and administrative division of the municipality located in the rural area*) aqueduct, the same that supplies the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, which consists of a water inlet with sand remover and storage tank, and has no treatment. There is an Administrative Board for the aqueduct and there is a plumber who is responsible for the maintenance.

For the layout of the wasted waters, about 50% of homes use septic tanks, the rest do the discharges at open pit.

The organic wastes are used as a fertilizer or are reused in feeding animals, others are recycled and the rest are buried.

- Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre

Access to this Vereda (*Political and administrative division of the municipality located in the rural area*) is performed through a branch that can be seen from the road which connects the municipalities of Cocorná and Granada, and goes first to the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino. The inhabitants move along the track, to reach the town of Cocorná to sell their products to the people, to receive the service provider, or go to mass, among other activities.

The Vereda (*Political and administrative division of the municipality located in the rural area*) has a Rural Education Center, the CER of Campo Alegre, which is attached to the new school methodology; account with the degrees from first to fifth, and in addition is home for 18 students from pre-school; after completing primary school, the students make their high school in El Molino. Within infrastructure, the school has two courts, found in poor condition,

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and a kitchen (see Photo 3-75 up to Photo 3-77). According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia - 2006, there are four illiterate people on the Vereda (Political and administrative division of the municipality located in the rural area).



Photo 3-75. Court in the school of Campo Alegre



Photo 3-76. Sports center, school of Campo Alegre.



Photo 3-77 Kitchen of the school restaurant

There is the construction of a health center, which is unattended, so that the population, which are affiliated to the Sisben, in levels 0, 1 and 2, must go to the hospital town of Cocorná Hospital. In addition, on a quarterly basis, the health center brigades are made. According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia - 2006, there were 23 people not affiliated to social security.

The water supply is performed through the multi Vereda (*Political and administrative division of the municipality located in the rural area*) aqueduct of the Vereda (*Political and*

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administrative division of the municipality located in the rural area) El Choco - El Molino and Campo Alegre, although it does not have a total coverage of the Vereda (Political and administrative division of the municipality located in the rural area)s; the people who do not have the service, are stocked in births close to their homes.

In the majority of houses, the disposal of the wastewater is performed to open pit. In regard to the disposal of the wastes, the organic are used to feed the animals and the rest is either burned or thrown to surface.

The Vereda (*Political and administrative division of the municipality located in the rural area*) was the recipient of the Antioquia Illuminated program, which came to a very high coverage, although not 100%

- Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos

This Vereda (*Political and administrative division of the municipality located in the rural area*) is the only one in the influence area of the El Molino hydroelectric project that does not have a walkable road that penetrate to the Vereda (Political and administrative division of the municipality located in the rural area). To access there are two routes: one by the area of the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, where they arrive using the access road to the Vereda (Political and administrative division of the municipality located in the rural area), and then followed by a bridle path. The second route is using the track that from the town of Cocorná communicates with the sector El Ocho -Vereda (*Political and administrative division of the municipality located in the rural area*) la Aurora, old track which communicated Cocorná with San Francisco, from where it continues through a royal path. The population of this Vereda (*Political and administrative division of the municipality located in the rural area*) moves until Cocorná to study, to sell their products as panela or banana and at Mass on Sundays (see Photo 3-78 and Photo 3-79).



Photo 3-78. Inside of a home on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los



Photo 3-79. Home of the president of the JAC, Vereda (*Political and administrative division of the municipality located in the*

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Mangos

rural area) Los Mangos

The Los Mangos school, which has the only recreation infrastructure in the Vereda (Political and administrative division of the municipality located in the rural area), has up to fifth grade; the population that continue studying moves up to the CER of the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino or to the municipal seat.

For health care, the inhabitants, which are affiliated to the Sisben, will find the health center of town, or use the health brigades that are performed in the Health center of the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre

The public services of this Vereda (*Political and administrative division of the municipality located in the rural area*) can be considered as one of the most deficient of the project influence area. Does not account with an aqueduct, and that is why the population's water supply is obtained from births, which is transported to the housing by means of pipes. Wastewater is disposed at open sky, like the solid waste, although the latter, the plastics are burned and the organic are used to feed animals. The only public service that has high coverage is energy, which is provided by public enterprises of Medellin, and presents a coverage close to 100 %.

- Granada
- Quebradona Abajo

To access this Vereda (Political and administrative division of the municipality located in the rural area), is used an unpaved road, which connects Vereda (Political and administrative division of the municipality located in the rural area)Quebradona Abajo-Las Faldas-El Libertador-La Selva and Galilea, with the head of the municipality of Granada. Previously there was a bridge over the San Matias River, which communicated Quebradona Abajo with the Vereda (*Political and administrative division of the municipality located in the rural area*) La Playa of Cocornay as well, with the route that linked to the municipal centers of the municipalities of Granada and Cocorná, path that was the most used by the inhabitants of this Vereda (Political and administrative division of the municipality located in the rural area); however, the bridge had been washed away by a crescent, staying without communication with the road mentioned above; at this point, they are using an artisanal bridge, adapted by the community..

The school, has within its space a sports board, only space for recreation in the Vereda (Political and administrative division of the municipality located in the rural area), has up to fifth grade, and it also operates a day care center that serves between 12 and 15 children. It has taken the form of new school, and account as part of their equipment, with four computers. For the secondary levels, the students must move toward the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas, Quebradona Arriba or to the municipal seat on weekends. According to the Vereda (*Political and administrative division of the municipality located in the rural area*) Atlas of Antioquia - 2006, live in Quebradona Abajo three illiterate people.

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The health center does not work, as it is situated in an area of high risk for flooding of the San Matias River. Then, for health care, population, which are affiliated to the Sisben, go to the municipal seat, or take advantage of the monthly visits of the promotor.

For the water supply, there are in the Vereda (*Political and administrative division of the municipality located in the rural area*) two aqueducts, each one with its administrative board and both need to be improved.

The provision of waste water and solid waste are open-pit, although some of the waste is buried or burned, and the organic are used as fertilizer.

The coverage of the energy service is 100 %, only public service of good quality, and which is provided by public enterprises of Medellin. .

- Las Faldas

The inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas who need to go to the municipal seat of Granada for medical care, market or sell their products (unrefined sugar, coffee, bananas, cassava, beans, among others), use the same road that communicates to the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo with the town, and use a ladder bus, which has a fare cost of \$5,000 .

On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a school, which has a sports center plate, two professors, one for primary and one in high school, and offers primary education from first to fifth, and bachelor from sixth to ninth; to continue their studies, the young people must travel to the urban center of the town.

All the inhabitants of Las Faldas are affiliated to the subsidized regime in levels 0, 1 and 2. In case you require medical care, people translate up to the health house of Galilea, or when the disease is considered serious, until the Granada Hospital

For the water supply the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) have an aqueduct, which consists of a water inlet and eight storage tanks, from where they are distributed to the houses by PVC line.

For the disposal of the wastewater, most homes use septic tank; the rest is done in open pit, which, together with the poor disposal of solid waste, are thrown into the gullies and ditches of the track, deteriorating the environment quality. Clarifies that the organic wastes are used as a fertilizer or food for animals

3.4.3 ECONOMIC DIMENSION

3.4.3.1 Area of indirect influence

It is important to remember that the two municipalities that are part of the influence area, Cocorná and Granada, are part of two of the areas in which the eastern subregion of the department divided, for planning purposes and characterization of the territory. In this case, it picks up such subdivision to have an overview of the economic dynamics in the indirect influence area

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“Reservoirs or Water Areas: are the municipalities of El Penol, Guatapé, San Carlos, San Rafael, Grenada, Concepcion and Alejandria. Their dynamics have undergone severe changes product of the dams construction, the more suitable agricultural land to produce were flooded, declined the agricultural activity type smallholdings farmer and to a large extent began to rely on tourism as a main activity, although with recession in the last five years by the armed conflict. In the reservoirs areas are located the flood lands for hydroelectric generation from the national grid. With medium thermal floors in its majority, and with a certain percentage of warm and cold floors, is the second most densely populated area of the subregion with 54.22 per cent inhabitants per square kilometer.

Forest area: Are formed by the municipalities of San Luis, Cocorná and San Francisco. It is a rich area in natural resources like the previous one, which combine the peasant and extractive activities of the forest with the informal trade around the road axis of the Medellín-Bogotá Highway This last activity like the rest of its dynamic has been seriously affected as a result of the military confrontation that in recent years has had the area as scenario " ⁵⁵ .

- Structure of the property.

In eastern Antioquia the ownership structure has changed in the last few decades, because of the increase in urban phenomenon with the construction of housing projects, which may be associated with the metropolization of Medellín as well, tourism is another of the elements that contributes to this change, as some people acquire small plots for the construction of recreation houses or second homes. With this, the evidence suggests an increase of the smallholdings, “which is reflected in the deconcentration of rural property, between 1996 and 2004, there were a greater number of owners with small farms”⁵⁶. In Table 3-115 you can appreciate the ownership structure in eastern Antioquia, in the period from 1996 to 2004.

Table 3-115. Structure of the rural property in eastern Antioquia 1996-2004 (%)

| Range in has | Owners | | Land Area | |
|----------------|------------|------------|------------|------------|
| | 1996 | 2004 | 1996 | 2004 |
| Between 0-20 | 93.7 | 93.9 | 45 | 40.3 |
| Between 20-100 | 5.7 | 5.4 | 36.1 | 33.9 |
| More than 100 | 0.6 | 0.7 | 18.8 | 25.9 |
| Total | 100 | 100 | 100 | 100 |

Source: Gaviria, Carlos Felipe; Munoz, Juan Carlos forced displacement and land ownership in Antioquia, 1996-2004. Readings of Economy -lect. Econ. - No. 66. Medellín, July-December 2007. Available at: <http://redalyc.uaemex.mx/src/inicio/ArtPdfRed.jsp?iCve=155217335001>

– Municipality of Cocorná

In the municipality of Cocorná, as a particular feature in the structure of the property, there is a splitting of the high ground and the greater part of the rural population is located in small production units. The trend observed is the segmentation in areas increasingly small.

According to the scheme of Territorial Organization from the subregion forests, " [...] *With respect to rural areas, the possession of the land is characterized by the preponderance of*

⁵⁵ Government of Antioquia- Administrative Planning Department Subregional Profile of Eastern Antioquia

⁵⁶ Gaviria, Carlos Felipe; Munoz, Juan Carlos forced displacement and land ownership in Antioquia, 1996-2004. Readings of Economy -lect. Econ. - No. 66. Medellín, July-December 2007. Available at: <http://redalyc.uaemex.mx/src/inicio/ArtPdfRed.jsp?iCve=155217335001>

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*smallholdings, there are no landlords. In 78 Vereda (Political and administrative division of the municipality located in the rural area) it is estimated that all farmers have land to work in productive units, which is considered an advantage; in this area some of the most notorious problems are: low profitability of the crops, poor quality of the housing and gaps in basic sanitation*⁵⁷. In Table 3-116 can be seen the tenure and the size of the plots of Cocorná, according to data from the Territorial Plan of Public Health of the municipality 2008-2011.

Table 3-116. Land Tenure in the Municipality of Cocorná

| Type | Percentage |
|---------------|------------|
| Owners | 80% |
| Sharecroppers | 5% |
| Tenants | 5% |
| Successions | 5% |
| Leisure | ----- |
| Other | 5% |

Source: Municipality of Cocorná. Local Health Address, Territorial Plan of Health. S. m.d

As can be seen in Table 3-117, in Cocorná the highest percentage of farms corresponds to those who are from 10 to 20 ha with 70 %, followed by those between 5 - 10 has. At the same time, it can be seen that the large farms of more than 50 has represent a minimum percentage, which confirms the high splitting of the ground of the Vereda (Political and administrative division of the municipality located in the rural area).

Table 3-117. Size of the land in the municipality of Cocorná

| Extension of the premises | Percentage |
|---------------------------|------------|
| Less than 5 has. | 5% |
| 5 - 10 hectares | 15% |
| 10 - 20 hectares | 70% |
| 20 - 50 hectares | 5% |
| More than 50 hectares | 5% |

Source: Source: Municipality of Cocorná. Local Health Address, Territorial Plan of Health. S. m.d

– Municipality of Granada

The situation of the structure of ownership in the municipality of Granada is not very clear; in sources consulted as the outline of Land Use and Development Plan of the municipality does not provide specific details in this regard. The only reference that is in the Scheme of Territorial order, asserts that in the municipality there is “High land fragmentation and lack of legalization of farms. In the municipality of Granada there is a high percentage of sites between 0 and 3 hectares, as well as a large percentage of sites without legalization, this is due to the fact that the lots are in a constant process of division since the majority are being ever more limited, due to the fact that many of these sites are obtained by inheritance, which is why a high percentage of the population is not concerned about to legalize their

⁵⁷ Scheme Management of Forests in the subregion. S. m.d.

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farms; as a result, this produces a steadily widening of the agricultural frontier and the intensive use of the soil, which is detrimental to the natural resources " ⁵⁸ .

As problematic elements are mentioned: the percent of sites between 0 ha and 3 ha is equivalent to 76.66 %, and only 45.10 % of sites are legalized; the remaining percentage face unresolved processes and there is an increase in the recreational farms.

- Productive and technological processes

“At present, the Eastern Antioquia is seat of numerous companies, is considered the agricultural pantry of the department and neighboring areas, national example in environmental affairs and tourism has a potential of some importance. In addition, account with the infrastructure, already mentioned, such as: Medellin -Bogota Highway, the airport Jose Maria Cordova, the enterprise settlement (industrial corridors), the free zone, the race track and, more recently, the development of the road plan, the technological park of Antioquia and its business incubator (Genesis). In addition to the above, has an important water wealth, biotic and landscape. All of this creates a strategic place for the economic development of Antioquia, getting to be the industrial subregion of the Department, specifically the Plateau, after Aburra Valley.

The economy in the subregion of Eastern Antioquia is characterized by having a wide variety of activities. These include agricultural activities, agro-industrial, industrial, mining, commercial and recreational activities and tourism. Together with these activities are carried out other sectors such as transport and telecommunications, financial services and banking and other activities that complement commerce. In addition to contribute with a good part of the gross departmental domestic product (GDP) as already noted, eastern Antioquia provides much of the exports from Antioquia with products such as flowers, textiles, clothing and coffee, leaving only the banana out of the most representative products.

In addition, “[...] eastern Antioquia is characterized by having a vocation for manufacturing and commercial excellence, however, dominate the agricultural and agro-industrial activities, only that they are not registered with this agency. Develop agricultural activities in national enhancement such as cultivation and marketing of vegetables, tubers and legumes; the poultry farm, swine and dairy, and the production of flowers for export, among other primary activities” ⁵⁹ .

From the point of view of the investment in productive infrastructure, machinery and equipment, in addition to the adoption of capital-intensive technologies, the paper industry, printing, and publishing lead with 25.5 per cent of the total, followed by the products of food and drinks with 22.1 %, flower growers and non-metallic mineral products contribute with 20.5 % and 15.4 % respectively (the World, July 23, 1999).

“But this industrial development in the subregion has not only brought positive effects, such as employment and personal income generation and municipal elections, but also harmful effects, such as pollution, that affect the life quality of its inhabitants. The industrial development, in general, has brought serious consequences for the environment with the gases emission into the atmosphere, the discharge of liquids to the water currents of and

⁵⁸ Scheme of territorial order of the municipality of Granada. Diagnostic Document. 2000

⁵⁹ Government of Antioquia-Departamento administrative planning. Subregional Profile of Eastern Antioquia, 2003.

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*solid waste deposited in the soil. Segments of the industry that pollute more are the textile industry, food, trash, and metalworking, responsible for 25% of the pollution, approximately. Addressing these problems requires control strategies and the design of technologies suited to a cleaner production, among other, matters in front of which have been working several companies of the subregion led from the Business Corporation in the East*⁶⁰ .

While in the municipalities are different economic activities, is characterized by agriculture and livestock, this is, the primary sector. In Cocorná, for example, are important the crops of sugarcane, coffee, yucca, bananas, fruit trees, banana and sugar cane, there is also cattle. For its part, in Granada stand out among the crops the coffee, sugar cane, tomato and cucumber, in addition there are extraction of timber and livestock.

It is important to bear in mind, that by the effects of armed conflict that has affected various areas of the socio-economic relations, farming activities were also affected, reflecting a decline in the same. However, not only the conflict has affected this economic sector, because among other causes, can mention " *the depletion of the soil, the low-tech and mishandling , the little training of the peasants, the poor utilization of the smallholdings, improper practices in the use of agrochemicals and the weak form of dealing with the market and products marketing* ".⁶¹

Technological processes are generally associated with serious problems of the natural resources such as land degradation by relating to the exploitation and use of inappropriate agricultural techniques. At the same time, continues to be planting in areas with high hillside slope, with very little or no conservation practice; the disproportional use of agrochemicals, planting clean crops in areas not suitable for this, there is use of not selected seeds, with ignorance of new technologies.

– Municipality of Cocorná

In the municipality of Cocorná productive processes are developed around permanent and transient crops; the first consist basically by not technically crops of coffee, bananas, fruit, coffee with grim and others, although there are about 200 ha of permanent technical crops with coffee (caturra, variety Colombia) and fruit. Between the transient crops are maize, beans, cassava and some vegetables, also include some permanent mixed crops⁶² .

Another important item within the production processes of the municipality, is the cultivation of bananas, in Rionegro, Santuario and Marinilla. In addition, the farmers supplement their economy with the planting and harvesting of other products such as fruit and yucca. Also common tangerine, tomato, which has an area of 10 ha and yields on harvested area of 21,000 kg/ha, being the Vereda (Political and administrative division of the municipality located in the rural area)of higher production El Molino, Las Playas, San Juan and Campo Alegre; another of the crops is the cucumber, which began to be planted in home gardens, later becoming important to marketing in municipalities such as Rionegro and Marinilla. Its

⁶⁰ Government of Antioquia-Departamento administrative planning. Subregional Profile of Eastern Antioquia, 2003.

⁶¹ Government of Antioquia-Departamento administrative planning. Subregional Profile of Eastern Antioquia

⁶² Scheme of territorial order Subregion Forests

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production occurs in the Vereda (*Political and administrative division of the municipality located in the rural area*) above mentioned, coinciding with the tomato production.

In correspondence to the situation presented in other municipalities in the sub region, in Cocorná armed conflict also affected the production in some Veredas (*Political and administrative division of the municipality located in the rural area*) as Los Limones, Majagual, Paila, La Cima, in these areas and others not identified, affected crops as transient tomato, beans, maize and cassava, and permanent crops such as coffee, banana and sugar cane.

However, this situation has been transforming. *"The agricultural economy has been recovering since the dynamics of the region has improved significantly and therefore the agricultural sector already generates surpluses that ensure improvement in the life quality of its inhabitants in spite of the delay caused by the displacement in the previous years. In 62 Veredas(Political and administrative division of the municipality located in the rural area) prevails the cultivation of coffee, sugar cane, plantain, cassava, fruits such as guava, papaya, orange, tangerine, guanabana, Borojo and lemon. It is also normal to find vegetables such as beans, green bean, tomato and cucumber, and products in the home gardens"*⁶³.

With regard to technological processes, technical agricultural activity especially focuses on coffee and sugarcane. *"These activities traditionally have had the greatest technical assistance, given the importance of their markets and production volumes, in addition to the significant amount of labor involved in the processes of benefit, of both coffee and sugar cane, of the latter in terms of the development of panela. However in recent years both products have had declines in production as a result of the fall in prices in the respective markets, which resulted in disincentives to the producer to continue investing the respective technological packages on their farms. This is reflected in coffee weeded plantations, little renewal; the same happens with the planting of sugar cane, which have been low in their yields Kgr/has"*⁶⁴.

In that sense," *the cane culture has had as one of its greatest limiting the size of holdings, a poor management of the technological packages, where there is little the renewal of the vines, there is no efficient management and seed selection, the cultural work related to fertilization are scarce. However this activity is not only part of one of the main productive lines of the municipality, but of the very nature of its inhabitants, which makes it necessary to rethink the purposes and objectives in the medium- and long-term in the improvement and increase in its efficiency, where the technological packages have as purpose goals not only of commercial type, but also supplement their technical strategies with others of social and cultural character, that make possible to recover the customs and the popular knowledge in the management of this crop that has a hundred or so years with presence in the Vereda (Political and administrative division of the municipality located in the rural area) and that still has historical cultural practices possible to relearn and reprocess, to make it*

⁶³ Territorial Plan of Health 2008-2011

⁶⁴ Scheme of territorial order Subregion Forests

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sustainable, in the coming years a crop that with the pass of time becomes the inheritance of the rural economy of peasant Cocorná " ⁶⁵ .

The main sugarcane Veredas (*Political and administrative division of the municipality located in the rural area*) are: Morritos, Los Mangos, La Tolda, La Aurora, La Inmaculada, La Peña, Campo Alegre, La Quebra, Cebaderos, El Jordan and Guayabal.

For its part, in regard to coffee, despite the fact that this has been a product representative for the economy of the municipality, its cultivation has been done with environmental and topographic constraints.

"Within the coffee zones made in the study "Coffee zone of influence and East of Antioquia", conducted by the National Federation of Coffee Growers and Cornare, it was found that the optimum climate for the cultivation was among the 1,300 to 1,700 meters above sea level; however, in the municipality are coffee crops below 1,300 meters, especially in the southeastern part, these areas have been classified as marginal to the production. There the drill bit and rust drastically affecting the coffee and reaches to the lower coffee border up to the 900 and 1,000 meters, are also frequent attacks of phoma sp. The coffee boom periods were decisive for the expansion of the culture and the displacement of other such as the cane and also allowed the monetization of the coffee economy.

The area of coffee-making tradition is located in the northeast corner, of this sector the Vereda (Political and administrative division of the municipality located in the rural area)that currently have a significant involvement in the production, according to the agricultural statistics are: Viadal, Higuera, Jordan, El Molino, Las Playas. The coffee zone coincides with the areas of greatest fractionation of ownership and better allocation of road infrastructure and services.

The largest volume of coffee is produced by small independent producers (0.5 and 1 ha.), used family labor force. According to studies by the National Federation of Coffee Growers the actions of the coffee growers are distinguished by reason of: Traditional farms that occupy 20% of the area sown, technified farms that occupy 30% of the surface, holdings in sustaining that occupy over 50 %. These elements are differentiators of the coffee growing activity and in the attitudes assumed by the growers programs as the renewal of coffee plants" ⁶⁶ .

In this context, one of the aspects that better reflects the sophistication and technological processes in the branches of the economy of the municipality is the production of panela, common activity in many of the farms planting cane since, in almost all there is a Trapiche (small press mill to extract sugarcane juice), either traditional or technified These are of restricted purchasing and installing, because they imply investment costs and in the training for the proper management of their various components such as improved stove tops, cleaner, weighting tables and material molding rooms

" The technified trapiche also involves the transformation of a hard work with animal traction to the use of mechanized systems, the elements related to the improvement in the presentation and production of clean and hygienic product, are among others the significant

⁶⁵ Scheme of territorial order Subregion Forests

⁶⁶ Scheme of territorial order Subregion Forests

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innovative elements that brings this pana system Of the 450 existing trapiches in Cocorná 350 are of animal traction (its source of power are horses), with a production of 300 kg in a working day of 16 hours; this improves the extraction of the juice of the cane, is passed to a 38% in animal traction, to a 55% processing. By mechanizing the trapiche you get 650 kilos in an eight-hour day by improving the conditions of efficiency, profitability, and humanization of the production work⁶⁷ .

In accordance with a program developed by the UMATA, between 1995 and 1997 reached to install 66 technologically advanced trapiches, were built 230 cleaner and renewed 150 has of cane.

With respect to the traditional trapiches, in accordance with the outline of territorial management, " are the most common, since its construction although it involves investments are mostly in rudimentary facilities where the ovens were built in an empirical manner, do not use any type of fuel, because it works with animal traction and salary costs are low, since it is used in the vast majority of family labor, the low costs are also related to the use of few inputs for the preparation of pana and the use of banana leaves as elements of packaging. It is estimated by the UMATA the municipality that the 67% of the existing trapiches are of the traditional type. As one of the biggest problems in this type of installations, it is the hygienic handling of pana, inadequate pre-cleaning, inadequate utensils, bad packaging of pana and the little handling of juice during the process of elaborating the pana⁶⁸ .

Another of the products that have permitted the diversification of the peasant economy is the guava; its collection is wilderness, to the extent that the growth of the trees is in the pasture, which has been implementing a formation of salvo pastoral systems, enabling future joint exploitation.

"The potential to create agro-industrial processes is around 1,880 tons. Currently and at the suggestion of the municipal UMATA tries to manage the crop only with organic matter and agricultural lime, with little use of agricultural lime, with the objective to continue getting an organic fruit free of chemicals, which guarantees a future quality certifications within the classifications and environmental quality of 'green products' ⁶⁹ . In addition, there are other fruit as guanabana, Zapote, borojó, avocado and vegetables such as cucumber and tomato.

In regard to livestock, in the municipality there are dual-purpose livestock, which has been developed locally in the warmer areas, without covering the demands of meat for the municipality itself. For its part, the livestock of milk has been traditionally carried out basically for subsistence, as is customary with the peasants keep an animal that provides the milk consumed by the family group. In 55 Vereda (*Political and administrative division of the municipality located in the rural area*) in the municipality, this activity is developed in a traditional way and approximately 700 farmers derive income for their families.

"The office of the municipal UMATA assists with visits, courses, implementation of demonstration plots with improved pastures, experience that begins to have wide acceptance among farmers. There was a time when the coffee economy prevailed in the

⁶⁷ Scheme of spatial order Subregion forests. S. m.d.

⁶⁸ Scheme of territorial order Subregion forests. S. m.d.

⁶⁹ Scheme of territorial order Subregion Forests

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Vereda (Political and administrative division of the municipality located in the rural area), is currently experiencing a revival in the livestock due to the steady decline in coffee production where it is possible to observe the change of coffee crops by pastures, however have been presenting problems of gullies and terraces produced by the continuous over grazing, the lack of rotation of the pasture and the lack of improved pastures, to provide greater protection to the ground”⁷⁰.

At present, "the average daily production of milk per cow is less than 4 liters and the lift and fattening of cattle is carried out in periods of very long time, surpassing the 3 years, affecting the profitability of the livestock activity”⁷¹.

The fish farming activity has been driven by the municipality and other entities such as the DRI and Cornare. “As a strategy for greater dissemination has been the constant linking of peasant women as a fish producer and its decisive intervention for the maintenance and upkeep of the ponds and in the management of their production. The Vereda (Political and administrative division of the municipality located in the rural area) with greater presence of fish ponds are Florida, Las Playas, San Juan, Agualinda and others such as Los limones and El Coco ”.

Other activities such as timber extraction and tourism, also represent an item within the economy of the inhabitants of Cocorná. The first is made around of species that have good marketing such as Comino, Cedro, Laurel and Canelo; however, faced with the lack of these, has turned to other considered common as Cirpo, Chingale, Pandequeso and Melcocho. The families who cultivate it are located in the Veredas (Political and administrative division of the municipality located in the rural area), Agualinda, El Estio, La Secreta and Santa Rita.

For its part, tourism has developed in some corridors of the municipality, where is found the abundance of water resources and the beauty of the landscape. However, to Cocorná attended people from the middle and lower middle of Medellín, who practiced the so-called "Pot tourism", by which the purchasing capacity at times does not match the expectations of income of some families of Cocorná who have dedicated themselves to this activity as economic strategy. Likewise, tourism has brought with it some effects that have transformed the social, economic and environmental dynamic of the municipality, especially stressing among young people.

According to data from the 2005 General Census Bulletin Profile Cocorná - Antioquia, the 62.9 % of rural dwellings occupied, with people present on census day, were agricultural activity, as you can see in the Figure 3-94 , whose distribution is presented by activities in the Figure 3-95 .

⁷⁰ Scheme of territorial order Subregion Forests

⁷¹ Territorial Plan of Health of the Municipality of Cocorná 2008-2011

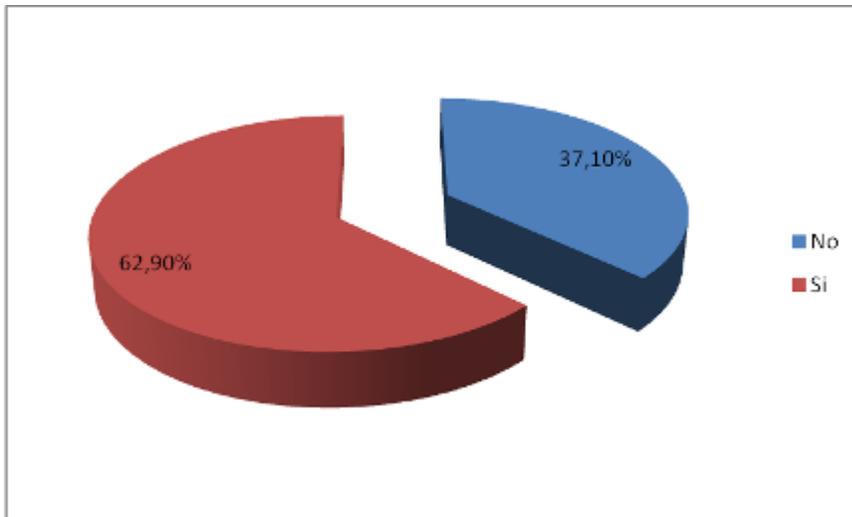


Figure 3-94. Census units associated with agricultural activity in the municipality of Cocorná, DANE Census 2005.

Source: *Bulletin 2005 General Census Profile Cocorná – Antioch*

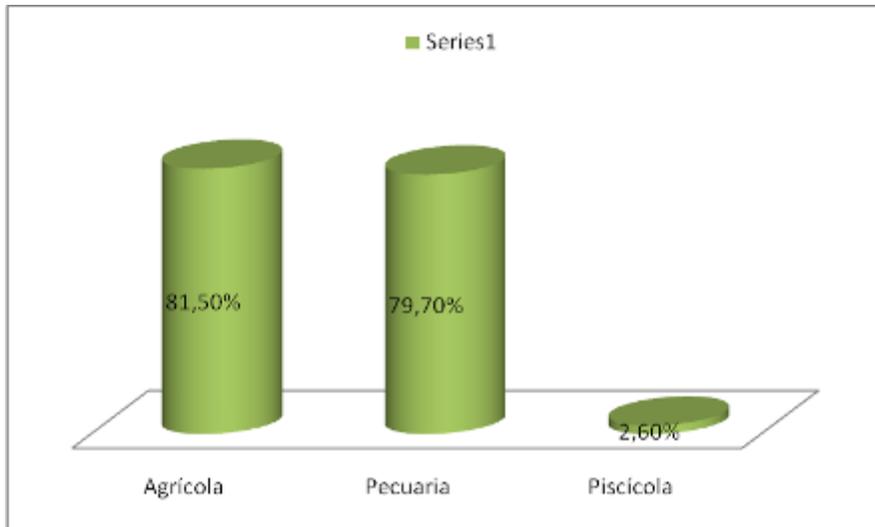


Figure 3-95. Census Units with agricultural, livestock and fish associated activities, Municipality of Cocorná, DANE census 2005.

Source: *Bulletin 2005 General Census Profile Cocorná - Antioch*

In addition, of the total crops associated with rural housing, the 20.5 % corresponds to transient alone, the 1.7 % transient associated, the 63.9 % to permanent alone and 13.9 per cent to permanent partners (see Figure 3-96).

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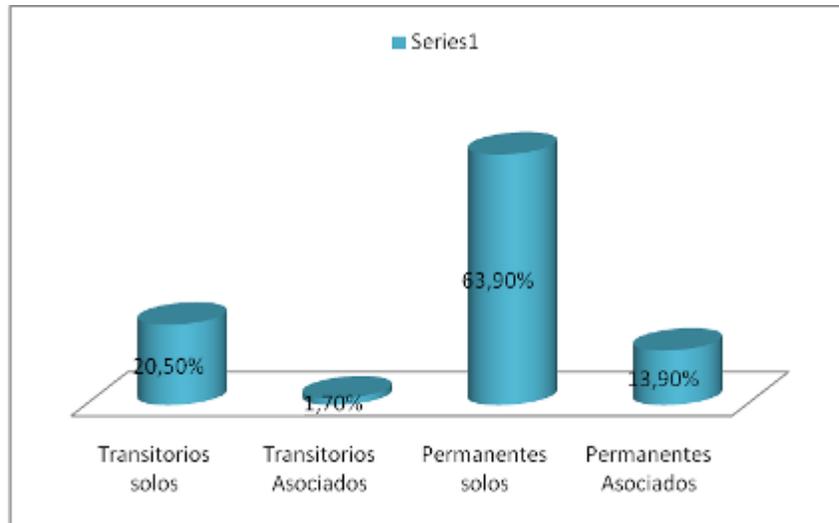


Figure 3-96. Types of crops in the census units, Municipality of Cocorná DANE Census 2005.

Source: *Bulletin 2005 General Census Profile Cocorná - Antioquia*

– Municipality of Granada

The productive processes of Granada are characterized by a predominance of agricultural activity, followed by livestock production and trade. The permanent crops more representative of the municipality are coffee, sugarcane and to a lesser extent the bananas. There are also surge crops (yearly) as chonto tomato, corn, beans, potatoes, carrots, cabbage and cucumber. In addition, it highlights the relative increase of fruit trees, cultivation of diversification.

The main coffee producers of the municipality are located on the Vereda (Political and administrative division of the municipality located in the rural area) Los Medios, La Aguada, La Merced, La Gaviota, La Quebra and La Linda, most of the coffee farms are technified with coffee caturra in a 90 %, Colombian coffee in a 5% and 5% with the variety bird.

The second most important crop is sugar cane panela, production that comes falling; its sophistication is very low and the varieties are not the most profitable. The Vereda (Political and administrative division of the municipality located in the rural area) that dedicated the most to this crop are: La Arenosa, El Libertador, La Estrella, Florida, La Cascada and Bella Maria. In the same Vereda (Political and administrative division of the municipality located in the rural area) are transformed the cane to get the panela.

The banana cultivation is carried out in partnership with the coffee; in 1993 it was reported 303 has, without automation, on the Vereda (Political and administrative division of the municipality located in the rural area) Las Faldas, Las Palmas, Quebradona Abajo, La Arenosa, Los Planes, Quebradona Arriba, in which predominates the banana Dominico and Petaco, which are exposed to a high probability of pests and diseases⁷².

⁷² Diagnostic Scheme of territorial order of the municipality of Granada

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In any case, according to the information provided by the scheme of territorial order, agriculture developed in the municipality has low technological development, since it is a traditional form of agriculture with no echoes of the ancestral knowledge strategies for the control of pests and diseases. Also, there is a significant deterioration of natural resources, low employment generation, little agro-industrial development, as a result, under performance in the production.

In the livestock sector, the main activity is the dual-purpose livestock, followed in order by the poultry, pigs and to a lesser scale, the beekeeping.

The raising is carried out with traditional techniques and the cattle in its majority is resulting from the crossing between Cebu and Holstein, Blanco Orejinegro and Brown Swiss. These animals usually have low nutrition levels which is reflected in the poor yields in the production of meat and milk. This is a livestock developed extensively. The pastures are composed of native grass, being supplemented with grass and Imperial King Grass. Among existing pasture it is also possible to find Star, Kikuyu and Brachisria Decumbs.

In this line were introduced some elements of agro-industrial processing, in the collection, cooling and processing milk for the production of quesito, white cheese, butter, pressed cheese, milk and flavored milk bag. However, at present, this small industry declined.

In relation to the panela, this has played a major item within the economy of the municipality; according to the Scheme of territorial order, are up to 400 trapiches, all with very early technology, the horizontal presses are moved with electric motors or CMPA, verticals are driven by mules or beasts.

However, gradual changes with incorporation of new technologies in the kilns; to the traditional type, have been added to other CIMPA type - International Center for the Improvement of the Panela-, modified. Also, the blocks of wood tables have been replaced by cement and pre cleaner were constructed for the cleaning of the juices. This has led to an improvement in the quality of panela and the performance.

“Usually the farming activity is carried out in a traditional way, due to the lack of training and deployment of technologies, this fact has prevented the primary sector and the municipality has reached higher levels of performance and competitiveness, it is as well as today we have an agricultural sector depressed, at the mercy of weather, pests, and market imperfections such as the instability of prices and the high presence of intermediaries”⁷³.

However, crops such as tomatoes Chonto Santa Cruz and chonto common, have some levels of sophistication, like the Cargamanto red bean, potato and Capira Cumanday, the carrot and the purple cabbage, crops that are not very important in the municipality.

“With the crisis that has been presented in the coffee production and the fall of the sugarcane cultivation, is promoting agricultural diversification with fruit trees, fish, vegetables and other vegetables, such as the cucumber cultivation, the latter is being carried out in a thechnified way; are reported 25 hectares in production on the Vereda (Political and administrative division of the municipality located in the rural area)of La Linda, La Quiebra, El Oso, Las Faldas, El Eden and El Tabor.

⁷³ Diagnostic Scheme of territorial order of the Municipality of Granada,2000.

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The fruit trees of cold weather as the Cape gooseberry, lulo, the tree tomato, the Blackberry, Passion flower and the warm climate such as passion fruit, pineapple, Borojo, avocado and citrus fruits are being stimulated for planting, taking into account what offers the municipality by the diversity of climates and the closeness to the Plateau and the metropolitan area of the Valley of Aburra and the free trade zone that offers great comparative advantages ⁷⁴ .

On the other hand, birds and pigs are very small lines that do not represent an important contribution to the economy of the municipality; however, they provide a source of food and income for family groups, where the woman are responsible for the lift and sustaining of their children

With regard to fish, the municipality records the existence of 51 ponds, with Cachama and Tilapia especially, with a representative production in the area.

The extraction of timber in the municipality is made primarily for the trellising of tomato crops and for the manufacture of the boxes in which they are transported; this is done mainly with species such as Siete cueros, Punta de lanza and Drago.

On the other hand, according to the 2005 General Census survey Profile Granada - Antioquia, in the municipality, the 6.0 % of the establishments engaged in the industry; the 51.3 per cent to trade; the 36.2 % to services and the 6.5 % to another activity, as can be seen in the Figure 3-97 .

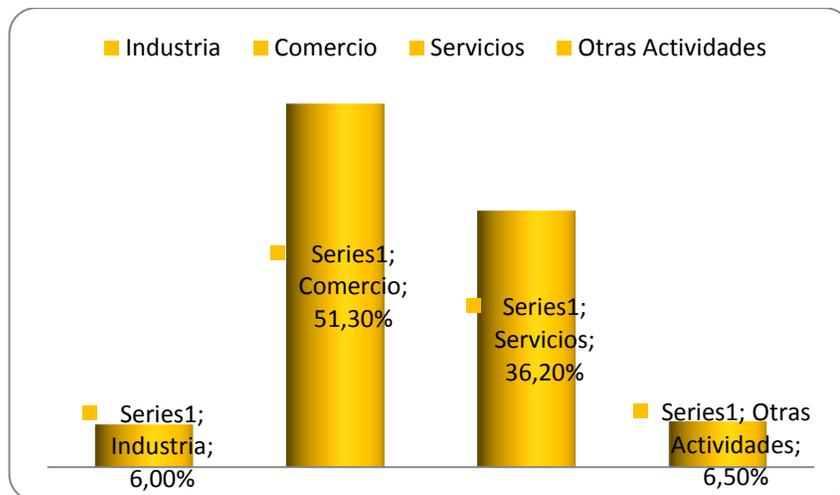


Figure 3-97. Establishments depending on economic activity, municipality of Granada, DANE Census 2005.

Source: 2005 General Census survey Profile Granada - Antioch

- Current labor market

“During 2009, the Colombian labor market increased 0.7 pp in the unemployment rate, as it is ranked at 12.0 %; equal behavior resulted in Antioquia, where it increased by 0.6pp and reached to 12.7 %. Thus, the unemployed were 367 thousand people. However, the inactive population declined by 6.3 %.

⁷⁴ Diagnostic Scheme of territorial order of the municipality of Granada, 2000.

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In Antioquia, the occupancy rate was 52.7 % and increased 2.6 pp. during 2009 increased by 7.1 per cent occupied in relation to the previous year, to reach 2,525 thousand people.

Meanwhile, the underemployment rate rose by 3.9 pp compared to 2008 totaling 27.8 % during 2009, and the underemployed came to 804 thousand people, because they increased 25.6 %⁷⁵ .

For its part, at the level of data of the subregions of the Department in 2004, the East population deals mainly in agricultural activities, coinciding with the situation with the two municipalities in the influence area of the project.

"The distribution of the occupied population by activities and subregions show the specialization areas in different economic activities. As shown above, the Valley of Aburra was concentrated in industrial and service activities, secondary and tertiary sector, absorbing for 2004 the 95.7 % of the employed population. Subregions as Uraba and East divide their population in agricultural activities, services and industries (particularly east); the rest of subregions concentrate occupation in agricultural activities"⁷⁶ .

"The subregions have specialized productivity, and with the exception of the Low Cauca and Middle Magdalena, all have an important stake in the added value of the agricultural sector. East, Southwest and Urabá stand out for the production of export goods (flowers, coffee, bananas and fruits) while the rest of subregions were characterized by the production of goods for domestic consumption. The industrial subregions are The Aburra Valley and the East. Mining is important for the Low Cauca, the Middle Magdalena and the Northeast. The financial sector is seated basically in The Valley of Aburra. The transport, storage and communications sector have a significant presence in the industrial subregions, export agricultural production and that at the same time have developed a structure of tourism services. The construction has a significant presence in the major urban centers of the Valley of Aburrá, the East, Uraba and the Southwest.

Finally, the sector of social, community and personal services, which have a strong component of public sector services, although aid to the development of all sub-regions, is not a fundamental activity for specialized subregions in the agricultural and mining sector, which have strong problems of violence and public order (Low Cauca, Middle Magdalena and Northeast) "⁷⁷ .

With regard to the municipality of Cocorná, according to data presented by the Development Plan of the Municipality 2008- 2011 and which are displayed in Table 3-118 , the activity with a higher percentage of employed population is agriculture with a 50.7 %, followed by trade with a 19.9 %, the third place is industry with 14.1 % and the sector with less offers is services with 12.3 %. On the other hand, the Municipal Administration represents a 12.7 % occupancy among the labor market of the Vereda (Political and administrative division of the municipality located in the rural area).

Table 3-118. Labor market indicators 2006, Municipality of Cocorná

⁷⁵ Report of Regional Economic Juncture - ICER - Department of Antioquia 2010

⁷⁶ ECONOMIC Edition Thematic Bulletin No. 1 ISSN: December 1900 2005 Government of Antioquia

⁷⁷ ECONOMIC Edition Thematic Bulletin No. 1 ISSN: December 1900 2005 Government of Antioquia

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| Municipality | % Of Dependency relationship | Per cent of the population by economic activity | | | | | | Working-age population | | Municipal Employees per thousand capita | Municipal Categorization (2007) |
|----------------|------------------------------|---|-------|----------|--------------|-----------|-------|------------------------|------|---|---------------------------------|
| | | Industry | Trade | Services | Agricultural | Other (4) | Total | Population | % | | |
| Cocorná | 74.5 | 14.1 | 19.9 | 12.3 | 50.7 | 3.1 | 100 | 10,843 | 74.1 | 12.17 | 6a |

Source: Development Plan of the Municipality of Cocorná 2008-2011

On the other hand, the data supplied by the Bulletin 2005 General Census Profile Cocorná - Antioquia, indicate that the 2.9 % of the households of Cocorná have economic activity in their homes (see Figure 3-98)

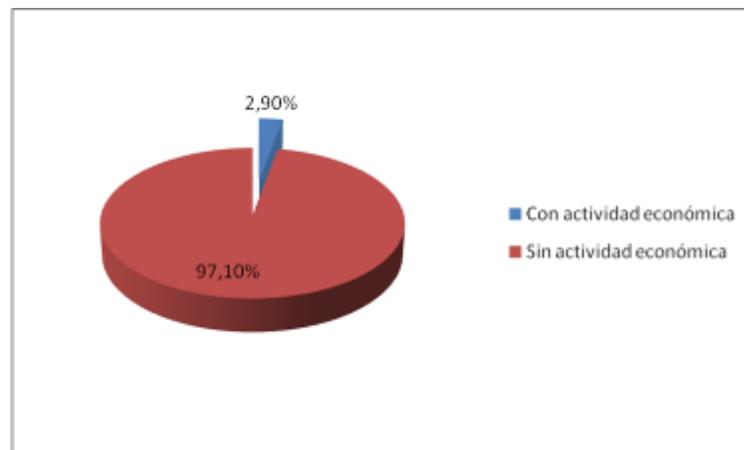


Figure 3-98. Homes with economic activity in the municipality of Cocorná, DANE Census 2005.

Source: Bulletin 2005 General Census Profile Cocorná - Antioquia

Likewise, in the 2005 General Census Bulletin Profile Cocorná - Antioquia, it is stated that in the number of establishments with employees from 0 to 10, trade activity is the most common (53.8 %) and in the group of 10 to 50 people, the main activity is services (80.0 %) (see Figure 3-99).

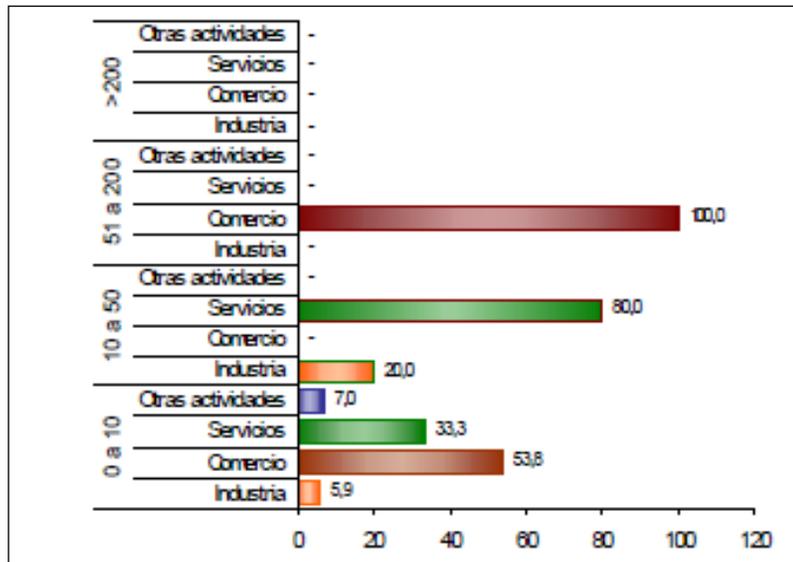


Figure 3-99. Establishments according to scale of staff for economic activity in the municipality of Cocorná.

Source: Taken from Bulletin 2005 General Census Profile Cocorná - Antioch

In regard to the municipality of Granada, is the agricultural sector which brings a greater number of direct jobs, for that reason, a large part of the population is engaged in these activities, either working on their own plot or as laborers. While the commercial sector is dynamic and increasingly develops, it is not enough to occupy the entire unoccupied labor force available in the municipality, there are also small wood workshops, locksmith shops and bakeries, where the demand for labor is negligible.

In sum, in the municipality there is a significant unemployment, which leads to good part of the population migrate to other municipalities in search of work opportunities. In this regard in the Scheme of territorial order states that " [...] *In general that spirit that covers the Granadine is adventurous accompanied by the practice of healthy habits that remains by tradition; it emphasizes the high degree of self-sufficiency at the level of subsistence, the traditional occupation of agriculture families have remained in the field, although in the current circumstances of high cost of inputs for planting, problems of the environment, public order, and low costs of agricultural products, some of the members, for the most part, the older men, have had to migrate to the urban centers of Cali, Buenaventura, Barranquilla, Medellin, Bogota in search of better income; In these cities they dedicated to the commercial activity, in which the Granadine demonstrates his cunning within the business of goods*"⁷⁸.

In accordance with the data submitted by the Statistical Yearbook of Antioquia, and that may be seen in Table 3-119, the activity in which the greater percentage of people deal is agriculture with a 50.2 %, followed by trade with 24.3 % and services with 17.1 %. The activity which represents a lower percentage of occupation is industry with 3.1 %. For its

⁷⁸ Diagnostic Scheme of territorial order of the municipality of Granada, 2000.

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part, the Municipal Administration provides a 4.36 per cent of the employment of the Municipality.

Table 3-119. Labor market indicators of the municipality of Granada 2006

| % Of dependency relationship | Per cent of the population by economic activity | | | | | Working-age population | | Municipal Employees for each 1,000 inhabitants |
|------------------------------|---|-------|----------|--------------|-------|------------------------|------|--|
| | Industry | Trade | Services | Agricultural | Other | Population | % | |
| 79.4 | 3.1 | 24.3 | 17.1 | 50.2 | 5.3 | 6,779 | 72.6 | 4.36 |

Source: Government of Antioquia. Statistical Yearbook Administrative Department of Planning 2007

According to the 2005 General Census survey Profile Granada - Antioquia, in Granada the 96.9 % of the establishments held between 1 and 10 jobs a month prior to the census, as can be seen in the Figure 3-100

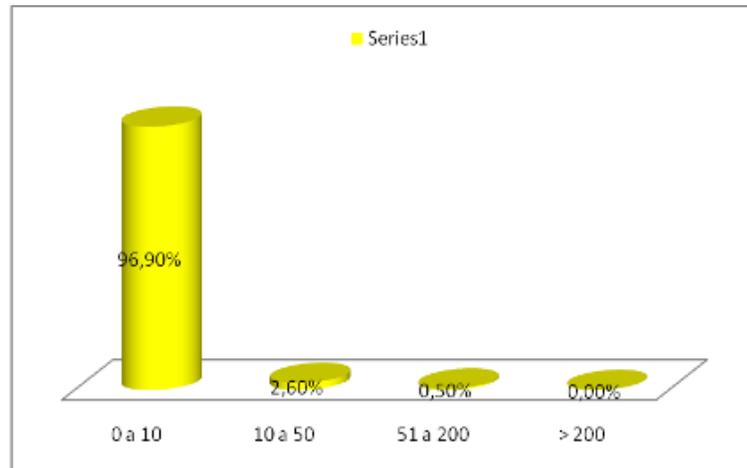


Figure 3-100. Establishments according to scale of people occupied the month prior to the census, municipality of Granada, DANE Census 2005.

Source: Bulletin 2005 General Census Profile Cocorná - Antioquia

- Poles of development or enclaves that interact with the project influence area

The development poles in eastern Antioquia are confined to the dynamics originated in a municipality as Rionegro, is considered a center of main relay according to the study "Analysis of the system of Urban Settlements of the Department of Antioquia", prepared by the Administrative Department of Planning in the 2000, given the location of services and industries in its territory; in this, at the subregional level, are provided administrative, financial, commercial, social (located headquarters of major universities) and cultural.

"Comparing Rionegro with other following hierarchical levels in descending order, it is found that this municipality participates in terms of the number and specialization of activities to a greater extent in terms of industry, commerce and services, which evidence that Rionegro

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really has been consolidated as a core for industrial deconcentration and receiver of population with respect to the Valley of Aburra.

The study defined also as centers of secondary succession, the municipalities of La Ceja, Marinilla, and Sonson, possessors of economic functions with an emphasis on administrative, commercial, social and to some extent agriculture services, although less presence of these functions with respect to Rionegro.

In Eastern Antioquia there are also major local centers with support functions of economic and commercial centers at top-level, basic services in the public and local social with ranges between 276.9 - 127.7 El Santuario, Carmen de Viboral, Guarne, San Carlos, Abejorral, the El Penol, La Union San Rafael, and El Retiro.

The rest of the municipalities (Granada, San Luis, San Vicente, Nariño, Guatapé, Cocorná, Alexandria, Concepcion and Angelia) are classified as secondary local centers with basic economic and commercial functions, suppliers of near population, and most important providers of basic services at local scale".⁷⁹

As can be seen in Table 3-120 , " the Eastern Antioquia is a subregion with a main relay center as is Rionegro; with three secondary rotation centers (La Ceja, Marinilla, and Sonson), two of them located in the highlands; with nine major local centers (El Santuario, El Carmen de Viboral, Guarne, San Carlos, Abejorral, El Penol, La Union San Rafael, and El Retiro), located mostly in the areas of the Plateau and reservoirs, they impress a greater development to these areas with respect to the forest and moor"⁸⁰

Table 3-120. Municipalities and respite centers in eastern Antioquia with location zone

| Subregion | Area | Main Respite Center | Area | Secondary Respite Center | Area | Major local Centers |
|-------------|---------|---------------------|---------|--------------------------|------------|---------------------|
| East | Plateau | Rionegro | Plateau | La Ceja | Plateau | El Santuario |
| | | | | Marinilla | | Carmen de Viboral |
| | | | Páramo | Sonson | | Guarne |
| | | | | | | La Unión |
| | | | | | | El Retiro |
| | | | | | Páramo | Abejorral |
| | | | | | Reservoirs | San Rafael |
| | | | | | | San Carlos |
| | | | | | | El Penol |

Source: Home processing, social team SAG, based in subregional profile of eastern Antioquia.

Among the physical infrastructure mega projects that are considered to be more important for the subregion, are the following: Free Zone, Departmental highway East tunnel project, Project of the dual carriageway Medellín-Bogotá Highway section Zamora-El Santuario and the Technological Park of Antioquia.

- Free Zone

⁷⁹ Subregional Profile of Eastern Antioquia

⁸⁰ Subregional Profile of Eastern Antioquia

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“The free zone of Rionegro arises within a strategy of the National Government and private companies, to respond to the needs of increasing exports of the country and especially the Antioqueans of some sectors, which were formed in their main shareholders: Suramericana de Seguros, Cementos Argos (belonging to the Antioquia Syndicate), Coltejer, Clothing Leonisa, Concreto and Promoter of Projects, among other”⁸¹.

This project has an area of 286,000 m², representing major benefits in the sense that companies that are located here, will be very close to the airport José María Córdoba, in addition to that they have "streamlining of customs formalities, exemption from payment of municipal taxes for industry and trade, reduced rates of public services, facilities for the import of technology and exemption of tariffs for machinery, raw materials or intermediate goods that come from any part of the country or abroad.

In the present economic sectors present in this space are: electric power, clothing, graphic arts, footwear, leather goods, toys, sporting goods, medical equipment and software. One of its most important expectations in addition to those of the rest of entrepreneurs and Antiocheans and large part of Eastern Antioquia is the full activation of the free zone of Rionegro. Some political and social sectors studied formulas and mechanisms for this project, generate the subregional and local benefits expected from its design and implementation in operation, which are not yet visible nor comply with the expectations”⁸².

- Department highway East tunnel Project

This project, at present, arise great controversy and concern among residents of the area and some environmental and academic organizations from Medellín and Valley of Aburrá.

“Is a project that dates back to more than 60 years ago and which aim is to bring closer the Aburrá Valley with the area of the Near East. Raised as a supplementary labor between the two valleys, this is one of the objectives conforming with the Medellín - Bogotá Highway a ring road between El Santuario, La Ceja, El Retiro and the south of the Valley of Aburra. The tunnel will have a length of 7.6 km that communicate the sector of Las Palmas with the airport José María Córdoba, in addition to 60 km in complementary road facilities that communicate the following sectors of the Plateau: El Retiro, La Ceja, El Canada, El Carmen de Viboral and El Santuario”⁸³.

- Technological Park of Antioquia

“The Technological Park, emerges as a concerted initiative between the official sector, the private universities of Antioquia, in search of the generation of innovative programs and projects that enable them to meet the various demands in terms of productivity improvement and preservation of the environment, in a framework of research development and application of cutting-edge technology.

An essential feature of the policy that guides the project is its humanistic content, both in the design of the scientific and technological development, as in its training component of new human resources that contribute to the effective implementation of the macro project in general.

⁸¹ Subregional Profile of Eastern Antioquia, 2003.

⁸² Subregional Profile of Eastern Antioquia, 2003.

⁸³ Subregional Profile of Eastern Antioquia, 2003.

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The Technology Park is located on the premises of Quirama. Their gestation process was in charge of the University of Antioquia, with the support of the College of Higher Studies Quirama. Have been involved in its promotion and logistical support and budget by the following entities: Catholic University of the East, School of Engineering at University of Antioquia, Medellin, Politecnico Colombiano Jaime Isaza Cadavid, Universidad Nacional de Colombia (Headquarters Medellin), Universidad Pontificia Bolivariana, Institute of Health Sciences -ESC-, Center for Research and Technological Development of the Pharmaceutical Industry (20 laboratories around the country), Technology Development Center of the Food Industry, Suramericana de Construcciones S.A. (Suramericana de Seguros), FEDEMADERAS, Center of the Food Industry -CIAL-, Clinic The Americas, ICA, CORPOICA, National Agriculture and Livestock Exchange, United Nations, UNESCO and the Department of Antioquia.

For the institutional development of the Park is projected to set in motion the creation of sectorial Technological Centers, the creation of new businesses, of technology businesses in the areas of biosafety, bioethics and patents of intellectual creation, Center of Training and business consultancy, an incubator for technology-based companies, Diagnostic Center, with an information bank for market research, liaison mechanisms and user diagnostics, Communications Center; International and National Banks with risk capital and national and international Traction Companies with high-technology. Also it was planned to carry out research for the industry sector of casting, metalworking, and chemical, agro-industry, pharmaceutical and environmental. It also proposes to lead research in social and cultural areas, as well as on the efficient management of energy. Bordering the Technological Park will be built a Technological Industrial field in which it will concentrate clean companies of high technologies.

The projection of the Park exceeds the subregional framework and even the departmental. In spite of the fact that the entities that financed the project are in the vast majority of Antioquia and their initial orientation was motivated from the recommendations made by the Monitor report on competitiveness in Antioquia, is looking for that its impact radiate on national development proposals" ⁸⁴ .

3.4.3.2 Direct influence area

The Vereda (Political and administrative division of the municipality located in the rural area) in the direct influence area are: San Lorenzo, La Inmaculada, El Molino, Los Mangos, Campo Alegre, El Chocó y San Juan in the Municipality of Cocorná; Las Faldas and Quebradona Abajo in the municipality of Granada.

- Property Structure

In this item will be presented the Vereda (Political and administrative division of the municipality located in the rural area) data, in accordance with the information gathered during the field work conducted in December 2011. It is important to highlight the local history of forced displacement, which has influenced the property structure. At present, in large part of the Vereda (Political and administrative division of the municipality located in the rural area) are abandoned farms in poor condition and in other cases, the site of housing

⁸⁴ Subregional Profile of Eastern Antioquia, 2003.

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settlement is fully invaded by vegetation; while, by the Program Return is Live, developed jointly by Social Action of the Presidency of the Republic and the municipal administrations, good part of the population has returned, several families have expressed their intention to not return because they have been established and developed economic activities of their own in other parts of the department and of the country.

As can be seen in Table 3-121 , in the Vereda (Political and administrative division of the municipality located in the rural area)of the influence area dominates the small property, with farms ranging between half and one hectare, although there are few cases of land of 20 ha. Likewise, the prevailing form of tenure is own paid over the others.

Table 3-121. A form of land tenure and ownership structure in the Vereda (Political and administrative division of the municipality located in the rural area)of the influence area

| Vereda (Political and administrative division of the municipality located in the rural area) Name | Data Source | N° of families* | N° of housing* | Form of tenure* | | | | N°. Sites" | Size Sites* |
|---|-------------|-----------------|----------------|-----------------|----------|-------|-------------------|------------|-------------|
| | | | | Own paying | Own paid | Lease | Another condition | | |
| La Inmaculada ¹ | Sisben | 11 | 10 | SD | 5 | SD | 5 | 13 | 1-5 Has |
| | T. field | 13 | 13 | | | | | | |
| San Lorenzo ² | Sisben | 121 | 118 | 13 | 234 | 34 | 129 | 132 | 1-2 Has |
| | T. field | 146 | 146 | | | | | | |
| Los Mangos | Sisben | 14 | 14 | 5 | 35 | SD | 8 | 105 | 1-6 Has. |
| | T. field | 13 | 13 | | | | | | |
| El Chocó | Sisben | 29 | 29 | 2 | 56 | 2 | 56 | SD | 2-5 Has. |
| | T. field | 42 | SD | | | | | | |
| San Juan | Sisben | 62 | 62 | 5 | 136 | 33 | 47 | 40 | 1-3 Has. |
| | T. field | 42 | SD | | | | | | |
| Campo Alegre | Sisben | 19 | 19 | 5 | 45 | 10 | 21 | SD | SD |
| | T. field | 21 | SD | | | | | | |
| El Molino | Sisben | 62 | 62 | 20 | 110 | 15 | 76 | SD | 2-3 Has. |
| | T. field | 65 | SD | | | | | | |
| Las Faldas | Sisben | | | 19 | 59 | 4 | 10 | 90 | ½- 4 has. |
| | T. field | 30 | 30 | | | | | | |
| Quebradona Abajo | Sisben | | | 6 | 66 | SD | 32 | SD | 1-8 Has. |
| | T. field | 46 | SD | | | | | | |

Source: Social development team own SAG, December 2011

¹: There is a site of 100 ha

²: There are several farms between 20 and 30 has

Data provided by the database of Sisben of the Municipality of Cocorná

•Data based on field work conducted in December 2011

SD: no data

On the other hand, in two of the Vereda (Political and administrative division of the municipality located in the rural area)of the area of influence, El Choco of the municipality of Cocorná and Las Faldas of the municipality of Granada, are experiences of community property on two community sugarcane businesses

On the other hand, with regard to the tenure of the displaced population in the municipality of Cocorná that occurs in Figure 3-101 , it can be seen that there is a greater number of

dwellings in the own paid way in stratum 2. Situation that differs with the municipality of Granada where there is in the condition modality, where there are more homes, remaining the same in the stratification, as you can see in Figure 3-102 .

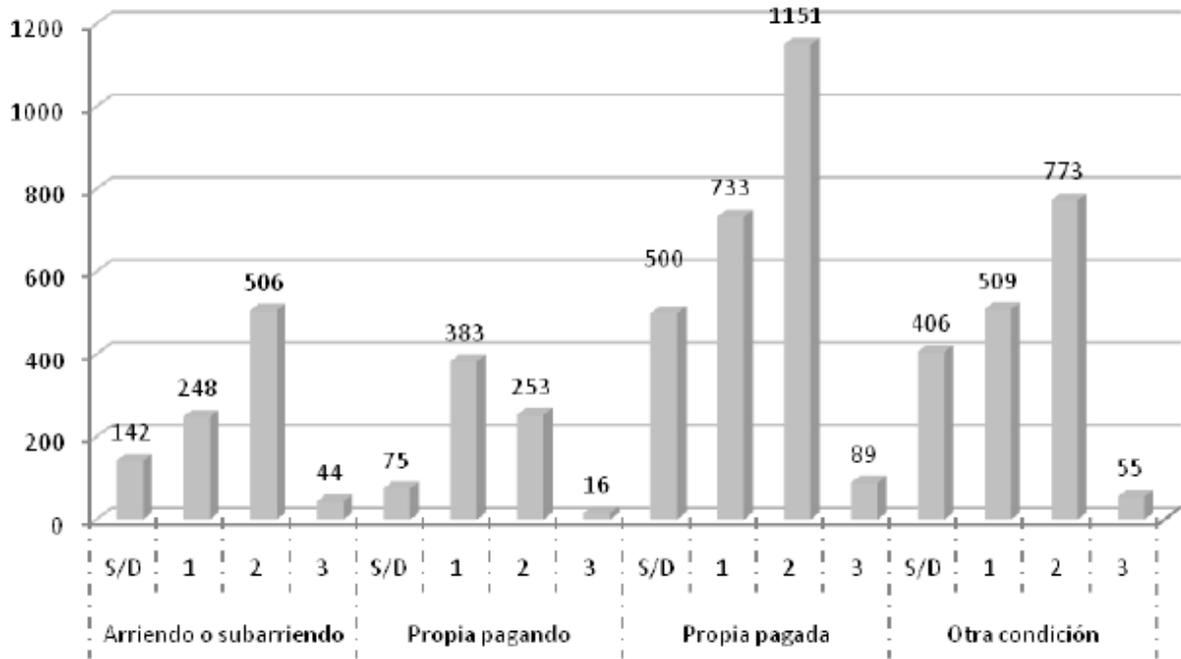


Figure 3-101. Housing tenure and socio-economic stratification of the displaced population in the Municipality of Cocorná.

Source: Government of Antioquia - UNHCR. 2010 Departmental Observatory of the forced internal displacement. Technical Report characterization of the municipal population in situation of displacement in the department of Antioquia. Version 2. Cooperation Agreement 2010 - cf- 26-005 DAPARD -UNHCR. Technical Secretariat of the departmental committee of comprehensive care for the displaced population- CDAIPD - Medellín DAPARD ANTIOCH, November 2010. Observatory of forced displacement CDAIPD Antioquia

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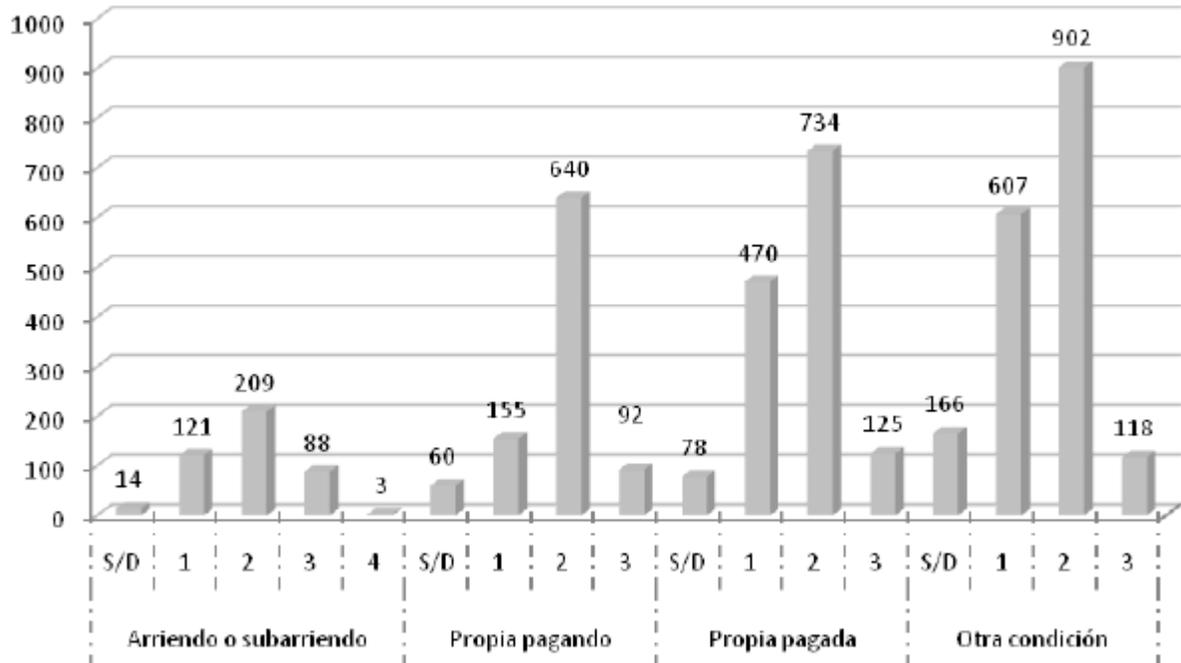


Figure 3-102. Housing tenure and socio-economic stratification of the displaced population in the municipality of Granada.

Source: Government of Antioquia - UNHCR. 2010 Departmental Observatory for forced internal displacement. Technical Report characterization of the municipal population in situation of displacement in the department of Antioquia. Version 2. Cooperation Agreement 2010 - cf- 26-005 DAPARD -UNHCR. Technical Secretariat of the departmental committee of comprehensive care for the population displaced - CDAIPD - Medellín DAPARD ANTIOCH, November 2010. Observatory of forced displacement CDAIPD Antioquia

“The exposed information on types of housing is a key element since the methodology of socio-economic stratification combines variables related to the materials, environment and urban context of the housing and many others associated with the number and class of economic activities in the environment of the housing and the level of unmet basic needs - NBI. The houses are classified in strata, not only according to the features listed, but to the municipal decisions that define the number of strata according to the number of inhabitants and squares, the number and kind of economic activity and level of unmet basic needs. In small municipalities stratification cannot reach the strata 5 and 6. Along Antioquia stratum 1 corresponds to "low - low" and " 2" to "low", levels at which is located the majority of the displaced population”⁸⁵.

- Productive and technological processes

⁸⁵ Government of Antioquia - UNHCR. 2010 Departmental Observatory of the forced internal displacement. Technical Report characterization of the municipal population in situation of displacement in the department of Antioquia. Version 2. Cooperation Agreement 2010 - cf- 26-005 DAPARD -UNHCR. Technical Secretariat of the departmental committee of comprehensive care for the displaced population- CDAIPD - Medellín DAPARD ANTIOCH, November 2010. Observatory of forced displacement CDAIPD Antioquia

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In the Vereda (Political and administrative division of the municipality located in the rural area)of the area of influence, the agricultural activity is the mainstay of the economy, in which protrude the production of sugarcane, bananas, coffee, beans, maize, cassava and citrus fruits. In the Vereda (Political and administrative division of the municipality located in the rural area)in the municipality of Granada, protrude the tomato and cucumber. As well, cattle is raised for milk and meat production, the latter does not cover local demand and the milk is usually for their own consumption and for the manufacture of cheese and butter, which is marketed at intra Vereda (*Political and administrative division of the municipality located in the rural area*) level. Similarly, in low proportion, presents the breeding of pigs and chickens.

In almost all cases, the work of the field is done by their owners such as farmers who cultivate their land, in a subsistence economy. Therefore, the technology used is incipient in most cases; depending on the type of crop, apply traditional knowledge or techniques that have been implemented with the advice of the UMATA and the SENA to the improvement in the cultivation of sugarcane, for example. In almost all the crops are agrochemicals as Lorban to counteract the pests and diseases and manure to increase the performance, although in some cases, due to its cost, these are not within the scope of the purchasing power of the farmer.

Within the techniques and technology used for the different crops, processing of sugarcane in the small livestock and energy sources used in the various Veredas (Political and administrative division of the municipality located in the rural area)s, were mentioned by the peasants during the field work conducted in December 2011, the following.

- Vereda (Political and administrative division of the municipality located in the rural area) La Inmaculada

With regard to the cane it s harvested by culling; planting through cholines or in rows, while it is the most common use of cholines, although among the peasants there is a belief based on the experience that "*is born better diced planted in a hole, but it takes more*". At the present time on the Vereda (*Political and administrative division of the municipality located in the rural area*) is carried out a program with IICA and the Secretary of Agriculture for the biological control of the worm of the cane with wasps.

In the processing of sugarcane are used diesel or electric engines, and beasts of draft for El Trapiche.

As far as the fuel used for cooking food, alternate energy sources such as firewood and gas, this reduces the cost of gas of pipette; in addition in some of the houses there are efficient stoves, which operate with firewood, for which, it is assumed, agro foresters orchards were implemented as the main source of supply of firewood needs.

Climatic fluctuations have brought changes in the cycles of planting and harvesting, as they have directly affected the crops. For example, the winter affects the bananas, sugarcane and cassava and the summer, the coffee and the pastures. As major problems in the agricultural sector, is mentioned by the peasants the marketing and the absence of supply chains, which favors the presence of intermediaries, which hoard good portion of the utilities.

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There are planted in addition to sugarcane, citrus, Borojo, cassava, plantain, corn and beans. In a program developed by CORNARE and the Presidential Agency Social Action, were delivered to the community seed for planting vegetables in cold weather, adapted to warm weather as carrots and potatoes, among others.

In earlier times was extracted wood to market, activity disappeared by the existing difficulties for the transfer, given the high cost represented by its transportation. However, the Vereda (*Political and administrative division of the municipality located in the rural area*) is rich in forest, although there are no valuable timber. In the farm Playa Loca, the only venue of more than 100 ha in the Vereda (*Political and administrative division of the municipality located in the rural area*), wood is removed and processes wood to obtain charcoal.

Agricultural work is taken in its entirety by men, who are the head of the household; women are mainly engaged in domestic work. In some cases, other family members support the agricultural work.

- Vereda (*Political and administrative division of the municipality located in the rural area*) San Lorenzo

The main economic activity of the inhabitants of San Lorenzo is agriculture, especially the men are those who are engaged in this activity, although, in some cases, women also harvest. The income earned by this activity ranges \$300,000. Women provide to the income of the family group, with the sale of eggs and onion. Planting corn and beans for personal consumption, which is also a contribution to the family economy.

Use ACPM engine and bagasse for the furnace used in the processing of cane for the production of panela, likewise, there is used traditional Trapiche pulled by a beast. On the Vereda (*Political and administrative division of the municipality located in the rural area*), its inhabitants generally cooked with gas of pipette, alternating with the use of wood, in addition, some families have efficient stoves, which also require firewood for their operation.

Usually the family account with a cow for milk production for home consumption, others have approximately 15 of fattening cattle; in addition, in some cases, the family group has a horse for the job and cargo transport.

On the Vereda (*Political and administrative division of the municipality located in the rural area*), in previous eras, they used to hunt animals as guaguas and rabbits, but from campaigns carried out by an ecological group, this activity has decreased. However, residents of Vereda (*Political and administrative division of the municipality located in the rural area*) La Quebra reach San Lorenzo where they hunt with dogs.

In the cultivation of cane they planted a piece or Choline; coffee and fruit are planted in sacks. When harvesting the cane, it is done in batch level cut or culled.

Earlier fungi was propagated for the control of the coffee berry borer, with a method that was to immerse in a pot with boiling water socks filled with rice. This method had disappeared with the introduction of the Colombian coffee first, and most recently with the coffee Castilla, species more resistant to this pest.

Livestock farming is traditional, without pasture improvement, where it leaves the cattle loose, being vaccinated only when necessary.

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The traditions related to planting and harvesting have been lost with the introduction of techniques and the transformation of the climate; previously it had specific times of planting as San Martin (29 March), La Candelaria (15 February) and San Jose (19 March) for beans and corn; the harvest of these products were as this: the beans at 7 weeks, the dry corn at 4 months and the choco or child corn at 3 months. At the moment, young people seem to show little interest in agriculture and this knowledge have fallen into disuse and tend to disappear with the death of persons who possess it.

Some chemicals are used to control weeds and pests in crops and pastures. Although, some adults have some knowledge about the biological control of pests in the cane as wasps and bees.

- Vereda (Political and administrative division of the municipality located in the rural area)
Los Mangos

The cane is cut, it is sown in any time of the year, grind weekly and the cycle is of a year to get to where they started. For planting bananas is extracted a Choline of the plant in the waning phase of the moon, they make the holes 40 cm in distance from each other, and plant them.. There is no practice to the use of fertilizers because of their high cost.

In some Trapiches horses are used as draft beasts and in others diesel or electric engines are used, in order to move crusher machines; in the kilns used the sugarcane bagasse as fuel. Some dwellings account with efficient stoves, although there was also cooking with gas and firewood; these energy sources will be alternating, in accordance with the duration of the process of preparation and cooking of the food; for example, foods that require more time for cooking, are cooked with wood, in order to save gas. In some cases using the electrical energy for cooking, although it is considered that this source of energy is not efficient for cooking.

In this Vereda (Political and administrative division of the municipality located in the rural area), according to data collected during the field work, fishing or hunting are not practiced.

On the other hand, with respect to the productive mode, in this Vereda (*Political and administrative division of the municipality located in the rural area*) economic activity, forms and livelihood strategies revolve around the daily farm work, agriculture of sugar cane and bananas, and sustaining some dairy cows for domestic use. The average number of children per family is three and the income of approximately \$300,000 pesos a month. The entire family collaborates in agricultural work and share the profits.

Planting products such as plantain, cassava, beans, corn and cane especially. Coffee production has decreased, the same as the cocoa; as another strategy planting vegetables such as squash to sell and raise livestock in low proportion and hens. The marketing of the production is done basically in the center of the urban municipality of Cocorná.

- Vereda (Political and administrative division of the municipality located in the rural area)
El Choco

In the cultivation of cane, to the four or five months will be cleaned, leaves sprouting and the female cane will be culling. In accordance with the tradition, was spread over the court and was culling.

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Chemicals are not used in the cultivation of sugarcane; using the composting obtained from the same degradation of the bagasse. Every two or three months 40 or 50 packages are obtained. As a fuel, it uses the sugarcane bagasse and firewood.

The Vereda (*Political and administrative division of the municipality located in the rural area*) produces panela with mechanized trapiches, which operate with diesel engine and electric machine. The maximum production occurs every 15 or 20 days. On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a Trapiche or "community ramada", to which belong 15 partners. In this are produced up to 25 loads of panela in a day⁸⁶.

The producers of panela are grouped in ASOPACO and some are affiliated to FEDEPANELA. Through the Office of the Secretary of Agriculture of the municipality, was labeled the panela approximately six months ago, mark that must be acquired by the producers to be able to sell their panela. On the other hand, in the community ramadas, it is promoted the non-use of chemicals in the manufacture of panela. Through Photo 3-80Photo 3-83 , illustrates the procedure for the processing of sugarcane in the trapiche community of Vereda (*Political and administrative division of the municipality located in the rural area*)El Choco and Las Playas.



Photo 3-80. Electric motors are used for the grinding of the cane
Source: field work month December 2011



Photo 3-81. Technicity in the cooking process of the panela

⁸⁶ A load is equivalent to 100 kilos of panela

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Source: field work during December 2011



Photo3-82. Development of panela at the Ramada community

Source: field work during December 2011

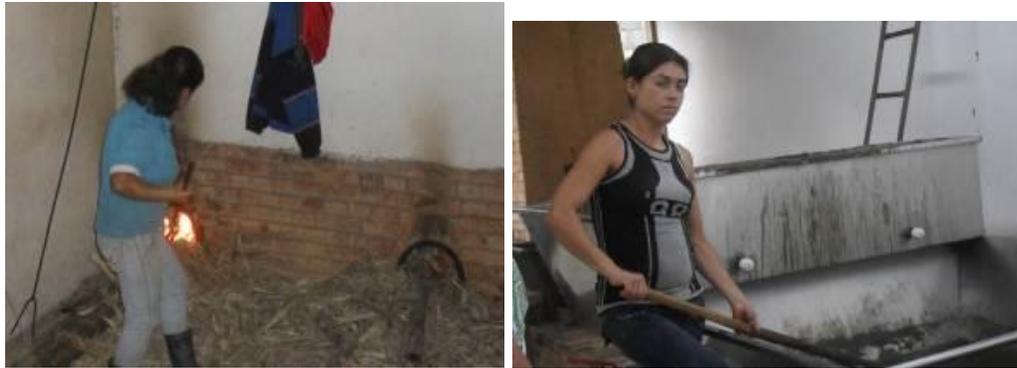


Photo 3-83. Person involved in the process of making the panela

Source: field work during December 2011

In earlier times to the forced displacement, the Vereda (*Political and administrative division of the municipality located in the rural area*) was producing such quantity of food delivering weekly six trucks, which carried the products to Marinilla, La Ceja and Medellín. On the Vereda (*Political and administrative division of the municipality located in the rural area*), at that time, there were collection centers or points where products were concentrated, to then be transported for their marketing.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) is practiced the hunting of animals like guagua, rabbit and gurre, for what is mainly used dogs, shotgun, traps and scaffolding.

With regard to the most important aspects of the production process, on the Vereda (*Political and administrative division of the municipality located in the rural area*) the main economic activity is agriculture and livestock. The main products are sugarcane, coffee, bananas, citrus, cucumber, tomato and passion fruit. In addition, dairy and cattle farming, and breeding of pigs and poultry. In most cases, the milk is for subsistence and for the processing of by-products such as cheese and butter, which are marketed within the Vereda (*Political and administrative division of the municipality located in the rural area*) or are used in the feeding of the family group. Panela is sold on Saturday in Cocorná, El Santuario,

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Marinilla and Rionegro, day in which pass through the Vereda (*Political and administrative division of the municipality located in the rural area*) up to three ladder buses, carrying the production toward the town of Cocorná.

- Vereda (Political and administrative division of the municipality located in the rural area)
San Juan

The method of planting more currently used is the excavation of furrows. Generally, for the establishment of the livestock, there is no improvement of pastures, therefore, there is not an adequate management of soil and it is not known whether the amount of grass is enough or not, for the number of heads or kilograms of weight, that support the paddocks.

The cucumber is permanently planted and harvesting; by tradition, the banana is planted in the waning phase of the moon. At present, the times of planting and harvesting the beans and corn are subject to changes in climate, which according with the sentiments expressed by the peasants, are becoming increasingly stronger, with an increase in rainfall, since it rains more in the area now, than five years ago.

Agrochemicals are used, although they have received training where it is recommended not to use them, especially those in the first category. Those used belong to the third and fourth category as Manzate, Lorban for the labor ants and Tecnomil. These people generally cooked with gas and firewood pipette, alternating its use in order to economize gas, which represents a significant monthly expense.

Occasionally some inhabitants of the urban area of Cocorná hunt animals as guagua and rabbit for home consumption, and sometimes are marketed, although in very little amount.

On the Vereda (Political and administrative division of the municipality located in the rural area), the main economic activity is agriculture, generally worked by men; women and children depend on the father, who is the head of household in most cases. Usually a daily wage will pay \$20,000, and the monthly salary is relative, since this depends on the working days per month. There was a lack of support for the farmer on the part of the state.

The main products are bananas, cucumber and onion, from which the surplus is marketed. Corn and beans are basically for their own consumption. Raise hens and chickens, mainly for subsistence. In this Vereda (*Political and administrative division of the municipality located in the rural area*) there is no panela production.

Products such as bananas and onions are sold in the urban area of Cocorná. However, it is expressed that marketing is not fair, because it is sold to the intermediary and the income generated does not reach a minimum wage per month.

- Vereda (Political and administrative division of the municipality located in the rural area)
Campo Alegre

Earlier in this Vereda (Political and administrative division of the municipality located in the rural area), in the cultivation of sugarcane were used the recaton as an indispensable tool, opening a small hole and placing the Choline in this. At present it is sown with the technique of furrows, there are rows with streets and eras. Also it was mentioned that the cane is different now, because before was also known as the black cane which was called the Mana. The cane grown today is called the "sinpelusa" and is planted in any time of the year.

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On the Vereda (*Political and administrative division of the municipality located in the rural area*) it is customary to cut cane throughout the year and they do not use chemicals for its cultivation. As an energy source in the trapiche it is used the bagasse from sugar cane and sometimes still tires are used, and the electric power for the operation of the engine. The cane processing machine consists of several parts like: table with channels, the masses, the pond, hose, the funds, the oven, the electric motor which is also known as Lister or India, the sieve and the dynamo.

Guagua is hunted with a dog and shotgun with "Ceba", i.e. by dangling hollow disguised by a surface, breaking with the weight of the animal and above, hanging, a bunch of bananas or a fruit. The "ceba" is also put at a distance of a prudent parapet or scaffold, where the hunter mounts with his shotgun, to wait for the guagua.

On the Vereda (Political and administrative division of the municipality located in the rural area), the entire population is engaged in agriculture, but it is considered that this is a work exclusively of men. Women remain in the homes, doing household chores. The main products are sugarcane, banana and coffee; for private consumption is planting tomatoes, beans and corn. Likewise, raise poultry, dairy cattle for their own consumption and horses are kept as beasts of burden and drawbar.

Products such as bananas and onions are sold in the urban area of Cocorná. However, it is expressed that marketing is not just, as it is sold to intermediaries and the income generated does not reach a minimum wage per month.

- Vereda (Political and administrative division of the municipality located in the rural area)
El Molino

In the Vereda (*Political and administrative division of the municipality located in the rural area*) are collected from three to four harvests of vegetables and then letting the ground rest; the corn planting is done on March 19, the day of Saint Joseph and in August, in the festivity of La Candelaria. There are used poisons such as Tamaran, Curacron, Manzate, Lorban and for the cucumber, tomato, chili and bean.

In the processing of sugarcane for obtaining panela, are used beasts of beasts and electric motors.

Related to the productive process, on the Vereda (*Political and administrative division of the municipality located in the rural area*) crops are coffee, cassava, bananas, fruit trees, tomatoes, and sugarcane (see Photo 3-84 and Photo 3-85). Some of the men were engaged working as laborers on private land or farms for other persons of the Vereda (Political and administrative division of the municipality located in the rural area); the daily wage ranges between \$20,000 and \$25,000. On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a garment manufacturing company, in which the work hour pays between \$1,500 and \$2,500 pesos.

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Photo 3-84. Storage of tomato on the Vereda (Political and administrative division of the municipality located in the rural area) El Molino

Source: field work during December 2012.



Photo 3-85. Plantain, maize and sugarcane, three of the base products of the economy of the families in the project influence area

Source: field work during the month of December 2011

There are also raise livestock, beasts of burden, some pigs and a few chickens, although on the Vereda (Political and administrative division of the municipality located in the rural area) is located a shed with approximately 1,500 hens, which generates some jobs for people of the Vereda (Political and administrative division of the municipality located in the rural area). In the past, in El Molino existed a collection center that was an important reference within the trade in the production of the municipality of Cocorná, however, this disappeared when the armed conflict reached its highest peak.

The hunting of guagua is practiced, activity that is usually made with shotgun and with dogs.

Vereda (Political and administrative division of the municipality located in the rural area) Quebradona Abajo

In the Vereda (Political and administrative division of the municipality located in the rural area) are planted different products such as sugarcane, cacao, coffee, cassava and beans.

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They involve some techniques and traditional customs, for example, the cane planting in crescent, the same as for cocoa and bananas. In waning is cut and skim In accordance with the belief and custom, cutting is carried out with machete, so earth do not wash.

Apply some chemicals for the control of pests and diseases in crops and cattle, among these were mentioned Whip, kills labor, venom to fumigate paddocks, stellar to fumigate the eras.

With regard to the processing of the cane for the production of panela, ACPM machines, electric motors, and presses with beast are used.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) the practice of hunting animals of mount as guagua and rabbit, with dogs, guns and trap is common.

Related to the productive process, in the Vereda (*Political and administrative division of the municipality located in the rural area*) the main economic activity is agriculture, where men perform with greater dedication, because women are concentrated mainly in the housework. The people of the Vereda (*Political and administrative division of the municipality located in the rural area*) receive approximately \$300,000 or \$400,000 per month, in the agricultural work; normally all the members of the household cooperate, with greater dedication of men.

The main products are sugarcane and coffee. For subsistence crops planting bananas, cassava and string bean; it has recently been introduced cocoa. In addition, there are beasts of burden, cattle in low proportion, and some pigs, there is also a shed with more than 100 hens. The marketing of the products is performed in the headers of Granada and Cocorná; some take their products to El Santuario, especially string bean, plantain and cassava.

- Vereda (Political and administrative division of the municipality located in the rural area)
Las Faldas

The cane is usually sown in rows or in "chorrillo", without any distance between plant and plant; the cut is made or distributed, taking the mature cane.

According to the population's perception of the Vereda (Political and administrative division of the municipality located in the rural area), in the present has been presented a lot of variation of the climate; in earlier times it was expected the waning phase of the moon for planting some crops such as bananas; and the cane was believed, had better results if cultivated in the crescent phase.

At the traditional trapiche the bagasse is used as fuel and the CMPA for engines of machinery of the cane crusher. On the Vereda (*Political and administrative division of the municipality located in the rural area*) there are mechanized trapiches for the processing of sugarcane and production of panela, and there is a successful experience of community panela engagement, which received contributions of Social Action of the Presidency of the Republic, CORNARE, Government of Antioquia, the municipality of Granada, the community and FEDEPANELA. In this project, which has 15 partners, is looking for and promotes that the process is completely natural without adding chemicals.

By variations in climate, farmers are claiming to be very affected by the presence of pests in crops. In the present are used products as Tamarán, Lorban liquid and powder against leaf-

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cutting ants and other diseases. On the other hand, on the Vereda (*Political and administrative division of the municipality located in the rural area*) there is no hunting or fishing.

The main economic activity in Las Faldas is agriculture, and in this work men and women participate, although the man is the one who assumes the role of head of household. With regard to the improvement of crops and technification, several families purchased credits with the Agrarian Bank. The main products are sugarcane, bananas and coffee. Other products such as beans and tomatoes, are for personal consumption, equally hens and chickens for fattening and the milk that is produced. Usually the number of heads of cattle is very small. Panela is sold in the urban area of Granada, and the coffee to the national federation of coffee growers.

With regard to the structure of production, in sum, a strong support of the economic activity in the Vereda (Political and administrative division of the municipality located in the rural area)of the influence area is the agricultural activity and in this the cultivation and processing of the cane for the production of panela. At the same time, other crops such as bananas, beans, coffee, potato, blackberry, wild fruit, citrus fruits, such as tangerine, guava and to a lesser extent other fruit trees as guanabana, Zapote, Borojo, avocado, and vegetables such as cucumber and tomato. Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino stands out as a producer of tomato and guanabana.

In Cocorná, the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos and Campo Alegre highlighted in the production of sugarcane; Los Mangos, for example, have a share of 9 %. In Granada among the Vereda (*Political and administrative division of the municipality located in the rural area*) were this crop is found more, La Arenosa stands out with a 20% share. The cultivation of bananas without technification associated with coffee, is another item that stands out in some Vereda (Political and administrative division of the municipality located in the rural area)of the influence area; among these are Las Faldas with a 25 %, Quebradona Abajo with 20% and La Arenosa with a 15 %. For its part, El Molino has a share of 6% and Los Mangos is also considered a major coffee producer.

In a widespread manner in these Vereda (*Political and administrative division of the municipality located in the rural area*) of the two municipalities the crops present a low level of technology, which represents high costs and low profitability. Despite this situation, the coffee and bananas have a representative market in the area.

In accordance with the outline and structure of production established in the area, the greater amount of coffee is produced by small independent producers, which generally cultivated land of 0.5 ha to 1 ha. And look to the family labor force, characteristic of peasant production system.

The marketing of these products is usually done in the urban center of Cocorná and Granada, where they are transported to other municipalities in the subregion as El Santuario, Rionegro, Marinilla and toward Medellín. This process demands a great deal of effort and costs for the peasants of the Vereda (*Political and administrative division of the municipality located in the rural area*) due to damaged roads, which in turn affects the frequency of the transport service provision (see Photo 3-86andPhoto 3-87). It is not

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strange to find that in times of abundant production of citrus fruits, such as tangerine and guava, these fruits are lost, because of the difficulties mentioned above, sometimes the peasant collecting orchids prefer not, given that the price offered by these does not compensate for the cost of transport and time.



Photo 3-86. Transport of products by the royal roads or trails
Source: field work during the month of December 2011

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Photo 3-87. The ladder bus picks up the products and carries them to the urban center of the municipality.

Source: field work during the month of December 2011

In a general way, we can say that the levels of articulation for the marketing of their products, is low among the peasants of the various Vereda (*Political and administrative*

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division of the municipality located in the rural area) on the direct influence area of the project. Because on one hand, the state of the roads and thoroughfares and another part to the existing customs versus the level of family income, in where we do not see the possibility of introducing changes as an opportunity.

- Characterize the current labor market

The inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) in the area of direct influence concentrated its occupation in agricultural activity, as has been said; this is the mainstay of the economy and one of the most important in the generation of employment and concentration of the labor force.

However, this productive branch cannot be considered as a formal economic alternative, since all of these tasks are carried out by the farmers themselves owners of their land, focusing on a subsistence economy. In the Vereda (*Political and administrative division of the municipality located in the rural area*) men also work as day laborers, however, by the same circumstances lived with the forced displacement and in the present with the return, there are few jobs generated.

" As a function of survival is present a high aversion to risk, which is manifested in the preference for maintaining a low production of monetary costs (such as that represents the inputs and the labor), little receptivity to credit, which limits their ability to use technology, and little provision in salaried labor.

Associated with the above elements we found high levels of exploitation in the commercial lines, and present high rate of underemployment, particularly in the young peasant population. Also there is a tendency to the development of techniques for survival such as the collection of wild guavas, the migration of peasants in search of work in other regions and localities, the proliferation of the so-called economy of the browse through both at the municipal bedside as along the track Medellín - Bogotá⁸⁷.

On the other hand, the EI Popal hydroelectric project, which is built at the moment by the Consortium BMS, and whose owner is the HMV Company engineers, provides a number of jobs in some of the Vereda (*Political and administrative division of the municipality located in the rural area*) that are a part of this project (see Table 3-122)

Table 3-122. Number of jobs generated by the Project EI Popal of Vereda (Political and administrative division of the municipality located in the rural area) in the influence area of the project EI Molino.

| Municipality | Vereda (Political and administrative division of the municipality located in the rural area) | Number of jobs generated during January 2012 |
|--------------|--|--|
| Cocorná | Los Mangos | 5 |
| | La Inmaculada | 8 |
| | San Lorenzo | 39 |
| Total | | 52 |

Source: Social Development Team own SAG, based on data from field work

⁸⁷ Scheme of territorial order of the Municipality of Cocorná, 2000.

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- Programs or private projects, private, public /or community, ongoing or planned.

According to the information recorded in the web page of the municipality of Granada, "There are registered 40 projects in the bank of programs and projects. Of these, 14 are executed or in process of execution"⁸⁸.

On the other hand, in the evaluation of the Development Plan of the Vereda (*Political and administrative division of the municipality located in the rural area*) 2008-2011, mention is made of the programs and projects that up to March of year 2011 had been executed or advanced a percentage in its execution, among those related to the improvement of the life quality of life of the population are named the following:

- Strengthening community organizations. 47 groups were assisted, with an investment of 67 million. Promotion in different spaces with the participation of children and adolescents and implementation of the policy of youth and children, with 40% implemented a public policy on youth, election of the CMJ and Mayor and an investment of 85 million. Planning for education (PEM, PEI and improvement plans), with 100 % municipal educational plan formulated and implemented, with an investment of 2 million and a half. Expansion of the educational service (educational coverage: farmer bachelor, post primary and secondary), with an investment of 12 million. Improvement of the educational infrastructure, to improve six I. E or C. E. R, in the physical infrastructure, with an investment of 533 million.
- Improve the health service to the population of the municipality, with the identification of beneficiaries and health insurance, with an investment of 10 million. Improve the public health programs in the municipality, for the health promotion and disease prevention, with an investment of 502 million. Development and implementation of the Territorial Plan of Health, with 100% designed and implemented the Health Plan Municipal Territorial, with an investment of 147 million. Improve the development of special programs for the population of the municipality, with the implementation of the Single Comprehensive Plan to care for the displaced population with an investment of 1.100 Million.
- Home improvement or construction to improve 300 housing units in their living conditions, with an investment of 282 million. Improve the agro-industrial development through the strengthening of the productive chain and transformation of fruit trees in the municipality of Granada, to support 171 users for strengthening fruit, with an investment of 4,300 million. Improve the agro-industrial development through the strengthening of the productive chain of milk, with the deployment of a livestock project dual purpose with 300 families in the town, with an investment of 80 million. Improve the productivity and livestock competitiveness through the implementation of a project of minor species (birds and fish), with the improvement of livestock productivity with 20 fish ponds and 10 sheds for birds, with an investment of 28 million. Improving agricultural productivity and competitiveness through the implementation of a project for the production of traditional crops (potatoes, beans, carrots, coffee and yucca. Among others), with the improvement

⁸⁸ ASSESSMENT DEVELOPMENT PLAN (Period 2008 - 2010). Available in http://www.granada-antioquia.gov.co/index.php?option=com_remository&Itemid=116&func=finishdown&id=411

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of agricultural productivity and competitiveness of 240 families with traditional crops, with an investment of 18,000 million.

- Improve the marketing processes of agricultural products, by structuring business plans and the development of strategic alliances through the municipality of Granada, with four business plans made and four alliances, implemented with entities, without investment set forth. Improvement of the communication channels of the municipality with the improvement of the tertiary roads, with an investment of 220 million. Comprehensive Project of drinking water and basic sanitation, with the implementation of 10 campaigns of training the community on issues of drinking water and basic sanitation, improvement or construction of 100 wells and septic tanks UNISAFAS, 100% updated and deployed the PGIRS Municipal, with an investment of 727 million. Improve the infrastructure and the facilities of the municipality, with improvement or construction of two communal huts, perform annual maintenance to the urban and rural sporting infrastructure annually, with an investment of 98 million⁸⁹.

For its part, the multi annual investment Plan 2008-2011 of the municipality of Cocorná, listed for implementation programs and projects such as upgrading and maintenance of rural and urban roads, drinking water and basic sanitation, educational infrastructure, strengthening community participation, improvement of public facilities, among others.

In addition, the two municipalities develop programs such as MANÁ, mental health program with the Departmental Office of Health of Antioquia, attention to the displaced population in DAPARD; with ICBF school restaurants, food package for older adults, hot lunch. Planning consulting with the Department of Planning of the Department of Antioquia, Program illuminated Antioquia with the government of Antioquia. With the Ministry of Social Protection, subsidies for the older adult. Families in Action, Emergency Humanitarian Aid and housing subsidies with Social Action of the Presidency of the Republic, among others.

On the other hand, in agreement with the arguments raised by the strategic lines of the development plans of the municipalities of Cocorná and Granada, were mentioned in both projects that in one way or another, are involved the Vereda (Political and administrative division of the municipality located in the rural area) in the project direct influence area. For example, in the PDM of Granada, in the axis of Social Development, which includes the agricultural sector, it is proposed the program "Strengthening of the productive chain of sugar cane for panela", where it was stated that the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas is one of those included in the draft, which includes 'technical accompaniment of the integral project *in the basin of Santa Ana, in agreement with the CISP, FAO and the Government of Antioquia - Secretary of Agriculture and Rural Development for the organization of the social base of three groups of sugarcane producers (72 technical assistance visits, 24 workshops and start the construction of a community trapiche Group Los Luchadores Vereda (Political and administrative division of the municipality located in the rural area) Las Faldas with a total investment of \$265,000,000)*".

Likewise, in the axis Social-Sector environmental development, it includes the same Vereda (*Political and administrative division of the municipality located in the rural area*) Program in

⁸⁹ Ibid.

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the strengthening of coffee production, through the renewal of coffee plants-convention National Federation of Coffee Growers and COOGRANADA: Renewal by planting 200,000 coffee trees on the Vereda (Political and administrative division of the municipality located in the rural area)of Santa Ana, Eden, Buena Vista, La Aguada, Quebradona Abajo, Las Faldas, Galilea, Los Planes and Los Medios (value of the project \$149,997,741).⁹⁰

On the other hand, in the PDM Cocorná on the strategic line 1 articulation and integration of the cocornense territory, in the Program Bridges, raises the Maintenance or improvement of pedestrian bridges in the rural area, as an articulator mechanism of the vial mesh in Cocorna. Recovery of La Arenosa, Pisquinal, La Tolda, Majagual, Sinai and other bridges.

In the infrastructure, in the public infrastructure program, it is benefiting the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, with the Project Suitability or improvement of the rural health posts; it includes all the Vereda (Political and administrative division of the municipality located in the rural area)in the municipality; in the infrastructure program of drinking water and basic sanitation, with the expansion and improvement project of rural educational centers-maintenance and improvement of educational facilities and school restaurants, including the I. E Cocorná, CER Campo Alegre and the Florida Project (CISP) and in the Program sports infrastructure, is the Vereda (*Political and administrative division of the municipality located in the rural area*) San Juan which is included with the construction of sports plates in the rural area of the municipality, as a mechanism of community integration, whose aim is to build four sports plates in the rural area: High of the Virgin, San Juan, El Recreo and other⁹¹.

Also as part of the Project El Popal, which is being built by the Consortium BMS and whose owner is HMV Engineers, currently running several projects that are part of the investment of 1% stipulated by the Colombian environmental legislation; among these is the construction of septic tanks and efficient stoves in La Aurora, San Lorenzo, La Piñuela and La Inmaculada, improvement of the aqueduct in the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo, construction of part of the sewerage system of the inhabited center La Piñuela.

In the framework of this same project, are now also running the programs of the Environmental Management Plan, which aimed at the improvement of the life quality of the population in the Vereda (Political and administrative division of the municipality located in the rural area)of the direct influence area; some of these include: Memory program and cultural heritage, community education program, program of rural entrepreneurship, rescue, monitoring and archaeological disclosure.

On the other hand, according to the information supplied by the chairmen of the boards of communal action of each Vereda (Political and administrative division of the municipality located in the rural area), in these have been carried out or hope to develop different projects in accordance with specific needs, among these mentions:

- Vereda (Political and administrative division of the municipality located in the rural area) Las Faldas

⁹⁰ Mayor of Granada. Development Plan municipality of Granada. Toward an inclusive Granada, solidary and in peace. 2008-2011

⁹¹ Mayor. Development Plan of the municipality of Cocorná 2008-2011. Development with Equity

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Within the projects in which has participated the JAC are a community store, which was liquidated and the product of this was destined to the purchase of cattle. The pana agro business Los Luchadores, is another project from which they have obtained very good results, being a successful experience of sustainable collective work, in addition the program "Returning is to live" is being conducted in conjunction with the Presidential Agency for Social Action and International Cooperation, Social Action⁹², also advanced the project "Huellas" with CORNARE and the municipality, which consisted in the delivery and implementation of the use of efficient stoves. Improving housing is being developed in conjunction with the Agricultural Bank and the Municipality.

- Vereda (Political and administrative division of the municipality located in the rural area) Quebradona Abajo

At present the most important project for the community; is the reconstruction of the bridge that connects the Vereda (*Political and administrative division of the municipality located in the rural area*) with Cocorná and Granada. This bridge was felled by an avalanche that occurred at the beginning of the year 2011, as a result of the intense winter wave. As a result, for the inhabitants of Quebradona Abajo is a priority to re-establish communication with the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Playas in Cocorná, Los Planes, Las Faldas, Quebrada Arriba and El Molino

Some inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) are participating in the program as an incentive to the return of displaced persons Return is Live, developed by the Presidential Agency for Social Action and International Cooperation - Social Action.

- Vereda (Political and administrative division of the municipality located in the rural area) San Juan

Through the Community Action Board projects have been developed as the installation of six septic tanks, through an agreement between the municipality of Cocorná and CORNARE.

It was also carried out a project for the improvement of housing, where it took 22 houses, with construction of a room of 2 m x 2 m, a bathroom and floors. The JAC plans to obtain resources to carry out a project of basic sanitation, by making a request to the municipal administration, as well as retrieved the sports board that collapsed due to the effects of a geological fault.

⁹² The Presidential Agency for Social Action and International Cooperation - SOCIAL ACTION, is the entity of the National Government that seeks to mobilize Colombia to overcome extreme poverty, advance in the reconciliation and lead the agenda of international cooperation of the country.

To achieve this purpose, the entity develops actions with victims of violence and displacement, aimed at ensuring returns and deliver the administrative redress where appropriate.

Within the work are the coordination of the National System of Care for the Displaced Population, the Network for Overcoming Extreme Poverty - USA, the National System of International Cooperation and the Coordination Center for Integral Action.

It also benefits the poorest with programs such as families in Action, income generation, infrastructure, food security and with its action contributes to the generation of conditions for peace and prosperity with programs such as the Group for Development and Peace. Available at:

<http://www.accionsocial.gov.co/contenido/contenido.aspx?catID=3&conID=544&pagID=820>

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- Vereda (Political and administrative division of the municipality located in the rural area)
Campo Alegre

In the present is ahead the Program Return is to Live, in conjunction with the Presidential Agency for Social Action and International Cooperation, Social Action; in accordance with the established process, on the Vereda (*Political and administrative division of the municipality located in the rural area*) the people affected by armed conflict have already signed up and the population has already been characterized.

- Vereda (Political and administrative division of the municipality located in the rural area)
El Molino

The greater emphasis and projection of the Community Action Board has been the improvement of the track, this is done through treats each month; recently received contributions from the Presidential Agency for Social Action and International Cooperation - Social Action, for the construction of a tranche of railing that allows the access of the ladder buses that provide the service of transporting cargo and passengers on the Vereda (Political and administrative division of the municipality located in the rural area); also with this same Agency is anticipating the implementation of the Program Return is to Live, where the population victim of forced displacement has already been registered and characterized; similarly, it has been carried out improvements in some houses, and the aqueduct, also occupies a good part of the Management of the Community Action Board.

- Vereda (Political and administrative division of the municipality located in the rural area)
El Choco

In the present with the Office of the mayor of the municipality and the Presidential Agency for Social Action and International Cooperation - Social Action, they put forward the implementation of the Program Return is to Live, through which are managed to aid the people who are returning, after the displacement caused by the armed conflict.

Has also been made for home improvement on the Vereda (Political and administrative division of the municipality located in the rural area); apparently there are still 14 families to be linked to this program.

With CORNARE campaigns have been conducted for the planting of trees, protection of creeks, and has done cleaning of water sources.

- Vereda (Political and administrative division of the municipality located in the rural area)
Los Mangos

One of the priorities of the Community Action Board is to keep the bridle path in good condition, organizing treats each month to do maintenance at the same; as in the other paths of the project influence area, some people participating in the program as an incentive to return of displaced persons "Returning is to live", developed by the Presidential Agency for Social Action and International Cooperation - Social Action, in conjunction with the Municipal Administration.

- Vereda (Political and administrative division of the municipality located in the rural area)
La Inmaculada

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At present, the Community Action Board in conjunction with HMV engineers, advancing the process of adoption of efficient stoves in the Vereda (Political and administrative division of the municipality located in the rural area), for this there is a contribution in material by the Company and the community should contribute with the workforce. At the same time, sowing must be done to ensure the orchard Leñero that will assist the proper functioning of these stoves. Also with HMV engineers will advance the installation of several septic tanks.

In addition, it has made the improvement of some houses with the participation of the municipality; this improved ceilings, floors and rooms were constructed on some houses.

Currently the program is implemented as an incentive for the return of displaced persons with Presidential Agency for Social Action and International Cooperation, Social Action, for which the entire population was registered and characterized.

In previous years was carried out⁹³ a PRISER in convention with CORNARE, in where were supplied corn and beans seeds, reforestation was made and planted grazing grass as brachiaria and king grass to keep the supply of cattle and beasts of burden.

- Vereda (Political and administrative division of the municipality located in the rural area) San Lorenzo

The inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) have been beneficiaries of several improvement projects on housing, but it is still necessary to improve other homes that are in poor condition. In this sense, was developed with input from ARGOS and DAPARD, a project where homes were awarded to seven families, with staffing some furniture and fixtures (beds, cots and buckets). Also, with the Committee of Coffee Growers, were built five houses and 24 improvements, consisting of construction of material parts and bathroom, or kitchen and bathroom.

The Community Action Board currently plans the preparation and submission of a project for water purification. Another project is the construction of the playground with the support of CORNARE and HMV engineers, using points earned with the collection of recyclable material.

In addition, with advice and contribution of the SENA, were lifted 250 chickens for fattening, where the SENA donated the chickens and the necessary nourishment for sustenance. For its part, the shed was built with contributions from the project's builder consortium El Popal (donated cement) and the Cooperative Pius XII (donated troughs).

⁹³ The Program for the exchange of **services -PRISER** - that delivers through their actions to each of the strategies of the Action Plan of the Corporation, was born 19 years ago in order to build local development actions with the community that becomes reality through the development and implementation of environmental projects that were sized in accordance with the needs of the same.

This program will solve environmental problems, which contribute to the Management, Conservation and Recovery of the Natural Resources of the region, converting the communities in managing and motivating for their own development through the participation, management, consultation and community organization.

This program conceived with human vision and from and to the man, who through time constructs a social fabric is reflected in leaders project managers of resources, jobs participatory, coordinators and administrators of their own projects. Cornare recognizes them for their labor as a significant contribution in the implementation of the same and an important resource as seed capital, including for other projects which in its majority continued to be environmental. Available at: http://www.cornare.gov.co/index.php?option=com_content&view=article&id=144&Itemid=173&lang=es

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Was carried out with other draft PRISER CORNARE, where reforestation was done, were delivered five efficient stoves and five septic tanks, elements that were raffled among the members of the ecological group.

The people who suffered forced displacement due to conflict, are participating in the programs Return is Live - families in their land, advance by Social Action of the Presidency of the Republic.

3.4.4 CULTURAL DIMENSION

3.4.4.1 Area of indirect influence

- Cultural characterization of not ethnic communities

In the historical overview outlined below on the East of Antioquia and the municipalities of Granada and Cocorná, it is important to take into account the recent history, where the armed conflict interrupted dynamic links built by centuries. Among the most dire manifestations of the war, the forced displacement framed predominantly the following years or what has been called the "post-conflict", where the population which have returned tries to return to an own medium, today the circumstances and the need to re-start and rebuild what was destroyed, makes it look like oblivious.

In the Subregion Reservoirs, where is located the municipality of Granada, the initial peopling occurred from different migratory movements raised by economic expansion projects addressed by centers of political and economic power as in Marinilla and Rionegro. Where in colonial times, these population movements were led by miners and free landless, which, in addition to working the agriculture and mining, linked sooner or later in the commercial activities that were established by the roads leading to the Magdalena River.

"It is clear that the occupation of this sector of the East had as the main argument to extend the economic border of Rionegro and Marinilla, as well as diversifying the productive activities carried out in each one of them and by this track strengthen its position of power centers; during this process resulted the forming of the Indian Vereda (Political and administrative division of the municipality located in the rural area) of El Penol which appears as the oldest of the foundations in this sector.

In parallel, there was the emergence of cooperation strategies intra and supra family that enabled diagrams of solidarity that is given went beyond the colonial restrictions between socio racial units. These alliances would almost certainly be the basis of new forms of partnership for the production, access to land and the exchange of goods production without having to count with capital for their achievement in local markets. Among them, special importance were the cronyism and the gamonalism, which then, during the nineteenth century would shape as part of the paradigm of parental social order of the republican Antioquia, in the dynamics of power relationships of local and regional order"⁹⁴.

⁹⁴ Binnacle. SUBREGIONAL PROCESSES: heterogeneity of the historical rhythms. Available at: <http://historico.prodepaz.org/1bitacora/5.htm> . Accessed December 29, 2011

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This dynamic originated from a series of population movements that ranged in accordance with the pace of economic activities, especially the trade, which demanded labor in trades such as freighters and muleteers. To which is added the population that moved around activities such as agriculture and animal husbandry, where subsequently departed to exercise as independent miners and later they were on their way to colonize some place where they took possession and started establishing crops for auto consumption. This property could be regular or permanent, in accordance with the gold mining in the area.

"This occasion also marked the way for the emergence of Granada and San Rafael, both populations are highly dependent on Marinilla as center of power and much more in commercial transactions on the proverbial way of Nare.

Grenada, also known as Vahos, is an extension of the migration generated from Marinilla whose interest was basically the opening of sites for the establishment of cattle herds, its foundation goes back toward 1814, but it is clear that the settlement can be located somewhat more back, because in this sector was already known the presence of some farms raised by neighbors of Marinilla and Rionegro, it was a dispersed population dedicated to the ongoing work of clearing, agriculture and mining. Development that additionally reached benefits as a site for step, overshadowed with the construction of the road to Santo Domingo and later with the construction of the railway of Antioquia" ⁹⁵ .

For its part, the migratory processes that occurred around Cocorná also originated in the expansionist process and dispute of the political and economic power between Rionegro and Marinilla, because, " *the offset of the agricultural frontier from the Valley of Aburra toward Guarne and the interest of rionegreros and marinillos and take advantage of the channels of communication to the Magdalena River by the road of Nare, conducive that inhabitants of the East and various sectors of the province of Antioquia seek sites located in the vicinity of the stewardship of the land of El Penol, to hook as workers, or sharecroppers. As a result of these pressures, the indigenous population was forced to undertake processes of colonization by their own account, abandoning the safeguards and addressing sectors away as the jungles of Cocorná and San Carlos [...]*"⁹⁶ .

At the same time, the refolding of the indigenous population on the part of the mestizo colonization, brought back a result as was the expropriation of land to some rich owners, for the creation of a safeguard of Indians in the vicinity of El Penol this land cession was offset by the Spanish crown with the award of those owners of new land in the vicinity of what today is the municipality of Cocorná, which later lead to a further migration toward the mentioned municipality of population that came to engage "the cultivation of cassava, arracacha, chili, cucumber, corn and some fruit trees. Also to the breeding of some domestic birds as piscos, chickens and turkeys; to the care of cattle ranches and mining work (Giraldo sf: 40). Products which in turn served to pay the tribute to the crown [...].

[...] arise then populations such as San Luis, Cocorná and San Francisco, in the lands of the former concessions Arbelaez and Zuluaga Duque; it is precisely in these lands far away from the institutional controls were indians who seeked asylum and free blacks and in some cases miners and gangs of slaves, in addition to free landless, who took advantage that

⁹⁵ Ibid.

⁹⁶ SUBREGIONAL PROCESSES: heterogeneity of the historical rhythms Available at: <http://historico.prodepaz.org/1bitacora/5.htm> . Accessed December 29, 2011

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dealers had made few improvements to their land. This particularity of owned land but wasteland, was decisive for the localization of scattered families, who most of the times, seeking escape from the regime of colonial administration and develop in a much more independent manner the exploitation of this vast territory, a circumstance that extends up to the twentieth century, when it is evidenced a strong population growth, fruit of the establishment of the state control agencies and with the dynamics of market economies of global trend; new order that led to the dispute of marking areas of interest not only official" ⁹⁷

This whole dynamic immigration would subsequently result in processes of social and economic interaction, that would in turn be cornerstone of the miscegenation and consolidation of a type of own population in the subregion.

As can be seen, the economic activities as an adaptation strategy, have played one of the most important roles in the consolidation of the current territory and the formation of the type of population, along with the dynamic economic and policies initiated by centers of power as Rionegro and Marinilla.

" At present, the contemporary economy has turned around to unique ways of production, since activities profitable during the colonial period and even Republican such as cattle ranching, mining and agriculture gradually caved in to pressure from exogenous and allowed during the second half of the twentieth century, the emergence of the tourism industry in the with the construction of the hydroelectric complex El Penol - Guatapé between 1964 and 1978, as part of the infrastructure required for the installation of the nascent industrial process of eastern Antioquia. It was a mega project that resulted in a strong trauma on the territory, because the flood wiped off the classic marks of the territory and limits were placed on the use of the space. As a result of these actions was raised on the part of the project owner (E. E. P. P) take advantage of the resort area for the development of tourism as a strategy to reduce the levels of impact on the communities; however, in spite of the clear intention to reduce the levels of affectation it did not contemplate the high social cost involved and the strong alteration that would result in the scheme of values of each of the Vereda (Political and administrative division of the municipality located in the rural area)involved in this process" ⁹⁸ .

Another notable aspect in this picture, and with which the beginning of the present, is the armed conflict, its escalation, and consequences, that has to do with the cultural transformation and its effects on the adaptive strategies and way of life.

" The military strategy adopted by the illegal armed groups has set up new spaces for use, has determined the system of land tenure and has taken other logical for the use of the soil; each of these elements determines in a radical way the access to the resources and the solidarity mechanisms of partnership for production, in which it is evident a splitting of the social fabric represented by leaders fearing for their safety and security and to those who have severe restrictions on the possibility of autonomous management" ⁹⁹ .

⁹⁷ SUBREGIONAL PROCESSES: heterogeneity of the historical rhythms. Available at: <http://historico.prodepaz.org/1bitacora/5.htm> . Accessed December 29, 2011

⁹⁸ Binnacle SUBREGIONAL PROCESSES: heterogeneity of the historical rhythms Available at: <http://historico.prodepaz.org/1bitacora/5.htm> . Accessed December 29, 2011

⁹⁹ Binnacle SUBREGIONAL PROCESSES: heterogeneity of the historical rhythms. Available at: <http://historico.prodepaz.org/1bitacora/5.htm> . Accessed December 29, 2011

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Currently, populations as Cocorná and Granada seek to restore their ancient socio-economic and cultural dynamic, following the alleged culmination of a war that affected economic activities by the displacement and led to the abandonment of plots and to the adoption of a new style of life in urban and strange contexts, usually in cities such as Cali, Barranquilla, and Bogotá.

In sum, with regard to facts that can be registered as changes in the cultural system and effects on adaptive strategies, we can say that the subregion with the highest incidence on the others as is of the Plateau, has introduced changes to general level, in terms of the implementation of modern infrastructure, both public and private, that has meant processes of mobilization of people between one and another municipality and the proximity to Medellín, also in a process of steady growth, and with an eye toward human resources and raw materials existing in the subregion, has led to the introduction of new cultural referents and the cultural mix that will normally originate in spaces for socio-economic and cultural interactions

Also, as has been said, the armed conflict is spearhead of profound transformations, since displacement, in addition to the economic consequences, brought in many cases, the social displacement with the resulting cultural changes. In this sense, although a part of the peasant population displaced is returning today, another segment of this population was established in other cities, where they develop another type of economic activity other than agriculture and is not willing to return; this situation is occurring especially among the young population.

The historical context that summarily has been constructed in the present text, gives an account of the processes of delimitation of the territory as geographical space and the development and constitution of the territoriality as socially constructed space by the inhabitants of the subregion of the eastern Antioquia and the municipalities of Granada and Cocorná.

In this regard, while the eastern Antioquia has been characterized by a wealth and diversity of supply in the natural resources and a great potential for its use, it is precisely this image of the abundance, existing between insiders and outsiders, which currently is promoting degradation processes and major environmental problems.

For example, with regard to the water, in the subregional profile of eastern Antioquia (2003), it is mentioned that "*in the population of the subregion there are few conservation habits, regulation and management of water resources, and in such circumstances, many municipalities that for all its territories still have lower rates of scarcity to the 20% or even 10 %, will have to rely in the near future to alternative supply sources*"¹⁰⁰.

The basin of the North Samaná River where in addition to other towns such as San Carlos and San Rafael, are Granada and Cocorná, is characterized by being ecologically fragile, with a considerable number of own and typical animal and plant species, whose conservation deserves a special attention, with problems that are generating a noticeable decrease in wildlife and a gradual and growing impoverishment of the population, a situation exacerbated by the effects of armed conflict.

¹⁰⁰ Subregional Profile of eastern Antioquia, 2003.

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With regard to soil and its use, the process of expansion of the agricultural frontier and livestock is increasing, with allocation of forested areas and exposure of fragile soils, have also caused impacts on natural forests. In addition, contamination of the resource with the use of agrochemicals in agricultural activities and fuel for the processing of sugarcane and the management and disposal of solid and liquid waste.

In some cases, there is also evidence of anthropic pressure by the occupation of fragile areas and hillside, exacerbating the situation of threat and risk to the people and the housing infrastructure and social and collective as idem, by landslides, subsidence and torrential avenues, among others.

In regard to the air, in a subregional context, industries do comply with the provisions of legislation; at the level of the municipalities of Cocorná and Granada, the problematic in this regard is low, associated with the absence of large-scale industries in these two territories.

In the forest, in accordance with the subregional profile of eastern Antioquia (2003), *“The knowledge of forest ecosystems in the subregion has been directed to the humid forests and highly humid tropical, it is necessary to direct efforts to the knowledge of the other forest ecosystems, Páramo of Sonson, cloud forests, dry forest. Although the largest area coverage in life zones corresponds to the very wet low montano forest”*.

Anyway, during the field work was evident in a sector, the extraction of timber, with a chainsaw, for sale in some municipalities of the coast and in Medellín. Likewise, it makes use of some timber species of the forest for the manufacture and sale of coal.

According to data of the subregional profile of eastern Antioquia (2003), and contributed by CORNARE, the main causes of these problems, associated with the form they are appropriated and establishes a relationship with the environmental resources are:

- Lack of knowledge about the wealth of resources and biodiversity.
- Existence of a culture oriented toward the exploitation of resources but not to its conservation.
- Existence of productive practices with minimum levels of conservation.
- Unplanned Changes in the productive vocation and land uses.
- Increase in the demand for land.
- Pressure by greater agricultural production leading to the irrational exploitation and the misuse of agricultural chemicals and pollutants.
- Primacy of private interests in the management and ownership of the resources.
- Reactive institutional actions.
- Low organizational and inter-institutional coordination among entities of local character, subregional and departmental, in the field of planning and implementing policies.
- Weak management training and new forms of resource use.

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- Educational offerings in environmental decontextualized matter and of little relevance¹⁰¹ .

On the other hand, the main features of this imbalance in the development and appropriation of natural resources on the part of the inhabitants of the area where Cocorná and Granada are:

- " In the area of reservoirs, the phenomena of degradation have resulted in the loss of the peasant vocation, decrease in agricultural food production, sedimentation of the dams and in particular, the type of political conflicts around the exploitation of energy resources .

*For the area of forests, the analysis of the diagnostics emphasizing aspects as socio political conflict by the exploitation of mineral resources, declining agricultural productivity by migration and forced displacement of the population, indiscriminate felling of woodland and erosion in areas adjacent to the road infrastructure "*¹⁰² .

- For its part, in relation to the appropriation of natural resources, in the rural area families continue to prepare their food by cooking with firewood, which is still abundant on their premises or nearby mountains, the fuel which alternate with the use of gas pipette, by what CORNARE has been promoting the program of the so called Efficient Stoves, of good acceptance among the population of the Vereda (Political and administrative division of the municipality located in the rural area)s.
- In the Forests and Waters areas are abundant springs, by which the Vereda (*Political and administrative division of the municipality located in the rural area*) aqueducts or the need for safe drinking water for homes and trapiches, is not a priority project for the rural community action. However, at present is seen and attaches importance to the fact that they are able to count with drinking water for human consumption.
- In the agricultural activity, especially in the cultivation and harvesting of the cane, still survive certain ancestral practices, based on inherited knowledge and in a seasonal calendar associated with moon phases and elements as the religious celebration to some saints such as St Martin (29 March), La Candelaria (15 February) and Saint Joseph. (19 March).
- Outside of the agricultural and livestock activity, although it is on a smaller scale, some farmers still rely upon the removal of common woods, to the exhaustion of those considered fine. In spite of abundant water resources, fishing is not a usual activity since, in certain areas, fish resources have been exhausted before the pollution caused by erosion, the wastewater and intensive agricultural activity.
- The violence in these municipalities changed the human landscape and some Vereda (*Political and administrative division of the municipality located in the rural area*) swept with everything that the communities had built over decades, not only the material, but with their roots and their cultural practices and knowledge.
- Cultural characterization ethnic communities.

¹⁰¹ Subregional Profile of eastern Antioquia (2003)

¹⁰² Subregional Profile of eastern Antioquia, 2003.

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Despite the ethnic auto recognition that some residents of the two municipalities have to be considered as blacks, mulattoes, afro or afro-colombian and indigenous, the figures dropped in the 2005 census,¹⁰³ speak of 0.2 % and 0.3 % for the municipalities of Cocorná and Granada, respectively, in the area are not officially recorded black and indigenous communities, in accordance with the certifications of the Ministry of the Interior and the Colombian Rural Development Institute, which are presented in Annex 1 and 2, respectively.

3.4.4.2 Direct area of influence

- Cultural modifications, potentialities, resistance and capacity to adapt to change.

As has been mentioned, the population of the different Vereda (*Political and administrative division of the municipality located in the rural area*) that make up the direct project influence area was subject to the effects of armed conflict in the area, which showed an escalation between the years 2000 and 2002, epoch in which were carried out targeted assassinations, massacres, kidnappings, retentions, torture, invasion of farms in the civilian population, among other violent actions.

In the present will be a separate brief context of the situation lived in the Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area and the manner in which these circumstances changed some cultural elements or impacted in one way or another in the cultural system and in the transformation of the territory, which is support of cultural expressions.

- Vereda (Political and administrative division of the municipality located in the rural area)
Las Faldas

In the era of armed conflict and as a result of this, was presented a massive displacement of the population; some families moved to Medellin, Bogota, Barranquilla, in where they had family members or just looking to safeguard their lives.

It is important to bear in mind that before the forced displacement, on the Vereda (*Political and administrative division of the municipality located in the rural area*) were families that had lived all the time in it; after the displacement and in 2008, began to arrive other people from Medellin, which stayed in Las Faldas.

- Vereda (Political and administrative division of the municipality located in the rural area)
Quebradona Abajo

Most of the population from the Vereda (*Political and administrative division of the municipality located in the rural area*) that was displaced by the armed conflict, did it between the years 2000 and 2001; this trip involved a collective agreement, which led to that in the year 2001 will hire a ladder bus where they moved the majority of inhabitants of the Vereda (Political and administrative division of the municipality located in the rural area), leaving it depopulated. At the end of the year 2002, several families began to return, and now some families of the Vereda (*Political and administrative division of the municipality*

¹⁰³ National Administrative Department of Statistics (DANE. General Census of Population and Housing. Antioquia Newsletter profile, Municipalities of Cocorná and Granada, 2005.

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located in the rural area) are included in the program "Returning is to Live". Quebradona Abajo is probably the most populated Vereda (*Political and administrative division of the municipality located in the rural area*) of Granada.

- Vereda (Political and administrative division of the municipality located in the rural area)
San Juan

Between 2001 and 2002, as a result of the internal armed conflict, was presented a massive displacement, which reduced significantly the population; prior to this fact, this was one of the Vereda (*Political and administrative division of the municipality located in the rural area*) with the most populated area, approximately 70 families. In the present are returning some of the families that had been displaced toward the Atlantic coast, Cali and the urban area of the municipality of Cocorná and people arrive for the first time to San Juan, from other Vereda (*Political and administrative division of the municipality located in the rural area*) in the area.

Almost all the people had always lived on the Vereda (*Political and administrative division of the municipality located in the rural area*), until forced displacement by the armed conflict occurred.

In the present, prevails the nuclear family with some cases of parental families mono shaped by widowed, or separated men and children. Apparently, this break-up of the family group was presented as effect of the movement toward the city, where several women chose not to return to their Vereda (*Political and administrative division of the municipality located in the rural area*), taking the man's decision to return alone.

Almost all the people had always lived on the Vereda (*Political and administrative division of the municipality located in the rural area*) until forced displacement by the armed conflict happened

- Vereda (Political and administrative division of the municipality located in the rural area)
Campo Alegre

Some people had come to the Vereda (*Political and administrative division of the municipality located in the rural area*) some 70 years ago, others came 27 years ago. Since 2001, families began to leave toward Cocorná by displacement, leaving five families in Campo Alegre; others are moving for short seasons, returning after some time.

- Vereda (Political and administrative division of the municipality located in the rural area)
El Molino

As in the other Vereda (*Political and administrative division of the municipality located in the rural area*), at the algid time of the armed conflict was presented a massive displacement of population. At the time, and after the war, several families gave their sites and others sold them at low price. Many of those young people who were displaced by the conflict did not return and at this time the young population is low, in fact, there are more child population that youth. At present, the land began to valorize again.

- Vereda (Political and administrative division of the municipality located in the rural area)
La Inmaculada

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Some of those families that live today on the Vereda (*Political and administrative division of the municipality located in the rural area*) were born and have lived in it their whole life; many of the families that were displaced by the armed conflict have not returned. At present, in La Inmaculada there are three families who are from Medellin.

In the era prior to the escalation of the armed conflict, on the Vereda (*Political and administrative division of the municipality located in the rural area*) were two sporting championships each year, in addition carried out inter Vereda (*Political and administrative division of the municipality located in the rural area*) championships in which there were collected funds for the JAC. These events have disappeared with the violence.

- Vereda (Political and administrative division of the municipality located in the rural area) San Lorenzo

Because of the armed conflict, the population of the Vereda (*Political and administrative division of the municipality located in the rural area*) moved massively in the year 2000; on that occasion, the people sought refuge in the urban center of the municipality of Cocorná, and other towns such as San Luis, Medellin and El Santuario. For the most part, the Vereda (Political and administrative division of the municipality located in the rural area)rs who had been displaced returned after three months and others after a year. In this Vereda (Political and administrative division of the municipality located in the rural area), at the algid time of armed conflict, happened a massacre of eight people and two events with MAP.

- Vereda (Political and administrative division of the municipality located in the rural area) El Choco

Prior to the intensification of the armed conflict, the families remained in their lands; when the conflict escalated, the vast majority of families left their homes; some returned later and currently live in their sites.

At the time of massive displacement caused by the internal armed conflict, on the Vereda (*Political and administrative division of the municipality located in the rural area*) were 92 families, after this fact, there were only five families. At that time, these family groups migrated to Medellín, the Atlantic coast and Cali mainly, displacement that lasted for 7 years; time after, some people had returned and others settled in the areas already mentioned. At present, some families are returning and continue to arrive; for example, in a month three families arrived.

- Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos

The forced displacement of population happened with more force before 2000, some families began to return in the year 2004. In the present, with the support of Social Action, other families returned for the incentive offered by the "Program Return is to Live".

In sum, picking up the main elements of this brief overview, it can be said that in cities such as Cali, Medellin, Bogota, Barranquilla, where the displaced population arrived these people initially engaged, in various activities such as street sales, supervision or as assistants in desk sales; women were serving in various activities. Subsequently, with the elapse of time, managed to establish their own business, which consisted of small food stores or various objects. In some cases, the younger members of the family obtained

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stable jobs, in which they remain at the present time and therefore they are not prepared to return to their Vereda (*Political and administrative division of the municipality located in the rural area*) to work once again as farmers. This, just as easily can be surmised, involves a change of activity and the introduction of new elements which would completely change a way of life and the conception of the world, with the implementation of new values and new forms of behavior.

On the other hand, adults of the family groups, usually the parents, have returned to work the land and highlight values of its peasant way of life.

Some young adults, leaders in each of their communities, promote the return of the festivities held in the municipality of Cocorná the month of August of each year and in Granada in the first month of the year, as a space for the meeting and strengthening of local values among the people which are outside of their Vereda (*Political and administrative division of the municipality located in the rural area*)s. However, after the festivities, people arriving opted to return to the cities where they had settled in the time of armed conflict or some before this time.

At present, also in some cases, there is change in economic activity among some people who are working at the El Popal hydroelectric project , although this has encouraged and promoted the need not to abandon the traditional activity that this population performed during almost all of their life, i.e. agriculture.

In this sense, we can say that it is the young population which is more exposed and has a higher degree of vulnerability to the loss of cultural autonomy or the fundamental values in the absence of opportunities for further study or work to help the family sustenance, given that the adult population, after having been forced to leave their land, and have remained for a time in an urban context, is convinced that the best option is to stay in their land, exercising as farmers and as sugarcane producers.

- Bases of the sociocultural system

Without doubt, the cultural references, support of the cultural system of the population of the Vereda (*Political and administrative division of the municipality located in the rural area*) that make up the area of influence, are based on aspects inherent to the Antioquian culture, such as food, shelter, economic activities, festivities and religiosity elements crossed by a conception of work and productivity very particular of the Antioquian peasant (see Photo 3-88). Another element that adds value to the identity of the people of the area, is the family as integrating axis and carrier of identity.



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Photo 3-88. The peasant

Source: field work during the month of December 2011

In this item, there will be a brief description to Vereda (*Political and administrative division of the municipality located in the rural area*) level, about cultural practices that have a cohesive effect between communities, and also show a relationship with the cultural identity of the inhabitants of the area of direct influence.

- Vereda (Political and administrative division of the municipality located in the rural area) Las Faldas

For the most part, the family is nuclear-type, with some cases of mono parental families, where the home head can be a man or a woman, separated or widowed (see Photo 3-89). These last two states are due to the effects of armed conflict and the forced displacement, given that many heads of household were killed; equally, forced displacement, in addition to the rootlessness, brought the breakdown of the family group. Before the armed conflict, the Giraldo were one of the families and surnames more recognized, now are mentioned other as Quiceno, Jaramillo, Herrera and Vargas.



Photo 3-89. The family

Source: field work during the month of December 2011

The majority of the present inhabitants of Las Faldas were born on the same Vereda (Political and administrative division of the municipality located in the rural area), their ancestors came to "knock down hill" and to work as laborers on the farms of two large landowners, to those that were bound and obeying the colonization process lived in eastern Antioquia, were awarded land by the state, who compensated the work of poor peasants and "the without land" with the right to occupy and exploit a part of the land. As has been said, in the era of armed conflict and as a result of this, was presented the massive displacement of the population.

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Almost the entire population of Las Faldas is catholic and profess devotion to San Roque and Las Animas of Purgatory. Therefore, occasionally participating in acts and rituals that formalize these beliefs and reinforce the faith. Almost all the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) have good knowledge about the medicinal properties of some plants and used them in case of some diseases.

The site of encounter for excellence is the school; there are the meetings of the Board of Communal Action and celebrates mass each month; also its facilities serve as headquarters for the activity performed by the religious missions. The plate of the school sports center, which is found in regular condition is another meeting place for young people and children who gather there to play football.

Another element of cohesion and that demand a collective effort is a trapiche or "ramada community", where 15 men and their family group are associated to obtain a produced, which is then sold for subsistence purposes, and sustainability of the family group and of this community company.

In the present with the transformation of the climate, has been presented variations in practices, customs, beliefs, and calendars linked to agriculture; in earlier times they waited for the waning phase of the moon for planting some crops such as bananas. It was believed, that the cane had better results if it was cultivated in the crescent phase. On climate change, even some farmers claim that its consequences may be more serious than the aftermath caused by the war.

- Vereda (Political and administrative division of the municipality located in the rural area) Quebradona Abajo

The majority of families in the Vereda (*Political and administrative division of the municipality located in the rural area*) are nuclear and numerous, because the number of its members can increase up to nine. The people who initially arrived to the Vereda (*Political and administrative division of the municipality located in the rural area*) did so around 1926; the school has approximately fifty years. The more traditional surnames are: Usme, Giraldo, Suarez, Marulanda and Aristizabal. This is the most populous Vereda (*Political and administrative division of the municipality located in the rural area*) of the municipality of Granada.

The inhabitants of Quebradona Abajo are Catholics in its majority and believers of the Virgin María Auxiliadora; on the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a prayer group and the legion of Mary, which meets weekly. Every three months, the parish priest celebrates mass in the Vereda (*Political and administrative division of the municipality located in the rural area*) and the inhabitants move on Sundays at the center of town to participate in the catholic cult. In the 2011 restarted the religious work of the Catholic missions, which had been interrupted since five years ago.

The main site of encounter is the school, where meets the Community Action Board and the community also uses the multifunctional court: "Even women get to kick ball there". The school is also the place where the children demonstrate their skills for the traditional songs, the teacher is a great motivator and encourage such expressions, therefore, in the school

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are carried out presentations, dances, litanies, which are verses to the people at which the listener responds "amen".

Other places for the concurrency have been the natural spas or "puddles", which have proved to be very affected by the winter wave; however, the custom is that in December, New Year and the holidays, comes a lot of people to the river to make stews.

Some practices of agriculture are still governed by moon phases; for example the cane planting during crescent, the same as the cocoa and bananas; in waning it is cut. Men are the ones that are engaged in this activity, though sometimes all the family members collaborate, and the women are responsible for the house work. The diet is supplemented with products that are grown in their own garden such as plantain, cassava, string bean, recently cocoa is grown.

Another of the important territorial milestones is the bridge that connects the Vereda (*Political and administrative division of the municipality located in the rural area*) with others as Los Planes, Lad Faldas, Quebrada Arriba and El Molino; however, this was knocked down by a storm that occurred in the month of March of the 2011.

- Vereda (Political and administrative division of the municipality located in the rural area)
San Juan

The Vereda (*Political and administrative division of the municipality located in the rural area*) is dominated by the nuclear family with some cases of mono parental families, conformed by widowed, or separated men and children. As in the previous case, this break-up of the family group, seem to be presented as effect of forced displacement. The surnames that are repeated more on the Vereda (*Political and administrative division of the municipality located in the rural area*) are Giraldo, Quintero and Gomez.

Apparently the peopling of the Vereda (*Political and administrative division of the municipality located in the rural area*) was given by processes of colonization in order to establish small farms, with the passing of time they were consolidated. In the beginning, the town was known as "Paraje La Peña". There were people who came from La Piñuela, Mazotes and Marinilla.

For the most part among the inhabitants of San Juan prevails the Catholic faith, and sticks the devotion in the heart of Jesus, and it is important the presence of the image of this saint in the houses. In honor of him, the first Friday of each month they attend the mass that is celebrated in the urban area of the town. At the same time, the residents of San Juan are linked to the tribute to the fallen Lord on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco. Therefore, this event is an opportunity not only for cultural expression, but for the strengthening of the existing links between the inhabitants of the different Vereda (Political and administrative division of the municipality located in the rural area)s.

Previously, one of the most important references for the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) was the soccer field and sports plate, which disappeared by the effects of a geological fault. In the present they are important sites, because they allow the encounter, the communal house and the school; there community celebrate Christmas, the meetings each month of the partners in the Community Action Board and other activities of community character.

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Among some residents of San Juan, an element that distinguishes the Vereda (*Political and administrative division of the municipality located in the rural area*) of others, is the musical tradition, which has existed, and that has been recognized, even outside of it. Between the years 70 and 80, several men of the Vereda (*Political and administrative division of the municipality located in the rural area*) were linked to the band of the municipality, as interpreters of wind instruments. At present, the gentlemen Joaquin Ramirez and Nepomuceno Lopez inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*), interpret the guitar.

The daily diet include products that are grown in the ground owned by the family; for example, the residents of San Juan they have no need to buy bananas, onions, cucumbers, corn and beans; equally hens and broiler chickens, that are bred and raised at home, are occasionally, source of protein in the family diet. In the Vereda (*Political and administrative division of the municipality located in the rural area*) some people possess knowledge and practice about techniques that are based on the use of natural substances or biological control of insect pests in crops in the home garden. With plant extracts as Ruda, calendula, garlic and onion respectively, they repel other types of insects and several pests.

- Vereda (*Political and administrative division of the municipality located in the rural area*)
Campo Alegre

In the Vereda (*Political and administrative division of the municipality located in the rural area*) families are nuclear-type, where in most cases the man is the head of household; however, there are some cases where the woman assumes the role of head of household. This Vereda (*Political and administrative division of the municipality located in the rural area*) was one of those that presented a situation highly critical, and the stigmatization and accusations of its inhabitants as members of the guerrilla, caused an almost total depopulation in the era of escalation of the armed conflict. The more traditional surnames are Aristizabal and Ramirez.

The peopling of the Vereda (*Political and administrative division of the municipality located in the rural area*) began approximately in 1940. This was given with the people of the same area, who had come to establish small areas of cultivation, which with time became stronger and with this, favoring the rootedness of the families.

Among the inhabitants of Campo Alegre prevails the catholic faith, worshipping the image of the Sacred Heart of Jesus and the Virgin Mary Auxiliadora; before the armed conflict were processions in honor of the Virgin Mary. As a fact that it is important to mention in this regard, it is the destruction by the armed actors of the image of the Virgin Mary that had remained as an icon, at a location near the school. This caused a lot of fear and astonishment among some inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*). Today the image of the virgin is located within the facilities of the school. Currently, the population of Campo Alegre, neighbors of the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Chocó, are linked to the tribute that is performed at the Fallen Lord in this last Vereda (*Political and administrative division of the municipality located in the rural area*), participating in the pilgrimage or procession that takes place in the month of August each year.

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One of the places where there are community activities is the school, where the meetings take place in the Community Action Board, the first Monday of each month. Likewise on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, which operates as zonal headquarters of the Center of the same name, meet every two months with the other boards of communal action, about topics that have to do with the approach and execution of community projects.

Sometimes make treats between the community, especially for transporting wood toward the ramadas, to fix the ditches, in order to do maintenance on the track, or to assist in the cleanup of the garden for a neighbor that may need if he is sick or incapacitated.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) men are engaged mainly in agriculture, and they are the ones who played the role of heads of households, women are the household chores (see Photo 3-90). In the land of their own is grown for family feeding bananas, tomatoes, beans and corn. Other components of the diet are poultry and milk and its derivatives obtained from the single or few cows that the family may afford



Photo 3-90. Antioquian Peasant Women is support of the family group.

Source: field work during the month of December 2012

- Vereda (Political and administrative division of the municipality located in the rural area) El Molino

The families of the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino are mainly nuclear-type, although there are some cases of extended family. Some residents have come from other Vereda (Political and administrative division of the municipality located in the rural area) in Cocorná or Medellín, or have changed land for houses in Medellín.

The peopling of the Vereda (*Political and administrative division of the municipality located in the rural area*) was initially by the family of Don Nacienceno Aristizabal that came from El Santuario; other people arrived from the same area. Now some people have come from other Vereda (Political and administrative division of the municipality located in the rural area) in Cocorná or Medellín, and several people from the Vereda (*Political and administrative division of the municipality located in the rural area*) have changed part of their land for houses in Medellín. Before the armed conflict, the more recognized names

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were Gómez, Giraldo, Zuluaga and Aristizabal. In the present have arrived approximately 20 families, which constitute the new population of the Vereda (Political and administrative division of the municipality located in the rural area); of the former inhabitants are still in El Molino some married couples, since these were those who have returned after an offset time, since children chose to remain in the city where they went (see Photo 3-91).



Photo 3-91. The image...peasants in the area.

Source: field work during the month of December 2011

The majority of the people of El Molino practice Catholic doctrine, they participate in the mass that is celebrated on the first Tuesday of each month and are linked to the festivities for the Fallen Lord promoted by the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Choco. Likewise on the Vereda (*Political and administrative division of the municipality located in the rural area*) have presence several times a year the religious missions driven by the Catholic Church.

The main gathering places and encounter are the school and the community store; in El Molino there is also a "fonda" that on weekends becomes a recreational site, especially for the male population. The sports center plate and the children's park, located in the school, are also gathering site for the adult population and the youth and children. Although on the Vereda (*Political and administrative division of the municipality located in the rural area*) there is also a ground court, the last tournament in it was carried out two years ago.

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Another space for the meeting are the feasts of the return, which are held on the Vereda (Political and administrative division of the municipality located in the rural area), already being traditional; there come many people that are in other cities, such as Cali, Bogota, Barranquilla, which were established in these during the armed conflict.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) is very important agriculture as a source of sustenance of the family group, for the subsistence coffee crops, cassava and plantain are planted For this activity are mainly responsible men, who are also heads of household, although in some cases, a woman also takes this role. In addition, there are fruit trees, especially citrus and guanabana. Some people breed and raise chickens and a few pigs (see Photo 3-92).



Photo 3-92. The work

Source: field work during the month of December 2011

One of the spaces that promotes community strengthening, the linkages and cooperation between Vereda (Political and administrative division of the municipality located in the rural area) as Campo Alegre, El Choco, Las Playas, San Antonio, Los Mangos and El Molino, is the realization of treats to do maintenance to the track.

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- Vereda (Political and administrative division of the municipality located in the rural area)
La Inmaculada

In La Inmaculada currently inhabit approximately 13 families from nuclear type, before the armed conflict, the number of family groups amounted to 28.

The Vereda (*Political and administrative division of the municipality located in the rural area*) was formed at the arrival of the Duque and Zuluaga families; the first arrived about 70 or 80 years from El Santuario, opening lands like the Zuluaga, although these arrived much later. In more recent times came from Medellín three families, the first of them settled in the Vereda (*Political and administrative division of the municipality located in the rural area*) four years ago. Approximately 50% of people who were displaced by the conflict have not returned.

Currently, the main referent and site of encounter is the school; there are activities carried out with a community character as the meetings of the Community Action Board. In the time prior to the conflict, the river with its bathing place and their territorial puddles were milestones for the meeting and sharing of the community; in holiday season, there met up to 2,000 people in a bathing place, attending family groups, or groups of boys, and they made stews or cooked chickens, after the bath they went to play.

The present report discusses with nostalgia and frustration the activities that were missing as a result of armed conflict; for example, prior to this time were two sporting championships a year, there were also inter Vereda (*Political and administrative division of the municipality located in the rural area*) championships in which they collected funds for the JAC.

Today, the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada, La Aurora and Los Mangos, participate together in masses which are held occasionally; the boards of communal action maintained good relations and championships held sporadically. It also recalls hankering musicians and troubadours who disappeared; even mentioned a very good singer, who was murdered in the era of armed conflict.

Men of the Vereda (*Political and administrative division of the municipality located in the rural area*) are principally engaged in cultivation of sugarcane, and sown for the sustenance of the family citrus, borojó, cassava, plantain, corn and beans. The diet of the family is complemented with the breeding of hens and the milk that is obtained from a cow that a family generally have.

- Vereda (Political and administrative division of the municipality located in the rural area)
San Lorenzo

In the Vereda (*Political and administrative division of the municipality located in the rural area*) prevails the nuclear family, with several cases of extended family. Currently, complete families which have migrated from other places have arrived to the Vereda (Political and administrative division of the municipality located in the rural area). The more common surnames in the Vereda (*Political and administrative division of the municipality located in the rural area*) are: Gómez, Ocampo, Guarín and Peláez.

In accordance with the existing oral tradition among the inhabitants of San Lorenzo, it is said that the founder of the Vereda (*Political and administrative division of the municipality*

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located in the rural area) was don Lodovino Gomez. Later came the gentlemen Juan Cancio Zuluaga, Tulio Atehortua (he still lives and has 110 years) and Arnoldo Gomez. They arrived at a place known as Botijas, knocking down the forest or hills to establish housing. Later, arrived on the scene a priest who changed the name of Botijas to San Lorenzo. The first school was located in the same place where is located the current, but that was built in mud wall. At that time were not gathered together men and women to study, therefore weekly on a school day men assisted and in the other, did the women. At the end of the week this routine was changed, that is to say, those that in the week had been busy in the morning, in the following week were attending in the afternoon.

Almost the entire population of San Lorenzo profess the Catholic faith, and this is expressed with membership to groups such as the Legion of the Santa Cruz, and other prayer groups; they meet with the population of Vereda (*Political and administrative division of the municipality located in the rural area*) La Piñuela. They are believers of Mary Auxiliadora and are integrated around the celebration of the ritual of the Holy Week.

The most important site for the meeting and participation is a school; there are the meetings of the Board of Communal Action the first Monday of each month, and trainings, bingo and other activities to raise funds for the works conducted by the JAC.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a group of elderly people of the Jones family who interpret the guitar, being recognized in the municipality of Cocorná. There are still traditional trapiches, where the force of beasts is used to run them.

Since the construction of the Medellín-Bogotá Highway, this artery was formed in a benchmark in the territoriality of the inhabitants of San Lorenzo, given that it transformed the mobility; however, this track brought other effects such as a high rate of accidents in young people and children in the area and the change of vocation of farmers by five families of the Vereda (*Political and administrative division of the municipality located in the rural area*), which established shops at the edge of the road. Through this way the inhabitants of San Lorenzo are mobilized to El Santuario, Marinilla, Rionegro and Cocorná and products come in and out of the Vereda (*Political and administrative division of the municipality located in the rural area*).

- Vereda (*Political and administrative division of the municipality located in the rural area*)
El Choco

The majority of families in El Chocó are nuclear-type and among the more traditional surnames are mentioned: Giraldo, Gomez and Arias.

The initial peopling of the Vereda (*Political and administrative division of the municipality located in the rural area*) was given by families from the municipalities of Granada, El Santuario and from the same municipality of Cocorná. Currently we are experiencing a return or resettlement of the families that were displaced by the armed conflict.

The majority of inhabitants of El Chocó profess the Catholic faith and believe in the Virgin of Carmen and the Fallen Lord, to the latter renders a tribute recognized in the area, on August 15 of each year, with a procession from the town center of the Vereda (*Political and administrative division of the municipality located in the rural area*) to the Vereda (*Political and administrative division of the municipality located in the rural area*) This celebration

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gathers approximately 3,000 people. On this occasion is celebrated a mass, prayer is done and then sacrifice pigs that are consumed in community after the procession. This festivity is made from four years ago, as an act of thanksgiving to God for the peace achieved in the area.

In this Vereda (Political and administrative division of the municipality located in the rural area), a very significant referent is the school as a site of encounter and meeting; a soccer field is also a prominent territory by its inhabitants, and the administrative figure of the zonal center is important, as it allows the meeting, the inter Vereda (*Political and administrative division of the municipality located in the rural area*) participation and integration. Also, the monument to the Fallen Lord becomes a major milestone for the manifestation of the devotion and encounter.

The main economic activities of the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) are agriculture and small livestock, activities which are performed especially by men, while women are concentrated in the household chores. What is produced not only leverages commercially, but that is part of the diet of the families; for example, include products such as bananas, citrus, cucumber, tomato and passion fruit. There is also utilized in the diet, milk, cheese, butter, and sometimes the poultry.

In accordance with the information gathered during the field work, before the forced displacement of the population, the Vereda (*Political and administrative division of the municipality located in the rural area*) was producing such quantity of food delivering out weekly six trucks with products toward Marinilla, La Ceja and Medellin; at that time there were places where they stored or concentrated products and then transport them for their marketing.

Between the Vereda (Political and administrative division of the municipality located in the rural area) that make up the zonal center of El Molino, to which belongs the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco, every two months realize football and basketball Championships.

The Community Action Board promotes the treats when it is necessary to help someone at work in their field, because he is sick, or when the area under cultivation is in a very weedy conditions and need to be clean. (See Photo 3-93). At times, around the convite, food is prepared and in others, each participant takes the food.

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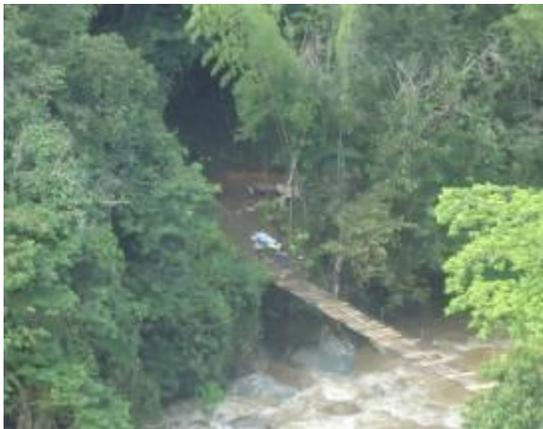


Photo 3-93. Solidarity

Source: field work during the month of December 2011

- Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos

Generally are nuclear families; the most common surnames in the Vereda (*Political and administrative division of the municipality located in the rural area*) are Giraldo and Blandon, families that had always remained on the Vereda (Political and administrative division of the

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municipality located in the rural area), until the time that was unleashed the armed conflict and forced displacement.

The road known as the "way of the 8 ", apparently was a key route of the ancient settlers of the Vereda (Political and administrative division of the municipality located in the rural area), who arrived from El Santuario, Rionegro, other places of Cocorná and Granada, opening ground or "dropping mount". The above-mentioned road leads from El Santuario to San Luis, with a detour on 8. These first settlers came seeking where to set up small areas of cultivation, which over time were consolidating, to provide the opportunity to shape family and ensure the livelihood.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) the entire population is Catholic, and congregate around celebrations, rituals and other manifestations that expressed the faith. For example, in the school is located a picture of the sacred Heart of Jesus, and religious missionaries have come from the year 1964, later in 1970, most recently in the years 2000, 2007 and 2011. These missionaries usually focus their attention in children and young people and are hosted by the Community during the time that they carry out their work.

The community is also linked actively in the processions that are performed every six months, when the parish priest visits the Vereda (Political and administrative division of the municipality located in the rural area); it is also spread the principles of the Legion of Mary, apostolic organization that promotes the existence and the strengthening of the Marian spirit in honor the Virgin Mary, among practicing Catholics. In the month of October of each year, participating in the celebration of the festivities of San Isidro in the Vereda (Political and administrative division of the municipality located in the rural area). At Christmas it is customary to make a "sancocho" for the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) and on December 24 holiday celebrating the birth of the God child with feast and gift-giving.

In the wakes and funerals throughout the family of the deceased expresses and shares their pain and the rest of the people on the Vereda (*Political and administrative division of the municipality located in the rural area*) give their condolences.

As can be seen, according to the above description, the cultural practices of the inhabitants of the area of direct influence are referred to a much broader context of the "paisa" culture or antioqueña, where the food, the popular festivals , patron saints, labor and productivity to achieve the livelihood, family and religion, are key elements.

In the food supply for example, maize is a fundamental component, since immemorial times it is exploited in the "paisa" culinary repertoire and using it in its various states: green, mature, child, cooked, baked, fermented whole, or ground and amassed. Just to mention some preparations, the gruel and "arepa" are of everyday consumption among the families of the area.

With regard to the festivities, this is deeply linked with piety, although this element is in continuous interaction between the sacred and the profane (see Photo 3-94); this is the case, for example of the celebration for the Fallen Lord in the Vereda (*Political and administrative division of the municipality located in the rural area*) The Chocó in the month of August, where after the procession, gather around the music and liquor. Pigs that have

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been previously slaughtered and prepared are consumed. Although according to Maria Teresa Arzila (1998), *“In the bandeja paisa culture the fiestas patronales disassociated from the religious to the holiday. Something different is presented in areas of the region where there have been presence of black and indigenous peoples over the centuries. Here the festive elements and profane is intimately associated with religious celebrations”*¹⁰⁴.



Photo 3-94. The religiosity

Source: field work during the month of December 2011

In any case, the parties to a patron saint, Christmas, the return festivals are celebrations that show a rooted passed down from the ancestors with great cultural significance. In the direct influence areamust be taken into account the circumstances raised by the armed conflict, in this sense, for example, the celebration at the fallen lord is being made from only four years ago, as a thanksgiving for the cessation of the war. In this case is also in evidence the interference of the church, which with interests of their own, has had a great influence on the way of being antioqueño, in the adoption of moral values and the behavior of the general population.

¹⁰⁴ CINEP. 1998 Colombia country of regions. Volume I. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Santafé de Bogotá, CINEP; Colciencias. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Available at: <http://www.banrepcultural.org/blaavirtual/geografia/region1/indice.htm>. Consulted on 12 January 2012

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Obeying a common pattern of the “paisa” culture “The population (In this case the Veredas)¹⁰⁵, of the regions worship images of the Inmaculada Concepción, la Virgen del Carmen [...]. Their holiday is celebrated on Decembe 8th., and July 16 [...]. To a lesser extent the peoples are devoted to the Heart of Jesus, the Holy Christ or other holy’ s”¹⁰⁶. In the case of the Vereda (Political and administrative division of the municipality located in the rural area) of the influence area this differs, precisely because these are the last saints mentioned by Arzila (1998), to which they express faith and devotion.

Also, in the workplace and the family are reflected cultural patterns and practices that demonstrate the cultural identity of a people that possesses a myth in which supports the belief in the existence of a "paisa race".

The mines and the ranches of the eighteenth century and the beginning of the nineteenth century, were the first scenarios which outlined the Antioquia families, in particular those extensive. These were added to the affine core and consanguine, a series of servers and collateral, who recognized some blood kinship or spiritual (the compadrazgo), which still lives among some cores or a duty necessary for domestic life.

In these families who colonized it and formed the Veredas (Political and administrative division of the municipality located in the rural area), the maternal figure and image performance still plays a major role, “The maternal figure drift toward a rough woman that is being confronted with the weather and geography along with her husband and children. Their central role is at home, raising and feeding children that are the energy reserve for the opening of borders. Now weighs more the fortress than fragility in the feminine image, accompanied by the holiness of the sacrifice. The male is made to fullness with the cultural images that have gone through the oral and written literature. The sawer, the drover, the guaquero, the farmer, the miner, the serpent enchanter the jobber Europe's present lack are emblematic In order, the merchant ”¹⁰⁷.

In fact, this image still survives in the current population; in the present, the woman is support of their families, and while, as seen in many cases, is the man who assumes the role of head of household, the woman is always behind, like a shadow that reflects, and supports the authority and the strength of the group. Although in many cases, by the effects of the war lived in the area, many widow women became heads of household. On the other hand, as a coping strategy, the female labor force has also been incorporated and has been highlighted in the agricultural work, for example in the area is highlighted the contribution of the women's labor in the production of panela.

In this way, the companies of the colonization and work are inseparable elements of a way of life. This could be the explanation to the capacity of resilience shown by the population of the area, as have almost returned to begin, since the conflict not only ended up with plots

¹⁰⁵ The parenthesis is our.

¹⁰⁶ CINEP. 1998 Colombia country of regions. Volume I. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Santafé de Bogotá, CINEP; Colciencias. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Available at: <http://www.banrepcultural.org/blaavirtual/geografia/region1/indice.htm>. Consulted on 12 January 2012

¹⁰⁷ CINEP. 1998 Colombia country of regions. Volume I. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Santafé de Bogotá, CINEP; Colciencias. Economics, Politics, daily life and culture of Antioquia and the Caribbean region. Available at: <http://www.banrepcultural.org/blaavirtual/geografia/region1/indice.htm>. Consulted on 12 January 2012

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and crops, but also that imploded and eliminated family groups. Today, many families from the different Vereda (*Political and administrative division of the municipality located in the rural area*) have returned to cultivate their land. However, it is important to take into account the aftermath of the war; for example, there are people who are not willing to return and in others, the pain manifests itself in emotional and mental disorders.

For all of the above, the realization of the project should include the context, before and after the armed conflict, and the consequences of this on the people and the territory and in a general manner on the cultural system.

- Use and Management of the environment

As mentioned in previous paragraphs, the pressure is greater on resources such as water, forest and the soil. In the Vereda (*Political and administrative division of the municipality located in the rural area*) of the area of influence, agriculture is, without doubt, the main activity for subsistence and therefore, one of which generates a greater impact on the soil and the forest; the use of chemicals for the cultivation of sugar cane and other crops such as tomato and passion fruit, contaminate not only the soil but also some water sources. Among the most commonly used chemicals, are especially mentioned Manzate, Lorban for the labor ants and Tecnomil.

The extraction of timber, very focused on a sector of the area of influence, with commercial destination, it seems that by now continues with the commitment of refit with new plants, part of the removal that is being done, and is authorized by CORNARE for its exploitation. In the area is still used in significant amount the firewood as fuel for cooking, which alternate with the use of gas of pipette.

In the Vereda (Political and administrative division of the municipality located in the rural area)of the influence area is still very common wildlife hunting and although it is for domestic consumption, this influences the detriment of the fauna of the area. This is practiced by inhabitants of the sector and by people who come from other nearby municipalities as El Santuario

Generally, the activities are carried out in agricultural land surrounding the housing site, and the sugarcane producers are also set in vicinity to the houses. The expansion of the agricultural frontier, in this case, without doubt, has its effects on the forest.

In general, is the agricultural activity which generates a greater interaction within the territory of the area of influence, especially in the process of production and marketing of panela", which is often sold in the town center of the two municipalities.

3.4.5 ARCHAEOLOGICAL ASPECTS

This numeral is excerpted from the report of archeological survey conducted for the El Molino and San Matias hydroelectric projects, for which it was attended by 2340 license of October 7th. 2011, and which is presented in Annex 11

3.4.5.1 Background and thematic research

Recently in the local context of the study area there have been several archaeological research: an archeological survey in the framework of the El Popal hydroelectric project in

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the basin of the Cocorná River (Cardona and Yepes, 2009b), then there was another archeological survey to about 3 km downstream of the previous one, where the Cocorná River has already poured its waters into the Calderas River, in the framework of the hydroelectric project San Miguel (Cardona and Yepes 2009c), and finally Cardona and Yepes (2011b), hasten the implementation of the management plan for archaeological, in the hydroelectric plant El Popal.

The location of the project area, at the southern end of the region of eastern Antioquia, where the Plateau ends and begins the slope toward the Samana and Magdalena Rivers, along with the features of the archaeological remains found, has specified to articulate the thematic and archaeological research hypotheses, to the dynamics of occupation of the human groups who settled in the basin of the Magdalena River and its major tributaries, they begin their channels in the mountain areas or areas of cordilleran slope, as the Samana and La Miel Rivers (Cardona and Yepes, 2009b and 2009c; Cardona and Yepes, 2011b).

So far, the archaeological evidence from the context reported near the area of study of the El Molino and San Matias hydroelectric projects, have been articulated to the assumptions that are being raised for the slope of the Antioquian Middle Magdalena, specifically with regard to the process of occupation of the cordilleran slope areas, where they are a reference, in addition to the facilities above mentioned in the basin of the Cocorná – Calderas Rivers, the work carried out in the basin of the La Miel River by Erigaie (1995 and 2000), Piazzini (2002), Piazzini and Lopez (2004), Botero, et al (2007) and Cardona et al (2009a), all within the framework of the hydroelectric projects La Miel and transfers of The Guarino and Manso Rivers.

In accordance with the characteristics of the vestiges reported by Cardona and Yepes (2009b and 2009c and 2011b), have been raised with dynamic cultural associations related with a pre-ceramic period, which is associated cultural and stylistically with another reported in the basin of the Medellín – Porce Rivers and ceramist with occupations early and late in the ceramics are observed stylistic characteristics of the basin of the La Miel River in the Middle Magdalena region (Cardona and Yepes, 2009b, 2009c and 2011b).

In effect, the archaeological record in the basin of the Cocorná - Calderas and San Matias Rivers, has been ordered in a chronological sequence in the following manner (Cardona and Yepes, 2009b and 2009c; Cardona, et al, 2011b):

- The first occupation

Called preceramic. Corresponds to archaeological remains associated with human groups that produced artifacts in stone, axes developed through bipolar carving, and boulders with worn edges, which correspond to utensils used for grinding or milling plant materials. These remains were found in the deposit 6, La Inmaculada, in a cultural layer or archaeological deposits of about 60 cm in thickness, which covers the horizons BP and the base of the AB, in which are only lithic artifacts and behind another of about 65 cm thick in the same cultural matrix (lithic material with the same technology of carving), but it differs from the previous, this layer, has abundant ceramic fragments (Cardona and Yepes 2011b).

In this cultural layer, in addition to the lithic artifacts and utensils were found abundant boulders and pebbles and some angular rocks, carried to the site as supply of raw materials

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and to adequate floors of occupation. Between levels 19 to 23 (from 95 cm to 115 cm depth), in the initial moments of occupation of the terrace, had already been taken to the site, in an area of 25 m² (which is the area of the idem), 2,426 rocks (mostly pebbled), with an approximate weight of 271.48 kg, to adequate the occupation floors. For the entire layer of soil that is associated with the pre ceramic occupation, (horizon Bp and base of the AB), they have a layer of rocks in the idem 1, with 7,526 units, with an approximate weight of 812,878.3 g (812.88 kg); what delivers close to a ton of rocks, carried to the site in an area of 25 m², during the time of the pre ceramic occupation (Cardona and Yepes 2011b).

The lithics set is characterized by a technology or industry of carving and its use without modifying pebbles, with raw materials of local origin as andesite, basalt, sandstone, quartzite, granodiorite, milky quartz and crystal quartz and semi cristaline; highlights the presence of elements in foreign raw material, in the Middle Magdalena region as yellow and gray chert (Cardona and Yepes, 2011b).

The carving work stand out for its complexity and frequency, 83 artifacts called axes, of which there are 24 with notch... These axes were developed through bipolar carving (51, seven of which are cut out) and by scabble of boulders 31 (17 of which were notes cut-out) (Cardona and Yepes 2011b).

It has been suggested that these artifacts are associated with activities related to the use of a wide range plant resources, on the part of the societies that exploited the tropical Andean forests, not in domestic contexts, as in the clearance and cleaning of the forest, or in domestic contexts, as in work with the wood for the construction of houses and as hoes for collection of tubers and other roots (Cardale et al, 1989: 5; Salgado, 1995: -96 In: Castillo et al, 2002; Otero and Saints, 2006. In: Cardona et al, 2011b).

As part of the stone tools used in the site, you have rounded boulders of various sizes and shapes, with traces of consistent in glare and picketing, which have been called generically modified utensils for use, which in some cases we were able to specify the category of the utensil, such as those in which are identified traces of wear on the edges, called boulders with worn edges, and other such as the hands of grind and plates, associated with the processing of plant elements and other associated activities to sharpen and strike. Within this general category of utensils is also considered a large amount of boulders which were transported to the site, to be used as utensil or in the development of artifacts, or as elements used in the adequacy of successive floors of occupation, as a usual practice, throughout the chronological section that lasted the pre ceramic occupation (Cardona and Yepes, 2011b).

A sample of coal, preceding from level 20 of excavation (95 cm-100 cm depth), threw a radiometric date of 8470 + /- 50 BP, with a probability of 95% that they are between 7590 and 7480 years A. C. (BETA - 302994). The date is associated with a time in which the site was already, in addition to the accumulation of rocks described above, axes, flakes and utensils as hands of grind sharpeners and polishers (Cardona and Yepes, 2011b).

This cultural layer and the archaeological remains which it contains, is associated with the first moments of occupation of the terrace, and indicates the presence of human groups pioneers of the occupation of the wet tropical forest of the basin of the Cocorná River, in an old broad alluvial terrace, in the middle of the forest, probably of gallery, and in a tropical environment, as is suggested by the samples and microfossils palaeobotanic, which also

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indicate, for the time of the peopling of the site, the intensive exploitation of palms and plant fibers and fabrics that can be associated equally to the palms, and some fruit trees and vegetable colored fibers (Cardona and Yepes, 2011b).

Following again Cardona and Yepes (2011b), the appropriation and use of local raw materials in the basin of the Cocorná (pebbles), indicate a broad knowledge of the environment by their former inhabitants and relates with a close interaction and knowledge which made the place inhabited, artifacts and utensils, a form of objectify the world, of appropriating it, which in turn is a key component of their cultural identity (Cardona and Yepes, 2011b).

In the basin of the Calderas River downstream from its confluence with the Cocorná River, Cardona and Yepes (2009c), in the framework of the archaeological study of the San Miguel hydroelectric project, reported the existence of three sites with materials that resemble the stone tools that has been describing. The three archaeological contexts associated with this occupation are sites 5, 10, and 13, where was not observed accumulation of rocks, or the array of dark soil, but that the artifacts were found in an array of yellow brown soil, without the high densities reported in the context that has been referencing - Deposit 6, La Inmaculada (Cardona et al, 2009b).

By the time there is evidence of these early settlements, occupying the alluvial terraces of the oldest Cocorná and Calderas, Rivers in a habitat which gave a broad range of biotic and Physical Environment resources different from those that had, for the same time, the low-lying areas of the Magdalena River¹⁰⁸, which is why they are differences in the stone tools, which could be making a difference in social and economic groups that inhabited these two regions in the same period.

In a broader spatial context, materials with these characteristics, as well as the archaeological contexts in which they are, have been reported in the basin of the Porce river (Castle, et al, 2002; Otero and Santos, 2006; Cardona et al, 2007; Cardona et al, 2011a), associated with human groups in a process of early occupation and exploitation and the domestication of the pre montane forests and humid tropical, aspect that is also related to the beginnings of the horticulture and agriculture; these contexts and the evidence in the basin of the Porce, is located chronologically between the 8,500 and 5,500 years AP (Cardona et al, 2011a). The reports show sites with very similar characteristics in regard to the contexts of deposition (archaeological deposits): accumulation of rocks, processing techniques and stylistic features of the carved artifacts, and chronologies (Cardona and Yepes, 2011a).

In addition to the above, there are only three sites with the same materials in size and in processing plants, but without accumulations of rocks, therefore, they were considered as transit sites (Santos, 2010); it is a question of the sites La Morena, on the southern slope of the eastern Aburrá Valley in the municipality of Envigado (Santos, 2010), La Blanquita in the south-western slope of the Valley of Aburrá, in the municipality of Itagüí, dated to 7,720 ± 50 years AP (Botero and Martinez, 2002), and El Pedrero in the highlands of eastern Antioquia,

¹⁰⁸ From early times was the occupation of the banks of the Magdalena river, hunters, gatherers, whose main evidences are instruments such as convex plane scrapers and projectile points found in camps in the valley of the river with antiques of at least 10000 years (Lopez, 1999)

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in the municipality of Carmen de Viboral, dating back to 6660 ± 100 years AP (Botero and Salazar, 1998).

All of these contexts delivered a comprehensive overview of spatial and temporal level of a demonstration or cultural tradition, handling and use of plant elements (stems, roots, and fruits), which relate to the beginnings of the domestication of the forest by human groups since the early Holocene, of which there are reports in other regions of the country such as the sites San Isidro in the plateau of Popayán, dated between 10,050 and 9,530 AP (Gnecco 2000. In: Santos 2008); Peña Roja in the middle course of the Caqueta river, in the Amazon jungle, dated between 9,250 and 9,125 AP. (Cavalier et. al. 1995 In: Santos 2008); El Sauzalito, El Recreo to the Alto Calima, in the Western Cordillera, dated between 9,670 and 9,300 AP., and between 8,750 and 7,830 AP, respectively (Cardale et. al. 1989 AND 1992. In: Santos 2008); El Pital, in the Middle Calima, dated 7,310 AP. (Salgado 1989 and 1995. In: Santos 2008); El Prodigio, on the eastern slope of the Cordillera Central, in the municipality of Chaparral, dated 7,370 AP. (Rodríguez 1991 and 1995. In: Santos 2008); multiple sites of the Medium Cauca, such as Jasmine dated 9,020 ± 60 and 7,599 ± 90 AP., Guayabito dated 7,990 ± 100 AP and Campoalegre dated 7,600 ± 90 AP. (Aceituno 2003. In: Santos 2008); sites located in the basin of the Porce river: the IIP -040, located in the sector of the creek Guaduas, with dates of 9120 ± 90 and 7710 ± 70 years AP (Castle et al, 2002), the deposits PIII0I - 40, with a date of 7190±40 AP and PIII0I - 52, with a date of 7.730±170 AP, located in the sector of La Primavera (Otero et al, 2006: 50), and the deposit PIII0P 59, located in the sector of La Manguita, with dates of 8340 ± 40 years AP (Cardona et al, 2007), and the site PIV-37, dated at 7340 years AP (Cardona et al, 2011a).

It should be noted that toward the low slope of the Magdalena, there have not been reported archaeological contexts similar to the one in the basin of the Cocorná River or to those reported in the eastern plateau of Antioquia, or in the basin of the Medellín – Porce Rivers; in contrast, the occupations reported so far in the basin of the La Miel, River is associated with a sequence of occupations potters, ranging from ceramics, considered early, with chronologies between at least 2000 years B.C.) until the 1200 years a.d. (Piazzini and Lopez, 2004; Cardona et al, 2009a, Cardona and Yepes, 2009b), until a late pre-Hispanic period, with two ceramic sets initially reported in the basin of the La Miel River called in accordance with their chronological order and the Butantán Forest (Cardona and Yepes, 2009a and 2009b).

- The second occupation

In the basin of the Cocorná River, there is evidence that ceramics are related with a ceramic called the Gold Complex, spatially located in the basin of the La Miel River in the cordilleran region of slope in the basin of the Magdalena River in its middle course (and in other areas of the Middle Magdalena), and located chronologically between 2000 BC and 500 ad (Cardona and Yepes, 2009a and 2009b).

Castaño (1985), was the first that made reference to the existence of a ceramic set in the basin of La Miel River which partnered as a previous component to the Colorados and Butantán phases and it called Complex El Oro, which presents characteristic elements as atypical funerary urns, ballot, big and heavy urns, with cream slips and some red, and vases with edge of "U", "flattened edges sub labial and ornately decorated with linear designs (and dotted, with designs of double arches, " ... *the walls of the neck are concave and fluidly in a*

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pronounced basal angle that supports a base slightly sub globular tripod or tetrapod. " .
(Brown, 1992: 26. In Cardona et al. 2009a.

The existence of ceramics associated with a chronological section prior to Colorados and Butantán, was subsequently corroborated by Piazzini and Lopez (2004), who were able to establish the same, a chronology of 2000 C to 700 A. D. C, being the oldest dates for the pottery of the La Miel River until the moment. The authors in reference described for the complex El Oro, abundance of red glaze and repetitive presence of semicircles decoration, which are located in an inverted form to the circumference of the edge of the pots, on the basis of dotted, fluted and roulette. There are also festooned and lobulated on the shoulder and body of the vessels, as well as applications in the form of shell. The thickened edges are rounded or chamfered reinforced." (Piazzini and López, 2004:32).

In the basin of the Cocorná River, this occupation was composed of human groups that were developed and used ceramic containers of various sizes and forms, which are pastries and coffee colored yellow-reddish, of smooth surfaces, with content of quartz, mica golden or silver mica and felspar, of fine and medium sizes. The thicknesses of the pastes vary between 4 mm and 8 mm and 9 mm and 15 mm, with an average thickness of 9 mm. Also prevail well polished surfaces to which they applied a bath of the same color of the paste (Cardona and Yepes, 2009b and 2009c).

In terms of the decor, there are incised horizontal parallel peripheral lines, triangular prints, vertical parallel incised lines and wide grooves, on the neck and body. Averted direct edges, and the decor in rows of triangular impressions on the external perimeter of the edge and incised parallel short vertical and diagonal lines located on the body; averted chamfered with decoration of incised lines edge, serrated stamped (ruler) and incised lines in herringbone; the forms of vases inferred correspond to sub globular pots (Cardona and Yepes, 2009b and 2009c).

In the basin of the Cocorná River there is a ceramic called The Piñuela set, with a dating of 3560 +/- 40 BP (Beta - 302996), in the horizon AB3, level of excavation 19 (90 cm - 95 cm depth), in the reservoir 1 (Cardona and Yepes, 2011b); this ceramic could be associated to the complex El Oro, while this complex has a dating of 1850 +/- 30 BP (Beta - 302995), at the base of the horizon A2, in level 8 of excavation (35 cm - 40 cm depth), in the deposit 6 (Cardona and Yepes,).

According to the radiocarbon dates obtained in the fields 1 and 6, associated with the ceramic set The Pinuela and complex El Oro respectively, could arise then, that the early ceramics in the basin of the Cocorná River presents a chronological span from 2020 years A. C. , up to the 240 years D. C. This chronological span arises by way of hypothesis, due to the fact that although there are archaeological deposits fairly representative, the later dating could be extended a few more years, if one takes into account that the information was obtained in level 8, and levels 7, 6 and 5, also contain, with greater frequency, ceramics of the complex El Oro (Cardona and Yepes, 2011b).

Ceramics associated with this period is reported by the authors in reference at the culture house of the municipality of Cocorná, where you will find complete pieces recovered in the process of building a soccer field in the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre. It is about six globular vessels and a bowl, with decorations with bands of red paint and cream, and red on cream, forming

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geometric patterns and spirals. There are also incisions and linear triangular impressions (Cardona and Yepes, 2009b).

The above features, along with the contexts of provenance, which by its geomorphologic characteristics are associated with housing, would indicate that the containers produced were used in a domestic context, but in distinct activities. So there are small containers of thin walls and large containers of thick walls, that were probably used to contain liquids and wet solid, serve and cook food, in the case of those who have smoked and soot (Cardona and Yepes, 2009b).

This is a period of occupation, in the basin of the Cocorná and Calderas Rivers, have been reported 13 deposits (three in the archaeological study of the El Popal hydroelectric project and 10 in the hydroelectric project of San Miguel), in a settlement pattern which shows fields located in broad and flat tops of hills and knives (six sites), high in alluvial terraces of the river (five deposits), and on slopes (two sites), indicating a scattered distribution along the portion of the studied basin in places with heights ranging from 630 meters above sea level, up to the 1,168 Meters above sea level (Cardona and Yepes, 2009b and 2009c).

In this period, in the basin of the La Mile River, it is reported the largest number of sites (strata, 2002; Cardona, et al, 2009a), and are considered to be the groups potters pioneers of the occupation of the life area in the tropical humid forest, watershed areas in cordillera, in a process of migratory waves from the low-lying areas on the banks of the Magdalena River (Piazzini, 2002. In: Cardona and Yepes, 2009a).

- The third occupation

The third occupation in the basin of the Cocorná River, is associated with the ceramic complex Butantán, reported in the Middle Magdalena region by Brown (1985), as the late phase of the horizon of funerary urns of Middle Magdalena and a local phenomenon of La Mile River. Are elements of the ceramic phase Butantán "... *cups inverted annular base decorated with zoomorphic (Rana) applied over the edge, made in ceramic black gloss; elliptical trays of lobulated handles in the ends ...*" (Brown, 1992:25).

For Piazzini and Lopez (2004), the ceramic Butantán is a ceramic complex that has a temporary short-term intermediate, 700 D. C. to 1200 D. C. , which is characterized by "... *thin walls, appearing as content of mica/degreasant, the surfaces are well finished, observing incisa sgraffito decoration on red glaze, shaping reasons semicircular or diamond representing spirals, as well as auctions and fingerprints visible on the outside of the edges, which, unlike the late more complex , are reinforced, thickened or chamfered .*" (Piazzini and López, 2004:32).

Ceramics associated with the complex Butantán in the basin of Cocorná River, corresponds to containers of varied sizes and shapes, with brown pasta (with quite eroded surfaces), that contain particles of quartz, mica and golden feldspar, fine and medium sizes, in proportions of 15% and 20 %, and thicknesses of pulp between 4 mm and 19 mm, with an average of 10 mm (Cardona and Yepes, 2009b).

The decorations consist of rings without smoothing, and incised lines short and long, parallel diagonals, incised lines forming triangles filled with lines of sigmoid grounds, located on the body. There are also rings without smooth with digital printing on the external perimeter of the lower part of the edge, circular prints, incised lines forming triangles filled with lines of

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sigmoid reasons; incisions parallel vertical lines long on the external perimeter of the body, and incised lines parallel short vertical located on the body, neck, or edge of the vessel (Cardona and Yepes, 2009b and 2009c).

In the basins of the Cocorná and Calderas Rivers have seven archaeological sites associated with this occupation (Cardona and Yepes, 2009c), with a distribution in broad and flat tops of hills (six sites), that even though there are very few, they have a tendency to continue from the previous period, a continuity of occupation of the areas of slope on broad hilltops, which are located in watershed in heights ranging from 800 meters above sea level to 1,117 meters above sea level. The other reservoir associated with this period, is located in an alluvial terrace.

- The fourth occupation

The fourth occupation in the basin of the Cocorná River is represented by a ceramic complex called The Forest.

The ceramic The Forest was reported for the Middle Magdalena region in the basin of the La Mile River for Piazzini (2002) and Piazzini and Lopez (2004), with chronologies between 1200 and 1550 years DC. The groups that developed and used this pottery, were those who came in contact with the Spaniards upon arrival at the Middle Magdalena (Cardona and Yepes, 2009a).

The ceramic The Forest is characterized by *“a more crude finish, more presence of thick walls and thick depressants of quartz, mica and feldspar. The edges are direct of simple profile or thinned and flat lip. There are also reinforced but unlike the previous complex almost always presented corrugation in their union with the neck. The decorations are quite different, the glaze is very low, with an abundance of deep incisions or intermittent diamond shaping forms, are also features the connections of the rolls without smoothing (corrugated) and impressions of tissue on the outer surface of the pots”* (Piazzini, 2002, in: Piazzini and López, 2004:32).

In the basins of the Cocorná and Calderas Rivers, the ceramic pasta presents coffee color pastas, smooth surfaces and winding, with content of particles of quartz, golden mica and feldspar, fine sizes; the decorations consist in prints of perimeter short vertical lines; in fluted edge horizontal parallel lines, parallel lines and forming diagonal hexagons; printing of short vertical lines perimeter; applications and ribbing edge horizontal parallel lines; prints of tissue in vegetable fiber (Cardona and Yepes, 2009b and 2009c).

In terms of forms, are averted chamfered, which allow us to infer the presence of sub globular pots. Between the edges are straight direct, some of which allow us to infer vessel forms such as bowls and hemiglobulares deflected, with diameters between 18 cm and 30 cm (Cardona and Yepes, 2009b).

3.4.5.2 The archaeological exploration

- Methodological Aspects

The archaeological exploration is understood as a phase of sampling that tries to estimate the archeological potential of the areas of civil facilities of the El Molino and San Matias hydroelectric projects. The methodology was directed toward the identification and characterization of units or subunits of landscape, called geomorphologic units minimum of

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prospecting (Piazzini, 2002, Cardona et al, 2007, and Cardona et al, 2011b), in terms of the identification of archaeological remains such as ceramics, lithics, and modifications in the relief, indicating that were used by the man in past times, which are called archaeological sites.

During the work of archaeological exploration, were walking tours of all the areas intended for civil facilities, reviewing and registering minimum units of landscape, identifying them in the degree of susceptibility of having been used by man, which is given by the geomorphologic characteristics such as size and outstanding data and by the presence of patterns of archaeological vestiges observed in previous research in each type of drive prospected (Renfrew and Bahn, 1993).

For the characterization of the landscape units in archaeological terms, during our tours were reviewed and the surfaces were recorded the relics found in them and archaeological samplings were carried out that consisted in boreholes of 50 cm x 50 cm; the quantity and spacing of these were influenced by the size of the geomorphologic units minimum and by the degree of susceptibility to be used by man.

The boreholes were excavated to variables depths, which depended on the degree of development of the soils and the presence of cultural relics. The methodology of excavation consisted in the lifting of successive layers of 5 cm in thickness, performing a reading Stratigraphic column of each one. With the realization of the boreholes is sought information about archaeological aspects such as: quality, density, spatial and vertical distribution of cultural relics, as well as their behavior in Stratigraphic correlation with the thickness of the cultural layer, the horizons of soil identified and chronologically ordered. The landscape units, which showed no evidence of earlier human occupation, as has been mentioned, they were called archaeological sites and were identified consecutively, accompanied by an alphanumeric code that identifies the context and research.

With the prospecting information was sought archaeological coverage of space and time, from which could be done a minimum characterization in terms of the Stratigraphic and aspects of cultural contents, that economical possibilities carry out an assessment of each unit prospected, in terms of its importance for understanding the social and historical processes of ancient human occupation of the area of study (basin of the San Matias and Cocorná Rivers), and thus pose hypotheses on the dynamics of settlement that will come under investigation in the area and to formulate guidelines for research to guide the subsequent archaeological interventions to be performed (archaeological management plan).

The information obtained was used to perform assessments to qualify the degrees of severity that the civil facilities cause to the archaeological sites identified, and therefore, the archaeological heritage of the Nation.

The evaluation was conducted with a view to propose measures to mitigate and compensate for the negative impacts that the civil facilities produce to the archaeological heritage identified, through the realization of a set of specific archaeological actions to perform in each of the fields that will be affected by the facilities, which makes up the Archaeological Management Plan.

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To collect the information during the field work, we used records for geomorphologic units, with the purpose of enabling the standardization of the information-gathering process and facilitate its systematization. The tab used contains the thematic and variables fields described in Tables. Table 3-123 and Table 3-124

Table 3-123. Thematic and variables fields for the collection of information in the archaeological sample units

| Thematic Field | Variable |
|--|--|
| Identification | Code of the prospected landscape unit. |
| | Code of the deposit. |
| Landscape Unit | Unit Type of landscape or geomorphologic unity. |
| | Planar Coordinates taken with GPS. |
| | Location with respect to the civil facilities. |
| | Dimensions: Length and width averages. |
| | Elements in surface: archaeological (benching, walls and stone floors). Human-caused (salting, livestock, plows etc.). |
| Archaeological activities carried out | Boreholes, cleaning of profiles and/or surface collection (A. S). |
| Information of the borehole | Physical Characteristics of the soil: exogenesis, reading profiles. |
| | Amount of cultural relics by levels of 5 cm. |
| | Stratigraphic Features: depositional events and cultural layers. |
| Supplementary Registration | Drawing of the plan metric landscape unit. |
| | Location of the archaeological elements identified. |
| | Location of the archeological interventions carried out. |
| | Photographic Record. |

Table 3-124. Registration Form for archaeological sampling units

| |
|---|
| ENVIRONMENTAL AND GEOGRAPHIC SERVICES ARCHAEOLOGICAL PROSPECTING IN THE HYDROELECTRIC CENTRALS. EL MOLINO AND SAN MATIAS, COCORNA, ANTIOQUIA REGISTRATION FORM FOR MINIMUM GEOMORFOLOGIC UNIT PROSPECTED -UMGP - |
|---|

Contextual Data

| | | | |
|---|---|---------------|---------|
| Geomorphologic Unity: | | | |
| Long: | Width: | Area: | Height: |
| N°. UMGP: | | N° Deposit: | |
| Coordinates X: | Y: | N: | W: |
| Municipality: | Vereda (Political and administrative division of the municipality located in the rural area): | Sector: | |
| Vegetation Type: | | Current Crop: | |
| Anthropic Elements : | | | |
| Type of alterations: | | | |
| Percentage of alteration: | | | |
| Archaeological Sampling (s)carried out: | | | |

Data- of the interventions carried out

| | | | | |
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| N° MA | Level | Ceramic Quantity | Lithic Amount | Other | Comments |
|-------|-------|---------------------|------------------|-------|----------|
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Stratigraphy

| Depth | Horizon | Color | Texture | Structure | Comments |
|-------|---------|-------|---------|-----------|----------|
| | | | | | |
| | | | | | |
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Date: _____ **Prepared:** _____

During the development of archaeological exploration, record the spatial information about the heliographic plates mapping printed to scale 1:10 and 1:25, provided by the project, including a GPS (Garmin Map), which contains the areas of facilities. With them was a spatial control of the routes of exploration and the location of archaeological sites identified with respect to the facilities.

As an important addition to the archaeological information that was recovered in the prospecting, in each of the landscape units where vestiges were found - archaeological sites -, was a freehand drawing (plan metric), where was located the type of vegetation, the recent anthropogenic intervention (houses, salting, fences), the erosive footsteps (trails, trampling of cattle, creeks), and the archaeological activities carried out such as boreholes and surface collections. This record was supplemented by digital photography.

- Results of the prospecting

The prospecting in the field are carried out through the recognition of the terrain and the realization of boreholes, review of exposed surfaces, collections of archaeological materials and the reading of Stratigraphic profile exhibited originated in previous anthropogenic activities.

The implementation of the activities of the field work, led to the location and prospecting of 17 landscape units called Minimum Units of geomorphologic Prospecting (UMGP), located in the areas designated for the construction of civil facilities such as deposits, track access to house of engines of the El Molino hydroelectric project , access road to the house of

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valves and relief pipeline, collection area and house of engines of the San Matias hydroelectric project .

In 12 of the 17 units of landscape prospected, were recovered archaeological remains; these units correspond to alluvial terraces and breaks in slope, in some of which are vestiges of the realization of adaptations to way of “banqueos”, with the purpose of obtaining major areas or more of the flat surfaces than those that the original relief surfaces delivered. These units with vestiges and adaptations, were outlined as archaeological sites and were identified with a consecutive number followed by the name of the Vereda (*Political and administrative division of the municipality located in the rural area*) or locality where they were found.

In the landscape units outlined as deposits, were recovered cultural material that consists of 263 ceramic fragments (97 with a size less than 2 cm, called micro fragments), and 40 lithic items. Table 3-125 shows the frequency distribution of these materials for each deposit and by arbitrary levels of excavation of 5 cm thick.

Table 3-125. Frequency distribution of lithic and ceramic material by deposit and level

| Level | Ceramic/Deposit | | | | | | | | | | | | Lithic/Deposit | | | | | | | |
|-------|-----------------|---|----|---|---|---|----|---|----|----|----|----|----------------|---|---|----|---|----|----|--|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 6A | 6B | 1 | 2 | 3 | 7 | 9 | 6A | 6B | |
| R. S | | 5 | 15 | | | | | 1 | | | | | | 2 | 2 | | | | | |
| 1 | | | | | | | | | 1 | | | | | | | | | | | |
| 2 | | | | | 3 | 7 | 4 | | 2 | | | | | | | | | | | |
| 3 | 2 | | | | | 1 | 1 | | 8 | 14 | 1 | | | | | | 1 | | | |
| 4 | 3 | | | 1 | | | 8 | | 14 | 4 | 4 | | | | | | 1 | | | |
| 5 | | | | 1 | 2 | | 17 | | 32 | 14 | 3 | 1 | | | | | | 1 | 1 | |
| 6 | | | | | | | 12 | | 18 | 3 | 5 | 5 | 1 | | | 1 | 1 | 1 | 5 | |
| 7 | | | | 2 | 1 | | 12 | | 3 | | | | | | | 3 | 3 | 2 | | |
| 8 | | | | | | | 5 | | | | | 1 | | | | 1 | | 3 | 1 | |
| 9 | | | | | | | 7 | | | | 2 | 1 | 1 | | | | 2 | | 1 | |
| 10 | | | | | | | 2 | | | | 2 | | | | | 2 | | 1 | | |
| 11 | | | | | | | 7 | | | | | | | | | 3 | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | 6 | | | | | | | | | | | | | |
| | 5 | 5 | 15 | 4 | 6 | 8 | 81 | 1 | 78 | 35 | 17 | 8 | 1 | 3 | 2 | 10 | 8 | 8 | 8 | |

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Of the 12 sites identified, 10 are affected by the El Molino hydroelectric project , although in this numeral describes the characteristics of all, including the two that are affected by the house of engines of the San Matias hydroelectric project :

- Deposit 1, Quebradona

This reservoir is located in the municipality of Granada, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo, in the planar coordinates X: 880,538 - AND: 1,163,332 , At a height of 1,315 meters above sea level, which corresponds to an alluvial terrace located in the left margin of the San Matias River. The terrace has an area of about 160 m² and presents alterations produced by erosion, of the trenching and the construction of a salting and a house. Its plant cover corresponds to cattle pasture (see Photo 3-95 and Photo 3-96). The deposit is located with respect to the civil facilities, in the surrounding area to the collection area.



Photo 3-95. Wide view, deposit 1



Photo 3-96. Detail, deposit 1

The geomorphologic context of the deposit, corresponds to a landscape of the basin of the San Matias River, where the basin opens a little, forming alluvial floodplain in the middle of a system of long mountain slopes moderately steep(see Photo 3-95 and Photo 3-96).

The site is being accessed by the unpaved road that part of the framework of the Cocorná Square and is directed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Playas, where you can take the Garrucha crossing the San Matias River and reach Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo, to the property of the Sanin family, where the archaeological site is.

In this unit was a borehole in which were recovered five fragments of ceramic and lithic artifact.

➤ Stratigraphy and cultural material

In the modal profile of the borehole carried out (see Photo 3-97), we observed a cultural layer of about 50 cm in thickness, which identified a succession of five soil horizons, two of which (A1 and Ab) contain material related to cultural events of occupation in pre Hispanic times, and are covered by an horizon, which contains no cultural material. The characteristics of the Stratigraphic column are the following:

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Photo 3-97. Stratigraphy test pit 1, reservoir 1

Horizon

Corresponds to an array of soil about 9 cm thick, dark brown (5YR 3/2, Munsell), loam and clayey structure in sub angular fine blocks; presents average roots and is part of the soil formed in current environmental conditions. There is no archaeological remains.

Horizon1

Corresponds to an array of ground of about 18 cm thick, dark brown (5YR 3/4, Munsell), loam and clayey structure in sub angular fine blocks; presents fine roots and charcoal, in addition to archaeological vestiges, such as five ceramic fragments. These materials are distributed at the top of the horizon, between levels 3 and 4 of excavation.

Horizon Ab

It is an array of ground about 14 cm thick, dark brown (5YR 3/1, Munsell), clay texture and structure in sub angular fine blocks... Covers levels 6, 7 and 8 of excavation and contains material corresponding to a cultural lithic artifact, located toward the roof of the horizon.

Horizon AB

Corresponds to an array of soil about 4 cm thick, reddish brown (5YR 4/4, Munsell), sandy clay texture and structure in sub angular fine blocks; presents very few fine roots and does not contain cultural material.

B Horizon

Corresponds to an array of soil to be evidenced from the 45 cm depth; brown yellow (10YR 5/6, Munsell), clay texture and structure in blocks sub angular fine blocks this horizon corresponds to the saprolite unit of landscape and is culturally sterile.

➤ Characteristics of ceramics

The ceramics samples recovered from this deposit consists of five fragments quite eroded, among which there are a micro fragment (see Photo 3-98). These correspond to parts of bodies of pots and do not present any type of decor. Only one of them presents traces of external painting of brown color.

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The ceramics presents pastes yellow, red and reddish brown colors, winding surfaces, with a thickness ranging between 5 mm and 12 mm and an average of 7.7 mm. The/degreasant is composed of particles of minerals such as: Quartz, feldspar and golden and silver mica, fine sizes to media.

Given the characteristics of this ceramic material and to the small sample, it is not possible to establish a cultural association in relation with the ceramic complexes identified in the region, although by its Stratigraphic location (roof of the Horizon A1), it could be suggested that this material is associated with the late occupations that have been identified in region.



Photo 3-98. Late fragments of ceramics, reservoir 1

➤ Characteristics of the lithic

The lithic element recovered in the borehole 1, corresponds to a flake in site of third order, found in the excavation of level six (see Photo 3-99).



Photo 3-99 Flake of third order, reservoir 1

– Reservoir 2, Quebradona

The archaeological site 2, Quebradona is located in the municipality of Granada, on the Vereda (*Political and administrative division of the municipality located in the rural area*)

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Quebradona Abajo, in the planar coordinates X: 880,932 - Y: 1,162,671 , At a height of 1,308 meters above sea level, in the left margin of the San Matias River. This corresponds to a break of slope, about 360 m², which presents erosion and product of the plow furrows of the earth. Its current plant coverage is devoted to livestock pasture (see Photo 3-100 and Photo 3-101). With regard to the civil facilities, is located in the surrounding area to the collection area.



Photo 3-100. Wide view, reservoir 2



Photo 3-101. Detail, reservoir 2

The site is accessed in the same way that the reservoir 1, because it is located on the premises of the same property.

In this unit were two surface collections, in which five ceramic fragments were recovered, including a micro fragment and a fragment of edge with wear; and a borehole, where only was found a flake of first order.

➤ Stratigraphy and cultural material

The modal profile of the borehole carried out (see Photo 3-102), has the following features and Stratigraphic of cultural contents: identified a cultural layer of about 45 cm in thickness, in the differentiated six horizons of soil, one of which (Ab), we found an artifact lithic flake (primary in sandstone), in an array of dark soil, of about 23 cm in thickness, which starts about 40 cm in depth.

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Photo 3-102. Test Pit 1, reservoir 2

The characteristics of the horizons are the following.

Horizon

Corresponds to an array of ground of around 9 cm thick, dark brown (5YR 3/3, Munsell), frank texture and structure in sub angular fine blocks; presents roots and corresponds to the average soil formed in current environmental conditions and altered by processes of cultivation and grazing. Does not present archaeological cultural material.

Horizon1

Corresponds to an array of soil about 9 cm thick, dark gray (5YR 4/2, Munsell), loam and clayey structure in blocks sub angular fine blocks; presents average roots of grass, and does not contain cultural material.

Horizon2

Corresponds to an array of floor of about 21 cm thick, dark brown (5YR 3/2, Munsell), loam and clayey structure in sub angular medium blocks; presents moderate amount of average grass roots and contains no cultural material.

Horizon Ab

Corresponds to an array of ground of about 23 cm thick, dark brown (5YR 3/1, Munsell), loam and clayey structure in sub angular fine blocks. Presents moderate quantity of fine roots and cultural material corresponding to an artifact in stone (a flake), located toward the roof of the horizon at a depth of 40 cm and 45 cm.

Horizon AB

Corresponds to an array of soil about 9 cm thick, red yellow (5YR 4/6, Munsell), clay loam soil texture and structure in blocks sub angular fine blocks, which presents very few fine roots and does not contain cultural material.

Horizon B

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Corresponds to an array of soil to be evident from the 61 cm depth, brown (7.5YR 5/8, Munsell), loam and clayey structure in blocks sub angular fine blocks. Presents very few fine roots and is culturally sterile.

➤ Characteristics of ceramics

The five fragments of ceramics recovered from this reservoir, correspond to parts of bodies of containers; the pastas are brown and reddish yellow, with thicknesses between 4 mm and 6 mm (on average 5 mm), of slick surfaces, with something of erosion (see Photo 3-103). These contain particles of quartz, feldspar and silver mica, fine to medium sizes. There are no decorations. Due to the characteristics of this material, it was not possible to associate any ceramic style or to some period of occupation reported to the area.



Photo 3-103. Ceramic fragments, reservoir 2

➤ Characteristics of the lithic

The lithic material recovered from this deposit corresponds to a flake of first order in sandstone, triangular in shape, found in the excavation of level nine, and a fragment of edge with worn edges in derived from granitic rocks, with an ovoid shape, recovered in surface (see Photo 3-104 and Photo 3-105). The cantos with worn edges are a type of a utensil, that in the study area, are associated with a pre-ceramic period (Cardona and Yepes, 2011b); however, on this site this association is not clear, due to the fact that it was found in surface, and the stratified context are not evidence.

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Photo 3-104. Fragment of edge with worn edges, reservoir 2



Photo 3-105. Flake of third order, reservoir 2

- Reservoir 3, Quebradona

The archaeological site 3, Quebradona is located in the municipality of Granada, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo, in the planar coordinates X: 881,053 - Y: 1,162,645, at a height of 1,308 meters above sea level. This corresponds to a gently sloping hillside, of about 3,500 m², whose surface is altered (95 %), by plow with tractor as preparation for the planting (see Photo 3-106 and Photo 3-107). With regard to the civil facilities is located in the surrounding area to the collection area.



Photo 3-106. Wide view, reservoir 3



Photo 3-107. Detail reservoir 3

The site is accessed in the same way that deposits 1 and 2, since it is located on the premises of the same property.

On this site were two surface collections in the area that was plowing with tractor, which led to the recovery of 15 ceramic fragments (two of these correspond to micro fragments), and two artifacts in stone; it was not possible Stratigraphic contextualization of these materials, since the horizons of soil were mixed in the process of plowing.

➤ Characteristics of ceramics

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The pottery has the following features: pastas of yellow red, red brown and red yellow, thicknesses between 4 mm and 11 mm (with an average of 7.9 mm) (see Photo 3-108). The surfaces are polished and there are scabs of coal. Contains particles of quartz, golden mica and felspar, fine to medium sizes.

In the sample there is a fragment of the body, two fragments of handles of rounded section and 10 edges without decorations, discriminated against by forms in the following manner: a horizontal edge thickened toward the east and thinned toward the end (the lip), five averted direct, two very averted edges chamfered (with diameters of 17 cm and 21 cm) and two averted chamfered (one of which has a diameter of 19 cm).

Because of the characteristics of this ceramic material, it is possible to associate the ceramics of complex El Oro, identified in the study area and in the Middle Magdalena region (Cardona and Yepes, 2009c).



Photo 3-108. Fragments of edges and handles associated with the complex El Oro, reservoir3

➤ Characteristics of the lithic

The lithic material from this site, recovered in surface, corresponds to a pebble in basalt, with an ovoid shape, with evidence of carving by scabble flake and a second-order, triangular in shape, in milky quartz (see Photo 3-109 and Photo 3-110). This type of material has been associated with ceramics of Complex El Oro in the study area. (Cardona and Yepes, 2009c).

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Photo 3-109. Edge with pebble size by scabble, reservoir 3



Photo 3-110. Secondary Flake, reservoir 3

– Reservoir 4, El Molino

The archaeological site 4, El Molino, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, in the planar coordinates X: 880,742 - Y: 1,161,947 , At a height of 1,418 meters above sea level, on the right bank of the San Matias River. Corresponds to a break of slope of average gradient of about 120 m², which is covered in low grasses and debris, and is altered by the removal of land for cultivation and for the construction of a fence and an electric post (see Photo 3-111and Photo 3-112). With regard to the civil facilities, is located in the surrounding area between the access routes to collection in the El Molino hydroelectric project .



Photo 3-111. Wide view, reservoir 4



Photo 3-112. Detail, reservoir 4

The site is accessed by the track that leads from the municipal seat of Cocorná to the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, at the end of which takes a path on the left hand, following the path of the track that leads to reservoirs 3 and 4.

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In this unit was conducted a borehole, which recovered cultural material consisting of four ceramic fragments.

➤ Stratigraphy and cultural material

The modal profile of the borehole (see Photo 3-113), presents a cultural layer of 31 cm in thickness with the following features and Stratigraphic of cultural content.

Horizon A

Corresponds to an array of ground of about 8 cm thick, dark brown (5YR 3/2, Munsell), loam and clayey structure in blocks sub angular fine blocks; presents abundant fine roots, and corresponds to the soil formed in current environmental conditions and altered by processes of grazing. Does not present archaeological cultural material.

Horizon A1

Corresponds to an array of ground (about 8 cm thick, dark gray (5YR 2.5 /2, Munsell), loam and clayey structure in blocks sub angular medium blocks; presents moderate average quantity of roots of the grass and does not contain cultural material.



Photo 3-113. Stratigraphy test pit 1, reservoir 4

Horizon A2

Corresponds to an array of soil about 7 cm thick, dark brown (10yr 4/3, Munsell), loam and clayey structure in blocks sub angular medium blocks; presents little amount of averages grass roots and contains cultural material, corresponding to two ceramic fragments.

Horizon AB

Corresponds to an array of ground (about 8 cm thick, brown (10yr 4/4, Munsell), texture and clayey silt structure in sub angular fine blocks, which presents very few fine roots and contains cultural material represented in two ceramic fragments.

Horizon B

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Corresponds to an array of soil to be evidence from the 61 cm depth, brown (10yr 6/8, Munsell), texture and clayey silt structure in sub angular fine blocks. Presents very few fine roots and is culturally sterile.

➤ Characteristics of ceramics

The ceramics samples recovered from this deposit consists of four fragments (see Photo 3-114). The pastas are brown, with thicknesses between 5 mm and 9 mm (7.5 mm on average); in the mineral inclusions are observed particles of quartz and golden mica, fine sizes; the surfaces are polished, in which there are scabs of coal. There are no fragments decorated.

In the sample there are two averted edges, thickened toward the east and thinned out in the end, which they could not determine the diameter, due to its small size. These features and the Stratigraphic position of the material (between horizons TO2 and AB), at a depth between 15 cm and 35 cm, allow you to associate the sample to the ceramics known in the area of study as the Complex El Oro.



Photo 3-114. Fragments of edges and bodies associated with the complex El Oro, reservoir 4

– Reservoir 5, El Molino

The archaeological site 5, El Molino, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino in the planar coordinates X: 881,001 - Y: 1,162,019 , At a height of 1404 meters above sea level, on the right bank of the San Matias River. The unit of landscape or geomorphology corresponds to a break of slope media, which covers an area of 108 m² (see Photo 3-115). Alterations are observed by trampling by livestock. With regard to the civil facilities, the reservoir is located in the area of the track to collection in the El Molino hydroelectric project

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Photo 3-115. Panoramic, reservoir 5

In this landscape unit was conducted a borehole, in which were recovered six ceramic fragments, two of them micro fragments, located between 5 cm and 35 cm depth. However, given the Stratigraphic disturbance detected in the pit (jumbled material), did not read the profile, nor the vertical location of cultural material found.

➤ Stratigraphy and cultural material

The Stratigraphic succession of the horizons of soil in the borehole was found quite disturbed, as it was observed a soil mixing of color yellow with brown and content scrambled pieces of adobe with few ceramic fragments, which present an unreliable Stratigraphic distribution (see Photo 3-116).



Photo 3-116. Borehole detail, reservoir 5

➤ Characteristics of ceramics

The two ceramic fragments recovered present pastas coffee-colored and pale red, sinuous and eroded surfaces, thicknesses ranging from 6 mm to 9 mm (whose average is 7.5 mm). Contains particles of quartz, feldspar and golden mica, fine sizes (see Photo 3-117).

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Since the sample does not contain fragments of diagnostics forms or decorations, it was not possible to establish a cultural association of this material with any of the ceramic sets already identified in the region.



Photo 3-117. Ceramic fragments, reservoir 5

– Reservoir 6, Los Mangos

The archaeological site 6, Los Mangos, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, farm Miraflores, in the planar coordinates X: 883,423 - Y: 1,160,610 , At a height of 964 meters above sea level, on the right bank of the San Matias River. The unit of scenery corresponds to a rest of gently sloping hillside, of approximately 2700 m² area and presents a vegetation coverage of grasses and some trees (see Photo 3-118 and Photo 3-119). There are recent anthropogenic alterations, such as the construction of an irrigation ditch, a fence in stone and removal of soil by product of a former coffee cultivation. With regard to the civil facilities, is located in the area for the reservoir SM4 of the hydroelectric project. El Molino



Photo 3-118. Wide view, reservoir 6



Photo 3-119. Detail, reservoir 6

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The site is being accessed by the unpaved road that part of the framework of the plaza of Cocorná and routed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, then takes a Vereda (*Political and administrative division of the municipality located in the rural area*) way on the left side of the track, which leads to the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos

The deposit made two boreholes, in which cultural material were recovered ceramic fragments represented by eight (four of which are micro fragments). The modal profile of pit 1 has the following features and Stratigraphic of cultural content.

- Stratigraphy and cultural material

In the test pit 1 (see Photo 3-120), was identified a Stratigraphic column of four horizons of soil, in a layer of 30 cm thick. In two of the horizons (A and A₁), it was found materials that are related to the occupation of the site in pre Hispanic times. The characteristics of the Stratigraphic column, are shown below.



Photo 3-120. Stratigraphy test pit 1, reservoir 6.

Horizon A

Corresponds to an array of soil about 7 cm thick, dark brown (7.5YR 3/4, Munsell), sandy and loamy texture and structure in sub angular fine blocks; presents abundant rootlets of grass and contains two ceramic fragments.

Horizon A₁

Corresponds to an array of ground about 11 cm thick, dark in color (7.5YR 4/3, Munsell), sandy and loamy texture and structure in sub angular fine blocks. Has a very small amount of fine roots and contains a ceramic fragment.

Horizon AB

Corresponds to an array of ground of about 12 cm thick, brown yellow (10yr 5/3, Munsell), sandy and loamy texture and structure in sub angular fine blocks Presents very few fine roots and rocks weathered, and does not contain cultural material.

Horizon B

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Corresponds to an array of ground that begins to insinuate itself into the 30 cm depth, yellow brown (10yr 5/8, Munsell), texture and clayey silt structure in sub angular fine blocks. Presents very few fine roots and rocks weathered and does not contain cultural material.

➤ Characteristics of ceramics

The ceramics presents pastes clear colors yellow and red yellow, quite eroded surfaces, thicknesses between 6 mm and 12 mm (8.5mm on average) (see Photo 3-121). Contains particles of quartz and feldspar, of medium sizes. None of the fragments decoration these features did not allow to associate the sample to any of the ceramic complexes outlined in the region.



Photo 3-121. Ceramic fragments, reservoir 6.

– Reservoir 7, Los Mangos

The archaeological site 7, Los Mangos, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, in the planar coordinates X: 882,760 - Y 1,160,711 , At a height of 1,128 meters above sea level, on the right bank of the San Matias River. Its geomorphology corresponds to a break of medium slope, which covers an area of 1575 m². Presents a vegetative cover of grass and trees (see Photo 3-122 and Photo 3-123). In this unit are presented alterations by the construction of a trapiche and creep the surface by cattle grazing. With regard to the civil facilities, is located in the area surrounding the site intended for the construction of the house of engines of the El Molino hydroelectric project

The site is being accessed by the unpaved road that part of the framework of the Cocorná Square and routed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, then takes a Vereda (*Political and administrative division of the municipality located in the rural area*) way on the left side of the track, which leads to the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos.

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In this reservoir was a borehole, in which were recovered 81 ceramic fragments (36 of them are micro fragments), and 10 lithics. The modal profile of the pit has the following features and Stratigraphic of cultural content.



Photo 3-122. Wide view, reservoir 7



Photo 3-123. Detail, reservoir 7

➤ **Stratigraphy and cultural material**

In the borehole (see Photo 3-124), is identified a layer of soil 75 cm thick, with a Stratigraphic column composed of a succession of six soil horizons, whose features are the following.



Photo 3-124. Borehole Stratigraphy, reservoir 7.

Horizon Ap

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Corresponds to an array of soil approximately 6 cm thick, brown (7.5YR 4/6, Munsell), loam and clayey structure in sub angular fine blocks; presents abundant medium and fine roots, and contains four ceramic fragments.

Horizon ABp

Corresponds to an array of ground of about 13 cm thick, brown (7.5YR 5/6, Munsell), sandy clay texture and structure in sub angular fine blocks. Has a very small amount of fine roots and contains nine fragments of ceramic material.

Horizon Ab

Corresponds to an array of ground about 25 cm thick, red yellow (5YR 4/6, Munsell), sandy clay texture and structure in sub angular fine blocks. Presents very few fine roots and contains ceramic cultural material: 53 Fragments and five lithic elements.

Horizon A1

Consists of an array of ground about 11 cm thick, red yellow (5YR 5/6, Munsell), loam and clayey structure in sub angular fine blocks. Presents very few fine roots and contains nine ceramic fragments and five lithic.

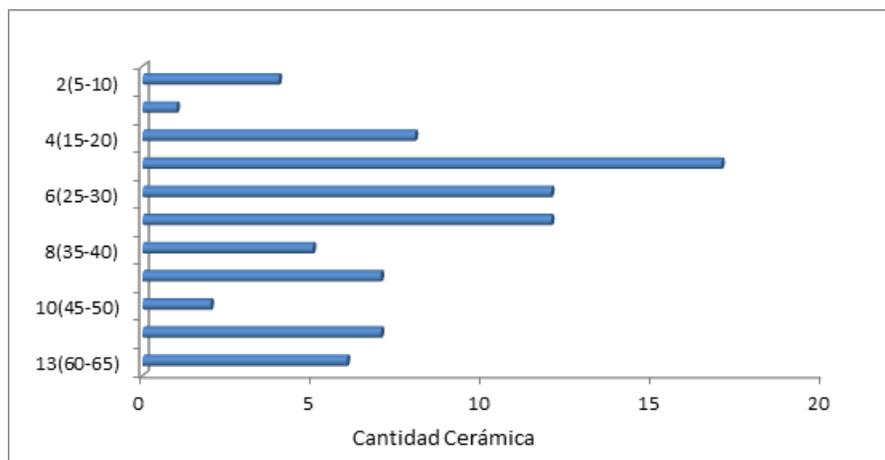
Horizon AB

It is an array of ground some 12 cm thick, reddish yellow (7.5YR 6/8, Munsell), loam and clayey structure in sub angular fine blocks. Presents very few fine roots and contains cultural material represented in six ceramic fragments.

Horizon B

Corresponds to an array of ground that begins to insinuate itself into the 67 cm of depth, of yellow-reddish brown (7.5YR 7/8, Munsell), texture and clayey silt structure in sub angular fine blocks. Presents very few fine roots and rocks weathered, and does not contain cultural material.

The distribution of the ceramic material by levels of excavation and horizons of soil (see Figure 3-103), indicates a ontogeny quantitative that starts in the horizon AB, linked to the beginnings of the occupation of the site, between the 55 cm and 67 cm depth.



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Figure 3-103. Ceramic Distribution by levels, reservoir 7

Then the amount of pottery begins a slight decrease in the horizon A1, between the 44 cm and 55 cm in depth, to continue progressively rising among the level 9 (40 cm - 45 cm) and 5 (20 cm - 25 cm), in what corresponds to the horizon of soil AB, which contains the greater frequency of ceramics, that would indicate a more intense occupation or already consolidated of the unity of landscape.

Subsequently, in the horizon **ABp**, the ceramic descends, in what seems to correspond to time which may be indicating the process of abandonment of the place. This corresponds to a layer of soil that goes from 10 cm to 20 cm in depth.

Finally, in the horizon of soil AP, again increasing the amount of ceramics, in an array of ground quite upset about 6 cm thick, which indicates that this pottery was removed by recent anthropogenic intervention.

➤ Characteristics of ceramics

The ceramic pasta presents colors of dark red, gray, red and dark brown, slick surfaces and eroded, in thicknesses between 5 mm and 12 mm, with an average of 9 mm (see Photo 3-125). Contains particles of quartz, feldspar and golden mica, of media sizes.



Photo 3-125. Ceramic fragments associated with the Complex El Oro, reservoir 7.

In the sample there is a fragment of straight edge without direct decor and two fragments of bodies of vases decorated: one with an incision of vertical parallel lines and the other with vertical with wide ribbed lines

The characteristics of this material and the Stratigraphic placement of the diagnostic material, establish an association of this ceramic material with the ceramic complex El Oro, referenced to the region by Cardona and Yepes (2009b).

➤ Characteristics of the lithic

The lithic material from this site corresponds to a core in andesite, a fragment of flake size bipolar in basalt, a pebble with an ovoid shape with lap belt wear in sandstone, a flake of

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first order in sandstone, two slices of third order in milky quartz and talc, respectively, and four wastes of carving in milky quartz and sandstone (see Photo 3-126Photo 3-129).



Photo 3-126. Pebble with wear, reservoir 7



Photo 3-127. Slices of first and third order, reservoir 7



Photo 3-128. Nucleus, reservoir 7



Photo 3-129. Fragment flake with bipolar flake, reservoir 7

– Reservoir 8, Los Mangos

The archaeological site 8, Los Mangos, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, in the planar coordinates X: 883,484 - Y: 1,160,319, At a height of 1,000 meters above sea level, on the right bank of the San Matias River, among the creeks El Tejar and Los Tubos The geomorphologic unity corresponds to a terracing rest on a hillside; the area associated with the archaeological site is about 247 m². Presents a vegetation coverage of grasses for livestock and fruit trees (see Photo 3-130andPhoto 3-131). No recent alterations are observed. Emphasizes the presence of a small slope, indicating that in pre-Hispanic times was there a benching for the establishment of a housing unit. With regard to the civil facilities, is located in the area intended for the SM3 tank of El Molino hydroelectric project

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Photo 3-130. Wide view, reservoir 8



Photo 3-131. Detail, reservoir 8

The site is being accessed by the unpaved road that part of the framework of the plaza de Cocorná Square and routed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, then takes a Vereda (*Political and administrative division of the municipality located in the rural area*) way on the left side of the track, which leads to the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos.

In this landscape unit were two boreholes, which were not used in cultural material recovered; however, in the south slope, is found a fragment of pottery, which was not picked up because it was very small and quite eroded. The modal profile of pit 1 presents the following Stratigraphic features.

➤ **Stratigraphy and cultural material**

In the test pit 1 (see Photo 3-132), was identified a succession of five Stratigraphic horizons of soil, in a layer of 34 cm thick, in which no cultural material was found. The characteristics of the Stratigraphic column are the following.

Horizon A

Corresponds to an array of soil about 4 cm thick, red (2.5YR 4/4, Munsell), loam and clayey structure in sub angular fine blocks, with abundant roots medium and fine.

Horizon A1

Corresponds to an array of soil about 9 cm thick, dark brown yellow (10yr 4/6, Munsell), sandy clay texture and structure in sub angular fine blocks Has a very small amount of fine roots.

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Photo 3-132. Stratigraphy test pit 1, reservoir 8.

Horizon A2

Corresponds to an array of ground some 12 cm thick, brown (7.5YR 4/6, Munsell), loam and clayey structure in sub angular medium blocks. Presents very few fine roots.

Horizon AB

Corresponds to an array of ground of about 8 cm thick, red yellow (5YR 5/6, Munsell), loam and clayey structure in sub angular medium blocks. Presents very few fine roots.

Horizon B

Corresponds to an array of ground that begins to insinuate itself into the 34 cm deep, reddish-brown (2.5YR 5/8, Munsell) and structure of rock weathering.

➤ Characteristics of ceramics

It was only found, using surface collection, a micro fragment of pottery rather eroded, which does not allow us to establish characteristics that enable any cultural association with the ceramic complexes identified in the area.

– Reservoir 9, Los Mangos

The archaeological site 9, Los Mangos, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, in the planar coordinates X: 883,510 - Y: 1,160,329, At a height of 998 meters above sea level, on the right bank of the San Matias River, among the creeks El Tejar and Los Tubos The geomorphologic unit associated with the deposit, corresponds to an extensive terracing on rest of the hillside, which reaches approximately 375 m² area. Presents a vegetation coverage of grasses for livestock and fruit trees (see Photo 3-133 and Photo 3-134).

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Photo 3-133. Wide view, reservoir 9



Photo 3-134. Borehole realization, reservoir 9

Recent alterations are observed, such as a trough for cattle. On the surface highlights the presence of a small slope, indicating that in pre-Hispanic times there was a benching for the establishment of a housing unit. With regard to the civil facilities, is located in the area intended for the SM3 tank of El Molino hydroelectric project .

The site is being accessed by the unpaved road that part of the framework of the Cocorná Square and routed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, then takes a Vereda (*Political and administrative division of the municipality located in the rural area*) way on the left side of the track, which leads to the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos

In this unit were two boreholes, there was recovered cultural material, which consists of 74 fragments of ceramic and eight lithic elements. The profile of the modal pit 1 has the following features and Stratigraphic of cultural content.

➤ Stratigraphy and cultural material

In the test pit 1 (see Photo 3-135), identified a Stratigraphic column of five horizons of soil, in a layer 50 cm thick. Was found cultural lithic material and ceramic in the Horizons A1 and A2. The characteristics of the Stratigraphic column are the following.



Photo 3-135. Stratigraphy test pit 1, reservoir 9.

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Horizon A

Corresponds to an array of ground about 10 cm thick, brown (7.5YR 4/3, Munsell), texture and structure in sub angular fine blocks with abundant roots medium and fine. Not cultural material found.

Horizon A1

Corresponds to an array of ground some 12 cm thick, brown (7.5YR 4/3, Munsell), loam and clayey structure in sub angular fine blocks. Presents little quantity of fine roots, coal and ceramic cultural material: 42 fragments and a lithic.

Horizon A2

Corresponds to an array of ground about 15 cm thick, brown (7.5YR 5/4, Munsell), loam and clayey structure in sub angular fine blocks Presents very few fine roots, carbon and ceramic cultural material: 12 fragments and a lithic.

Horizon AB

Corresponds to an array of ground of about 8 cm thick, brown (7.5YR 5/6, Munsell), loam and clayey structure in sub angular fine blocks. Presents very few fine roots, coal, and does not contain cultural material.

Horizon B

Corresponds to an array of ground that begins to insinuate itself into the 50 cm deep, reddish yellow (7.5YR 6/8, Munsell), clayey sand texture and structure in sub angular fine blocks. Presents very few fine roots and does not contain cultural material.

The distribution of the ceramic material by levels of excavation and horizons of soil (see Figure 3-104), indicates a ontogeny quantitative that starts in the horizon **A2** associated with the beginning of the occupation of the site, between the 35 cm and 40 cm depth.

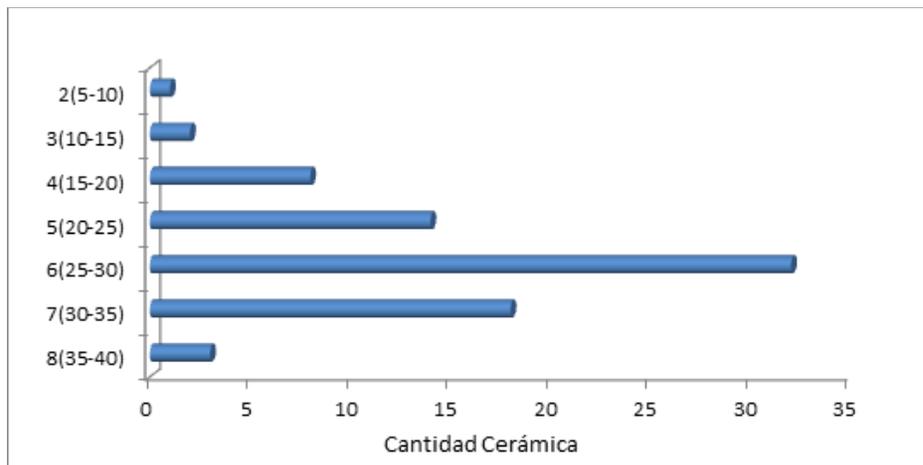


Figure 3-104. Ceramic Distribution by levels, reservoir 9

Subsequently, the amount of ceramic increases gradually until it reaches a peak, in the horizon A2, level 6 (25 cm - 30 cm), from which begins to decrease, until the level 1 (0 - 5

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cm) of excavation, in the horizon A. The vertical distribution of ceramics frequencies, show a typical mode distribution (in the form of campaign), with a quantitative ontogeny that identifies a start-intensification - decrease, which is associated with top-greater intensity-abandonment, the occupation of the landscape unit, which would be also indicating a single occupation.

➤ Characteristics of ceramics

The ceramics presents pastes yellow red colors, coffee and coffee dark, slick surfaces, polished and eroded, in thicknesses between 5 mm and 10 mm for an average of 7.5 mm (see Photo 3-136). Contains particles of quartz, golden mica and feldspar, of medium sizes.



Photo 3-136. Ceramic fragments associated with the complex El Oro reservoir 9

In the sample there are two fragments of averted rounded, one of which presents an incision of an external perimeter line at the base of the neck. There are also seven fragments internal paint decorated with brown color.

The characteristics of this material and its Stratigraphic location enables it to establish a partnership with the ceramic complex El Oro referenced for the region.

➤ Characteristics of the lithic

The lithic material from this reservoir consists of four slices of asymmetrical shape: one of second-order, two of the third order in site and one of the third order, chert yellow thermos altered (see Photo 3-137). Also recovered four debris in milky quartz.



Photo 3-137. Slices of first and second order, reservoir 9

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– Reservoir 10, Los Mangos

The archaeological site 10, Los Mangos, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, in the planar coordinates X: 883,532 - Y: 1,160,350, At a height of 992 meters above sea level, on the right bank of the San Matias River, among the creeks El Tejar and Los Tubos The unit corresponds to a landscape terracing on rest of the hillside, approximately 1,247 m² in area. Presents a vegetable cover of grasses for livestock and fruit trees (see Photo 3-138 and Photo 3-139). Surface alterations observed are not recent. Emphasizes the presence of a small slope, indicating that in pre-Hispanic times there was a benching for the establishment of a housing unit. With regard to the civil facilities, this landscape unit is located in the area destined for the SM3 tank of the El Molino hydroelectric project



Photo 3-138. Wide view, reservoir 10



Photo 3-139. Borehole realization, reservoir 10

The site is being accessed by the unpaved road that part of the framework of the plaza de Cocorná and routed to the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, then takes a Vereda (*Political and administrative division of the municipality located in the rural area*) way on the left side of the track, which leads to the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos.

In this deposit were two boreholes, which recovered cultural material, represented in 35 fragments of pottery. The modal profile of the pit 2 has the following and Stratigraphic features of cultural content.

➤ Stratigraphy and cultural material

In the test pit 2 (see Photo 3-140 and Photo 3-141), identified a Stratigraphic column of a succession of five horizons of soil, in a layer 45 cm thick. The characteristics of the Stratigraphic column are the following.

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Photo 3-140. Borehole Stratigraphy 1, reservoir 10



Photo 3-141. Reading Stratigraphic column borehole 1, reservoir 10

Horizon A

Corresponds to an array of ground about 3 cm thick, reddish brown (10yr 3/6, Munsell), loam and clayey structure in sub angular fine blocks, with abundant roots medium and fine; not found cultural material.

Horizon A1

Corresponds to an array of soil about 9 cm thick, brown (10yr 4/3, Munsell), clayey sand texture and structure in sub angular fine blocks. Presents medium average quantity of roots and fine coal and ceramic cultural material, represented in 14 fragments.

Horizon A2

Corresponds to an array of ground of about 13 cm thick, brown (10yr 4/4, Munsell), clayey sand texture and structure in sub angular medium blocks. Presents very few roots medium and fine, coal and 17 ceramic fragments.

Horizon A3

Corresponds to an array of ground of about 12 cm thick, brown yellow (10yr 5/4, Munsell), clayey sand texture and structure in sub angular fine blocks. Presents very few fine roots, coal and cultural material represented in three ceramic fragments.

Horizon AB

Corresponds to an array of ground of about 8 cm in thickness, color red yellow (5YR 5/6, Munsell), frank texture and structure in sub angular fine blocks. Presents very few fine roots and does not contain cultural material.

Horizon B

Corresponds to an array of ground that begins to insinuate itself into the 45 cm deep, red yellowish (5YR 5/8, Munsell), texture clayey silt and structure in sub angular fine blocks. Presents very few fine roots and does not contain cultural material.

The distribution of the ceramic material by levels of excavation and horizons of soil, indicates an ontogeny quantitative that starts in the A3 horizon and ends in the horizon A1, with a bimodal distribution, indicating that present two peaks, in levels 5 and 3 (see Figure

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3-105). However, the characteristics of the ceramics and the emergence of this from the 10-cm depth, seem to indicate that correspond to a single occupation of the landscape unit, associated with early ceramics, called Complex El Oro

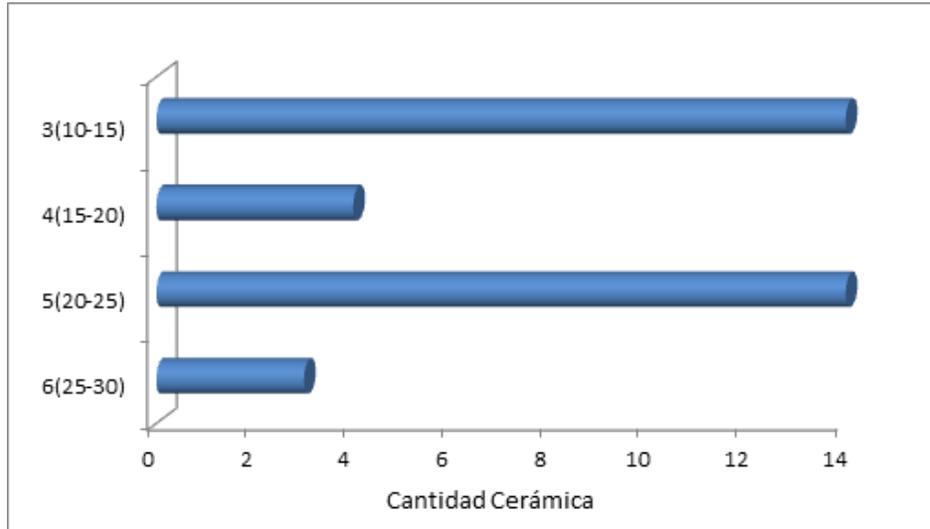


Figure 3-105. Ceramic Distribution by levels, reservoir 10

➤ Characteristics of ceramics

The ceramic pasta presents colors of dark red, dark brown and yellow, of surfaces polished and eroded, in thicknesses between 5 mm and 15 mm, with an average of 7.8 mm (see Photo 3-142). Contains particles of quartz, golden mica and feldspar, of medium to fine sizes

In the sample there are two fragments of edges very averted, thickened to the east and thinned out toward the end. Although there are no fragments decorated, the characteristics of the pasta, the types of edges and its Stratigraphic location, establish an association of this ceramic material with the ceramic complex El Oro, referenced to the region.



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Photo 3-142. Ceramic fragments associated with the complex El Oro, reservoir 10

– Site 6A, La Inmaculada.

The archaeological site 6A, La Inmaculada, is located in the municipality of Cocorná, on Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada, in the farm Playa Loca, in the planar coordinates X: 884,968 - Y: 1,159,593 , At a height of 809 meters above sea level, on the left bank of the Cocorná River and right banks of the San Matias River. Its geomorphology corresponds to a second alluvial terrace level, adjacent to another identified as deposit 6 by Cardona and Yepes (2009b), by what has been identified as site 6A. Presents an area of about 1,908 m² and seems to have a suitability (terracing). Presents a vegetation coverage of cattle grazing and no recent alterations are observed on the surface (see Photo 3-143 and Photo 3-144). With regard to the civil facilities, this is located in the area destined to the house of engines of the San Matias hydroelectric project .



Photo 3-143. Wide view, reservoir 6A



Photo 3-144. Detail, reservoir 6A

This deposit is reached by following the track Medellin - Bogota, up to the sector of La Mañosa, Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo of the municipality of Cocorná, where it takes the new access road to the house of engines of the El Popal hydroelectric project (where is located the reservoir 6, which is running the archaeological management plan by the same authors of the present study), located contiguously to the house of engines of the San Matias hydroelectric project , where is located the site 6A.

In this unit were done two boreholes, which recovered cultural material consisting of 17 fragments of ceramic and eight lithic elements.

➤ Stratigraphy and cultural material

In the test pit 1 (see Photo 3-145), identified a Stratigraphic column composed of a succession of seven horizons of soil, in a layer of 53 cm thick. The characteristics of the Stratigraphic column of the borehole 1 are the following.

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Photo 3-145. Borehole Stratigraphy 1, site 6A

Horizon A

It is an array of ground of approximately 6 cm thick, dark reddish brown (10yr 3/2, Munsell), texture and frank structure in sub angular medium blocks, with abundant roots medium and fine, where was not found cultural material.

Horizon A1

Corresponds to an array of soil about 7 cm thick, dark brown reddish (5YR 3/3, Munsell), Frank texture and structure in sub angular fine blocks. Presents medium average quantity of roots and fine coal and a fragment of pottery, located toward the base of the A horizon.

Horizon A2

Corresponds to an array of ground of about 13 cm thick, brown (7.5YR 3/3, Munsell), clayey sand texture and structure in sub angular fine blocks. Presents very few roots medium and fine, coal and ceramic cultural material composed of six fragments and a lithic.

Horizon A3

It is an array of soil about 9 cm thick, dark brown yellow (10yr 4/4, Munsell), clayey sand texture and structure in sub angular fine blocks. Presents very few fine roots, coal, five fragments of ceramic and two lithic elements.

Horizon Ab

Corresponds to an array of ground of about 8 cm thick, dark brown yellowish (10yr 4/6, Munsell), clayey sand texture, structure in sub angular fine blocks. Presents very few fine roots and cultural material contains ceramic: a fragment and a lithic.

Horizon AB

Corresponds to an array of ground about 10 cm thick, brown yellow (10yr 5/6, Munsell), texture and clayey silt structure in sub angular fine blocks. Presents very few fine roots and does not contain cultural material.

Horizon B

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Corresponds to an array of ground that begins to insinuate itself into the 53 cm depth, yellow brown (10yr 6/8, Munsell), texture and clayey silt structure in sub angular fine blocks. Presents very few fine roots and does not contain cultural material.

The distribution of the ceramic material by levels of excavation and horizons of soil (see Figure 3-106), indicates an ontogeny quantitative that starts in the horizon Ab (level 10), and ends on the horizon A1 (level 4). In the deeper levels (10, 9, 8 and 7) it has the lower frequencies, stressing that in level 8 ceramic was not found.

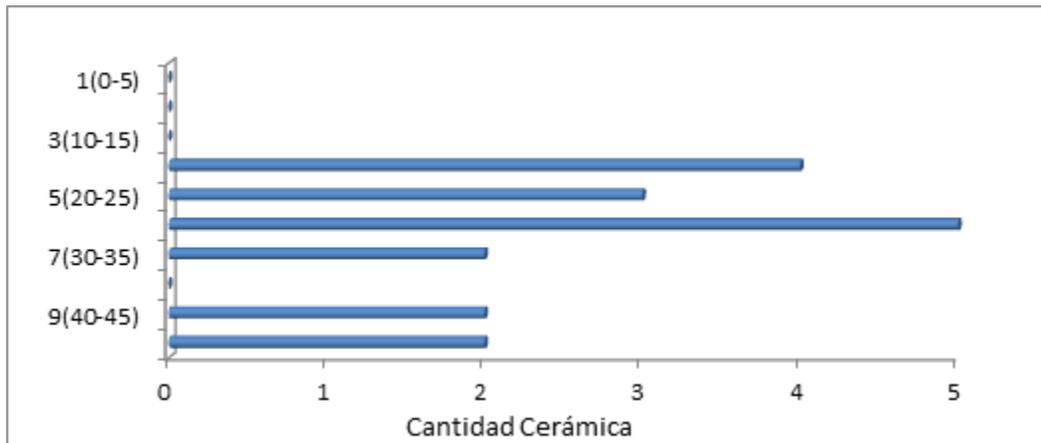


Figure 3-106. Ceramic Distribution by levels, reservoirs 6A

Then, toward the level 6, you have the higher frequencies, which begin to decrease in the following levels, 5 and 4. Due to the low frequencies in the deeper levels, the hiatus or level 8 without ceramic, does not seem to indicate the presence of two occupations, which seems to be corroborated by the characteristics of the ceramics, as will be seen later.

➤ **Characteristics of ceramics**

The ceramic pasta presents colors of dark red, brown, dark brown and dark yellow, slick surfaces, polished and eroded, in thicknesses between 5 mm and 12 mm, with 8 mm on average (see Photo 3-146). Contains mineral particles of sizes of fine quartz, feldspar, gold and silver micas.



Photo 3-146. Ceramics associated with the complex El Oro, reservoir 6A

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In the sample there are two fragments of edges; one averted, thickened toward the middle, thinned down to the final, and one very averted toward the east and thinned down to the end, that presents a print of two internal perimeter rows of points. There is also a fragment of the body, decorated with parallel lines vertical ribbed.

These characteristics of the pasta, of the types of edges and decorations, allow to ask an association of this material with the ceramic complex El Oro, referenced to the region.

➤ Characteristics of the lithic

The lithic material from this deposit corresponds to two chants flake scars (fragmented) of site (see Photo 3-147), a discoid flake of first order in site (see Photo 3-148), a flake of first order triangular in sandstone (see Photo 3-148), and a flake of asymmetric third order semi crystalline quartz, and three rounded edges of ovoid form of raw materials, such as shale, basalt and site (see Photo 3-149).



Photo 3-147. Pebbles fragmented, reservoir 6A



Photo 3-148. Slices of first order, reservoir 6A



Photo 3-149. Rounded edges with an ovoid shape, reservoir 6A

– Site 6B, La Inmaculada

The archaeological site 6B, La Inmaculada, is located in the municipality of Cocorná, on the Vereda (*Political and administrative division of the municipality located in the rural area*) La Inmaculada, in the farm Playa Loca, in the planar coordinates X: 885,024 - Y: 1,159,606 , At a height of 793 meters above sea level, on the left bank of the Cocorná River and right banks of the San Matias River. The geomorphologic unity corresponds to a second alluvial

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terrace level, adjacent to the terraces outlined as deposit 6 (Cardona and Yepes, 2009), and 6A (see Photo 3-150 and Photo 3-151); the area is 1,600 m². Recent alterations by the step of a fence and a gap of about 3 m in diameter, which is full of water. With regard to the civil facilities, this is located in the area destined to the house of engines of the San Matias hydroelectric project .

In this deposit as well as the 6A, can be accessed by following the track Medellin - Bogota, up to the sector of La Mañosa in the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo of the municipality of Cocorná, where it picks up the new track to house of engines of the El Popal hydroelectric project , where is located the unit of landscape associated with deposit 6 (Cardona and Yepes, 2009b)

In this deposit were two boreholes, where recovered cultural material composed of eight fragments of ceramic and nine lithic elements.



Photo 3-150. Wide View, reservoir 6B



Photo 3-151. Borehole, reservoir 6B

➤ Stratigraphy and cultural material

In the test pit 1 (see Photo 3-152), identified a Stratigraphic column of six horizons of soil, in a layer of 53 cm thick. The characteristics of the Stratigraphic column are the following.



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Photo 3-152. Borehole Stratigraphy 1, site 6B

Horizon A

Corresponds to an array of ground about 10 cm thick, dark brown reddish (5YR 3/2, Munsell), texture and structure in sub angular fine blocks, with abundant medium and fine roots, in which was not found cultural material.

Horizon A1

Corresponds to an array of ground about 14 cm thick, dark brown reddish (5YR 3/3, Munsell), texture and structure in sub angular fine blocks. Presents average quantity of medium and fine roots coal and a fragment of pottery, located toward the base of the A horizon.

Horizon2

Corresponds to an array of ground about 10 cm thick, reddish brown (5YR 4/3, Munsell), loam and clayey structure in sub angular fine blocks. Presents very few roots medium and fine, coal and cultural material composed of five ceramic fragments and a lithic element.

Horizon 3

Corresponds to an array of ground about 11 cm thick, brown (7.5YR 4/4, Munsell), loam and clayey structure in sub angular fine blocks. Presents very few roots medium and fine coal, two ceramic fragments and three lithic items.

Horizon AB

Corresponds to an array of ground of about 8 cm in thickness, brown yellow (7.5YR 5/6, Munsell), silt clay texture and structure in sub angular fine blocks Presents very few fine roots and does not contain cultural material.

Horizon B

Corresponds to an array of ground that begins to insinuate itself into the 53 cm deep, red yellow (10yr 6/8, Munsell), texture clayey silt and structure in sub angular fine blocks Presents very few fine roots and does not contain cultural material.

The distribution of the ceramic material by levels of excavation and horizons of soil (see Figure 3-107), indicates an ontogeny quantitative that starts in the horizon A3 (level 9), and ends on the horizon A1 (level 5). The distribution of pottery presents very low frequencies, which do not indicate an ontogeny quantitative, but if higher frequencies toward the level 6 of excavation (horizon TO2).

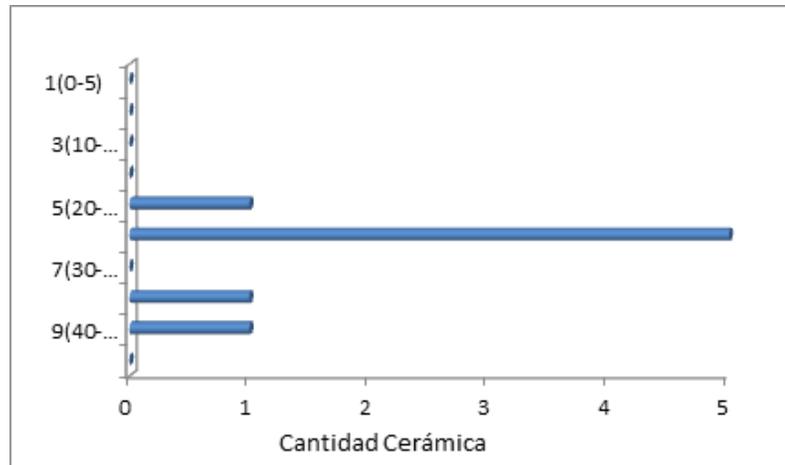
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Figure 3-107. Ceramic Distribution by levels, reservoir 6B

➤ Characteristics of ceramics

The ceramic pasta presents colors of brown, dark brown and red yellow, slick and eroded surfaces, in thicknesses between 4 mm and 10 mm for an average of 6.3 mm (see Photo 3-153). Contains particles of quartz and feldspar, fine sizes.



Photo 3-153. Ceramic fragments associated with the complex El Oro, reservoir 6B

In the sample there are two fragments of edges, one direct and averted one of form not defined by its size. The characteristics of the pasta and the type of edge, establish an association of this material with the ceramic complex El Oro, referenced to the basin of the Cocorná River.

➤ Characteristics of the lithic

The lithic material from this deposit corresponds to four fragments of pebble, two in site and two in milky quartz (see Photo 3-154). There were also two slices of bipolar size discoid, in shale and basalt (see Photo 3-155); a flake of second order in site and two asymmetric slices of third order in sandstone and quartz semi crystalline (see Photo 3-156).

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Photo 3-154. Fragments of pebble, reservoir 6B



Photo 3-155. Bipolar flakes in size, site 6B



Photo 3-156. Slices of third and second-order reservoir 6B

Table 3-126 show archaeological sites identified with the archaeological activities carried out in each one, the amount of recovered materials and its location with respect to the facilities.

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Table 3-126. Characteristics of archaeological sites identified in the prospecting

| UMG P | Reservoir | Coordinates | | Height METERS ABOVE SEA LEVEL | Area M2 | Location in the work | Samplings | Ceramic | Lithics |
|----------|-----------|-------------|-----------|-------------------------------------|------------|---|-------------------------------|---------|---------|
| | | X | Y | | | | | | |
| 1 | 1 | 880,538 | 1,163,332 | 1,315 | 160 | Bordering collection area | Probe 1 P. | 5 | 1 |
| 3 | 2 | 880,932 | 1,162,671 | 1,308 | 360 | Bordering collection area | Probe 2 R. S. and 1P Probe | 5 | 2 |
| 4 | 3 | 881,053 | 1,162,645 | 1,308 | 3,500 | Bordering collection area | Surface 1 R. | 15 | 2 |
| 5 | 4 | 880,742 | 1,161,947 | 1,418 | 120 | Surrounding area between the track to collection and deposit 3 El Molino | Probe 1 P. | 4 | |
| 8 | 5 | 881,001 | 1,162,019 | 1,404 | 108 | Area of track to collection between deposits 3 and 4 El Molino | Probe 1 P. | 6 | |
| 10 | 6 | 883,423 | 1,160,610 | 964 | 2,700 | Area of the reservoir 4 San Matias | Probe 2 P. | 8 | |
| 12 | 7 | 882,760 | 1,160,711 | 1,128 | 1575 | Area of house of engines El Molino | Probe 1 P. | 81 | 10 |
| 13 | 8 | 883,484 | 1160319 | 1,000 | 247 | Area of reservoir SM3 El Molino | 1 R. S and 2 P. Probe | 1 | |
| 14 | 9 | 883,510 | 1,160,329 | 998 | 375 | Area of the reservoir 3 El Molino | Probe 2 P. | 78 | 8 |
| 15 | 10 | 883,532 | 1,160,350 | 992 | 1,247 | Area of Deposit SM 3 El Molino | Probe 2 P. | 35 | |
| 16 | 6A | 884,968 | 1,159,593 | 809 | 1,908 | Area of house of engines San Matias | Probe 2 P. | 17 | 8 |
| 17 | 6B | 885,024 | 1,159,606 | 793 | 1,600 | Area of house of engines San Matias | 2 Boreholes | 8 | 9 |

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3.4.5.3 The material vestiges cultural associations and chronology

The prospecting delivered as a result the identification of 12 archaeological sites located in the area of direct and indirect influence of the civil facilities of the El Molino and San Matias hydroelectric projects.

Although it is about hydroelectric projects with small areas of influence, are important for the exercise of archaeological research by two aspects considered basic. The first is that the study area corresponds to a geographical area very particular, framed within the landscape of high mountain slope, toward the Middle Magdalena, Antioquia and Caldenses, in a sector where the Cocorná and San Matias Rivers meet.

The second aspect is that in this area are being carried out other hydroelectric projects located staggered (El Popal and San Miguel), in which archaeological studies carried out (Cardona and Yepes, 2009b and 2009c), along with the progress being made (management plan for the El Popal hydroelectric project , Cardona and Yepes, 2011b), have been delivering a corpus of valuable information, which has allowed us to begin to understand the particularities of the occupation dynamics of this part of the mountain slope of the Middle Magdalena, in correlation with the low-lying areas of the same river.

In the 12 archaeological sites identified, were recovered 263 vestiges ceramic and 40 lithic elements, in cultural deposits identified in the landscape units prospected, formed by dark organic soil, with average thickness of 60 cm.

Although it was a low frequency of materials, elements 3.3 and 22.9 lithic ceramic fragments by deposit, and their conservation status is precarious, some diagnostics elements of type of carving in the lithic elements and forms of edges and decorations in the ceramics, which have been made possible by way of hypothesis relate these materials and the fields to which they are associated with the management of the archaeological record and the dynamics of settlement being proposed in the study area, by the same authors of this work (Cardona and Yepes, 2009b, 2009c and 2011b), which have traces associated with four historical periods: pre-ceramic, early ceramic, medium ceramic and late ceramic

- Deposits with lithic material and ceramic

During the prospecting were found lithic materials developed with local raw materials, which consist of slices of boulders, carved edge and some slices of bipolar size. In relation to these materials, as already stated in the history section, recently Cardona and Yepes (2011b), in the framework of the implementation of the management plan of the hydroelectric archaeological project El Popal, excavated site 6, La Inmaculada, which corresponds to a terrace adjoining the site 6A and 6B of the study, which reported the existence of two cultural layers:

The first layer, deeper, contains only lithic materials, some of them with features similar to those that have been making reference in this study, and associated with a pre-ceramic period, with a radiometric date of 8470 + /- 50 BP, (Cardona and Yepes, 2011b).

The second layer, more superficial, contains lithic material with the same characteristics of the previous layer, but associated with pottery with features similar to the complex El Oro, by what has been associated material carved to this pottery as a cultural continuity that incorporates the pottery, with persistence in lithic technology (Cardona and Yepes, 2011b).

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In the contexts identified in this study, prospecting phase, are not yet very clear these Stratigraphic differences: The fields 6A and 6B, La Inmaculada, correspond to two units of landscape of the large alluvial terraces, contiguous to the stratified tank, excavated as deposit 6 (Cardona and Yepes, 2011b), but in the boreholes are not observed characteristics that stand out in the deposit 6, as are a layer of deep soil (more than 1 m), an adaptation of stone, with abundant carved boulders and abundant hatchets and slices obtained by bipolar carving.

In these two reservoirs there is a cultural layer of dark soil, of about 60 cm thick, with lithic material which consists of artifacts produced with local raw materials such as site, milky quartz and semi crystalline, shale, basalt, sandstone and derived from granitic rocks. The artifacts correspond to two boulders with traces of flake scars (site 6A) and slices obtained through bipolar carved and carved edges (site 6B). These materials have been associated with either a pre ceramic occupation as an early ceramics (Cardona and Yepes, 2011b).

Although the frequency of material are very low to analyze a Stratigraphic sequence, in Figure 3-108 and Figure 3-109 sequence of materials by defecation levels, in which there is a tendency to have ceramic fragments and lithic items toward the deeper part of the sequence, so that it might be thought that the cultural deposits identified in these landscape units, adjacent to the reservoir 6, La Inmaculada, that deposits called 6A and 6B, and could correspond to activities related to the early ceramics occupation, related to the Complex El Oro , as some lithic elements indicate and the characteristics of the edges and the decoration of the ceramic samples recovered: thickened averted toward the middle and thinned down to the final, very averted toward the east and thinned down to the final, with decoration of internal perimeter rows of printed dots.

Stratigraphic situation similar to that of the previous deposits, is presented in fields 7 and 9, Los Mangos. The first, identified as a broad rest of medium hillside, on the right bank of the San Matias River, and the second corresponds to a terracing, relatively small, on rest of hillside, because it gives an approximate area of 375 m².

In these two fields there is a cultural layer 75 cm in reservoir 7 and 50 cm in reservoir 9, dark brown, with cultural materials up to 60 cm and 45 cm deep, respectively. Are the two deposits where it was found the highest frequencies of ceramic fragments and lithic artifacts: 81 And 10 respectively for deposits 7, and 78 and 8 respectively for deposit 9.

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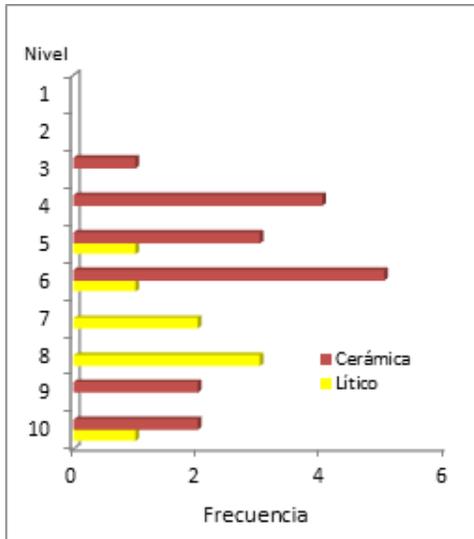


Figure 3-108. Frequency of materials reservoir 6A

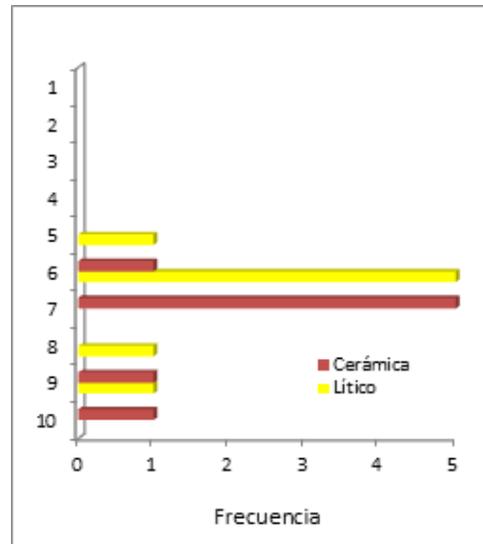


Figure 3-109. Frequency of materials reservoir 6B

In the deposit 7, the lithic material corresponds to a core, a fragment of flake of tall to bipolar, a pebble with an ovoid shape with wear lap, two slices and four waste of height, while in pit 9, the lithic material consists of four slices asymmetric and four debris in milky quartz. All these artifacts produced in local raw materials, so that it highlights a flake in chert yellow, with traces of thermo-alteration, as material from a foreign lithological context.

These lithic materials are associated with ceramic fragments, because there is the confluence of the two materials until level 10 (50 cm), in the reservoir 7, and up to 35 cm in the reservoir 9. It should be noted that there are six fragments of ceramics in the deposit 7 at level 13, where do not appear lithics, while at the site 9, to level 9, you have two lithic artifacts where there is no pottery (see Figure 3-110 and Figure 3-111).

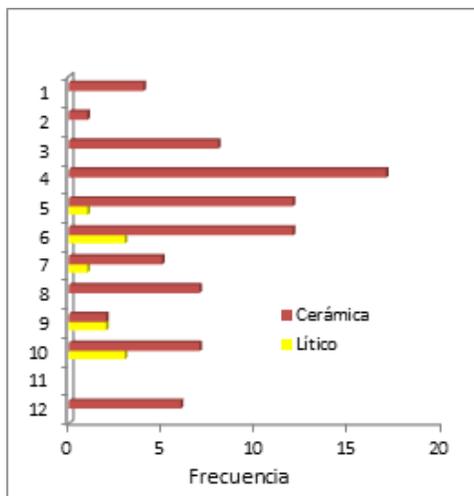


Figure 3-110. Frequency of materials

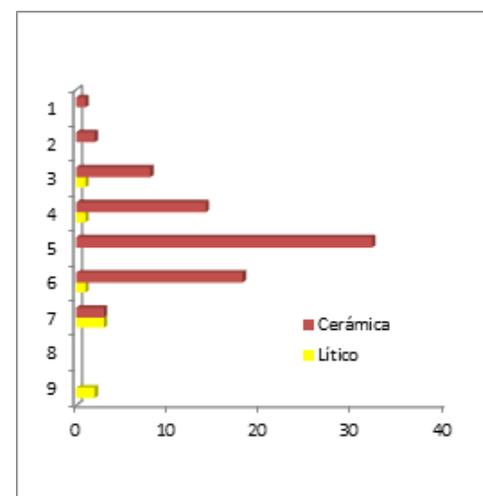


Figure 3-111. Frequency of materials

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reservoir 7

The tendency of the depositional sequences of lithic and ceramic in the two sites in question, which can be seen in the two figures above, indicate, along with the characteristics of the materials found (ceramic material found as a direct straight edge and two fragments of bodies of vases decorated with incised lines and parallel lines fluted), a partnership with the reports of Cardona and Yepes (2009b and 2011b) in the deposit 6, which pose an association to a pre ceramic occupation or early ceramics or Complex El Oro.

For its part, in deposit 1, which corresponds to a relatively small alluvial terrace, located in the left margin of the San Matias River, there is a cultural layer of about 50 cm thick, dark brown color, with a buried horizon of about 14 cm thick, black in color, in which it was found a flake in site of third order (in the level of six excavation), and the ceramic material, which consists of five fragments (found in levels 3 and 4 of excavation), presents no diagnostic features of shape, or decoration that will allow imply an association with the complex identified in the area.

The deposit 2, Quebradona corresponds to a rest of hillside relatively small (about 360 m²). In this unit are identified a cultural layer of about 45 cm in thickness, which found a primary flake in sandstone, in a dark horizon of buried soil of about 23 cm thick, which starts at 40 cm depth. On the surface, were also recovered a fragment of pebble with wear and five ceramic fragments, that do not observe diagnostics elements of forms or decorations, it was not possible to associate some ceramic style or period of occupation of those reported in the area.

The deposit 3, Quebradona corresponds to a gently sloping hillside, of about 3,500 m², which surface is altered (95 %) by plow with tractor and is dedicated to tillage. The lithic material was recovered in the area removed by the plow and corresponds to a pebble in basalt, with an ovoid shape, with evidence of carving by scabble, and a flake of second order triangular in shape, in milky quartz. In this deposit were recovered 15 ceramic fragments also in surface which has features such as two fragments of handles of rounded section, a thickened horizontal edge toward the middle and thinned toward the lip, five averted direct, two very averted edges beveled and two averted chamfered. In the study area, this type of lithic materials and ceramic have been associated with the complex El Oro (Cardona and Yepes, 2011b).

- Deposits with only ceramic material

Of the 12 sites identified, only in five are found ceramic fragments; it covers the sites 4, 5, 6, 8 and 10, among which stands out the deposit 8 by its higher frequency ceramic fragments (35), while in remaining reservoirs the frequency is between one and eight fragments.

The samples obtained in the fields 5, 6 and 8 showed no diagnostic features to establish partnerships with complex reported in the study area.

The deposit 5, El Molino, corresponds to a small rest of medium hillside (108 m² area), with a Stratigraphic quite disturbed, because it is observed soil mixing of yellow with brown color and content scrambled pieces of adobe with six ceramic fragments, which leaves a Stratigraphic association unreliable. As for the deposit 6, corresponds to an extensive rest of

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gently sloping hillside (2,700 m² in area). Was identified a layer of dark color and a 30 cm thick on the horizons A and A1 were found eight fragments of pottery. For its part in the reservoir 8, which corresponds to a small terracing on a break of slope (with an area of 247 m²) and with a layer of 34 cm in thickness, we found only a single piece of ceramic surface collection, on the southern slope, which was not picked up by being very small and quite eroded.

Contrary to the foregoing, were identified in 4 deposits, El Molino and 10, the Los Mangos, ceramic fragments diagnostics of shapes and designs that enabled to associate the material and the contexts to the ceramic El Oro reported in the region.

The deposit 4 corresponds to a small rest of hillside (120 m² in area), average gradient; presents a cultural layer of dark colored soil of 31 cm thickness. The ceramic sample consists of four pieces, among which are two thickened averted edges toward the middle and thinned out in the end, these characteristics next to the Stratigraphic position of the material (between horizons TO2 and AB), at a depth between 15 cm and 35 cm, let associate it with ceramic identified in the area of study as the Complex El Oro. The reservoir 10 corresponds to an extensive terracing on a rest of hillside, of 1,247 m² in area, with a layer of 45 cm thicker of dark color. The ceramics recovered consists of 35 fragments, in which there are two fragments of edges very averted, thickened to the east and thinned out toward the end, that its Stratigraphic location, establish an association of this ceramic material with the ceramic complex El Oro referenced for the region.

- The deposits and the hypothesis of occupation

As a consequence, there were 12 archaeological sites in five of which, the characteristics of the materials gave no information to make a partnership with the historical periods or with the ceramic complexes reported to the area; it covers sites 1, 2, 5, 6 and 8. This leaves the seven remaining reservoirs with ceramic materials and lithic artifacts that allowed to bring by way of hypothesis, a partnership with an early pottery occupation, related to the ceramic complex El Oro, reported in the area by Cardona and Yepes (2009b, 2009c and 2011b). Table 3-127 present deposits with their cultural associations.

Table 3-127. Archaeological sites and cultural association

| Depo sit | Coordinate | | Height METERS ABOVE SEA LEVEL | Area m ² | Landscape Unit | Ceramic | Lithics | Cultural Association |
|-------------|------------|-----------|--|------------------------|----------------------------------|---------|---------|-------------------------|
| | X | Y | | | | | | |
| 1 | 880,538 | 1,163,332 | 1315 | 160 | Alluvial Terrace | 5 | 1 | Indefinite |
| 2 | 880,932 | 1,162,671 | 1308 | 360 | Hillside rest | 5 | 2 | Indefinite |
| 3 | 881,053 | 1,162,645 | 1308 | 3,500 | Soft easy slope | 15 | 2 | Complex El Oro |
| 4 | 880,742 | 1,161,947 | 1418 | 120 | Hillside rest | 4 | | Complex El Oro |
| 5 | 881,001 | 1,162,019 | 1404 | 108 | Hillside rest | 6 | | Indefinite |
| 6 | 883,423 | 1,160,610 | 964 | 2,700 | Hillside rest | 8 | | Indefinite |
| 7 | 882,760 | 1,160,711 | 1128 | 1,575 | Hillside rest | 81 | 10 | Complex El Oro |
| 8 | 883,484 | 1,160,319 | 1000 | 247 | Terracing on hillside rest | 1 | | Indefinite |

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| Depo | Coordinate | | Height | Area | Landscape | Ceramic | Lithics | Cultural | |
|------|------------|-----------|--------|-------|----------------------------|---------|---------|-------------|----|
| 9 | 883,510 | 1,160,329 | 998 | 375 | Terracing on hillside rest | 78 | 8 | Complex Oro | El |
| 10 | 883,532 | 1,160,350 | 992 | 1,247 | Terracing on hillside rest | 35 | | Complex Oro | El |
| 6A | 884,968 | 1,159,593 | 809 | 1,908 | Alluvial Terrace | 17 | 8 | Complex Oro | El |
| 6B | 885,024 | 1,159,606 | 793 | 1,600 | Alluvial Terrace | 8 | 9 | Complex Oro | El |

In accordance with the data that have been exposed, there are seven archaeological contexts with cultural evidence associated with a single occupation, that for the area has been called early pottery, with a ceramic identified as Complex El Oro Pottery of this complex was initially reported in the basin of the La Mile River (Brown, 1985), who catalog it as a previous component to the Colorados and Butantán phases (Brown, 1992: 26. In Cardona et al 2009c).

Subsequently, Piazzini and Lopez (2004), set for the ceramic complex in reference and in the same river basin La Mile, a chronology of 2000 C to 700 A. D. C, being the oldest dates for the pottery of the La Mile River until the moment.

In the basin of the Cocorná River, in the study area El Popal hydroelectric project, in the deposit 6 - La Inmaculada, obtained a date of 1850 + /- 30 AP. With this date, and taking into account other of 3560 + /- 40 AP, obtained in the field 1 of the project mentioned above, combined with a ceramic recognized as early, called La Piñuela, which could be of particular traits of a brace of the same ceramic phenomenon style so far identified in the basin of the Cocorná River, could be assumed that this pottery in the basin of the San Matias, Cocorná and Calderas Rivers, is contemporary to the complex El Oro, of the basin of the La Mile River, in the Middle Magdalena, in concordance with the radiometric data of 1950 years A. C reported by Piazzini and Lopez (2004).

In the basin of the Cocorná River, this occupation was composed of human groups that were developed and used ceramic containers of various sizes and forms, which are pastries and coffee red yellow colored, of smooth surfaces, with content of quartz, golden or silver mica and felspar, fine and medium sizes. The thicknesses of the pastes vary between 4 mm and 8 mm and 9 mm and 15 mm, with an average thickness of 9 mm. Also prevail well polished surfaces, to which they applied a bath of the same color of the paste (Cardona and Yepes, 2009b and 2009c).

In terms of the decor, there are incised horizontal parallel peripheral lines, triangular print, vertical parallel incised lines and wide grooves, on the neck and body.

Ceramics associated with this period are reported by the authors in reference at the culture house of the municipality of Cocorná, where you will find complete pieces recovered in the process of building a soccer field in the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre. It is the six globular vessels and a bowl, with decorations with bands of red paint and cream, and red on cream, forming geometric patterns and spirals. There are also incisions and linear triangular impressions (Cardona and Yepes, 2009b).

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Ceramic materials have recurrent characteristics such as decorations in incised horizontal lines diagonal and vertical lines of unguates and dotted lines (sometimes combined and forming designs zoned leached cap located on internal or external perimeter of the chamfered edges and thickened (vessels sub globular) and in the part of the body of direct edges (bowls). According to reports from Cardona and Yepes (2009b), are also incised horizontal parallel peripheral lines, prints triangular, vertical parallel incised lines and wide grooves on the body and neck of vases of direct sub globular averted.

For this occupation raise by way of hypothesis, for the river basin La Mile, ERIGAIE (2000), are able to interact with farmers who knew for millennia the usable type of plants in these environments. What is uncertain is whether treatment of migrant populations that knew about this technology and occupied areas previously not colonized (Op city, 2000).

On the other hand Piazzini (2002) proposes that the occupations relating, called early, exhibit the greatest number of sites in the chronological sequence of the basin of the La Mile River, and are therefore indicative of the establishment of scattered settlements in the middle and upper basins of the tributaries of the Magdalena River, possibly formed independent political units with clear signs of territorial domain. This settlement was based on the colonization of the sloping land, since enclaves in the lowlands of Magdalena, and therefore are considered to be the pioneers of the occupation of the tropical rain forests, in watershed areas of the cordillera, in a process of migratory waves from the low-lying areas on the banks of the Magdalena River (Piazzini, 2002). (Op cit, 2002).

The basins of the Cocorná and Caldera Rivers have nine archaeological sites associated with this occupation, to which are added three reported in the study conducted in the framework of the El Popal hydroelectric project (upstream of the present study), and seven in the present study, for a total of 19 contexts associated with this occupation in the area of study.

The settlement pattern displayed in the frame of the archaeological study of the hydroelectric project San Miguel (Cardona and Yepes, 2009c), four fields located in broad and flat tops of hills and knives (sites 6, 7, 17 and 18), and four high in alluvial terraces of the river (sites 9, 11, 12, and 13), which are added to the sites identified in the framework of the archaeological study of the El Popal hydroelectric project (Cardona and Yepes, 2009b), which is located one in alluvial terrace and two in broad peaks of hills, and the identified in this study, located: three in alluvial terraces, five breaks in slope, and three correspond to terraces on breaks of the hillside.

This distribution of contexts indicate a pattern of distribution along sections of the river basins of the Cocorná, Calderas and San Matias Rivers, in units of micro reliefs landscape broad and flat, with elevations ranging from 630 meters above sea level, up to the 1,418 meters above sea level.

In the distribution patterns of its deposits, dominated by the occupations of landforms of the alluvial terraces, hilltops and breaks of hillside broad, which indicates that those landforms occupied by their conditions of topography were best suited for the establishment of the housing; however, there are jobs of adaptations as banqueos (terraces), in relatively flat and spacious areas, which did not seem to require such work.

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The presence of lithic artifacts carved with the same technology of the pre ceramic, could be indicating an occupation product of a thousand-year process, with trajectories of change toward local groups potters and not of the occupation of these slopes, at least for the higher, on the part of migrant groups of the lowlands of the Magdalena River, as suggested by the hypothesis by Piazzini (2002); this is perhaps of occupations with parallel cultural relations that make up a vast territory, whose early evidence (pre ceramic), are to be found in the basins of the rivers tributaries of the Magdalena as El Samana and La Mile, as found in the basins of the Cocorná - Calderas and San Matias Rivers, confluent of the Magdalena River and tributaries of the river Samana south River..

3.4.6 POLITICAL/ORGANIZATIONAL DIMENSION

Developing this numeral, will complement the information presented in the Diagnosis of Environmental Alternatives of the Hydroelectric Development of the San Matias River (2008), with stage information raised in the field for this environmental impact study, conducted in the month of December 2011.

3.4.6.1 Political Aspects¹⁰⁹

- Governance

Unlike many other sub regions of the department of Antioquia and the country, the Eastern Antioquia has counted with the presence of various institutions of national and departmental order. However has been reduced to the support and accompaniment in the local management, mainly from the departmental government, from administrative decentralization process.

In the local order, from the moment that the municipalities are beginning to assume the decentralization, and the creation and consolidation of sector organizations, with advances in the inter institutional articulation of strategies and with communities.

At present there is a greater closeness of the administrative bodies among themselves and the communities, outside of the political - traditional party relations. The foregoing does not mean, however, that has been abandoned neither the practice of political patronage and sponsorship to political organizations, nor that they will put aside the search to defend their actions in the traditional bipartisanship.

Compared to the credibility of institutions and the image that these projected, perceptions vary from one municipality to another, as well as between different entities, whether these are local, national or departmental. This situation, to a large extent, depends on the degree of commitment, performance, and continuity of the officer on duty.

The growth of the electoral abstention in the past periods of popular election¹¹⁰, allow to infer a certain discredited of the democratic institutions. However, in good part this abstention was a product of the repression of armed actors; in addition, there are sectors of the population who refuse to participate in the processes of popular election, as it persists

¹⁰⁹ Government of Antioquia. - PLANEA. Profile of the subregional east of Antioquia.

¹¹⁰ The percentage of voter turnout for the first popular period was 31 %, for the third of the 50% and for the next period of the 69 %, (ESAP, 1999).

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the association of the political practice with corruption. Even sectors of the medium population (professionals), are inhibited from taking part in the public administrations for fear of being involved in such practices.

The electoral support to the mayors and municipal councils, which on average is greater than 50% of the voters, allows to think about some average levels of acceptance of the popularly elected leaders. However, this global flag does not allow to view two associated realities; on one side the existence of municipalities where the mayors were elected with the participation of a minimum percentage of electoral potential (case of the municipalities of Cocorná and Granada, where the electoral process has been affected directly by the armed repression) and on the other, the loss of credibility in these administrations as it progresses through the implementation of their program proposals. There are few municipalities in the east where you will recognize a proper management of the outgoing Administrator group.

Cocorná and Granada, both stemming from colonization from Marinilla, a municipality historically conservative, are in turn eminently conservative; however, with the establishment of the mechanism of popular election of mayors, the electoral landscape changed considerably, although the weight of the party in the local politics is still evident, both in the past and the present. In the 1993 elections, for example, the Conservative party was able to win the mayor's office, but during his tenure the Aedil was forced to resign under pressure from the community which accused him of corruption. However, after the armed conflict in the area, the Conservative Party returned to win the elections for mayor and municipal council, in both 2007 and 2011.

In the municipalities of Cocorná and Granada, the conservative hegemony has always been remarkable, although with some traditional opposition of the Liberal Party, which virtually disappeared after the violent events that occurred in the past few years, and that if it has returned to take force, has been through the positioning of new actors in the political scene, under the tents of shrub groupings of the old parties. This is the case with the incoming mayor of Granada, supported by Radical Change , or Dolly Zuluaga, candidate for mayor in the fair of 2011, but with the backing of a dissident group of the conservative party. Mrs. Zuluaga, although was second in the elections, achieving a significant number of votes in a hotly contested elections.

"The war", as they call the inhabitants of the municipalities of the East from Antioquia to the escalation of violence experienced in the region between the nineties and the beginning of the next decade, deeply affected the electoral dynamics. Even more, taking into account the coercion that exercised the guerrilla warfare against the municipal administrations, to avoid the control of the paramilitaries on the same; example of this action, was the murder during the year 2007 of the candidates by the party Wings - Team Colombia to the council of Cocorná, Medardo of Jesus Vásquez and Gildardo Antonio Toro. In the recent past, however, the exercise of the right to vote has been recovering gradually, process that is evident in the following election statistics:

- In the elections of October 2007 for mayor and municipal council, the total number of voters at Cocorná accounted for 51.6 % of its electoral potential. The popularly elected mayor was Hector Duque Ramirez, an affiliate of the Colombian Conservative Party, with a percentage of 56.8 of the votes.

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- For the municipal council, the Colombian Conservative Party was left with six of the 11 seats, the movement Wing Team Colombia with four, and the rest accounted for the remaining Citizens Convergence Party.
- For its part, in the elections held in October 2011 for mayor, the percentage of the vote in Cocorná was 57.43 per cent of the Council and to 57.85 %, showing a slight increase of about 6% with respect to the votes of the 2007. Was chosen as Mayor Jorge de Jesus Vasquez Montoya, also conservative and who previously had occupied the mayor on four occasions.
- The Council for the Conservative Party won four of the eleven seats, the Alliance Party Independent Social other four, the Party Radical Change two seats and the Party of National Integration (PIN), one.
- With regard to the municipality of Granada, the total number of voters in the 2007 accounted for only 31.1 % of the estimated electoral potential. He was elected as mayor popular Nelson Armando Garcia Amaya, affiliated to the same political party of their similar Cocorná, with an overwhelming majority of 70.8 % of the votes; that is to say, few voted, but almost all did it for the same candidate.
- This municipality council was composed by the Colombian Conservative Party with five seats, the Granada for All movement with three and the Colombian Liberal Party with a single seat.
- However, during the elections of 2011, the flow of vote increased by almost 16% with respect to elections in 2007, from 31.1 to 47.09 % in the case of the vote for mayor. In terms of the vows for the Council, the percentage was in the order of 46.95 %, showing a very similar percentage of the vote for mayor. Was elected as mayor Freddy Castaño Aristizabal, a young candidate that was presented to the community as a representative of the opposition, backed by Radical Change.

That has to do with the Council, the Conservative party won four seats, Radical Change two and finally the party of the U, the Green Party and Liberalism a seat each.

3.4.6.2 Coexistence and Security

"The New day" of Ibagué reported well in February of 2009, the confession of the commander of the Autodefensas Unidas of Middle Magdalena, Ramón Isaza, about his involvement in the massacre of the brothers Buitrago during the year of 1982, in a house in the Vereda (*Political and administrative division of the municipality located in the rural area*) Santa Rita¹¹¹ :

¹¹¹ There have been consulted four different sources to refer to this fact: The page www.verdadabierta.com , the article "History of the crew Carlos Alberto Buitrago del ELN", the retired colonel Luis Alberto Villamarin, appeared in the Time on 18 August 2007, the Nuevo Dia of Ibagué and page www.colombianuncamas.org , prepared by a collective of 17 national organizations for the defense of human rights. In true Open is referred to as scene of the massacre the vereda Santa Rita de Cocorná; Colonel Villamarin in change, he said that this took place in a Vereda (*Political and administrative division of the municipality located in the rural area*) of the same name, but located in the district of La Merced de Cocorná; the New Day mentions a house of Cocorná, without stopping in the matter and in Colombia never more in turn say that Santa Rita is located in the district of Puerto Cocorná, the municipality of Puerto Triunfo. It is likely that the fact has taken place in Puerto Triunfo, but according to the web page of the municipality, there is no such Vereda (*Political and administrative division of the municipality located in the rural area*) with that name.

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“The former head of the block of the Middle Magdalena of the AUC, Ramón Isaza, shall be required to compensate the family of the ELN guerrilla Carlos Alirio Buitrago. The man was killed by the own former paramilitary leader along with four of his family in a house in Cocorná, Antioquia, on 12 September 1987. The story was revealed yesterday during the free version of Isaza when the mother of Buitrago asked the ex-combatant for the fate of his son.

Camilo Guiza, lawyer of the former paramilitary leader, explained that his client has told a prosecutor of Justice and Peace how he came to the house of Buitrago to install surveillance, because he had information that there were guerrillas. Former paramilitary leader explained that the men walked toward a puddle. Isaza came up to that point where there were more people, identified the five suspected guerrillas and ordered assassination.”
112

The sub region of the Eastern Antioquia was until a few years ago one of the most intractable scenarios of confrontation between the armed groups in Colombia. In this sense, the strategic potential of the sub region, was in its time, the more attractive factor for the settlement of the FARC and the ELN from the end of the seventies, in the municipalities of the moorland areas, dams and forests.

This fact, together with the power that these groups had on the Vereda (Political and administrative division of the municipality located in the rural area) and municipalities, led to the subsequent dispute between these guerrillas with the army and the paramilitaries, as well as between themselves, facing away from each other in a given time, in the same manner as would face later blocks from the Cacique Nutibara Metro of the Autodefensas Unidas de Colombia, demonstrating that it was not an ideological conflict between ideas, but a fight where each group fought solely by their interests.

It should be borne in mind that in Eastern Antioquia is generated near the 40% of the country's electrical energy, which enabled the guerrillas unleash since the end of the nineties, when the drug money had become a force capable of challenging a weak military state, an offensive based primarily on the dynamite attacks against the electrical infrastructure and the periodic crashes of Medellín-Bogotá. Highway The control exercised by the guerrillas had been making evident throughout the length and breadth of the country and in different ways, ending by radicalizing the army's position as a response, in addition to providing the perfect excuse for the emergence and proliferation of illegal armed groups, organized exclusively in order to defend themselves against them and hunting them

“The territorial encroachment of those in arms allowed them the implementation of a strategy of enemy wear, aimed to hit the infrastructure of vital importance, as the transmission towers of energy and hydroelectric power plants”¹¹³.

In addition the geographical features and infrastructure of the territory, the thick forest that low by the Foothill to the Middle Magdalena Antioquia, the advantages that eventually would give them the territorial control on the Medellín - Bogota Highway, the steep slopes of the

¹¹² El Nuevo Dia, Ibagué . February 24 2009. In fact Carlos and Alirio Buitrago were two different people, two of the five brothers who were killed.

¹¹³ ISU Hydroelectric Development of the San Matias River - El Molino SAG. Medellín, 2008.

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mountains and a profuse network of bridle paths, allowed them to use it as a refuge and at the same time as the corridor between the Middle Magdalena and the interior of the country.

The origins of the conflict are lost in the century, but it is possible to remember however some of the events that played an important role in its configuration. It was the seventies, and the emergence of base communities throughout Latin America was booming; in the municipalities of the far east of Antioquia specifically, had begun to emerge a number of popular organizations, cooperatives of rural labor, sports organizations and other groups, the product of a working active database of advance between other actors by Catholic priests. In the middle of this picture, in the rural area of San Luis and Puerto Triunfo, were born several "basic Christian communities", groups of young people dedicated to the evangelization and the community work organized by father Bernardo Lopez Arroyave, a former member of the house of Antioquia by the conservative party, which had become priest.

The retired colonel Luis Alberto Villamarin said: " ...And among the remaining urban - referring to the support groups of the first ELN - was the catholic priest Bernardo Lopez Arroyave, who activated a clandestine cell with several seminarians, other clergy and nuns who worked in an educational institution in Barrancabermeja, including a Spanish nun identified by the alias of Pillar or Casilda, at the time concubine of priest Manuel Perez Martinez."¹¹⁴

After four years as parish priest of Station Cocorná, town of Puerto Triunfo, father Lopez had to escape the municipality on September 17th.1982, after suffering an attack to his life. That same day in the night, four armed men arrived at the home of the Buitrago in Vereda (*Political and administrative division of the municipality located in the rural area*) Santa Rita asking for Don Manuel, a father of seven children, but he was not at the time; the men then took five adult children and shot them in El Cafetal; Carlos, the eldest son, was only 20 years. The journalist Juan Alberto Gomez tells as well the facts:

"- Jose released the cry: "Hey, come, here they are." All ran in the direction of the scream. The first to arrive was Don Manuel and the image embedded forever: once we saw to all in line, as they came, they were shot and then fell; they were in line."¹¹⁵

All Santa Rita had already been made aware. First the voice ran fine, buzzed with hollowed out with the palms of the hands, after expanded gaining in height up to become a martial and resonant invitation. Gustavo Buitrago, his brother Rigoberto, Ricardo Castaño and three more men, were roaming the Vereda (*Political and administrative division of the municipality located in the rural area*) they came with rifles, the eyes fixed in their youth faces crossed chest of cartridge belts. Now said bringing five martyrs among its reasons to take up arms.

On that tremendous day were born two fronts of the ELN that became the terror of Eastern Antioquia: The Carlos Alirio Buitrago and Bernardo Lopez Arroyave. Because if the paramilitaries have been born as a reaction or revenge against the guerrillas, also those led to the birth of two of the guerrilla fronts of most invidious remembrance not only in the middle of Antioquia, but in Colombia.

¹¹⁴ History of the crew Carlos Alirio Buitrago. Luis Alberto Villamarin polishing. The Time, August 8, 2007.

¹¹⁵ The Autodefensas Campesinas Middle Magdalena In: Verdadabierta.com (consulted the 22-12 -11) http://www.verdadabierta.com/index.php?option=com_content&id=420

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Behind the massacre, paradoxically, was a friend of Don Manuel Buitrago, settler as him in those lands, with which he met many evenings to chat, to the beat of some spirits and a guitar. It was already known throughout the region, almost like a myth. He was called Ramon Isaza and forged the Autodefensas Unidas of Middle Magdalena to his image and likeness.¹¹⁶

The massacre of the Buitrago is then a milestone in the cyclical course taken by "the war" in Eastern Antioquia, as they insist on calling the armed conflict among the inhabitants of the region: As in a Shakespearean tragedy, Don Ramon Isaza was commissioned to give origin to the armed structures with which he had raced later the territory.

Between the main characters of the armed conflict in the East, then it is necessary to highlight the name of this man, the paramilitary leader Ramon Isaza, alias "El Viejo", who currently makes up part of the program of Justice and Peace of the National Government. "The Old" was from Sonson, but arrived at the Middle Magdalena armed during the colonization of Puerto Triunfo, unleashed after the death of Jorge Eliecer Gaitan in '48, then the emergence of the primitive Vereda (Political and administrative division of the municipality located in the rural area), around a military bastion for the defense of the river.

Had been settled for years already in his property and his children had grown up, when he founded a self-defense group around 1978, motivated by the imminence of his abduction at the hands of the guerrillas. In this way, from the farm "La Estrella" and by the protection together with his family (his sons Omar, Roque, Ruben, his son-in-law alias "Mac giver", and his nephews and Miguel Hernán) began to offer his services to the landowners and merchants of the region, in a few years came to control Puerto Triunfo, Vereda (*Political and administrative division of the municipality located in the rural area*) by Vereda (*Political and administrative division of the municipality located in the rural area*) Already in 1982 "El Viejo" ran a successful private security business, which was spreading into the interior of Antioquia, sponsored by money of ranchers and drug traffickers who were looking for in this way to protect their property from the guerrillas.

*"While the interest of the old Isaza was never expanded, with the passage of years, when their families were taking control, began to leave their original region in the Magdalena and were climbing over the mountain. Each time were less auto defense and more offensive. And since the massacre of 14 peasants on May 3 1997, on the Vereda (Political and administrative division of the municipality located in the rural area) La Esperanza, the Carmen de Viboral, bordering on the Medellin-Bogotá Highway, dug in full in a paramilitary offensive expansion, like many of the other paramilitaries of the country."*¹¹⁷ The structure of Isaza centered then its expansion in the control of the Medellin-Bogotá Highway, but also toward the projected area of moor of eastern Antioquia.

Alias Mac Giver had under its jurisdiction the highway, the other divided Puerto Triunfo. His power in La Piñuela for example, one of the zonal centers Cocorná, was immense; there Mac Giver forced many families to move, "Although the (Isaza) always said he was doing it to defend themselves, recounts the former peace adviser of Antioquia, Jaime Fajardo

¹¹⁶ History of the crew Carlos Alirio Buitrago. Luis Alberto Villamarin polishing. The Time, August 8, 2007.

¹¹⁷ The Autodefensas Campesinas Middle Magdalena. In: Verdadabierta.com (consulted the 22-12 -11) http://www.verdadabierta.com/index.php?option=com_content&id=420

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Landaetta-. As all group ended abusing engaging in massacres and contributed to the displacement of San Luis, Cocorná or San Francisco, populations that reduced its population almost to half" ¹¹⁸ .

Already in the mid nineties, when the paramilitaries began to expand throughout the national territory, a new paramilitary structure came to the East; it was the called Metro block, led by retired captain of the army Carlos Mauricio García alias "double zero" or "Commander Rodrigo", who had armed structures both in the Northeast and West of Antioquia, as in Medellín. For 2003, the Metro Block had become the counter insurgent organization with the most important presence in the middle of the department.

Double Zero negotiated the territory with the Auto defensas Unidas of Middle Magdalena, agreeing with them to establish Medellín -Bogotá Highway as dividing line; in this way, the structures of Ramon Isaza were left with the middle of the motorway and Double Zero with the West, with the exception of San Luis.

Its growth was recorded simultaneously in Medellín and in the East, region used by the guerrillas to hide the kidnapped, because being a remote area of the zone, allowed to be used as a hiding place and refuge, in an era where the miraculous catches hurried away from the people and have stopped the flow of vehicles by the Medellín -Bogotá Highway, collapsing the fragile municipal economies tourism-based. The two centers of operations of this structure, were located in the municipality of Cristales in San Roque, a municipality in the northeast of Antioquia and in El Jordan, municipality of San Carlos, to the east of the department.

But the contradictions between the Metro block and the underground armed structures of the Block Cacique Nutibara , under the command of Diego Fernando Murillo, alias "Don Berna", raised by the refusal of Double Zero to participate in negotiations with the government next to structures dedicated to drug trafficking, generated multiple clashes, from which came out victorious the structure of "Don Berna", with the support of other drug traffickers, including Carlos Mario Jimenez alias "Macaco". From this confrontation, the Cacique Nutibara got toward the end of 2003, the complete withdrawal of the Metro block toward the rural area of the municipality of San Roque and others in the region of the Northeast.

However, while the paramilitaries settled in the area, the guerrillas did the same. Not only the ELN, FARC also gradually decided to engage in eastern Antioquia, in accordance with the strategic guidelines for the Seventh Conference of 1982 and at a time when the region started to gain importance with the construction of the Medellín-Bogotá Highway, dams of San Carlos 1 and 2, Jaguas, Calderas and the extension of the energy lines ¹¹⁹ .

The ELN and the FARC began to act together on some occasions, but also to compete by the territorial control of the motorway and the surrounding municipalities. According to the Corporation Asovida of Granada, for the beginning of the decade of 2000, the territorial control over the municipality was divided in the proportion of 80 per cent for the ELN and the

¹¹⁸ Op cit, www.verdadabierta.com

¹¹⁹ See: Report Current Panorama of eastern Antioquia. Observatory of the Presidential Program for Human Rights and IHL. Presidency of the Republic, 2003.

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20% for the FARC, but toward the end of the decade, the same proportion had been reversed. In the Photo 3-157 you can see the house of alias El Aguila, feared commander of the ELN, a native of the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre, in Cocorná.



Photo 3-157. Home of alias The Eagle on the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre.

Strong examples of the positioning of the guerrillas, were the attacks of which was the victim Cocorná in 1998, the first on 31 July and the second on November 30, through which had spread terror among the community. It is important to emphasize that in the second fact, the ninth Front of the FARC and the Carlos Alirio Buitrago acted together, detonated a car bomb in the framework of the Square¹²⁰, and also flew the bridge over the creek La Chorrera.

The front 47, under the command of Nelly Arias Moreno alias "Karina", from 2003 occupied the northeast margin of the Medellin - Bogota. Highway The ninth front at the same time, dealt with the southeastern margin of the highway, with a presence in San Carlos, San Rafael, Granada, San Francisco and Cocorná, among others, in addition to the limits with the Middle Magdalena. Both fronts, in addition to the Carlos Alirio Buitrago and Bernardo Diaz Arroyave of the ELN, were responsible for ruining the economy of the municipalities to the margin of the highway, through the continuous blocks performed between 1996 and 2000.

In summary, and according to data from the Observatory of the Presidential Program for Human Rights and IHL, by the beginning of the twenty-first century each of the structures had a defined area of influence: The ninth Front of the FARC was seated in San Carlos; 47 between Abejorral and Sonson; the opposite Carlos Alirio Buitrago of the ELN had its zone of influence in San Luis, Cocorná, Granada and part of San Francisco; the Bernardo Lopez Arroyave between Guarne, San Vicente, El Penol, Guatapé, Grenada, El Santuario and Rionegro; the Metro Block of the AUC acted between the Carmen de Viboral, the Union, El Retiro and Rionegro; the Autodefensas Unidas from Middle Magdalena in Sonson, Argelia,

¹²⁰ Scheme of territorial order Subregion forests. Covenant Idea-A. Medellín. P. 18

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San Francisco and part of the Union and the Block Cacique Nutibara in Guatapé, San Rafael, San Carlos, Alejandria, Concepcion and El Penol¹²¹ .

This situation would endure until well into the first decade of the new century, but after the death of Jesús Muñoz, alias "Iván Ríos" on 7 March 7th.2008, and the delivery on May 18th. of the same year of alias "Karina" in Sonson, the 47 was absorbed by the ninth, transforming itself in this way the scene of conflict. For the year 2009, the army was focused on destroying the front, which went from having close to 500 members at the end of the 90 to 385 evil counted in 2003 and 40 or 50 in 2008, counting those absorbed from Front 47.

Among the last blows that have beaten the FARC in the area, may refer the following: In fighting with the army in San Carlos, was gunned down alias "The Coico", fourth in command of the front 9, on October 30th. 2009 and December 16th.. was bombed by the army also, Rubén Antonio Garcia, alias Danilo, together with nine of his men¹²² .

However the most bitter episodes of this war, were not those in which was directly affected the region's infrastructure; most dramatic was the continued abuse on the part of the armed groups against the social structure and against the very life of the Veredas (*Political and administrative division of the municipality located in the rural area*) Among the most effective tactics, within the guerrilla strategy for subjecting the population to a state of terror, were the intimidation by means of threats, the abduction and murder of mayors and municipal council members to force them to give up; with which was looking to affect local governance and weaken the state presence in the municipalities where they wanted to expand their influence. Among the victims of this undermining can be mentioned the mayors of Granada Jorge Alberto Gomez Gomez, kidnapped three times between 1997 and 2002, and subsequently murdered, on July 13th. of that same year; Carlos Mario Zuluaga Gómez, kidnapped on August 16th. of the following year and Ivan Dario Castaño kidnapped in November 2001¹²³ .

In 2002, the mayors of the region, tired of the bankruptcy of their economies by the continuing armed strikes and blockages in the road Medellín-Bogotá, sought dialog with the FARC and the ELN, with the hope of obtaining decrease of violent acts in the road. But this goal was achieved only when, beginning in August, the Government took measures in the framework of Operation "Meteor", advanced by the National Army, which have regain control on the track. The change in the safety conditions led to the fact that since the 2007 there could be vehicular traffic during the 24 hours of the day.

It was between the years 1994 and 2003, that the actions related to the armed conflict is increased in a more meaningful way, especially during the years following 2000, when it reached its climax with the massacre of 21 people in the town of Granada on the part of the AUC and with the subsequent decision and partial destruction of the town center by the guerrillas that same year, in which there was a balance of 23 dead.

¹²¹ Current panorama of eastern Antioquia. Op cit. P. 5
http://www.derechoshumanos.gov.co/Observatorio/Publicaciones/documents/2010/Estu_Regionales/orientantioqueno.pdf
 (Consulted December 4 of 2011)

¹²² See: The Colombian, Dec 17 2009.

¹²³ Information displayed in the Hall of the ever more of Granada. The violence against the mayors and councilors on the part of the guerrillas continued claiming victims, in the elections of 2007 were also assassinated the candidates to the council in Cocorná, Medardo de Jesus Vásquez and Carlos Alberto Atehortua Cano, from the party Alas-Equipo Colombia.

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In Figure 3-112 and Figure 3-113 illustrate the displacement figures in both municipalities and in that sense, give the idea of the dynamics of the conflict from 1998 to 2010:

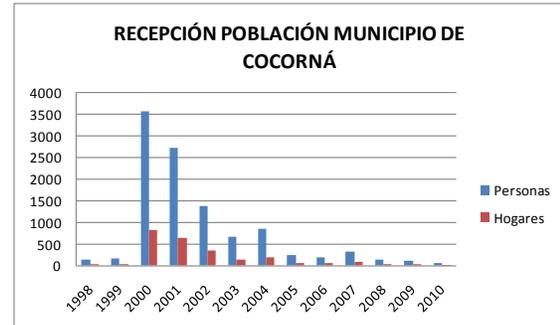


Figure 3-112. Reception and expulsion of population in the municipality of Cocorná

Source. Developed by the working group of SAG on the basis of information from the Observatory of the presidential program for Human Rights (HR) and international humanitarian law (IHL).



Figure 3-113. Reception and expulsion of population in the municipality of Granada

Source. Developed by the working group of SAG on the basis of information from the Observatory of the presidential program for Human Rights (HR) and international humanitarian law (IHL).

Thus, a reliable indicator of the way in which the war was disrupting the social structure in the affected municipalities, is the number of displaced persons that in few years reconfigured the demography of eastern Antioquia. Clear examples of this phenomenon are the cases of Cocorná and Granada

After 2003, military operations rose steadily, which helps to explain the changes in the dynamics of the conflict. The increase in the initiative of the Public Force, was announced by clattering through the operation "Martial" that led the IV Brigade from that year, and directly influenced the change of tactics of the guerrillas, which is reflected in the proliferation of anti-personnel mines to protect the shelters and prevent access to strategic sites, which had an impact on the deterioration of the public order situation..

As the different armed actors were disputing the territory, the civilian population was exposed to a rain of unbearable misfortunes, which were intertwined with each other, intensifying the anguish and distress prevailing; small and large extortion, threats, abductions, killings, harassment, firing from the air, interrogations, and disappearances. When it did not seem possible that something could worsen the situation, the minefields began to proliferate.

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“According to the presidential program for Comprehensive Action against Anti-personnel mines, of the 32 departments of Colombia, there are mines in 31. Escapes San Andres Island....and the ten municipalities of the country with the largest number of civilian victims, six are Antiochians: San Carlos: (54 victims), San Francisco (50), Tarazá (49), Cocorná (42), Argelia (36) and Anorí (33)”¹²⁴.

At the present time, according to data of the Presidential Program for Comprehensive Action against Anti-personnel Mines (AICMA), Colombia is the second country in the world with more victims by anti-personnel mines (MAP) and Unexploded Ordnance (UXO), surpassed only by Afghanistan. The country has registered 9,555 victims since 1990, year in which it began to be a record, until 2008, and Antioquia department figures as the most affected, with 2,160 accidents.

HALO Trust, an international organization that has a memorandum of understanding with the AICMA to study 11 municipalities in the country, including Sonson, Abejorral, San Luis, San Rafael and Cocorná, affirms that the mines in these municipalities tended to be placed on the tracks directed to areas formerly occupied and traveled by the FARC or around key infrastructure for the population¹²⁵. In Table 3-128 can be seen the gravity of the phenomenon in the most affected municipalities of Antioquia, including Granada in the sixth place and Cocorná in the eighth:

Table 3-128. Municipal Territorial Prioritization for the management of the Comprehensive Action against Anti-personnel mines in Antioquia - December 2007.

| Municipality | Accidents | Civilian Casualties |
|---------------|-----------|---------------------|
| San Francisco | 54 | 42 |
| Taraza | 28 | 35 |
| San Carlos | 54 | 30 |
| Argelia | 28 | 27 |
| Ituango | 46 | 20 |
| Granada | 20 | 15 |
| San Luis | 36 | 12 |
| Cocorná | 15 | 12 |
| Yarumal | 5 | 12 |
| Sonson | 32 | 11 |
| Mutata | 8 | 11 |
| Anorí | 34 | 10 |

Source: Presidential Program for Comprehensive Action against Anti-Personnel Mines

Already in 2008, Cocorná had requested the Government to send them humanitarian demining (see Photo 3-158); however, there have been obstacles and difficulties in this regard. In fact, until the present, the year of 2012, has not been able to devise a mine plan, but the army has responded to the allegations of MAPE and UXO found in the area, and since 2006 there haven't been accidents, says the former secretary of the municipal government, Milton Ramirez.

¹²⁴ The Colombian, 13 July 2008.

¹²⁵ Presidential Program for Comprehensive Action against Anti-Personnel Mines

<http://www.accioncontraminas.gov.co/situacion/paginas/situacionvictimasminasantipersonal.aspx> (consulted the 23-12 -11)

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Photo 3-158. Prevention messages against antipersonnel mines

The Observatory of the Presidential Program for Human Rights and IHL, points to the connection that the actions of armed actors increasingly involve civilians in a dynamic process in which the displacement has been constant, because the actions of the self-defense forces and the guerrilla to maintain their influence in the area, depend on their capacity to hold over the population. In some areas, while the members of the self-defense forces signal to rural communities, such as guerrilla collaborators, Farc, on their part, intimidate by their alleged closeness to the rival groups and as a result, has finished imitating the practices of terror of its critics.

The effects of conflict on the population can be seen clearly in the rise of homicides and kidnappings rate. By the end of the previous decade, these rates were very close to the national average; but at the beginning of 2000 began to increase at the expense of the rebound of the Autodefensas Unidas de Colombia in the region, and its strategy to compete with the guerrillas the territory through attacks on civilians; this until 2002, where there is a downward trend.

The abduction also acquired critical dimensions. Considering the figures since 1998, they rose up to the year 2000, to lower during that decade considerably, in response to operations deployed by the Public Force. Also, in recent years, the guerrillas have appeal to a lesser extent of plagiarism, as a result of the offensives of the self-defense groups against them.

With regard to the East sub region, the Center of the Presidential Program for Human Rights and IHL says:

“In terms of responsibility the ELN has accumulated the greatest number of plagiarized compared to other groups. Between 1998 and 2003, there were 1,197 cases representing 37% of the department. Its peak was 2000, since when their behavior was inclined to the low. The decline in the last year - 2003 - was considerable because rose from 217 in 2002

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to 67 in 2003 (...) jumps to view the intensity and persistence of kidnapping in towns such as San Luis, Rionegro, Cocorná, the Union, Grenada and Sonson"¹²⁶.

However, as the study says the Observatory for Human Rights and International Humanitarian Law, the intensification of the armed conflict is the result of the development of plans directed toward the control of high value areas for the actors at the margin of law. There is no doubt that in the current conditions, the resolution of a large number of problems that beset eastern Antioquia depends critically on the overcoming of this conflict, and in this sense, the restoration of the ability to preserve public order is an indispensable element to ensure the effective control over the territory.

In the month of July 2008, the same Observatory of the Presidency of the Republic presented the report on the panorama of the region of eastern Antioquia during the first half of 2008. It says that " *in the month of September 2007 we said that '...the tranquility [in eastern Antioquia] is, for now, apparent, and it is also necessary to build a structural peace, concerted among all the armed actors'. Various events that occurred during the first half of this year allow us to affirm that that tranquility attained in the territory in the past two years remains fragile. While the confrontation of different forces in weapons is not so, the calm of many communities is still unstable*"¹²⁷.

Among the events, the Observatory mentions that in the course of the semester were eliminated important subversive commanders, one more was assassinated by his own escort and other two were demobilized; all of them had been present in the East and its vicinity, including Dario of Jesus Calle Correa, known as the alias Timoleon, the ELN and alias "Karina" of the front 47 of the FARC, one of the most renowned.

However, some actions carried out by each and every one of the actors in the conflict, exposed the fragility before mentioned; for example, the presented in San Luis and Cocorná, where they have heard comments from some members of the military forces, arguing that the activity of accompaniment that carry out certain entities, such as the Freedom Legal Corporation to the Association of Small and Medium-sized producers of eastern Antioquia -ASOPROA in nature, is insurgent. It is important to highlight that Gerardo Ciro, a member of this association, was murdered in strange circumstances, allegedly by paramilitary forces, in the month of March of 2008, which shows once more the rearmament and restructuring of demobilized paramilitary in the territory.

Dealing with the issue of rearmament and paramilitaries recurrences, continuing with the information of the Observatory, some Veredas (*Political and administrative division of the municipality located in the rural area*) in Granada indicate the presence of suspicious small armed groups not insurgents, where some of their members are demobilized paramilitary and other more, members that did not demobilize; it has been reported that they moved by the whole area with tranquility, with lists of people to execute for their alleged links with guerrilla forces. The presence of these "strange" people is not an isolated event; there are a few facts of relations with other, relationships that have to do among others, with the handling and processing of illicit crops and control of transport routes for narcotic drugs.

¹²⁶ Observatory of the Presidential Program for Human Rights and International Humanitarian Law: landscape of the region of Eastern Antioquia during the first half of July 2008 2008.

¹²⁷ Op cit.

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In the canyon of El Melcocho, River on the Vereda (*Political and administrative division of the municipality located in the rural area*) of Cocorná Pailania, several families that have returned to their land, are planting and processing coca under the "permission" of demobilized paramilitary of the municipality of San Francisco; this area also has a strong military presence, and forced the demobilization of alias "Karina". Similarly, in some Veredas (*Political and administrative division of the municipality located in the rural area*) In the municipality of San Luis, have been settled since December and January of 2010, between 350 and 400 families from the region of Cauca Antiochian, also dedicated to the plantation of coca. It is difficult to understand the presence of such a large number of families to perform this illegal work, without the presence or accompaniment of any armed group to exercise control and give the respective "licenses" and "permissions", says the Observatory.

The presence of paramilitary groups and demobilized rearmed not only is there by sectors in the illicit crops but also in the paths of inputs for their cultivation and processing, and in the output and marketing of the final product.

The paramilitaries, known since 2007 as Águilas Negras, made their appearance in various municipalities, districts and Vereda (*Political and administrative division of the municipality located in the rural area*) in the Middle East, as La Union, San Francisco, San Luis, Cocorná, Sonson and Guarne, the inhabitants of some Veredas (*Political and administrative division of the municipality located in the rural area*) as Alejandria, near the dam of San Lorenzo, also had the presence of that group, who announced that they are the new "control" and the new "authority" in the area, causing fear and uncertainty among the peasants who experience once more, the threat of violence hovering around their lands.

After a look at this balance, highlights the words of the Observatory in 2007: "*The need for a change in the moral values of society as a whole where is profoundly valuable the presence of the other with his life and dignity and where prime the respect for life before the political and ideological differences.*"

It is important to note that in the municipalities of Cocorná and Granada, prevail the consequences derived from the armed conflict, evident in the decline of the population. In the case of Granada, it is estimated that in the conflict years the population decreased by 64% and currently are living in this municipality only 9,800 inhabitants¹²⁸.

There are still veredas (*Political and administrative division of the municipality located in the rural area*) in both municipalities with much less population than they did eight years ago, as is the case of Quebradona Abajo, Las Faldas and La Arenosa in Granada; or El Molino and Campo Alegre in the municipality of Cocorná, which, several years after initiated the call return, have not even recovered the 40% of the population they had once. In a similar situation are La Inmaculada and Los Mangos of the same municipality that up to the present moments only count 10 and 13 families, respectively.

For being located these Vereda (*Political and administrative division of the municipality located in the rural area*) in a watershed, from where dominate both the basin of the Cocorná River to the west as the San Matías to the East, turn it in a strategic place for the

¹²⁸ Municipality of Granada. Op. Cit. , 2008.

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guerrillas of the ELN, who used it as a refuge and even as a hiding place for the people abducted in the highway or in the other municipalities. Its geographical position stamp then the fate of these paths, when the Self-defense forces arrived in 2003 and later the army, each group exercise by means of violence their respective control on the civilian population.

In the beginning, and according to the testimonies of some locals, in the mid-nineties began to arrive some outsiders to the Vereda (*Political and administrative division of the municipality located in the rural area*) of Campo Alegre and El Molino, including a psychologist called "Jonathan" and others, who came to the community, gaining the confidence of young people to initiate a process of indoctrination that would culminate in the second of many of them to the guerrillas. When the paramilitaries arrived to dispute their territory, these young people became eventually victimizers of their own communities.

The armed conflict then changed not only the economic dynamic and everyday life of the area, but even the community bonds and the demographics from the Veredas (Political and administrative division of the municipality located in the rural area), which have in common the fact of having suffered a series of massive depopulation carried out in some cases in term of a day or two. Only after the years, people have begun to return, finding that their houses were looted, some even with graffiti on their walls that announce the presence of one of the armed groups, denoting the state of chaos in which these locations were a few years ago.

3.4.6.3 Community Participation

- Cocorná

In Cocorná, community participation has been increasing, after the violent deaths of many community leaders. Since 2003 has been developing the process for a Constituent Assembly, which, however, has had its ups and downs, related to matters of public order and political will. According to the current development plan, "*little by little, this process has been positioned in the Vereda (Political and administrative division of the municipality located in the rural area) and is recognized by the different social actors, politicians and government, bringing to the approach of Municipal Administration with the community, with the impetus to activities of organizational strengthening of the zonal centers of social control in the public management or public discussion on the participation as law and democratic governance as an alternative. At present the Assembly articulates much of the living forces of the municipality, constituting the largest local scenario where deliberate on central issues of this territory*"¹²⁹.

In 2008 and according to the ISU the hydroelectric development of the San Matias - El Molino Rivers there were 32 organized groups, of which 23 were active. Among these is ASOCOMUNAL which brings together 72 councils and AMORAC Communal Action which brings together 27 organizations of environmental character of the municipality (see Table 3-129).

Table 3-129. Organized groups. Municipality of Cocorná

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|---------------------------------|
| Municipal Constituent Assembly. |
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¹²⁹ Municipality of Cocorná. Development Plan 2008 - 2011: Development with equity. Secretary of Planning. 2008



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ASOCOVER.
Breeders' Association of Cocorná -ASOCOGAN.
Association of Producers of Panela of Cocorná -ASOPACO.
Health Pastoral Care.
Social Ministry.
Group of Las Abrazadas.
Vereda (Political and administrative division of the municipality located in the rural area)Committees Association for Sports -ACOVERD.
Association of Women Heads of Household -CABEFAMI.
Municipal Association of Rural and Indigenous Women in Cocorná -AMMCIC.
Municipal Association of Environmental Organizations in Cocorná -AMORAC.
Organization of victims of the conflict - AVVICC.
Association of Community Action Boards -ASOCOMUNAL.
Cabildo Mayor.
FUSOARE.
Corporation Guarida.
Municipal Association of Displaced - OASIS.
INCOTEXCO.
COOPETRANSCO.
Women's Association of Cocorná -ADMUC.
Greening San Jose.
Municipal Association of Victims - ASOMAC.
Association of Women War Widows "Ladies of Bethany".
Committee for the disabled.
Mother Football School.
Cooperative of Farmers of Cocorná -COPROCAM.
Society of Public Improvements -SMP.
Organization San Vicente de Paul.
Association of Small Farmers.
Cooperative COOPRESER.
Municipal Committee of Coffee Growers.
ASOARTES.
Association of Agricultural Producers El Melcocho of Cocorná.
Associative Working Enterprise La Piñuela
Rotary Club.
Agricultural Community Company Los Molineros -ECOMOROS.
Association of Agricultural Producers of the Santo Domingo River -ASOPADOC.
Association of Agricultural Producers Macanal -ASOPRAM.

Source: Municipality of Cocorná. Development Plan 2008 - 2011 development with equity. Secretary of Planning. 2008

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The Communal Action Boards and the different organizations and associations have on the part of municipal administrations a poor support for their processes of participation and little strengthening in their community work. The armed conflict has been one of the main causes that participation has not had the desired results, as well as the little political will of the managers on duty.

There are currently 68 formed rural communal action boards and four urban communal action boards, but there are five boards in the process of cancellation of the legal personality since the Veredas (*Political and administrative division of the municipality located in the rural area*) don't have inhabitants due to the armed conflict.

Through the Agreement N° 04 of November 13, 2005 were organized the zonal centers and the zonal committees of community and citizen participation.

- Municipality of Granada

Before and after the guerrilla warfare of 2000, the number of groups, associations and committees that have arisen since the communities organized have increased (see Table 3-130). One could say that Grenada is a seedbed of alliances. However, the most curious thing is that these have been spontaneous. They have been established among all public and private sectors, and the community itself, with or without conventions.

Until 1998, the municipality of Granada was doing important work in the area of promotion and strengthening of the community action; there are obvious achievements up to that date, reflected in the opening and maintenance of roads, community infrastructure, roads, engraving, communal huts and schools, among others.

Table 3-130. Organized groups. Municipality of Granada

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| Association of Municipal Boards of Communal Action -ASOCOMUNAL. Association of Municipal Boards of Communal Action Santa Ana -ASOCOMUNAL SANTA ANA. Save and Credit cooperative Pius X -COOGRANADA. Save and Credit Cooperative -COCREAFAM. Cooperative of Transporters Granada -COTRAGRAN. Cooperative CRECER Coffee Farmers' Cooperative of eastern Antioquia. Youth Home female peasant girl Mary. Youth Home farmer for men Providence Christian Social, home to Our Lady of Fatima. Granada Corporation Always Ours Society of St Vincent de Paul. Wellness Center of the old San Jose. Association of Women -AMUCIC. Associations of farmers, sugarcane producers, farmers. Ecological Association of Siete Cueros Municipal Board of Education -JUME. Municipal Council of Rural Development -Cmdr. |
|---|

Source: Municipality of Granada. Development Plan 2008 - 2011: "Toward an inclusive Grenada, solidarity and peace". Ministry of Planning. 2008

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Ending the decade of the nineties, was developing an interesting experience in the municipality with the implementation of the Project to Support the development of the Rural Micro enterprise -PADEMER¹³⁰, which was strengthening the associations of sugarcane producers, breeders' association and association of farmers, among others, but at the end of 2000, the escalation of war, as in Cocorná, ended the process of community participation and the leaders became the main target of the armed actors¹³¹ ..

Before 2000, the year in which violence increased, in each one of the Veredas (*Political and administrative division of the municipality located in the rural area*) worked the Community Action Board with a total of 2,620 affiliates. Currently there are Veredas (*Political and administrative division of the municipality located in the rural area*) that do not have this figure due to its desertion, but the existing ones, in spite of problems in its representativeness, they work in the development of their activities and for the fulfillment of the objectives. They have organized the working committees: Education, Health and Solidarity, Public Facilities and Housing, economic, ecological, Sports and Culture and in some cases, the Business Committees Communal Store.

At this point, it is necessary to mention the incentive for returns and rural relocations - IRR - Return is to Live, which makes presence in all the paths of the influence area, both in Cocorná as in Granada, although barely being deployed. This consists in “a strategy to implement rapid measures to support and accompaniment to the population victim of forced displacement, aimed at the generation and/or empowerment of capabilities for the sustainment and dignified livelihood contributing to the process of socio-economic stabilization. The strategy seeks to contribute to the effective enjoyment of rights of the victim population returned or relocated in power, income generation, housing ...”¹³²

The benefits of the program are the following:

- Community accompaniment for the generation of capacities and symbolic actions for collective reparations during 24 months.
- Incentives tied to the return or resettlement:
- Monetary incentive in cash, in six bi-monthly payments.
- Supplies and materials to: Reduction of basic shortcomings housing and/or social infrastructure.
- Implementation of projects for food security and cash flow concerted with the home or community.
- Implementation of productive initiatives concerted with the household or community.

¹³⁰ This program, implemented by the Ministry of Agriculture, through COOGRANADA, starting in 2008 was renamed Development opportunities for investment and capitalization of the assets of the rural micro enterprise as an instrument of business support to the green markets.

¹³¹ Municipality of Granada. Development Plan 2008 - 2011: "Toward an inclusive Grenada, solidarity and peace". Secretary of Planning. 2008

¹³² Informative document, incentive for returns and Rural relocations - IRR - Return is Live

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- Generation of basic skills for the development of productive initiatives and community building through training in social issues, technicians, according to the productive ideas, environmental and organizational strengthening.
- Support for the processes of credit management, public-private partnerships and marketing, nomination to calls for housing, among other actions, aimed at ensuring the concurrency to households accompanied by the offer of State entities represented in the National Care System of and comprehensive reparation of victims¹³³.

3.4.6.4 Organization and institutional presence

Listed below is information raised in field, about the organizations and programs that currently have an impact on each of the Veredas (*Political and administrative division of the municipality located in the rural area*) of the project direct influence area.

- Cocorná
- San Juan

Relations are maintained for the education and training with the Vereda (*Political and administrative division of the municipality located in the rural area*) that belong to the Zonal Center San Juan: San Juan, La Peña, Montañita, San Antonio, Los Potreros and La Arboleda, as well as with the Zonal Center of El Molino: El Molino, Buenos Aires, Viadal, El Choco, Las Playas, Campo Alegre, Los Mangos and Santa Barbara. Likewise, with the 18 Veredas (*Political and administrative division of the municipality located in the rural area*) that are grouped by the Association of Small and Medium Producers of Eastern Antioquia ASOPROA, and also with ASOCOMUNAL.

The Community Action Board (JAC) is the organization of most important basis of the Vereda (*Political and administrative division of the municipality located in the rural area*). The name of the managers are listed below:

- President: Claver Antonio Vargas: 3217675545
- Vice President: Hortensia Alzate
- Secretary: Cecilia Montoya: 3132694853
- Treasurer: Celsa Rosa Buitrago
- Fiscal: Fabio Alonso Aristizabal

The group of the senior citizens is mentioned as another space for participation, however its members attend the grouping that exists in the town center of the town.

- El Chocó

The Community Action Board is an important organization in the Vereda (*Political and administrative division of the municipality located in the rural area*) the dignitaries of the board of directors are:

- President: Carlos Henrique Giraldo Gómez - 3206148542

¹³³ ABC families in their own land. Incentive for returns and Rural relocations - IRR. Working Group of returns and relocations. Direction Social Solidarity Network - Social Action. PS1 and 2.

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- Vice president: Héctor Quintero
- Secretary: Amparo Quintero
- Treasurer: Darío Gómez
- Fiscal: Deyanira Guarín

The Community Action Board account with sports Committee, Committee on Health and Labor Committee, which organizes treats when there is a need to attend someone in their field.

ASOPROA is another of the organizations that organizes meetings for the promotion of projects and led the process of creating Community stores in ECHOPAC 19 Veredas (*Political and administrative division of the municipality located in the rural area*) grouping 500 families. Also, the Freedom Legal Corporation has distributed seeds among the community

- El Molino

The most representative organization is the Community Action Board, whose board is composed of:

- President: Arcesio Carlos Gomez. Phone: 3205620444
- Vice-president: Héctor Darío Gómez.
- Secretary: Nubia Amparo Escobar.
- Treasurer: Olga Ines Mejia.

With the Veredas (*Political and administrative division of the municipality located in the rural area*) of Campo Alegre, El Choco, Las Playas, San Antonio and Los Mangos are made treats to fix the track. There is also a youth group, Legion of Mary, third age group, and a board of the aqueduct. There are carried out treats each month, for the betterment of the track, housing, and maintenance of the aqueduct.

El Molino is the meeting point of zonal center, also called Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino of zonal center meet every two months.

- Campo Alegre

The most representative organization of the Vereda (*Political and administrative division of the municipality located in the rural area*) is the Community Action Board, which has no legal personality, and its managers are listed below:

- President: Oscar Dario Giraldo Aristizabal. Phone: 3127611576
- Vice President: Joaquín Emilio Salazar Aristizabal.
- Secretary: Fidelina Lopez Montes.
- Treasurer: Jorge Eliécer Giraldo Aristizabal.
- Fiscal: Mary Rubiela Ramirez.

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The Board is currently concentrated in the processes of relocation, the return of the people to the Vereda (Political and administrative division of the municipality located in the rural area), according to the chairman of the Board.

Another example of organizational activity at the Vereda (*Political and administrative division of the municipality located in the rural area*) is the parents' association. Elder adults make activities along with them in El Molino

– Los Mangos

The directive of Community Action Board is composed of the following members:

- President: Manuel Tiberius Giraldo Gomez. Phone: 3133413843
- Vice President: Marina Vasquez.
- Treasurer: Miguel Angel Giraldo.
- Fiscal: Wilmar Giraldo.
- Secretary: Lina Maria Salazar.

– San Lorenzo

The JAC is an organization of important basis on the Vereda (Political and administrative division of the municipality located in the rural area), with 160 active partners, whose officers are listed below:

- President: Argiro Ocampo José Ramírez. Phone 3117186291
- Vice President: (At the time there is no representation in this post)
- Secretary: Angela Gomez and Marcela Quintero
- Treasurer: Mary Guarin
- Fiscal: Dario Atehortua

On the Vereda (*Political and administrative division of the municipality located in the rural area*) there are also several people associated with the Association of farmers and ranchers and the JAC is associated to ASOCOMUNAL.

– La Inmaculada

The most representative organization is the Community Action Board, and the names of the directors appears below:

- President: Aldemar Duke. Phone: 3122518950
- Vice President: Carlos Alberto Cardona.
- Treasurer: Willington Arango.
- Secretary: Natalia Cardona.
- The board has 16 members.

Previously, there was a sports committee, but this is inactive. On the other hand there is an active parents association

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- Granada
 - Quebradona Abajo

The most representative organization is the Community Action Board, whose executives are:

- President: Marleny Usme Giraldo. 3127073949
- Vice President: -----
- Treasurer: Soledad Aristizabal
- Secretary: Cristina Monsalve.

- Las Faldas

On the Vereda (Political and administrative division of the municipality located in the rural area), the JAC is the most important organization. The names of its executives are listed below:

- President: William Herrera M. 313645261
- Vice President: Gerardo Mejia
- Secretary: Rosalba Ramirez Arias
- Treasurer Ivan Quiceno Ildoro
- Fiscal: John Paul Galeano Jaramillo

There are other organizations, such as the parents' association, the panela Community Industry Los Luchadores, the Parents' Association and several prayer groups. Other spaces of participation are ASOCOMUNAL, the Association of sugarcane producers, ASOAGRICULTORES and the Breeders' Association.

3.4.7 TRENDS OF DEVELOPMENT

With regard to the trend of development of the municipalities and Veredas (*Political and administrative division of the municipality located in the rural area*) it is important to bear in mind, that according to the planning processes that have been carried out by the competent authorities of the department of Antioquia, the municipalities of Granada and Cocorná are assigned to geographic planning called administrative sub regions; therefore, data will be analyzed at the subregional and municipal level in relation to its insertion in the department.

The area of water reservoirs, formed by the towns of San Carlos, San Rafael, El Penol, Guatapé, Granada, Alejandria and Concepcion, have an opportunity for the development of tourism, which in large part depends on their highway development. Although at the time there are enclaves that could generate development they are disjointed and focused on their particular and individual targets, around the production of energy, tourism and recreational social and agricultural production. However it should be borne in mind that this area has been one of the areas most affected by the armed conflict, which has set the pace of development in periods of boom and decline alternately. “The *water reservoirs area related*

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to the development of the hydroelectric sector and tourist resort, is also linked through some of its municipalities to the metropolitan dynamic ¹³⁴.

In accordance with the point raised by the subregional profile of eastern Antioquia-2003, there are some specific actions that should be made to enhance what are seen as opportunities and set forth in the preceding paragraphs. Among these activities are mentioned “the *mitigation of environmental conflicts that have to do with the recovery of the forest and of productive soil for their sustainable use, the use of the landscape for the enjoyment of the tourist and the occupation with the road network as a public space to the protection*” ¹³⁵.areas.

The perspective for the development in the forests area are the municipalities of San Luis, San Francisco and Cocorná which have been impacted by the Medellin - Bogota Highway significantly. This area, despite its richness in biodiversity and potential development has along with the moor area, the lowest rates of economic and social development of eastern Antioquia.

It owes a large part of the hydroelectric potential of the Department, and although it is not a direct producer of the subregional wealth is indirectly involved with the water production and conservation.

The intervention for the development of the area is focused in the sustainable use of forests for biodiversity, the regulation of mining production, the development of techniques for the management and marketing of exotic crops and others permanent, taking advantage of the opportunities offered by the Medellin - Bogota Highway [...].

[...] In summary various positive aspects to the subregional development as: In the natural physical, the diversity of the climate, natural resources and strategic ecosystems; in the physical artificial, the infrastructure to support the production and marketing (Airport, the Free Trade Zone, financial services, high road density, energy generation); high coverage of public services in the highlands; diversity of productive activities (industry, agribusiness, agriculture, animal husbandry of milk, porcine, non-metallic mining); trade and services; variety of exportable products.

In the civic is highlighted the presence of solidarities and affinities of a historic cultural tradition; good levels of entrepreneurship, commercial tradition, experience in participatory planning and concerted, existence of a high number of institutions and social organizations and citizens, public and private provision to work for education.

In the human stands out a great proportion of young people (44 %), presence in a large number of institutions of higher education, increase in the basic, secondary and technical education, development of educational projects and alternative experiences in preventive health.

In the social and institutional are representative the administrative structures of the Plateau, the institutional professional and social leadership, the sources of support for the

¹³⁴ Subregional Profile of eastern Antioquia. 2003

¹³⁵ Subregional Profile of eastern Antioquia. 2003

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subregional and local management, the media and the processes for the collective management of the conflict and peace.

The management of the development plans of the municipalities of Cocorná and Granada

- Municipality of Cocorná

The Municipal Development Plan for Cocorná 2008 -2011 "development with equity", specifically the Social Pact signed in the Constituent Assembly in the month of June 2007. This planning tool reflects the proposals of the government program and converts them into strategic lines, composed of programs, projects, goals, targets and indicators, aimed at achieving a "development with equity", taking as a starting point the vision of local development, built collectively in the days of work carried out with the community in the whole territory of the municipality.

The referents taken into account, according to this document, as support for the formulation of the plan were : International, as, Objectives El Milenio; National, as, Colombia II Centenary 2019, the National Development Plan 2006 - 2010, EU state: Development for All; Departmental, such as the Departmental Development Plan 2008 - 2011, Antioquia for all hands to the work; and , the Strategic Plan of Antioquia PLANS TO; Regional, such as the construction project in the Strategic Plan of the East of Antioquia, PLANEEO; the Project System of Protected Forests Areas, moors, and wetlands of the Southeastern and Middle Magdalena; local, such as: Citizen Agendas (women, victims, tourism, education, environment), Agreement 04/2005 on the zonal centers, the scheme of territorial order, the Plan of Integrated Solid Waste Management of the municipality, the Municipal Educational Plan 2007 - 2015, the project of the Ecotourism Development Plan 2007 - 2017, the Management Plan for wastewater discharges, Cultural Development Plan; Environmental Management Plan, the Management Report of the previous administration, among other plans and local sector studies.

Through the unbiased look at the preceding, was consulted the dynamics of current development, on which it is necessary to articulate and frame the local development, in order to be consistent with the policies, programs and projects that show the trend of future development.

The five strategic lines bet for the future of the municipality of Cocorná for 2008 - 2011, were:

- **Strategic Line 1** : Articulation and Territorial Integration: Its overall objective is to improve the physical and productive infrastructure to facilitate the local and regional integration of the territory of Cocorná; within this line are programs such as: retrieve the rural road network for the urban and rural integration; bring together the various rural communities to the municipal seat; articulate local authorities with the external entities that maintain a presence in the municipality; support subregional projects as articulating axis between communities and institutions; and advance infrastructure facilities such as articulation of strategies for communities.
- **Strategic Line 2** : Integral human development, equitable and sustainable: The overall objective is to provide solutions to the unmet needs of health, education, sanitation, drinking water, public utilities, housing and recreation sport, with special emphasis on

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children, women, the elderly, the disabled and in general all the vulnerable population, by offering quality services.

Within the programs is available: construction of new housing; improvement and relocation of housing which are located in high-risk area; disaster prevention and response; extension of coverage and improvement of public services at home; ensure better health and an efficient implementation of the general system of social security; implement and deliver inclusive education, appropriate and equitable; improve the living conditions of vulnerable populations with emphasis on the older adult, childhood and adolescence.

- **Strategic Line 3** : Reactivation of the economy: It has as overall objective reactivate, energize and improve the competitiveness and sustainability of the local economy, encouraging the productivity and competitiveness with the use of natural resources and the local and regional potential. Included within this actions lines as: agricultural, technical assistance, training and education and the improvement of the marketing chain, institutional development and strategic integration in the actions of the offices UMATA-UGAM, strengthening partnerships and productive groups, support for productive projects for vulnerable populations, among others.
- **Strategic Line 4**: Culture for Citizen Participation: Its objective is to improve democratic governance and increase the incidence of citizenship organized political processes in the social and economic. This line is aimed at designing the strategy to ensure the inclusion of the grassroots organizations and organized groups in the processes of development of the municipality through programs and projects to generate capabilities to local actors (institutional development) and collective construction of a democratic order (governance).
- **Strategic Line 5**: Development and Institutional Strengthening: Seeks to modernize the operation and the institutional capacity of the municipal level of government to exercise their functions in accordance with the law, framed in the parameters of administrative effectiveness and efficiency, with programs such as training to public officials, technological modernization, upgrade and implementation of planning instruments.

- Municipality of Granada

The Development Plan of the municipality of Granada for the period 2008 - 2011 "Toward an inclusive Granada, Solidarity and Peace", is supported by the information and analysis of the regional situation collected in the Departmental and National Development Plan, PLANEA, the results of the TOWS institutional matrix in the progress achieved in the implementation of the scheme of territorial order and in the development plans of the previous administrations.

The strategic direction of the municipality is done in the framework of the implementation of five axes of Strategic Management, which are the following:

- **Shaft of Strategic Management I**: Institutional development: Its overall goal is the strengthening of governance for optimal provision of institutional services. It is based on two strategies: strengthen public administration to improve the efficiency and offer some timely services with quality in the municipal administration. Includes actions such as redefining the administrative and operational structure of the plant of charges,

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accountability to control entities and the general community, improve the physical infrastructure and staffing of the locative institutional facilities, development of a communications program and corporate relations.

- **Shaft of Strategic Management II** : Political development: Seeks to strengthen the social structure, coexistence, the inclusion and solidarity in the inhabitants of the municipality, based on five strategies: to promote the improvement of the coexistence in the municipality, promoting community involvement, develop programs for the comprehensive care of children and adolescents, offer better conditions of public order and improve the control mechanisms for the enforcement of the rules and statutes.

Includes actions such as: development of programs and projects for the negotiated solution to conflict and the promotion of a culture of coexistence, development of programs and projects of accompaniment and support to the communities, which will motivate participation and community action; promotion of the participation of children and youth in the different scenarios of community participation, development of projects and inclusions of protection of children and adolescents; promoting the return of the displaced population from the perspective of comprehensive security, project for the prevention of accidents with anti-personnel mines, mine clearance and care for victims.

- **Axis of Strategic Management III** : Social development: Whose goal is to implement a model of integral sustainable human development, which will be carried out through the following strategies: improvement of the educational policies in an efficient routing of the sector, improvement of administrative processes and pedagogical improvement of learning environments, strengthening the coexistence and the relations of the educational community, implementation of special programs to the interior of the education sector, strengthening of the Casa de la Cultura, development of the school of arts, promotion of sports and recreational activities, improving the delivery and management of health care services.

Includes actions such as the improvement of the physical infrastructure and staffing the facilities for the education sector, development of coexistence manuals, implementation of programs of food supplements such as restaurants and school families in action, development of schools initiation and sports training in the different disciplines, the improvement of infrastructure for the delivery of health services IPS, health promotion and disease prevention, comprehensive care for the displaced population, attention to the disabled population and overall improvement of housing.

- **Strategic Management Axis IV**: Economic Development and Competitiveness: Looking for the local economy with the use of the potentialities that offers the municipal territory. To do this are proposed the following five strategies: formulation of macro projects, improve the agro-industrial development, promote the business incubation and productive enterprises, improve productivity and competitiveness in the agricultural sector and improve the marketing processes of agricultural production.

Among the actions to be executed are: formulation of projects for the technical feasibility of construction of a plant for the generation of electrical energy, strengthening of the productive chain of fruit and sugar-cane, promotion of strategic alliances with the SENA, CORPOICA, ACOPI, for the development of training programs; strengthening livestock

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activity of dual intent, implementation of minor species programs, development of projects to strengthen the traditional agriculture (potato, beans, carrots, coffee, among others); development of projects of alternative agriculture, such as organic farming.

- **Shaft of Strategic Management V: Territorial Development:** Whose goal is to articulate sort and integrate the territory in a framework of rational use of natural resources and the conservation of the environment. Shall be carried out by applying the following strategies: improving the planning and management instruments of the territory, manage resources for the maintenance of the network of tertiary roads and road maintenance even specific streets where necessary, improve public services in the urban and rural areas and sort environmentally the basins of the municipality.

Includes actions such as the community's participation in the processes of management of public facilities, manage resources for the stratification and nomenclature, improving public infrastructure (communal huts, sports venues, cultural and other social infrastructure and community), manage resources for the implementation of the Plan for the Development of the municipal aqueduct micro basins (watershed Minitas) and strengthening community participation in the administration of aqueducts¹³⁶.

In accordance with the above context, trends or approach for development of the areas where they are located in the municipalities in the project influence area, focus mainly on an expansion and development of projects in the electric sector and tourism; in this sense, it is directing attention to the use and conservation of water as the wealth of the area. Equally, the Medellin- Bogota Highway, is an important axis of development, in both is the way of communication that allows articulation with other areas of the department and of the country, and by the importance that it represents for the marketing of products from an area that is rich in biodiversity. Aspects that are not isolated from the metropolitan dynamics determined by Medellín, as city region.

In the municipalities, the approaches of the strategic development plans are directed to the development and consolidation of projects in roads construction, improvement and qualifications of the social services, especially education, health, and recreation. The reactivation of the local economy, with increased productivity and improved marketing, improving governance with the opening of new and more spaces for participation the strengthening of the public administration, with a better addressing of the finance according with the needs of each municipality.

However, it has to bear in mind that there are limitations, challenges and a past marked by the armed conflict, which, even after almost 10 years of its appearance there remain serious aftermath, which, at present, the population is trying to overcome.

In effect, it is obvious the uneven development in the sub region and in the towns; for example, the Plateau has always marked a pattern of development focused on the industry, which has been guided by external agents with the consequent acceleration and invasion of the rhythms and dynamics. At the same time, as a result of the war, the productive sector went through serious invasions of which barely, in each Vereda (Political and administrative division of the municipality located in the rural area), is trying to overcome. The participation of communities in planning their own development, nor has it been a fortitude in the two

¹³⁶ Environmental Assessment of the alternatives of the Hydroelectric Development of the San Matias River - .El Molino

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municipalities; therefore, the governance has not pointed out with adequacy at a local structural and equitable; development, also the education system has not been a mainstay of the accumulation of social capital, which maximize as a driver of development based on needs, expectations and knowledge of people in their own territory.

Perhaps, a potential or a fortitude, is the ability to recovery or resilience of the population of the Vereda (*Political and administrative division of the municipality located in the rural area*) to re-establish productive activities and promote the development of projects that improve their existing conditions, with respect to the state of the roads and the implementation of productive projects such as the processing and marketing of panela.

3.4.8 INFORMATION ON POPULATION TO RE-LOCATE

In the present item makes a description of the three families who were identified as possible relocation candidates of affected by housing, by the construction of some of the facilities of the El Molino hydroelectric project , on the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos of the municipality of Cocorná (see Table 3-131, Table 3-132 and Annex 12).

Table 3-131. Population to resettle by the El Molino hydroelectric project

| Municipality | Vereda (Political and administrative division of the municipality located in the rural area) | Number of dwellings | Number of people |
|--------------|--|---------------------|------------------|
| Cocorná | Los Mangos | 3 | 8 |
| Total | 1 | 3 | 10 |

Source: Fieldwork carried out during the month of December 2011

Table 3-132. Total population by age and gender

| Age ranges | Women | Men |
|-------------------|----------|----------|
| 0-5 Years | 1 | 1 |
| 6-11 Years | 0 | 0 |
| 12-17 Years | 0 | 0 |
| 18-23 Years | 2 | 1 |
| 24-29 Years | 0 | 0 |
| 30-35 Years | 1 | 0 |
| 36-41 Years | 0 | 0 |
| 42-47 Years | 1 | 0 |
| 48-53 Years | 0 | 0 |
| 54-59 Years | 1 | 0 |
| 60 Years and more | 0 | 2 |
| Total | 6 | 4 |

Source: Fieldwork carried out during the month of December 2011

- Level of roots

The level of rootedness is directly related to the time spent on the Vereda (Political and administrative division of the municipality located in the rural area), in addition to other factors such as the ties of kinship and neighborliness.

The three families living in the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, which can be affected by the construction of the El Molino hydroelectric project , have a high level of belonging, given that

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they have remained in it for more than 40 years. However, it should be taken into account, the mass movement that occurred as a result of the conflict between the years 2000 and 2004, a situation that led to some people not to return, especially young people.

- Dynamics of kinship ties and neighborly relations with the other inhabitants of the area.

In the area required for the completion of some of the facilities of the project (planned road that will lead to the substation and subsequently tended of the transmission line), are located three families that are related to each other, since the heads of each family group are brothers and a third is the son of one of the above. They are working together in a venue next door neighbor where is located the cultivation of sugarcane property of the families, as well engaged in the panela production, with the labor of the family group. In one of the homes live the president of the Community Action Board of the Vereda (Political and administrative division of the municipality located in the rural area), so the network of neighborhood is dynamic and extensive.

- Economic Base

A general feature of the sector where are located the families to resettle is the cultivation of sugar cane and the production of panela, as the basis of the family economy, which is carried out by men. In addition, there are other crops such as plantain, cassava and some citrus fruit, papaya, and guanabana, also contribute to the upkeep of the group. These products are marketed in the town of Cocorná, and are also used for domestic consumption.

- Site of Origin and mobility

As has been said, the families to resettle are composed of people from the same area or who came from other places in the same area of eastern Antioquia. Its capacity of mobility is reduced for purposes of marketing or acquisition of products to support families, and for the request for medical or administrative services in the urban center of the town, as can be seen in the Table 3-133 .

Table 3-133. Mobility reasons

| Municipality | Vereda (Political and administrative division of the municipality located in the rural area) | Mobility | | |
|--------------|--|---|--|--|
| | | Provenance | Destination | Reason |
| Cocorná | Los Mangos | Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos | Vereda (Political and administrative division of the municipality located in the rural area) El Molino | Access to transportation service and education |
| | | | Town of Cocorná | Marketing of products, access to medical and educational services. And attend mass |
| | | Vereda (Political and | Access to medical services and education | |

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| | | | <i>administrative division of the municipality located in the rural area)</i> Campo Alegre | |
|--|--|--|---|--|

Source: Fieldwork carried out during the month of December 2011

- Family Structure

The three families to resettle are nuclear-type, with four and three members, respectively, as can be seen in the Table 3-134 .

Table 3-134. Family Structure of the families to resettle

| Name | Age | Gender | Marital Status | Relationship with the head of household |
|--------------------------------------|-----------|--------|----------------|---|
| Family 1 | | | | |
| Manuel Tiberio Giraldo Gómez | 65 | M | Married | Head of Household |
| Ana Lucia Aristizabal | 56 | F | Married | Wife |
| Yuri Liliana Giraldo Aristizabal | 22 | F | Unmarried | Daughter |
| Wilmar Alexander Giraldo Aristizabal | 19 | M | Single | Son |
| Family 2 | | | | |
| Miguel Angel Giraldo Gómez | 65 | M | Married | Head of Household |
| Ligia Ester Ciro | 44 | F | Married | Wife |
| Santiago Giraldo | 3 | M | Single | Son |
| Family 3 | | | | |
| Evelio of Jesus Giraldo Aristizabal | 34 | M | Married | Head of Household |
| Maria Salazar López Virgelina | 21 | F | Married | Wife |
| Andrea Giraldo Soralli Salazar | 18 Months | F | Unmarried | Daughter |

Source: Fieldwork carried out during the month of December 2011

- Level of vulnerability

- To establish the level of vulnerability of families to resettle were taken into account criteria such as:
 - If the heads of household are small landowners or day laborers
 - If there are in the zone high rates of unmet basic needs.
 - If families have high dependence on the environment, both natural as well as family and neighborhood.
 - If it is native population or with seniority in the area.
 - If the family has previously suffered displacement (for any reason)
 - If the livelihood depends on the activity at the premises or in the immediate environment

To qualify the vulnerability, was established the following scale:

- High Vulnerability: if the family meets more than four of these criteria
- Vulnerability Media: if the family meets between one and three criteria
- Low Vulnerability: if the family does not meet with any of the criteria.

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In the case of the families to resettle by affectation of the facilities in the El Molino hydroelectric project , the three families have high vulnerability,

- Construction characteristics, spatial distribution and allocation of housing.

The homes of the three families are located adjacent to the other, although not together. The houses are of one floor, one of which is built with mud walls, tile roof and cement floor and the other two have its walls built of brick, cement floor and ceilings, and one has tile roof and the other in zinc. The houses are equipped with electricity and water from birth, conducted through PVC lines One of them has a septic tank.

- Expectations that the family has compared between the project and the possible transfer.

In general terms, there were not expressed rejection or opposition to the housing transfer. However, the owners did express concern about the transfer of the panela facilities, from which depend the two family groups. They also argued that if the resettlement was necessary, they prefer to be relocated in nearby sites close to theirs or in the same venue.

- Linking members to community-based organizations at Vereda (*Political and administrative division of the municipality located in the rural area*) level and position currently occupied.

As has been said, the owner of one of the homes that have been affected is the president of the Community Action Board of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, Mr. Manuel Tiberio Giraldo Gomez. The other two families, are also active partners of the Board.

- Cultural Networks

A fact to highlight in this case, is the process of forced displacement lived by the population of the area, as a result of armed conflict between the years 2000 and 2004; in this Vereda (*Political and administrative division of the municipality located in the rural area*), before the conflict, there were 105 families, today there are 13, they are dedicated to the agricultural activity basically, and the processing of sugar cane for the production of panela. These are farming families, whose livelihood depends on family labor and in some cases, the work to the day journal in neighboring lands. Its main interactions are set with the Vereda (*Political and administrative division of the municipality located in the rural area*) of zonal Center El Molino, which is made up, in addition with Los Mangos, the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, Buenos Aires, Viadal, El Choco, Las Playas, Campo Alegre, and Santa Barbara. With the inhabitants of these Vereda (*Political and administrative division of the municipality located in the rural area*) are related to level the organization and community participation and laying down some networks of neighborliness, taking advantage of the single track of existing communication, which, in some, sections will be adequate for the project.

The residents of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos have as a benchmark an important territorial school, where they meet and make use of a small plate sports center, the facilities of this school will not be affected by the path of the planned road. For purposes of this, the territory of the Vereda

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(Political and administrative division of the municipality located in the rural area) will be transformed at visual and spatial level.

- Alternatives of transfer and receiving population

It should be borne in mind that the fill tab of the identification of the potential families to resettle, was only a preliminary survey on the alternatives for transfer, for this reason, when we have well defined the planning and design of the project will be necessary to refer back to these families, to make a consultation process in an optimal manner about the chosen site for the housing relocation.

The procedure to follow, to complement this information, is included in the Environmental Management Plan of this study, in the relocation program for Infrastructure and Housing

3.5 ENVIRONMENTAL ZONING

3.5.1 GENERAL INFORMATION

The objective of the environmental zoning is to identify environmental aspects of interest to delimit "homogeneous areas" in response to factors that may induce or aggravate situations or undesirable states of natural or human environment, taking as a basis for reference the current conditions.

These unwanted or unfavorable conditions may be related to limitations in the use of a natural resource or an ecosystem, which provides environmental goods and services, or can also refer to the generation of risk situations that threaten the health or the physical integrity of the population, due to the introduction of pollutants or inductive factors deteriorating over-exploitation conditions. In either case, the permanence of the occupation and the use of the territory is threatened, in the short, medium or long term.

3.5.2 PHYSICAL ENVIRONMENT

3.5.2.1 Environmental Zoning for the water component

To establish the environmental zoning by water quality, are taken into account the current conditions of quality, measured by the index NFS-WQI, the current gradient and the use of this resource by the population.

The reason for including the gradient as a major factor in the quality of the water, despite being an attribute of the current, has to do with the increase in the capacity of bio degradation of organic material in the most turbulent flow. As speed increases, the water can gain significant amounts of atmospheric oxygen, which let compensation for what is being consumed in the processes of oxidation.

The proposed criteria are presented in the Table 3-135 , indicating the ranges utilized and aspects for its interpretation.

Table 3-135. Definition of criteria for zoning

| Characteristic | Possibilities | Description of the current |
|----------------|---------------|----------------------------|
|----------------|---------------|----------------------------|

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| Characteristic | Possibilities | Description of the current |
|--|---------------------------------------|---|
| Current water quality | High | It corresponds to good quality currents (according to the NFS-WQI, |
| | Media | It corresponds to medium quality currents (according to the NFS-WQI) |
| | Low | It corresponds to low quality currents (according to the NFS-WQI) |
| Gradient of the current | High | Includes those currents with gradient greater than 10% |
| | Low | Current with a gradient less than 10% |
| Supply of aqueducts, irrigation systems and/or scattered users | Irreplaceable - Supplies at least one | The current from which depends, exclusively, one of the systems of water supply for human consumption, agriculture use, recreational or industrial of a community. Due to geographical, climatic and topographic features is not possible to obtain a resource of a different source, either by shortages and contamination or because the cost of its acquisition are unpayable. |
| | Replaceable - Supplies at least one | In this case the water resource can be obtained from alternate sources at reasonable prices, so that the service is guaranteed for the users. |
| | Not supplying none | Current which does not supply water for any of the established uses or that facilities only for dilution of effluents. |

With the above criteria, is defined the environmental zoning for the water component in the following manner:

- *High Environmental Zoning:* Flows with any water quality and low gradients, which provide little oxygen transfer and confer reduced ability to absorb the pollutant loads. They are used by at least one user and are irreplaceable.
- *Medium Environmental Zoning:* Creeks with good or average water quality and any gradient. They are used by the population, but are replaceable.
- *Low Environmental Zoning :* Flows of water quality with medium to low and high gradient. Not supplying for consumption or other uses.

The results of this environmental zoning are presented in Cartography 2148-04-EV-DW-033, where it is noted that all the creeks of the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos reaches a medium value. The rest of currents in the influence area were classified as low.

3.5.2.2 Environmental Zoning for the soil component.

Using the analysis of the conflict by soil usage as an indicator. These conflicts are determined on the basis of a comparison between the current use and potential use of the soil, defined in accordance with the system of agrologic classes. According to the presence or not of conflict and its severity, is considered the environmental zoning as follows (see Table 3-136 Cartography 2148-04-EV-DW-036):

Table 3-136. Pedagogical environmental zoning

| Current Use | Agrological Class | Potential Use | Type of conflict | Environmental Zoning |
|-------------|-------------------|---|------------------|----------------------|
| Open Forest | 3S-2 | Agriculture with clean crops, semi clean, dense, semi forest and livestock. | Without conflict | Low |
| | 3S-7 | Clean Crops semi clean, dense, semi forest and livestock with improved pastures | Without conflict | Low |

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| Current Use | Agrological Class | Potential Use | Type of conflict | Environmental Zoning |
|----------------------------|----------------------------|--|---|----------------------|
| | 7P-5 | Protective Forests producers, conservation | Without conflict | Low |
| | 7P-7 | Protective Forests producers, silvo pastoral systems, conservation | Without conflict | Low |
| Dense Forest of Guadua | 3S-2 | Agriculture with clean crops, semi clean, dense, semi forest and livestock. | Without conflict 5 | Low |
| | 3S-7 | Clean Crops, semi clean, dense, semi forests and livestock with improved pastures | Without conflict | Low |
| | 6P-7 | Forest producer plantations producing, silvo pastoral systems, cattle-ranching. Crops of semi forests and dense. | Without conflict | Low |
| | 7P-5 | Protective Forests producers, conservation | Without conflict | Low |
| | 7P-7 | Protective Forests producers, silvo pastoral systems, conservation | Without conflict | Low |
| | High Secondary Vegetation. | 3PS-7 | Clean crops, semi clean crops, semi forests, temperate climate; livestock in improved cutting pastures. | Without conflict |
| 3S-2 | | Agriculture with clean crops, semi clean, dense, semi forests and livestock | Without conflict | Low |
| 3S-7 | | Clean crops, semi clean, dense, semi forest and livestock with improved pastures | Without conflict | Low |
| High Secondary Vegetation. | 6P-7 | Forest producing plantations, silvo pasture systems, cattle-ranching. Semi crops and dense forest. | Without conflict | Low |
| | 7P-5 | Protective Productive Forests, conservation | Without conflict | Low |
| | 7P-7 | Protective Productive Forests, silvo pasture systems, conservation | Without conflict | Low |
| Low Secondary Vegetation | 3PS-7 | Clean crops, semi clean, semi forest, temperate climate; livestock in improved cutting pastures. | Lightweight conflict ₁ | Low |
| | 3S-2 | Agriculture crops with clean, semi clean, dense, semi forest and livestock | Without conflict | Low |
| | 3S-7 | Clean crops, semi clean, dense, semi forest and livestock with improved pastures | Lightweight Conflict | Low |
| | 6P-7 | Forest plantations producing, silvo pastoral systems, cattle-ranching. Crops and dense semi forest | Without conflict | Low |
| | 7P-5 | Protective productive forest, conservation | Severe Conflict ¹ | High |
| | 7P-7 | Protective productive forests, silvo pastoral systems, conservation | Conflict medium 1 | Medium |
| Clean grass, grass weeded | 3PS-7 | Clean crops, semi clean, semi forest, temperate climate; livestock in improved cutting pastures. | Lightweight conflict ₂ | Low |
| | 3S-2 | Agriculture crops with clean, semi | Without conflict | Low |

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| Current Use | Agrological Class | Potential Use | Type of conflict | Environmental Zoning |
|-------------------------------|-------------------|--|-----------------------------------|----------------------|
| | | clean, dense, semi forest and livestock. | | |
| | 3S-7 | Clean crops, semi clean, dense, semi forest and livestock with improved pastures | Lightweight Conflict | Low |
| Clean grass, grass weeded | 6P-7 | Forest plantations producing, silvo pastoral systems, cattle-ranching. Semi forest crops and dense | Without conflict | Low |
| | 7P-5 | Protective productive forests, conservation. | Severe Conflict ² | High |
| | 7P-7 | Protective producers forest, silvo pastoral systems, conservation | Conflict medium | Medium |
| Grass trees | 3PS-7 | Clean crops, semi clean, semi forest, temperate climate; livestock in improved cutting pastures. | Lightweight conflict ³ | Low |
| | 3S-2 | Agriculture crops with clean, semi clean, dense, and livestock. | Without conflict | Low |
| | 3S-7 | Clean crops clean, semi clean, dense, semi forest and livestock with improved pastures | Lightweight Conflict | Low |
| | 6P-7 | Forest plantations producing, silvo pastoral systems, cattle-ranching. Semi forest Crops and dense | Without conflict | Low |
| | 7P-5 | Protective producers forests, conservation | Severe Conflict ³ | High |
| | 7P-7 | Protective producers forests, silvo pastoral systems, conservation | Lightweight Conflict | Low |
| Crops | 3PS-7 | Clean crops , semi clean, semi forest, temperate climate; livestock in improved cutting pastures. | Without conflict ⁴ | Low |
| | 3S-2 | Agriculture with clean crops, semi clean, dense, and livestock. | Without conflict | Low |
| | 3S-7 | Clean crops, semi clean, dense, semi forest and livestock with improved pastures | Without conflict | Low |
| Crops | 6P-7 | Forest plantations producing, silvo pastoral systems, cattle-ranching. Semi forest crops and dense | Lightweight Conflict | Low |
| | 7P-5 | Protective producers forests, conservation | Severe Conflict ⁴ | High |
| | 7P-7 | Protective producers forests, silvo pastoral systems, conservation | Severe Conflict | High |
| Discontinuous urban structure | 3PS-7 | Clean crops, semi clean crops, semi forest, temperate climate; livestock in improved cutting pastures. | Without conflict ⁶ | Low |
| | 3S-2 | Agriculture crops with clean, semi clean, dense, and livestock | Without conflict | Low |
| | 3S-7 | Crops clean, semi clean, dense, semi forest and livestock with improved pastures | Without conflict | Low |
| | 6P-7 | Forest producing plantations, silvo pastoral systems, cattle-ranching. Semi forest crops and dense | Severe Conflict ⁶ | High |
| | 7P-5 | Protective producers forests, | Severe Conflict | High |

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| Current Use | Agrological Class | Potential Use | Type of conflict | Environmental Zoning |
|-------------|-------------------|--|------------------|----------------------|
| | | conservation | | |
| | 7P-7 | Protective producers forests, silvo pastoral systems, conservation | Severe Conflict | High |
| Bare Soil | 3PS-7 | Clean crops, semi clean crops, semi forest, temperate climate; livestock in improved cutting pastures. | Severe Conflict | High |
| | 3S-2 | Agriculture crops with clean, semi clean, dense, and livestock. | Severe Conflict | High |
| | 3S-7 | Clean crops, semi clean crops, dense, semi forest and livestock with improved pastures | Severe Conflict | High |
| Bare Soil | 6P-7 | Forest plantations producing, silvo pastoral systems, cattle-ranching. Semi forest crops and dense | Severe Conflict | High |
| | 7P-5 | Protective producers forests, conservation | Severe Conflict | High |
| | 7P-7 | Protective producers forests, silvo pastoral systems, conservation | Severe Conflict | High |

(1) In the project influence area, the areas with low secondary vegetation are part of areas of pastures that have been abandoned, because the productive activity is restarting after being abandoned, or because it is a very productive soil that has not received periodic maintenance. By being these zones associated with livestock production, it is considered that can put forward the following conflicts: Mild, because there is no improved pastures; medium, because although there are trees associated to the pasture, it is not handled as silvo pastoral systems and there are not protective forests localized, and severe because the livestock grazing is totally opposite to a protective forest or to a protection area .

(2) for grazing in general is considered the Mild conflict due to the absence of improved pastures; medium for clean pasture or weeded pastures because the grass component has dominance over the tree and there is no conservation and severe for both clean as wooded grounds, because they are opposed to the producers uses that are recommended for protection.

(3) It is determined as mild conflict because in the wooded pasture predominates the tree component on the grass and it is assumed, despite not being taken as a conservation practice clearly established within the production techniques of the area, such as silvo pastoral systems.

(4) In the project influence area the predominant crop is sugarcane, which is considered as a permanent cultivation and is managed with harvest from culls without making level cut. With this in mind, the conflict was described as mild where the recommended uses include permanent crops, considering that requires some simple practices to conserve the soil resource, given the conditions of strong slopes and the high susceptibility to erosion, and as severe, where the potential use is for protection and it does not support crops.

(5) The Guadua bamboo is used in the area as a protective cover

(6) For the urban structure was considered the severe conflict in the areas in which the strong slopes require a strict choice of usage due to the susceptibility to erosion and the likelihood of occurrence in mass movements. These zones are risk areas to establish housing or any other type of infrastructure. The mild conflict was determined for the areas in which despite not being the recommended use, the limitations are given more by the conditions of soil fertility and productivity than for the risks of landslides.

- High Environmental Zoning: Soils with conflict in the severe range. Corresponds to areas that require strict selection of use or that its only use is the protector and do not accept productive activities, however they have located crops or pastures.
- Medium Environmental Zoning: Present conflict within the medium range. Refers to soils that are used without management practices and that these are complex because they include the establishment of facilities for the control of erosion that can be expensive to

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be implemented by the owners of the land and for the production technologies that are developed in the area.

- *Low Environmental Zoning:* There are no conflicts or these are slight In the latter case the uses are appropriate but it requires simple practices and low-cost for safekeeping as path of crops and rotational grazing.

3.5.2.3 Zoning for the air component

Given the quality of the air found in the area where the concentration of all parameters evaluated (PM 10, SO 2 , 2 , CO) are below the established in the national regulations, as can be seen in section 3.2.9.2 , was taken as a criterion for the zoning of the air component, the noise.

During the monitoring done on four sampling points, it was found that the levels of environmental noise recorded are influenced by multiple sources, such as wild and domestic animals, insects, noise generated by the flow of the San Matias River, agricultural activities, even specific streets where necessary with vehicle traffic and people.

The results obtained were compared with the required under resolution 627 of 2006 the MAVDT, assigning it to the area of study the Sector D or suburban area of rural tranquility and moderate noise.

For the sampling points defined for the study of environmental noise it is concluded that there are areas of non-compliance with the permissible standards required by the environmental regulations in force for all the points in evening hours, in the daytime at two points during the holidays, this is due to the presence of sources described above.

Taking into account the results described it is set the environmental zoning for the air component - noise, with an average sensitivity, which occurs in Cartography 2148-04-EV-DW-034

3.5.3 BIOTIC ENVIRONMENT

Based on the concept issued by Margales (1995), with respect to the incidence of loss of vegetative cover in the decrease of ecological niches and therefore of the faunal diversity, it was determined the biotic sensitivity from the types of coverage, considering in the analysis the greater or lesser structural complexity and its resilience to shocks

The bare and degraded land was considered, by default, with low environmental sensitivity. For other coverage was conducted the following analysis:

3.5.4 STRUCTURAL COMPLEXITY

The structural complexity of the ecosystem refers to the development of different strata and bio types which allows for greater complexity in the food chains. For this criterion were established the following sensitivity ranges:

- Low sensitivity. Ecosystem with little variety of strata and environments, usually corresponds to open areas. For the study area were considered in this category the permanent arable crops, consisting primarily of sugarcane, the transitional crops and

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weeded pastures and clean pastures, because in them is formed one layer only and there is no significant variety of environments.

- Average Sensitivity. Presents combination of strata and environments in which there are species with different distributions and habits, which can be grouped or not in available bio types.

For the study area were considered in this category the following coverage: low secondary vegetation, which offer, at the time of the evaluation, resources for wildlife and contribute to the diversity of environments; wooded pastures, which presented predominance of the tree component on the gramine and forming strata in some sectors, in addition to offer diversity of environments and be connectors with forest remnants, and dense forest of Guadua bamboo that has some vertical structure and provides environmental services related to the protection of soil and water.

- High Sensitivity. Presents elements to a large number of strata and biotopes, and environments with very distinct micro climates, which allows for greater diversity of species (forests). Their structural complexity is greater than that of the pastures, crops and Low Secondary Vegetation. In the study area were grouped in this category of sensitivity open forests and high secondary vegetation.
- Extremely high sensitivity. In this category are grouped the dense forests, which by its advanced succession status and less intervention, presented greater complexity than the intervened forests and preserved in these elements of the original ecosystems.

3.5.5 RESILIENCE

Refers to the resilience of the system, which is considered as the possibility of reversing the disruptive processes to regenerate conditions similar to those which existed before the intervention, without substantially changing the composition and diversity of species. Sensitivity ranges are defined:

- Low sensitivity. High Capacity of recovery; it is capable of restoring the existing species, even though they can be colonizing. In this category were considered the pasture, crops and Guadua.
- Average Sensitivity. Average recovery capacity; it incorporates new species, but also other retrieves those that existed previously. There were grouped in this category the high secondary vegetation and the low secondary vegetation.
- High Sensitivity. Low Capacity of recovery, it is substantially altered the composition and diversity of species and for the needs of the species it is difficult to reestablish the existing ones. In this category are the forests.

Once evaluated the elements for each ecosystem, was established the sensitivity as indicated in the Table 3-137 and can be seen in the Cartography 2148-04-EV-DW-035

Table 3-137. Biotic Sensitivity

| Vegetation coverage | Vulnerability by structural complexity | Vulnerability by recovery capacity. | Sensitivity |
|---------------------|--|-------------------------------------|-------------|
| Dense Forest | Very high | High | Very high |

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| Vegetation coverage | Vulnerability by structural complexity | Vulnerability by recovery capacity. | Sensitivity |
|----------------------------|--|-------------------------------------|-------------|
| Open Forest | High | High | High |
| High Secondary Vegetation. | High | Medium | High |
| Dense Forest of Guadua | Medium | Low | Medium |
| Low Secondary Vegetation. | Medium | Medium | Medium |
| Crops | Low | Low | Low |
| Grass trees | Medium | Low | Medium |
| Weeded Grass | Low | Low | Low |
| Clean Grass | Low | Low | Low |

3.5.6 SOCIO-ECONOMIC ENVIRONMENT

To determine the economic sensitivity of the influence area of the El Molino hydroelectric project in the socio-economic environment, there are six variables that give an account of the sensitivity of the population in its territory, with regard to the conditions of the environment and that correspond to elements of the cultural components, demographic, economic, and political space.

3.5.6.1 Mobility

In general, the inhabitants of the area of direct influence of the Project face difficult conditions for their mobility, given that tracks and existing roads are in poor condition, structures along a road, and the maintenance that almost always must be done by the same communities with their own resources is poor. This situation becomes critical in the winter seasons, when some Vereda (*Political and administrative division of the municipality located in the rural area*) are left without communication due to landslides, rock falls of large size and the hollow of large dimension that are generated on the tracks. All of this affects mobility, productivity, marketing of products and access to basic services. Tracks to the most important mobility in the project influence area are:

- Track El Molino - Las Playas Tertiary track of municipal nature approximately 2.5 km
- Track to Cocorná - Chocó - Molinos - Campo Alegre - Los Mangos. Track of 8 km approximately, which is in bad condition, and that communicates the urban zone of the municipality of Cocorná, with the Veredas (*Political and administrative division of the municipality located in the rural area*) in the high terrains of the influence area.
- Track Granada-Ramal -El Choco-Cocorna. This track communicated the Vereda (Political and administrative division of the municipality located in the rural area) of Granada from the influence area with the track El Ramal, which is the road that connects to the urban zone of the municipalities of Cocorná and Granada. Currently interrupted by the collapse of the bridge over the San Matias River.

On the basis of the above features, the following categories are defined:

- High Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of direct influence area, where its inhabitants remain completely isolated for indefinite periods of time, by landslides, obstruction of the pathways by falling rocks or large hollow, the transit is interrupted or involves spending more time by fall of bridges, use of alternative ways or other means of transport such as the manual Garrucha. In this

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category are classified the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco and El Molino of the municipality of Cocorná and Las Faldas and Quebradona Abajo of the municipality of Granada . **Rating 3.**

- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area, where the inhabitants have bridle paths which lead to places where they can take means of transport. In this range are located the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, La Inmaculada and Campo Alegre. **Rating 2.**
- Low sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct area, where the town sits near the center of town or have a track nearby. In this category are the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) San Juan and San Lorenzo of the municipality of Cocorná. Rating 1.

3.5.6.2 Armed conflict and forced displacement

Almost the entire population of the Vereda (*Political and administrative division of the municipality located in the rural area*) in the area of direct influence of the project suffered forced displacement as a consequence of the armed conflict, this situation came to a critical point in the late 90 and early in the first decade of 2000. At present, a part of this population is in the process of return and another part was established in cities like Medellín, Barranquilla, Cali and Bogota. This, in some cases, led to the disruption of family groups, because while some members of the families decided to return to their land, others chose to remain permanently in the aforementioned cities. At present the situation of public order, apparently, has returned to "normal". Another aspect to take into account is the trend toward "natural" of the inhabitants of the two municipalities to migrate to other cities to set up businesses. In accordance with this context, we define the following ranges to establish the degree of sensitivity for these populations.

- High Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area where a large part of its population moved, with a low return of population; at the present time large number of dwellings and productive areas are abandoned, and there is a low representation and participation level. In this category are the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos and Campo Alegre in the municipality of Cocorná. Rating 3
- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area where a large part of its population is displaced, with return of population today, recovery of some productive areas and housing, and with a level of organization, representation and involvement focused on the president of the JAC. In this situation are the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas and Quebradona Abajo of the municipality of Granada. Rating 2
- Low sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area where the majority of the population moved, with a process of gradual return and which are still returning, with economic activities recovered in large part, with some homes still abandoned and with a good level of organization,

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representation and participation. Here at this level also includes the Vereda (*Political and administrative division of the municipality located in the rural area*) that by its location with respect to the urban center of the town, had some security assurances or opportunity to protect their lives, favoring the permanence of some families on their land, despite the manifestation of the conflict and the presence of armed groups. In this range can be placed the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, El Choco, San Juan, La Inmaculada and San Lorenzo of the municipality of Cocorná. Rating 1

3.5.6.3 Habitual Activity

The economic activity that is predominant in the Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area is farming, protruding sugarcane cultivation for the production of panela. There are also other crops such as banana, cucumber and tomato, of which they sell their surplus, and food crops such as beans and cassava. In addition, some families have between 2 and 7 head of cattle for the production of milk and dairy products such as cheese and butter. Other families also have chickens and pigs and make harvesting of fruits such as guava, tangerine, lemon and orange. The production of panela is usually marketed in the town of Cocorná and Granada and other products such as bananas and guava are sold in El Santuario. Although it also presents the case, that the buyers of the citrus fruit at harvest time, enter the Vereda (*Political and administrative division of the municipality located in the rural area*) to buy these products. In all the Vereda (*Political and administrative division of the municipality located in the rural area*) there is a high dependence on the work income in the plots and the marketing of panela and other products mentioned above. According to these characteristics, the following categories are defined:

- High Sensitivity. Paths of the influence area where the economic productivity has decreased significantly by the abandonment of populations as a result of armed conflict, whose population is severely affected by the lack of links with direct markets for trading their products, or because they do not have the economic capacity or technique to improve their plots performance, and its inhabitants depend mainly on the agricultural activity carried out in these. In this category are the following paths of the project influence area: Los Mangos, Campo Alegre, El Molino, El Choco, San Juan and La Inmaculada of the municipality of Cocorná. Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas and Quebradona Abajo of the municipality of Granada. Rating 3
- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area, where its residents have other occupation alternatives and income generation, in addition to the agricultural activity. In this range is Vereda (*Political and administrative division of the municipality located in the rural area*) San Lorenzo. Rating 2
- Low sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area, where its population does not necessarily depend on activities related to the work of the earth, and their occupation is completely different from the development of farming activities. In this category is not located any of

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the Vereda (*Political and administrative division of the municipality located in the rural area*) of the project direct influence area. Rating 1

3.5.6.4 Population Density

In the Vereda (*Political and administrative division of the municipality located in the rural area*) of the project direct influence area the population density ranges between 24.91 and 128 persons per km². This population is usually seated in a scattered fashion in the territory, with some cases where small cores are evident in certain sectors of some Vereda (*Political and administrative division of the municipality located in the rural area*)

According to data collected during the completion of the field work in the month of December 2011, the population density in each of the paths of direct influence area is the following: The Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre has a population density of 88.9 inhabitants/km², on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Choco density is 128 inhabitants/km², El Molino in the population density is 84.9 inhabitants/km², in San Juan is of 76.3 inhabitants/km², in Los Mangos is of 24.91 inhabit/km², La Inmaculada is 28.41 inhabit/km², in San Lorenzo is 56.64 inhabit/km², in Las Faldas of 40.6 inhabitants/km² and Quebradona Abajo is of 71.4 inhabitants/km².

In agreement with previous data and taking into account the historical behavior in terms of processes of forced displacement due to the effects of armed conflict are set, the following categories.

- High Sensitivity. Paths of direct influence area where the number of inhabitants is between 52 and 105 and its population density is ≤ 88.9 inhabitants/km². It is considered that these Veredas (*Political and administrative division of the municipality located in the rural area*) are more vulnerable to a new event of forced displacement, the resettlement of population, mass migration processes by different causes, or to the presence of armed actors, taking into account that they already moved one time and are now in the process of slow return, reconstruction of the territoriality and social, political and economic ties. In this category are the Veredas (*Political and administrative division of the municipality located in the rural area*) Los Mangos, Campo Alegre and La Inmaculada Rating 3
- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area on where the number of inhabitants is 120 to 200 inhabitants and its population density is ≤ 76.3 inhabitants/Km². In these Vereda (*Political and administrative division of the municipality located in the rural area*) with a greater number of population than the previous, the number of families that have returned have been significant, and in the case of the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Juan, by being close to the town of the municipality of Cocorná, have made possible a closer relationship with the own territory despite the displacement, and a greater opportunity in front of the facility to maintain social and economic ties with the population and relatives who have settled in the urban center of the town; similarly, was feasible to sustain a connection with the plots, or at least supervise land and housing. In the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo and Las Faldas, although the circumstances were different in terms of its proximity to the urban center of

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the town, there are now a significant number of population in the process of reconstruction of social, economic and political ties. Rating 2

- Low sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area with a number of inhabitants between 210 and 600, with a population density of ≤ 128 habit/hm². It is considered that in these Vereda (*Political and administrative division of the municipality located in the rural area*) which currently have the highest number of inhabitants, a significant amount of people have returned in a staggered manner to their homes and plots, with a territoriality rebuilt from neighborhood links, community participation and organization representative, with a development of productive processes developed and where there is the possibility of access to means of transport and access to the local markets, as they are located at the edge of the existing roads. In this case, in the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Chocó there is a successful experience of panela ramada community, which can be done in conjunction with the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Playas; on the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino, economic activities enable the livelihood and the marketing of surpluses, for its part, in the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo, its inhabitants have the Medellín -Bogotá Highway for access to services and markets, and 39 (7 %) of its inhabitants are working with the consortium that built the current project El Popal . Qualification 1.

3.5.6.5 Type of inhabitants

In all the Vereda (*Political and administrative division of the municipality located in the rural area*) in the project direct influence area, most of the population are peasants who are engaged in agricultural activities, and to a large extent to the planting and processing of cane for panela production. On the other hand, among these people they have significant roots to their territory, some even remained in their homes despite the conflict, and others who were displaced forcibly, preferred to return to work their plots, rather than remain in other cities doing different activities than agriculture.

Among the features that distinguish them as peasants stands out a mode of production based on family labor, a complete economic dependency of what is being produced in their plots, own religious practices of the catholic religion, attachment to food traditions own the type of peasant population categorized as Antioquia, family structure where stands out the role of the man as a supplier and the women as the basis of the family group (although, in some cases this also gives work to the family, especially in the panela business as they engage sugarcane producers), local forms of relationship based on solidarity and kinship, festivities linked to religion, and techniques of agriculture where there are still some beliefs associated with the seasonal cycle, the traditional knowledge with the incorporation of new inputs, looking for the increase in performance and productivity, among other elements.

According to the elements found in regard to the type of population are defined the following categories:

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- High Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) on the influence area where the majority of its population is rural, with customs and characteristics of this type of population and way of life, and in despite the forced displacement caused by the armed conflict and migration processes inherent in this population, there are still traditional practices and customs. All the Vereda (*Political and administrative division of the municipality located in the rural area*) of the area of influence, except San Lorenzo. Rating 3
- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of influence area where the population is composed in its majority by peasant population, but that have already been impacted by the development of infrastructure projects with the Bogota - Medellín Highway and the El Popal hydroelectric project . The Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo can be included in this range. Rating 2
- Low sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) on the influence area where the population is composed by people coming from Bogota or Medellín and laying down first or second homes in the area of direct influence of the project. There are no Vereda (*Political and administrative division of the municipality located in the rural area*) to be considered in this classification. Rating 1

3.5.6.6 Quality of the infrastructure of social services

In almost all the Vereda (*Political and administrative division of the municipality located in the rural area*) of the direct influence area of the infrastructure project of basic social services such as health posts, schools, courts, playgrounds or other spaces for the practice of sport or for recreation, are in a bad condition, or do not exist. In the majority of the Vereda (*Political and administrative division of the municipality located in the rural area*) the physical plant of the schools is impaired in ceilings and floors.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre for example, there is the infrastructure of a health center but it is not provided and are not given any service on a regular basis; it is only used as headquarters for the health brigades that are occasionally made (approximately 3 times per year); in the school there are two tennis courts in poor condition, the other areas are in good condition.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) of El Choco is a school with a physical plant in good condition, which has a small plate sports center, although some elements of the endowment and desks are deteriorated; there is also a soccer field and does not count with a health center for the attention of the inhabitants, they must go to the municipality hospital.

For its part, the Vereda (*Political and administrative division of the municipality located in the rural area*) El Molino has a school with physical plant in regular condition, which has a small court; there is no health center, for this reason, when we make health brigades in Campo Alegre, the inhabitants of El Molino go to this place.

The facilities of the school of San Juan presented some problems such as humidity and patios in poor condition, there is no court since it disappeared due to the effects of a geological fault, nor is there a health center, and the inhabitants of the Vereda (*Political and*

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administrative division of the municipality located in the rural area) go to the municipality hospital in case of need.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos there is a school with a regular infrastructure condition, which has a small plate sports center; there is no health center, and the inhabitants of the Vereda (*Political and administrative division of the municipality located in the rural area*) take advantage of health brigades that are performed in Campo Alegre or going to the hospital in the capital of the municipality.

In the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo the physical plant of the school is in good condition, although the court is impaired and some desks are in poor condition. On the Vereda (*Political and administrative division of the municipality located in the rural area*) there is no health center, which is why the inhabitants of San Lorenzo are moved to the Vereda (*Political and administrative division of the municipality located in the rural area*) La Granja or La Piñuela, where a nurse goes there for two or three days a week. In case of medical care of another type is required, the inhabitants of San Lorenzo visit the Municipality Hospital..

In La Inmaculada the physical plant of the school is located in fair condition, including a small surrounding court; on the Vereda (*Political and administrative division of the municipality located in the rural area*) there is not a health center, and for this reason, the inhabitants of La Inmaculada go, in case of need, to the Health Center La Piñuela, where they travel by foot or by mule, in a period of approximately 40 minutes; and leveraging health brigades that are carried out in the own Vereda (*Political and administrative division of the municipality located in the rural area*) once a year.

On the Vereda (*Political and administrative division of the municipality located in the rural area*) Las Faldas there is a school with a physical plant in good condition, a small plate sports center that is found in its facilities is located in fair condition, the people who live in this neighborhood, in case of need, go walking half an hour or more until the health center of Galilea. When the disease is considered serious, they move up to the hospital in Granada.

Finally, the school in the Vereda (*Political and administrative division of the municipality located in the rural area*) Quebradona Abajo account with a good physical plant, although the recreation areas are damaged; they had to close the health center by the risk involved in its location for close proximity to the river, a health promoter comes each month to the Vereda (*Political and administrative division of the municipality located in the rural area*) to make controls and teach some practices of oral health.

In Table 3-138 you can see the existing social infrastructure in the Vereda (*Political and administrative division of the municipality located in the rural area*) and the quality of their state.



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Table 3-138. Existing social infrastructure and state on the Veredas (Political and administrative division of the municipality located in the rural area)of the direct influence area

| Campo Alegre V. | | | V. La Inmaculada | | | V. El Chocó | | | V. El Molino | | | San Juan V. | | | V. Los Mangos | | | San Lorenzo V. | | | V. Las Faldas | | | V. Quebradona Abajo | | | | | |
|-----------------|-----|------|------------------|-----|---|----------------|-----|---|----------------|-----|---|----------------|-----|---|----------------|-----|---|----------------|-----|---|----------------|-----|---|---------------------|-----|---|-----|----|---|
| School | | | School | | | School | | | School | | | School | | | School | | | School | | | School | | | | | | | | |
| Yes | Not | B | Yes | Not | R | Yes | Not | B | Yes | Not | R | Yes | Not | R | Yes | Not | R | Yes | Not | B | Yes | Not | B | Yes | Not | B | | | |
| X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | |
| Court or plate | | | Court or plate | | | Court or plate | | | Court or plate | | | Court or plate | | | Court or plate | | | Court or plate | | | Court or plate | | | | | | | | |
| Yes | No | M | Yes | No | R | Yes | No | R | Yes | No | R | Yes | No | | Yes | No | R | Yes | No | R | Yes | No | R | Yes | No | R | Yes | No | R |
| X | | | X | | | X | | | X | | | | X | | X | | | X | | | X | | | X | | | X | | |
| Health Post | | | Health Post | | | Health Post | | | Health Post | | | Health Post | | | Health Post | | | Health Post | | | Health Post | | | | | | | | |
| Yes | No | SDT. | Yes | No | | Yes | No | | Yes | No | | Yes | No | | Yes | No | | Yes | No | | Yes | No | | Yes | No | | Yes | No | |
| X | | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | | | X | |

Source: own social team SAG on the basis of data collected during the field work, in the month of December 2011
 Conventions: B= good, R= regular, M= bad, SDT= without staffing.

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According to a previous context are defined the categories described below:

- High Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area that do not have health center and must go to the urban center of the town to seek health services, in addition their schools have a physical plant in regular condition and do not have spaces for recreation and sport. In this range is the Vereda (*Political and administrative division of the municipality located in the rural area*) Los Mangos, San Juan and La Inmaculada Qualification 3
- Average Sensitivity. Vereda (*Political and administrative division of the municipality located in the rural area*) of the influence area that have schools with physical plant in good condition and with spaces for recreation and sport in fair condition, at this level are the rest of the Veredas (*Political and administrative division of the municipality located in the rural area*) in the influence area (El Molino, El Choco, Las Faldas, Quebradona Abajo and Campo Alegre). Although, it is pertinent to clarify that although on the Vereda (*Political and administrative division of the municipality located in the rural area*) Campo Alegre there is a health center, it is not endowed and is occasionally open when carrying out health brigades. Qualification 2
- Low sensitivity. In this range cannot be included any of the Veredas (*Political and administrative division of the municipality located in the rural area*) of the area of influence, given that the conditions of existence and access to basic social services have significant levels of difficulty or a total lack. Qualification 1

According to the criteria taken into account for the qualification of the environmental sensitivity of the influence area without a project the final results are presented in Table 3-139 .

Table 3-139. Sensitivity for the cultural and demographic criteria

| Vereda (Political and administrative division of the municipality located in the rural area) | Rating by variable | | | | | | Total Score |
|--|--------------------|--|-------------------|--------------------|---------------------|---|-------------|
| | Mobility | Armed conflict and forced displacement | Habitual Activity | Population Density | Type of inhabitants | Quality of the infrastructure for basic social services | |
| Campo Alegre | 2 | 3 | 3 | 3 | 3 | 2 | 16 |
| El Chocó | 3 | 1 | 3 | 1 | 3 | 2 | 13 |
| San Juan | 1 | 1 | 3 | 2 | 3 | 3 | 13 |
| El Molino | 3 | 1 | 3 | 1 | 3 | 2 | 13 |
| Los Mangos | 2 | 3 | 3 | 3 | 3 | 3 | 17 |
| La Inmaculada | 2 | 1 | 3 | 3 | 3 | 3 | 15 |
| San Lorenzo | 1 | 1 | 2 | 1 | 2 | 3 | 10 |
| Las Faldas | 3 | 2 | 3 | 2 | 3 | 2 | 15 |
| Quebradona Abajo | 3 | 3 | 3 | 2 | 3 | 2 | 16 |

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3.5.6.7 Social Sensitivity

The socioeconomic sensitivity superimpose the criteria for mobility, armed conflict and forced displacement, habitual activity, population density, type of people, quality of infrastructure for basic social services (see Table 3-139), in accordance with the ranges set in , Table 3-140 economic activity.

Table 3-140. Sensitivity Range of the demographic and cultural criteria

| Sensitivity | Qualification range |
|-------------|-----------------------------|
| Low | Less than 13 |
| Medium | 13 To 14 |
| High | Greater than or equal to 15 |

According to the score, the settlements in the project direct influence area in terms of its socio-economic sensitivity, are graded as follows (see Plan 2148-04-EV-DW-039):

- High Sensitivity : are considered with high sensitivity the Vereda (Political and administrative division of the municipality located in the rural area) that have reached a total score of 15 to 17 points, among these are Los Mangos, Campo Alegre, La Inmaculada, Quebradona Abajo and Las Faldas.
- Average Sensitivity : In this range are included the Vereda (*Political and administrative division of the municipality located in the rural area*) that totalized a score of 13 points, in this level are the Veredas (*Political and administrative division of the municipality located in the rural area*) El Choco , San Juan and El Molino.
- Low Sensitivity: This category includes the Vereda (*Political and administrative division of the municipality located in the rural area*) that totalized a score between 1 and 12 points in this range can be included the Vereda (*Political and administrative division of the municipality located in the rural area*) of San Lorenzo.

3.5.7 GENERAL ENVIRONMENTAL ZONING

Based on the environmental, pedagogical, biotic and social zoning, was made a general zoning of the influence area of the El Molino hydroelectric project , based on criteria that are defined in Table 3-141 , and the results are presented in Cartography 2148-04-EV-DW-037.

Table 3-141. Criteria for the general zoning of the influence area

| Sensitivity | Weights of sensitivities (%) | Sensitivity Values | | Overall Sensitivity ¹ | |
|-------------|------------------------------|--------------------|--------|----------------------------------|-------------|
| | | Sensitivity | Values | Value | Sensitivity |
| Pedagogical | 0.10 | High | 5 | 4 To 5 | High |
| Biotic | 0.50 | Medium | 3 | 2.1 To 3.9 | Medium |
| Social | 0.40 | Low | 1 | 1 To 2 | Low |

¹: The overall sensitivity was calculated as the sum of the sensitivity value of the criterion by the weight given to the criterion.