ENVIRONMENTAL IMPACT STUDY FOR THE RUMICHACA - PASTO DUAL CARRIAGEWAY ROAD PROJECT, PEDREGAL – CATAMBUCO SPAN, UF. 4 Y UF. 5.1, CONCESSION CONTRACT UNDER SCHEME APP NO. 15 OF 2015

Géminis Consultores Ambientales

CHAPTER 6. Environmental Zoning

San Juan de Pasto, March 2017

TABLE OF CONTENTS

INDEX OF TABLES

No table of figures entries found.

INDEX OF FIGURES

No table of figures entries found.

6. ENVIRONMENTAL ZONING

Based on the environmental characterization of the area of influence, the environmental zoning of the Rumichaca - Pasto dual carriageway road project , Pedregal – Catambuco span, aims to identify areas that, according to sets of abiotic, biotic and socio-economic parameters, reflect relatively homogeneous degrees of potentiality or fragility within a given but dissimilar area. Zoning seeks to delimit and typify areas of homogeneous characteristics, interpriting them in terms of environmental sensitivity of the area, without the project, without them losing their interrelationships with the set of scenario activities; the aforesaid in accordance with what requirements in the terms of reference for Environmental Impact Studies for Road and/or Tunnel Construction Projects, stipulated by the MADS in Resolution 751 of 2015.

Environmental zoning involves considerations framed within a set of potential parameters that reflect the prevailing conditions in the region in each dimension; whose comprehensive analysis is done by setting a relative rating system so that the expressions between parameters are comparable.

Thus, according to the environmental characterization of the area of influence of the project and current legislation, the abiotic, biotic and socio-economic environment was analyzed for the environmental zoning.

6.1. Methodology

To establish the environmental zoning of the project, the methodology proposed by the Ministry of Environment and Sustainable Development, by resolution 0751 of 26 March 2015 was used, which suggests some variables to be taken into account, such as:

- Areas of special environmental significance such as natural areas, sensitive ecosystems, riparian forests, biological corridors, presence of areas with endangered or critically endangered endemic species.
- Environmental recovery areas such as eroded areas, conflict over land use or contaminated.

- Economic production areas such as livestock, agricultural, mining, among others.
- Areas of social importance such as settlements, physical and social infrastructure and of historical and cultural importance.

Based on project description and characterization of the current development environment, the physical, biotic and socio-economic variables were defined d in order to establish environmental sensitivity areas, where they are found; from the physical standpoint those environmental recovery areas, which includes geology, geomorphology, slope and land use conflicto are considered. From the biotic standpoint and based on the forest cover analysis, the special environmental significance areas among which the sensitive areas, vegetation cover and fragmentation were defined.

Finally, from a socio-economic standpoint, according to the characteristics analysis of each territorial unit crossed by the project, sensitive areas were defined given the importance to the community, whether from the point of view of infrastructure, population centers, population density and archeological potential.

The following sequence was established for the project's environmental zoning:

- Obtaining primary information for the project's area of influence where information was collected from themedia abiotic, biotic and socio-economic environment, in addition to considering the infrastructure on a 1:25.000 scale .
- Qualitative and quantitative assessment of the units of each topic according to their importance and environmental sensitivity. The environmental sensitivity qualification was divided into three categories:

  - Low (B)
  - Medium (M)
  - High (A)

  Only these three variables were defined due to constraints in territory homogeneity, in its physical and biotic factors, which will be explained later.

Likewise, in the subsequent environmental management zoning process, according to Resolution 751 of 2015, this should be classified in the intervention area with high, medium, or low restriction, with variations in the high and low, according to the project's interaction with the environment, with intervention or restriction values; and for this process the main input is this zoning, so methodologically the same imput is required to achieve these output values, reason why the only the following points are considered.

- Overlap of thematic information per component.

- Obtain intermediate products corresponding to the zoning by component: abiotic, biotic and socio-economic; which will integrate the information from the environmental sensitivity to the thematic units.

- Intermediate zoning overlay to obtain the final environmental zoning.

Figure 6.1 shows the defined methodological scheme for the environmental zoning of the Rumichaca – Pasto dual carriageway project, Pedregal – Catambuco span.

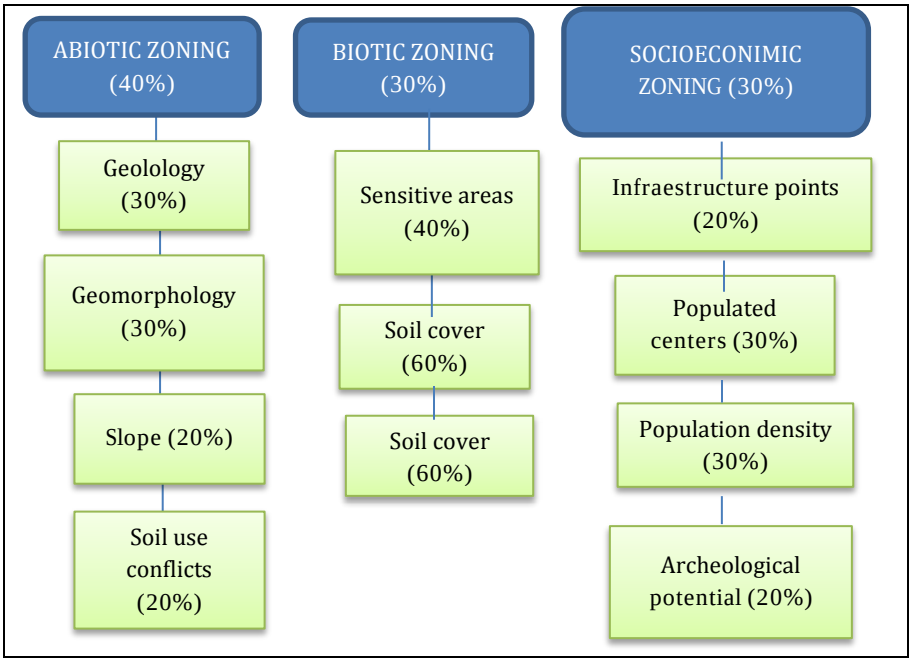

Figure 6.1 Evaluation and weighting scheme of the different zoning to obtain total environmental zoning

Source: (Géminis Consultores Ambientales, 2016)

6.1.1 Selection and relative qualification of the expression of the parameters

- Control system (SC)

This refers to the standards, legislation and spatial figures that involve some type of restriction on the use of components of the natural support system. The area of influence of the Rumichaca - Pasto dual carriageway road project, Pedregal – Catambuco span, corresponds to regional or municipal protected areas, to decrees or other legal rules that, in particular, restrictict and effect water courses and protection areas thereofand restrictive measures on land uses established in the EOT in the municipalities of Imues, Yacuanquer and Pasto.

Protected Areas: in the area of influence of the road project there are no national, regional or local protected areas. Analized secondary information discards the presence of forest reserve areas of law 2 of 1959, areas of the National Protected Areas System, or

strategic ecosystems, sensitive and protected areas in the area of influence of the dual carriageway road project , Pedregal – Catambuco sector, which could be directly affected with construction of the dual carriageway.

The Tremactos Colombia tool is used for preliminary verification and overlap of the areas of influence of the road project with information from the National Natural Parks System, local protected areas system of the municipality, Galeras civil society reservation, National protective forest reserves and regional protected areas.

In this sense, and in order to validate obtained information, a resquest was made to the Ministry of the Environment and Sustainable Development-MADS, and the Colombian National Parks, as well as to the regional environmental authorities such as CORPONARIÑO, Municipal town hall of Pasto, and City hall of the Department, town halls of the municipalities of Tangua, Yacuanquer and Imues, for information regarding the existence or non-existence of protected areas or strategic ecosystems in the area of influence of the Rumichaca-Pasto dual carriageway road project, informing that the area of interest does NOT overlap with any category recognized by the environmental authorities in the "Sole national registry of protected areas (RUNAP), regulated by Decree 1076 of 2015, in its article 2.2.2.1.3.3 "Sole register of protected areas SINAP". See Annexs 5.2.1.5, 5.2.1.5-b, 5.2.1.5, 5.2.1.5-d and 5.2.1.5-e).

Regulations: as part of the environmental zoning exercise, the 30 meters riparian corridor established in Article 83 of Decree 2811 (18/12/1974) and fountainheads with 100 meters protection area as indicated in Article 3 of Decree 1449 (27/06/1977) were considered.

6.1.2 Abiotic Zoning

Sensitive areas were zoned from the abiotic point of view by identifying the most important parameters having an impact on the environment which received a grade and a weighted average for the final zoning. In this way, environmental recovery areas such as geology, geomorphology, slope, land use conflict were taken into account.

- Geology

For the geological component of the project, the environmental sensitivity for each the geologic unit was determined, classifying them for the total set of environmental zoning. Territorial geology homogeneity was found because the region as a whole has a volcanic origin, with a lower intervention level of the Guaitara River of some more recent alluvial deposits, so the sensitivity classification resulted in two levels, medium and high.

Table 6.1 Geological unit classification

Geological unit		***Zoning category***
Anthropic fill (Qant)	2	Medium
Lahars and pyroclasts (TQvlp)	2	Medium
Lava (TQvl)	2	Medium
Boiling avalanches and debris (TQva)	2	Medium
La Magdalena sedimentary volcanic set (TQsv)	3	High
Aluvial deposits (Qal)	3	High
Rain of ashes (Qvc)	3	High
Colluvial deposits (Qc)	3	High
Ash and pumice flows (TQvf)	3	High
Lava and ashes (TQvlc)	3	High

Source (Géminis Consultores Ambientales, 2016)

- Geomorphology

Based on landforms, their landscape environmental importance, and their influence on the environment, the sensitivity classification in the project area was determined. This component includes landforms and landscapes of volcanic origin, actively intervened by the river dynamics of the area, clearly marking a river landscape in the lower parts, with steep slopes in the river valley, and in the higher parts pyroclasts hills, preserving the volcanic landscapes. With this morphogenesis, the sensitivity classification, generates levels that are similar with differences in the degree of progress of the water networks on the volcanic landforms. As a result, three levels of sensitivity, high, medium and low were obtained and are shown below.

Tabla 6.2 Geomorphology classification

Landform		*Zoning category*
Anthropic bodies	1	Low
Rolling hills of pyroclastic deposits	1	Low
Colluvions	2	Medium
Hills with denuded pyroclastic mantles	2	Medium
Denuded slopes with steep slope	3	High
Small alluvial-coluvio valley with deep dissection	3	High
Pronounced alluvial valley	3	High
Mass movements, crowns and erosion	3	High

Source (Géminis Consultores Ambientales, 2016)

- Land use conflicts

Areas with high land-use conflict sensitivity of the"overused" type were identified, as they severely alter soil capacity and properties; areas with medium sensitivity are those areas with a type of “underused” conflict, which does not drastically alter soil properties slightly affecting them, which may have a higher capacity to support activities; and areas with lower sensitivity to the areas that do not have any kind of conflict, because their use is appropriate were identified.

Table 6.3 shows assigned sensitivity values, in accordance with the characterization of the area of influence of the project:

Tabla 6.3 Soil use conflicto

USE CONFLICT		ZONING CATEGORY
Sever overuse	3	High
Slight and moderate overuse	3	
Sever underuse	2	Medium
Slight and moderate underuse	2	
Appropriate	1	Low

Source: (Géminis Consultores Ambientales, 2016)

- Slope

Based on slope percentage in the project area, the following classification was established according to the attributes code manuela of soil and land surveys. (Instituto Geográfico Agustín Codazzi, 2001).

Table 6.4 Slope classification

SLOPE		ZONING CATEGORY
Level 0-1%	1	Low
Slight flat 1-3%	1	Low
Slightly sloping 3-7%	1	Low
Moderately sloping 7-12%	1	Low
Strongly sloping 12-25%	2	Medium
Slightly steep 25-50%	2	Medium
Moderately steep 50-75%	3	HIgh
Strongly steep 75-100%	3	HIgh
Totally steep >100%	3	HIgh

Source: (Géminis Consultores Ambientales, 2016)

Thus, with weighing assigned to each layer and considering the weight of each one in the abiotic environment zoning, the information was matched to establish the component's degree of sensitivity, categorized according to ranges of Table 6.5.

Table 6.5 Degrees of abiotic environment sensitivity to intervention

DEGREE OF SENSITIVITY TO INTERVENTION	COLOR	VALUE
HIgh	**Rojo**	**3**
Medium	**Naranja**	**2**
Low	**Verde**	**1**

Source: (Géminis Consultores Ambientales, 2016)

6.1.3 Biotic zoning

The final biotic zoning is obtained by integrating the variables of sensitive areas (hydrogeological and drains), vegetal cover and fragmentation, defined for the area of influence; since the latter serve as the physical environment in which they operate and interact with the species of flora and fauna of the area.

· Sensitive Areas

The evaluation of the environmentally sensitive areas within the biotic environment are based on analyzing the presence of areas of special environmental significance and ecological importance which are useful for development of throphic chains and that are highly sensitive to the anthropic type interventions, as their capacity for regeneration and recovery can be affected by overexploitation of their resources; these areas include, but are not limited to, areas established as sensitive areas (water bodies), vegetation cover and fragmentation.

The presence of economic production areas where agricultural activities and/or farming are developed are taken into account, since from the biotic point of view they are ecosystems of economic importance, but of low environmental sensitivity, as they do not offer the conditions conducive to the development of food networks, but they do provide a livelihood for a large part of the population of the region.

For the area of influence, water sources in relation to Decree 2811 and Decree 1449 that establish 30 m of riparian corridors and artificial lentic type bodies and water outcrops such as springs and basins identified within the area of influence were used, assigning an equal protection zone. Table 6.6 shows water sources sensitivity criteria.

Therefore, sensitive areas are categorized according to the following table.

Table 6.6 Classification of sensitive areas for biotic environmenta zoning

SENSITIVE AREAS		ZONING CATEGORY
Hydrogeology	3	High
Drains	3	High

Source: (Géminis Consultores Ambientales, 2016)

· Soil cover

Valued natural covers owe their importance category to their degree of intervention, given that their state of conservation has greater ecological importance and environmental supply offer. The lower the degree of anthropic intervention, the greater its category of importance.

Three main types of covers were identified for the study in accordance with CORINE Land Cover classification corresponding to urbanized areas, agricultural lands, and forests and semi-natural areas. The largest extension covers are the heterogeneous agricultural areas, although there are also small areas of secondary vegetation or in transition.

Of above covers, those with the highest ecological importance correspond to the natural units, including secondary vegetation, although the live fences and scattered trees in pastures considered as disturbed habitats and handled by the man, play an important role in the diversity conservation; given that grasses can serve as biological corridors for wild fauna and flora by increasing the structural connectivity of the landscape.

However, for the zone where there are plans to build the project the most representative cover corresponds to agricultural territories, which are categorized as low sensitivity. Unlike the rivers, forests, shrublands, grasslands, and secondary vegetation, which have a high degree of biotic importance because these formations have focal species, and are associated with the vast majority of birds and mammals in the region.

Table 6.7 shows the degrees of sensitivity generated for the different types of cover in accordance with CORINE Land Cover classification, keeping in mind that the greater part of the territory of the area of influence is altered with agricultural and artificial territories, which have low sensitivity, leaving small quantities of shrubby and wooden vegetation in the territory, so there are few variables to categorize, resulting in the use of three levels of environmental sensitivity for the vegetable covers, high, medium and low.

Table 6.7 Classifcation regarding types of current soil cover in the biotic environment area of influence, based on their biotic importance

COVER		CODE	CURRENT COVER	VALUE
Water surfaces	3	511	Rivers	High
Semi-natural forests and areas	3	314	Riparian forest	High
	3	321	Pasture	Medium

	3	322	Shrubs	Medium
	2	315	Forest plantation	Medium
Agricultural territories	2	232	Wooded pastures	Medium
	2	244	Mosaic of pastures with natural spaces	Medium
	2	245	Mosai of crops and natural spaces	Medium
	2	243	Mosaic of crops, pastures and natural spaces	Medium
	2	233	Weedy pastures	Medium
	1	231	Clean pastures	Low
	1	215	Tubers	Low
	1	242	Mosaic of pastures and crops	Low
	1	211	Other transitory crops	Low
	1	222	Permanent shrub crops	Low
	1	241	Mosaic of crops	Low
	1	224	Agro-forest crops	Low
Artificial territories	1	122	Road and train networks and associated terrains	Low
	1	121	Industrial or comercial areas	Low
	1	112	Discontinuous urban fabric	Low
	1	111	Continuous urban fabric	Low

Source: (Géminis Consultores Ambientales, 2016)

The flora and fauna diversity of the region, as well as the richness of species, were associated with the different types of current soil cover. These parameters are indicators of the ecological importance of the forest cover for the maintenance of biodiversity and ecological processes.

· Fragmentation

Fragmentation is the process of dividing a continuous habitat into sections. The resulting fragments differ from the original habitat by smaller in size, by being isolated to a greater or lesser degree. The fragmentation categories are minimal, strong and extreme.

Table 6.8 Fragmentation classification

FRAGMENTATION		ZONING CATEGORY
Minimun	3	High
Strong	2	Medium
Extreme	1	Extreme

Source: (Géminis Consultores Ambientales, 2016)

6.1.4 Socio-economic zoning

Refers to the presence of schools, housing, industrial infrastructure, pipelines transporting oil products, high voltage power interconnection lines, archaeological sites, among others, present in the areas of influence of the project. All these socio-economic aspects are considered in the zoning with a High environmental sensitivity.

Then the social sensitivity refers to the degree of propensity to generate social impacts (physical and/or intangible) due to intervention effects on the social environment and on any of its elements. In other words, it is the degree of susceptibility to damage the social environment balance, or partially affecting any of its elements (in their value, significance or use) by the incidence of certain actions on the physical environment. In this case the social fabric is also more sensitive to interventions.

According to the aforesaid, the classification is generated in the following social environment tables:

Tabla 6.7 Social zoning classification

SOCIAL UNIT		ZONING CATEGORY
Social infrastructure (Hamlets, Housing, School, Sports Arena)	3	HIgh

Production associated infrastructure (Road, paths, water holes, sugar presses, warehouses)	3	High
Productive areas (crops, livestock)	2	Medium

Source: (Géminis Consultores Ambientales, 2016)

When matching selected variables, the following zoning of the socio-economic environment is defined as shown in Table 6.10.

Tabla 6.8 Degrees of intervention sensitivity for the socio-economic environment

DEGREE OF INTERVENTION SENSITIVITY	COLOR	VALUE
High	**Red**	**3**
Medium	**Orange**	**2**
Low	**Green**	**1**

Source: (Géminis Consultores Ambientales, 2016)

6.2. Results

6.2.1. Abiotic environment zoning

According to matches made between the areas of influence of the abiotic environment (hydrography, soil use conflict, slope and threat), the geoesferica layer is defined as a common area, as seen in the Figure 6.2 and Figure 6.3.

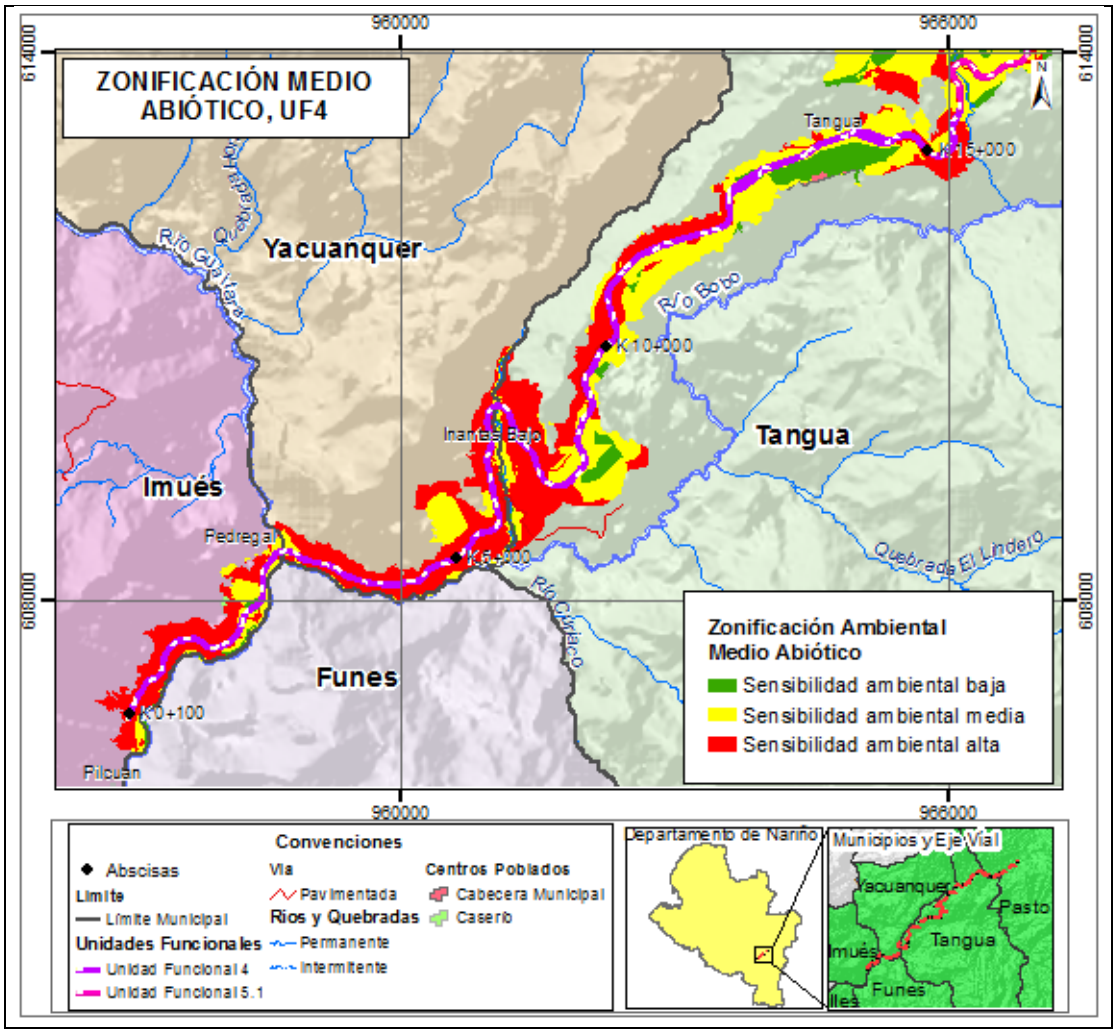

Figure 6.2 Abiotic environment zoning UF 4

Source: (Géminis Consultores Ambientales, 2016)

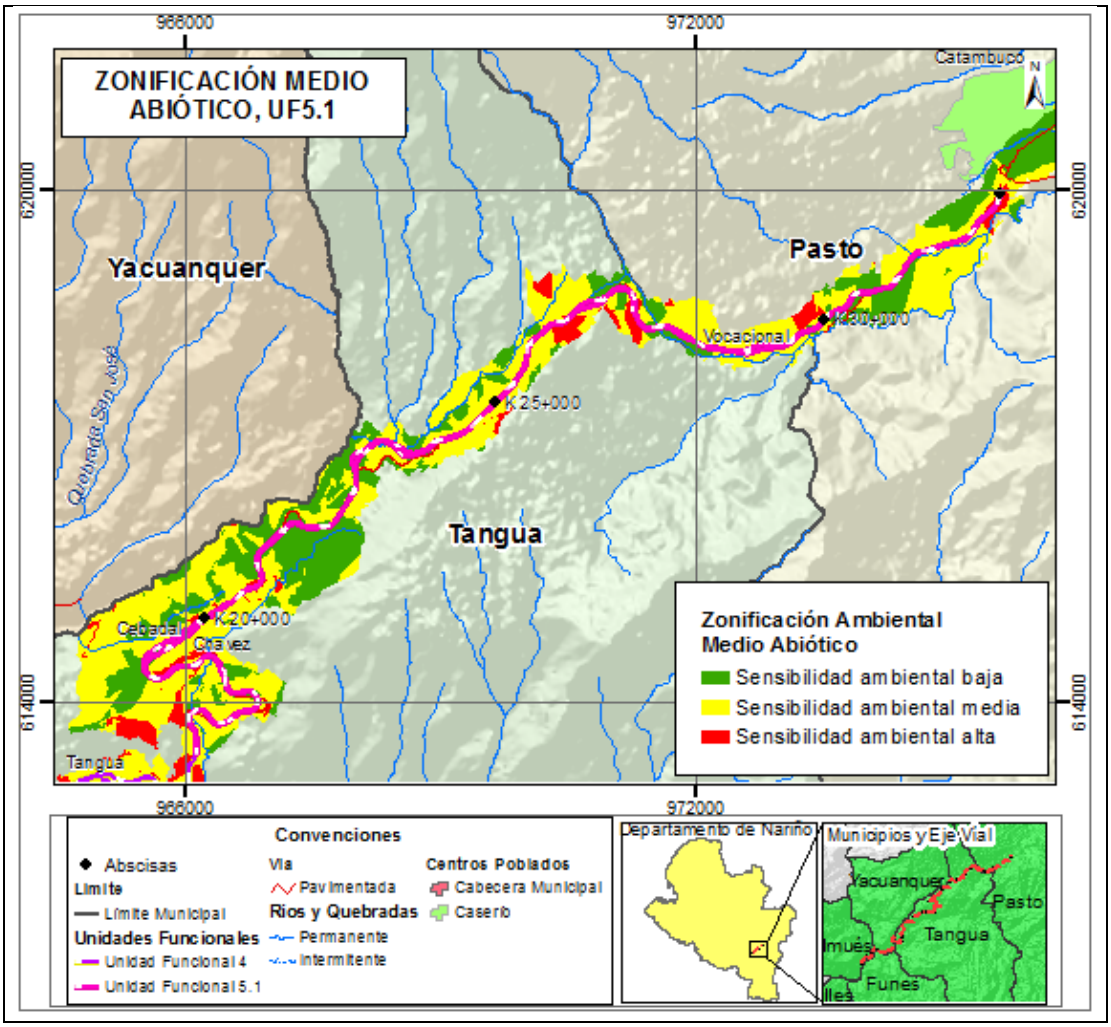

Figura 6.3 Abiotic environment zoning UF 5.1

Source: (Géminis Consultores Ambientales, 2016)

Thus, for the Rumichaca - Pasto dual carriageway road project, Pedregal – Catambuco Span, a 452.39 hec abiotic environment was established, which refer to places with *sensitivity*; 999 hec correspond to areas with *average sensitivity* and 482.21 hec presented *high sensitivity*. Table 6.11 shows classified areas in each specific sensitivity level and their respective percentage.

Table 6.9 Identified sensitivity categories for the abiotic environment

SENSITIVITY	AREA (HEC)	PERCENTAGE %
Low	452,39	23,40
Medium	999	51,66
HIgh	482,21	24,94
TOTAL	**1933,6**	100,00

Source: (Géminis Consultores Ambientales, 2016)

As to the abiotic component, the greater part of the territory has an average 51.66% sensitivity and 23.40% low sensitivity, mainly in the northern area of the project where volcanic features are conserved and closer to the Galeras volcano; and 24.49% high sensitivity in the southern part of the project, where there is evidence of strongest river dynamics.

6.2.1. Biotic environment zoning

The total area of influence for the biotic environment of the Pedregal - Catambuco dual carriageway road project, Rumichaca – Grass span, is of 1933,6 hec. Follows the results of the biotic environmental zoning carried out for the project and the area occupied by each type of cover, as shown in Table 6.12.

Table 6.10 Environmental sensitivity identified for the biotic environment

RATING	CODE	CURRENT COVER	AREA
HIgh	511	Rivers	20,890075
HIgh	314	Riparian forest	29,32377
Medium	321	Pasture	112,190841
Medium	322	Shrubs	22,734616
Medium	315	Forest plantation	25,297172
Medium	232	Wooded pastures	3,153785
Medium	244	Mosaic of pastures with natural spaces	197,068402
Medium	245	Mosaic of crops and natural spaces	31,997714
Medium	243	Mosaic of crops, pastures and natural	224,67892

		spaces	
Medium	233	Weedy pastures	80,904884
Low	231	Clean pastures	152,030234
Low	215	Tubers	12,032984
Low	242	Mosaic of pastures and crops	481,599949
Low	211	Other transitory crops	15,108676
Low	222	Permanent shrubby crops	8,356405
Low	241	Mosaic of crops	202,066781
Low	224	Agro-forest crops	156,722272
Low	122	Road and railroad network and associated terrains	48,541584
Low	121	Industrial or comercial areas	4,685832
Low	112	Discontinuous urban fabric	48,868617
Low	111	Continuous urban fabric	55,362337

Source: (Géminis Consultores Ambientales, 2016)

Considering above table, the area of biotic influence results in 1933,6 hec, of which 1055,47 hec correspond to *low sensitivity*, 471.21 hec have *medium environmental sensitivity* and 406.92 hec have *high environmental sensitivity* as shown in Table 6.13. Follows the environmental sensitivity categories identified for the biotic environment, whose spatial distribution is shown in Figure 6.4 and Figure 6.5.

Table 6.11 Environmental sensitivity categories identified for the biotic environment

SENSITIVITY	AREA (HEC)	PERCENTAGE %
Low	1055,47	54,59
Medium	471,21	24,37
HIgh	406,92	21,04
Total	**1933,6**	100,00

Source: (Géminis Consultores Ambientales, 2016)

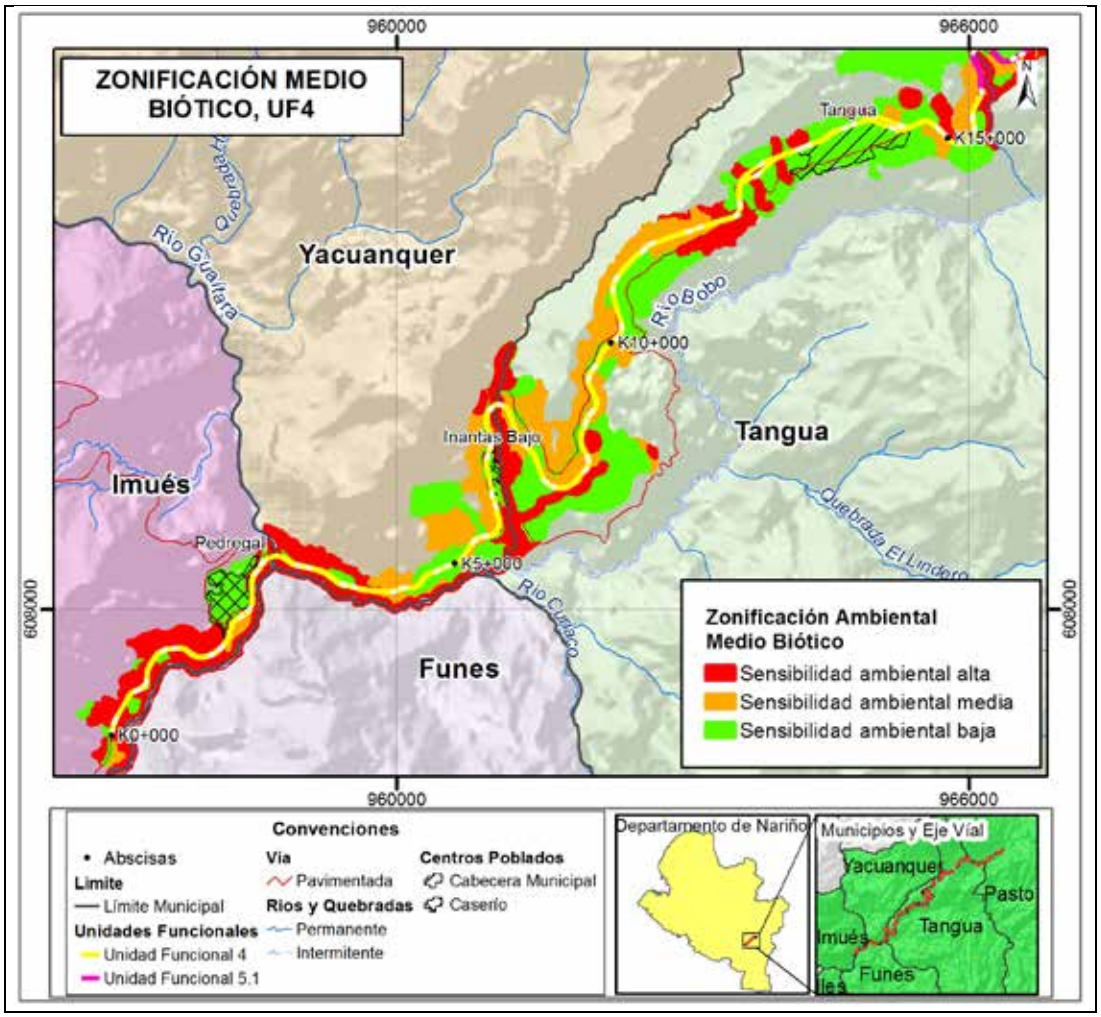

Figure 6.4 Biotic environment zoning UF 4

Source: (Géminis Consultores Ambientales, 2016)

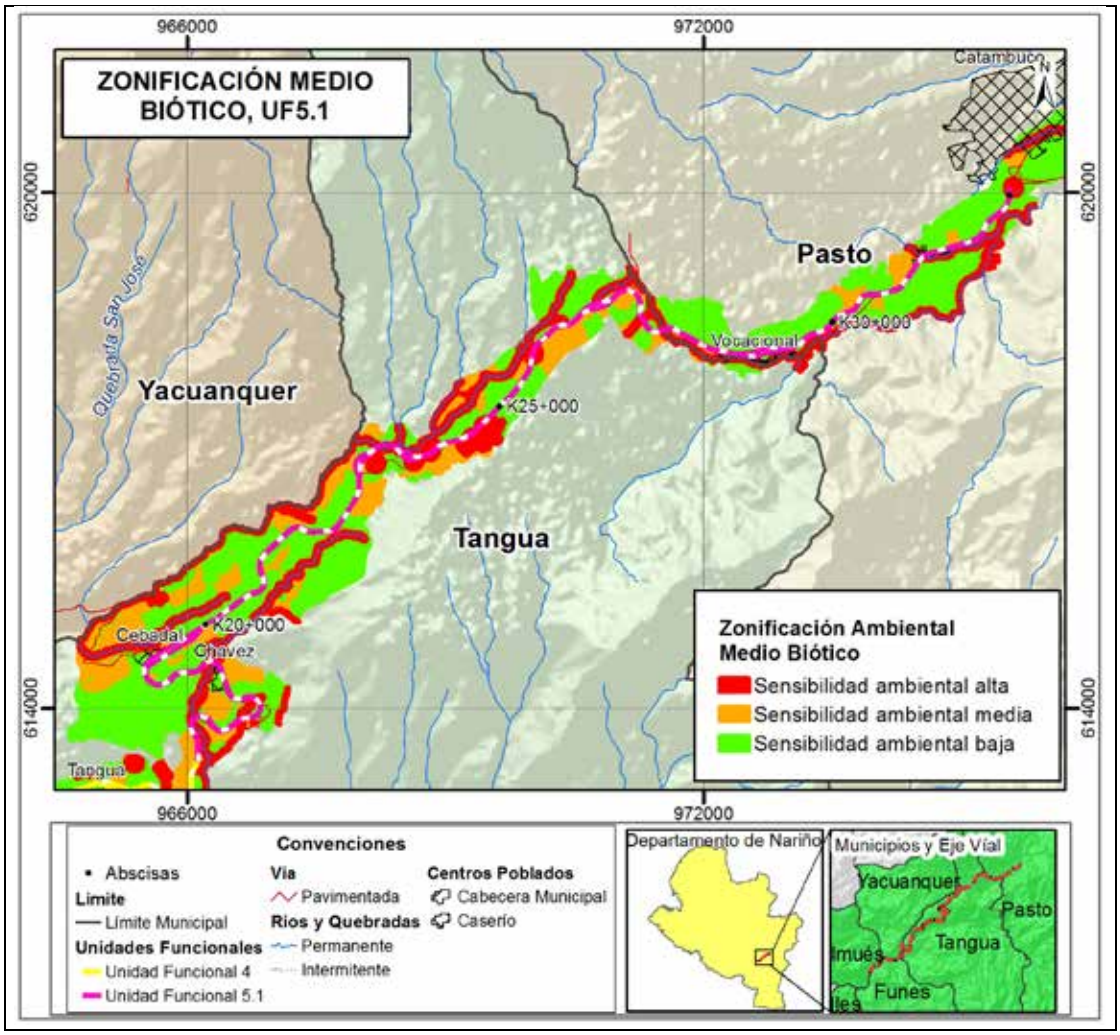

Figure 6.5 Biotic environment zoning UF 5.1

Source: (Géminis Consultores Ambientales, 2016)

For biotic zoning, the greater part of the territory has low 54.59%, sensitivity due to the strong anthropic interventions on natural covers, generating a territory mostly artifical, with population infrastructure, agriculture and livestock; leaving patches of shrub vegetation, 24.37%, and in last place sensitive areas with 21.04%.

6.2.3 *Socio-economic enviroment zoning*

For the socio-economic environment zoning, variables were matched related to infrastructure, population centers, road network, places of cultural interest and population density.

This zoning resulted in that 253.61 hec correspond to *high sensitivity* areas, 631.29 to *medium sensitivity* areas, and 1048,71 to *low sensitivity* areas. Table 6.14 shows the percentages and qualified areas in each sensitivity level, specified for the Pedregal – Catambuco span, and their spatial distribution is shown in Figure 6.6 .

Tabla 6.12 Sensitivity categores identified for the socio-economic environment

SENSITIVITY	AREA (HEC)	PERCENTAGE %
Low	1048,71	54,24
Medium	631,29	32,65
HIgh	253,61	13,12
TOTAL	**1933,6**	100,00

Source: (Géminis Consultores Ambientales, 2016)

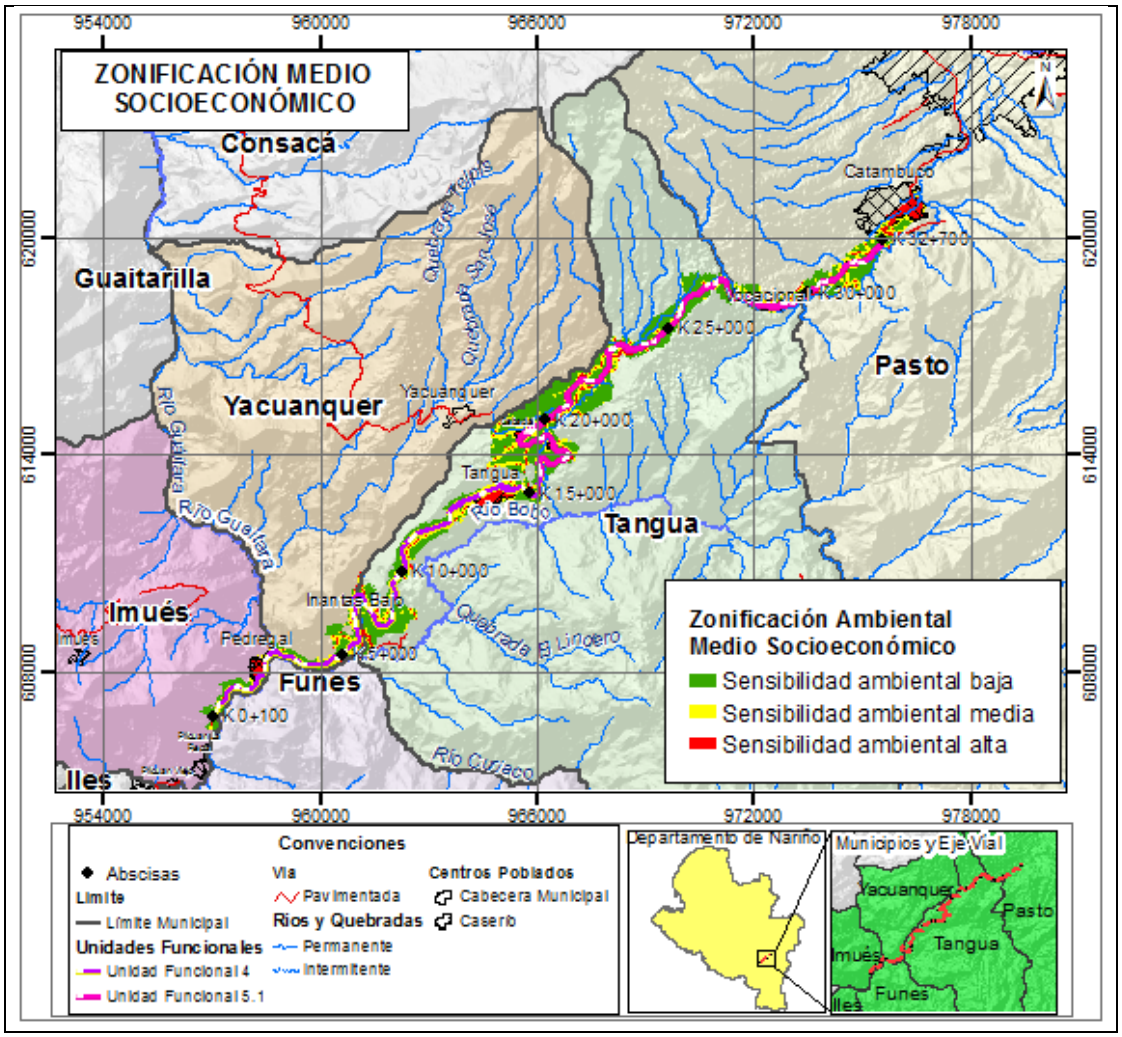

Figure 6.2 Socio-economic environment zoning

Source: (Géminis Consultores Ambientales, 2016)

This zoning evidences that the environmental sensitivity of the area of influence of the road corridor is lower with 54.24%, considering that in the said territory there is no evidence of interaction of the population, resulting in moderate development of anthropogenic dynamics in this territorial extension. For its part, 32.65% of the sensitivity is average and only 13.12% is recorded as high specifically in those areas where there are mainly populated centers and their surroundings. Spaces with little

population interaction have however agricultural activities, reason why they are areas that also have population interaction on the part of the population living in the territory.

6.2.4 *Total environmental zoning*

From identifuing areas wjere sets of abiotic, biotic and socio-economic parameters reflect relatively homogeneous degrees of potentiality or fragility within a given area, it was determined that the environmental sensitivity of the area without a project, is the one shown in Table 6.15, which classified areas with High, Medium and Low environmental sensitivity.

Table 6.13 Environmental sensitivity categories identified of the Pedregal - Catambuco span

SENSITIVITY	AREA (HEC)	PERCENTAGE %
Low	1185,37	61,30
Medium	537,80	27,81
HIgh	210,43	10,88
TOTAL	**1933,6**	100,00

Source: (Géminis Consultores Ambientales, 2016)

This i show for the project's area of influence 1185,37 hec have *low sensitivity* representing 61.30%, while *medium sensitivity* occupies 27.81% with an area of 537.80 hectares and the *high* with 10.88% equivalent to 210,43 hec. The spatial distribution of the different identified categories, in relation to the layout of the project is shown in Figure 6.7 and Figure 6. 8.

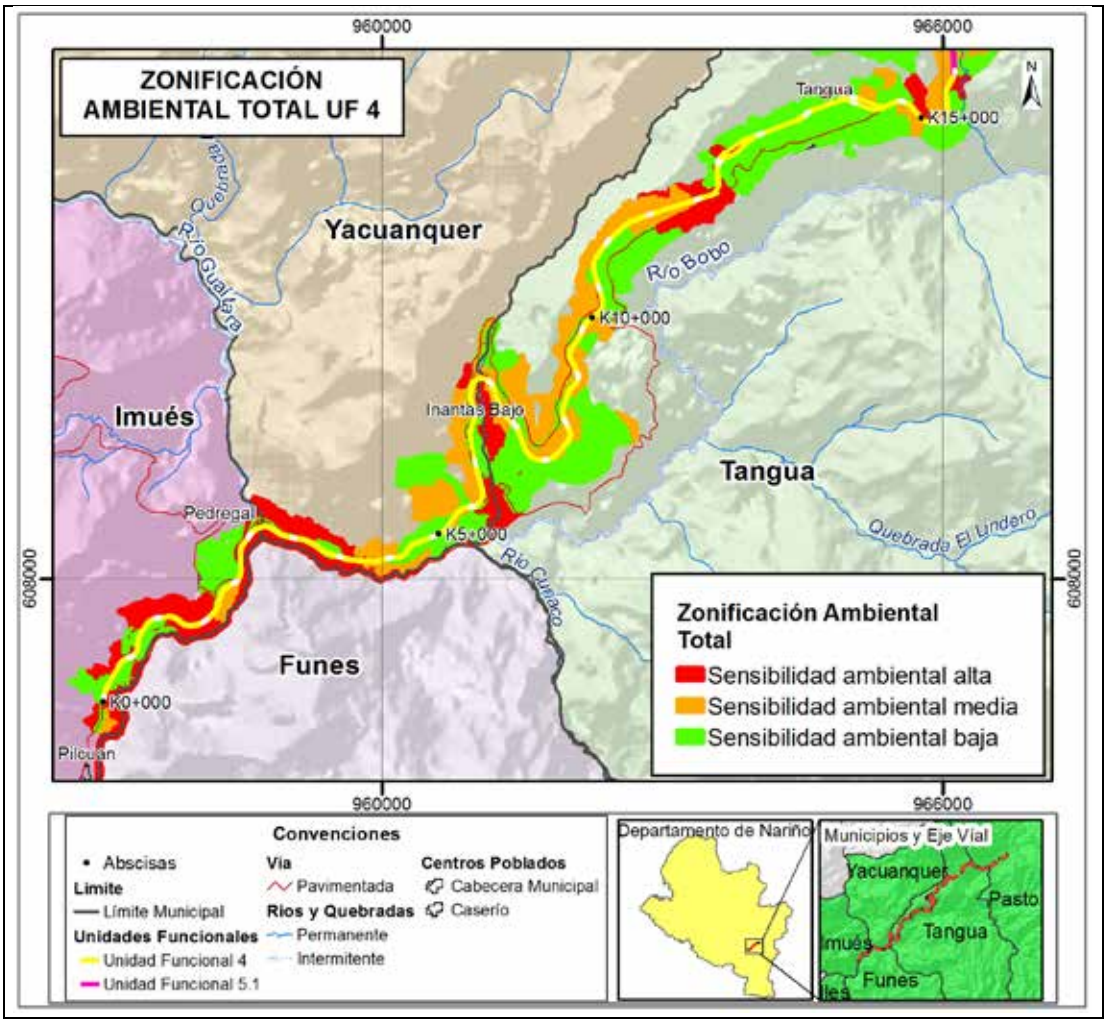

Figure 6.3 Total environmental zoning UF 4

Source: (Géminis Consultores Ambientales, 2016)

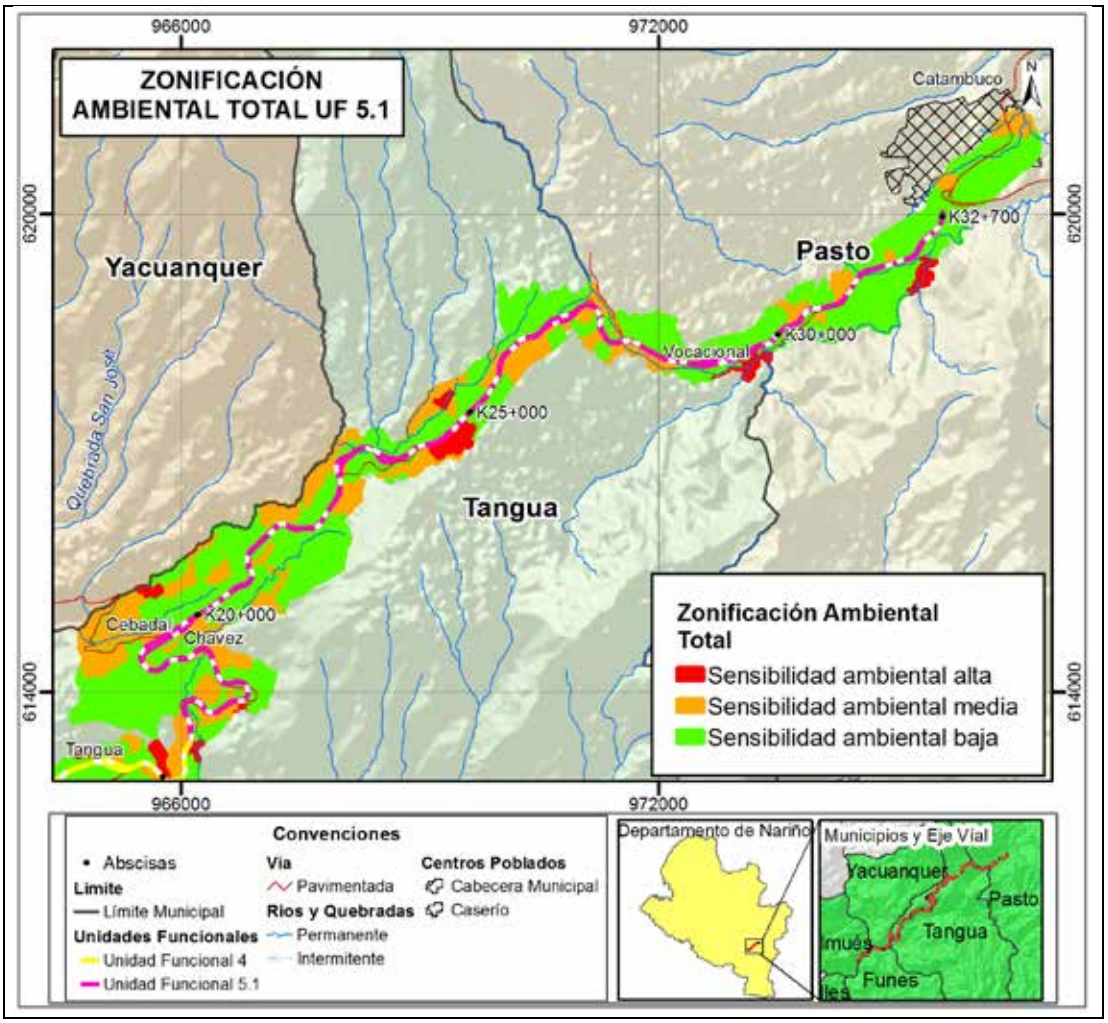

Figure 6. 4 Total environmental zoning UF 5.1

Source: (Géminis Consultores Ambientales, 2016)