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

Géminis Consultores Ambientales S.A.S

Chapter 10. ENVIRONMENTAL ECONOMIC VALUATION

San Juan de Pasto, March 2017

TABLE OF CONTENTS

INDEX OF TABLES

INDEX OF FIGURES

10. ENVIRONMENTAL ECONOMIC VALUATION

This document integrates the Environmental Impact Study for the environmental impact study for the Rumichaca - Pasto road project, Pedregal-Catambuco span, concession contract under scheme APP No. 15 of 2015, based on the document General Methodology for Submission of Environmental Studies of the Ministry of the Environment, Housing and Territorial Development[1] .

The objective of this section is to perform an economic evaluation exercise methodologically adjusted to legal requirements, allowing us to elucidate by applying environmental economic assessment strategies (internalization, economic valuation), obtaining decision making criteria and global order effects indicators (positive and negative) associated with implementation of the project on abiotic, biotic and socio-economic environment.

10.1 Environmental Economic Assessment Methodology

In accordance with the Manual of Economic Evaluation of Environmental Impacts of Projects Subject to Environmental Licensing, the environmental cost-benefit analysis is a planning tool that allows you to make decisions, as well as, to conclude on the environmental viability of a project from the variations produced thereby on social welfare.[2]

The methodological process detailed in the specific study on treatment of negative impacts as cost generators, is illustrated in Figure 10.1 Methodological steps for the economic evaluation. The positive impacts of benefit generators will follow a similar process except when selecting relevant impacts, whose specific cases are outlined in the corresponding section.

[1] Ministry of the Environment, Housing and Territorial Development. (2010). General methodology for the submission of Environmental Studies. Bogota.
[2] Ministry of the Environment, Housing and Territorial Development; de los Andes University. (2010). Technical Manual of economic evaluation of environmental impacts of projects subject to environmental licensing. Bogota.

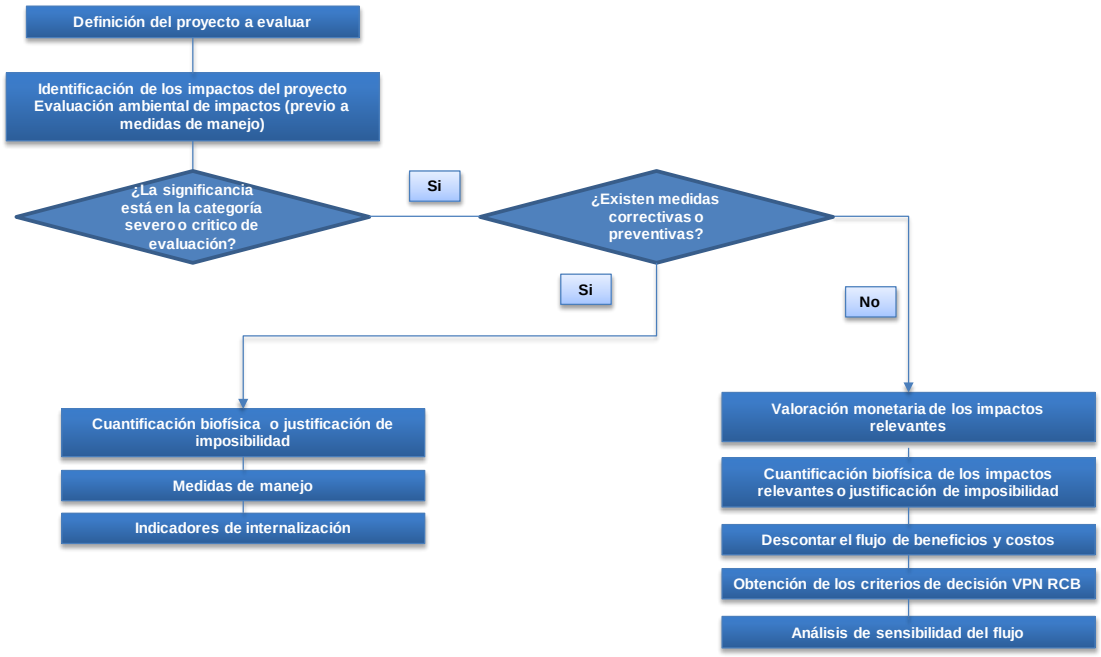

Figure 10.1 Methodological steps for the economic valuation

Source: Géminis Consultores Ambientales, 2016,
Based on Ministry of the Environment, Housing and Territorial Development; de los Andes University, 2010.

In this order of ideas, Figure 10.1 allows abstracting the most important steps to apply during the process of environmentally assessing the impacts, which are summarized below:

Step 1. Define the project to be assessed: The proper definition of the project enables, initially, establishing economic flows that will be included in the analysis.

Step 2. Identify impacts relevant to the economic evaluation: In this step, the most relevant impacts that will be part of the economic evaluation and appropriate economic evaluation strategy are recognized, whether internalization or monetary valuation.

Step 3. Internalization analysis: The internalization impacts analysis allows including management plans, as well as monitoring and follow-up plans as instruments for internalizing the negative impacts. Thus, impacts that can be internalized do not derive

in their economic valuation, since they would not be generating effects resulting in social costs.

Step 4. Physical quantification: As a result of this evaluation process stage, the physical quantities of identified impacts are obtained in such a way as to facilitate translating the resulting amounts to monetary values.

Step 5. Monetary valuation of the most relevant impacts: The physical units of obtained physical amounts of the most relevant impacts are converted to standardized and comparable monetary units.

Step 6. Discount the flow of benefits and costs: This exercise allows bringing all derived values regardless of the project phase where they are materialize to a present value. This value will allow comparing the monetary values of identified benefits and costs.

Step 7. Obtain decision criteria: The first criterion calculated is the NPV (net present value) that allows observing if the project is beneficial in terms of welfare for society or if the simple implementation of the project generates more harm than benefits to the environment and the society.

The second criterion calculated is the benefit-cost ratio that indicates the magnitude of losses or gains in welfare for society with respect to the costs incurred by project development.

Obtaining these two criteria allows knowing whether the project as a whole impacts negatively or positively the environment in which it is developed.

Step 8. Sensitivity analysis: Having obtained criteria indicators, it is necessary to observe how they vary in response to changes in the parameters under which the flow of benefits and costs are built. This exercise is used to identify variables (of a socio-economic, biotic or abiotic nature) whose behavior must be taken into account throughout project implementation because any drastic change can seriously affect the decision making criteria indicators making a project be beneficial to generating environmental losses during its development.

Lastly, it is important to note that aforesaid exercise developed under an economic perspective, that is, the results obtained therefrom, should not be construed under no circumstances as a financial project evaluation.

10.2 Define the project to be evaluated

The Pedregal-Catambuco road span is part of the "Rumichaca - Pasto" road project. This stretch of road has an estimated origin - destination length of 32.76 Km. The fundamental purpose of the project is to convert the existing infrastructure into a high specification dual carriageway, improving the communication of all the country's southwest between Cali, Popayán, Pasto and the border with Ecuador. The activities are described in detail in Section 3.2.2 of Chapter Project Description.

10.3 Identify relevant impacts to the economic evaluation

Considering that, technically, it is not feasible to carry out the economic evaluation of all environmental impacts identified in the assuming is assumed that the other impacts can be controlled and have negligent effects (Ministry of the Environment, Housing and Territorial Development; de los Andes University, 2010). In this sense, impacts selected as relevant to the economic evaluation were identified as those negative impacts that were evaluated in the two highest importance categories, shown as severe or critical in the environmental impact evaluation (in this respect to note that environmental impacts evaluated as critical were not evaluated). With regard to positive impacts, those referring to beneficial impacts or high beneficial impacts were evaluated. To clarify that in addition to matrix identified impacts, the benefit to the local economy from the temporary employment offered by the project are included.

Under these considerations, fifteen (15) impacts were evaluated , that due to the environmental evaluation conducted, as contained in the evaluation matrix with project in the respective chapter, obtained the qualification of *severe*, *critical*, *beneficial* and *highly beneficial*. These impacts as expected are generated almost in entirely during the **construction phase** (14), and one in the abandonment and final restoration phases, which is considered as an impact correct

activity reason why its inclusion will not be evaluated in the economic evaluation. (Table 10-1)

Table 10-1 Significant impacts considered for the economic evaluation

ETAPAS DEL PROYECTO	CONSTRUCCIÓN					ABANDONO Y RESTAURACIÓN FINAL
ACTIVIDADES DEL PROYECTO / IMPACTO AMBIENTAL	Remoción de cobertura vegetal	Descapote	Excavaciones y/o explanaciones	Construcción de superestructura para viaductos y puentes	Empradización y revegetalización	Manejo Paisajístico
Fenómenos de remoción en masa					53	
Inestabilidad de laderas					52	
Cambio en la estructura del suelo		-75			58	
Modificación del uso actual del suelo	-62				58	
Obstrucción o alteración de cauces, márgenes y rondas hídricas					75	55
Cambio en la superficie de coberturas de bosques y áreas seminaturales	-56				66	
Fragmentación y cambios en la conectividad de hábitats	-58		-57			
Modificación en la composición y estructura de la fauna	-54	-53				
Cambio en la infraestructura vial existente				54		

10.4 Environmental economic assessment strategy

The following was considered when defining the economic analysis method to be used, (i) the possibility of internalization based on preventive or corrective management measures, (ii) the possibility of joint evaluations for income-generating activities whose impacts or effects were closely linked, and even that the effects of an impact could be the causes or consequences of others; (iii) the characteristics of income-generating activities as generators of costs or benefits, in particular when defining benefits from some impacts identified as positive. (See Table 10-2).

Table 10-2 Negative impacts evaluation strategy

Impact	Strategy
Mass removal phenomena	Internalization. This positive impact derives from the re-vegetation activities, which, although inherent to the construction process, trigger positive externalities on the instability conditions of the slopes existing in the road corridor where the greater part of the road is built; for this reason, the impact is internalized in the costs incurred in the construction of the work indirectly becoming defensive expenditures.
Slope instability	Internalization. This impact has a series of measures that not only contribute to mitigate the effects, but also prevents and corrects any contingent effect. It is also worth clarifying that, in spite of the fact that the area of influence is geomorphologically characterized, there is an impossibility due to the uncertainty to determine the exact location where the impact could happen; however, management measures that will be implemented are mainly aimed at preventing these situations.
Soil structure changes	Monetary valuation. A joint evaluation with the impact of modifying the current land use is considered, given that vegetation cover and top soil removal activities are carried out. In this regard, we proceeded to the monetary valuation by changing of use of a series of productive agricultural and forestry activities to be used as road, which includes the road structures, ZODMES, temporary installations, superstructures, etc.
Current land use modification	
Obstruction or alteration of channels, margins, and riparian corridor	Internalization. Derived from re-vegetation activities part of the construction process, and of the landscape management activity in the abandonment and final restoration stages, both of which are required by the work, but which end up by unleashing positive externality, reason why is considered to be internalized as a shadow price.
Changes in forests cover and semi-natural areas	Monetary valuation. These impacts are evaluated by means of the monetary valuation of the vegetation cover according to forest inventories made and are associated to a loss for carbon capture. With these two aspects, the factors having an incidence on the loss of ecosystem functionality provide thereby are appraised.
Fragmentation and changes in the habitats connectivity	Internalization. To highlight that the current state of fragmentation of habitats includes the current road reason why the barrier effect, although it can accentuate in some way due to the dual carriageway expansion, had already generated that effect, is considered internalized with management and dependent on the value attributed to the change in forest cover.
Changes in fauna composition and structure	Internalization. This impact refers to the fauna component and will be evaluated from the internalization of its effects by means of proposed preventive and corrective management measures. It is also necessary to emphasize that the project proposes as the primary measure constructing fauna crossings.

Impact	Strategy
Changes in current road infrastructure	Monetary valuation. The positive impact on mobility and infrastructure will be valued expressed in less travel time with consequent operation reduced operation costs.

Source: Géminis Consultores Ambientales, 2016,

10.5 Internalization analysis

The next paragraph presents the relationship of impacts selected in the previous section. In this respect to consider that internalized environmental impacts are understood as all those impacts that are prevented and/or corrected through development of the activities presented in the project's management plans, so that these violations of the resources or impacted environmental service return to levels close to those they had before the project, or simply preventing their occurrence. This means, that the social costs of such damages are borne by the project by managing to incorporate the social costs (internalize) in the costs of implementing those plans and therefore within the flow of private costs.

In this regard, it is worth noting that Law 99 of 93 states in Article 1, numeral 7 that "The State shall promote incorporating the environmental costs and the use of economic instruments to prevent, correct and restore environmental deteriorations for the conservation of renewable natural resources", this refers to the concept of internalization of externalities specially developed by Baumol and Oates. In this order of ideas, externalities are due to environmental goods and services in general being understood as of common use or as pure public goods, this feature on the rights of property usually does not have a market defined price, so that neither the use nor the impact thereto is incorporated in the private costs of whoever uses or impacts such goods or services. Such externalities imply that the costs for the use and damage of environmental goods or services by a private person, is transmitted to the society for whom the goods or services are of common or public use.

In this way internalization allows including externalities in the private costs (of the private agent) by correcting this flaw in property rights. Such internalization processes are treated from the economy of public property and transaction costs through the command-and-control solutions based on the Pigou and Coase theories. So, the first

seeks control by means of direct intervention such as taxes, while the second opts for allocating the property rights of the impact to the agent that caused them. However, a more pragmatic approach arises from developments in environmental management that are closest to Coase.

In this sense, the command-and-control mechanisms whether of the Pigouvian or Coasiano type, together with other institutional arrangements of the organizations (such as reputation) will lead to the search for instruments such as environmental management plans, which seek to correct and/or prevent environmental costs such as internalization mechanisms of these costs.

As indicated above, the internalization assumption under the exante focus of the study is subject to monitoring and follow-up of the measures listed below. In this way, with the understanding that these measures are designed to prevent and/or correct the impact only after (ex-post focus) monitoring and/or follow-up, can conclude on the effectiveness of such measures and therefore on assumed internalization. Impacts evaluated in this section respond to the results obtained in Chapter 8, which in regard to Chapter 11.1, establish the environmental management measures taken for each one thereof.

10.5.1. Mass removal and slope instability phenomena

As noted in above chapter 8 and in the environmental assessment matrixes, these impacts make up the landform element of the geospheric component.

- Biophysical quantification

In general terms the mapping, the geological, morphogenetic and structural characteristics of the road corridor have defined the landforms present in the study area, with emphasis on the stability conditions of the lithological units and the response thereof to these weathering and erosion processes, which are presented in Table 10-3.

Table 10-3 Local geomorphology

LANDSCAPE	LANDFORMS	MORPHOGENETIC ENVIRONMENT	NOMENCLATURE	PRESENCE PERCENTAGE
Rolling hills	Pyroclastic deposit rolling hills	Volcanic, denudational	VDldp	35%
Rolling hills	Rolling hills with pyroclastic mantles	Volcanic, denudational	VDcmp	30%
Mountain	Denuded hillsides with steep slopes	Denudational	Dldp	20%
Valley	Colluvial-alluvial deep dissection small valley	Fluvial	Fvca	2%
Valley	Steep alluvial valley	Fluvial	Fvap	5%
Anthropic	Anthropic bodies	Anthropic	Antr	2%
Valley	Colluvions	Denudational	Dqc	5%
Erosional	Mass movements, crowns and erosion	Denudational	Dmce	1%

Source: Géminis Consultores, 2016. Línea base abiótica.

As described in the geology and geomorphology baseline, based on these lithological, structural and geomorphological features homogeneous areas were defined, on which the mass removal analysis was based. In this sense, an extension development on this topic is found in the abiotic baseline. However, the component is briefly addressed. Identified unstable areas in Homogeneous Zone I were analyzed according to the lithology and the processes associated with each one of them, making the pertinent classification in the form of erosion, falls, landslides or flows and their possible causes, mobilized material, type and speed of the movement.

9 sectors with instability were located along the corridor of Homogeneous Zone I according to field survey. These sectors present instability due to erosion, rock landslides and the action of gravity, according to the materials present in the area mainly volcanic materials, mostly ash, lahars and pyroclastic (Local Geological Maps, scale 1:5000).

The slopes in these spans vary from moderately inclined (7-12%) to fully steep (100%), which corresponds to lahars and pyroclastic (TQvlp) and, to a lesser extent, La Magdalena Volcanic Sedimentary Unit (TQsv).

In the K16+100 area, coordinates 966.060E and 613741N, on the cut slope of the road in Lahars and Pyroclastic unit (TQvlp) the presence of low magnitude old gravitational movements were observed, associated with highly weathered materials reflecting a level IIA. Diffused soil erosion from runoff water dispersing the fine pyroclastic deposit materials was also noted. Some of the vulnerable sectors are described below.

The PD 5-2 on the left slope of the current road that leads to the municipality of Pasto, at K16+520 coordinates 966.273E and 613768N, in the upper part of the cut there was evidence of material rupture from the top of the slope in the Lahars and Pyroclastic unit (TQvlp). The detachment does not cover the full slope cut of the road reason why it only applies to accommodation of the pyroclastic deposit after having been intervened. The lower part of the slope has deposit of materials removed by the natural erosion of the pyroclastic materials of the slope.

The PD 5-3 on the slope of the route at K16+620 coordinates 966.368N and 613709E debris flows were observed emerging along the slope from its top. These rocks corresponding to the Lahars and Pyroclastic unit (TQvlp) become detached due to erosion of the pyroclastic deposit matrix, leaving the blocks of volcanic rock without support leading to detachment of the blocks causing flows.

The PD 5-4 in K16+804.43 with coordinates 966.532N and 613801E, there is a slope of pyroclasts of the Lahars and Pyroclastic unit (TQvlp), which is composed of volcanic rock blocks in a fine ash compositional matrix. Diffuse erosion was identified that develops by removal of particles by runoff, which accumulates in the lower part of the slope developing a deposit of materials removed by erosion.

Homogeneous zone II presents in the flat morphology a semi-flat in the Ash Rain unit (Qvc) with slopes ranging from 1-3% slightly flat and 25-50% slightly rugged or steep identified at the edge of the road in the current cut slopes.

In the homogeneous zone II sites that present mass removal processes were identified that are related with surface units or layers unconsolidated pyroclastic deposits. These processes are classified as erosion, falls, landslides or flows.

6 sectors with instability were identified along the corridor of Homogeneous Zone II. These sectors have instability mainly due to erosion, landslide of rocks and the action of gravity, considering the materials present in the area, mainly volcanic materials mostly ash, lahars and pyro-clasts. Some of these sectors are described below.

The slopes in mentioned spans vary from moderately inclined (7-12%) to heavily rugged (75-100%), the flatter areas correspond to the Rain of Ashes unit (Qvc) and the largest to lahars and pyro-clasts (TQvlp) and lavas and ashes (TQvlc) which are found in less exposure. They are described according to the field survey, their lithology and phenomenon explanation or the current process.

In PD 5-10 on the right slope on the current road, on K21+480 coordinates 967.080E and 615982N is a rotational slip in the ashes of the Lahars and Pyroclastics (TQvlp). The slippage is very punctual and its surrounding slope presents stability.

In the Lahars and Pyroclasticsunit (TQvlp), at K22+050 with 967.596E and 616063N coordinates is a scar of fine material collapse that fall with sudden rotation movement supported at the base, which is deposited in the lower part of the slope.

- Measures, indicators and costs

Management measures aimed at prevention and correction of this impact are described in detail in Chapter 11. These measures are MRSZ-1 Management and disposal of debris and excavation materials (ZODME), MRS-2 Management of slopes; MRS-3 Management and control of erosion and MRS-4 Management of construction materials and equipment.

Management measure **MRS-1** Management and disposal of debris and materials of excavation (ZODME), include among other actions:

Surplus materials from demolition and excavation activities will be moved and deposited only in sites approved for such end by the environmental authority and the owner of the property. These areas will be approved in requested environmental license for Project execution, and must have authorization and approval from the owner of the property by means of minutes a contract depending on the agreement reached with the owner.

During the landfill implementation process, the following activities will be sequentially performed, prior agreement of the owners or holders of the land and intervention design.

_ Access conditioning (improvement) to facilitate equipment operation
_ Remove shrubs and herbaceous plants
_ Top soil removal
_ Construction of filters, drains and retaining walls
_ Extend and compact the material in layers
_ Re-vegetation
_ Incorporate organic soil or plant trees as compensation, in consultation with the owner of the property.

Sludge will be disposed of in the sites indicated in the drawings or approved by the environmental authorities and shall in no case be disposed of in permeable land, close to aquifers, surface currents or buildings. Deposited sludge must be covered with impervious materials (clay) and disposed of in such a way that runoff waters do not cross them.

Affected areas that will not be intervened by the project, once the excavation activities are finished and the total volume of debris is removed, will be recovered to their initial condition.

The organized ZODME will be delivered to the owner via minutes of close-out, that specifies compliance with previous agreements.

MRSZ-2 Management of slope will include the following activities:

- Verify conservation of the organic layer of the soil, vegetal cover and vegetal debris of the areas to be intervened during road construction to ensure that they are incorporated in sites that remain without vegetal cover or in recovery of degraded areas.
- Confirm cuts and fills forming designs which will take into account the type of material and the geometry of the slopes, so as to include the measures preventing drag of materials building forks and/or other works.
- Check erosion and protection works such as re-vegetation just after excavating the slopes.
- Monitor maintenance of the drainage structures so they remain are free of sediment.
- Verify intervened area delimitation to avoid changing a larger space than is actually required for the project and reduce the incidence of erosive processes.

Finally, the purpose of MRS-4 Management of construction materials and equipment is to provide follow-up to building materials, in order to prevent or minimize deterioration of environmental conditions of the area and to follow up on the actions for the environmental management on the use of construction equipment at the site of the works and temporary stock piling areas. Follow-up of this measure includes fulfilling the following aspects regarding management of materials:

- Abide by the regulations set forth in the Management and Disposal of Surplus Excavation Materials Program and in accordance with provisions of Resolution 541 of 1994.
- Verify third party permits of material sources, which must have the necessary environmental permits for their operation.
- Verify traffic management and signage measures with visual inspections and photographic records.

- **MRS-4** Management of construction materials and equipment aims to follow-up building materials, to prevent or minimize deterioration of area environmental conditions and follow-up on actions for environmental management of the use of construction equipment at the worksite and temporary stock piling areas**.**

Monitoring will be aimed at implementing those aspects that relate to soil resources.

- *Indicators*

Monitoring indicators for these actions are:

(Volume of non-reusable disposed of material in authorized ZODME /volume of non-reusable material generated)* 100 100% compliance value

(Volume of disposed of waste (excavation and debris)/ volume of waste generated (excavation and debris))*100 100% compliance value

Engineering designs will serve as the basis to verify proposed execution of slopes to be shaped, while monthly reports and photographic records, such as inspection rounds are the tool to verify re-vegetated or stabilized areas. 100% compliance value.

The information obtained allows covering the evaluation of all measures taken since both shaped areas and the total of re-vegetated slope areas are the end result of the target and the target proposed in the management plan in order to minimize the impact from removing the soil and that there is visual harmony with the landscape. 100% compliance value.

Laboratory records, photographic records and monthly maintenance records are the tools and sources of information to measure proposed indicators. These indicators make it possible to evaluate proposed activities as a whole and to ensure a healthy environment in the community, the assurance of equipment and machinery condition leading to compliance with schedules and reports and measures to be taken during project development. 100% compliance value

- *Costs*

The costs associated with the management and disposal of excavation debris and materials in selected and authorized sites (ZODME), including rental of the premises, the topographic site survey, soil studies and analyzes to establish land carrying capacity, studies and geotechnical, stability and handling of runoff type works, as well as the revegetation of intervened sites, are included in the total Project budget and in other environmental management plan costs.

10.5.10. Fragmentation and changes in habitats connectivity

This impact refers to the component fauna, like the flora that can be severely affected in particular by the removal of vegetal cover and other activities that involve modifying the area, as well as installation and operation of camps and processes plants that drive away the fauna.

- Biophysical quantification

Although it's impossible to quantify the impact as such, not only because of the uncertainty of the effects but also because there is no in depth ecological characterization on populations and communities, which would overwhelm the scope of the EIA; the base line shows the characterization of the fauna present in the area of influence. A more extensive analysis on this component is in the fauna biotic baseline component.

Sampling made as part of the EIA showed that for the study area there is the possible presence of 21 species of amphibians, all belonging to the Anura order representing about 3% of the species recorded at a national level. Two reptiles species were identified, both from the Squamata order, one from the Sauria (*Riama columbiana)* suborder and one from the Serpentes (*Sibon nebulata*) suborder.

With regard to birds, passerines had the greater representation with 48 species, followed by the Apodiformes with 11 species, the Piciformes obtained 5 species and the Accipitriformes, Columbiformes, and Strigiformes reported 4 species each. As to mammals, chiropteras are the most abundant (28 species), followed by rodents (17 species) and carnivora (14 species).

With regard to the landscape analysis that allows determining the fragmentation that could affect the biodiversity mentioned in previous paragraphs.

The fragmentation analysis was carried out using the landscape context index of each fragment, using equation proposed in the terms of reference for construction of highways of the Ministry of the Environment and Development (MADS). To highlight that the reference buffer area for each fragment identified was 500 meters.

Landscape context index equation (CP):

$$CP = AN / ATB$$

Where:
CP = landscape context
AN = natural area inside the buffer and
ATB = total buffer area

This analysis as described in greater detail in the biotic baseline in the landscape analysis component shows that there is currently a strong natural fragmentation for all natural cover analyzed, these being: open forest, riparian forest, dense herbaceous woody ground, open rocky herbaceous, dense shrubs and secondary or in transition vegetation.

- Measures, indicators and costs

Measures seeking to prevent this impact are developed through the management measure MRF-1 FAuna management. Indicated actions are:

The pre-construction and construction stages activities can directly and indirectly affect fauna communities, reason why different actions must be considered before starting the activities and parallel to them, as described below.

Drive off wildlife

Drive off wildlife seeks to generate ecological conditions causing environmental stress in the communities of amphibians, reptiles, birds and mammals, forcing them to migration to other places, therefore, at least one hour before carrying out activities that affect the habitat of species such clearing and topsoil removal and taking into account the following:

- It is important to previously know the existing fauna in the drive off and rescue area. The project's baseline must be reviewed as well as general bibliography and fauna inventories previously carried out in the area and in the region; the purpose of this is to

have general information of the species that are likely to be the work area and timely and easily identify in the field.

- Drive off must be led and carried out by professionals specialized in different areas, i.e., for amphibians and reptiles a herpetologist biologist, for mammals a mastozoologist biologist and for bird an ornithologist biologist, who should have good knowledge of visual and auditory techniques of taxonomic identification and should be familiar with those species that are found in the study area.

- To achieve the most effective drive off different techniques to generate indirect environmental disturbances on wildlife should be used, depending on the group of individuals who want to drive off, such as noise with special sounds that alert or stress the animals, controlled biomass removal, controlled intervention in shelter places, sticks to move tree branches and shrubs and predator hormones to achieve the highest percentage of migrant individuals.

- It is important to ensure effective drive off of most individuals to, insofar as possible, minimize handling and possible increased stress of individuals.

- Having concluded the drive off and given that many species are cryptic and instead of fleeing they encrypt even more so rescue and relocation activities of individuals must be carried out.

Wildlife rescue and relocation

The wildlife rescue and relocation activities should be made together with topsoil removal activities and/or forest exploitation, taking into account:

- Have specialist that capture the individuals or nests, depending on the characteristics of each species, who must select potential locations to establish new wildlife shelters (extension, similarity and closeness to the habitat where it was removed to ensure the survival of populations).

- Individuals with disability or injured by accidents or similar must be delivered to a wildlife rescue center, until the animal can be released.

- Capture, record and release or transfer of the animals must follow specific management protocols for each group of fauna (amphibians, reptiles, birds and mammals); capture must have tools such as hook to catch snakes, Sherman or Tomahawk traps for mammals, mist nets for birds and flying mammals.

- Each individual captured by the different methodologies used must be checked by a veterinarian, who will established the health conditions and if it can be immediately relocated or requires medical attention before being released.

- Requirements of each species must be considered when transferring, for example amphibians and reptiles can be transported in fabric bags (with wet litter for amphibians, birds and mammals in special cages or crates, ensuring the health of the individual as well as that of the researcher who manipulating.

- After the medical check-up by the veterinarian with the latter´s approval for relocation, the individual is release, prior identification of a place with similar conditions to the site where it was caught. To record release site coordinates by means of GPS and make the photographic record.

- An activities log format must be kept to include capture, check-up and release dat of each individual.

Fauna crossing: fauna crossing will be installed in strategic areas along the Rumichaca - Pasto, corridor taking into account:

1- Selecting the location of fauna crossings: The infrastructure points that require building fauna crossings will be identified based on analyzing three factors:

- Factor 1. Identify habitats of interest to the groups of special attention fauna.
- Factor 2. Identify sectors of the territory of interest for ecological connectivity, and, in particular, for the movement of wildlife.
- Factor 3. Identify spans of conflict, where there is a high rate of mortality of animals or of accidents caused by collision of vehicles with large mammals. This aspect will be evaluated based on data of parallel or close to roads under construction, or from own when subject to improvement projects.

Animal crossings will be placed as determined necessary, based on analyzing above factors:

- Facilitate safe crossing points preventing wildlife access involving road safety risks where vehicles circulate.
- Avoid isolating habitat fragments of referenced species.
- Facilitate animals the access to basic resources (food, shelter, reproduction, etc.) maintain a given population.
- Facilitate structures that allow crossing the road infrastructure in roads where wildlife normally travel.

2- Wildlife crossing density: The road corridor identified several areas where animal crossings would be necessary, due to above mentioned factors; the chapter on management measures shows the locations of these crossings.

3. Choice of structure type

The type of structure is made based on:

Criterion 1. Interest of the section for ecological connectivity and for wildlife movements
Criterion 2. Topographical constraints
Criterion 3. Species or wildlife groups of special reference.

Proposed crossing could generally be deployed on bridges and viaducts, if a skywalk is necessary an ecoduct (air-bridge with vegetal cover depending on the wildlife focus groups) is recommended which allows the crossing of most of the faunal groups; to also make the corresponding signs mentioned below:

Wildlife crossing signs: prevention and information signs will be installed along the road corridor, taking into account:

- Strategic and critical sites should be identified for wildlife crossing, indicating the presence of wildlife in these areas and to avoid the risk of accidents and run over incidents with the wildlife.

- Speed humps must also be installed in places where wildlife has been seen in order to regulate the speed in areas of sighting and transit of wild animals, especially for night traffic when the wildlife is very active.

- *Indicators*

Drive off the largest number of wildlife individuals from natural habitats that will be affected by project activities so they can naturally look for other shelters.

(Number of work fronts where drive off is carried /total number of work fronts)*100 100% Expected Value

(Interviews with evidence of wildlife drive off / Number of interviews of applied drive off)*100 100% Expected Value

Rescue and/or transfer of wildlife which may be affected by the project´s road activities. Rescue cases.

(Number of individuals rescued by work front /total number of work fronts)*100 100% Expected Value

Build wildlife crossings in sites identified as critical
Number of Wildlife crossings and effectiveness thereof through wildlife monitoring, number of species that cross by time.

Install sigs in sites identified as critical
(Number of signs installed at wildlife crossing in areas where high run overs have bee detected/number of signs scheduled)*100 100% Expected Value

- *Costs*

Four professionals for 12 months plus the necessary equipment (mist nets, mammals traps, tomahwack, shermann traps, herpetological piza camera) field materials, logistics.

The other costs are included in the general project budget.

10.6 Monetary valuations

Follows the monetary valuations projected in the numeral 0. Both the biophysical quantification and the economic valuation as such will be simultaneously developed, making the relevant notations.

10.6.1. Monetary valuation of costs by impacts of soil structure Changes and Modification to the current land use

As previously indicated, although these two impacts relate to particular aspects of soil effects, the joint assessment is presented because on the one hand same activities are generated such as plant cover removal, excavations, grading, Zodme operation, etc.

On the other hand, the effects of both impacts overlap given that the "dramatic" change in use has the effect of change in the ground structure.

The valuation set out from crossing cover interpretation geographic information and the final project design in terms of intervention areas, this included the dual carriageway, zodme, superstructures, tolls and other related works, temporary facilities.

Given the agricultural vocation of the region, predominant covers are related to this activity, below is the categorization of these areas according to the covers:

Table 10-4 Identifying uses by area

Covers	Uses
2.1.1. Other transitory crop	Wheat
2.3.1. Clean pastures	Livestock
2.3.2. Wooded pastures	Livestock
2.3.3. Shrubby pastures	Livestock
2.4.1.Mosaic of crops	Potatoes
2.4.2. Mosaic of pastures and crops	Livestock and wheat
3.1.5. Forest plantation	Eucalyptus

Covers	Uses
2.1.5.1. Potatoes	Potatoes
2.2.2.2. Coffee	Coffe
2.4.3.1. Mosaic of crops, pastures and natural shrub spaces	Livestock and wheat
2.4.3.2. Mosaic of crops, pastures and natural wooded spaces	Livestock and wheat
2.4.4.1. Mosaic of pastures with natural grassy spacies	Livestock
2.4.4.2. Mosaic of pastures with natural shrub spaces	Livestock
2.4.5.1. Mosaic of crops and natural shrub spaces	Wheat
2.4.5.2. Mosaic of crops and natural wooded spaces	Wheat

Géminis Consultores Ambientales S.A.S., 2016

As can be seen in Table 10-4 Identification table of uses by area, when crop mosaics were observed wheat crops was assigned thereto given their importance to the region and the presence of flour mills. In addition, according Fenalce[3] information, Nariño occupies third place in national production. On the other hand, the other transient crops identified were potato, banana plantain. The banana plantain is an undervalued crop in this area so it was decided to quantify the wheat since it has more value, which would tend to overestimate, but underestimating is avoided. Similarly, given that there were exclusive potatoes and coffee areas, identified in covers, the mosaics of temporary crops such as wheat ere assumed, leaving the potatoes and coffee areas to value these crops.

Furthermore, in terms of the mosaics, determined in accordance with the Corine Land Cover 2010 National Legend the Mosaics areas are distributed between a 30% and 70% in the areas of crops, therefore and for practical purposes 50% distribution among the areas that make up the mosaic was used. That is, for mosaics of pastures and crops, 50% was assumed for livestock and 50% for wheat. For mosaic of crops, pasture and natural shrubs, 50% was assumed in natural areas and 50% in crops and pastures so livestock was assumed to be 25% of the area and 25% wheat, and so on and so forth. The mosaics are made in its entirety as wheat.[4]

[3] National Federation of cereal and legume farmers, Economic and Marketing Support Department 2016. Cereal Indicators 2012.

[4] IDEAM, 2010. National Earth Cover legend. CORINE Land Cover methodology adapted for Colombia 1:100.000 scale. Institute of Hydrology, Meteorology and Environmental Studies. Bogotá, D. C., 72p.

Table 10-5 Valuation areas due to soil use changes

Distribution	Total area per cover (ha)	Valuation area per mosaic distribution
Coffee (100%)	0,514268	0,514268
Eucalyptus (100%)	2,882871	2,882871
Livestock (100%)	29,644524	29,644524
Livestock and wheat (50%)	31,20305	15,601525
Potatoes (100%)	19,00811	19,00811
Wheat (100%)	0,341303	0,341303
Livestock and wheat (25%)	100,136236	25,034059
Livestock (50%)	58,735441	29,3677205
Wheat (50%)	14,208779	7,1043895

Géminis Consultores Ambientales S.A.S., 2016

Based on Table 10-5 valuations were made. **This evaluation was based on market prices**.

Interest variables were the technical yield by area or animal and in the case of eucalyptus estimated on the basis of the trade volume estimated for forest harvesting. To note that to calculate the costs for loss of employment income that could be forfeited by the activity, cost structures were used, although their value, that is, the value of the agricultural wage was determined as the average of the area of influence.

This in itself this is a double dipping of costs since the producer price (which was used) provides for the labor (at least the remunerated one) invested in production, however it was decided to pursue this double dipping to prevent underestimates the costs. It is also important to note that although the payment process by farm size and easement acquisition recognizes the private opportunity cost since it is a market price, this estimate is made to capture the social opportunity cost.

- Cost valuation for changing the use of pastures dedicated to dairy farms

· **Tabla 10-6 Cost valuation for changing the use of pastures dedicated to dairy farms**

Area (Hec)	99,6478285
Yield (large livestock unit -450Kg/Ha)	1
Average UGG milk load (large livestock unit-450 Kg) per hectare	0,85
Areas affected of pastures and wooded pastures cover	99,65
Cattle production in affected area (load x affected area)	84,70
Estimated annual milk production per animal, with a duty cycle of 300 days / 15 l per day (liters).	4.500,00
Estimated milking females 60%	50,82
Estimated milk production reduction in affected area (liters)	228.691,77
Price paid to the producer 2016. Fedegan (COP/liter)	834,00
Annual milk production loss in affected area (COP2016)	190.728.933,18
Animals for meat 13% (the dairy herd is basically composed of milking females, calves, heifers for fattening, replacement heifers and cows that are are coming out of the milk production cycle and are destined for meat)	11,01
Weight	400,00
Price paid to the producer 2016. Fedegan average price for live animals (COP/kilogram)	3.000,00
Annual meat production losses in affected area (COP 2016)	13.213.302,06
Permanent jobs generated per every 100 animals	7,90
Total number of jobs affected	7,00
Average wage in area of influence (COP)	15.000,00
Average wages generated per year (COP))	38.325.000,00
Total loss costs dairy livestock production / year (COP)	242.267.235,24

Géminis Consultores Ambientales S.A.S., 2016

The numbers taken from Fedegan and the National Livestock Fund[5, 6], the results show annual costs of 242,267,235.24 COP (Colombian Pesos). However, although the project is developed in pre-construction, construction and Abandonment and Final Restoration stages, these costs have been projected to a period of 20 years, as impairment time and this would include the operation life of the road under concession scenarios.

This projection was prepared using a discount rate of 12% and an inflation adjustment in the 5%annual costs. The Net Present Value (NPV) calculation used the following equation.

$$VPN = \frac{Current\ value}{(1 + discount\ rate)^{Period}}$$

Table 10-7 Net Present Value (NVP) of the cost of changing the use of pastures dedicated to livestock activities at 20 years

Year	Livestock production loss	NVP livestock production loss
0	242.267.235,24	242.267.235,24
1	254.380.597,01	227.125.533,04
2	267.099.626,86	212.930.187,23
3	280.454.608,20	199.622.050,52
4	294.477.338,61	187.145.672,37
5	309.201.205,54	175.449.067,84
6	324.661.265,82	164.483.501,10
7	340.894.329,11	154.203.282,28
8	357.939.045,56	144.565.577,14
9	375.835.997,84	135.530.228,57
10	394.627.797,73	127.059.589,28
11	414.359.187,62	119.118.364,95
12	435.077.147,00	111.673.467,14
13	456.831.004,35	104.693.875,45

[5] Fedegan-National livestock fund. 2016. Colombian livestock. Big numbers. Refernce numbers. Strategic Colombian Livestock Plan PEGA 2019

[5] Gómez M. 2016. Corporatization and livestock competitiveness Forum. Costs and productivity indicators in the Colombian livestock. Bureau of Economic Research of Fedegan

Year	Livestock production loss	NVP livestock production loss
14	479.672.554,57	98.150.508,23
15	503.656.182,29	92.016.101,47
16	528.838.991,41	86.265.095,13
17	555.280.940,98	80.873.526,68
18	583.044.988,03	75.818.931,26
19	612.197.237,43	71.080.248,06
Total	8.010.797.281,18	2.810.072.043,00

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-7 the NVP (net present value) of these costs reaches 2,8 billion COP.

- Cost valuation for changing the use of wheat crop dedicated soil

- **Table 10-8 Cost valuation for changing the use of wheat crop dedicated soil**

Area (Ha)	48,08
Yield (Ton/Ha) Fenalce data (2016)	2,85
Total requested production (ton)	137,03
Average producer price (COP/ton) Fenalce-Q1-2019s	691.000,00
Costs for loss of production	**94.688.861,88**
Profitability (average yields for corn and soybeans Fanalce 2012. Since wheat crops has been on the decline in recent years (Fenalce data) these data may be overestimating the profitability, data from the municipality of Túquerres places wheat profitability in -10%)	0,14
Labor costs (cost structure for small corn producer of Fedesarrollo 2012, the percentage of labor in intensive-labor activities such as crops, disease control and harvest	0,56
Costs for loss of income for labor (the estimate was based on the average profitability for corn and soybeans from Fanalce 2012 and cost structure for corn Fedesarrollo 2012. Profitability for price was discounted and the labor percentage was calculated).	**45.284.569,44**
Total costs (COP/affected areas/year)	**139.973.431,31**

Géminis Consultores Ambientales S.A.S., 2016

The figures were taken from Fenalce and Fedesarrollo [7, 8]the results show annual costs for 139,973,431.31 COP (Colombian Pesos). In this case labor and profitability data were used for the corn and soybean crops of the Fedesarrollo referenced study. This data was used given the sparse and not updated information concerning wheat crops, however this data may be overstating the costs since both corn and soybeans are currently a better market than wheat. As indicated in the table, in Tuquerres, a municipality adjacent to the project, wheat profitability could be even at negative levels despite its extensive cultivation in the department.

However, despite the fact that presented project is developed in pre-construction, construction and Abandonment and Final Restoration phases, these costs have been projected for a period of 20 years, as impairment time, this would include the operation life of the road under concession scenarios. This projection was developed using a discount rate of 12% and an inflation adjustment in the 5% annual costs.

Table 10-9 NVP of the cost for changing the soil use dedicated to wheat crops

Year	Wheat production loss	NPV wheat production loss
0	139.973.431,31	139.973.431,31
1	146.972.102,88	131.225.091,85
2	154.320.708,02	123.023.523,61
3	162.036.743,42	115.334.553,39
4	170.138.580,59	108.126.143,80
5	178.645.509,62	101.368.259,81
6	187.577.785,10	95.032.743,58
7	196.956.674,36	89.093.197,10
8	206.804.508,08	83.524.872,28
9	217.144.733,48	78.304.567,77
10	228.001.970,16	73.410.532,28
11	239.402.068,66	68.822.374,01
12	251.372.172,10	64.520.975,64
13	263.940.780,70	60.488.414,66
14	277.137.819,74	56.707.888,74

[7] National Federation of cereal and legume farmers, Economic and Marketing Support Department 2016. Cereal Indicators 2012.
[8] Fedesarrollo. 2012. Production costs of 12 agricultural products. Research Director Juan José Perfetti.

15	290.994.710,72	53.163.645,70
16	305.544.446,26	49.840.917,84
17	320.821.668,57	46.725.860,48
18	336.862.752,00	43.805.494,20
19	353.705.889,60	41.067.650,81
Total	4.628.355.055,38	1.623.560.138,86

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-9 the NPV (net present value) of these costs reach 1.6 billion COP.

- Cost valuation for changing the soil use dedicated to potato crops

- **Table 10-10 Cost valuation for changing the soil use dedicated to potato crops**

Area (Ha)	19,00811
Yield (Ton/Ha)	30
Total production loss (Ton)	570,24
Average producer price (COP/ ton) Econopapa Fedepapa Bulletin Q1-2016	1.594.500,00
Costs for loss of production	**909.252.941,85**
Profitability (Data Municipality of Túquerres)	0,137
Labor costs (cost structure for small potato producer of Fedesarrollo 2012, the average labor percentage is used for labor in labor-intensive activities such as cultivation, weed control and harvest)	0,47
Costs for loss of income for labor (the estimate was based on the average profitability and cost structure for small potato producer from Nariño of Fedesarrollo 2012. Profitability for price was discounted and the labor percentage was calculated).	**366.186.468,11**
Total costs (COP/affected area/year)	**1.275.439.409,96**

Géminis Consultores Ambientales S.A.S., 2016

Figures were taken from Fedepapa and Fedesarrollo[9, 10] the results show annual costs of 1,275,439,409.96 COP. However, despite the fact that presented project develops in pre-construction, construction and Abandonment and Final Restoration stages, these costs have been projected to a period of 20 years, as impairment time, this would include the operation life of the road under concession scenarios. This projection was developed using a discount rate of 12% and an inflation adjustment in the 5% annual costs.

Table 10-11 NPV of the cost for changing the soil use dedicated to potato crops

Year	Potato production loss	NPV potato production loss
0	1.275.439.409,96	1.275.439.409,96
1	1.339.211.380,46	1.195.724.446,84
2	1.406.171.949,49	1.120.991.668,91
3	1.476.480.546,96	1.050.929.689,61
4	1.550.304.574,31	985.246.584,01
5	1.627.819.803,02	923.668.672,51
6	1.709.210.793,17	865.939.380,47
7	1.794.671.332,83	811.818.169,19
8	1.884.404.899,48	761.079.533,62
9	1.978.625.144,45	713.512.062,77
10	2.077.556.401,67	668.917.558,85
11	2.181.434.221,75	627.110.211,42
12	2.290.505.932,84	587.915.823,20
13	2.405.031.229,48	551.171.084,25
14	2.525.282.790,96	516.722.891,49
15	2.651.546.930,51	484.427.710,77
16	2.784.124.277,03	454.150.978,85
17	2.923.330.490,88	425.766.542,67
18	3.069.497.015,43	399.156.133,75
19	3.222.971.866,20	374.208.875,39
Total	42.173.620.990,90	14.793.897.428,54

Géminis Consultores Ambientales S.A.S., 2016

[9] Econopapa Fedepapa Bulletin Q1-2016
[10] Ibid.

As shown in Tabla 10-11 the NPV (net present value) of these costs reaches 9 billion COP.

- Cost valuation for changing the soil use dedicated to coffee crops

- **Table 10-12 Cost valuation for changing the soil use dedicated to coffee crops**

Area (Ha)	0,514268
Yield (Ton/Ha) (based on Finagro data for dry parchment – solar exposure system)	3,25
Total production loss (Ton)	1,67
Average producer price (internal dry parchment price sack 125 Kg second Q 2016 Federación Nacional de Cafeteros = COP 808.000), former price per ton = COP 6.464.000	6.464.000,00
Costs for production loss	**10.803.742,14**
Profitability (based on cost study and coffee prices study)	0,50
Labor costs (based on Diario La República data)	0,60
Costs for loss of income for labor	**3.241.122,64**
Total costs (COP/affected area/year)	**14.044.864,79**

Géminis Consultores Ambientales S.A.S., 2016

The numbers were taken from Finagro[11], Federación Nacional de Cafeteros[12] and the La República[13] newspaper, the results show annual costs 14.044.864,79 COP.

However, despite the fact that presented project develops in pre-construction, construction and Abandonment and Final Restoration stages, these costs have been

[11] Finagro. Sector information. s.f. Available at https://www.finagro.com.co/informaci%C3%B3n-sectorial-productos/cafe. Recovered in September 2016

[12] Federación Nacional de Cafeteros. 2016. Internal base-daily price since 2003. Available at https://www.federaciondecafeteros.org/particulares/es/quienes_somos/119_estadisticas_historicas/. Recovered in September 2016

[13] Diario La República. 2013. Colombian coffee production is the most expensive one in 29 countries. Available at http://www.larepublica.co/economia/la-producci%C3%B3n-colombiana-de-caf%C3%A9-es-la-m%C3%A1s-cara-entre-29-pa%C3%ADses_59036. Recovered in September 2016

projected to a period of 20 years, as impairment time, this would include the operation life of the road under concession scenarios. This projection was developed using a discount rate of 12% and an inflation adjustment in the 5% annual costs.

Table 10-13 NPV of the cost for changing the soil use dedicated to coffee crops

Year	Coffee production loss	NVP coffee production loss
0	14.044.864,79	14.044.864,79
1	14.747.108,03	13.167.060,74
2	15.484.463,43	12.344.119,44
3	16.258.686,60	11.572.611,98
4	17.071.620,93	10.849.323,73
5	17.925.201,98	10.171.241,00
6	18.821.462,07	9.535.538,43
7	19.762.535,18	8.939.567,28
8	20.750.661,94	8.380.844,33
9	21.788.195,03	7.857.041,56
10	22.877.604,79	7.365.976,46
11	24.021.485,02	6.905.602,93
12	25.222.559,28	6.474.002,75
13	26.483.687,24	6.069.377,57
14	27.807.871,60	5.690.041,48
15	29.198.265,18	5.334.413,88
16	30.658.178,44	5.001.013,02
17	32.191.087,36	4.688.449,70
18	33.800.641,73	4.395.421,60
19	35.490.673,82	4.120.707,75
Total	464.406.854,43	162.907.220,39

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-11 the NPV (net present value) of these costs reaches 162 billion COP.

- Cost valuation for changing the soil use dedicated to eucalyptus forest crop.

For this evaluation it is worth noting that field work identified the eucalyptus forest as the main area crop. The volume used was based on the estimated eucalyptus commercial volume required for forest harvesting in all areas of intervention.

Table 10-14 Cost valuation for changing the soil use dedicated to eucalyptus forest crop

Commercial volume (m3)	98,25
Hard Wood price (Indexmundi, hard wood, August 2016)	870.000,00
Loss for Wood production	**85.477.500,00**

Géminis Consultores Ambientales S.A.S., 2016

Given the long production cycle of forest crops, this cost, was one-time project for the period of 20 years, in other words it is updated in the zero period reason why its NPV is the same current value, i.e. 85,477,500.00 COP.

10.6.2. Monetary valuation of costs due to the impacts of Modifying the vegetal cover and Change in the protective vegetation of water bodies

As noted previously, these two impacts are evaluated by means of the monetary valuation of the loss for carbon capture. It is true that this valuation is limited to one of the aspects related to these impacts as is the ecosystem service of climate regulation.

In this regard, the effects, for example, on water regulation in the case of the impact of Change in the protective vegetation water bodies, is very complex to biophysically quantify that would even require a pre- and post-testing to the activity and it depends on multiple variables specific to each place reason why its valuation is complex.

This valuation was based on market prices. It considered carbon market prices for future Europe (European Emission Allowances - USA) emissions permission contracts with 2016maturity. This reference market is used given that Colombia has no developed market to issue reference prices.

The USA is located at 5.90 euros per ton of carbon. Using previously calculated uncaptured carbon at an exchange rate of COP/EUR (euros) 3000 COP/EUR is obtained.

The interest variable in this case was the total volume of required forest harvesting, which is a proxy of the aerial biomass of the area of project intervention.

Table 10-15 Cost valuation for loss of CO2 capture

Total volume (m3)	3.640,62
Wood density (kg/m3) (based on an average density for tropical forests of 0.64 g/cm3)	640,00
Total mass (Ton)	2.330,00
Total carbon in biomass (Ton) (adjusted by a factor of 0.5 suggested IPCC,2006)	1.165,00
Total carbon equivalent (Ton) (adjusted for specific weight ratio or 37 IPCC, 2003)	431,05
Carbon Bonds Price USA European market (EUR) (Based on annual average 2016. Sendeco2.Com)	5,30
Exchange rate (COP/EUR)	3.300,00
Total cost CO2 (COP)	**7.539.054,15**

Géminis Consultores Ambientales S.A.S., 2016

The figures were taken from the 2003 and 2006[14], IPCC and Natalia. Et.al. (2014), the prices were taken from the SendeCO2 system. The results show annual costs of 7,539,054.15 COP.[15]

However, despite the fact that presented project develops in pre-construction, construction and Abandonment and Final Restoration stages, these costs have been projected to a period of 20 years, as impairment time, this would include the operation life of the road under concession scenarios. This projection was developed using a discount rate of 12% and an inflation adjustment in the 5% annual costs.

Table 10-16 NPV Cost valuation for loss of CO2 capture

Year	CO2 costs	NPV CO2 costs
0	7.539.054,15	7.539.054,15
1	7.916.006,85	7.067.863,26

[14] IPCC - Intergovernmental Panel on Climate Change. www.ipcc.ch/.
[15] Natalia, M. D., Giudice, R., Vargas, C., & Rojas, E. (2014). Estimate of the carbon contents of the aerial biomass in the forests of Peru.

Year	CO2 costs	NPV CO2 costs
2	8.311.807,20	6.626.121,81
3	8.727.397,56	6.211.989,19
4	9.163.767,43	5.823.739,87
5	9.621.955,81	5.459.756,13
6	10.103.053,60	5.118.521,37
7	10.608.206,28	4.798.613,78
8	11.138.616,59	4.498.700,42
9	11.695.547,42	4.217.531,65
10	12.280.324,79	3.953.935,92
11	12.894.341,03	3.706.814,92
12	13.539.058,08	3.475.138,99
13	14.216.010,98	3.257.942,80
14	14.926.811,53	3.054.321,38
15	15.673.152,11	2.863.426,29
16	16.456.809,72	2.684.462,15
17	17.279.650,20	2.516.683,27
18	18.143.632,71	2.359.390,56
19	19.050.814,35	2.211.928,65
Total	**249.286.018,37**	**87.445.936,57**

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-16 the NPV (net present value) of these costs reaches 87 million COP.

10.6.3. Valuation of the benefits related to local employment generation

This benefit is based on **market prices** paid as average wage in the area of influence. This average wage was fixed at 15,000 COP, reason why the monthly income for these workers does not reached 500 thousand COP even working 30 days a month. Project offered salary for unskilled labor as a proxy of the local workforce which can be hired is of a minimum wage equivalent to 689,455 COP.

Based on this data and the number of jobs expected to be generated, the differential between the local average income and net income for the project was calculated as a means of collecting the opportunity cost of the local workforce.

Table 10-17 Valuation of local employment generation related benefits

Average wage for the area of influence	15.000,00
Average monthly revenue	450.000,00
Project unskilled labor wage	689.455,00
Project differential local salary	239.455,00
Forecasted unskilled labor (preconstruction, construction, Abandonment and Final Restoration)	201,00
Forecasted unskilled labor (Post-construction)	98,00
Project income benefits (pre-construction, construction, Abandonment and Final Restoration)	**481.304.550,00**
Benefits forecasted unskilled labor (Post-construction)	**281.599.080,00**

Géminis Consultores Ambientales S.A.S., 2016

As with the costs, these benefits were projected to 20 years, which made it possible to include the jobs generated in the operation stage (post-construction) related to road tolls and maintenance staff. The flow was prepared with a discount rate of 12% and an inflation adjustment of 5%.

Table 10-18 Valuation of benefits related to local employment generation

Year	Benefits for local labor employment	NPV benefits for local labor employment
0	481.304.550,00	481.304.550,00
1	505.369.777,50	451.223.015,63
2	530.638.266,38	423.021.577,15
3	557.170.179,69	396.582.728,58
4	585.028.688,68	371.796.308,04
5	281.599.080,00	159.786.880,54
6	295.679.034,00	149.800.200,50
7	310.462.985,70	140.437.687,97
8	325.986.134,99	131.660.332,47
9	342.285.441,73	123.431.561,69
10	359.399.713,82	115.717.089,09

Year	Benefits for local labor employment	NPV benefits for local labor employment
11	377.369.699,51	108.484.771,02
12	396.238.184,49	101.704.472,83
13	416.050.093,71	95.347.943,28
14	436.852.598,40	89.388.696,82
15	458.695.228,32	83.801.903,27
16	481.629.989,73	78.564.284,32
17	505.711.489,22	73.654.016,55
18	530.997.063,68	69.050.640,51
19	557.546.916,87	64.734.975,48
Total	**8.736.015.116,41**	**3.709.493.635,76**

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-18 the NPV (net present value) of these costs reaches 3.7 billion COP.

10.6.4. Valuation of the benefits associated with positive change impacts in the existing road infrastructure

As a note prior to this paragraph, the problem of scales between the cost valuation at the local level and the mobility benefits that may exceed this scale must be recognized.

However, in the context of the economic evaluation, the social effort in infrastructure construction has a wider scale that in this case was evident only at the operation stage. In these scales and in that moment is where the benefit lies for which the company invests huge amounts of resources.

Below valuations show two types of benefits:

- The first by the savings in time referred to the improvement in design.
- The second refers to the savings on operating costs for the projected traffic increase.

Both valuations were based on **market prices** and the interest variables were obtained from the Rumichaca - Pasto Highway Demand Study, which provided data for the specific stretch.[16]

- Valuation of the benefits by travel time savings

Table 10-19 Design speed, current speed and estimated DAP

Current average speed (Km/hora)	43,33
Current average speed (Km/min)	0,72
Design speed (Km/hora)	60,00
Design speed (Km/min)	1,00
Availability to pay Cars (COP/min) (Rumichaca - Pasto Highway Demand Study Data, 2015)	118,00
Availability to pay Buses (COP/min)	118,00
Availability to pay Trucks (COP/min)	306,00
Distance	32,76
Current time (min)	45,36
Projected time (min)	32,76
Saved time (min)	12,60

Géminis Consultores Ambientales S.A.S., 2016

Valuations were based on the Availability to pay (WTP) calculated for the Rumichaca - Pasto Highway Demand Study for the type of vehicles, cars, buses and trucks.

Referenced study observed the current traffic flow and projected traffic flow in scenarios for the years 2020, 2030 and 2040 in three scenarios, pessimistic, base and optimistic.

The 2030 estimate was used for this valuation in its three scenarios, to project the flow of benefits to 20 years. It is important to highlight that there are only 14 years to 2030, while there are 24 years to 2040, the projections to 2030 are actually an underestimate of the projections to 20 years which would be up to 2036 (closer to 2040); however, the

[16] Group consulted topic. 2015. Demand Study Highway Rumichaca - Grass

2030 data is used as a way of keeping a conservative estimate and even underestimating the benefits.

Table 10-20 Valuation of the benefits for saving travel time in the year 2030

	Pessimistic scenario	Base scenario	Optimistic scenario
Projected Annual Daily Average Traffic (ADDT) Cars in the year 2030 (20-year concession scenario)	4.402,32	4.623,92	5.002,97
Total time saving ADDT	6.545.368,92	6.874.837,88	7.438.415,14
Annual time saving value	2.389.059.656,39	2.509.315.826,39	2.715.021.527,32
Projected ADDT Buses in the year 2030 (20-year concession scenario)	1.184,43	1.243,86	1.345,80
Total ADDT time saving value	1.761.005,95	1.849.376,59	2.000.932,24
Annual time saving value	642.767.170,76	675.022.454,70	730.340.266,66
Projected ADDT Truck in the year 2013 (20-year concession scenario)	2.385,00	2.504,68	2.709,94
Total ADDT saving time value	9.195.608,62	9.657.061,82	10.448.454,06
Annual time saving value	3.356.397.146,48	3.524.827.564,07	3.813.685.730,23
Total annual time saving value in the year 2030	**6.388.223.973,63**	**6.709.165.845,16**	**7.259.047.524,21**

Géminis Consultores Ambientales S.A.S., 2016

Based on Table 10-20, the flow of benefits was projected using a discount rate of 12%. In this case it was not adjusted for inflation since the preferences expressed in the DAP do not behave in accordance with the inflation but depend on multiple factors, hence they were assumed to be constant over time. In this way the flow was built assuming a

constant DAP and the values were distributed linearly along the length of the flow. In any case this assumption maintains a conservative estimate of the benefits.

Table 10-21 Flow of benefits for saving time over 20 years

Annual value	Pessimistic scenario	Base scenario	Optimistic scenario
1	319.411.198,68	335.458.292,26	362.952.376,21
2	638.822.397,36	670.916.584,52	725.904.752,42
3	958.233.596,04	1.006.374.876,77	1.088.857.128,63
4	1.277.644.794,73	1.341.833.169,03	1.451.809.504,84
5	1.597.055.993,41	1.677.291.461,29	1.814.761.881,05
6	1.916.467.192,09	2.012.749.753,55	2.177.714.257,26
7	2.235.878.390,77	2.348.208.045,81	2.540.666.633,47
8	2.555.289.589,45	2.683.666.338,06	2.903.619.009,69
9	2.874.700.788,13	3.019.124.630,32	3.266.571.385,90
10	3.194.111.986,82	3.354.582.922,58	3.629.523.762,11
11	3.513.523.185,50	3.690.041.214,84	3.992.476.138,32
12	3.832.934.384,18	4.025.499.507,09	4.355.428.514,53
13	4.152.345.582,86	4.360.957.799,35	4.718.380.890,74
14	4.471.756.781,54	4.696.416.091,61	5.081.333.266,95
15	4.791.167.980,22	5.031.874.383,87	5.444.285.643,16
16	5.110.579.178,91	5.367.332.676,13	5.807.238.019,37
17	5.429.990.377,59	5.702.790.968,38	6.170.190.395,58
18	5.749.401.576,27	6.038.249.260,64	6.533.142.771,79
19	6.068.812.774,95	6.373.707.552,90	6.896.095.148,00
20	6.388.223.973,63	6.709.165.845,16	7.259.047.524,21
Total	**67.076.351.723,13**	**70.446.241.374,16**	**76.219.999.004,25**

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-21, for these 3 scenarios the total NPV was calculated for this benefit as shown below.

Table 10-22 NPV of the flow of benefits for time saving over 20 years

Annual NPV	Pessimistic scenario	Base scenario	Optimistic scenario
0	319.411.198,68	335.458.292,26	362.952.376,21
1	570.377.140,50	599.032.664,75	648.129.243,23

Annual NPV	Pessimistic scenario	Base scenario	Optimistic scenario
2	763.897.956,03	802.275.890,29	868.030.236,47
3	909.402.328,61	955.090.345,58	1.033.369.329,13
4	1.014.957.956,04	1.065.949.046,40	1.153.313.983,41
5	1.087.454.952,90	1.142.088.264,00	1.235.693.553,65
6	1.132.765.575,93	1.189.675.275,00	1.287.180.785,06
7	1.155.883.240,75	1.213.954.362,25	1.313.449.780,67
8	1.161.043.433,79	1.219.373.801,37	1.319.313.395,76
9	1.151.828.803,36	1.209.696.231,51	1.308.842.654,52
10	1.131.260.431,87	1.188.094.513,09	1.285.470.464,27
11	1.101.877.044,03	1.157.234.915,35	1.252.081.621,04
12	1.065.803.688,42	1.119.349.248,48	1.211.090.853,68
13	1.024.811.238,87	1.076.297.354,31	1.164.510.436,23
14	980.367.894,32	1.029.621.193,53	1.114.008.708,13
15	933.683.708,88	980.591.612,89	1.060.960.674,41
16	885.749.054,18	930.248.739,91	1.006.491.711,22
17	837.367.803,32	879.436.833,95	951.515.273,21
18	789.185.925,75	828.834.317,71	896.765.386,46
19	741.716.095,63	778.979.621,90	842.824.611,33
Total	**18.758.845.471,87**	**19.701.282.524,52**	**21.315.995.078,09**

Géminis Consultores Ambientales S.A.S., 2016

Table 10-22, shows a NPV for 20 years between COP 187 million and COP 21.3 billion of benefits in trip time saving by improving road speed.

- Valuation of the benefits by reducing vehicular operation costs

These benefits were calculated at **market prices** and were based on projections of project vehicular demand, given that when you switch to a dual carriageway with best features traffic flow is expected to increase. In this regard, calculations use vehicular projection estimates identified in the previous section, and average operation cost for 2014 per kilometer traveled in hilly and mountainous terrain Invias 2009 adjusted for inflation for the Rumichaca - Pasto Highway Demand Study. These values were adjusted for inflation to 2016 for this valuation.

Table 10-23 Average operation costs

Terrain	Car	Buses	Trucks
Average operation costs 2014 (COP/Km)	813,94	2.953,25	4.111,50
Operation costs 2016 (5% annual inflation) (COP/Km)	895,33	3.248,58	4.522,65

Géminis Consultores Ambientales S.A.S., 2016

Based the Rumichaca – Pasto HIghway Demand Study. 2015.

The valuation for different 2030 scenarios was projected with these prices as shown below.

Table 10-24 Valuation of the benefits for operation cost savings in the year 2030

	Pessimistic scenario	Base scenario	Optimistic scenario
ADAT (annual daily average traffic) projections Cars in the year 2030 (20-year concession scenario)	4.402,32	4.623,92	5.002,97
Differential ADAT increase in the year 2030	1.236,32	1.457,92	1.836,97
Total value saved costs with ADAT increase (COP)	1.106.915,66	1.305.317,50	1.644.696,25
Annual value savings in operational Costs by traffic increase in the year 2030 (COP)	404.024.214,95	476.440.886,32	600.314.132,45
ADAT projections Buses in the year 2030 (20-year concession scenario)	1.184,43	1.243,86	1.345,80
Differential ADAT increase in the year 2030 (COP)	494,43	553,86	655,80
Total value costs saved with ADAT increase (COP)	1.606.182,94	1.799.267,85	2.130.408,49
Annual value saving in operational Costs with traffic increase in the year 2030	586.256.772,15	656.732.766,92	777.599.097,96
ADAT projections Trucks in the year 2030 (20-year concession scenario)	2.385,00	2.504,68	2.709,94
Differential ADAT increase in the year 2030 (COP)	1.012,00	1.131,68	1.336,94
Total value costs saved with	4.576.924,87	5.118.213,21	6.046.522,71

	Pessimistic scenario	Base scenario	Optimistic scenario
ADAT increase (COP)			
Annual value saving in operational Costs with traffic increase in the year 2030	1.670.577.578,96	1.868.147.821,75	2.206.980.788,13
Total annual value saving in operational Costs with traffic increase in the year 2030	**2.660.858.566,05**	**3.001.321.474,99**	**3.584.894.018,55**

Géminis Consultores Ambientales S.A.S., 2016

The flow of benefits was based on Table 10-24, using a discount rate of 12% and an inflation adjustment of 5%. Values were distributed lineally along the flow.

Table 10-25 Flow of benefits for operational costs savings along 20 years

Annual value	Pessimistic scenario	Base scenario	Optimistic scenario
1	133.042.928,30	150.066.073,75	179.244.700,93
2	279.390.149,43	315.138.754,87	376.413.871,95
3	419.085.224,15	472.708.132,31	564.620.807,92
4	558.780.298,87	630.277.509,75	752.827.743,89
5	698.475.373,59	787.846.887,18	941.034.679,87
6	838.170.448,30	945.416.264,62	1.129.241.615,84
7	977.865.523,02	1.102.985.642,06	1.317.448.551,82
8	1.117.560.597,74	1.260.555.019,50	1.505.655.487,79
9	1.257.255.672,46	1.418.124.396,93	1.693.862.423,76
10	1.396.950.747,17	1.575.693.774,37	1.882.069.359,74
11	1.536.645.821,89	1.733.263.151,81	2.070.276.295,71
12	1.676.340.896,61	1.890.832.529,24	2.258.483.231,68
13	1.816.035.971,33	2.048.401.906,68	2.446.690.167,66
14	1.955.731.046,04	2.205.971.284,12	2.634.897.103,63
15	2.095.426.120,76	2.363.540.661,55	2.823.104.039,61
16	2.235.121.195,48	2.521.110.038,99	3.011.310.975,58
17	2.374.816.270,20	2.678.679.416,43	3.199.517.911,55
18	2.514.511.344,91	2.836.248.793,87	3.387.724.847,53
19	2.654.206.419,63	2.993.818.171,30	3.575.931.783,50

Annual value	Pessimistic scenario	Base scenario	Optimistic scenario
20	2.793.901.494,35	3.151.387.548,74	3.764.138.719,47
Total	**29.329.313.544,25**	**33.082.065.958,07**	**39.514.494.319,43**

Géminis Consultores Ambientales S.A.S., 2016

As shown in Table 10-25 the total NPV was calculated for this benefit based on the values for these 3 scenarios, as shown as follows.

Table 10-26 NPV of the Flow of benefits by operational costs savings along 20 years

Annual value	Pessimistic scenario	Base scenario	Optimistic scenario
0	133.042.928,30	150.066.073,75	179.244.700,93
1	249.455.490,57	281.373.888,28	336.083.814,24
2	334.092.174,87	376.840.028,95	450.112.251,21
3	397.728.779,60	448.619.082,08	535.847.918,11
4	443.893.727,24	500.690.939,82	598.044.551,46
5	475.600.422,04	536.454.578,38	640.762.019,42
6	495.417.106,29	558.806.852,48	667.460.436,90
7	505.527.659,48	570.211.073,96	681.082.078,47
8	507.784.479,39	572.756.659,11	684.122.623,46
9	503.754.443,84	568.210.971,34	678.693.078,83
10	494.758.828,77	558.064.346,85	666.573.559,57
11	481.907.950,10	543.569.169,01	649.259.960,62
12	466.131.201,73	525.773.749,79	628.004.426,19
13	448.203.078,59	505.551.682,49	603.850.409,80
14	428.765.700,18	483.627.247,28	577.663.019,58
15	408.348.285,89	460.597.378,36	550.155.256,74
16	387.383.976,57	436.950.637,95	521.910.678,83
17	366.224.347,59	413.083.586,30	493.402.952,67
18	345.151.914,90	389.314.887,88	465.012.703,41
19	324.390.897,46	365.897.451,02	437.042.014,49
Total	**8.197.563.393,37**	**9.246.460.285,06**	**11.044.328.454,94**

Géminis Consultores Ambientales S.A.S., 2016

Table 10-26, shows a NPV for the 20 years between COP 8.1 billion and COP 11 billion of benefits in operational costs savings for expanding to dual carriageway, allowing a higher vehicular flow.

10.7 Cost-benefit Analysis and Sensitivity Analysis

The cost benefit analysis presented below is divided into two sections. Those paragraphs present different scenarios that constitute the sensitivity analysis since the discount rates are amended, the inflation adjustments and even costs by forcing the flow are increased.

- The first paragraph presents the four years scenario in order to demonstrate the cost-benefit during the pre-construction, construction and Abandonment and Final Restoration stages. Especially given that only the employment benefit is shown.

- The second section shows the cost-benefit analysis for the road operation, highlighting the time saving and cost savings benefits of the operation. As previously noted, the problem of scales between the valuation of the costs at a local level and mobility benefits that go beyond this scale.

It is important to note that, in the context of economic evaluation, the social effort in the infrastructure construction has a wider scale which can only be evident in the operation stage. At those scales that go beyond local and at the time of operation is where the benefit is reason why the company invests huge amounts of resources in developing this type of infrastructure.

10.7.1. Cost-benefit analysis during the pre-construction, construction and Abandonment and Final Restoration.

Below are the scenarios analyzed for the pre-construction, construction and Abandonment and Final Restoration stages. Scenario 1 could be understood as a base scenario, calculated with a discount rate of 12% and average inflation. While the remaining scenarios show 5% more environmental discount rates and 20% more

private, which denote the social preferences as well as showing a 3% and 7% inflation. In both scenarios, the flow is pressured by raising the costs by a 20%.

Table 10-27 Cost-benefit analysis during the construction, preconstruction and Abandonment and Final Restoration stages

Scenario 1 (12% discount rate, 5% inflation adjustment)		
Year	**Cost-Benefit**	**NPV Cost-benefit**
0	-1.283.436.945,45	-1.283.436.945,45
1	-1.257.857.417,72	-1.123.086.980,11
2	-1.320.750.288,61	-1.052.894.043,85
3	-1.386.787.803,04	-987.088.166,11
4	-1.456.127.193,19	-925.395.155,73
Total	**-6.704.959.648,02**	**-5.371.901.291,26**
	Cost-Benefit Ratio	**0,495**
Scenario 2 (5% discount rate, 3% inflation adjustment, 20% cost increase)		
Year	**Cost-Benefit**	**NPV Cost-benefit**
0	-1.540.124.334,54	-1.540.124.334,54
1	-1.561.282.546,36	-1.486.935.758,44
2	-1.694.368.021,56	-1.536.841.742,91
3	-1.837.483.350,93	-1.587.287.205,21
4	-1.991.352.040,39	-1.638.290.251,81
Total	**-8.624.610.293,78**	**-7.789.479.292,91**
	Cost-Benefit Ratio	**0,263**
Scenario 3 (20% discount rate, 7% inflation adjustment,20% cost increase)		
Year	**Cost-Benefit**	**NPV Cost-benefit**
0	-1.026.749.556,36	-1.026.749.556,36
1	-971.716.837,45	-809.764.031,21
2	-984.388.474,78	-683.603.107,49
3	-996.286.670,49	-576.554.786,16
4	-1.007.307.469,97	-485.777.136,37

Scenario 1 (12% discount rate, 5% inflation adjustment)		
Year	**Cost-Benefit**	**NPV Cost-benefit**
Total	**-4.986.449.009,06**	**-3.582.448.617,59**
	Cost-Benefit Ratio	**0,302**

Géminis Consultores Ambientales S.A.S., 2016

As shown, the different cost-benefit valuation scenarios yield negative NPVs and cost-benefit ratios of less than 1 indicating a poor generation of benefits identified essentially in employment, with regard to project cost in these stages referred to in the previously developed valuations.

As shown below, social benefits are evidenced when the road starts operating.

10.7.2. Cost-benefit analysis in a 20 years operation scenario

This analysis was set up in three scenarios. A base scenario, a pessimistic scenario and another optimistic from the private point of view.

In the base case scenario shown below, the base scenario for the benefits by reducing travel time and reducing operating costs was used. This scenario was calculated with a 12%discount rate and a 5%inflation adjustment.

Table 10-28 Cost-Benefit Analysis. Base scenario for a 20 years operation

Year	Total Benefit-Cost	PNV Total Benefit-Cost
0	-1.279.217.129,44	-1.279.217.129,44
1	-777.171.855,84	-693.903.442,71
2	-372.305.545,90	-296.799.701,77
3	28.152.696,04	20.038.532,97
4	423.982.466,60	269.448.522,45
5	814.952.342,20	462.425.845,10
6	1.200.819.328,10	608.372.442,53
7	1.581.328.279,81	715.312.606,56
8	1.956.211.295,61	790.080.932,68
9	2.325.187.078,73	838.485.770,55

Year	Total Benefit-Cost	PNV Total Benefit-Cost
10	2.687.960.267,51	865.451.267,16
11	3.044.220.732,25	875.140.716,12
12	3.393.642.836,74	871.063.590,54
13	3.735.884.662,97	856.168.342,05
14	4.070.587.197,03	832.922.789,49
15	4.397.373.474,30	803.383.693,14
16	4.715.847.681,96	769.256.910,88
17	5.025.594.216,51	731.949.357,45
18	5.326.176.694,30	692.613.834,22
19	5.617.136.912,50	652.187.662,26
Total	**47.916.363.631,98**	**9.384.382.542,23**
	Benefit-cost Relation	**1,86**

Géminis Consultores Ambientales S.A.S., 2016

The pessimistic scenario is shown below. In this scenario the pessimistic scenario for the benefits by reducing travel time and reducing operating costs was used. This scenario was calculated with a 5% discount rate of future intertemporal preference (more environmental) and a 7% inflation adjustment as well as a 20% cost increase.

Table 10-29 Cost-Benefit Analysis. Pessimistic operation at 20 years

Year	Total Benefit-Cost	PNV Total Benefit-Cost
0	-1.665.235.667,56	-1.665.235.667,56
1	-1.347.715.533,36	-1.283.538.603,20
2	-1.047.224.225,57	-949.863.243,15
3	-757.835.965,38	-654.647.200,41
4	-480.327.966,11	-395.167.006,43
5	-215.531.846,03	-168.874.841,07
6	35.662.563,32	26.611.953,83
7	272.303.142,19	193.520.759,29
8	493.371.122,44	333.932.995,75
9	697.776.422,17	449.792.903,25
10	884.352.653,74	542.915.814,93

Year	Total Benefit-Cost	PNV Total Benefit-Cost
11	1.051.851.782,38	614.995.952,35
12	1.198.938.410,89	667.613.769,27
13	1.324.183.664,26	702.242.869,33
14	1.426.058.646,22	720.256.521,30
15	1.502.927.437,79	722.933.794,77
16	1.553.039.605,63	711.465.337,45
17	1.574.522.186,08	686.958.814,35
18	1.565.371.108,02	650.444.027,91
19	1.523.442.015,36	602.877.737,02
Total	**9.589.929.556,46**	**2.509.236.689,00**
	Benefit-Cost Relation	**1,11**

Géminis Consultores Ambientales S.A.S., 2016

The optimistic scenario is shown below. In this scenario the optimistic scenario for the benefits by reducing travel time and reducing operating costs was used. This scenario was calculated with a 20% discount rate of future intertemporal preference (more private) and a 3% inflation adjustment as well as a 20% cost increase.

Tabla 10-30 Cost-Benefit Analysis. Optimistic operation at 20 years

Year	Total Benefit-Cost	PNV Total Benefit-Cost
0	-869.596.119,22	-869.596.119,22
1	-351.828.367,88	-293.190.306,57
2	155.706.534,53	108.129.537,87
3	661.932.704,66	383.062.907,79
4	1.166.810.880,52	562.698.148,40
5	1.670.300.622,29	671.256.358,62
6	2.172.360.276,95	727.519.061,37
7	2.672.946.941,89	745.970.435,51
8	3.172.016.427,40	737.709.641,34
9	3.669.523.218,12	711.178.183,52
10	4.165.420.433,19	672.738.655,04
11	4.659.659.785,35	627.134.224,75
12	5.152.191.538,71	577.852.567,79

Year	Total Benefit-Cost	PNV Total Benefit-Cost
13	5.642.964.465,30	527.413.347,91
14	6.131.925.800,33	477.594.642,47
15	6.619.021.196,04	429.610.691,72
16	7.104.194.674,26	384.250.920,91
17	7.587.388.577,46	341.988.217,51
18	8.068.543.518,38	303.062.859,68
19	8.547.598.328,17	267.547.212,50
Total	**77.799.081.436,44**	**8.093.931.188,93**
	Benefit-Cost Ratios	**12,19**

The results show positive NPVs in the three scenarios, with cost-benefit ratios greater than 1. Although adjusted, the base and pessimistic scenarios show cost-benefit ratios between 1.11 and 1.86, which is a positive approach in tune with reality than that presented in the optimistic scenario which reaches a cost-benefit ratio of 12.19. However, this possibility should be considered.

10.8 Conclusions

The two cost-benefit scenarios analysis to 4 years and 20 years reflecting the construction and operation periods show (as stressed above) that development of this type of infrastructure generates long-term social benefits. The expected society benefits when making this type of projects is not quantifiable in its construction, but in the operation, that is, to the extent that the road is used by society.
The indicators for the first 4 years stage yielded negative NPVs and cost-benefit ratios below 1. However, when mobility benefits in terms of time saving and cost savings are capitalized by operating costs, the NPV criteria indicators and cost-benefit ratios are very favorable.

Analyzed scenarios show a sensitivity to intertemporal preferences expressed in the discount rates, as well as variations in costs derived from their direct change and the inflation generated adjustment.

The contrast between the four years and 20 years analysis, as evidenced by the criteria indicators of Net Present Value and Cost-benefit ratio, allows observing that in the long

term for society the project is preferable despite the costs (social) in its construction phase.