Chapter 3

Study areas

3. Description of the study areas

The proposed model of spatial analysis for the Sustainable Environmental Planning of Rural Areas (SEPRA) will be applied to two Venezuelan rural zones: Rivas Dávila municipality (Mérida State) and Quíbor Valley (Lara state). These two study areas were selected by taking into account the following characteristics:

1. The main economical activities carried out in the study areas are constituted by agriculture, which defines the zones are as rural.

2. The systems of land use affect the natural conditions and therewith generate environmental conflicts between the permanency of the natural resources and the economical activities. Thus, the implementation of environmental planning processes is needed in order to promote the sustainable development.

3. In spite of indicated similarities, the areas belong to different environmental regions. Rivas Dávila is a humid and sub-humid intermountain valley with altitudes between 1000 and 3600 m a.s.l. and steep relief. Quíbor, is a broad low valley, relatively plain between 550 and 1000 m a.s.l, located in a semi-arid region. The socio-cultural contrasts between the areas are also important. Thus, an evaluation of the efficiency of the model for environmental assessment in different environmental conditions can be carried out.

5. Because the study areas represent two of the most common agricultural systems of the country, the applicability of this method in other rural regions of Venezuela could be enhanced.

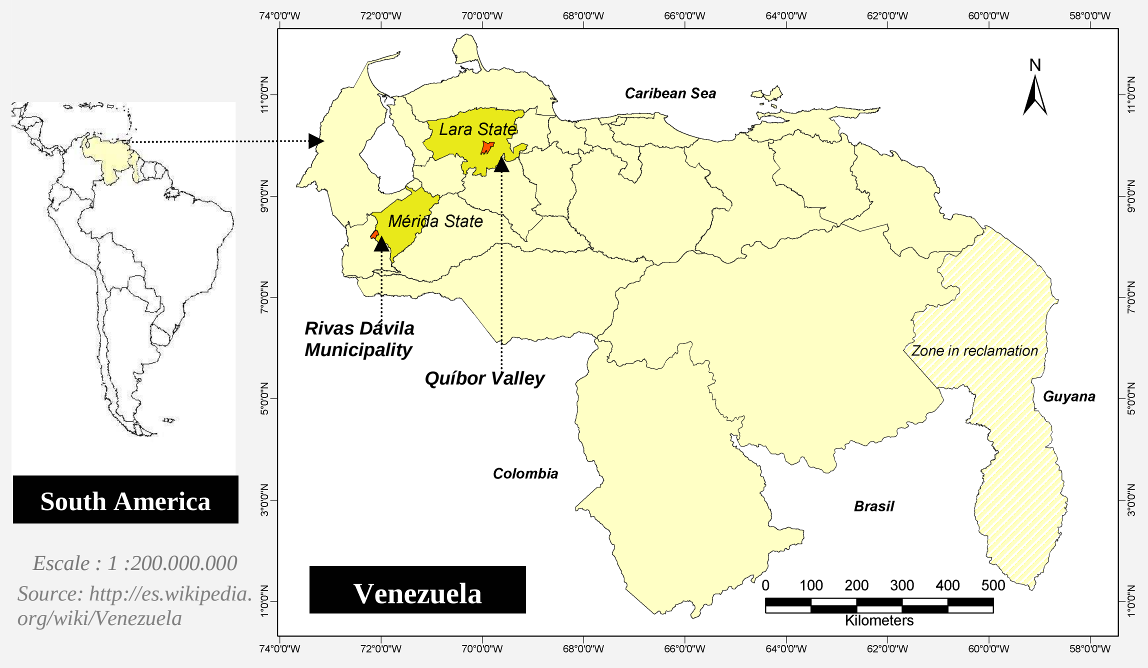
6. Finally, it must be emphasised that the local authorities of these two areas have been interested in the establishment of strategies in order to control the current and potential environmental problems. This offers an important opportunity for the possible application of the results of this work.

As introduction, this chapter contains a condensed geographical characterization of Venezuela. After this, the description of both areas Rivas Dávila Municipality and Quíbor Valley is presented.

3.1 Localization of study areas

Venezuela is located in northern South America, between 00°38'53" to 12°12'00" N latitude and 59°47'50" to 73°22'38" W longitude. The country has an area of 916,445 km^2 and 21,800 km of coast on the Caribbean Sea. Venezuela bounds with Guyana and the Atlantic Ocean to the east, Brazil and Colombia to the south and Colombia to the west. To the north the borders are established with the territorial sea of several Caribbean countries (Venezuela, 2008).

The study areas are located in the west of Venezuela forming part of two different geographical regions. Rivas Dávila Municipality belongs to the Mérida state in the Andean region, constituted by the highest mountains range in the country, which determines a great variety of climates and ecosystems. There the environmental conditions of the valley-bottoms favour the agriculture; however many anthropogenic activities occupy very steep hillslopes with negatives impacts on these frequently fragile ecosystems.



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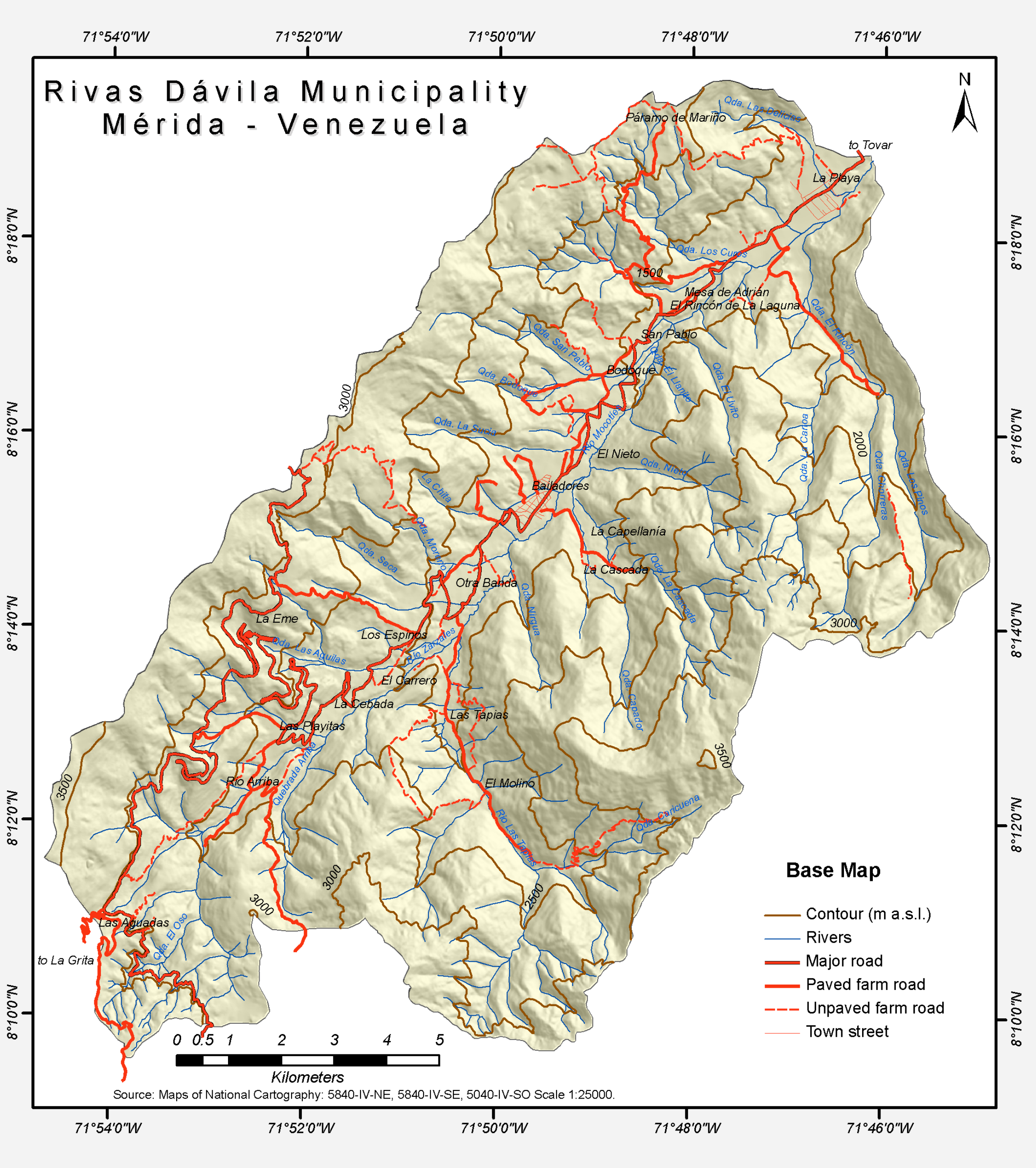
Source: http://es.wikipedia.org/wiki/Venezuela

Map 3.1: Relative localization of study areas.

Quíbor Valley is located in the Lara state which is part of the Center Western region of the country. This region is characterized by intermountain valleys located in a transition zone among the Andean, Coriano and Coastal ranges. Among these moderately high mountains, broad and relatively plain valleys are located where intensive agricultural systems and important urban areas are emplaced.

3.2 Rivas Dávila Municipality

Rivas Dávila is a municipality of the Merida state, located in the southwest of Venezuela, between 8°09’23” to 8°19’27” north latitude and 71°44’59” to 71° 54’48” west latitude (Map 3.2).



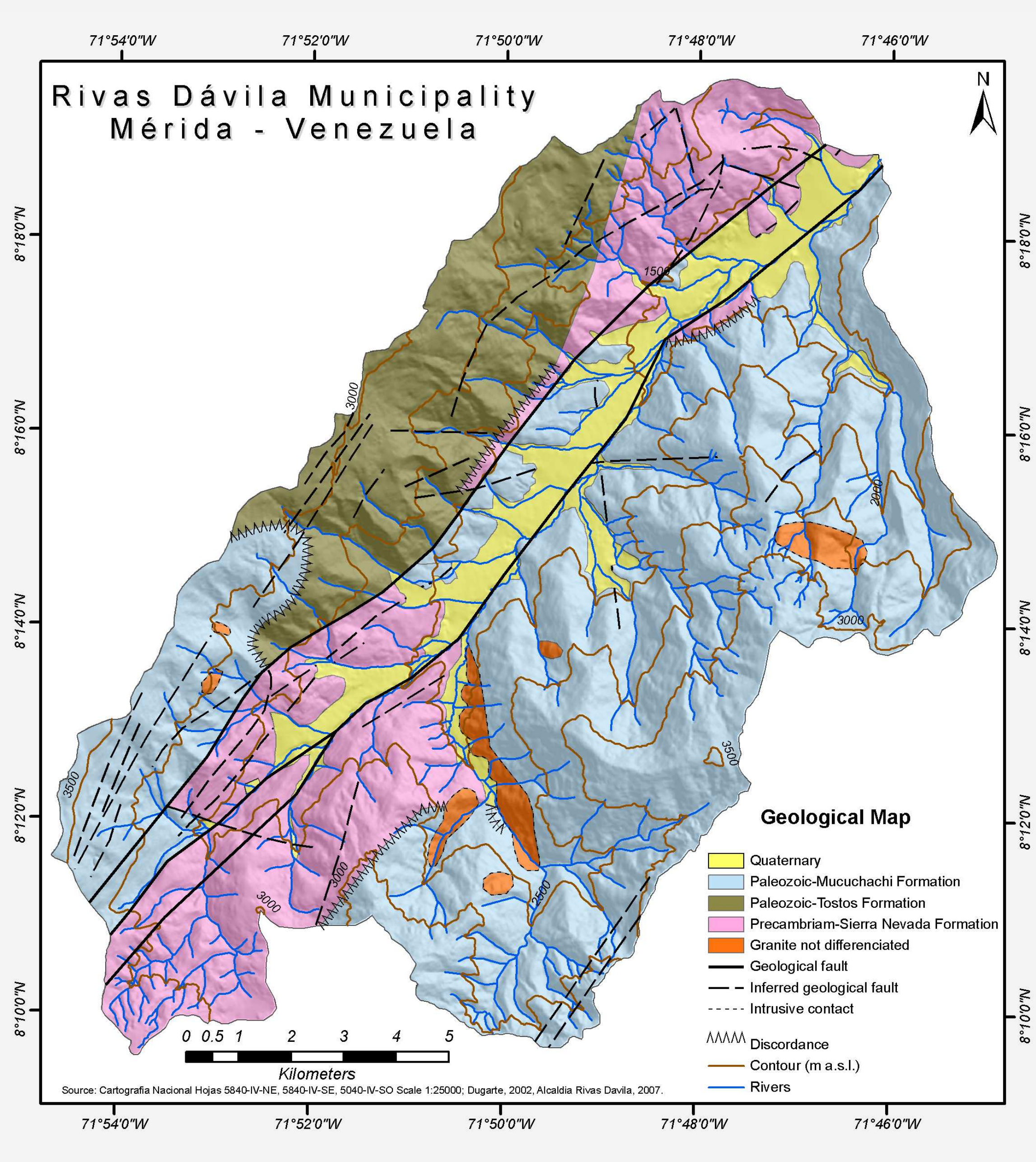
Source: Maps of National Cartography: 5840-IV-NE, 5840-IV-SE, 5040-IV-SO Scale 1:25000.

Map 3.2: Rivas Dávila Municipality, base map.

With 18,500 ha, the area occupies the high catchments of the Mocoties River, a tributary of the Chama River, which is an important river of the Maracaibo Lake basin.

3.2.1 Geology

The geological characteristics play primary role in the landscape configurations, as well as in the natural hazards and, consequently, in the potentialities or limitations for the land use. In this geological analysis the geology formations, lithology, geological faults and seismicity are considered. The area is made up by three geological formations (Map 3.3).



Source: Cartografia Nacional Hojas 5840-IV-NE, 5840-IV-SE, 5040-IV-SO Scale 1:25000; Dugarte, 2002, Alcaldia Rivas Davila, 2007.

Map 3.3: Geological map.

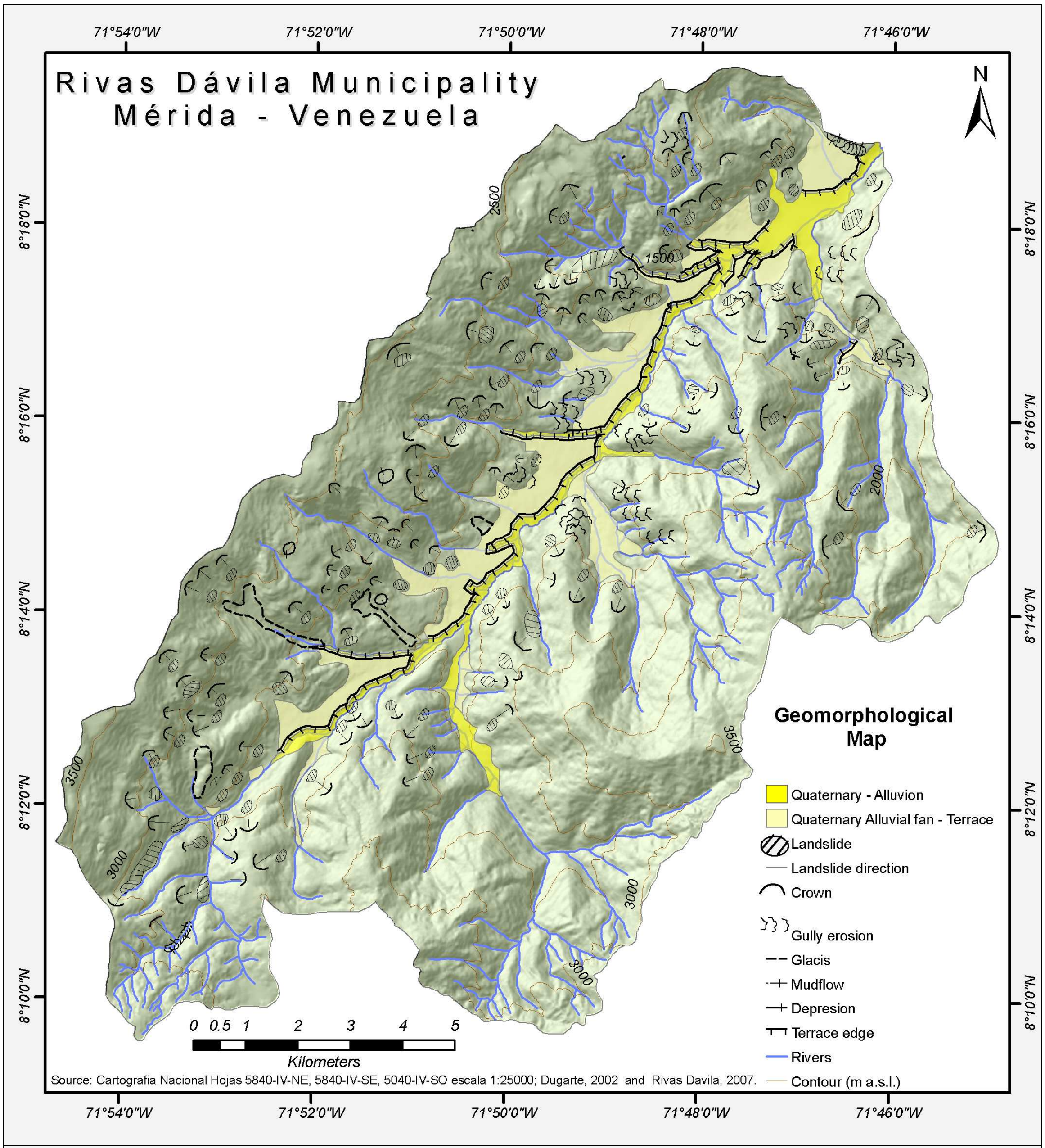
The Sierra Nevada formation (Precambrian) underlies two sectors of the central valley and is composed of granites and gneisses. The Mucuchachí formation (Palaeozoic), composed of phyllites, shale and limestone, almost totally dominates the east slope of the valley and a portion of the south west. The Tostós formation, in the north-east, is basically composed of shale, phyllite, schist and gneiss. In general, the bedrocks of three formations are characterized by a moderate and high susceptibility to fracturing and weathering, which determine high instability in the steep slopes (CORPOANDES, 1995; Mora, 2004; Ferrer and Laffaille, 2005; Alcaldía Rivas Dávila, 2007).

Rivas Dávila is crossed by the Boconó geologic fault in the NE-SW direction. This is one of the most important and active fault systems in the country and extends for about 500 km between the borders with Colombia and the Caribbean coast of Venezuela (Audemard et al., 2008) (Figure 4.1). A complex fault system associated with this fault can be identified in Rivas Dávila. This intense structural fracturing generates high seismicity. Indeed, during the last few centuries telluric movements of high intensity have been recorded (Schubert and Vivas, 1993; Samudio, 1999; Palme and Altez, 2002; Palme et al., 2005).

3.2.2 Relief

The altitudinal variation of the valley has a marked influence on other environmental characteristics such as climate, geomorphology, vegetation and land-use. Physiographically the catchment configures a high and narrow intermountain valley with NE-SW orientation, whose relief is characterized by very steep slopes around the Quaternary deposits of the valley bottom. About 53% of the area is classified as very steep slope with inclination greater than 45%, while only 8% has slopes with inclination lower than 15%.

In this rift valley, the Quaternary deposits are located especially in the lowest section of the sunny slope (Map 3.4) which defines the asymmetric form of the valley (Schubert and Vivas, 1993). These deposits predominantly belong to late Pleistocene and Holocene and are composed by alluvial fans and terraces.



Source: Cartografia Nacional Hojas 5840-IV-NE, 5840-IV-SE, 5040-IV-SO escala 1:25000; Dugarte, 2002 and Rivas Davila, 2007.

Map 3.4: Geomorphological map.

Coalescent fans built by transversal torrents are frequently located above older terraces deposited by the Mocoties River (Vivas, 1994). An active hydro-morphodynamics represented by mass movements has shaped the landscapes. Erosion, landslides and floods in the area are a latent threat to the structural stability as a combined result of the geological, geomorphological, climatic and anthropogenic factors. With respect to this, in 2005 an atypical storm in the small catchments of Las Tapias sector caused landslides with affectation on settlements and croplands (Figure 3.1). Besides natural causes, the intensive anthropogenic interventions of the watershed has an important influence on the causes and consequences of these phenomena

Source: IMPRADEM, 2005

Source: IMPRADEM, 2005

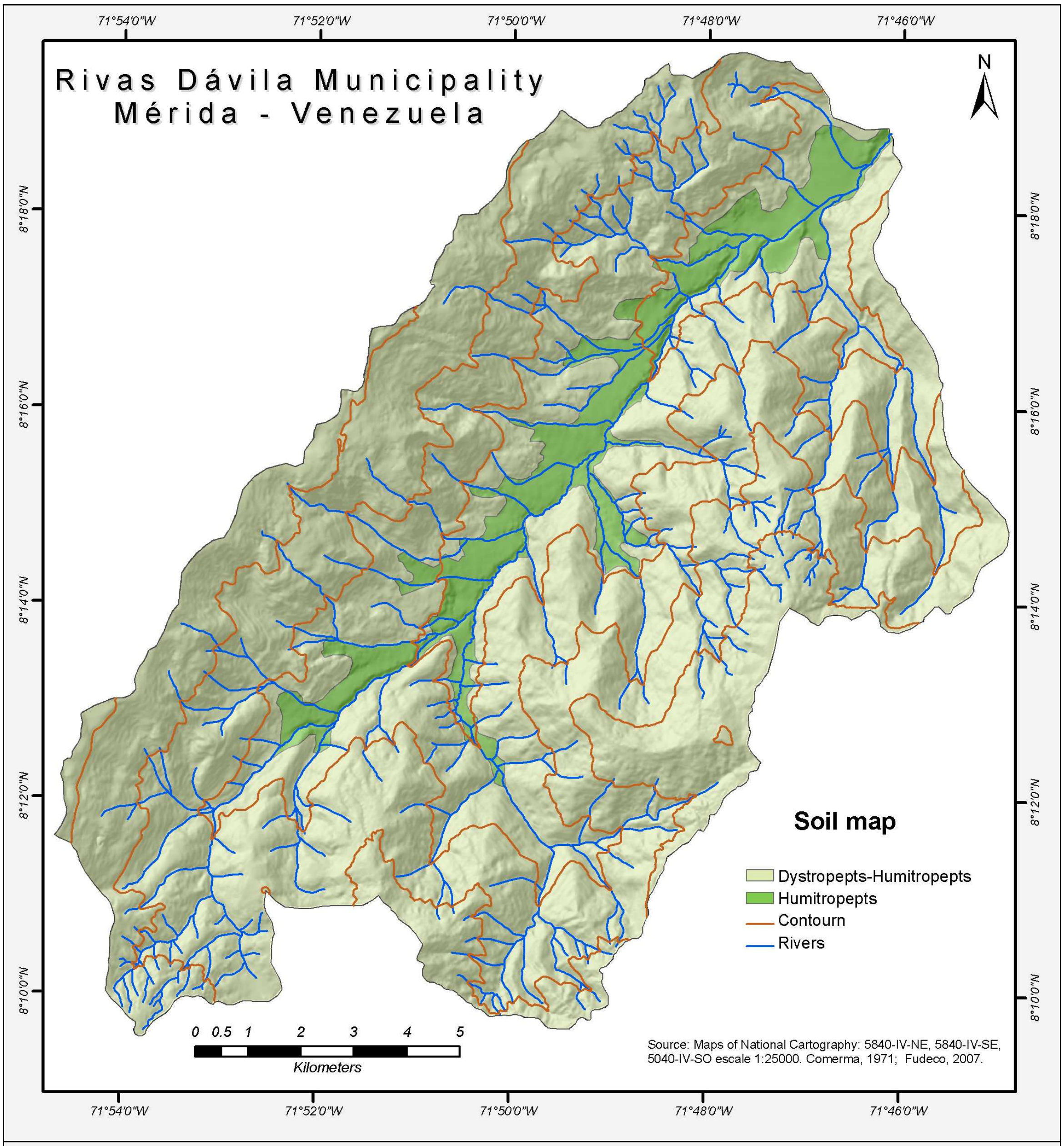
Figure 3.1: Debris flow and mudflow in Las Tapias sector, February 2005.

3.2.3 Soils

According to the Soil Map of Venezuela (Comerma, 1971), the soils of Rivas Dávila are classified as Inceptisols (USDA taxonomy). The humid and sub-humid local conditions favor this type of young soil which presents a cambic horizon and an ochric epipedon. Its altered horizon has lost bases or iron and aluminum but retain some weatherable minerals (USDA, 1999).

At the level of great groups, these soils are classified as Dystropepts in the slopes and Humitropepts in the valley bottom (Map 3.5) (MARN, 2007). The Dystropepts are soils formed in situ from the alteration of the parental material; the Humitrpepts are formed on colluviums and are differentiated of the Dystropepts due to their larger contents of organic matter (Comerma, 1971).

In the sector southwest of Rivas Dávila, Mejía and Vera (2001) observed a larger level of clay in those soils formed from phyllite and shale of the Mucuchachí formation, where an active morphodynamic occurs. Soils, whose parental material are the granites, shales and gneisses of the Sierra Nevada formation are deeper and sandy. As occurs in the same type of soils described in others zones of the Andean region dominated by similar environmental conditions, the soils of Rivas Dávila are more developed and deeper in concave relief of the valley bottom. In these positions the soils have a larger level of organic matter, clay and silt and a larger capacity of water retention (Manrique et al., 1997; Gutiérrez et al., 1998).

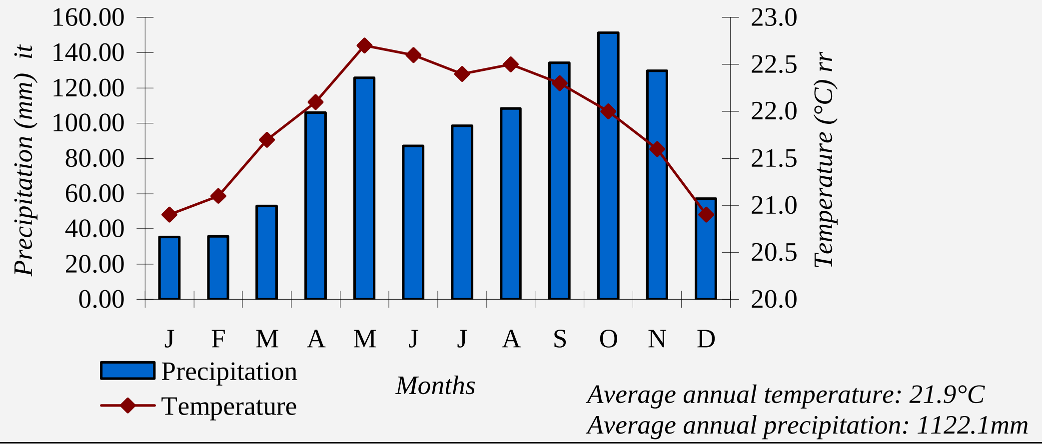


Source: Maps of National Cartography: 5840-IV-NE, 5840-IV-SE, 5040-IV-SO escale 1:25000. Comerma, 1971; Fudeco, 2007.

Map 3.5: Soil map.

3.2.4 Climate

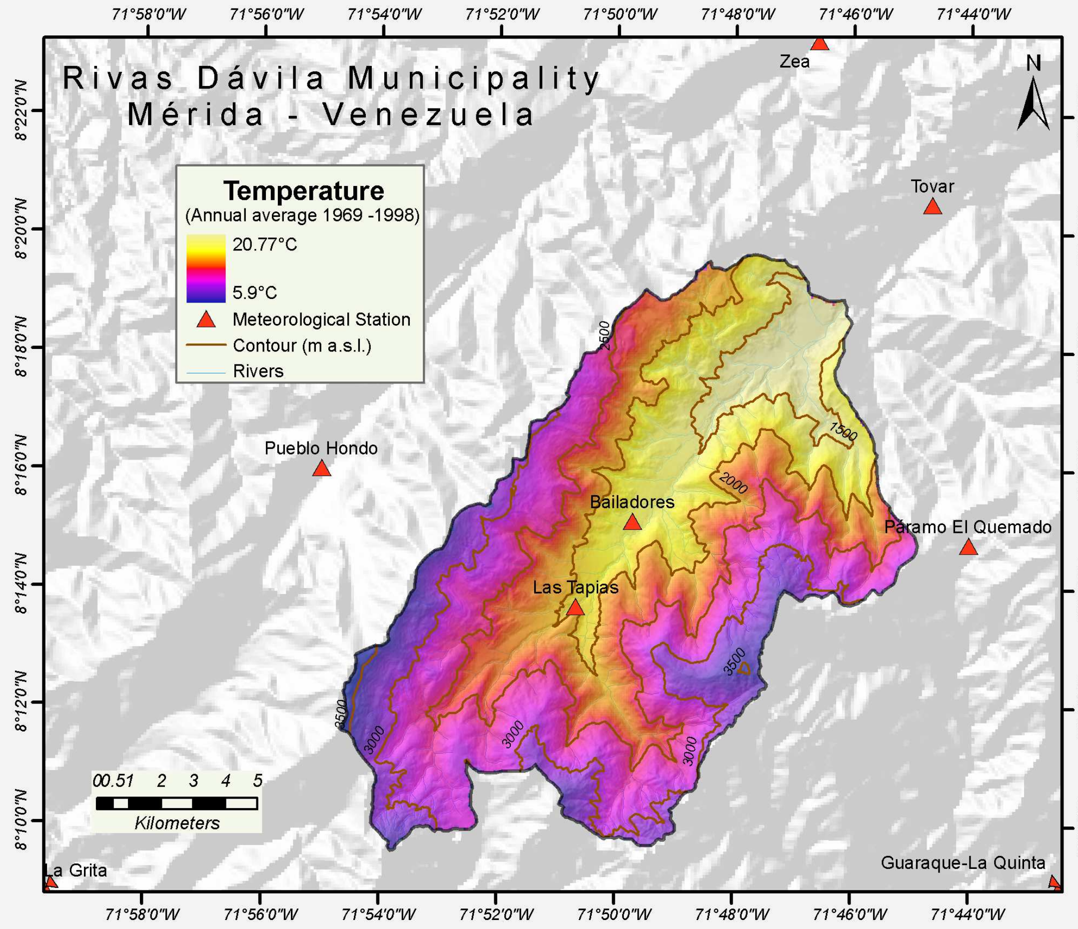
Due to the lack of a good system of climate stations, only scarce data of nine meteorological stations are available. Three of them are located inside of the area and six outside. All stations have monthly and annual precipitation average between 1968 and 1998 while only one of them has temperature data. The monthly average precipitation and temperature of Tovar station, located at 952 m a.s.l., 4 km northeast of Rivas Dávila are graphically represented in Figure 3.2.



Average annual temperature: 21.9°C
Average annual precipitation: 1122.1mm

Figure 3.2: Climate data of Tovar station (1969-1998).

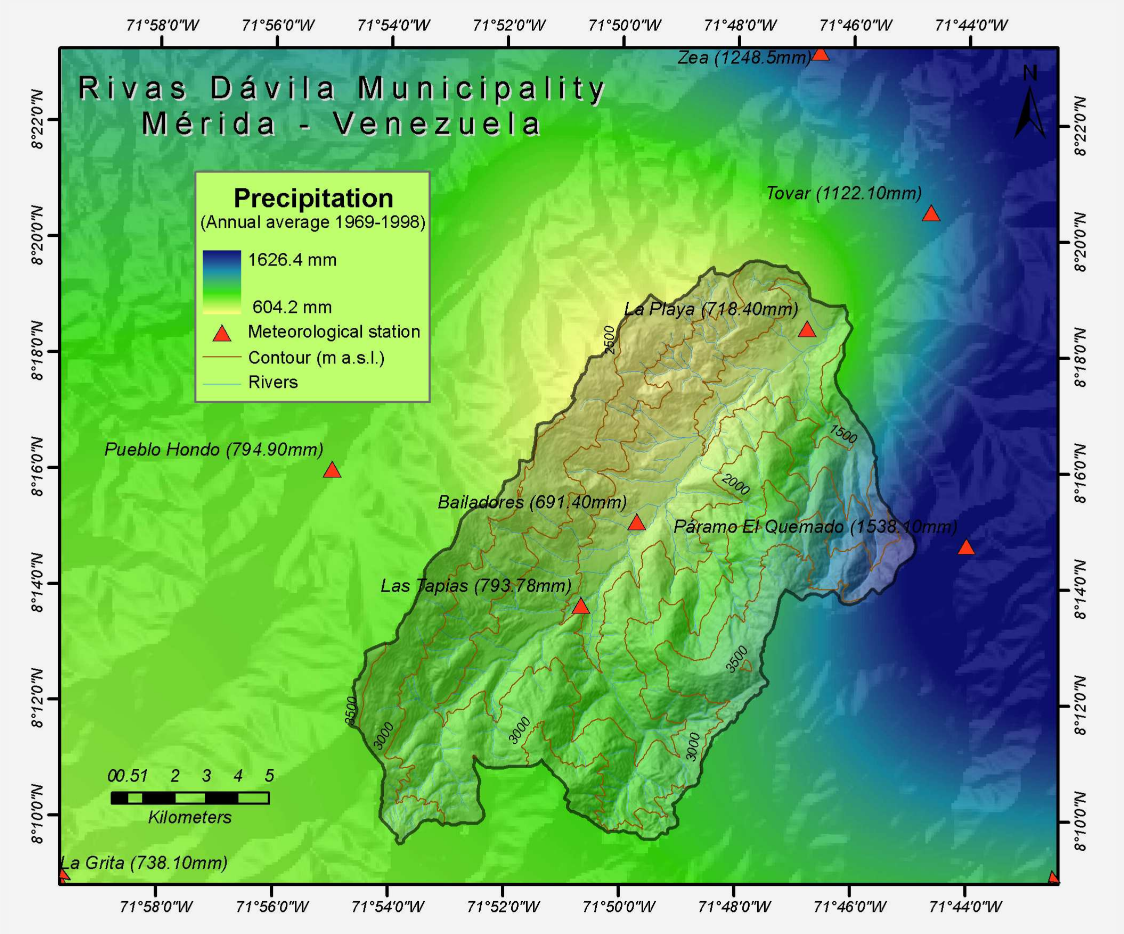
The temperature gradient of -0.6°C/100 m determined by Silva (1999) for the Chama river basin, where the study area is located, was used as reference to create the Map 3.6, taking into considerer data from Tovar station and the map of elevations.



Map 3.6: Average annual temperature, period 1968-1998.

The lowest sector in the north shows the highest average temperature around 20°C while the high mountains, at 3600 m a.s.l., have annual averages of about 6°C. A small variation between the coldest and warmest month - less than 5°C- defines the isothermal condition of the climate.

Map 3.7, created using the Kriging interpolation technique (ArcGis 9.1) shows the annual average precipitation of the study area. The precipitation varies according to the altitude and the slopes of the valley. In the east slope the annual average of precipitation reaches 1,300 mm, near to the Páramo El Quemado station west of the study area, while in the central zone of the valley the climate station Bailadores shows an annual average of 691.4 mm.



Map 3.7: Average annual precipitation, period 1969-1998.

The dryer conditions around Bailadores determine a sub-humid sector which covers the northwest of the watershed, between the valley bottom and the summit. This sector at the same time receives high radiation levels due its east exposition, which generates a larger rate of evapotranspiration and less water availability. Toward the southwest, a gradual increase of the precipitation can be observed, however the annual averages only reach values around 800 mm. The east side, with more humid conditions, shows a predominant increase of the precipitation in the west-east direction towards the head watershed, reaching its maximal values in the catchment of El Rincón river.

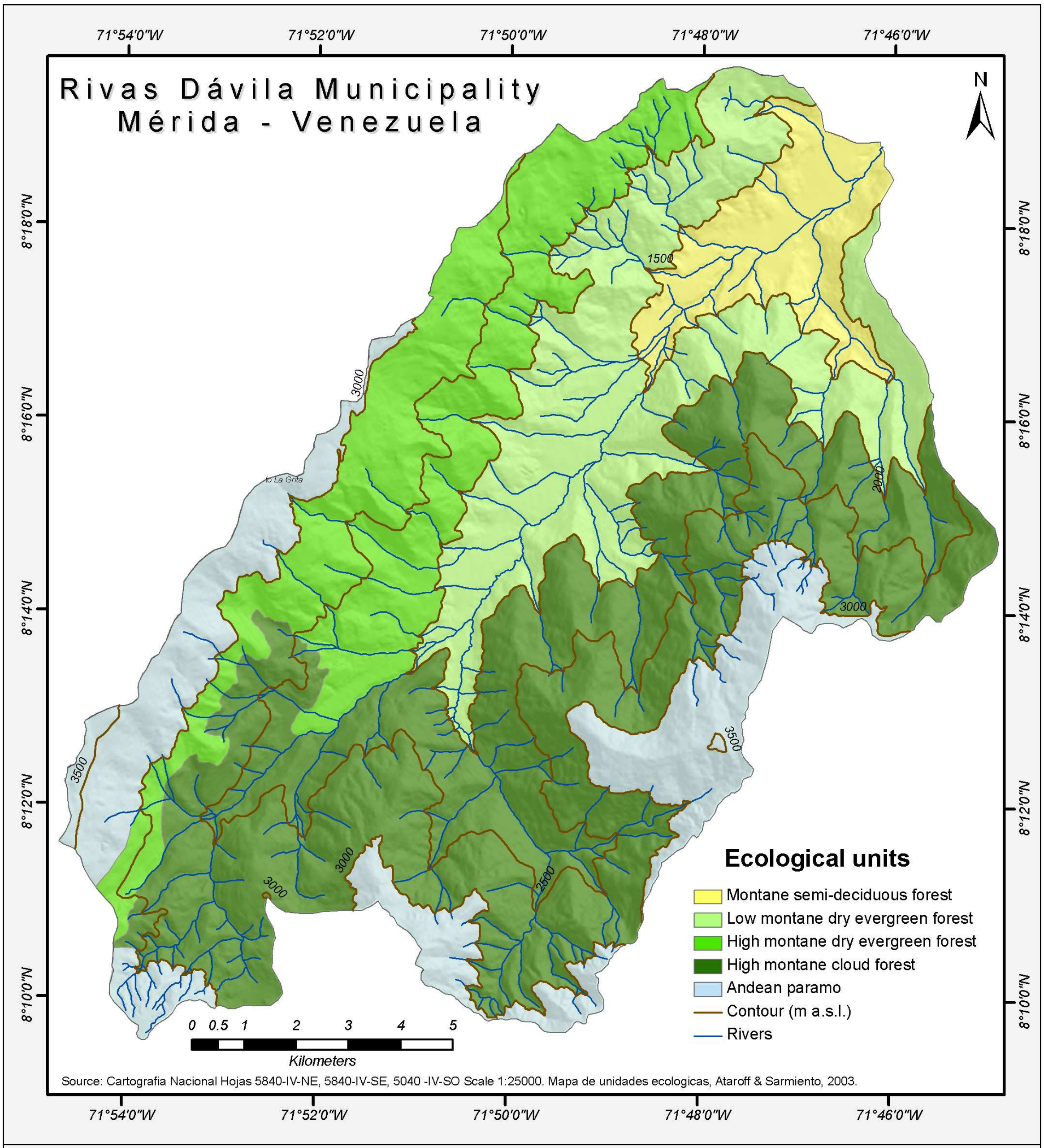
The climate conditions of the valley influence the regimen of the dendritic drainage system of the watershed. Thus, perennial and longer streams drain mostly the east slopes of the valley, whereas the west slope is characterized by intermittent and shorter streams. All of these streams are intensively used to maintain the irrigation systems in which the local agriculture is supported.

3.2.5 Vegetation

The natural vegetation of the area has been highly disturbed in the valley bottom and in its east-exposed slope of the valley (sunny slope), where the villages and the agricultural activities are mainly located (CORPOANDES, 1995; Mora 2004; Alcaldía Rivas Dávila, 2007). The dryer conditions of the east-exposed slope (sunny slope) determine sparser and lower vegetation than those of the west exposed slope (shady slope) (Figure 3.3).

Figure 3.3: Dry east-exposed slope and humid west-exposed slope.

In the study area Ataroff and Sarmiento (2003) recognized five ecological units according to the type of dominant vegetation (Map 3.8).



Source: Cartografia Nacional Hojas 5840-IV-NE, 5840-IV-SE, 5040 -IV-SO Scale 1:25000. Mapa de unidades ecologicas, Ataroff & Sarmiento, 2003.

Map 3.8: Ecological units.

The montane semi-deciduous forest located in the north of the area covers the lowest and warmest sector of the area, dominated by a sub-humid precipitation regimen. The original vegetation, as a consequence of a severe intervention, has been reduced to small relicts located in very steep slopes and around of some of the streams. The natural forest has an irregular canopy between 20 and 30 m, although emergent trees can reach more height.

The low montane dry evergreen forest occupies a colder thermal floor between the 1500 m and 2000 m a.s.l. One part of this unit, located in the east-exposed slope and extended to the southwest, belongs to the dryer sector of the valley; while another portion occupies a more humid sector in the west exposed slope. The unit presents a high level of intervention especially in the east slope or sunny slope. This vegetation in the more elevated and inclined sectors of the shady slope presents a lower grade of intervention.

The sunny slope of the study area, between 2,000 m a.s.l. and 3,000 m a.s.l. the high montane dry evergreen forest has been identified. This unit is endowed with a low forest whose maximal height can reach 15 m. Like the above mentioned units, this forest has been severely disturbed by anthropogenic uses. Due to this, it can be frequently found in sectors of very steep slopes and highest altitudes. The presence of this forest is an indicator of the dryer conditions of the west slope of the valley.

The more humid conditions of the west-exposed slope allow the presence between 2,000 m and 3,000 m a.s.l. of the mountane cloud forest. This unit belongs to an area of colder temperatures, high cloud cover, high relative humidity and low insolation. The forest is dense and high and constitutes the vegetation type with the largest extension and less intervention of the area. However, in some sectors such as the valley of the Las Tapias River, the natural forest has been highly replaced by agricultural uses.

The Andean Paramo is one of the most fragile ecosystems of the Andean Mountains. This vegetation is located above of 3000 m a.s.l. where an annual average temperature of less than 10°C dominates. The annual average precipitation is about 800 mm in the west slope and 1000 mm in the east slope. The vegetation is characterized by shrubs and grasses of low height (<1.5m) which have been slightly intervened especially in those sectors of more accessibility such as in the south of the area.

3.2.6 Land use

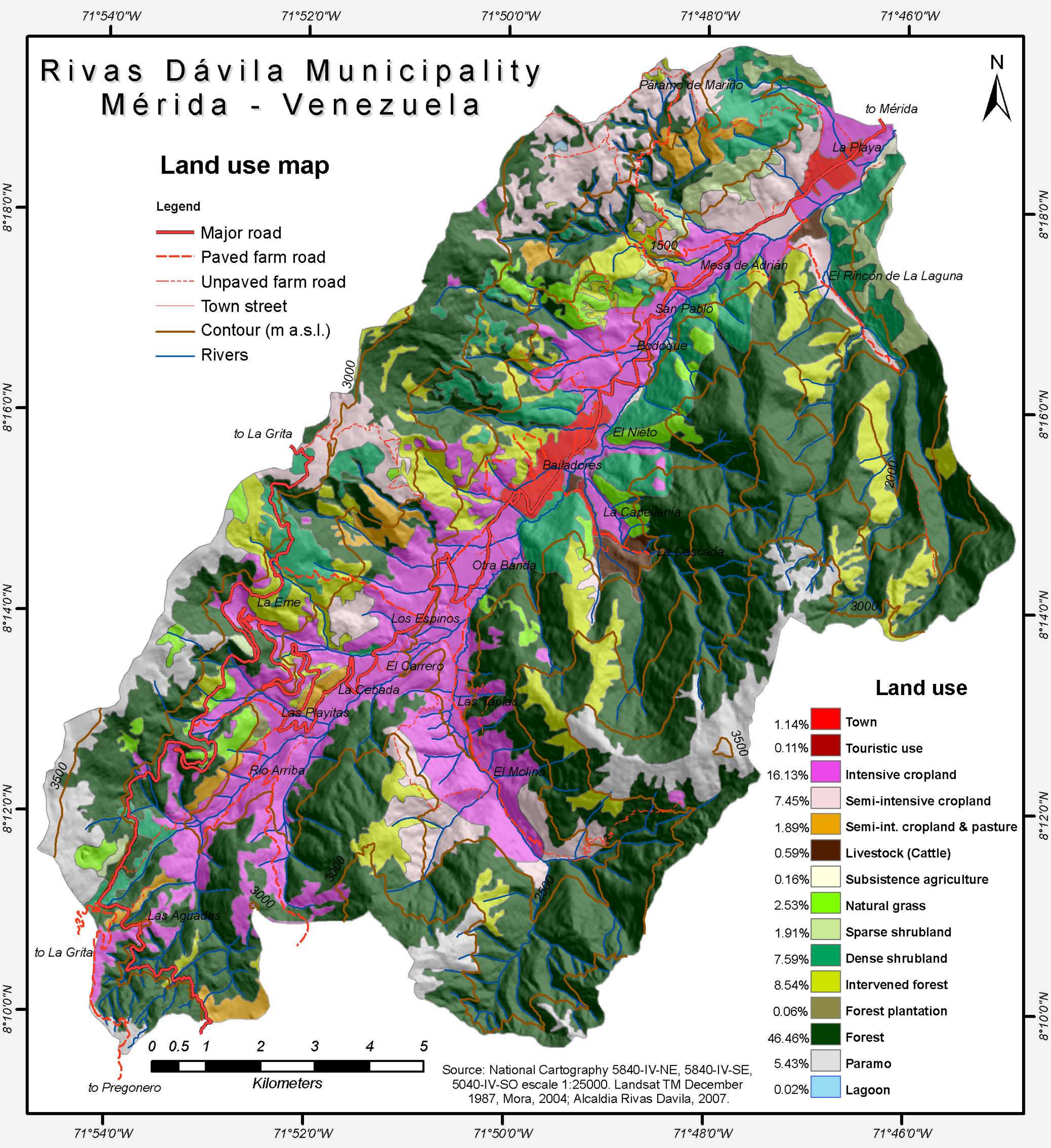
Rivas Dávila is a valley of ancient anthropogenic occupation even before the colonial period (Ramírez y Pérez, 1985). Most of the valley-bottoms, of lower slope gradient and located near to the streams have been traditionally used by agricultural activities and towns. The agriculture, however, had an important impulse during 1960s and 1970s when the traditional farming of corn, wheat and sugar cane were replaced by carrot, cabbage, beetroot and scallion, among other crops. Cattle breeding and the traditional crops of potatoes were also intensified. At the same time, the irrigation systems were improved and an intensive use of pesticides and synthetic fertilizers was also adopted (Sandia et al., 2001). Thus, Rivas Dávila increased not only the diversity and quantity of farm products but also the land extensions and consequently the environmental impacts.

Nowadays Rivas Dávila is one of the most important horticultural zones of the Mérida state, especially due to products such as cabbage, scallion, celery, lettuces, leek and potatoes. Other important agriculture activities are integrated by traditional an intensive cattle and flower crops, which have been more recently introduced. In 2003, agriculture products reached 47,314 t. (Alcaldía Rivas Dávila, 2007). This amount represents an increase of 27.3%, with respect to the average production of the period 1994-1998, which was of 34,414 t (Sandia et al., 2001).

From an environmental point of view, the intensive use of the land has significantly deteriorated the quality of natural resources, due to the reduction of the natural areas, intervention of the high watershed, increasing soil erosion, and pollution of water bodies and reduction of their stream flows (CORPOANDES, 1995; Sandia, 1995; Mora, 2004; Alcaldía Rivas Dávila, 2007). Also, the intensive use of pesticides has had negative effects on the environmental quality affecting the health of the people (Sandia, 1995; López, 1996).

According to the map of land use elaborated in this research by means of the use of Landsat TM, aerial images and field work (Map. 3.9), the principal land cover of the area is represented by forest (47%) and intensive cropland (16%). Other types of natural vegetation take up 26% of the land while other agricultural uses occupy 10% of the municipal surface. Towns and tourist activities cover only 1% of the area.

The predominant permanency of the natural forest on the west-exposed slope (shady slope) of the valley can be related to its geographical condition, which allows the development of dense vegetation such as the cloud forest and characterized by several restrictions such as very inclined relief and difficult accessibility. Additionally, the importance of the agricultural activities of the valley can be valuated by means of this map. The agriculture occupies almost the whole valley bottom and progressively intervenes in natural areas with very steep slopes or head watersheds, which represents a serious threat to environmental stability.



Source: National Cartography 5840-IV-NE, 5840-IV-SE, 5040-IV-SO escale 1:25000. Landsat TM December 1987, Mora, 2004; Alcaldía Rivas Davila, 2007.

Map 3.9: Land use map.

The spatial distribution of the population, villages and towns also responds to the geographical characteristics, which favour the human settlements in the valley-bottoms. According to the population census Rivas Dávila municipality had about 16,000 inhabitants in 2001 with a projection of population for 2008 of 18,500 inhabitants (Alcaldía Rivas Dávila, 2007; INE, 2008;). The most important town is Bailadores, the capital, which together with other nearby communities has a concentration of about 7000 inhabitants. La Playa in the north of Rivas Dávila is the second town, according to its population and infrastructure. However, about 50% of the population lives in several sparse villages located along the valley bottom close to the principal road, but also in several lateral valleys such as Las Tapias, La Capellanía, Nieto, San Pablo and Rincón de La Laguna. It is important to appoint that due to the high aesthetic value of the landscape, tourist activities of regional importance have been developed in the area, which represent an important alternative of sustainable development in the area (Figure 3.4).

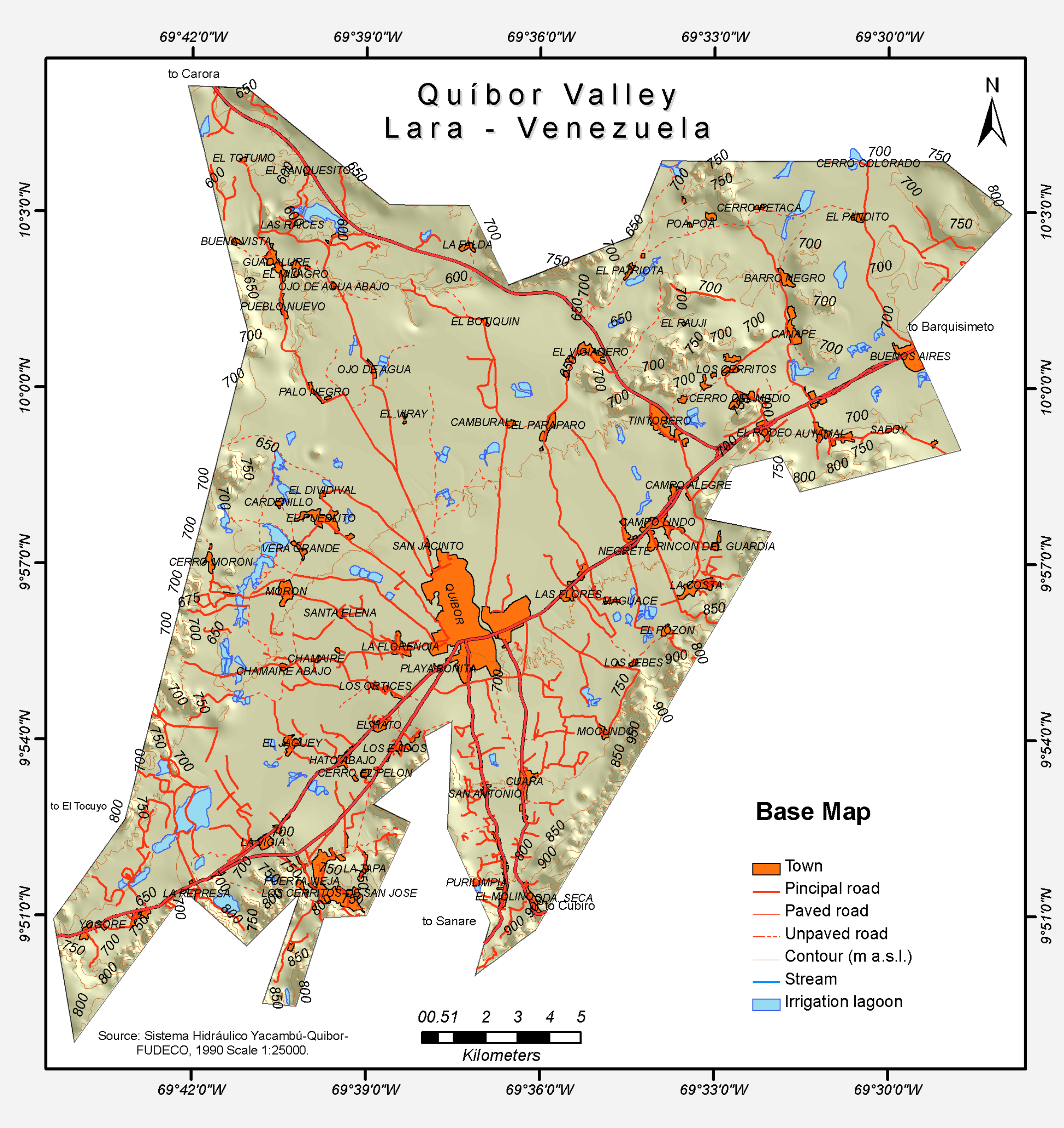
La Cebada sector (October, 2007)

Natural Park
La Cascada (October, 2007)

Figure 3.4: Croplands and tourist park.

3.3 Quíbor Valley

The Quíbor Valley is located in the Jiménez municipality of the Lara state, Venezuela, between 9°48’50 to 10°05’08” north latitude and 69°27’53” and 69°44’22” west longitude (Figure 3.10). The valley belongs to the Tocuyo River watershed, which drains into the Caribbean Sea. Integrated by a surface of 43,395 ha, in 1982 this area was delimitated and designated by the Venezuelan Government as an *“Area of Agricultural Use of Quíbor Valley”*.



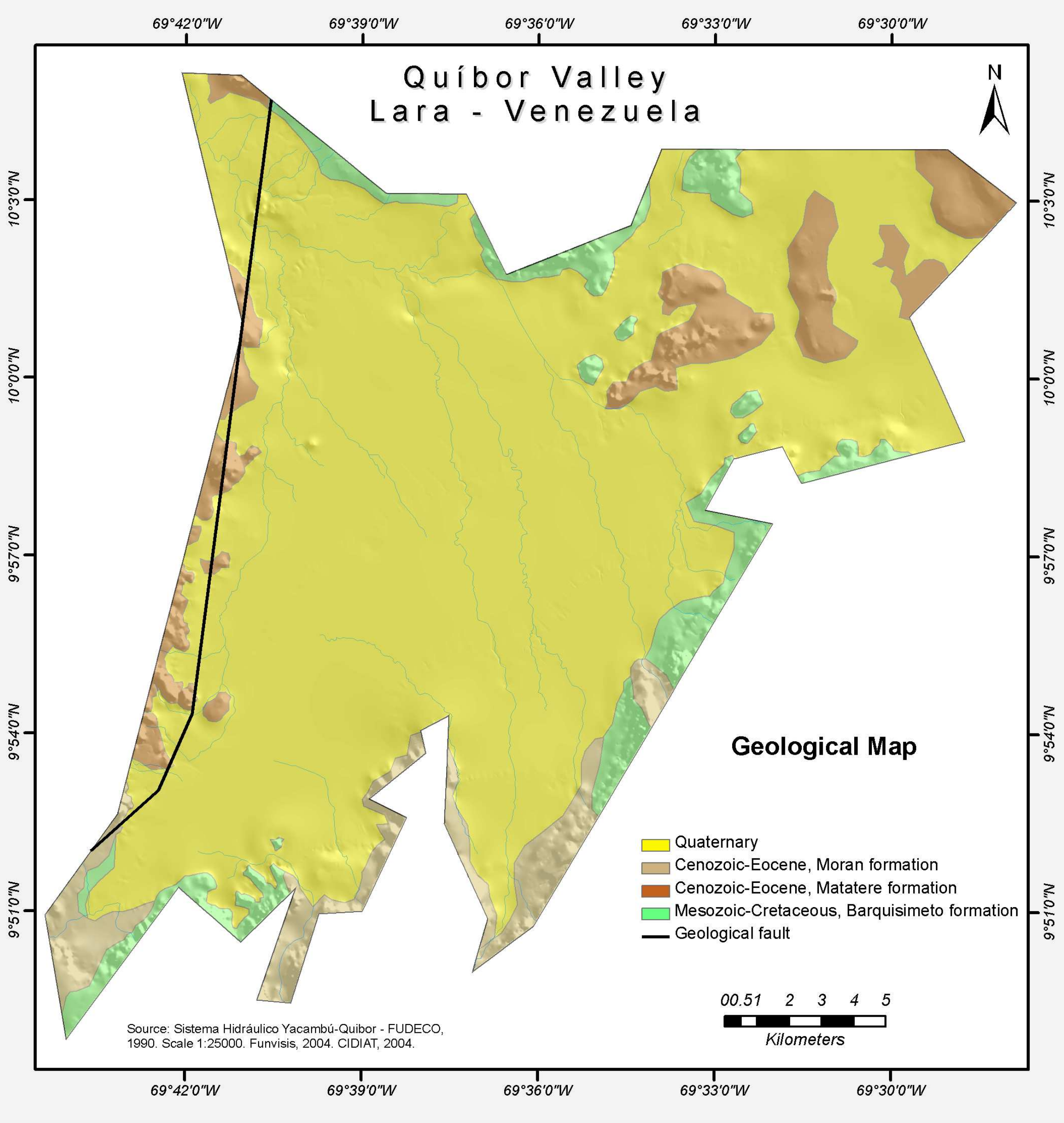
Source: Sistema Hidráulico Yacambú-Quibor-FUDECO, 1990 Scale 1:25000.

Map 3.10: Quíbor Valley, base map.

The Venezuelan legislation establishes that an area officially designated as “*Agricultural Use*” is a surface with high ecological and socio-economical potentialities for agricultural uses, which should be preserved to carry out these activities, avoiding and controlling any other use that could affect agriculture being the principal economic activity (Venezuela, 1983).

3.3.1 Geology

Three geological formations outcrop in the hills around the valley (Map 11). The valley bottom is covered by Quaternary deposits.



Source: Sistema Hidráulico Yacambú-Quibor - FUDECO, 1990. Scale 1:25000. Funvisis, 2004. CIDIAT, 2004.

Map 3.11: Geological map.

The Barquisimeto formation (Cretaceous) outcrops in several hills around the valley. It is composed of limestone, lutites and marlstone with a low grade of metamorphism and great deformation by folds (CIDIAT, 2004; PDVSA, 2008). The Matatere formation, present in the south of the area, is composed of a thick sequence of sandstones and lutites. Blocks of limestone, belonging to the Barquisimeto formation, can be found in this bedrock. This formation presents a high level of deformation by folds due to its contact with the Barquisimeto and Moran formation (Cidiat, 2004). The Moran formation, which outcrops in the south of the area, is integrated by white sandstones with a high content of quartz.

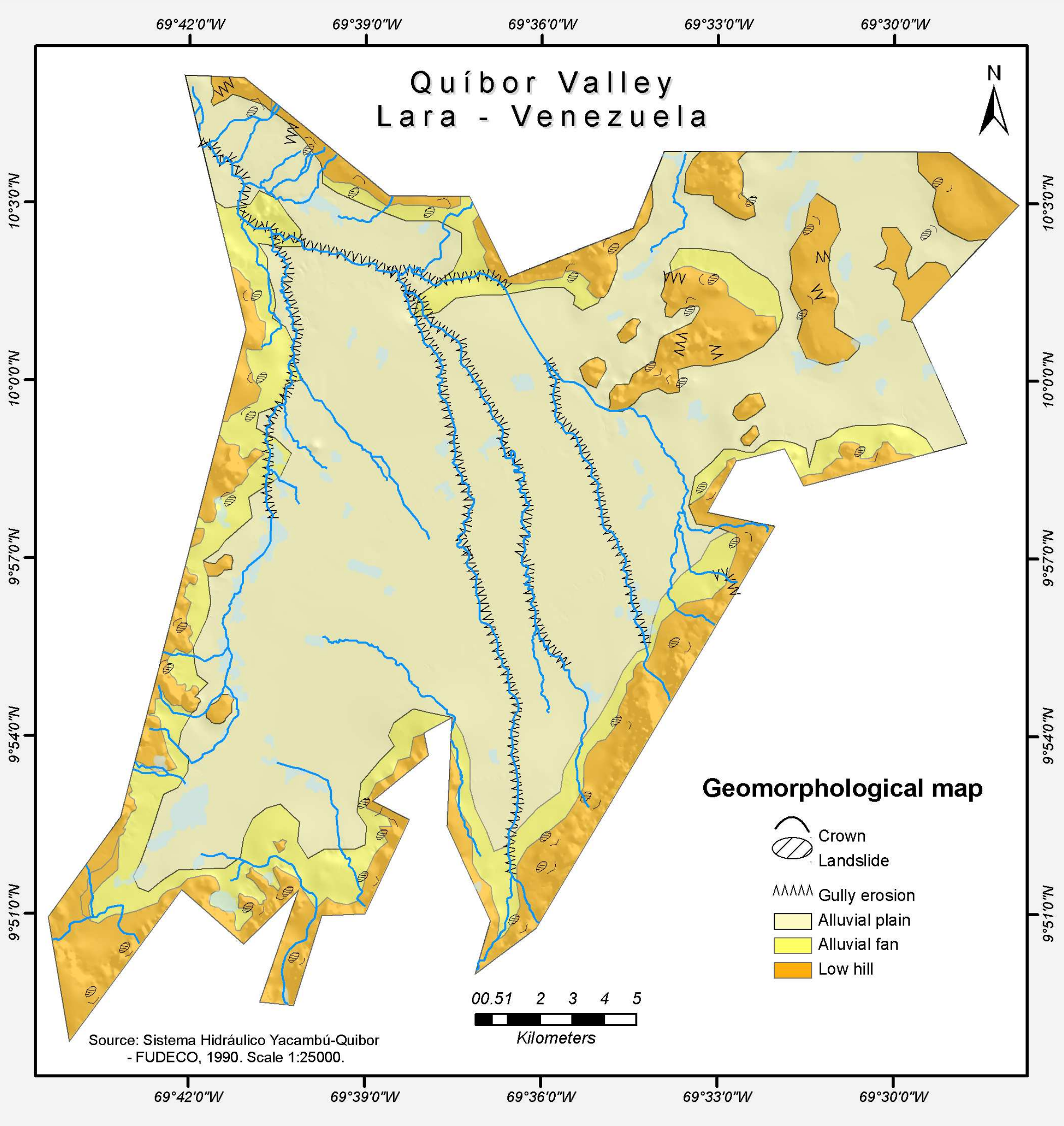
These formations underlie the Quaternary deposits of the valley bottom where also the Quíbor aquifer is located, favoured by the permeability of Quaternary deposits and the bedrock of the Moran formation. This aquifer has been subject to over-exploitation in most recent decades, which has finally led to a lowering of the water table, and salt-water intrusion (UNDP, 2005).

CIDIAT (2004) observed also complex contacts among the three geological formations. Thus, in some zones the Barquisimeto formation (Cretaceous) is above the Matatere formation (Cenozoic-Eocene) and these two are above the Morán formation (Cenozoic-Eocene).

Within the limits of the study area only one geological fault has been identified, however, it is recognized that the area is located in the influence area of the Boconó fault systems. Specific evidence of the Tocuyo fault has been found in the bedrocks of the southwest of the area as well in the northeast. It is most likely that this fault underlies the Quaternary deposits in the centre of the valley (CIDIAT, 2004; PDVSA, 2008). The high grade of seismicity of the area has been broadly recorded throughout the last few centuries by means of large earthquakes that occurred in the area (Escobar and Rengifo, 2001; Palme and Altez, 2002; Choy et al., 2003).

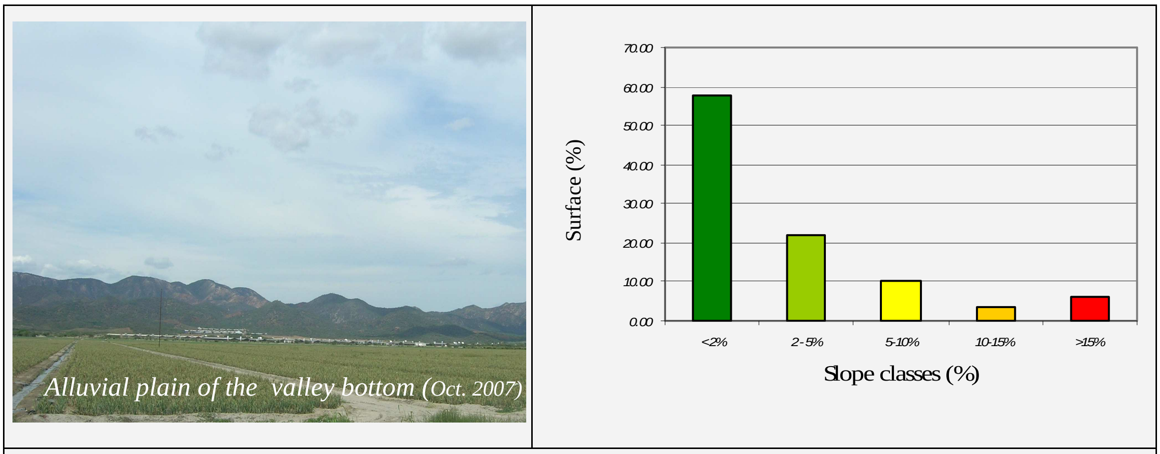
3.3.2 Relief and Geomorphology

The area is characterized by a broad valley surrounded by low hills whose altitude varies between 512 m a.s.l. and 1020 m a.s.l. Almost 80% of the area, with inclination less than 5%, is composed of alluvial plains. The remains 20% of the area is composed of gently undulating hills and alluvial fans (Map 3.12 and 5.30; Figure 3.5).



Source: Sistema Hidráulico Yacambú-Quibor - FUDECO, 1990. Scale 1:25000.

Map 3.12: Geomorphological map.



Alluvial plain of the valley bottom (Oct. 2007)

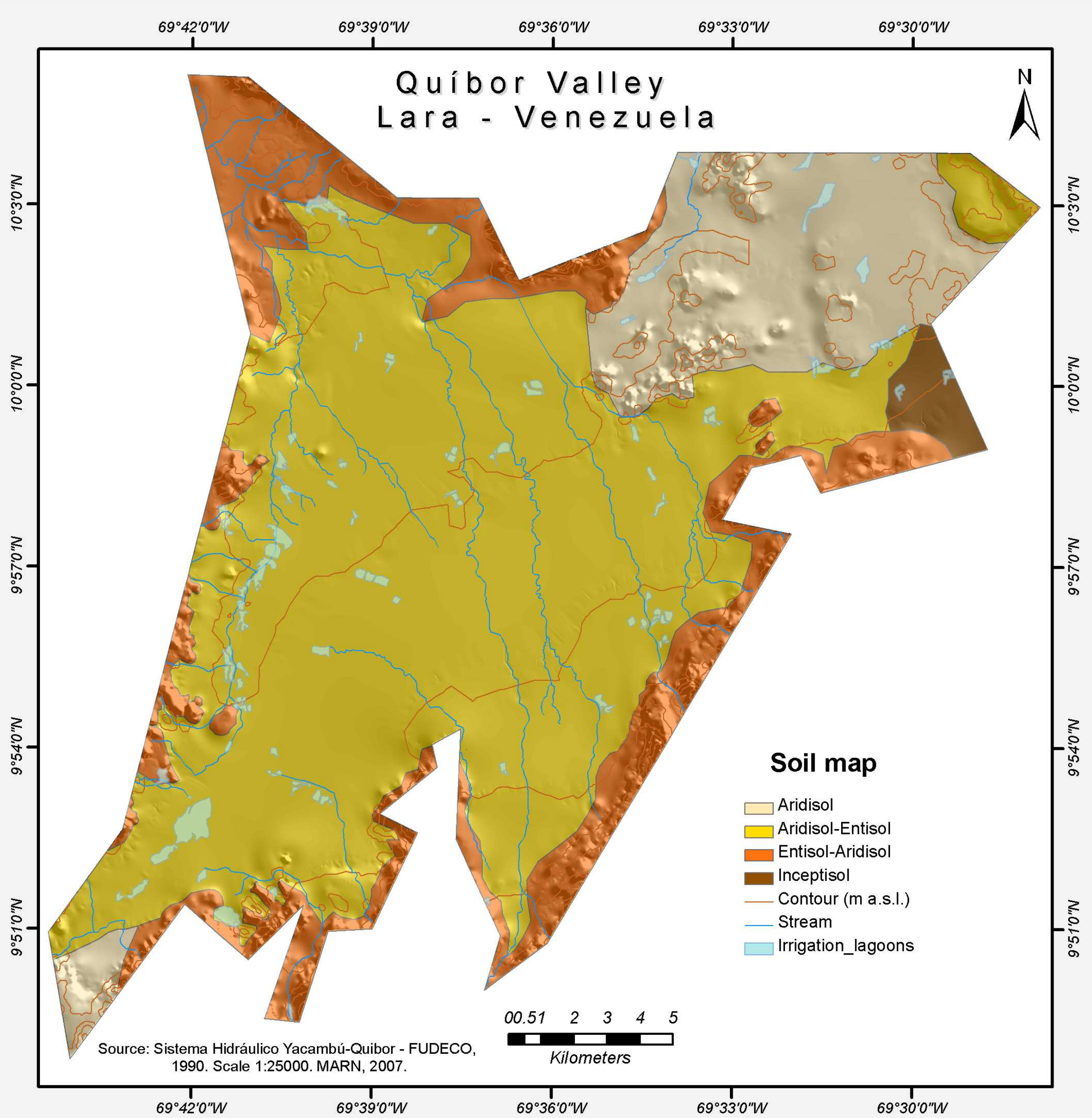
Figure 3.5: Relief characteristics.

The Quaternary sediments are composed of clay and silt with insertions of sand, gravel and larger rocks. Clay and silt predominate in the superficial layers while the thickness of the sediments increases with the depth of the deposit, and reach up to 200-230 m in the center of the depression (CIDIAT, 2004; Ecology and Environment, 2004).

Active morphodynamics are dominated by erosional processes. In the hill slopes these processes can result in gully erosion. The valley bottom is highly affected by splash erosion due to its conditions of high anthropogenic intervention; sparse density of vegetation; and soil of low permeability, fine texture and poor structure. Sheet and gully erosion are also frequent in those bare areas without vegetation cover, most classified as abandoned land (Ecology and Environment, 2004; UNDP, 2006). In some areas of the north the erosion has even generated badlands. Mass movements are relatively important in hilly areas where, as a result of storms and sparse vegetation cover, landslides of low intensity occur.

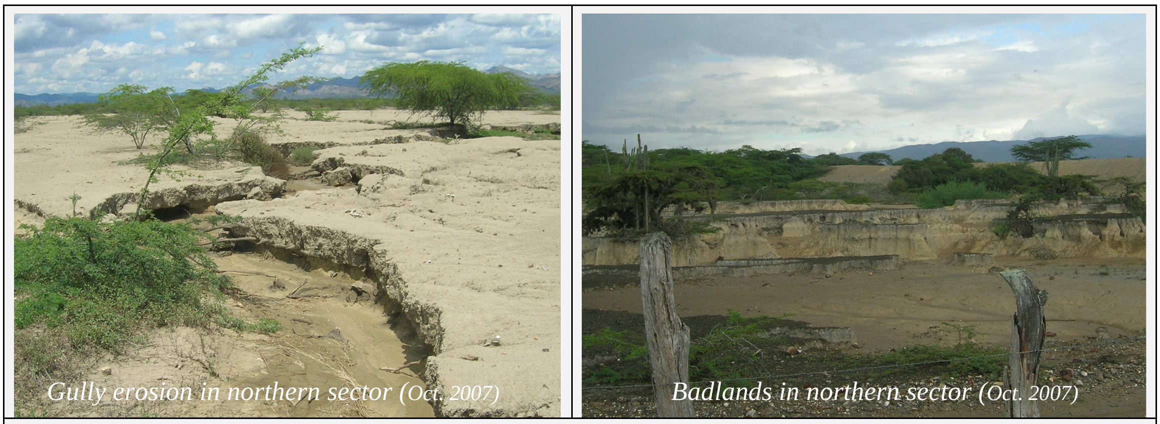
3.3.3 Soils

The soils of the area are characterized by a low pedogenesis and poor contents of organic matter. Most soils in the area are classified as aridisols; entisols and inceptisol have been described for the north of the valley (Map 3.13). The soil texture varies between clay and sandy loam. Most soils present a silt fraction higher than 50%. In general, soils are of low permeability, low structural stability and has high susceptibility to erosion (Villafañe et al., 1999). Moreover, due to the semiarid conditions of the valley, the limited drainage as well as the use of groundwater with high salt content, the soils results in being highly susceptible to salinity (Pla, 1985; Villafañe, 1999; Rázuri et al., 2005; UNDP, 2006). The dominant canal irrigation, instead of drip irrigation, represents an inefficient water use which also increases the problems of salinity (UNDP, 2006). Soil erosion and salinity should be controlled in order to preserve resources and to maintain the agricultural development (Figure 3.6).



Source: Sistema Hidráulico Yacambú-Quibor - FUDECO, 1990. Scale 1:25000. MARN, 2007.

Map 3.13: Soil map.



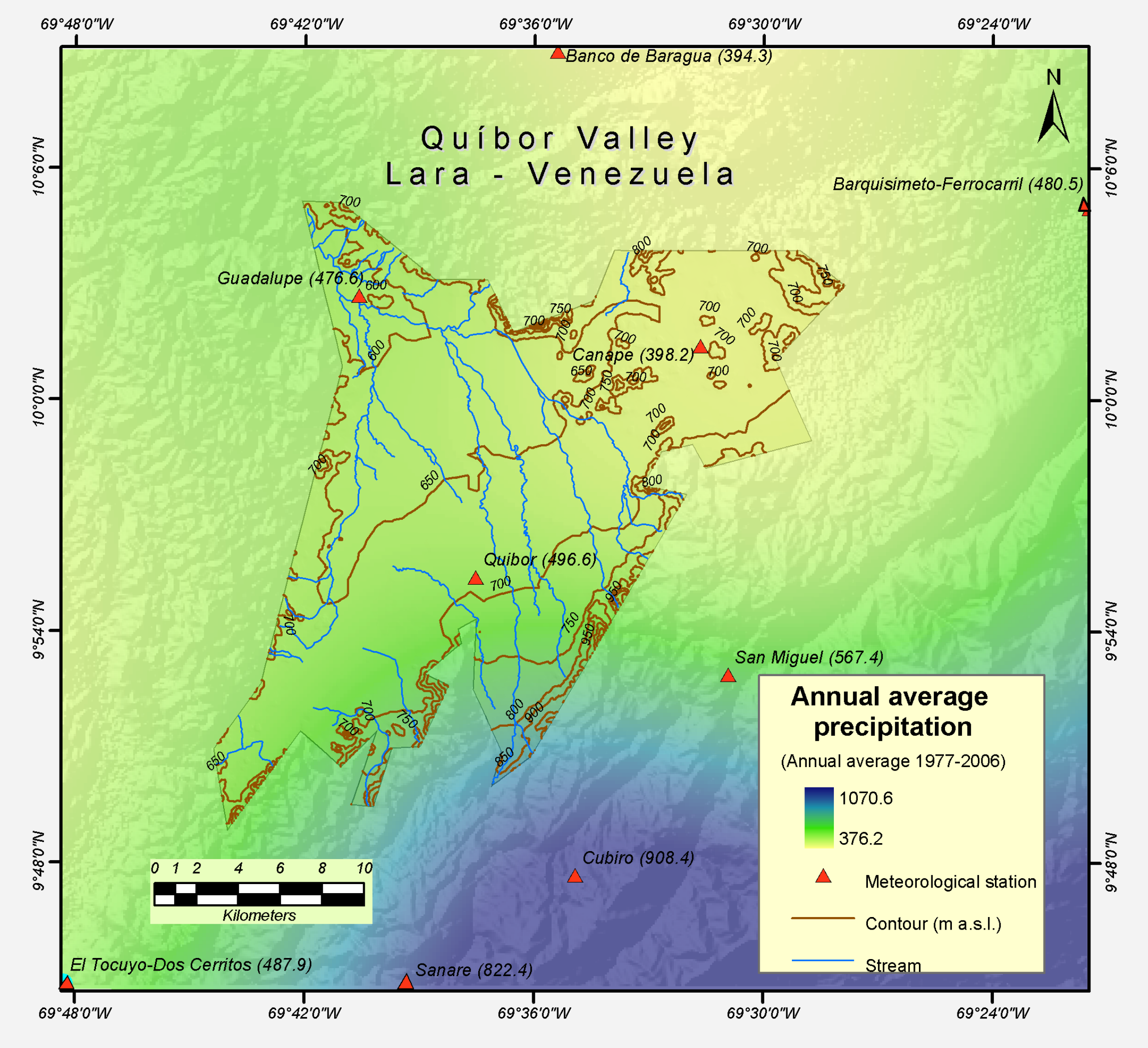
Gully erosion in northern sector (Oct. 2007)

Badlands in northern sector (Oct. 2007)

Figure 3.6: Severe erosion processes.

3.3.4 Climate

For the study area climate data of nine meteorological stations are available for the period 1977-2006. All of them have records of monthly precipitation and four of them monthly average temperature. Quíbor station has even evaporation data. The Quíbor Valley is located in a semiarid to sub-humid region where the average annual precipitation varies between 400 mm in the northwest, and 700 mm in the southeast. Annual average precipitation higher than 600 mm occurs only in a small sector of the southeast. The average annual temperature varies between 25.5°C in the lowest sector in the north and 22.8 °C in the hills of the southeast. The Quíbor climate station registers an annual average temperature of 25.4°C. The difference between January, the coldest month (24.3°C), and September the warmest (26.1°C), indicates the isothermal condition of the climate (Map 3.14; Figure 3.7).



Map 3.14: Annual average precipitation, period 1977-2006.

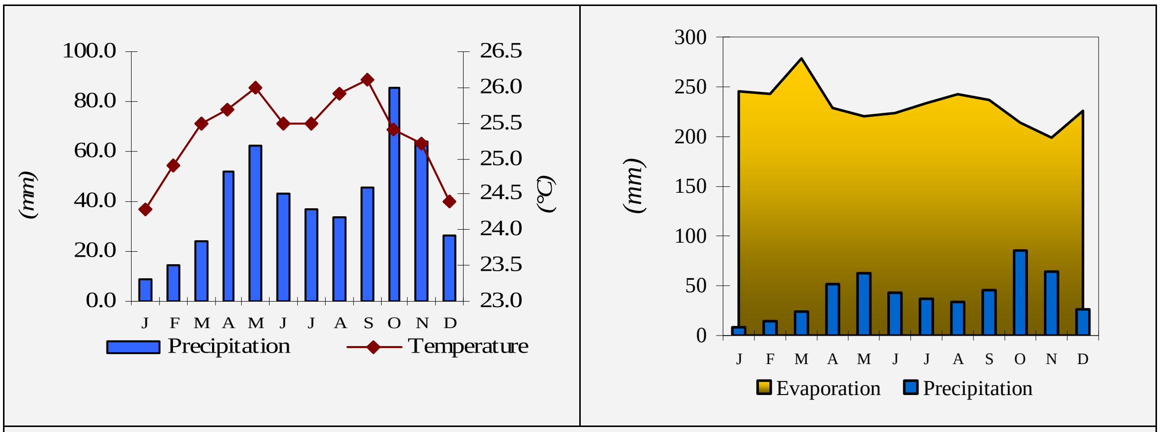


Figure 3.7: Precipitation, temperature and evaporation of Quíbor station (1977-2006).

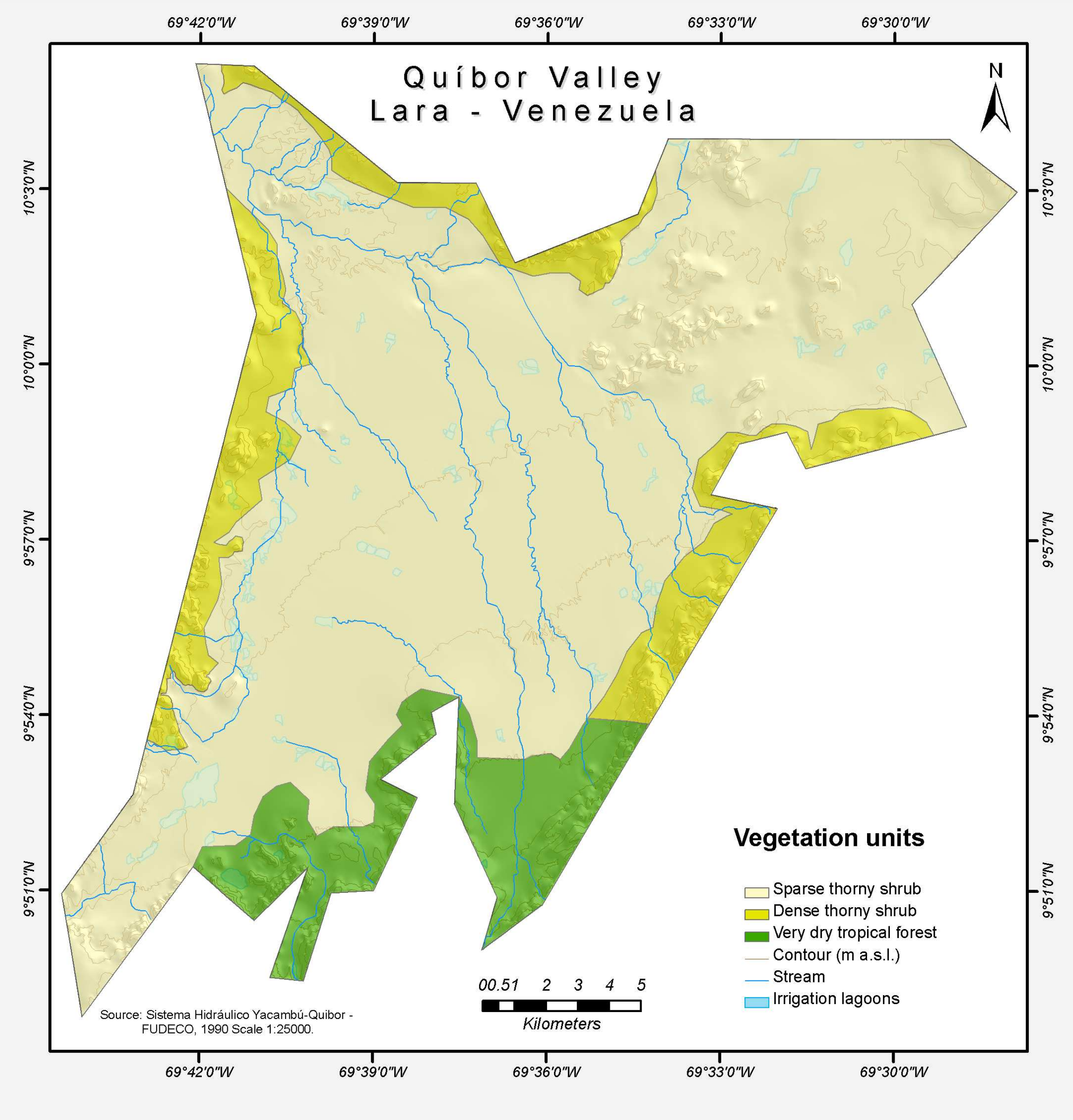
As Figure 3.9 indicates, the arid condition of the valley is characterized by a high evaporation rate, whose monthly average is always higher than the monthly average precipitation. This then determines a high soil moisture deficit, which limits the vegetation development and represents one of the local restrictions for the agriculture activity.

Although rainfall-intensity data are not available, the rainfall erosivity can be pointed out as important in the area due to the occurrence of larger and short-term rainfalls (Ecology and Environment, 2004).

3.3.5 Vegetation

The natural vegetation of Quíbor has been severely intervened, especially in the alluvial plains where agriculture activities have been traditionally developed. Thus, the vegetation cover in most parts of the area corresponds to secondary successions. According to the ecological conditions, three types of vegetation units can be recognized: sparse thorny shrub, dense thorny shrub and very dry tropical forest (Map 3.15).

The thorny shrub corresponds to xerophytic vegetation including grass, shrubs, trees of low height and cactus. In the less intervened hills dense cover of this xerophytic vegetation can be found. The higher trees and some cactus can reach heights up to 8 m (Renfagro, 1994; Cuello, 1999; Ecology and Environment, 2004). In the southwest of the valley a very dry vegetal forest can be found (Figure 3.8).



Map 3.15: Vegetation units.

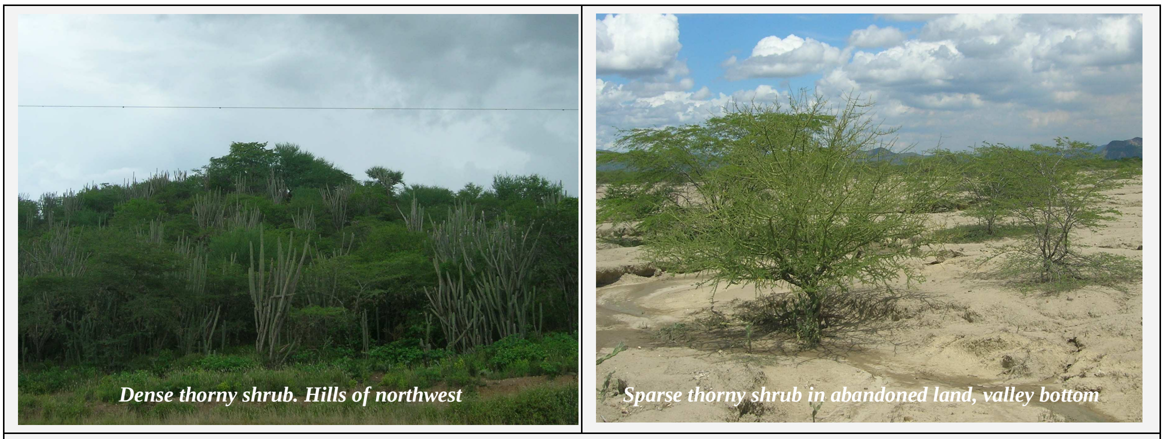


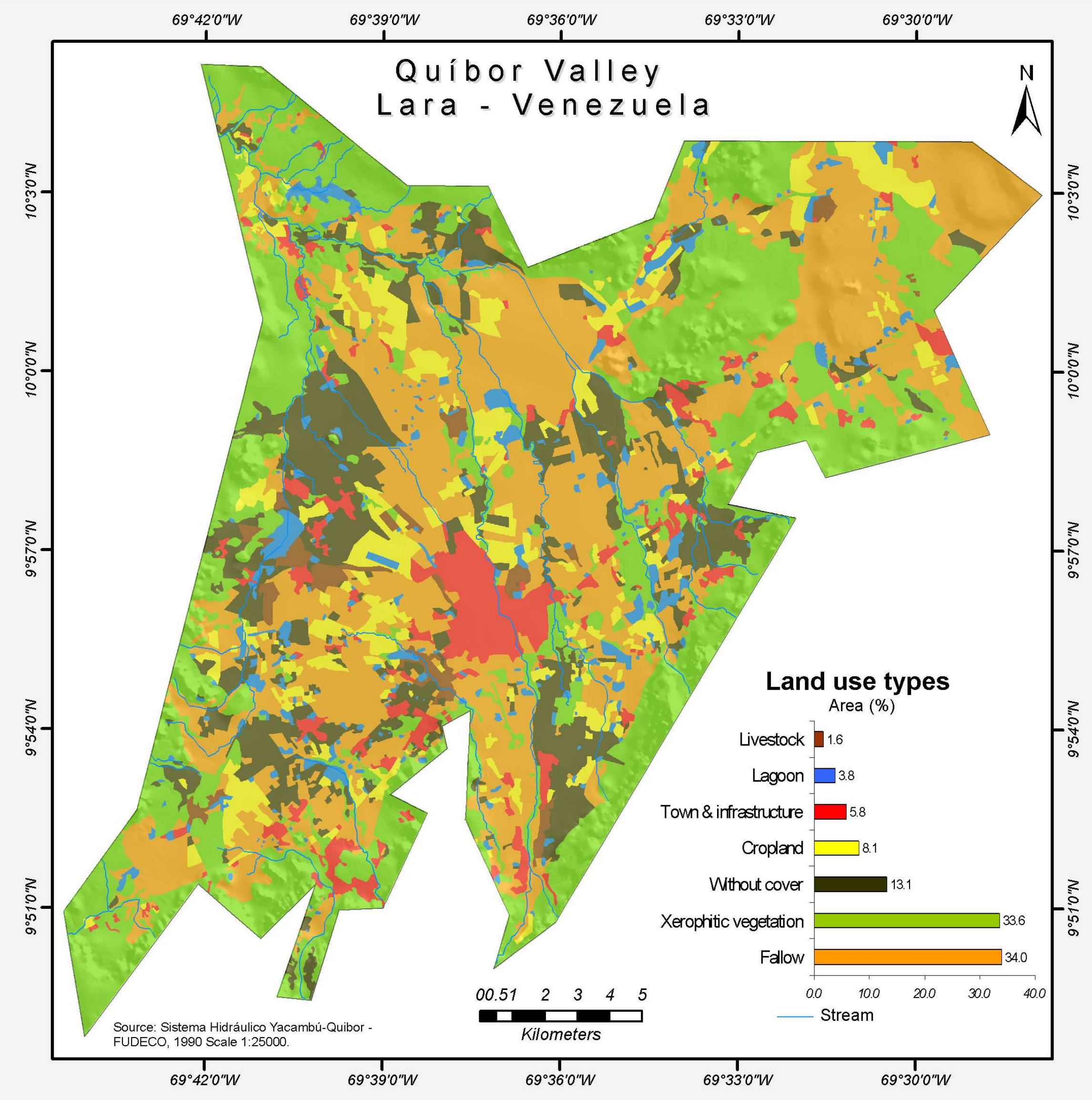
Figure 3.8: Vegetation cover.

Within the study area the wood species of the original forest are very scarce because they have been intensively disturbed for several uses, especially for woodcraft activities. This traditional activity is still very important, especially in the northwest, around the Guadalupe town. Nowadays the trees used as raw material, such as vera (*Bulnesia arborea*), roble (*Platymiscium polystachum*) and miguelito (*Vallea stipularis*), among others, are provided by original forests located in neighboring zones (Delgado, 2002).

3.3.6 Land-use

Quíbor Valley is an area of ancient anthropogenic interventions, as it was inhabited by Aboriginal communities since as early as fifth century B.C. (Arvelo, 2000). The incipient farming, carried out by the Aborigines, was intensified in the colonial period when crops like wheat, barley, cotton, onion, among others, as well as cattle breeding and goats, were introduced (FUDECO, 1972; SHYQ, 1998; Arvelo, 2000). The beginning of the groundwater exploitation during the 1950s contributed to the impulse of the agriculture. Moreover, from the 1970s this activity was diversified by means of the cultivation of vegetables and grazing. During the last few decades the agriculture of Quíbor Valley has been significantly increased so that it has reached a level of national importance, due to the high level of production of onion, paprika and tomatoe (Fudeco, 1997; SHYQ, 1998; Sandia et al., 2001).

In accordance with studies carried out in the area such as SHYQ (1998), Lavalin (2003) and Florentino (2005), and taking into account the information obtained during the fieldwork, a map of land-use was constructed (Map 3.16). By means of this map the anthropogenic intervention grade and the importance of the agricultural activities can be evaluated. Thus, a third part of the area is covered by the typical xerophitic vegetation; most of this moderately or highly intervened. Although, some plain sectors of the northeast have this natural vegetation, it is mainly restricted to the hills due to the intensive agriculture of the valley bottom. The agricultural uses take up about the half of the area. These are integrated by fallow land (34%), cropland (8%), livestock (1.6%), and even the lagoons built for irrigation (3.8%). 13% of the area are lands without vegetation or any productive use. Most are affected by erosive processes of moderate and severe magnitude (Lavalin, 2003). Towns and other infrastructure cover only 6% of the valley.



Source: Sistema Hidráulico Yacambú-Quibor - FUDECO, 1990 Scale 1:25000.

Map 3.16: Land use map.

In spite of the large surface occupied by agriculture, annually the fallow field is about 3,500 ha (Juana, 2006). This is a result of the crop rotation and the limited availability of water for irrigation. The agriculture in the area has been developed by means of control and storage of the scarce surface water, the intensive use of groundwater and, in lower importance, use of sewage. Canal irrigation is the most applied system, but in a few cases drip irrigation is also applied. It is recognized in the area that the excessive exploitation of the aquifer threatens its permanence and potential use (SHYQ, 1994; Dugarte, 2001; Garduño and Nanni, 2003; Colombo and Medina; 2005).

In the study area the onion crop covers about 2,100 ha, which represents 33% of the 6,300 ha cultivated at national level (Lavalin, 2003; Agrevo, 2008). However, due to the high productivity of this crops in the area, about of 26.5 t/ha (Agrevo, 2008) the valley contributes with 40% of national onion production. Paprika, tomatoes and sugar cane are also important crops. With less importance also crops such as scallion, chard, lettuce, cucumber, fruits and corn are cropped. Additionally, different types of livestock such as cattle, poultry, pigs, sheep and goats are very common in the Quíbor Valley. During the last few decades the breeding of cattle, poultry and even pigs have been technically improved. Breeding of sheep and goats still remain as traditional activities carried out by small farmers (Renfagro, 1994; Lavalin, 2005) (Figure 3.9).

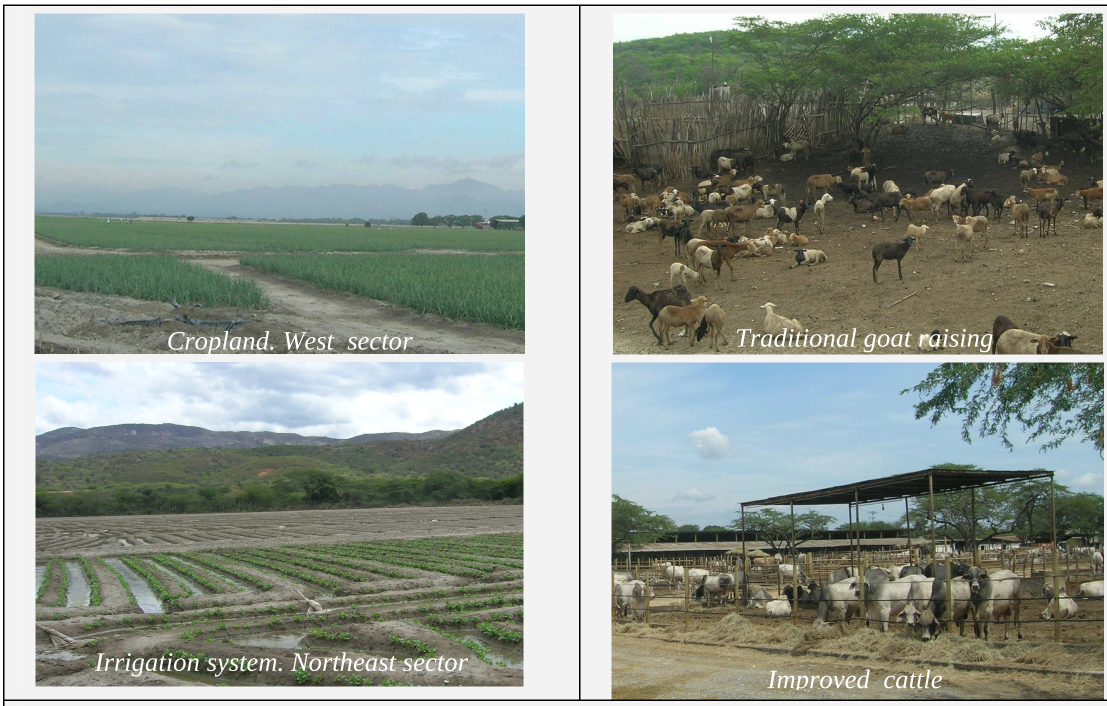


Figure 3.9: Quíbor Valley, agricultural activities.

The population of the Quíbor Valley totals about 85,000 most of whom reside in Quíbor, the municipal capital (INE, 2008). Also, many little towns and villages are located around the agricultural areas. Quíbor, and some other towns like Guadalupe and Tintorero have national notoriety due to the handicrafts which are traditionally practised there, such as woodcraft, ceramic, woven and rock carving (Figure 3.10)

In spite of the importance of agriculture, as well as the diversity of economical activities some socioeconomic problems affect most of the people. Thus, high poverty levels of the people and a lack of public services have been indicated by several studies (Cabeza et al., 1994; SHYQ, 1998; Sandia et al., 2001).

Figure 3.10: Towns and typical handicraft of Quíbor Valley.

3.3.7 The project “Hydraulic System Yacambú-Quíbor”

In order to support and strengthen the agricultural capacities of the Quíbor Valley, in 1973 the National Government started a hydraulic project addressed at supplying the requirements of water for agricultural uses in the Quíbor Valley. The project also increases the availability of drinking water in the region. In spite of its importance and the large quantity of invested economical resources, the project has not been concluded.

The Hydraulic System Yacambú-Quíbor project (Figures 3.11) is integrated by four main components: 1) Construction of a dam of height 162 m in the watershed of Yacambú River, which belong the Orinoco River Basin; the dam is totally concluded. 2) Creation of a reservoir in which the required water by the project will be stored. This stage is still not finished. 3) Construction of a 24.5 km tunnel which will transport the water from the reservoir to the Quíbor Valley. The tunnel was finished in 2008. 4) Construction of the irrigation system in the Quíbor Valley in order to increase the irrigated land and enhance the agricultural production; this stage is still in the planning phase. However, official information indicates that the project will be put into operation in 2010 (MINCI, 2008; SHYQ, 2008).

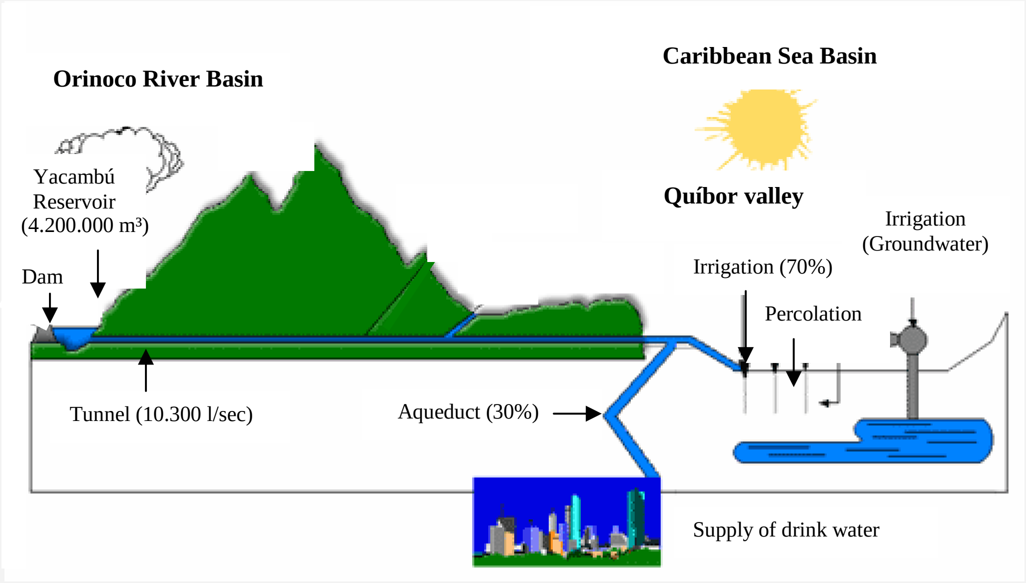


Figure 3.11: Hydraulic System Yacambú Quíbor.

Source: SHYQ, 2008

The main objective of the project is to increase the current annual irrigated surface from 3,500 ha to 26,000 ha (Juana, 2006; SHYQ, 2008), which will be a significant impulse to the agricultural production. In this sense, it is expected that with the intensification of agricultural activities without the necessary environmental measures the impacts on the already altered natural resources would be increased. By means of this research basic guidelines for sustainable land-use of the valley will be generated. It is expected that the result of this work will contribute to the sustainability of the future agricultural development of the area.