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10 ECONOMIC ENVIRONMENTAL ASSESSMENT

10.1 INTRODUCTION

This chapter contains the valuation of environmental costs and benefits, and the Cost-Benefit Environmental Analysis of the Rumichaca Pasto Divided Highway Project, San Juan – Pedregal Segment, and its area of influence located in the department of Nariño.

The economic valuation of environmental impacts was carried out according to the General Methodology to present Environmental Studies, number 2.3.2, establishing the economic evaluation process within the Environmental Impact Assessment and as per the Technical Manual for Economic Assessment of Environmental Impacts of Projects Subject to Environmental Licensing. (CEDE – UNIANDES - MAVDT 2010).

To assess environmental impacts - benefits and costs – of the project, it takes into account baseline information, area of influence, identification and evaluation of environmental impacts and environmental management programs designed to prevent, mitigate or compensate environmental impacts, which are part of chapter 3, Project description, Chapter 5 Characterization of the area of influence and Chapter 8 Environmental assessment of the environmental impact study for the project.

Within the EIA concept, the economic valuation begins with sets of impacts identified and assessed that given their environmental significance value have been assessed as severe impacts, negative in nature or environmental costs, positive in nature, which constitute environmental benefits.

It is thereby determined that the Rumichaca Pasto Divided Highway Project, San Juan – Pedregal Segment, has an area of influence (AI) of 1629.23 hectares, including areas foreseen for the disposal of left over materials (ZODMES), camps and sources of materials.

10.2 GENERAL ASPECTS OF THE PROJECT

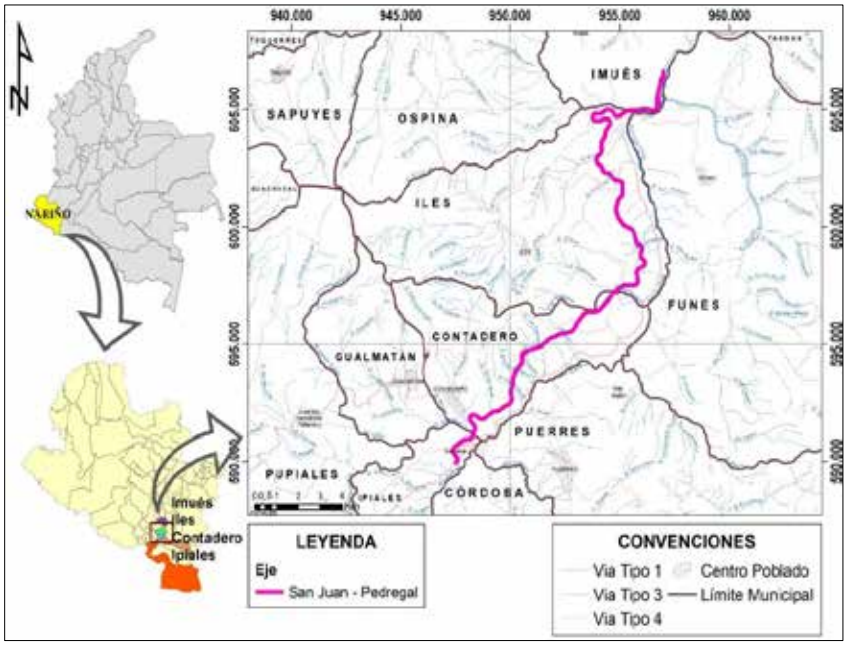
The Rumichaca Pasto Divided Highway Project, San Juan – Pedregal Segment is located in the Department of Nariño, in the municipalities of Ipiales, Contadero, Iles and Imués; **Table 10-1** exhibits the townships through which it plans to build the project and in **Figure 10-1**, graphically shows its location.

Table 10-1 Project location

DEPARTMENT	MUNICIPALITY	TOWNSHIPS
Nariño	Ipiales	El Rosal, San Juan, Boquerón
	Contadero	La Providencia, San Francisco, Aldea de María, Las Delicias, El Capulí, El Culantro, Las Cuevas, Ip. Ospina Pérez, San José de Quisnamuez
	Iles	Alto el Rey, Urbano, Tablón Alto, Tablón Bajo, Tablón Alto, El Rosario, El Porvenir
	Imués	Pilcuán

Source: GEOCOL CONSULTORES S.A., 2017.

Figure 10-1 Project location



Source: GEOCOL CONSULTORES S.A., 2017

10.3 TECHNICAL CONCEPTS OF THE PROJECT

The Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment; takes into consideration the construction of 29.16 KM, located from PK15+750 to PK44+909; corresponding to three segments; a construction segment of the second lane of the parallel to the existing one (1.25 km), a segment of new roads (25.26 km) and the construction of the second lane parallel to the existing road (2.65 km).

Table 10-2 shows the technical specifications of the project for the three segments into which it has been divided in the design, roads, bridges and other works contemplated therein. These Segments have been defined according to parameters such as morphological characteristics, type of works required, and ease of construction, among others.

Table 10-2 Technical Specifications

STRETCH	ABSCISSAE	LENGTH (KM)	BRIDGES			OTHER WORKS
			Number	Abscissae	Total length (m)	
I-Second lane parallel to existing **II-Vía nueva** **III-second lane**	PK15+750 hasta PK17+000 PK17+000 hasta PK42+261 PK42+261 hasta	29,16	Puente Boquerón. Puente El Tablón Alto. Puente Quebrada	PK18+700 y PK18+960 PK36+604.35 y PK 6+847.85	260 243,50	Construction of four (4) intersections; Interchange connection with San Juan. Interchange connection in Contadero Interchange connection Pilcuán Connection with Iles road

parallel to existing lane	PK44+909		Macal Puente Vereda El Porvenir Puente Río Sapuyes.	PK37+343 y PK 7+528.60 PK38+781 y PK39+006 PK41+056.60 y PK42+256.60	185 225 200	Construction of five (5) skidding trenches

Source: as of EIA. Chapter 3. Description of the project. 2017

10.3.1 Project stages and activities with the potential of generating environmental and social impacts

The Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment, will consist of three phases: pre-construction, construction, abandonment and final restoration as related herein below with its activities, as of its EIA. Chapter 3. Project description

- **Phase 1: Pre construction. Stage prior to the commencement of works, comprises the following activities:**
  - **Approaching and information with community and competent authorities**
  - **Negotiation of lands and easements**
  - **Contracting and training personnel**
  - **Mobilization of construction materials, supplies, machinery, equipment and personnel**
- **Phase 2: Construction. Refers to the physical execution of works, activities related are:**
  - **Acquisition of goods and services**
  - **Intake of surface water**
  - **Generation of solid wastes for the project**
  - **Generation of domestic and industrial liquid wastes for the project**
  - **Removal of topsoil, stripping and cleaning**
  - **Moving and removing existing infrastructure in the areas to be intervened**
  - **Land movement (excavations and landfills)**
  - **Installation and operation of camps**
  - **Installation and operation of process plants (asphalt, concrete, grinding)**
  - **Operation and maintenance of machinery and/or equipment**
  - **Construction and Operation of Debris and Excavation Material Management Zone**
  - **Building the sub-base, base and base course**
  - **Building surface layer**
  - **Cementation and foundation of towers for bridges and viaducts**

- **Construction of superstructure for bridges and viaducts**
- **Construction of hydraulic works (including riverbed occupation)**
- **Treatment of slopes**
- **Grass patching and revegetation**
- **Installation of tolls**
- **Abandonment and final restoration**
- **Dismantling of temporary facilities and camps**
- **Final cleansing of intervened areas**
- **Landscape management**

10.3.2 Duration of works

The construction project of the Rumichaca – Pasto Divided Highway Project, San Juan Pedregal Segment, will have a total duration of 1184 days.

10.4 AREA OF INFLUENCE

Chapter 5 of this Environmental Impact Study includes the Characterization of the Area of Influence of the Rumichaca – Pasto Divided Highway Project. Area where it generates direct and primary environmental impacts on the sites to be intervened with this road project, in terms of abiotic, biotic, socioeconomic and cultural components.

The area of intervention of the Divided Highway Project has an extension of 1629.23 hectares, located in the jurisdiction of the municipalities of Ipiales, Contadero, Iles and Imués, in the department of Nariño.

10.5 ENVIRONMENTAL ASSESSMENT

10.5.1 Environmental impacts of the project

Based on the Guidelines of the Technical Manual for the Economic Assessment of Environmental Impacts it begins with assessing impacts as the strategy to prioritize impacts in order to address the environmental analysis and the economic valuation.

By applying the methodologies established on the EIA to assess environmental impacts, it identified the activities of the project that would generate greater impact on the environment and It establishes which environmental elements have the greater affectation potential given the importance values of the Environmental Impact for the development of the project.

The EIA of the Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment, Chapter 8. Environmental Assessment, describes the impacts assessed for the biotic, abiotic and socioeconomic components, resulting in relating the activities of the project with the potential of generating impacts the environmental offer in the area under study, which is the result of the characterization of the abiotic, biotic

and socioeconomic and cultural aspects in each of the components and indicators presented in one of the EIA Chapters - Characterization of the Area of Influence of the project, and the characterization of natural resources by the project, presented in Chapter 5 of the EIA.

10.5.2 Selection of Impacts subject to Economic Valuation

Impacts identified and assessed within the EIA for each of the abiotic, biotic and socioeconomic components were grouped according to the value of environmental importance rated as severe impact.

The selection criterion consisted on identifying negative impacts in each stage of the project, which had a relevant importance rate, likewise, selecting their impacts which constituted positive impacts in the stages of the project, either because management measures allowed for the improvement of existing environmental conditions, due to the direct benefits to the population by generating employment and other means of compensation.

10.5.2.1 Negative Impacts or Environmental Costs

Based on the review of the environmental impact matrix of the project as shown on the EIA, it carried out the selection of the negative impacts or environmental costs susceptible to economic value, which means those of relevant importance. **Table 10-3**, **Table 10-4**, and **Table 10-5** make a brief description of the environmental costs by abiotic, biotic and socioeconomic components.

Table 10-3 Environmental costs of the abiotic component

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITIES**	**DESCRIPTION**
Construction	**Soil**	Change of the use and potential use of soil	Construction and Operation of Debris and Excavation Materials Management Zone (ZODME).	Impact is considered moderate due to the generation of solid wastes by the project, these generate a visual impact on the environment, in addition, they may generate in time, contamination due to leaching, resulting in the affectation of the potential use of soil. Similarly, it is considered negative and moderate due to the removal of topsoil, stripping and cleaning, installation and operation of camps, these activities strip soil from its vegetation, which is being used to protect and preserve the soil. On the other hand, farming and fishing activities are affected, where land has the potential to be used in those activities. Also, it is considered severe as regards land movements, (Excavations and Landfills), soils under this activity loose their total productivity, due to the loss of soil horizon and changes on the morphology profile. It is also considered negative due to the construction and operation in the debris and excavation materials management Zone (ZODME). In these areas it cannot develop the potential use of soil. Farming and fishing activities and conservation will be affected by the performance of this activity. Positive impacts for grass patching and revegetation activities are considered moderate, due to the fact that these activities give rise to protection and recovery processes, trying to leave the area in similar conditions to those found, reducing erosion and compacting processes and enhancing infiltration capacity
			Land movements (Excavations and landfills)	

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITIES**	**DESCRIPTION**
				in addition to contributing to the development of soil fauna.
		Change in soil physical-chemical and biological properties	Construction and Operation of the Debris and Excavation Materials Management Zone (ZODME).	Impact on the change of soil's physical-chemical and biological properties is considered negative and moderate due to project's household and industrial generation of liquid wastes, this activity relates to the discharge of household and industrial waste waters through spraying fields, and proper treatment should be ensured given that waste waters may contain heavy metals, which contribute to one of the groups of environmental pollutants that are deemed of high concern in terms of soil degradation, specifically due to their mobility and low concentrations where they begin to show their toxic effects. On the other hand, it is considered severe as a result of land movements (excavations and landfills) and the construction and operation of debris and excavation material management Zones (ZODME), where it deems that the soil has lost all its natural conditions as a result of transformations to the natural landscape, the affectation of flora and fauna and soil degradation, the increase of erosive processes and affectation of landscape resulting from not restoring topsoil.
			Land movements (Excavations and Landfills)	
		Changes on soil stability	Construction and Operation of the Debris and Excavation Materials Management Zone (ZODME).	Changes in soil stability, is the impact generated as of the loss of topsoil and/or organic topsoil; but it may also occur when modeling or triggering agents act and is related to the presence of water in soil in charge of reducing resistance to the cutting of materials. Conducting cuts and landfills for the construction of the project has a negative effect on impact, as it modifies the natural slopes of mountains, generating erosion processes and mass removal. Another activity that generates a severe impact to soil stability relates to the construction and operation of the Debris and Excavation Materials Management Zone (ZODME) because by performing such activity it generates new mountain relief and creates new stability conditions in filled areas.
			Land movements (Excavations and Landfills))	
			Removal of topsoil. Stripping and cleaning	
	Surface Waters	Altering riverbanks	Construction of hydraulic works (including occupation of riverbanks)	The impact of altering riverbanks as a result of the construction phase of hydraulic works, implies having a severe impact as a result of the direct intervention of water sources, such as rivers, creeks, brooks, among others, modifying the natural conditions of these water bodies due to redirecting or adjusting courses to allow the construction of the project. On the other hand, and rated as moderate are topsoil, stripping and cleaning removal tasks; movements generated by excavations and landfills, surface water intake and demolition and removal of existing infrastructure of debris and excavation material management Zones (ZODME), which leads to the direct alteration of riverbanks. Treatment of slopes, grass patching and landscaping are other aspects that generate moderate and positive impacts with respect to changes in surface waters as they indirectly favor riverbank stability.
	Underground water	Alteration of ground water currents.	Land movements (Excavations and Landfills)	Alteration of ground water currents could be the result of some activities during the construction stage, mainly those related to land movement, (excavations and landfills) rated as severe impact; generally leading to changes in discharge areas due to the removal of large volumes of land that may lead to

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITIES**	**DESCRIPTION**
				the exposure of ground or surface water mirrors. The construction of ZODMEs is deemed as activities that generate moderate impacts on ground water currents as they cover the terrain and hence temporally or permanently modify seepage of rainwater. On the other hand, the removal of topsoil, stripping and cleaning, in addition to the cementation and foundations for bridges or viaducts, it does not generate further affectation to ground currents, as these are deemed superficial or temporary interventions. On the other hand, the removal of topsoil.
		Alteration of recharge zones	Construction and Operation of Debris and Excavation Materials Management Zone (ZODME).	The alteration of ground water currents may be the result of some activities during the construction stage, especially those related to land movement (excavations and landfills) rated as severe impact; generally giving rise two changes in discharge areas due to the removal of large volumes of land that may provoke the exposure of surface or ground water mirrors. The construction of ZODMEs is identified with activities generating moderate impacts on ground water currents, as it covers the terrain and hence, temporarily or permanently modify water mirrors seepage. On the other hand, the removal of topsoil, stripping and cleaning in addition to cementation and foundation of bridges viaducts does not generate Great affectation two underground water currents as these interventions are deemed superficial or temporary. In the scenario with the project, the construction and alteration of debris and excavation materials management area resulting from maintenance and refurbishing of roads (ZODME) generates a severe impact to the alteration of recharge zones due to the build up of generally impervious material on potential recharge zones.
	Air	Changes to air quality due to particulate matter	Installation and operation of process plants (asphalt, concrete, grinding)	Changes on the concentration of particulate matter on these types of projects are generally identifiable due to the size of particles produced, which generally exceed 10 μg. Areas with greater affectation on account of this impact are all those close to the generation point, as most of the time suspended particles tend to settle quite fast. The foregoing is conditioned to the size of particles and wind speed in the area. During the construction phase, topsoil, stripping and cleaning removal activities, demolition and removal of existing infrastructure in the areas to be intervened, and land movements (excavations and landfills) and the construction of ZODMEs operation, may lead to this type of impact, generating particulate matter or dust resulting from transferring materials from one side to another and the wind's action, which is short-lived, and is an immediate result of the activity. However, during these activities the production of particulate matter is not constant in time, in addition, it has recovery characteristics and can be mitigated; greater exposure may occur during the dry season, hence it was rated as an irrelevant or moderate impact, depending on the intensity of each activity.

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITIES**	**DESCRIPTION**
		Variation of sound pressure levels.	Installation and operation of process plants (asphalt, concrete and grinding)	The operation of process plants and the operation of such equipment may increase sound pressure levels in over 80 decibels (dB), affecting existing communities and ecosystems in the surrounding camp area. Hence, the analysis established that the intensity of impact may be very high, with partial extension, constant during the project and the execution of works in camps, therefore it is considered as of severe environmental importance.
	Landscape	Changes on landscape integrity	Cementation and foundations of bridges and viaducts Construction of overhead structures for bridges and viaducts Construction and operation of Debris and Excavation Materials Management Zone (ZODME). Demolition and removal of existing infrastructure in the area to intervene Removal of topsoil stripping and cleaning	The impact of demolition and removal of existing infrastructure in project areas, was considered as of severe importance due to the fact that these areas are related to landscaping units previously modified by anthropic activities, over these areas it foresees the construction of the Divided Highway, increasing the presence of conflicting elements, initially due to equipment and machinery necessary as well as to the debris resulting from the demolition generating a high, extensive, direct and frequent visual impact, therefore there will be a high visual sensitivity. On the other hand, land movement (excavation and landfills) were assessed as of moderate importance to the extent material cuts are required, modifying geoform characteristics and generating changes in landscaping units. Given the characteristics of the project, impact was considered extensive, with direct and permanent effect in the landscape, affecting attributes such as the natural regeneration of vegetation and the dominance of anthropic modifications. They are in fact related to the Construction and Operation of Debris on Excavation Materials Management Zone (ZODME), which was considered as severe environmental importance as it represents a change in-line attributes, chromatic forms and correspondence, in addition to altering topsoil regeneration, intensifying erosive processes and incrementing contrast between soil and rock, reducing the quality of the scenic background. Visual areas protrude in a dispersed manner in the area of influence and being close to the roads they are linked to increased visual sensitivity. The building of the sub-base, as well as the base and the base course, and the surface layer and the construction of hydraulic works (including the occupation of riverbanks) implies a moderate impact to the extent that the presence of conflicting elements of the construction of works, increases the number of conflicting elements, which in turn increases visual sensitivity and fragility. As it relates to a linear project, it is extensive as regards the area of influence and its direct effect will be permanent on the landscape. When dealing with cementation and foundations for bridges and viaducts, as well as the construction of overhead structures for bridges and viaducts, they may generate on the entire landscape a negative impact of severe environmental importance, to the extent it implies the construction of large infrastructure, which visually represents an increase in a more artificial landscaping system and the number of conflicting elements present, generating relevant changes in visual quality and landscape integrity. As it is subject to the functioning of the roads, these structures are strongly related

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITIES**	**DESCRIPTION**
				to a high visual sensitivity, and although they are specific, their effects on the landscape will be permanent and direct.

Source: as of the EIA. Chapter 8. Environmental Assessment. 2017.

Table 10-4 Environmental costs of the biotic component

BIOTIC ENVIRONMENT				
PHASE	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITY**	**DESCRIPTION**
Construction	**Fauna**	Affectation of the structural and functional connectivity of wildlife habitats.	Construction and Operation of Debris and Excavations Materials Management Zone (ZODME).	The construction and operation of debris and excavation materials management zone (ZODME), its environmental importance is high, given that here it carries out the total transformation of the area, altering not only the natural topsoil, but also the use of soil, landscape, existing ecological relations among different wildlife groups. The loss, transformation and fragmentation of these habitats constitute the main consequence affecting ecological corridors, in this case, some species may drastically change some vital ecological processes, as well as their mobility patterns to avoid areas which are not favorable for feeding or reproduction.
		Alteration of soil fauna	Removal of topsoil, stripping and cleaning	Soil fauna is responsible for the build up and decomposition of organic matter in soils, affecting all transformation of such organic matter, nutrients and some mineral fractions such as salts and clays. This fauna conducts an array of functions, such as accelerating the transformation and inclusion of plant and animal waste on soil, increasing contact surface over which microorganisms may act. Every activity that generates a change in topsoil, the elimination of the organic topsoil's and subsequent replacement in the form of inorganic elements implies the disappearance of all microorganisms and invertebrates that make up the soil fauna.
		Changes in the structure, extension and availability of wildlife habitats	Construction and operation of Debris and Excavations Materials Management Area (ZODME). Removal of topsoil, stripping and cleaning	This project is currently undertaking the construction phase, in the topsoil, stripping and cleaning removal activities and in the Construction and Operation of Debris and Excavation Materials Management Zone (ZODME), as well as grass patching and vegetation. These actions generate a negative impact, affecting to a great extent animal species that live in the areas through which the two-lane project will be built and its surrounding areas. Topsoil, stripping and cleaning removal activities severely affect habitats of resident species, by eliminating topsoil; it totally modifies habitats and their surrounding environmental conditions. The intervention the project will conduct, also leads to the fragmentation of the habitat and the border effect, which arises when an ecosystem is fragmented and biotic and abiotic conditions of the fragments and the surrounding matrix change (Kattan, 2002). In the case of roads, this effect will be evident nearby or on the borders of the road, giving rise to new conditions with higher temperature, less humidity, greater radiation and greater susceptibility to wind. In the construction and operation of debris and excavation materials management zones, fauna habitats will also be affected due to the loss and fragmentation of habitats generated by changes in soil use, which interrupts the ecological dynamics on coverered areas, such as lower secondary vegetation or mosaic of grasses and crops.

BIOTIC ENVIRONMENT				
	Hydrobiology	Alteration of habitats of hydro biological communities	Construction and Operation of Debris and Excavation Materials Management Area. (ZODME).	The construction activity of hydraulic works (occupation of riverbanks) and the removal of topsoil, stripping and cleaning may lead to the alteration of the water habitat due to the occupation of the riverbed, the change in the structure of the current in the trench intervened and the increase in the amount of sediments contributed by the water component during the transit of vehicles. These processes interact to produce changes in water habitat conditions, making the ecological dynamics of communities living there, much more difficult.

Source: as of the EIA. Chapter 8. Environmental Assessment. 2017.

Table 10-5 Environmental costs of the socioeconomic component

SOCIOECONOMIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITY**	**DESCRIPTION**
Pre Construction	**Social Infrastructure**	Changes on social infrastructure and public utilities (collective facilities, aqueduct, sewage, electric power, etc.)	Land and right of way negotiation	Some houses located within the design of the project, will probably be required by it; this may generate expectations or uncertainties in families due to the negotiation of their land and the new place where they will settle, it is vital to ensure that they may continue with their daily activities, as a family, education, as well as their economic activities. Also, during the course of the project, some public utility and social services may also be affected, as per the foregoing; the negotiation of land and the right of way is rated as negative with a severe environmental importance. The increase of immigrant population on account of financial reasons generates saturation of social services, such as education and health, which sometimes cannot even provide service to the population in their area and do not have minimum parameters in terms of coverage and quality. In addition, poor water quality for human consumption, results in illnesses and the saturation of the health system, hence the Contracting and Training of personnel is rated as negative with severe environmental importance. Most territorial units are located near main roads, either departmental or national, implying high traffic levels both of machinery and vehicles. This dynamic represents alterations in lifestyle of communities and represent limitations in mobility, mainly for children and elderly population.
Pre- Construction and Construction			Contracting and training of personnel	

Source: as of the EIA Chapter 8. Environmental Assessment. 2017.

10.5.2.2 Positive impacts or Environmental Benefits

The selection of positive impacts or environmental benefits was conducted as of the review of the impact matrix for the project in its EIA with a severe impact rating in terms of environmental significance. **Table 10-6** and **Table 10-7** provide a brief description of the selected environmental costs per biotic, abiotic and socioeconomic components.

Table 10-6 Environmental benefits of the abiotic component

ABIOTIC ENVIRONMENT

ABIOTIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITY**	**DESCRIPTION**
Abandonment and final restoration	**Landscape**	Changes in landscape integrity	Landscaping	Lastly, the impact generated by landscaping management activities was assessed as positive of severe environmental value, because although it contemplates the reshaping of the landscape, it may increase the area represented by landscape units related to the transformation of covered areas, such as clean lawns and forest, although visually they provide color, texture and shape integrity, having a positive effect regarding its visual condition.
Construction			Grass patching and revegetation	Grass patching and revegetation will generate a positive impact of the severe environmental value as it implies the recovery of topsoil to plant pastures and grass, which from a visual standpoint generate a positive impact, although from a functional and ecological perspective, they do not have a significant repercussion in the intervened landscape. For grass patching and revegetation activities the environmental importance rate was moderate and its affectation positive, given that the actions to be undertaken allow for the recovery, to a certain extent, of microhabitats related to soil, in addition, it allows topsoil regeneration areas, which could potentially become a habitat for species with grazing habits.
			Treatment of slopes	Impact generated on landscape integrity was considered positive and of severe environmental importance, given its extension and permanence in the landscape. As part of this management, in some cases it uses shrub-like plant species that help retain soil and avoid erosive processes, which increases scenic beauty, quality and integrity.

Source: as of EIA. Chapter 8. Environmental Evaluation. 2017.

Table 10-7 Environmental benefits of the abiotic component

SOCIOECONOMIC ENVIRONMENT				
PHASES	**ENVIRONMENTAL ELEMENT**	**ENVIRONMENTAL IMPACTS**	**ACTIVITY**	**DESCRIPTION**
Pre-Construction and Construction	Economic and Productive Structure	Change in the offer and demand of goods and services	Contracting and training of personnel	With the construction of infrastructure works it generates improved dynamics in the economic area, because during the construction stage it requires displacement of people and machinery, which in turn require a series of goods and services. Economic characteristics of population show that demand for goods and services focuses on basic necessity goods and in some cases, restricting the use of some of those elements due to low-income levels of families, daily pay-out does not exceed twenty five thousand pesos. Food comes mainly from subsistence crops that families grow in their land; hence their diet is limited to those products. Contracting and training of personnel will allow the population involved in the project to increase their buying power, generating increases in demand of goods and services and consequently their offer, people will be able to access products that they cannot regularly buy due to limited
Construction			Acquisition of goods and services	
			Mobilization of construction materials, inputs, machinery, equipment and personnel.	

SOCIOECONOMIC ENVIRONMENT				
				income. The mobilization of construction materials, supplies, machinery, equipment and personnel (floating population), will require food, housing and transport, among other goods, this demand is serviced with the existing offer in the area, which according to the characterization made, it services demands of people living in the area, without production surplus, which in turn increases production; regarding services rendered, to increase economic dynamics, generating surpluses to satisfy demand and in turn, leading to improved wellbeing of the community. This situation generates a wave of growth due to the acquisition of goods and services, a circle that becomes larger and larger until it reaches a break-even point between offer and demand, increased revenues for the population, and floating population generate increased demand, driving the economy, which lasts in time.
Abandonment and final restoration	**Social infrastructure**	Changes in the status of road infrastructure	Landscaping management	Changes in the status of road infrastructure is affected in a positive manner due to activities that include actions to improve road infrastructure, which are of great importance for the population as their current status is rather poor, and therefore will positively influence the mobility of such population. It is important to consider the relationship of territorial units with the rural district of the municipality and the exchange in social services and goods and services. The community benefits by having better roads for its mobilization and hence the transport of products from rural arras to the municipal district, reducing transfer costs

Source: as of EIA. Chapter 8. Environmental Assessment, 2017.

10.6 ECONOMIC ASSESSMENT OF ENVIRONMENTAL IMPACTS

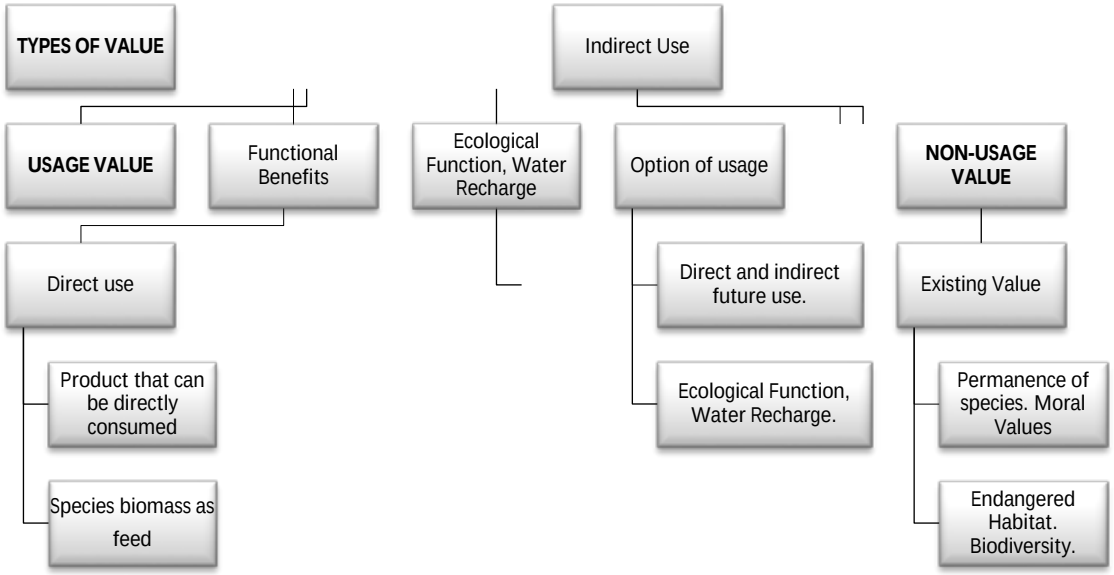
10.6.1 THEORETICAL FRAMEWORK FOR ECONOMIC VALUATION

According to the neoclassical economic vision, valuation is a metric tool that gathers the capacity of ecosystems to satisfy essential needs to life. Ecosystems can be assessed from anthropocentric perspectives where humans assign a value to goods and services of the ecosystem, and from a perspective based on the characteristics of the ecosystem itself, considers its intrinsic value. (WWF, 2014).

In the economic assessment of environmental impact, one begins considering that projects use environmental goods and services, therefore one must pay for those natural resources, and the result is the environmental cost of the project. The foregoing allows the operator of projects to internalize environmental costs as of compensation and mitigation actions as evidenced in the Environmental Management Plan, hence complying with environmental standards.

The economic valuation of environmental impacts implies obtaining the Total Economic Value (TEV), which comprises Usage Value (UV) and Non-usage Value (NUV) of the resource identified, and the values that may be monetized and those that cannot be monetized as shown in **Figure 10-2** and its description in **Table 10-8**

Figure 10-2 Usage and Non-usage Value



Source: Bolt, Ruta y Sarraf (2005); Freeman (2003), Chapman et al (2003).

Table 10-8 Types of Value

TYPES OF VALUE	
Usage value -VU: relates to the direct or indirect use of goods and services of ecosystem by an individual or society. It is divided into:	Direct usage value - DUV: refers to benefits obtained by an individual or society on the use or consumption of ecosystem's goods and services. (i.e. use of timber, seeds, recreation)
	Indirect usage value- IUV: refers to benefits, which are not exclusive to a particular individual, but extend to other individuals in society. i.e. regulation of erosion, water regulation, climate regulation, etc.)
Value of option: it refers to delaying the use of a determined environmental asset for the future. Upon opening the option of taking advantage of such resource at a later date. (i.e. (people would be willing to pay in order to preserve biodiversity to preserve genetic material, such as wild crops)	
Non-usage value - NUV: is the value that individuals or society assign to the mere existence of ecosystems or to the desire to leave benefit in such ecosystems for future generations. It is divided into:	Legacy value - LV: is the value of leaving benefits of ecosystems, directly or indirectly, to future generations (i.e. protection of habitats for the enjoyment of future generations.)
	Value of existence - VE: it is the value that individuals assign to ecosystems, just because they exist. Even if such ecosystem is not currently in use, or will be in use or does not receive any direct or indirect benefit thereof. (i.e. preservation of Panda bears)

Source: as of WWF (2014) and Pulgar & Vidal (2014).

According to the previous benefits, the Total Economic Value (VET – for its Spanish acronym) is expressed in the following equation:

$$VET = VU + VNU = (VUD + VUI + VO) + (VE + VL)$$

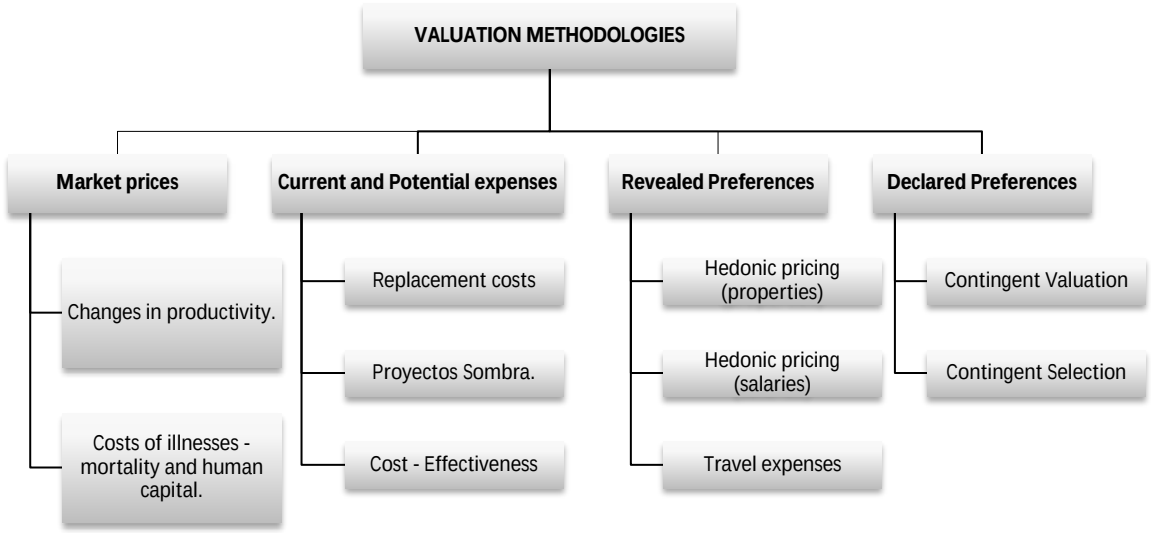
With this equation, one summarizes economic valuation concepts of natural resources and environmental impacts, their instrumentalization and inclusion in development policies and decision-making processes. VET importance focuses on the fact that any natural resource is characterized by having other different values to

the direct use value. If one estimates only usage value, one may underestimate true benefits and/or environmental costs. (Aznar Bellver & Estruch Guitart, 2012)

10.6.2 Economic Valuation Methods for Environmental Impacts

Progress of environmental economy has allowed for the development of methodologies to estimate environmental costs and benefits related to the development of projects. Each method has its own scope and requirements of information that depends on the type of value to be estimated, (usage option and existence) which in turn depend on the type of environmental goods and services. **Figure 10-3** exhibits valuation methodologies.

Figure 10-3 Valuation Methodologies



Source: CEDE – UNIANDES- MAVDT, 2010

It is useful to classify environmental impacts and they way in which a State impacts, either directly or indirectly, men and ecosystems. Freeman (1979), establish the guidelines to classify environmental impacts as of the type of affectation, generating and constituting the starting point for the selection of the most appropriate valuation method, according to available information. Following find a brief description of valuation methodologies.

a. Market pricing direct method: market pricing direct methods assesses the offer and demand of an environmental good and therefore its price. This method includes change in productivity, avoided costs, cost of illnesses and cost of opportunity.
b. Expenses as an approach of benefits: it is an expense that is not longer incurred and represents a benefit. It includes preventive expenses, replacement expenses and expenses of shadow projects.
c. Revealed preference methods: These methods value preferences of individuals by stating the existence of hypothetical markets (Freeman III 1993, Azqueta Oyarzun 1994 cited in Viglizzo et al., 2011). Meaning, that they assess actual behavior both of consumers or producers to identify the value of goods that are not placed in the market when studying supplementary or substitution markets. It

includes methods of replacement cost, travel expenses, hedonic pricing, evasion of damage costs, revenue of net factor, pricing by satisfaction level and production function.

d. Declared preference methods: they assess preferences and selections of people to determine willingness to pay for those services to which it is difficult to assign a monetary value; using surveys and asking to declare their preferences as regards rendering environmental goods and services, which are subsequently used to calculate the value. It may be valued through contingence assessment and selection model.
e. Technique to transfer benefits or value transference: it consists on extrapolating estimated values or functions through other studies conducted based on any economic valuation methodology.

10.6.2.1 Methodologies based on Market Prices

The price of market method estimates the economic values of products and/or services of ecosystems that are bought and sold in commercial markets, and it is used to quantify value changes in the amounts or quality of a good or service (MAVDT, 2003). In this regard, methodologies based on market prices, are: a) changes in productivity (using normal or corrected economic prices – when there are market distortions – of goods and/or services impacted); b) cost of illnesses (quantifies the costs an individual must incurr to service his illness); and c) costs of human capital costs (relates the loss of productivity of human beings as a result of premature death).

10.6.2.1.1 Changes in Productivity

The quality of environmental goods and/or services determines the levels and changes in productivity of other goods, commercial in nature. These changes in productivity generate, as a result, in changes in the environmental quality, either loss of value or gains in production.

Measures used to estimate changes in productivity are based on traditional revenues less costs analyses. Physical changes in production due to environmental changes are values using market prices for supplies and products.

Monetary quantification of the effects on productivity serve to add the results obtained within the project's cost-benefit analysis, in order to consider positive and negative externalities that the economic project generates, on a case-by-case basis.

10.6.2.1.2 Cost of Illnesses (morbidity[1]) and Human Capital (morbidity[2])

The objective of the environmental assessment per cost of illness is intended to quantify morbidity costs related to changes on the environmental quality as a result of a megaproject.

The morbidity valuation through a cost of illness focus, estimates the variation of expenses incurred by individuals as a result of a change in the incidence of a specific illness. Both direct costs (i.e, doctor's appointments, treatment costs, etc.) and indirect costs (i.e. salaries) are included in the estimate.

The valuation of costs of illnesses related to environmental contamination (air, water, soil) requires information on the implicit harm function (related to the dosage-response function), which relates to the level of contamination (exposure) with the degree of effect on health (response).

[1] Change in the probability of a person becoming ill
[2] Change in the probability of dying at a specific age.

The usefulness of valuing morbidity changes and/or morbidity generated by a project helps to aggregate costs/benefits to human health (morbidity and/or mortality) due to changes in environmental quality (water, air, soil). These costs must be added within the costs of the megaproject as a negative externality generated upon population.

To that end, for aggregation it can only take into account population effectively affected, also the result must be shown in unit terms, meaning as cost of treatment or cost of illness per person.

10.6.2.2 Methodologies based on costs

Methodologies based on expenses (preventive, reposition, replacement, etc.) relate the estimate of the values of costs incurred to remediate damage. In these methods it does not provide measure of economic values based on the willingness of individuals to pay for a product or service. The assumption of this method is that if people incurring expenses to avoid damage to ecosystem services, or to substitute ecosystem services, such services must cost at least what people are paying to replace them.

The economic valuation of environmental impacts based on a cost focus, relates to the economic valuation of a set of measures necessary to restore, prevent and compensate environmental damages of a project or economic activity.

Methods that include preventive expenses or replacement costs have become a widely used alternative for project assessment, given the difficulties in using direct methods or that are supported on the use of econometric models, where more often than not, the required information is not available. (Rivera, 2001)

It uses market prices to estimate the environmental cost-benefit, either through prices of products or production costs, and to that end, it assumes that market prices reflect relative shortage of resources and therefore, these are economically efficient prices. To avoid biases during the valuation, in addition to the replacement cost or restoration of the affected good, it must include the cost of opportunity related to loss of productivity. (GEF, MMA, & PNUD, 2010)

Methodologies based on costs, are:

- Replacement Costs (used as an estimate of the contamination cost),
- Shadow costs (similar to reposition and restoration of a physical asset or a natural resource),
- Cost – effectiveness (seeks to estimate the cost of environmental protection in terms of cost of alternate ways of achieving a specific objective)

10.6.2.3 Methods based on Revealed Preferences

10.6.2.3.1 Hedonic pricing methods

According to Aznar Bellver & Estruch Guitart, (2012, p. 44) the hedonic value method consists on measuring to what extent the value of specific market goods are a function of the level reached by a determined variable. It consists on determining the value of an environmental asset or resource by means of a study of how the former makes the value of market goods change.

Hedonic pricing seeks to unveil all attributes of a good that explain their price and find out the quantitative importance of each of them. One of the most common examples in literature correspond to housing as one

does not only buy a property, but also one selects its surroundings, the neighborhood, air quality, noise level, green areas, among other (Azqueta, Alviar, Dominguez, & O´Ryan, 2007).

Part of the objectives of this valuation method described by Barzev, (2002) relate to 1. Making prices of goods or attributes explicit, when no formal market exists for them. And, 2. Using these prices to assess decisions that affect the offer of such attributes (changes in quality).

Economic assumptions stated by this method, according to Rosen, (1974) quoted by the Ministry of the Environment, (2003) correspond to: 1. Prices of goods (real estate and rural property) the latter as relates to environmental characteristics or attributes of its environment. 2. The range of characteristics or attributes of a good is continuous. 3. The amount of a specific characteristic may vary independently, allowing for a linear specification of prices. 4. The selection of a place of a good (real estate: housing and rural properties) depend on individual`s preferences, revenues and prices of environmental attributes in these goods.

In a nutshell, the price reflects the value of determined attributes according to transactions at the time the function of balancing prices arises when offer equals demand, the maximizing rationality of agents, consumers and producers, as well as the existence of perfect competition, which implies that prices reflect the valuation that agents grant to goods. (MAVDT, 2003).

10.6.2.3.2 Travel Costs Method

The Travel Cost Method allows estimating Payment Availability (DAP – for its Spanish acronym) for environmental goods and services, which use is mainly recreational. The economic cost of visiting the site for recreation is used as a substitute measure of its price. (MAVDT, 2003).

The main objective of this method is to estimate the value on account of using such goods, so if a person visits a specific place for recreational purposes, it implies that the enjoyment of such service, provides as a minimum a benefit, which equals travel costs.

10.6.2.4 Methods based on Declared Preferences

10.6.2.4.1 Contingent Valuation Method

The market price method is applicable to values of direct use. Where the value is estimated as of the price in commercial market (offer and demand law). This method may be used to value changes in quantity or quality of environmental goods or services. It uses standard techniques to measure economic benefits of market goods, based on the amount that people negotiate at different prices and the amount supplied at different prices. (MAVDT, 2003).

In cases where environmental goods are exchanged in the market, it observes market prices to obtain an estimate of the marginal value of such goods. However not all environmental goods are usually exchanged in markets, which makes it necessary to use other economic valuation methods.(Linares Llamas & Romero Lopez, 2008).

The method measures usage of resources negotiated in the market, it is an estimate of the surplus of demand and offer using market price data and amounts. The total net economic benefit or surplus of the product is the sum of surplus of demand and surplus of offer.

Avoided costs - this is one of the valuation methods with a market price, corresponding to the cost of avoiding damages and preserving environmental quality. It uses goods and services cost as a benefit measure provided by the ecosystem. (WWF, 2014)

10.6.2.4.2 Transfer of Benefits Method

The benefits Transfer Method, the transfer of results or the transfer of values is based on the premise that the economic value of an environmental asset may be extrapolated as of the result of any study undertaken. (Azqueta et al., 2007). The best advantage of this focus, upon using secondary information, allows cost and time saving.

In this methodology it uses existing information, it makes adaptations and uses economic information of a specific place under certain condition of a resource or a policy and a place exhibiting similar conditions. (MAVDT, 2003). To adapt economic values, it takes into account market distortions such as subsidies, price controls and taxes that may alter the valuation generally these are adjusted to eliminate the effect of distortions stemming from market flaws.

It is based in terms of transference and the transfer value, which is made as of assessing consumer surplus.

The methodological guide for economic valuation of environmental goods and services and natural resources of the Ministry of the Environment (2003) begs the following questions: 1. What was the purpose of generating the estimated value in the initial study? 2. Which group of users was considered in the initial estimate? 3. The study is directed to a specific and sole problem or it is influenced by the size of the estimates obtained? 4. Are values consistent in time? 5. Is it relevant to transfer it to the project that is being valued? 6. Are there adjustments to avoid biases in estimates?

The transfer methodology of fixed values consists on two method, the transfer of benefits of a unique study for the transference method, and it is based in only one relevant study for the site of intervention and the transference of an approximate average value of the benefits of the site of intervention, based on a set of relevant studies and applicable to our subject matter and calculates the extent of the benefits as a statistical measure, by means of a mean or medium (Baca, 2011).

It is important to highlight that when transferring values among different countries, it should adjust income per capita and all other indicators in the country under study.

10.7 ENVIRONMENTAL COST-BENEFIT ANALYSIS

Economic efficiency is related to social profitability indicators; Economic Net Present Value – ENPV and Cost Benefit Ratio – CBR. Alternatives that have greater levels of social profitability indicators would be those that would ensure the most efficient use of resources.

Determining social profitability indicators is possible through and economic assessment or Cost Benefit Analysis. The cost benefit analysis is a project assessment tool, which allows estimating the net benefit of a megaproject, measured from losses and gains generated over social wellbeing.

During the Cost Benefit Analysis, one values positive and negative impacts of the project, which correspond to environmental costs and benefits. It establishes a balance between benefits and costs of the project and it is known as net economic flow and it obtains the discounted flow of benefits and costs using to that end a social discount rate to obtain the social profitability indicator, known as Net Present Value, which is estimated with the following equation.

$$VPN = \sum_i \frac{B_i - C_i}{(1+r)^i} = \sum_i \frac{B_i}{(1+r)^i} - \sum_i \frac{C_i}{(1+r)^i}$$

Where, B_iBenefits: correspond to the valuation of positive impact in year i; C_iCosts: the value of negative impact in year $i; r$ is the social discount rate; i: is the year indicator.

Once NPV is calculated, it applies each acceptance or reject criterion of the project, as shown in **Table 10-9**

Table 10-9 Interpretation of the NPV indicator

NET PRESENT VALUE	INTERPRETATION
$VAN > 0$	Project benefits are greater than costs therefore the project is profitable from a social standpoint, which would imply going ahead with the project.
$VAN = 0$	The project generates benefits equal to costs, considering the social discount rate therefore it does not generate substantial impact on social wellbeing.
$VAN < 0$	Project costs are greater than its benefits. Therefore, it must reject the megaproject, as it generates losses in social wellbeing.

Source: CEDE, Uniandes. MAVDT 2010.

Another social profitability indicator that may be used for the decision analysis corresponds to the Benefit Cost Ratio. Which is the result of the quotient between current value of benefits and current value of costs.

$$RBC = \frac{\sum_i \frac{B_i}{(1+r)^i}}{\sum_i \frac{C_i}{(1+r)^i}} = \frac{VAN_{beneficios}}{VAN_{costos}}$$

Results of this indicator show the contribution of the project to the wellbeing of society as a whole and of its interpretation as shown in **Table 10-10**

Table 10-10 Interpretation of BCR.

BENEFIT COST RATIO	INTERPRETATION
$RBC > 1$	The megaproject generates social wellbeing therefore the megaproject is accepted.
$RBC = 1$	The megaproject does not show substantial changes in social wellbeing therefore it is indifferent.
$RBC < 1$	The megaproject worsens social wellbeing, therefore its execution is not recommended.

Source: CEDE, Uniandes. MAVDT 2010.

The last stage consists on conducting a sensitivity analysis due to the uncertainty regarding some future costs and benefits. Therefore, this analysis must calculate NPV with different parameters, such as: discount rate, physical and monetary amounts of investment and production, shadow prices of the investment and production and life span of the project. With this analysis in mind, it seeks to identify which parameter produces greater sensitivity on NPV. (MAVDT, 2003).

10.8 ECONOMIC VALUATION OF THE ENVIRONMENTAL IMPACTS OF THE PROJECT

10.8.1 OBJECTIVES

10.8.1.1 General Objective

Conduct an economic valuation of environmental impacts generated by the Rumichaca Pasto Divided Highway Project, San Juan – Pedregal Segment, on the physical, biotic and socioeconomic components in its pre construction, construction and operation stages.

10.8.1.2 Specific objectives

- Conduct an economic valuation of environmental impacts as of the matrix for environmental impacts and the environmental management plan, to mitigate, prevent and compensate direct impacts of to the project.
- To economically value the environmental impacts related to the project on natural resources and population.
- Conduct an environmental cost benefit analysis of the project and their interpretation of the resulting profitability indicators.

10.8.1.3 SCOPE OF THE VALUATION

The economic evaluation of environmental impacts will comply with:

- Requires established and terms of reference of the Environmental Impact Study for road and/or tunnel construction projects M-M-INA-02, Version No. 2, (ANLA, 2015), adopted by Resolution 751 of 26 March 2015 of the Ministry of the Environment and Sustainable Development (MADS – for its Spanish acronym).
- General methodology for the presentation of environmental studies Number 2.3.2. Economic valuation of the process of the Environmental Impact Assessment, and
- Technical Manual of Economic Valuation of Environmental Impacts of Projects subject to Environmental Licensing. (CEDE – UNIANDES - MAVDT 2010).

10.8.2 VALUATION PROCEDURE

The procedure for the economic valuation of environmental impacts follows the path established in the Technical Manual of Economic Valuation of Environmental Impacts (CEDE – MAVDT, 2010) for the application of the environmental economic cost benefit analysis (ACB – for its Spanish acronym), in decision making as described in **Table 10-11** considering the stages of the project.

ACB incorporates the environmental impact assessment as of the affectation of environmental goods and services impacted within the economic valuation.

Table 10-11 Stages of the Environmental Cost-Benefit Analysis

N.	STAGES
1	Definition of the project to assess
2	Identification of Project impacts
3	Identification of the most relevant impacts
4	Physical quantification of most relevant impacts
5	Monetary valuation of most relevant impacts
6	Discounting Flow of Benefits and Costs
7	Obtaining Main Decision Criteria
8	Sensitivity Analysis

Source: CEDE, Uniandes – MAVDT, 2010. Economic valuation of environmental impacts in projects subject to environmental licensing.

Information requirements for the economic valuation of environmental impacts are grouped in technical information, which allows quantifying changes in the quality or quantity of environmental goods and services derived from the activities proposed, it allows estimating, in an objective manner, the relationship between cause and effect of total environmental physical and marginal damages. Economic information consists on gathering information on prices of goods and inputs related to environmental goods and services, in conventional markets. This information is useful to express all changes in terms of environmental quality or quantity derived from modifications in the environment resulting from Government policies and human action.

The Project valuation process is conducted by a monetary approximation of negative impacts or environmental costs for each environmental component and element involved, and followed by environmental benefits. Subsequently, environmental costs and benefits are consolidated by environmental components and elements involved, to finally discount the flow of costs and benefits and estimate different economic indicators.

10.9 VALUATION OF ENVIRONMENTAL COSTS

Valuation is made by identifying, assessing and selecting environmental costs and environmental benefits in each phase of the project for biotic, abiotic and socio economic components established and the EIA of the Rumichaca Pasto Divided Highway, San Juan – Pedregal Segment, in Chapter 8, rated as severe impacts as per number 2.3.2. Economic valuation of the Environmental Impact Assessment of the General Methodology for the Presentation of Environmental Studies and the Technical Manual of Economic Valuation of Environmental Impacts in Projects Subject to Environmental Licensing. (CEDE – UNIANDES - MAVDT 2010) involving ecosystem services related to the environmental impact generated.

10.9.1 Valuation of environmental costs

As of the EIA of the Rumichaca Pasto Divided Highway Project, San Juan – Pedregal Segment, number 10.4.2.1 evidences Negative Impacts or Environmental Costs; selected impacts will be susceptible to valuation, given the high rate obtained during EIA. The following table summarizes the foregoing. **Table 10-12**.

Table 10-12 Environmental impact to assess

PHASES	COMPONENT	ENVIRONMENTAL ELEMENT INVOLVED	ENVIRONMENTAL IMPACTS

PHASES	COMPONENT	ENVIRONMENTAL ELEMENT INVOLVED	ENVIRONMENTAL IMPACTS
Construction	**Abiotic**	**Soil**	Change in the use and potential use of soil
			Change in physiochemical and biological properties of soil
			Modification of soil stability
		Surface waters	Alteration of water courses
		Underground waters	Alteration of flow on underground water networks
			Alteration of recharge zones
		Air	Modification in air quality from particulate matter
			Variation of sound pressure levels
		Landscape	Changes in landscape integrity
Construction	**Biotic**	**Fauna**	Affectation of the structural and functional connectivity of wildlife fauna
			Alteration of soil related fauna
			Changes in structure, extension and availability of wildlife fauna habitats
		Hydrobiology	Alteration of habitats in hydro biological communities
Pre-Construction and Construction	**Socioeconomic**	**Social Infrastructure**	Changes in the state of social infrastructure and public services (collective equipment, aqueduct, sewage, electric power, etc.)

Source: as of EIA. Chapter 8. Environmental Assessment., 2017.

10.10 ABIOTIC ENVIRONMENT

- **ENVIRONMENTAL ELEMENT AFFECTED: Soil**

o **ENVIRONMENTAL IMPACT: Change in the use and potential use of soil.**

To value the impact, it takes as reference the loss of productivity due to soil changes, which relates to the cost of opportunity for productive activates to allow the development of the project's infrastructure.

In order to measure affectation of farming activities in the direct area of influence and specifically in the car door it is established the following for the environmental economic valuation of impacts:

- ü In the EIA it determines de maximum area to intervene due to topsoil changes it corresponds to 219,86 ha due to loss of its total productivity during the undertaking of the project.
- ü Productive activities in the project's direct area of influence correspond to potato, maize, peas and bean crops and some fruit shrubs such as blackberry and sweet tomato. Data extracted from EIA, Chapter 5, and Characterization of the area of influence. Socioeconomic environment.
- ü Average yield of crops in tons/hectare as of the information obtained from the Colombian Farming Sector's communication and information network www.agronet.gov.co of the Farming and Rural Development Ministry. 2017 corresponds to:

Crop	ton/ha
Potato	21.04
Maize	1.72
Peas	4.95
Beans	0.93

Blackberry	7.14
Sweet tomato	13.45
Average yield	**8.20**

ü **Average yield of crop prices expressed in COP/Kg for the last 6 years in Pasto's main market in the department of Nariño as of the information obtained from the Colombian Farming Sector's communication and information network www.agronet.gov.co of the Farming and Rural Development Ministry. 2017.**

Crop	Price 2017/kg
Potato	736.62
Maize	1,219.56
Peas	2,084.57
Beans	2,037.14
Blackberry	2,133.33
Sweet tomato	1,419.47
Average price	1,605.11

As per the foregoing, in 2017 the environmental impact value changed in the use and potential use of soils corresponding to $4,312,562,140 and the value for 2017 corresponds to: **$2,896,667.74**

· **ENVIRONMENTAL ELEMENT AFFECTED: Soil**

o **ENVIRONMENTAL IMPACT: Changes in the physical-chemical and biological properties of soil**

Impact valuation is carried out by means of the methodology transfer resulting from benefits, taking the area of 219.8 hectares expressed grasses/lawns, as of the reference value, the analyses conducted by Costanza, et al (2014), aims at reaching an approximate economic value of the benefits of preserving ecosystems.

It considers a reference figure USD 4,418 per hectare for the type of ecosystem in the project. The procedure consists on multiplying the values by the factor resulting from the division of the Consumer Price Index in 2011 for Colombia (0.0373) over the CPI in the US (0.01632), both corresponding to trend related behavior of inflations in those countries in 2011, and it allows for the multiplying effect of:

F=0,0373/0,01632= 2,286

Hence, the value for 2011 is USD 2,219,880.65, which expressed in COP at a representative market rate of $1,942.70 per USD, corresponds to $4,312,562,140 and the value for 2017 corresponds to: **$5,588,870,459**.

· **ENVIRONMENTAL ELEMENT AFFECTED: Soil**

o **ENVIRONMENTAL IMPACT: Modification of soil stability**

For the economic valuation of impacts, it takes into account the erosion tonnage value for hectare of IDEAM (2012) that corresponds to one time per hectare per year. Regarding the project, it corresponds two 219.8 tons per year. The referenced value to quantify erosion tonnage is the figure resulting from final disposal regarding the comprehensive management of solid waste PGIRS 2007-2022, the reference value equals $62,800 per ton, hence, the resulting in environmental cost due to the modification of soil stability amounts to **$13,807,208**

· **ENVIRONMENTAL ELEMENT AFFECTED: Surface water**

o **ENVIRONMENTAL IMPACT: Alteration of water courses**

The economic approximation related to this impact is calculated with the market price methodology as of the EIA, intake points required buy the Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment.

It is estimated that water demand amounts to 486,028.90 m3/year for industrial and domestic use during the stages of the project. The calculation is estimated as of the volume (l/s) of intake sources, with rainy season from October to June (Mayors Office of Pasto, 2007).

Table 10-13 Water intake points requested by the Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment

INTAKE	SOURCE	TIME	VOLUME (L/S)	
			Domestic use	Industrial use
1	Río Guáitara	All year		1.50
2	Río Boquerón	All year	0.45	1.50
3	Quebrada La Humeadora	Rainy season	0.45	1.50
4	Quebrada Moledores	Rainy season	0.45	1.50
5	Quebrada San Francisco 2	Rainy season	0.45	1.50
6	Quebrada El Macal	Rainy season		1.50
7	Río Sapuyes	All year	0.45	1.50
8	Quebrada Yamurayán	Rainy season		1.50
9	Quebrada San Francisco	Rainy season		1.50
10	Quebrada Culantro	Rainy season		1.50
11	Quebrada El Manzano	Rainy season		1.50

Source: GEOCOL CONSULTORES S.A., 2017.

The reference volume per cubic meter of water amounts to 1,319.9 (Empopasto S.A E.S.P, 2017) resulting in an annual cost due to surface water occupation of $ **641,504,685.88**

- **ENVIRONMENTAL ELEMENT AFFECTED: ground waters**

o **ENVIRONMENTAL IMPACT: alteration of the flow of ground water network**

It uses the replacement cost methodology assuming that the cost of treating industrial and domestic wastewater estimated for the project as expressed herein below

- ü Volume it foresees to dispose Divided Highway project 0,44 l/s (0,00044m3) up to 4 hours/day. According to EIA.
- ü The cost of wastewater treatment corresponds to $62,117.65/m3 (Valuation of the Divided Highway Project - Ruta del Sol, 2011)

It is estimated the annual discharge of the project would amount to 143,655,754.35 m3. The environmental cost on account of the alteration of the flow of groundwater's network amounts to $ **143,655,754.35 each year**.

o **ENVIRONMENTAL ELEMENT AFFECTED: ground water**

o **ENVIRONMENTAL IMPACT: alteration of recharge zones.**

Given the affectation of the resource resulting from the temporary or permanent modification of the area of influence of the project, on account of the alteration of recharge zones due to the accumulation of materials it is estimated in the EIA. Chapter 3. Description of the project, the volume of daily waste generation during the project is (125 kg/day).

- ü The generation of lixiviates for the project is estimated as (0.087 m3/day) from data obtained in the comprehensive management plan for solid waste PGIRS 2007-2022 in Pasto, Nariño (146.88 m3/day per 209000 kg of waste/day). The value of reference to calculate the cost of treatment per cubic meter in a leaching treatment plant amounts to $62,117.65/m3 (Valuation of the Divided Highway Project Ruta del Sol, 2011)

The environmental impact due to the alteration of ground waters recharge zone equals $ **6.460.901,01** per year.

- o **ENVIRONMENTAL ELEMENT AFFECTED: Air**
- o **ENVIRONMENTAL IMPACT: Modification of air quality from Particulate Matter**

It uses the cost of valuation method for health, integrating in the result the sum of three variables; Direct costs, such as hospitalization, medicines and medical expenses; indirect costs, among them, days away from work or school; and lastly, the effects on their well-being of society, which lead to a reduction in the quality-of-life of the population. It takes into account the following variables

- ü Based on EIA information. Chapter 5. Characterization of the area of influence taking into account demographic territorial units included in the project (vulnerable population)
- ü Morbidity rate due to acute respiratory illnesses amounts to 80% (SDS,2016)
- ü Direct or indirect costs related to the treatment of acute respiratory illnesses, corresponding to $31,713.73/person according to calculations in the study carried out by the Magazine Panamericana de Salud Publica in Colombia for 2005

Table 10-14 Valuation of health affectation of the population

VALUATION OF HEALTH AFFECTATION OF THE POPULATION	
Vulnerable population (children < 14 years and adults >60)	63,135.00
Morbidity due to upper ways illnesses per pm10 (80%)	50,508.00
Direct and indirect costs $/person	31,713.73
costs ($)/year	**$ 1,601,797,279**

Costs related to health due to the modification of air quality from Particulate Matter amounts to **$1,601,797,279** per year

- o **ENVIRONMENTAL ELEMENT AFFECTED: air**
- o **ENVIRONMENTAL IMPACT: Variation of sound pressure levels**

The methodology to evaluate impact is by transfer of benefit, which allows adapting the information of an original source to the Colombian case. The reference study was developed in Spain and determined that the cost of average reduction of levels per decibel per year (Salazar, 2004), given the figure of 109,95 Euros per 1 decibel per year. The project estimates issuing around 267.2, which for 2004 would amount to 28,499.04 Euros.

Transference is made taking into account Colombian and Spanish CPI for 2004, producing a multiplying effect of F.

F=CPI Colombia year 2004/ CPI Spain year 2004= 5.5/3.04=1.80

Likewise, for 2004 the Euro Market Representative Rate vis-à-vis the Colombia peso amounted to $1,822.32. Hence, affectation values for 2004, amounted to $51,934,370 times the coefficient 1.80, corresponds to $93,481,866. In 2017 it would amount to **$162,723,889.13.**

- **ENVIRONMENTAL ELEMENT AFFECTED: landscape**
- **ENVIRONMENTAL IMPACT: Changes in landscape integrity**

The impact does not need to be valued as it is offset with the benefit over the environmental element itself and the nature of the impact.

10.11 BIOTIC ENVIRONMENT

- **ENVIRONMENTAL ELEMENT AFFECTED: Fauna**
- **ENVIRONMENTAL IMPACT: Affectation of the structural and functional connectivity of wildlife habitats**

The valuation of environmental costs is made with the market price method, given the allocation of prices to ecosystems' goods and services in the ecosystems' market related to structural and functional connectivity of habitats such as carbon capture.

It conducts calculations of losses attributable to the regulation ecosystem's service per carbon capture. S219.86 ha

Table 10-15 Calculation of environmental costs

Prices CO2 SENDECO2 [1]	ton C €/ ha	Ton C COP/ ha	Area ha	Carbon capture mean Ton C/ha[2]	Price per Ton C COP/ ha
CER (€)	€ 5.66 [3]	$ 18,140.40 [4]	219.86	19649,62107	**356,452,082.89**
[1] European negotiating system for CO2 in a regulated market. Certificate of Emission Reduction - CER. www.sendeco2.com. 2017					
[2] As of the biotic characterization in the Classification of the Area of Influence. It estimates in average that carbon capture per ton, C/ha equivalent amounts to 89.37 based on air biomass estimated using field data and information of remote sensors as per studies conducted by Galindo et al., (2011) published by the Hydrology Institute, Meteorology and Environmental Studies (IDEAM)					
[3] Average price per ton C/€ average in the international carbon market from 2008 to 2017					
[4] Exchange rate mean EURO € - COP $ 3,204.28 on 16 May 2017. Banco de la Republica de Colombia. www.banrep.gov.co. 2017					

Source: GEOCOL CONSULTORES S.A., 2017

The affectation of structural and functional connectivity in wildlife fauna are estimated in $**356,452,082.89**

- **ENVIRONMENTAL ELEMENT AFFECTED: Fauna**
- **ENVIRONMENTAL IMPACT: Alteration of soil related fauna – Changes in structure, extension and availability of wildlife habitats.**

Given the complementarity of impacts related to the Fauna element, the economic value is estimated by replacement costs as of the EIA. Chapter 11. Plans and programs, where it determines the Total Cost of Reforestation per Hectare is $10,751,000.

Thus, for 219.86 ha, replacement cost per alteration of soil related fauna, changes in the structure, extension and availability of wildlife fauna amount to **$2,363,714,860.**

· **ENVIRONMENTAL ELEMENT AFFECTED: Hydrobiology**

o **ENVIRONMENTAL IMPACT: Alteration of habitats in hydro biological communities**

The impact is valued through the transfer of benefits methodology, the reference value stems from Costanza, et al (2014), which value per hectare is USD 188 per 2011 for wetlands, with rich hydrological communities. The procedure consists in multiplying the values by the factor resulting from the division of Colombian CPI in 2011 (0.0373) over the US CPI (0.01632), both corresponding to a trend related behavior of inflation in such countries during 2011, allows for the multiplier effect of:

F=0.0373/0.01632= 2.286

For which the value during 2011 is USD $94.463, which expressed in Colombian pesos at a market representative rate of $1,942.70 per USD, corresponds to $183,513,283 and the 2017 value amounts to: **$ 237,824,275.**

10.12 SOCIOECONOMIC ENVIRONMENT

· **ENVIRONMENTAL ELEMENT AFFECTED: Social Infrastructure**

o **ENVIRONMENTAL IMPACT: Changes in the state of social infrastructure and public services (collective equipment, aqueduct, sewage, electric power, etc.)**

The valuation methodology in the socioeconomic component on account of the change in social infrastructure is based in the change of income in the region by potential changes in the per capita income of the population located in the area of influence of the project.

It estimates that 12.5% will be the annual expectation of the project given the investment. GDP per capita is forecasted in the region for 20 17, based on data from the National Statistics Department, 2005 for 176,658 inhabitants in the direct area of influence of the project (large and small territorial units). The expectation for inhabitants corresponds to $134,370/year

The cost related to the change in the state of social infrastructure and public services due to the expectations that the project might have amounts to **$ 23,737,543,602.69/ year**

10.13 VALUATION OF ENVIRONMENTAL BENEFITS

According to neoclassical economic theories, socio-environmental benefits are the results of all those involuntary effects generated upon the wellbeing of people and companies, which are also known as positive externalities, which cause benefits to third parties (Chang, 2005). Likewise, the General Methodology to present Environmental Studies adopted by Resolution 1503 of August 4, 2010; it considers as benefits: the values of preventive, corrective and mitigation actions and the employment generated, as well as taxes on account of the project.

Acfording to the foregoing, benefits are determined by positive externalities on account of the development of the project, the generation of employment and is summarized in **Table 10-16** giving a value of relevant environmental significance and positive in nature, which makes it susceptible to valuation according to the General Methodology and their remaining as they are supported by employment and investments the company must undertake.

Table 10-16 Environmental benefits of the construction stage to evaluate

PHASES	ENVIRONMENT	ENVIRONMENTAL ELEMENT AFFECTED	ENVIRONMENTAL IMPACTS
Pre- Construction and Construction Abandonment and final restoration	Socioeconomic	**Economic and Productive structure**	Changes in the offer and demand on account of goods and services
		Social Infrastructure	Changes in the state of road infrastructure
Abandonment and Final Restoration Construction	Abiotic	**Landscape**	Changes in landscape integrity
1% investments			

Source: as of the EIA. Chapter 8. Environmental Assessment., 2017.

- **Investments related to intake from water sources (1%)**

The evaluation of this environmental benefit is directly related to the investment of specific destination as a result of intake of surface loquacious waters throughout the project for domestic and industrial use. The Evaluation relates to the economic resources estimated as of the 1% destined to the recovery, preservation, conservation and surveillance all water basins that feed water sources got provide the resource, according to Decree 1900 of 2006. Table 14 shows the distribution of investment resources:

Table 10-17 Investment of 1%

Activity	Percentage to invest	Value
Reforestation	50%	$ 3,891,118,566
Isolation of water system.	10%	$ 778,223,713
Purchase of land	20%	$ 1,556,447,426
Incentives to landowners for revegetation and conservation	20%	$ 1,556,447,426

Source: GEOCOL CONSULTORES S.A., 2017

10.13.1 SOCIOECONOMIC ENVIRONMENT

- **ENVIRONMENTAL ELEMENT AFFECTED: Economic and Productive Structure**

o **ENVIRONMENTAL IMPACT: Change in the offer and demand of goods and services**

The methodology to value the impact as a benefit relates to contracting manpower for the project, specially unskilled manpower, taking into consideration that during the first quarter of 2017 unemployment rate reached 11.5% (DANE, 2017) in the Nariño department. Table 15 shows the values related to the creation of employment under the premise that manpower contracted for the undertaking of the project is manpower from the department.

Table 10-18 Project employment

Number of jobs generated by the project	Minimum salary SMLMV (Integral)	Duration of the project (months)	Total value in pesos ($)
250	$1,121,337	39	**$10,933,035,750**
* it takes into account the project with data from the Chapter, Project Description. ** salary is based on the monthly minimum salary for 2017, amounting to $732,900. *** the time in the job is adjusted to the project timetable, which duration has been established as 39 months.			

Source: GEOCOL CONSULTORES S.A., 2017

· **ENVIRONMENTAL ELEMENT AFFECTED: Social infrastructure**

o **ENVIRONMENTAL IMPACT: Changes in the conditions of road infrastructure**

Given the changes in the state of road infrastructure, it takes operation costs, which translate as development benefits for the project, as well as savings in travel time, all of this as a result of an improved articulation of space-functional relations in the region, from different places and towards different destinations enabled by the border road.

§ **Operational costs:**

Table 10-19 Costs of time saved in annual travel

Type of vehicle	Daily number of vehicles*	Operation costs on paved roads ($/Km)** Mountainous (Chapter 3)	Operation costs on paved roads ($/Km)** Curved slightly sloppy (Chapter 3)	Average costs of operation Terrain 2014	Total Costs per Category 2014 per Km
I	2936	857	864	861	$74,341,116
IE	48	1130	1140	1135	$1,588,637
II	1103	1857	1872	1864.5	$59,968,808
IIA	12	2471	2482	2476.5	$866,577
III	114	1363	1379	1371	$4,557,533
IV	51	2352	2371	2361.5	$3,511,928
V	169	4157	4266	4211.5	$20,754,440
Total					$165,589,040
Total (2017, aggregate to March-DANE)					**$192,574,346**
Total year-2017					**$70,289,636,463**
*Chapter on Traffic Divided Highway Project Rumichaca-Pasto. **Data from INVIAS 2014. ***Kilometer of the project 29,16.					

Source: GEOCOL CONSULTORES S.A., 2017

ü Costs due to savings in time

According to CONPES 3760 of 2013, time savings on the Divided Highway Medellin-Cali is estimated in COP 8.3 trillion per year, corresponding to savings of $19,861,210,816 per kilometer and per vehicle, savings amount to $1,986 according to the mobility of 10,000,000 vehicles on this road, for the Segment San Juan-Pedregal shows the following:

Table 17. Cost by savings on annual travel

Daily vehicles (average)	Annual vehicles	Average value per vehicle	Total value ($) 2013	Total value ($) 2017
4433*	1,618,045	$1,986	**$3,213,633,285**	**$3,990,362,984**
*Chapter on traffic in the Divided Highway Project Rumichaca-Pasto.				

Source: GEOCOL CONSULTORES S.A., 2017

10.13.2 ABIOTIC ENVIRONMENT

- **ENVIRONMENTAL ELEMENT AFFECTED: Landscape**
- **ENVIRONMENTAL IMPACT: Changes on landscape integrity.**

It does not need to be valued; the benefit is offset with the negative nature of the impact.

10.14 COST-BENEFIT ANALYSIS

Project's cost-benefit analysis shows a proportionality principle between costs and benefits of the project, hence the ABC of the project will equal to: **2.68**, which makes the project feasible.

AÑO	2017	2018	2019	2020	2021	2022	2023
ENVIRONMENTAL BENEFITS							
Investments due to water intake (1%)	$ 7,782,237,131	$ 8,229,715,766	$ 8,702,924,423	$ 9,203,342,577	$ 9,732,534,775	$ 10,292,155,525	$ 10,883,954,467
Change in the offer and demand of goods and services	$ 10,933,035,750	$ 11,561,685,306	$ 12,226,482,211	$ 0	$ 0	$ 0	$ 0
Changes in the state of road infrastructure	$ 74,279,999,447	$ 78,551,099,415	$ 83,067,787,632	$ 87,844,185,420	$ 92,895,226,082	$ 98,236,701,582	$ 103,885,311,923
SUBTOTAL	$ 92,995,272,328	$ 98,342,500,487	$ 103,997,194,265	$ 97,047,527,997	$ 102,627,760,857	$ 108,528,857,106	$ 114,769,266,390
ENVIRONMENTAL COSTS							
ABIOTIC ENVIRONMENT							
Changes in the use and potential use of soil.	$ 2,896,668	$ 3,063,226	$ 3,239,362	$ 3,425,625	$ 3,622,598	$ 3,830,898	$ 4,051,174
Changes in physical-chemical and biological properties of the soil.	$ 5,588,870,459	591,023,051,000	$ 6,250,068,765	$ 6,609,447,719	$ 6,989,490,963	$ 7,391,386,693	$ 7,816,391,428
Modification of soil stability.	$ 13,807,208.00	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Alteration of watercourses.	$ 641,504,685.88	$ 678,391,205	$ 717,398,700	$ 0	$ 0	$ 0	$ 0
Alteration of recharge zones.	$ 6,460,901.01	$ 6,832,403	$ 7,225,266	$ 0	$ 0	$ 0	$ 0
Modification in air quality due to Particulate Matter.	$ 1,601,797,279.00	$ 1,693,900,623	$ 1,791,299,908	$ 1,894,299,653	$ 2,003,221,883	$ 2,118,407,141	$ 2,240,215,552
Variation in sound pressure levels.	$ 162,723,889.13	$ 172,080,513	$ 181,975,142	$ 0	$ 0	$ 0	$ 0
BIOTIC ENVIRONMENT							

Affectation of structural and functional connectivity of wildlife habitats	$ 356,452,082,89	$ 376,948,078	$ 398,622,592	$ 421,543,391	$ 445,782,136	$ 471,414,609	$ 498,520,949
Alteration of soil fauna – Changes in structure, extension and availability of wildlife fauna habitats.	$ 2,363,714,860	$ 2,499,628,464	$ 2,643,357,101	$ 2,795,350,134	$ 2,956,082,767	$ 3,126,057,526	$ 3,305,805,834
Alteration of hydro biological communities habitats.	$ 237,824,275,00	$ 251,499,171	$ 265,960,373	$ 281,253,095	$ 297,425,148	$ 314,527,094	$ 332,612,401
SOCIECONOMIC ENVIRONMENT							
Changes in the state of social infrastructure and public services,	$ 23,737,543,602,69	$ 25,102,452,360	$ 26,545,843,371	$ 0	$ 0	$ 0	$ 0
SUBTOTAL	$ 34,713,595,910	$ 36,695,026,553	$ 38,804,990,580	$ 12,005,319,617	$ 12,695,625,495	$ 13,425,623,961	$ 14,197,597,339
CASH FLOW	$ 58,281,676,418	$ 61,647,473,934	$ 65,192,203,685	$ 85,042,208,380	$ 89,932,135,362	$ 95,103,233,146	$ 100,571,669,051
NPV Social discount rate 12%	$ 52,037,211,087.20	$ 55,042,387,441.19	$ 58,207,324,719.06	$ 75,930,543,196.72	$ 80,296,549,430.53	$ 84,913,601,022.79	$ 89,796,133,081.60

	2024	2025	2026	2027	2028	2029	2030
ENVIRONMENTAL BENEFITS							
Investment due to water intake (1%)	$ 11,509,781,849	$ 12,171,594,305	$ 12,871,460,978	$ 13,611,569,984	$ 14,394,235,258	$ 15,221,903,786	$ 16,097,163,253
Changes in the offer and demand of goods and services	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Changes in the state of road infrastructure and public services	$ 109,858,717,358	$ 116,175,593,606	$ 122,855,690,239	$ 129,919,892,427	$ 137,390,286,242	$ 145,290,227,701	$ 153,644,415,794
SUBTOTAL	$ 121,368,499,207	$ 128,347,187,912	$ 135,727,151,217	$ 143,531,462,412	$ 151,784,521,500	$ 160,512,131,487	$ 169,741,579,047
ENVIRONMENTAL COSTS							
ABIOTIC ENVIRONMENT							
Changes in the use and potential use of soil.	$ 4,284,117	$ 4,530,454	$ 4,790,955	$ 5,066,435	$ 5,357,755	$ 5,665,826	$ 5,991,610
Changes in physical-chemical and biological properties of the soil.	$ 8,265,833,935	$ 8,741,119,386	$ 9,243,733,751	$ 9,775,248,441	$ 10,337,325,227	$ 10,931,721,427	$ 11,560,295,409
Modification of soil stability.	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Alteration of water courses	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Alteration of recharge zones.	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Modification in air quality due to Particulate Matter.	$ 2,369,027,946	$ 2,505,247,053	$ 2,649,298,759	$ 2,801,633,437	$ 2,962,727,360	$ 3,133,084,183	$ 3,313,236,524
Variation in sound pressure levels	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0

BIOTIC ENVIRONMENT							
Affectation of structural and functional connectivity of wildlife habitats	$ 527,185,904	$ 557,499,093	$ 589,555,291	$ 623,454,720	$ 659,303,367	$ 697,213,310	$ 737,303,075
Alteration of soil fauna – Changes in structure, extension and availability of wildlife fauna habitats.	$ 3,495,889,670	$ 3,696,903,326	$ 3,909,475,267	$ 4,134,270,095	$ 4,371,990,625	$ 4,623,380,086	$ 4,889,224,441
Alteration of hydro biological communities habitats.	$ 351,737,614	$ 371,962,527	$ 393,350,373	$ 415,968,019	$ 439,886,180	$ 465,179,635	$ 491,927,465
SOCIOECONOMIC ENVIRONMENT							
Changes in the state of road infrastructure and public services	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
SUBTOTAL	$ 15,013,959,186	$ 15,877,261,839	$ 16,790,204,394	$ 17,755,641,147	$ 18,776,590,513	$ 19,856,244,468	$ 20,997,978,525
CASH FLOW	$ 106,354,540,022	$ 112,469,926,073	$ 118,936,946,822	$ 125,775,821,265	$ 133,007,930,987	$ 140,655,887,019	$ 148,743,600,523
NPV Social discount rate 12%	$ 94,959,410,733.79	$ 100,419,576,850.98	$ 106,193,702,519.91	$ 112,299,840,414.81	$ 118,757,081,238.66	$ 125,585,613,409.88	$ 132,806,786,180.95

2031	2032	2033	2034	2035	2036

ENVIRONMENTAL BENEFITS

Investment due to water intake (1%)	$ 17,022,750,140	$ 18,001,558,274	$ 19,036,647,874	$ 20,131,255,127	$ 21,288,802,297	$ 22,512,908,429
Changes in the offer and demand of goods and services	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Changes in the state of road infrastructure	$ 162,478,969,702	$ 171,821,510,460	$ 181,701,247,311	$ 192,149,069,032	$ 203,197,640,501	$ 214,881,504,830
SUBTOTAL	$ 179,501,719,842	$ 189,823,068,733	$ 200,737,895,186	$ 212,280,324,159	$ 224,486,442,798	$ 237,394,413,259

ENVIRONMENTAL COSTS

ABIOTIC ENVIRONMENT

Changes in the use and potential use of soil,	$ 6,336,128	$ 6,700,455	$ 7,085,732	$ 7,493,161	$ 7,924,018	$ 8,379,649
Changes in physical-chemical and biological properties of the soil.	$ 12,225,012,395	$ 12,927,950,608	$ 13,671,307,768	$ 14,457,407,965	$ 15,288,708,923	$ 16,167,809,686
Modification of soil stability.	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Alteration of water courses	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Alteration of recharge zones.	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
Modification in air quality due to Particulate Matter.	$ 3,503,747,624	$ 3,705,213,112	$ 3,918,262,866	$ 4,143,562,981	$ 4,381,817,852	$ 4,633,772,379
Variation in sound pressure levels	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0

BIOTIC ENVIRONMENT

Affectation of structural and functional connectivity of wildlife habitats	$ 779,698,002	$ 824,530,637	$ 871,941,149	$ 922,077,765	$ 975,097,237	$ 1,031,165,328

Alteration of soil fauna – Changes in structure, extension and availability of wildlife fauna habitats.	$ 5,170,354,846	$ 5,467,650,250	$ 5,782,040,139	$ 6,114,507,447	$ 6,466,091,626	$ 6,837,891,894
Alteration of hydro biological communities habitats.	$ 520,213,294	$ 550,125,558	$ 581,757,778	$ 615,208,850	$ 650,583,359	$ 687,991,902
SOCIOECONOMIC ENVIRONMENT						
Changes in the state of road infrastructure and public services	$ 0	$ 0	$ 0	$ 0	$ 0	$ 0
SUBTOTAL	$ 22,205,362,290	$ 23,482,170,621	$ 24,832,395,432	$ 26,260,258,169	$ 27,770,223,014	$ 29,367,010,837
CASH FLOW	$ 157,296,357,553	$ 166,340,898,112	$ 175,905,499,753	$ 186,020,065,989	$ 196,716,219,784	$ 208,027,402,421
NPV Social discount rate 12%	$ 140,443,176,386.36	$ 148,518,659,028.57	$ 157,058,481,922.72	$ 166,089,344,633.27	$ 175,639,481,949.69	$ 185,738,752,161.79

10.15 SENSITIVITY ANALYSIS

The sensitivity analysis allows determining if in despite of taking away one of the benefits of the project, for the 1% investment, the project continues being viable as RBC is 2.45,

COSTO / BENEFICIO	RBC
$34,713,595,910	2.45
$85,213,035,197	

Source: GEOCOL CONSULTORES S.A., 2017.

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