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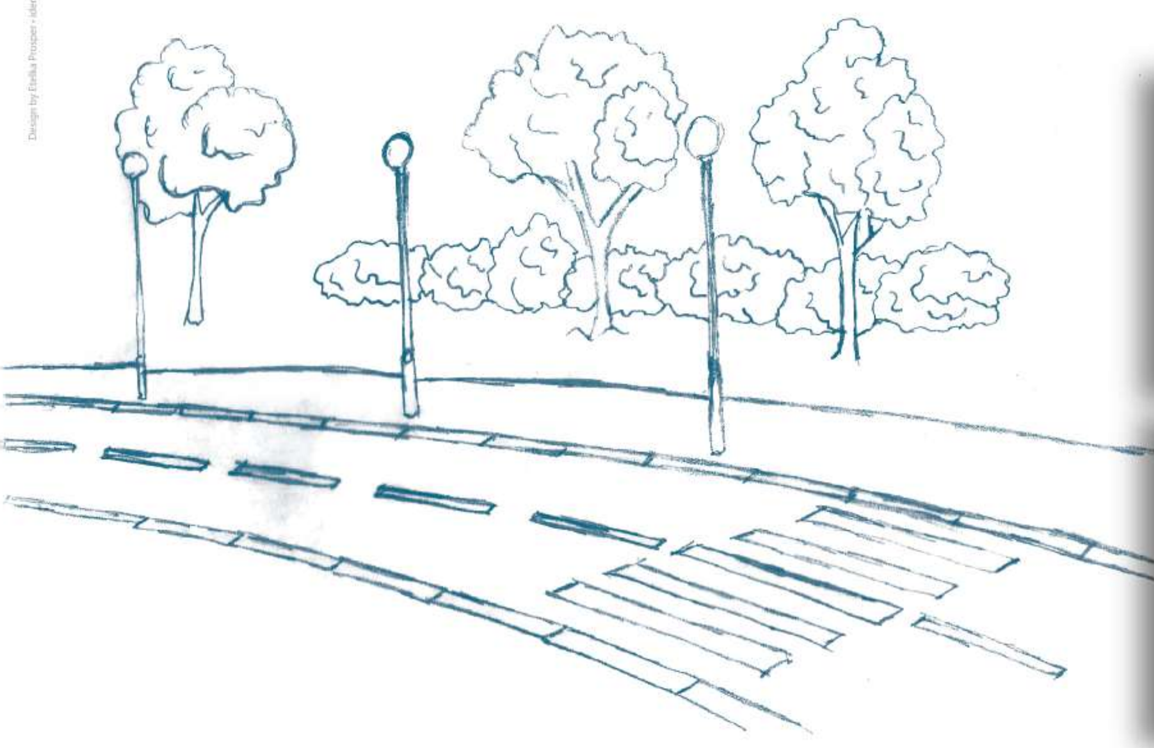
Benefit-Cost Analysis

Cost Benefit Analysis of Road Infrastructure Solutions



COPENHAGEN CONSENSUS CENTER

Haïti Priorise
Un plan de développement alternatif

COST BENEFIT ANALYSIS OF ROAD INFRASTRUCTURE SOLUTIONS

Haïti Priorise

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Abstract

Haiti, like other developing countries, has serious problems in the domain of road infrastructure. It is undeniable that the country's road network is deficient; roads are degraded faster than they are rehabilitated or constructed. The national road network is approximately 700 km long and connects cities of socio-economic importance. It is used by up to 4,000 vehicles per day for the busiest routes. These structural problems hinder the socio-economic development of the country. Many parts of the country are landlocked, a situation that entails enormous post-harvest losses and high operating costs. Thus, the principal aim of this work is to identify all the costs and benefits of two road infrastructure interventions, namely the construction of National Road No. 5 and the construction of a bridge.

The Northwest Department is the country's poorest department in terms of road infrastructure and basic infrastructure. Because of this, it is necessary to intervene within this department. That being so, National Road No. 5, 83 km long, linking Gonaives to Port-de-Paix, passing through numerous communes in the departments of Artibonite and the Northwest, must be built. Based on the cost-benefit ratio calculation, the construction of this road should provide a better state of being for the northwestern population overall. In the South Department, there is also a bridge that needs to be constructed on the river ''Les Anglais.'' This intervention, according to the calculation of the cost-benefit analysis, envisages an improvement in living conditions at regional and national level since it would imply a 57% reduction in post-harvest losses. This is a bridge that has a span of 25 meters, and it should have a length between 120 and 150 meters. These interventions will undoubtedly entail direct costs: costs of work and related activities, major maintenance costs, regular maintenance costs and other costs, such as the costs related to travel delays and work accidents. The benefits that have been identified, based on the analysis of benefit-cost ratios (BCRs), allow us to conclude that these two interventions are worth implementing, thereby improving the living conditions of the target populations.

Policy Summary

Overview

The problem of road infrastructures in Haiti plays a particularly crucial role in the development of the country, taking into account the precarious state of transport systems, both from the point of view of road construction and their organization and maintenance. This is a situation that involves several decades of road insecurity and a lack of interconnection of the country's different regions. Currently, none of the three modes of transport: road, sea and air transport can adequately meet the basic needs of the population, let alone bolster sustainable development of the country's economy. The road network, initially structured around a national, departmental and communal network, is now weakened, consisting of infrastructure that is essentially in a state of extreme deterioration, after having lost nearly 30% of its expanse over the 15 last years.

However, the Ministry of Public Works, Transport and Communication defines and conducts the national transport policy. In this capacity, the MTPTC plans investments in the transport sector, defines the applicable technical standards, ensures monitoring of the state of infrastructure, regulates transport services, contracts and supervises construction and public works companies and engineering offices, and performs certain construction, rehabilitation or maintenance work directly. There is also the Road Maintenance Fund (FER), an autonomous body created by the law published in the Moniteur on July 24, 2003, which administers the funds devoted to road maintenance but does not contract the companies in charge of the road maintenance, which is the responsibility of the MTPTC.

In Haiti, people who do not possess a vehicle have to use public transportation for travel. Road transport is by far the most widely used. There is no state company that organizes public transport. The latter is left to the discretion of micro businesses that do not correspond to any legal framework for the organization of public transport. The transportation system is usually conceived to provide easy access to goods and services and to enable people to move quickly and safely. It influences personal choices. It plays an important role in the economy, social development and health. However, in Haiti, particularly the Northwest Department, the system is inadequate, unstructured and unsafe.

Factors Relating to Implementation

Costs

The costs considered in a cost-benefit analysis are the amounts to be disbursed to carry out a project and the negative effects of the project for users or the whole of society. Transportation project costs are usually divided into three categories:

- Costs of work and related activities;
- Major maintenance costs;
- Regular maintenance costs.

Other cost categories can be considered in the cost-benefit analysis of transport projects, such as, for example, the costs of travel delays and accidents during work.

Potential Sources of Integrated Revenues

Commonly, in developing countries such as Haiti, major road infrastructure projects are often financed by international aid. That said, as part of these interventions, potential sources of income may be international donor agencies or friends of Haiti, the public treasury and loans in the PetroCaribe program. However, it must be emphasized that each of these different sources has its drawbacks. For example, if one chooses to finance these interventions by:

- Domestic credit: Given the scarcity of resources, public spending can restrict the dynamism of the private sector by reducing credit available in the economy. Financing budget expenditure through borrowing can lead to higher interest rates on the financial markets and thus increase the cost of financing for the private sector.

- Taxation: Infrastructure financing through direct and/or indirect taxation creates distortions and savings are reduced, thus limiting the sources of private sector financing.

- External aid: The best option would be to choose external aid financing because international aid is one of the important sources of massive investment in infrastructure in developing countries. However, the ability of aid to engender economic growth has been a source of controversy among economists for years.

Monitoring and Control Indicators

Within the framework of these interventions, monitoring and control indicators will be: the number of road accidents per year, the rate of atmospheric emissions from motor vehicles, the post-harvest loss reduction rate, regional level GDP, the number of lives saved per year, level of local income, rates of access to services, educational outcomes, food availability, disease data, mortality, job creation and number of creation of SMEs.

Implementation Partners

Legally, the only authority in the country responsible for implementations in transport is the Ministry of Public Works, Transport and Communication (MTPTC). Nevertheless, it can always delegate its duties to other construction firms according to specific agreements. There is also the MPCE, which is the Ministry that coordinates public investment projects in the country and, of course, other partners who are used to working with the MTPTC on road infrastructure.

Calendar

As part of the intervention on the road from Gonaives to Port-de-Paix, construction of the road is planned over a two-year period starting in 2017, and the installation of two toll stations will be over a period of one year. It is obvious that these two activities can be done simultaneously. In the calculation of costs, maintenance is planned on the road every five years.

Concerning the Les Anglais bridge construction intervention, the installation work will be done over a period of one year and the maintenance work every three years.

Calendar for the Port-de-Paix road:

No. of Activ	Activities	Costs per Activity	
		Year 1	Year 2
1	Plan, quotes, research	2,490,000	-
2	Construction	60,000,000	60,000,000
3	Equipment	2,250,000	2,250,000
4	Dismantlement	2,490,000	-
5	Construction of toll stations	4,787,815	-
6	Acquisition of operation equipment	371,942	371,942
Total cost of implementing activities per year		72,389,757	62,621,942

Justification for the Intervention

Benefits

The primary benefits arising from transportation projects are generally as follows:

- Travel time savings: One of the advantages of transportation projects is the reduction in travel times resulting from improved traffic conditions. The monetary component associated with this time gain can be established fairly easily in the benefit-cost analysis if one agrees at the outset to the following premises:
  a) For an individual, time spent traveling has an opportunity cost in the sense that it reduces the time available for other activities such as work or leisure;
  b) The time saved during travel represents a gain for the individual in terms of his or her available time budget, an opportunity to assign this time to an activity such as work or leisure
- Reducing the number or severity of accidents: One of the important objectives of transportation projects is to improve the safety of users, which generally results in a reduction in the number of accidents on roads. However, to be able to measure safety gains from transportation projects, one must know the value to society of a life saved or a lesser accident, whether it involves injuries or only property damage.

- Reduction in the cost of using vehicles: The cost of using vehicles corresponds to the costs represented by using a vehicle to cover a kilometer. It includes fuel consumption, tire wear, kilometric depreciation and maintenance.
- Reduction of some environmental impacts: Since the implementation, use and maintenance of new road infrastructure can all bring about a wide range of potential consequences to the natural and human environment throughout the duration of the normal life of the road infrastructure (30 to 75 years as the case may be), it is more pragmatic to consider here only some more easily quantifiable environmental issues. To this end, it is suggested that we focus on the monetary evaluation of the benefits of reducing the following environmental impacts :

  1. The evaluation of the benefits of reducing emissions of certain air pollutants from road traffic;
  2. The evaluation of the benefits of reducing GG emissions from road traffic.

Table of Costs and Benefits

Interventions	Benefit	Cost	Benefit-Cost Ratio	Data quality
Intervention 1	37,199,822,902.03	16,520,306,618.60	2.3	Average
Intervention 2	1,331,616,701.48	883,389,966.63	1.5	Average

Note: All figures are based on a discount rate of 5%

List of Acronyms

CBA: Cost-Benefit Analysis

VOC: Vehicle Operating Costs

DALY: Disability-Adjusted Life Year

FER: Fonds d’Entretien Routier [Road Maintenance Funds]

GG: Greenhouse Gases

MPCE: Ministère de la Planification et de la Coopération Externe [Ministry of Planning and External Cooperation]

MTPTC: Ministère des Travaux Publics, Transport et Communication [Ministry of Public Works, Transport and Communication]

GDP: Gross Domestic Product

SME: Small and Medium Enterprises

QALY: Quality-Adjusted Life Year

BCR: Benefit-Cost Ratio

NR: National Roads

NPV: Net Present Value

VSL: Value of Statistical Life

1. Introduction

Economists are almost unanimous in recognizing that infrastructure comprises various elements necessary for the functioning of the economy. Infrastructure can have very significant economic impact, increasing the profitability of enterprises through, notably, accessibility and facility of trade, stimulation of the labor market and investment in the private sector. Moreover, it affects productivity and therefore competitiveness on foreign markets, as well as a country's ability to attract foreign investment. This situation is particularly true in developing countries, as the level of infrastructure is generally relatively low in these countries and their marginal productivity is therefore expected to be relatively high. For a developing country like Haiti, the establishment of quality infrastructure is a major challenge. According to a report by the World Bank (1994), public infrastructure is the wheel of economic activity, and infrastructure failures in poor countries are delaying their economic take-off. However, the contribution of road and motorway infrastructure to regional and local economic development has been the subject of extensive research for a long time to find out whether it is necessary or sufficient for development.

In developing countries, particularly in Haiti, the question of the construction of transportation infrastructure is often associated with that of territorial development policies. First, it should be noted that Haiti has a population growth rate of 2.5% and is experiencing strong urbanization, so that in the metropolitan area of Port-au-Prince the density is 10 to 18,000 inhabitants/km2[1]. Nevertheless, the majority of the population lives in rural areas. Hence a certain regional planning challenge to meet the needs of the population in terms of mobility and access to goods and services. Successive governments have never made roads and means of transport a priority for the country's economic, social and health development. In addition, successive political crises did not help. The last major road works in Haiti date back to 1975 with the construction of National Roads 1 and 2. Since then, there has not really been an extension of the road network. On the contrary, the latter, initially structured around a national, departmental and communal

[1] Pan American Health Organization (2007). Haïti: Santé à l’Amérique 2007, PAHO/WHO. [Online] www.paho.org/hia/archivosvol2/ paisesfra/haiti%20frances.pdf.

network, has lost nearly 30% of its expanse over the past 15 years[2]. A timid rehabilitation program in recent years with the collaboration of international actors has not brought about any significant change.

The road network in Haiti remains deficient. Roads are degraded faster than they are rehabilitated or built. According to the MTPTC, there are 3,400 km of roads approximately classified as national roads, departmental roads and communal roads. Once again, according to the statistics of the MTPTC, only 10% of the network is in good condition compared with 50% in a very bad condition, with an average of 80% in bad condition. The national road network is approximately 700 km long and connects cities of socio-economic importance. It is used by up to 4,000 vehicles per day for the busiest routes. The departmental network comprises 1,500 km and ensures movement for approximately 1,000 vehicles[3]. It connects towns of lesser importance with national roads. The communal roads, which are usually suitable for motor vehicles, ensure the function of services for the commune. Traffic is very low. The inadequacy of the road network, combined with the pitiful state of roads and transport vehicles, causes the isolation of a significant part of the rural population, which accounts for two thirds of the general population. In fact, more than half of these inhabitants do not have any access to transportation services, and more than a third have access only through difficult roads. These conditions limit in the extreme access to basic services (procurement of provisions, education, health) and opportunities for economic development (production, trade).

In terms of road infrastructure, the Northwest Department is one of the most neglected departments of the country. The Northwest is the only department in the country that does not have access to a kilometer of concrete or asphalt road. Port-de-Paix is therefore connected to no other city except by clay roads. It is a geographically difficult area that requires adapted road infrastructure. The Northwest is highly vulnerable to hydro-meteorological hazards due to the lack of mitigation work, including protection of slopes, drainage of drains and gullies, and

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[2] Ministry of Public Works, Transport and Communications of Haiti (s.d.). Enjeux et défis de la lutte contre la pauvreté: transport routier, MTPTC

[3] Short-term migration is also a possibility. Although it is not taken into account in canonical urban models, it is an important feature of rural economic activity in developing countries such as India (Imbert and Papp, 2015)

stabilization of riverbanks. Besides the construction of bridges on the national road able to facilitate its access to the outside in case of disasters, the department is as-if isolated from the rest of the country. This situation, coupled with the progressive degradation of river banks, may make it difficult to access certain communes such as Saint-Louis du Nord, Anse-à-Foleur and Chansolme in the event of disasters. To this end, National Road NR5, that is to say the stretch of road from Gonaïves to Port-de-Paix, is of vital importance in enabling the Northwestern Department to have easy access to enter.

This research, based essentially on cost-benefit analysis, will address two road infrastructure interventions that should be a priority for the Haitian state in the coming years. First of all, the construction of the road from Gonaives to Port-de-Paix and then the construction of a bridge over the Les Anglais River. For the first, it is better to opt for an asphalt road instead of a dirt road because it is a geographically difficult area. In fact, the 83 kms of road linking Joffre and Port-de-Paix crossroads have 21 newly constructed bridges. The majority are in the Northwest Department between the communes of Chansolme and Bassin-Bleu.

With regard to the second intervention, this bridge will link two of the country's departments, namely the department of the South and that of the Grand'Anse. It is therefore a departmental road, which is an alternative to a national road. That is to say, by constructing this bridge over the Les Anglais River, people will be able to reach different communes of the Grand'Anse adjacent to the South Department more quickly and at lower costs. This intervention envisages an improvement of the living conditions at the regional and national level because it would imply a 57% reduction in post-harvest losses. In effect, it is a bridge that has a span of 25 meters and it should have a length between 120 to 150 meters. For the moment, the place where the vehicles pass over is a little too close to the coast. As a result, 2 to 3 km of roads will have to be constructed to move the bridge much further from the coast. In order to better address these interventions, we will begin by conducting a literature review to give an idea of the different work that has already been done in this field. Then, we will present the theoretical framework and finally demonstrate how the various calculations of costs and benefits have been realized.

And we will provide recommendations to the authorities concerned for the implementation of these interventions.

2. Literature Review

2.1. Integration of Different Market Types

This work will first complete a literature review on constraints on labor market participation in developing countries. It is well documented that workers in low-income countries are much more likely to be either self-employed or workers in informal sectors with low growth and productivity relative to the size of the formal sector (La Porta and Shleifer, 2014). The majority of self-employment and informality is in the agricultural sector. In addition, models of the urban economy would allow for the prediction that the construction of rural roads would facilitate the movement of agricultural and urban markets. The Alonso-Muth-Mills model predicts an urban perimeter beyond which labor will be used only in agriculture, with urban income net of travel costs being lower than agricultural income (Brueckner, 1987).

Rural roads could be considered an extension of this perimeter because the cost of travel has been lowered. It predicts that the labor force will leave agriculture but only in villages that are sufficiently close to cities to allow for movement[4]. However, business models are more agnostic about the impact of rural road construction. If one thinks that the previously unknown village roads are analogous to the transformation of a closed village economy into an open economy, it is to be expected that the village economy specializes in its comparative advantage. As Matsuyama (1992) points out, this comparative advantage for the poor can be very good in agriculture.

Some business models focusing on structural change include labor market frictions that create a wedge between farm and non-farm wages (Tomb, 2014). If we interpret road construction and

[4] Other studies also suggest that the lack of transport infrastructure in rural areas can contribute significantly to rural underdevelopment. Wantchekon and Stanig (2015) demonstrate that transport costs are a powerful predictor of poverty in sub-Saharan Africa. Fafchamps and Shilpi (2005) show cross-sectional evidence that villages closer to cities are more economically diverse, with residents more likely to work for wages. In the literature on political science, it is demonstrated that roads increase the bargaining power of small farmers in relation to their landowners and their ability to engage in collective action (Shami, 2012).

reduce this friction, we should expect a greater movement toward agriculture as wages increase. However, if we consider that this friction is between rural and urban wages, we expect that the net wage of rural workers in urban employment will increase and the forecasts of sectoral distribution of labor will be ambiguous.

We consider the possibility that roads not only facilitate trade but also productivity of labor within and outside agriculture. First, we expect agricultural productivity to increase due to lower transportation costs to import inputs such as fertilizer and exports. However, it is theoretically unclear whether the relative productivity of the agricultural labor force will increase or decrease, while other sectors should also see these productivity gains. Second, workers may experience a drop in research and travel costs, thereby reducing barriers outside the village. This represents an increase in the demand for labor, which should translate into an increase in the wages of the villages. Given that work productivity has been found to be higher outside agriculture in a wide range of countries, called the "agricultural productivity gap" (Gollin et al., 2014)[5], it is likely that this demand will come mainly from non-agricultural activities. Road construction should thus increase workers' ability to decide in favor of some other field because of the productivity gap, leading to the reallocation of labor (and perhaps land and capital) away from agriculture. Higher wages in the village may then result in a change in the sectoral composition of employment in the villages, which will depend on the demand curves for labor in and out of agriculture. It is also possible that there is an income where workers leave jobs where the marginal utility of earnings is now less than that of recreation.

2.2. Poverty Reduction

Although most trade theories predict that lowering trade barriers will generally increase overall income, the effect of road construction on poverty is theoretically ambiguous. We hypothesize that a road will have offsetting effects on the demand for labor and production. By lowering the cost of exporting, a road will increase the demand for inputs (such as labor) and products. By reducing the cost of importing, a road increases competition, potentially reducing demand. Recent work has provided solid evidence that there are likely to be losers as competition and

[5] [3] **Fritz Gérald Chéry,** "La Structure de l'Economie & la Réformen de l'Etat en Haiti" ; imp. Henry Deschamps

access would change the returns of various assets and skills. Depending on the distribution of these assets, roads could lead to increased poverty, especially if adjustment costs are high.

2.3. Reduction of Post-harvest Losses

Higher food prices in 2008 and 2011 have raised concerns about the capacity of the growing world population to feed itself in the coming years with renewed interest in the level of post-harvest losses and the potential for reduction of PHL to improve food security (Kaminski and Christiaensen 2014, Zorya, Morgan and Rios 2011). The fight against PHL, particularly in developing countries, could play an important role in reducing the amount of production needed to feed this growing population (Beretta et al., 2013; Buzby and Hyman, 2012). 34 years after the World Food Conference, held in Rome (Italy) in 1974, and UN Resolution 271, which provided for a 50% reduction in PHL in developing countries by 1985 to increase food security (Booth & Burton 1983; Boxall 2001), this has resulted in significant research and food-loss reduction activities, and a number of national and regional loss assessments have been conducted around the world. However, when raw material prices resumed their downward trend, emphasis was placed on economic liberalization and trade to ensure food security (Zorya, Morgan and Rios, 2011). Food losses due to inappropriate post-harvest handling, lack of appropriate infrastructure and poor management techniques are once again of concern. Food losses, defined as "any decrease in food mass throughout the food supply chain," can occur at any stage of the marketing stages - from production (for example, crop damage, spills), or microorganisms during storage, to distribution and retailing to domestic consumption (for example, deterioration, table waste) (Rosegrant, Tokgoz and Bhandary 2013). Kummu et al. (2012) suggest that an additional one billion people could be fed if food crop losses were halved, potentially alleviating some of the pressure on the significant increase in production that would be needed.

2.4. Impact on Migration

The construction of roads could also influence migration decisions through multiple mechanisms. There may be a net migration towards areas with rural roads, which are now more attractive places to live. However, roads reduce the cost of migration from rural areas (Morten Et Oliveira, 2014, Bryan et al., 2014) and can therefore induce greater emigration. In the presence of migration, changes in the composition of local economic activity and poverty may be attributable to changes in the composition of the population rather than sectorial reallocation or higher earnings for village-based inhabitants.

2.5. Fight against Corruption

Olken (2007) illustrates how the essential institutional dimensions of the sector can be analyzed. He studied how to reduce theft and grafting in public works by conducting controlled field experiments in Indonesian villages. Some village leaders involved in road construction were informed that, at the end of the project, they would be visited by public auditors. Other villages were chosen to participate in "Accountability Meetings," during which project coordinators accounted publicly for the use of government funds. Villagers would receive anonymous forms to graft.

Olken concludes that audits reduce missing spending by 8%, measured with differences between the official project costs and the cost estimate of an independent engineer. Increased participation of the population in surveillance had little impact on average! The general implication of the policy is that in certain contexts, traditional top-down surveillance can play an important role in reducing corruption and thus improving resource utilization in road maintenance. A strong message in deciding how best to ensure the long-term sustainability of commitments to maintain a new or rehabilitated road!

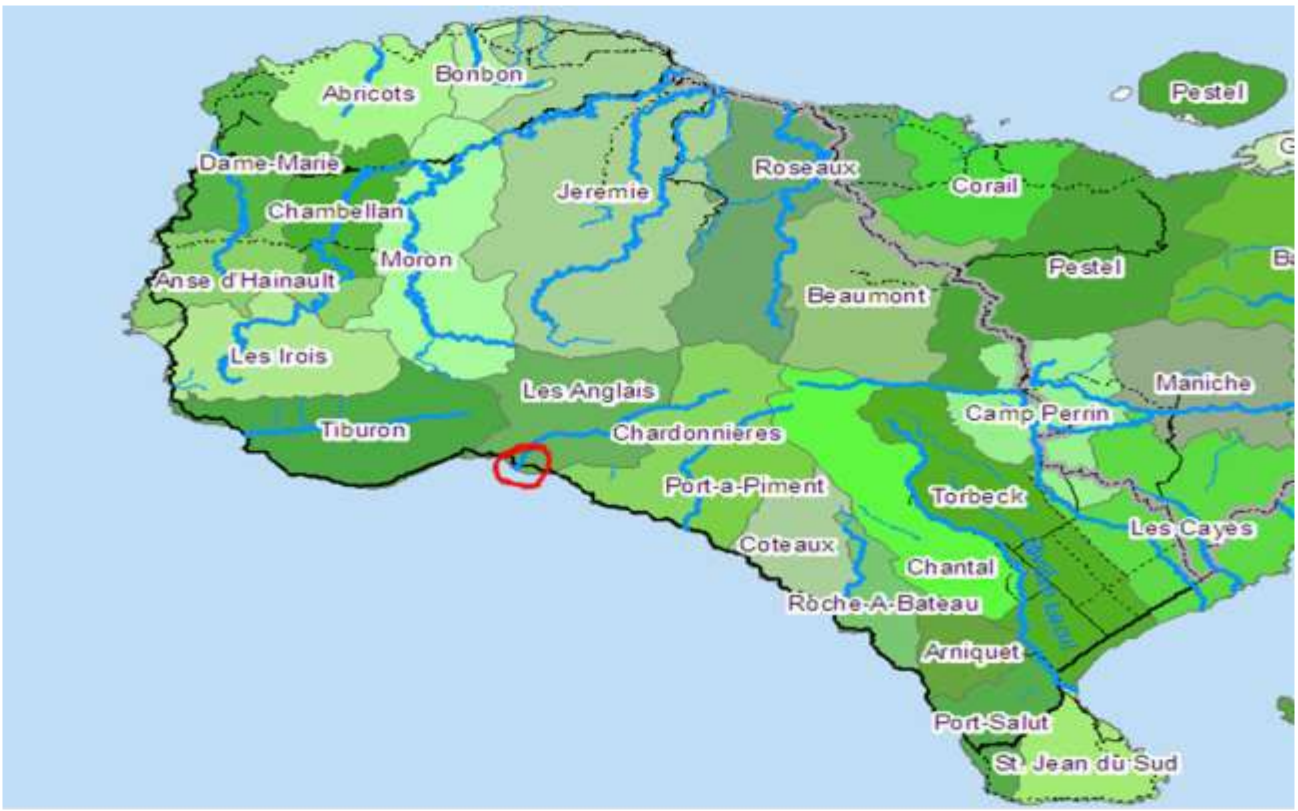
In Haiti, the low priority given by the state to infrastructure for several decades is the cause of one of the weaknesses of the Haitian economy. Roads have a high opportunity cost for other sectors of activity. Not only are they expensive and deteriorate rapidly, but they are also an indirect factor in the stagnation in other sectors of production: agriculture, tourism, trade, etc. By believing in giving priority to this sector in the name of growth, the state neglects parts of the national economy, sectors exposed to external competition that should be organized in order to advance the national economy, which is lagging in the face of its competitors[6].

The infrastructure problem can be boiled down to the additional costs in this sector of activity, the opportunity costs of the rest of the economy and also lost earnings for other companies. A

[6] Valérie Meunier*,* "l'Analyse coût-Bénéfice: Guide Méthodologique"; les cahiers de la securité industrielle

road that costs one million dollars more costs one million in reduced investment for other sectors of the national economy. An impassable road means food losses for the agricultural sector or a higher transport cost, thus a deterioration in the competitiveness of all other sectors of the economy. To this must be added the leakage of currency owing to the too frequent call to foreign firms to build if there has been a program to strengthen the capacity of this country for some time.

Maps Showing the 'Les Anglais' River and National Road No. 5 Respectively



Source: National Center for Geospatial Information (CNIGS)

3. Theory

The main problem in a cost-benefit analysis is to obtain a monetary measure of the community benefits of a preventive action. Indeed, while estimating the costs that would be incurred by a project is generally fairly easy, valuing benefits, such as reducing the level of risk in road infrastructure, is more difficult as there is no "market" where this type of consequence is exchanged. The approach adopted by the cost-benefit analysis is to deduce this measure from individual risk behaviors. A concept used to monetize non-market quality changes is that of willingness to pay.

3.1. Willingness to Pay

Willingness to pay measures what an individual would be willing to give to benefit from a commodity (or the benefits of a project). It is a monetary measure of the variation in an individual's well-being which would be necessary for him or her to accept the change of situation associated with a public decision (such as the realization of a project), or what a person would be willing to give up in terms of other opportunities for consumption.

In an equivalent manner, one can evaluate the willingness to receive, what the individual would like to obtain in compensation for the reduction of a good or a service.

Thus, in the cost-benefit analysis, we move from the value given by individuals to the value for society by simple aggregation (each individual preference has the same weight; the unweighted sum of individual willingness to pay is calculated).

3.2. Opportunity Cost

The opportunity cost is the cost of a commodity or service estimated in terms of unrealized opportunities (and the benefits that could have been derived from these opportunities). It is the value of the best unfulfilled option, that is, the measure of the benefits that are waived by assigning available resources to a given use. The assumption underlying this notion (and implicit in the cost-benefit analysis) is that the available resources are limited and, therefore, it is not possible to acquire or realize all available options.

In cost-benefit analyses, the concept of willingness to pay is used to monetize the benefits of a decision (for example, to estimate the value accorded by a company for a 10% reduction in the amount of fine particulate matter in the air); the notion of opportunity cost is the one that underpins assessment of costs.

3.3. Methods of Evaluating Costs and Benefits

In general, the consequences of a project or decision fall into one of the following four categories:

• direct costs: costs in capital, operating costs, etc.

• indirect costs: loss of productivity, loss of competitiveness, opportunity costs of delayed investments, etc.

• direct benefits: damage avoided (decreased likelihood and severity of accidents), improved air quality, etc.

• indirect benefits: innovation, better image or reputation, lower insurance premiums, etc.

The objective of cost-benefit analysis is to attribute a monetary value to each of the identified consequences, a more or less easy task, or a direct task, depending on whether these consequences relate to market goods or services, for which the analyst can obtain data to estimate changes in surplus. If costs are usually already available or easily expressed in monetary terms, benefits often have no market value and are more difficult to quantify.

3.4. Revealed Preference Methods (Samuelson, 1938)

Revealed preference methods consist of inferring the well-being individuals derive from non-market goods by studying existing situations and the decisions that they actually make. Observation of their behavior provides information about their preferences and, therefore, about the value they attribute to a good.

Sometimes the well-being that individuals derive from non-market goods can be approached by observing similar goods for which markets exist. For example, the increase in social well-being linked to the supply of social housing by the government can be approached by observing the rental market in the private sector. Willingness to pay for increased safety can be approached by observing the purchasing behavior of individuals in markets for commodities that emphasize risk prevention (alarms, smoke alarms, etc.) or protection (system on cars, helmets, etc.). We can estimate the implicit value of time (spent in traffic jams, waiting at a ticket booth, etc.) by a wage function.

3.5. Willingness to Pay for Risk Reduction

In the context of a cost-benefit analysis of alternative transport risk reduction projects, the expected benefits are obtained by the different avoided damages. Their estimation is, therefore, based on the measurement of the monetary value of the reductions of risks, the consequences of which are deaths, injuries, material damage, loss of production, etc.

While the estimate of material damage avoided is relatively straightforward and explicit, the valuation of reductions in risks to human health and life is more difficult. Several methods have been applied to this question, notably in the United States by academic circles and regulatory agencies, the latter being responsible for the regulatory evaluation required by the federal government.

The importance that each individual attributes to health risks or his or her estimate of the probability of survival is reflected on a daily basis in decisions and choices, such as taking a car, deciding whether to quit smoking, choosing a balanced diet or enrolling in a climbing club. Many of these decisions are made through a market, for example when the individual purchases products that meet safety standards or, on the contrary, are manufactured from hazardous or noxious materials, or when he or she accepts employment with significant occupational risks. For each decision, determination is made between the risk inherent in the product purchased or the activity initiated and the utility (satisfaction) derived therefrom, reflected in the prices and quantities exchanged on the corresponding markets.

3.6. Value of Statistical Life

The monetary estimate of the value of human life is a difficult question but necessary for economic calculation. It is indispensable in any research procedure for the efficient allocation of resources to pollution control projects, but also to transport projects, for example, and, therefore, such a concern has not arisen with the interest raised by environmental issues. In this area as in all those of economic valuation, there are two methods of measuring a price, measuring the value of scarcity and willingness to pay.

Let us point out that this VSL is not a measure of the value of a human life but rather of the value to an individual of a marginal reduction in the probability of a fatal accident.

3.6.1. Compensated Human Capital Methods

This method is due to the work of C. ABRAHAM, J. THEDIE and M. Le Net. ABRAHAM and J. THEDIE point out that it is not a question of measuring the price of human life but how much a community agrees to spend to save a human life. The compensated human capital valuation method proposes to estimate the scarcity value of this capital.

Indeed, it is a matter of calculating the price of the mathematical expectation of human life taken in a given statistical population, the price being intended to be included as liabilities or assets for the operations envisaged.

A distinction should be made between economic and affective elements.

In the event of human losses avoided as a result of the construction of a road project improving safety or in the case of a project which increases the risk of loss of human life, such as nuclear energy, for example, the following costs are generally considered.

- Direct Losses: these correspond to the consumption of the following resources

- Medical expenses (ambulance, care, drugs, use of equipment, rehabilitation... if there is a handicap).

- Damage to vehicles, public and private property, resource costs related to repairs, etc.

- General expenses, such as legal fees, expertise, insurance services, etc. They should be recorded net of tax (transfer).

- Actual Production Losses: they estimate the actual production lost by the community, due to the death or temporary or permanent incapacity of an actor.
- Affective Losses: these are the damages borne by the injured or the parents of the victims. The authors distinguish:

- affective damage of relatives (in case of death),

- pain and suffering (pain of the injured),

- diminution of enjoyment, which affects an individual in his leisure and not in his production (left hand damaged for an amateur violinist),

- "pretium vivendi" (the desire to live from the one whose life is threatened). We could add:

-aesthetic damages, a particular form of diminution of enjoyment.

3.6.2.. Methods of Revealed Values

3.6.2.1.. Value Obtained by the Value of Wage Premiums (Dar).

For hazardous work (essentially). This gives results that are fairly dispersed and difficult to transpose. THALER and ROSEN (1979) examined wage differentials and risk differentials in their study. They found that an increase in mortal risk of 1 per 1000 resulted in a premium of $260.

This could mean that society implicitly accepts a loss of a human life for $260,000 paid, which would be roughly equivalent to three times today, but it is not certain that the same results would be obtained, to the extent that the value of human life may have increased.

3.6.2.2.. The Value of the Year of Life Earned

The question of the value of human life has been the subject of much work in the field of health economics, notably to assess the relative value of alternative treatments for the same illness. This work has introduced two operational concepts: QALY (quality adjusted life year) and DALY (disability adjusted life year)[7].

A QALY (1970) is a unit of measure of life expectancy weighted by the remaining quality of life. Thus the life span of an actor in a certain state of health is weighted by the quality of life related to health. This quality, measured by a utility coefficient (preference score 2), is established among the population.

A QALY value of 1 corresponds to a quality of life of perfect health, a value of zero to one of death. In such a way that a treatment that saves an extra year of life for a patient with a quality of life of 0.5 would be worth 1 QALY.

4. Calculation of Costs and Benefits

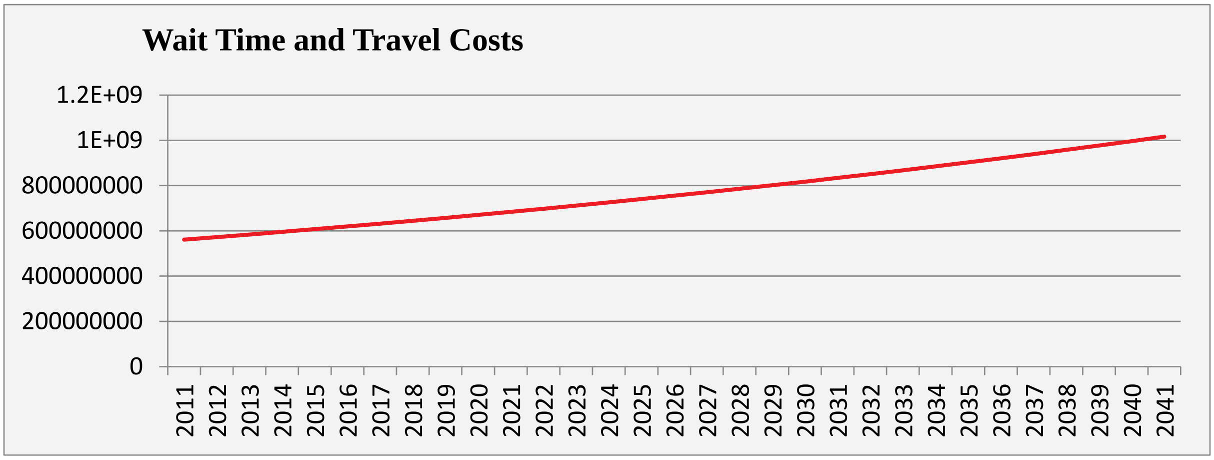
4.1. Baseline Scenario: the Status Quo

4.1.1. Wait Time and Travel Costs

The current condition of National Road No. 5 is so deplorable that it results in a very high cost in terms of wait time and travel. The chart below provides an estimate of the stream of costs related to wait and travel time in the event the intervention does not take place.

[7] Sassi F. Calculating QALYs, comparing QALY and DALY calculations. Health Policy Plan 21(5):402-408, 2006

Projection of Wait Time and Travel Costs without Intervention

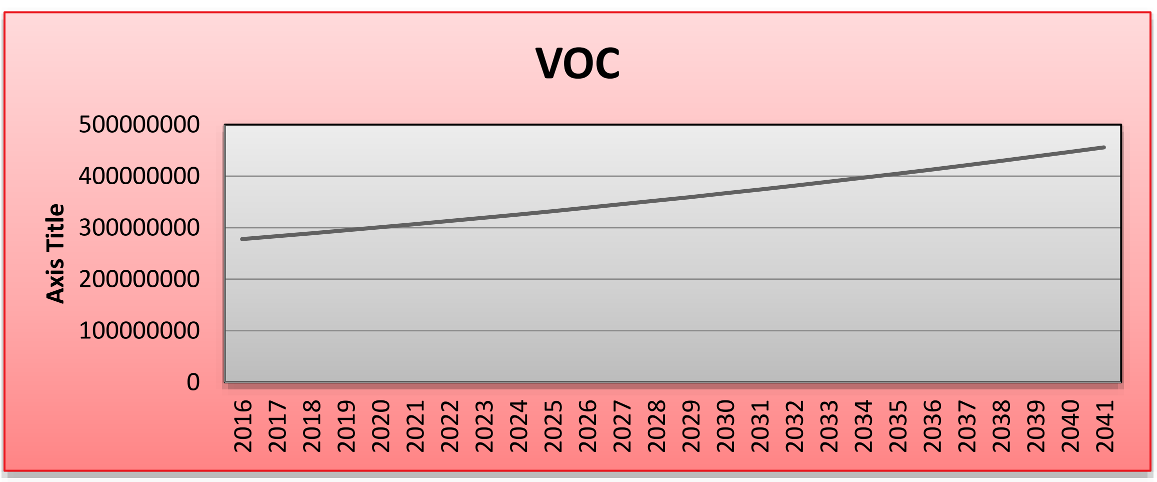


Source: MTPTC, for the travel volume for a given week in 2011.

4.1.2. Vehicle Operating Costs

Vehicle operating costs include acquisition cost, annual average gasoline cost, annual average lubricant cost, annual average tire cost and total annual maintenance cost. This data is based on information gathered at focus groups and the author's own estimates. The chart below shows the projected streams of vehicle operating costs by vehicle type without the intervention.

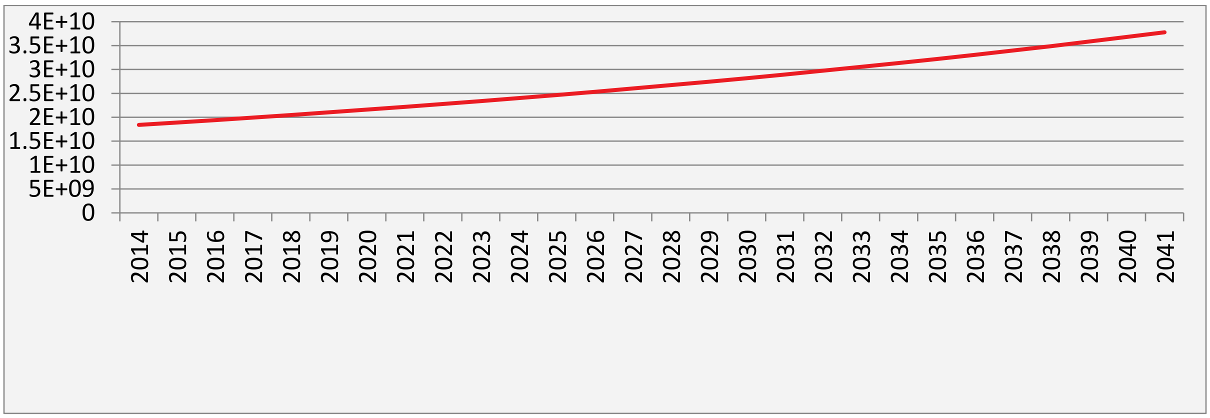
Projection of Vehicle Operating Costs without Intervention



4.1.3. Post-Harvest Loss

Up-to-date data on agricultural production in Haiti is not available. As a result, data from 2005 published by FAOSTAT were used. For the projection of value stream of agricultural production, the base year 2014 is considered.

Post-Harvest Loss without Intervention



4.2. Scenario 1: The Road is Asphalt

4.2.1. Calculation of the Costs of Intervention on the Road from Gonaives to Port-de-Paix

The calculation of costs was accomplished in four steps:

Step 1: Calculation of initial installation costs

Initial installation costs ($IIC_{t)}$ are the sum of the costs of different activities such as road plan studies, surveys, research costs, construction of infrastructure and equipment, and dismantling We realize a projection

$$\textbf{Initial installatin costs}_{\,t} = \begin{cases} \textbf{Cost of study} + \textbf{construction} + \textbf{dismantling} \;\; \textbf{if } t = 2017 \\ \qquad\qquad\qquad \mathbf{0} \qquad\qquad \textbf{if not} \end{cases}$$

NB: the initial installation costs are calculated for the first year of the project.

Step 2: Calculation of maintenance costs

Maintenance costs (MC_t) represent the sum of the costs of repairing the surfaces of the roadway, the treatment of cracks and roadwork signage. These different components are calculated on the basis of the cost of constructing infrastructure and equipment. Based on data from public transport projects already carried out by the MTPTC, in general, they represent about 27% of the cost of constructing infrastructure and equipment, that is, 10%, 15% and 2% respectively for the repair of road surfaces, the treatment of cracks and the roadwork signage. Road maintenance will be carried out at a frequency of every 5 years, thus, to estimate the annual stream of maintenance costs, the costs have been broken down by year.

Step 3: Cost of two toll stations

In Haiti, roads do not yet have toll stations. In addition, at the MTPTC there is no previous study on the cost of a toll station. Therefore, to estimate this parameter, a study was used in a southern country like Haiti: Cameroon. This cost consists of three components: the cost of construction of the station, labor and operating equipment. The latter are determined by an estimate based on a study carried out in Cameroon. As with the initial installation costs, toll station costs are calculated only for the first year of the project. The toll station cost (TSC_t) is the annual sum of the different categories mentioned above.

Step 4. Calculation of total costs

After calculating the stream of the different cost parameters for the construction of the road, the sum is calculated for each year.

$$\boldsymbol{TC_t = IIC_t + MC_t + TSC_t}$$

Finally, for the calculation of costs (C_t) for the entire duration of the intervention, an NPV of the total costs is realized while taking account of the % p.a.

$\boldsymbol{C_{it} = NPV\ (i, CT_t)}$, with i = (3%, 5%, 12%)

4.3 Calculation of Benefits for the Road from Gonaives to Port-de-Paix

4.3.1 Reduction in Wait Time and Travel Costs

Reduction in travel time brought about by improved traffic conditions is one of the often substantial benefits of transportation projects. The monetary component associated with this time gain in benefit-cost analysis is based on two main parameters: labor time savings and cargo time savings.

Labor Time Savings

The time spent by an individual to move about has a cost and this is an opportunity cost in that it reduces his or her time available for carrying out other activities such as work, leisure, studies or shopping. Waiting time or additional traveling time creates costs such as delays in work, resulting in a reduction in wages or the prolongation of a working day. The time gains realized during post-intervention travel represent a gain for the individual in terms of his/her available time budget, which might be called labor time savings.

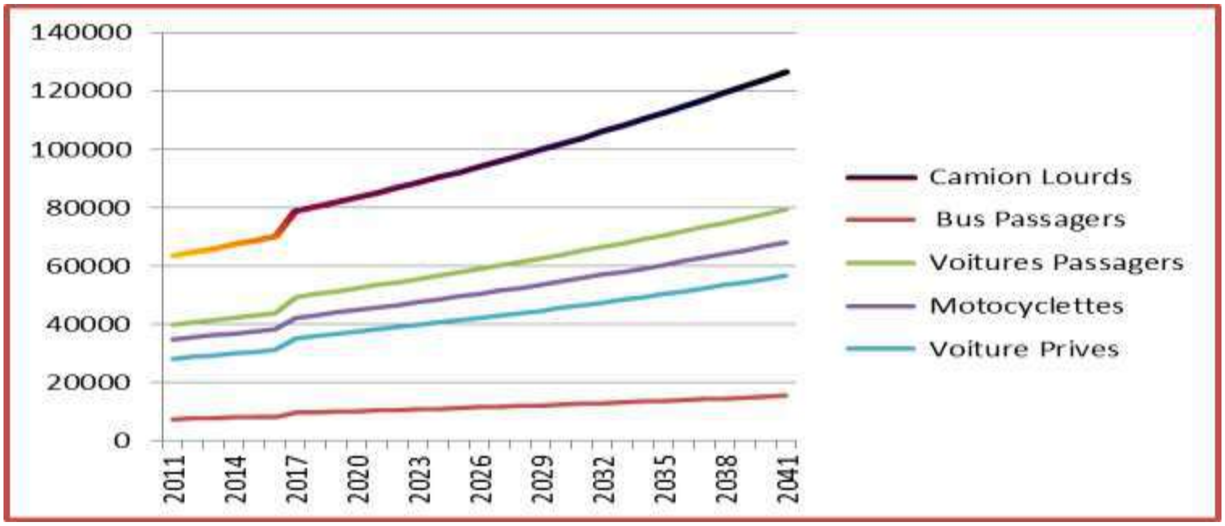
This benefit is calculated in three steps:

- A projection of the stream of trips on the road throughout the lifetime of the intervention.
- Estimated time savings by type of vehicle per trip.
- A NPV of the product of the time estimate and the travel volume by vehicle type over the period t of the duration of the intervention

<u>Step 1: The projection of the stream of trips on the road throughout the lifetime of the intervention.</u>

From data available at MTPTC on the volume of trips made for a given week in 2011.

Projection of Trips for the Road after Intervention



That is x_{tj}: $Annual\ traffic\ before$ at time t for vehicle type j

y_{tj}: $Additional\ Annual$ traffic after at time t for vehicle type j

z_{tj}: Total $Annual$ traffic at time t for vehicle type j

The projection of the traffic is realized with the formula:

$$\boldsymbol{x_{tj} = x_{2011j}(1+r)^{t-2011}}$$

While taking account of the type (j) of vehicle

Additional annual traffic after at time t for vehicle type j

$$\boldsymbol{y_{tj}} = \begin{cases} \mathbf{0} & \boldsymbol{if\ t} < 2017 \\ \mathbf{0.10} * \boldsymbol{x_{tj}} & \boldsymbol{if\ not} \end{cases}$$

Total annual traffic at time t for vehicle type (j)

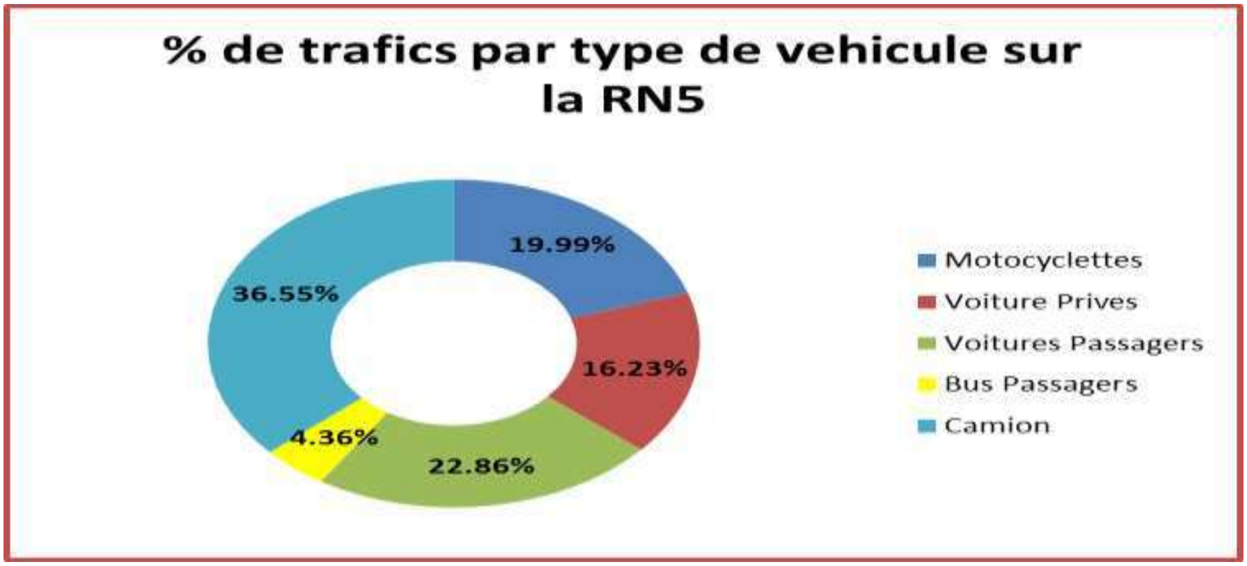
$$\boldsymbol{z_{tj} = x_{tj} + y_{tj}}$$

Step 2: Estimated time savings by type of vehicle per trip

We consider that the amount of traffic is not homogeneous for different types of vehicles (see figure 1), furthermore the number of passengers per vehicle is not identical.

For the calculation of this parameter, from the available data on the amount of traffic by vehicle type at the MTPTC, travel time savings for each type of vehicle were calculated.

Figure 1



Source: MTPTC

With the following formula:

$$LTST_j = TR_j * n_j * a$$

$LTST_j$: Labor time savings per trip for vehicle type j.

With $TR_j = \frac{L}{S_{1j}} - \frac{L}{S_{2j}}$ (Time reduction for vehicle type j.)

a: The value of time.

L: Length of the route.

n_j: Number of persons per trip in vehicle type j.

S_{1j}: Speed before the intervention and S_{2j}: speed after the intervention

STEP 3: Calculation of labor time savings

In this step, a NPV of the product of the estimate of time reduction and travel volume per vehicle type was first produced over the period t of the duration of the intervention.

$LTS_{ij} = NPV(i, LTST_j * z_{tj})$, with i= (3%, 5%, 12%)

Then the sum is calculated for the different types of vehicles.

$\boldsymbol{LTS_i = \sum_{j=1}^{5} LTS_{ij}}$, with i= (3%, 5%, 12%)

Time Savings Parameter: Cargo

For the calculation of this parameter, only the truck trips are considered.

Truck trip stream projections are used to determine the volume of trips over the duration of the intervention.

Cargo time savings per trip (CTST) is determined based on truck time reduction (TR), the estimated average value of cargo per trip (C) and the cargo time savings factor (f).

$$\boldsymbol{CTST_{ca} = TR_{ca} * C_{ca} * f}$$

The estimated average value of cargo per trip and the cargo time savings factor are estimated via a Focus group for drivers and owners of vehicles in the Northwest.

Finally, as with the labor time savings.

$\boldsymbol{CTS_{ica} = NPV(i, CTST_{ca} * z_{tca})}$, with i= (3%, 5%, 12%)

The economic value of the benefit reduction of costs related to wait time and travel is the sum of the two parameters "labor time savings and cargo time savings".

4.3.2. Reduction in Vehicle Operating Costs

This benefit is calculated in three steps:

Step 1: Calculation of the annual operating costs of vehicles by vehicle type

Vehicle operating costs include acquisition cost, annual average gasoline cost, annual average lubricant cost, annual average tire cost and total annual maintenance cost. This data is based on information gathered at focus groups and the author's own estimates.

Step 2: Projection of vehicle operating cost streams

The projection of vehicle operating cost streams by type of vehicle over the duration of the intervention is calculated by the formula:

$$\boldsymbol{VOC_{tj}} = \begin{cases} \boldsymbol{x_{2016j} * VOC_{Annuel\,j}} & \boldsymbol{if\ j = 2016} \\ \boldsymbol{VOC_{2016j}(1+r)^{t-2016}} & \boldsymbol{if\ j} > 2016 \end{cases}$$

With $\mathrm{VOC_{tj}}$: vehicle operating cost of the year (t)of the vehicle type j

$\mathrm{x_{2016\,j}}$: Annual traffic in 2016 of type j vehicles; r: Annual growth rate of trips.

Step 3: Calculation of VOC reduction

Calculation of VOC reduction

$\boldsymbol{VOC_i = (1 - s)(\sum_{j=1}^{5} NPV(\,i, VOC_{tj})}$,

with i= (3%, 5%, 12%); s: supposed reduction of the VOC

Table 2: VOC Summary

Benefits	Before intervention	After	Difference
Supposed reduction of the VOC		30%	
NPV 3%	6,224,112,860	4,356,879,002	1,867,233,858
NPV 5%	4,902,051,127	3,431,435,789	1,470,615,338
NPV 12%	2,533,903,485	1,773,732,440	760,171,046

4.3.3 Reduction of Accident Related Costs

After the construction of the road, the risk of accidents will be diminished. This benefit is calculated in three steps:

Step 1: Projection of "Lives Saved" streams

In order to project this stream, the number of hours spent on the road by vehicle type was estimated (see Table 3). The weighted average between the number of trips and the type of vehicle was calculated for each year before and after the intervention. Finally, the latter are multiplied by the quotient of death per hour per accident to make the difference to find the number of lives saved

Table 3: Amount of Time Spent on the Road in Hours by Vehicle Type

	Motorcycles (J=1)	Private Cars (J=2)	Passenger Cars (J=3)	Passenger Buses (J=4)	Trucks (J=5)
Time spent on the road before intervention (T_{1j})	2.075	2.766666667	2.766667	2.766667	3.32
Time spent on the road after intervention (T_{2j})	1.106666667	1.0375	1.0375	1.0375	1.106667

The calculation can be summarized as follows:

$$\textit{Travel time } (TT_t) = \begin{cases} \sum_{j=1}^{5} x_{tj} * T_{1j} & \textbf{Before intervention} \\ \sum_{j=1}^{5} z_{tj} * T_{2j} & \textbf{After intervention} \end{cases}$$

Lives Saved (L_t) = (TT_{t1} - TT_{t2})*q; with q: the quotient of accidental death per hour.

Step 2: Estimating the economic value of lives saved

Reduction of accident costs (RAC_{it}) $= L_t * \frac{pib_t}{hab_t} * DALYS_i$

With i = ***(3%, 5%, 12%)***

Step 3: Calculation by scenario

Finally, a NPV of the accident cost reduction streams is produced with 3 scenarios

$$\mathrm{RAC}_i = \begin{cases} NPV\ (i, \mathrm{RAC}_{it}) & 1\ GDP\ per\ cap \\ NPV\ (i, \mathrm{RAC}_{it}) * 3 & 3\ GDP\ per\ cap \\ NPV\ (i, \mathrm{RAC}_{it}) * 8 & 8\ GDP\ per\ cap \end{cases}$$

The medium scenario was used in the calculation of this benefit.

4.3.4. Reduction in Post-harvest Loss

Step 1: Projection of the stream of the value of agricultural production in the Northwest economy

Up-to-date data on agricultural production in Haiti is not available. As a result, data from 2005 published by FAOSTAT were used. For the projection of the streams of the value of agricultural production, the base year is the year 2014.

$$AP_t = AP_{2014}(1+gdp)^{t-2014}$$

With: gdp: growth rate of GDP in %;
AP_t: Agricultural production for year t

Step 2: Projection of post-harvest loss reduction stream

The formula is:

$$\boldsymbol{PLR_t} = \begin{cases} \mathbf{0} & \boldsymbol{for\ \ t} < 2017 \\ \boldsymbol{AP_t(PHL_1 - PHL_2)} & \boldsymbol{if\ not} \end{cases}$$

With PHL_1 and PHL_2: Proportion of post-harvest losses without and with intervention respectively.

Step 3: Estimation of the total value of the reduction in post-harvest losses.

$$\boldsymbol{PLR_i = NPV(\ i, PLR_t)}$$

With i= (3%, 5%, 12%)

4.3.5. Economic Benefits

Step 1: Projection of Northwest GDP stream

$$\boldsymbol{Gdp_t^{no} = GDP_t * \alpha}$$

With GDP_t: Projections of GDP based on the previous real growth rate of 2.7% from 1975 to 2014. α: Northwest proportion in the national economy.

Step 2: Calculation of benefit

$$BE_t = Gdp_t^{no} * \delta$$

With: δ: Statistical increase in regional GDP

Step 3: Calculation of benefit

The calculation of the benefit is made from a NPV

$$BE_i = NPV(\,i, BE_t)$$

With i= (3%, 5%, 12%)

4.3.6. Revenue from Toll Stations

The calculation of revenue from toll stations is based on the traffic stream and also on the price fixed by vehicle type. This benefit is calculated in 3 steps:

Step 1: Calculation of toll station revenue stream by vehicle type.

In the calculation of labor time savings, the total traffic stream has already been estimated ($\boldsymbol{z_{tj}}$). Considering that there are no toll stations in Haiti, data on the price of toll stations by vehicle type are not available. Consequently, according to information gathered by transporters in the Northwest and other countries with the same economic level as Haiti, the following rates (Table 4) were estimated by vehicle type.

Table 4

	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Trucks
Cost of passage in gourdes ($\boldsymbol{\theta_j}$)	75	150	250	300	500

$RE_{tj} = \boldsymbol{z_{tj}} * \theta_{tj}$ With θ_{tj} the price fixed per vehicle type at time t.

It should be noted that a price adjustment is expected with the level of the cost of living.

Step 2: The calculation of total revenues of toll stations by vehicle type using a NPV

$$RE_{ij} = \boldsymbol{NPV}(\ \boldsymbol{i}, RE_{tj}) \qquad \text{With i= (3\%, 5\%, 12\%)}$$

Step 3: The calculation of total revenues

The sum of the total revenues of the different types of vehicles is calculated.

$$RE_i = (\sum_{j=1}^{5} \boldsymbol{NPV}(\ \boldsymbol{i}, RE_{ij})$$

4.4 Scenario 2: The Road is Gravel

Although almost all the national roads in Haiti are asphalt, it is interesting or even important in the context of this work to present another scenario in order to give an alternative to the decision makers. For this purpose, we will just present a table of costs and benefits for this scenario very briefly because asphalt is considered the norm applied in Haiti.

For this class of road, routine maintenance and deep pothole maintenance will be carried out with granular material of 5 m3/km/A. A profile every 30 days and a 15 cm thick granular material load when thickness reaches 10 cm. Therefore, the cost of building and maintaining the gravel road will be reduced by 55% compared to scenario 1, that is to say, it will be approximately 8, 162,415,202.833 HTG since there will be no toll stations to be built and maintenance costs will be significantly reduced.

In terms of the benefits, it is evident that there are some that will be lowered compared to scenario 1, and there are others that will not be taken into account in this scenario. And if the road is gravel, the demand for vehicles will certainly decrease. Given that benefit calculations are heavily dependent on vehicle streams, benefits such as reduction in wait time and travel costs, vehicle operating costs, and reduction of post-harvest losses will be revised to downward. Road users will need much more time to make the journey then when the road is in asphalt; vehicles will require significantly more resources for maintenance; the risk of having a lot of accidents on the gravel road is not much different from that on the clay road and, finally, the produce produced in this department will always be difficult to sell in other markets. This situation leads us to make assumptions, taking into account the difficulty of finding available data, on all of these benefits. It is assumed that the benefits of the scenario in which the road is gravel have decreased by 60% compared to those of the asphalt road. This leads us to a monetary value of approximately 20,740,377,581.4 HTG; 15,324,913,258.6 HTG; 7,112,124,543.36 HTG respectively for the discount rates of 3%, 5% and 12%.

Hence, the different Cost-Benefit Ratios for this scenario: 2.54; 1.87; 0.87 for the rates of 3%, 5% and 12%, respectively.

4.5. Calculation of the Cost of Construction of the Les Anglais Bridge

Step 1: Initial installation costs

Initial installation costs (IIC_{t}) are the sum of the plan, quotes, research costs, construction of infrastructure and equipment, expropriation and dismantling.

We realize a projection:

$$\textbf{\textit{Initial installation costs}}_{t} = \begin{cases} \textbf{\textit{Cost of study}} + \textbf{\textit{construction}} + \textbf{\textit{dismantling}} \;\; \textbf{\textit{if }} t = \mathbf{2017} \\ \mathbf{0} \qquad \textbf{\textit{if not}} \end{cases}$$

NB: the initial installation costs are calculated for the first year of the project.

Step 2: Maintenance costs

Maintenance costs (MCt) represent the sum of the costs of repairing the surfaces, the treatment of cracks and roadwork signage. These different components are calculated on the basis of the cost of constructing the main bridge and 2.5 kilometers of road. Based on available data from projects already carried out, in general, they represent about 30% of the cost of constructing infrastructure and equipment, that is, 10%, 15% and 5% respectively for the repair of surfaces, the treatment of cracks and the roadwork signage. Bridge maintenance will be carried out at a frequency of every 5 years, thus to estimate the annual stream of maintenance costs, the costs have been broken down by year.

Step 3: Calculation of total costs

After calculating the stream of the different cost parameters for the construction of the bridge, the sum is calculated for each year.

$$TC_t = IIC_t + CE_t$$

Finally, for the calculation of costs (C_t) for the entire duration of the intervention, an NPV of the total costs is realized while taking account of the % p.a.

$C_{it} = NPV$ (*i*, TC_t) *with i= (3%, 5%, 12%)*

4.5.1 Calculation of the Benefits of Construction of the Les Anglais Bridge

4.5.1.1 Reduction in Wait Time and Travel Costs

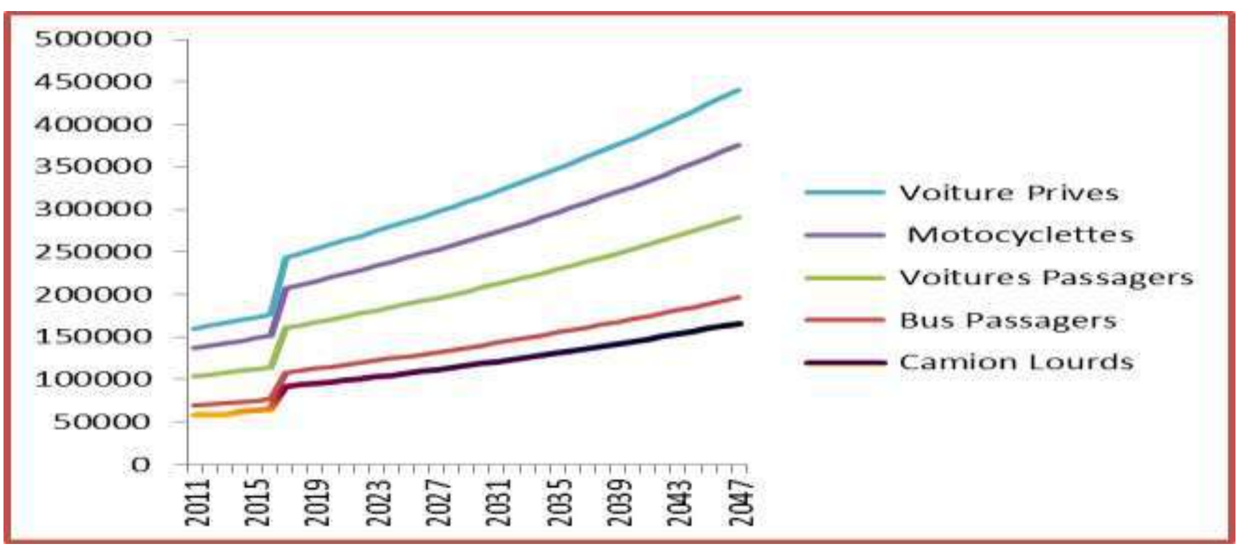
Just as for the road, this benefit is calculated in three steps:

- A projection of the stream of trips on the bridge throughout the lifetime of the intervention.
- Estimated time savings by type of vehicle per trip.
- A NPV of the product of the time estimate and the travel volume by vehicle type over the period t of the duration of the intervention

Step 1: The projection of the stream of trips on the bridge throughout the lifetime of the intervention.

This projection was made from data available at the MTPTC on the volume of trips made for a given week in 2011.

Projection of Trips for the Bridge after Intervention



That is x_{tj}: $Annual\ traffic\ before$ at time t for vehicle type j

y_{tj}: Additional $annuel$ traffic after intervention at time t for vehicle type j

z_{tj}: Total $annuel$ traffic at time t for vehicle type j

The projection of the traffic is realized with the formula:

$\boldsymbol{x_{tj} = x_{2011j}(1+r)^{t-2011}}$, **r the annual growth rate of trips without intervention.**

While taking account of the type (j) of vehicle

Additional $annual$ traffic after at time t for vehicle type j

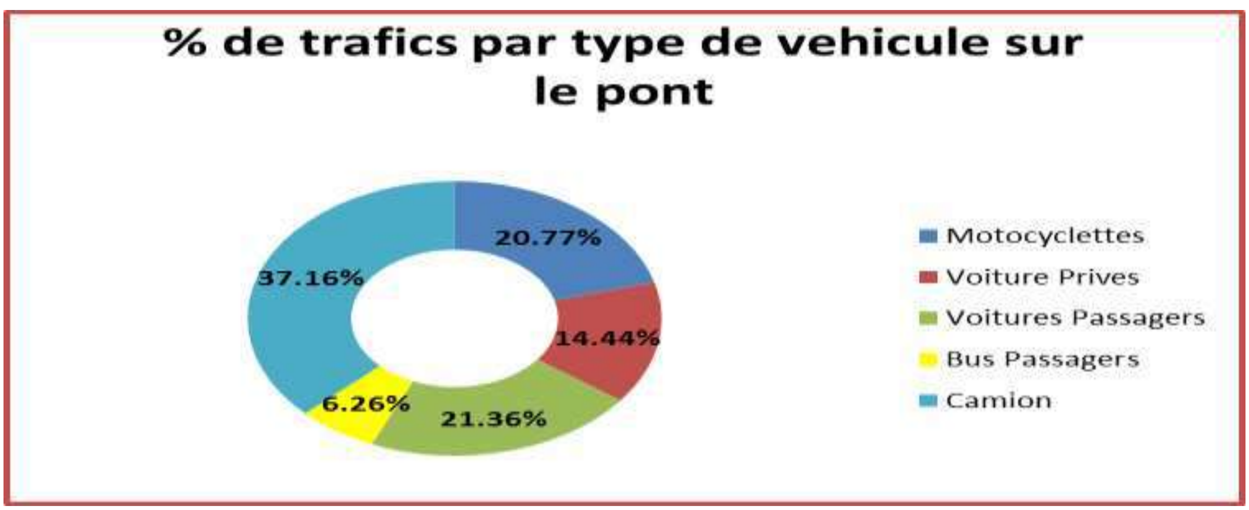
$$\boldsymbol{y_{tj}} = \begin{cases} \mathbf{0} & \boldsymbol{if\ t} < 2017 \\ \mathbf{0.10} * \boldsymbol{x_{tj}} & \boldsymbol{if\ not} \end{cases}$$

Total $annual$ traffic at time t for vehicle type (j)

$$\boldsymbol{z_{tj} = x_{tj} + y_{tj}}$$

Step 2: Estimated time savings by type of vehicle per trip

For the calculation of this parameter, available data on traffic numbers by vehicle type were used from the MTPTC. Travel time savings for each type of vehicle were calculated.



$\boldsymbol{LTST_j = TR_j * n_j * a}$ (Labor Time Savings per Trip for vehicle type j)

With $\boldsymbol{TR_j} = \frac{\boldsymbol{L}}{\boldsymbol{S_{1j}}} - \frac{\boldsymbol{L}}{\boldsymbol{S_{2j}}}$ (Time reduction for vehicle type j.)

$\boldsymbol{a}$: The value of time.

L: Length of the route; $\boldsymbol{n_j}$: number of persons per trip in vehicle type j; $\boldsymbol{S_{1j}}$: speed before the intervention and $\boldsymbol{S_{2j}}$: speed after the intervention.

<u>STEP 3: NPV of the product of the time reduction estimate and of the trip volume by vehicle type over the period t of the duration of the intervention</u>

Formula:

$$\boldsymbol{LTS_{ij} = NPV(i, LTST_j * z_{tj})} \textit{, with i= (3\%, 5\%, 12\%)}$$

Time Savings Parameter: Cargo

For the calculation of this parameter, we proceed in the same way, that is to say only the truck trips are considered.

- Truck trip stream projections are used to determine the volume of trips over the duration of the intervention.

Cargo time savings per trip ($\boldsymbol{CTST}$) is determined based on truck time reduction (TR), the estimated average value of cargo per trip (C) and the cargo time savings factor (f).

$$\boldsymbol{CTST_{ca} = TR_{ca} * C_{ca} * f}$$

The estimated average value of cargo per trip and the cargo time savings factor are estimated via a Focus group for drivers and owners of vehicles in the South.

Finally, as with the labor time savings

$$\boldsymbol{CTS_{ica} = NPV(i, CTST_{ca} * z_{tca})}\textit{, with i= (3\%, 5\%, 12\%)}$$

4.5.2 Reduction in Vehicle Operating Costs

For the calculation of the reductions in vehicle operating costs, we have:

<u>Step 1: Calculation of the annual operating costs of vehicles by vehicle type</u>

Vehicle operating costs include acquisition cost, annual average gasoline cost, annual average lubricant cost, annual average tire cost and total annual maintenance cost. These data were collected through focus groups.

Step 2: Projection of vehicle operating cost streams by type of vehicle over the duration of the intervention

By the formula:

$$\boldsymbol{VOC_{tj}} = \begin{cases} \boldsymbol{x_{2016j} * VOC_{Annual\,j}} & \boldsymbol{if\ j = 2016} \\ \boldsymbol{VOC_{2016j}(1+r)^{2016-t}} & \boldsymbol{if\ j} > 2016 \end{cases}$$

With $\boldsymbol{VOC_{tj}}$: ***vehicle operating cost of the year*** $(\boldsymbol{t})$***of vehicle type*** $(\boldsymbol{j})$; $\boldsymbol{x_{2016\,j}}$: Annual traffic in 2016 of type j vehicles; **r**: annual growth rate of trips.

Step 3: Calculation of VOC reduction

$$\boldsymbol{VOC_i = (1-s)(\textstyle\sum_{j=1}^{5} NPV(\,i, VOC_{tj})}\,,$$

with i= (3%, 5%, 12%); s: supposed reduction of VOC

4.5.3. Reduction in Post-harvest Loss

Step 1: Projection of the stream of the value of agricultural production in the economy of the South

For the projection of the streams of the value of agricultural production, 2014 is considered as base year.

$$AP_t = AP_{2014}(1 + gdp)^{t-2014}$$

With: gdp: growth rate of GDP in %;
AP_t: Agricultural production of the South for year t

Step 2: Projection of post-harvest loss reduction stream

The formula is:

$$PLR_t = \begin{cases} \mathbf{0} & \boldsymbol{for\ t} < 2017 \\ \boldsymbol{AP_t(PHL_1 - PHL_2)} & \boldsymbol{if\ not} \end{cases}$$

With PHL_1 and PHL_2: Proportion of post-harvest losses without and with intervention respectively.

Step 3: Estimation of the total value of the reduction in post-harvest losses.

$\boldsymbol{PLR_i = NPV(\,i, PLR_t)}$ With i= (3%, 5%, 12%)

5. Conclusion

The cost-benefit analysis of the construction of the road from Gonaives to Port-de-Paix and the bridge over the Les Anglais River is of capital importance for the implementation of these interventions by the Haitian State. Remember that cost-benefit analysis is a tool to aid in decision-making. It is used to compare the benefits and costs of projects or solutions envisaged as part of a project in order to determine which option allows procurement of the best economic advantage, namely the option that maximizes the return on investment for society. Establishing the scenario or project that is most economically profitable for society will necessarily have to take into account the constraint of the budgetary context facing the government.

A project that satisfies the criterion of economic efficiency is obtained when the sum of the economic benefits is greater than the sum of the economic costs. Thus, the totality of the benefits that the project provides for certain individuals makes it theoretically possible to compensate those who are disadvantaged by the project, which means that the well-being level of society as a whole will be higher after the implementation of the project or the solution adopted.

Consequently, the construction of the road from Gonaives to Port-de-Paix certainly has costs (direct and indirect) and benefits arising therefrom. Based on the different MTPTC data, the total costs of this intervention have been estimated at **18,138,700,450.74 HTG (3%, discount rate)**, **16,520,306,618.60 HTG (5%)** and **13,199,819,039.00 HTG (12%)**. The total benefits of the Port-de-Paix road were estimated for the same discount rates at **51,850,943,953.70 HTG**;

38,312,283,146.65 HTG; **17,780,311,358.42 HTG** respectively. This gives the different ratios of 2.9 for a rate of 3%, 2.3 for a rate of 5% and finally 1.8 for a rate of 12%. It can therefore be concluded that, in terms of economic efficiency, this intervention should be implemented in Haiti, specifically in the northwest department, which is one of the departments of the country where socio-economic conditions are more deplorable. With such cost-benefit ratios, it is clear that the implementation of this intervention will bring considerable changes leading to improved living conditions for the northwestern population.

The direct and indirect costs of the construction of the bridge over the ''Les Anglais'' River came to **1,010,584,314.59 HTG**; **883,389,966.63 HTG**; **653,036,530.01 HTG** for discount rates of 3%, 5% and 12% respectively. The benefits resulting from the construction of this bridge were estimated at **1,774,247,371.31 HTG**; **1,331,616,701.48** HTG; **621,741,282.92 HTG** for the same discount rates respectively. To this end, the different cost-benefit ratios have been calculated to see if this intervention is being implemented by the Haitian State in the South Department. 1.8, 1.5 and 1 were obtained as ratios for the rates of 3%, 5% and 12%, respectively. That said, the construction of this bridge will be part of regional development because it will facilitate access between several municipalities in the greater region of the South. In other words, this bridge will allow regional economic and social integration.

In the end, we recommend the implementation of these two interventions in road infrastructure. In addition to the various calculations, the literature in this domain tells us how construction of road infrastructure is beneficial to developing countries. It has been clearly demonstrated in this research paper that the construction of National Road No. 5 will have positive impacts at several levels. It will allow the integration of the different markets in the Northwest Department since the roads facilitate not only the trade but also the productivity of labor inside and outside of agriculture. It will also help to reduce post-harvest losses and to combat extreme poverty in this department, which is one of the country's poorest, because the road will have compensatory effects on the demand for labor and production. By lowering the cost of exports, a road will increase the demand for inputs (such as labor) and products. By reducing the cost of importing, a road increases competition, potentially reducing demand.

Summary Table

Interventions	Discount Rate	Benefit	Cost	Benefit-Cost Ratio	Data Quality
Road Construction P-de-P to Gonaives	3%	51,850,943,953.70	18,138,700,450.74	2.9	Average
	5%	38,312,283,146.65	16,520,306,618.60	2.3	
	12%	17,780,311,358.42	13,199,819,039.00	1.3	
Bridge Construction Les Anglais	3%	1,774,247,371.31	1,010,584,314.59	1.8	Average
	5%	1,331,616,701.48	883,389,966.63	1.5	
	12%	621,741,282.92	653,036,530.01	1.0	

Bibliographic References

- ✓ **Valérie Meunier**, "l'Analyse coût-Bénéfice: Guide Méthodologique;" les cahiers de la securité industrielle
- ✓ **Binswanger, H., S. Khander and M. Rosenzweig**,"How Infrastructure and Financial Institutions Affect Agricultural Output and Investment in India," Journal of Development Economics, 1993, 41 (2) 337-366
- ✓ **Corinne Meunier**, "Infrastructures de transport et developpement, l'apport de l'economie des réseaux;" les cahiers scientifiques du Transport No 36/1999- Pages 69-85
- ✓ **Fritz Gérald Chéry,** "La Structure de l'Economie & la Réformen de l'Etat en Haiti;" imp. Henry Deschamps – Page 209
- ✓ **Glenn P. Jenkins,** "Cost-benefit Analysis for Investment Decisions," Development Discussion paper: 2011-1
- ✓ **MTPTC(2015**), "Rapport sur l'élaboration d'une Stratégie Nationale de Sécurité Routière Rapport Initial" – revised February
- ✓ **Government of Quebec** (2016), "Guide l'analyse Avantages-coûts des projets publics en transport routier, Méthodologie," Edition 2016
- ✓ **World Bank**, World Development Report 1994: Infrastructure for Development, June 1994
- ✓ **Sassi F**. Calculating QALYs, Comparing QALY and DALY Calculations. Health Policy Plan, 2006
- ✓ **Olken, B.A. and Barron, P.** The Simple Economics of Extortion: Evidence from Trucking in Aceh, Journal of Political Economy, 2009, Vol.117, no. 3
- ✓ **Khander, S. R. and Koolwal, G.B.** Estimating the Long-term Impacts of Rural Roads: a Dynamic Panel Approach, World Bamk Policy Research Working Paper Series, 2011
- ✓ **Van de Walle, D.** Impact Evaluation of Rural Road Projects, Journal of Development Effectiveness, 2009, Vol. 1(1), pp. 15-36

- ✓ **Gibson, J. and Rozelle, S.** Poverty and Access to Roads in Papua New Guinea, Economic Development and Cultural Change, 2003, Vol. 52(1), pp. 159-185

- ✓ **Casaburi, L., Glennerster, R. and Suri, T.** Rural Roads and Intermediated Trade: Regression Discontinuity Evidence from Sierra Leone, 2013

- ✓ **Asher, S. and Novosad, P.** Market Access and Occupational Choice: Evidence from Rural Roads in India, Job Market Paper, 2015

- ✓ **Khandker, S.R.., Z. Bakht, and Koolwal, K.B. Gayatri,** "The Poverty Impact of Rural Roads: Evidence from Bangladesh", 2006

APPENDICES

Appendix 1: Raw Data on Traffic

	NR 5			Les Anglais Bridge	
	Amount of traffic per week	Amount of traffic per week	# of people on average traveled/years	Amount of traffic per week	# of people on average traveled/years
Motorcycles	669	2	69576	640	66560
Private Cars	543	5	141180	445	115700
Passenger Cars	765	12	477360	658	513240
Passenger Buses	146	45	341640	193	351260
Trucks	1223	5	317980	1145	238160
Total	3346	/////////////	1347736	3081	1284920
Source:	SCPVL / MTPTC			SCPVL / MTPTC	

Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

APPENDIX 2: PROJECTION OF TRIPS ON NR5 WITH INTERVENTION FROM 2016 TO 2041

Total Traffic						
Year	Number	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Heavy Trucks
2011	173992	34788.00	28236.00	39780.00	7592.00	63596.00
2012	177472	35483.76	28800.72	40575.60	7743.84	64867.92
2013	181021	36193.44	29376.73	41387.11	7898.72	66165.28
2014	184642	36917.30	29964.27	42214.85	8056.69	67488.58
2015	188335	37655.65	30563.55	43059.15	8217.82	68838.36
2016	192101	38408.76	31174.83	43920.33	8382.18	70215.12
2017	215538	42311.09	35296.14	49368.21	9661.30	78900.83
2018	219848	43157.32	36002.06	50355.58	9854.53	80478.85
2019	224245	44020.46	36722.10	51362.69	10051.62	82088.42
2020	228730	44900.87	37456.54	52389.94	10252.65	83730.19
2021	233305	45798.89	38205.67	53437.74	10457.70	85404.80
2022	237971	46714.87	38969.79	54506.50	10666.86	87112.89
2023	242730	47649.16	39749.18	55596.63	10880.20	88855.15
2024	247585	48602.15	40544.17	56708.56	11097.80	90632.25
2025	252537	49574.19	41355.05	57842.73	11319.76	92444.90
2026	257587	50565.67	42182.15	58999.58	11546.15	94293.80
2027	262739	51576.99	43025.79	60179.58	11777.07	96179.67
2028	267994	52608.53	43886.31	61383.17	12012.62	98103.27
2029	273354	53660.70	44764.04	62610.83	12252.87	100065.33
2030	278821	54733.91	45659.32	63863.05	12497.92	102066.64
2031	284397	55828.59	46572.50	65140.31	12747.88	104107.97
2032	290085	56945.16	47503.95	66443.11	13002.84	106190.13
2033	295887	58084.06	48454.03	67771.98	13262.90	108313.93
2034	301805	59245.75	49423.11	69127.42	13528.16	110480.21
2035	307841	60430.66	50411.58	70509.96	13798.72	112689.82
2036	313998	61639.27	51419.81	71920.16	14074.69	114943.61
2037	320278	62872.06	52448.20	73358.57	14356.19	117242.48
2038	326683	64129.50	53497.17	74825.74	14643.31	119587.33
2039	333217	65412.09	54567.11	76322.25	14936.18	121979.08
2040	339881	66720.33	55658.45	77848.70	15234.90	124418.66
2041	346679	68054.74	56771.62	79405.67	15539.60	126907.04

Source: MTPTC

APPENDIX 3: TIME SAVINGS: ANNUAL LABOR/TYPE OF VEHICLES NR5

	Number	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Trucks
2011	173,992.00	924,461.45	3,349,766.23	11,326,281.39	8,106,064.13	9,657,197.14
2012	177,471.84	942,950.68	3,416,761.55	11,552,807.02	8,268,185.42	9,850,341.08
2013	181,021.28	961,809.69	3,485,096.78	11,783,863.16	8,433,549.12	10,047,347.90
2014	184,641.70	981,045.89	3,554,798.72	12,019,540.42	8,602,220.11	10,248,294.86
2015	188,334.54	1,000,666.81	3,625,894.69	12,259,931.23	8,774,264.51	10,453,260.76
2016	192,101.23	1,020,680.14	3,698,412.59	12,505,129.86	8,949,749.80	10,662,325.97
2017	215,537.58	1,124,381.24	4,187,342.73	14,056,266.16	10,315,481.62	11,981,270.51
2018	219,848.33	1,146,868.87	4,271,089.59	14,337,391.49	10,521,791.25	12,220,895.92
2019	224,245.29	1,169,806.25	4,356,511.38	14,624,139.32	10,732,227.08	12,465,313.84
2020	228,730.20	1,193,202.37	4,443,641.61	14,916,622.10	10,946,871.62	12,714,620.12
2021	233,304.80	1,217,066.42	4,532,514.44	15,214,954.55	11,165,809.05	12,968,912.52
2022	237,970.90	1,241,407.75	4,623,164.73	15,519,253.64	11,389,125.23	13,228,290.77
2023	242,730.32	1,266,235.90	4,715,628.02	15,829,638.71	11,616,907.74	13,492,856.59
2024	247,584.93	1,291,560.62	4,809,940.58	16,146,231.48	11,849,245.89	13,762,713.72
2025	252,536.62	1,317,391.83	4,906,139.39	16,469,156.11	12,086,230.81	14,037,967.99
2026	257,587.36	1,343,739.67	5,004,262.18	16,798,539.24	12,327,955.42	14,318,727.35
2027	262,739.10	1,370,614.46	5,104,347.43	17,134,510.02	12,574,514.53	14,605,101.90
2028	267,993.89	1,398,026.75	5,206,434.37	17,477,200.22	12,826,004.82	14,897,203.94
2029	273,353.76	1,425,987.29	5,310,563.06	17,826,744.22	13,082,524.92	15,195,148.02
2030	278,820.84	1,454,507.03	5,416,774.32	18,183,279.11	13,344,175.42	15,499,050.98
2031	284,397.26	1,483,597.17	5,525,109.81	18,546,944.69	13,611,058.93	15,809,032.00
2032	290,085.20	1,513,269.12	5,635,612.01	18,917,883.59	13,883,280.11	16,125,212.64
2033	295,886.90	1,543,534.50	5,748,324.25	19,296,241.26	14,160,945.71	16,447,716.89

2034	301,804.64	1,574,405.19	5,863,290.73	19,682,166.08	14,444,164.62	16,776,671.23
2035	307,840.74	1,605,893.29	5,980,556.54	20,075,809.40	14,733,047.91	17,112,204.65
2036	313,997.55	1,638,011.16	6,100,167.68	20,477,325.59	15,027,708.87	17,454,448.75
2037	320,277.50	1,670,771.38	6,222,171.03	20,886,872.10	15,328,263.05	17,803,537.72
2038	326,683.05	1,704,186.81	6,346,614.45	21,304,609.55	15,634,828.31	18,159,608.48
2039	333,216.71	1,738,270.55	6,473,546.74	21,730,701.74	15,947,524.88	18,522,800.65
2040	339,881.05	1,773,035.96	6,603,017.67	22,165,315.77	16,266,475.37	18,893,256.66
2041	346,678.67	1,808,496.68	6,735,078.03	22,608,622.09	16,591,804.88	19,271,121.79

Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

APPENDIX 4: COV STREAM/TYPES OF VEHICLES NR5

	Number	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Trucks
2016	192101	8,720,660.37	41,060,328.34	49,626,177.28	24,082,980.79	154,316,419.10
2017	195943	8,895,073.57	41,881,534.90	50,618,700.83	24,564,640.41	157,402,747.48
2018	199862	9,072,975.04	42,719,165.60	51,631,074.84	25,055,933.22	160,550,802.43
2019	203859	9,254,434.55	43,573,548.91	52,663,696.34	25,557,051.88	163,761,818.48
2020	207937	9,439,523.24	44,445,019.89	53,716,970.27	26,068,192.92	167,037,054.85
2021	212095	9,628,313.70	45,333,920.29	54,791,309.67	26,589,556.78	170,377,795.95
2022	216337	9,820,879.98	46,240,598.69	55,887,135.87	27,121,347.91	173,785,351.87
2023	220664	10,017,297.58	47,165,410.67	57,004,878.58	27,663,774.87	177,261,058.90
2024	225077	10,217,643.53	48,108,718.88	58,144,976.15	28,217,050.37	180,806,280.08
2025	229579	10,421,996.40	49,070,893.26	59,307,875.68	28,781,391.38	184,422,405.68
2026	234170	10,630,436.32	50,052,311.12	60,494,033.19	29,357,019.20	188,110,853.80
2027	238854	10,843,045.05	51,053,357.35	61,703,913.85	29,944,159.59	191,873,070.87
2028	243631	11,059,905.95	52,074,424.49	62,937,992.13	30,543,042.78	195,710,532.29
2029	248503	11,281,104.07	53,115,912.98	64,196,751.97	31,153,903.64	199,624,742.94
2030	253473	11,506,726.15	54,178,231.24	65,480,687.01	31,776,981.71	203,617,237.79
2031	258543	11,736,860.68	55,261,795.87	66,790,300.75	32,412,521.34	207,689,582.55
2032	263714	11,971,597.89	56,367,031.79	68,126,106.77	33,060,771.77	211,843,374.20
2033	268988	12,211,029.85	57,494,372.42	69,488,628.90	33,721,987.20	216,080,241.69
2034	274368	12,455,250.44	58,644,259.87	70,878,401.48	34,396,426.95	220,401,846.52
2035	279855	12,704,355.45	59,817,145.07	72,295,969.51	35,084,355.49	224,809,883.45
2036	285452	12,958,442.56	61,013,487.97	73,741,888.90	35,786,042.60	229,306,081.12

2037	291161	13,217,611.41	62,233,757.73	75,216,726.68	36,501,763.45	233,892,202.74
2038	296985	13,481,963.64	63,478,432.88	76,721,061.21	37,231,798.72	238,570,046.80
2039	302924	13,751,602.91	64,748,001.54	78,255,482.44	37,976,434.69	243,341,447.73
2040	308983	14,026,634.97	66,042,961.57	79,820,592.09	38,735,963.39	248,208,276.69
2041	315162	14,307,167.67	67,363,820.80	81,417,003.93	39,510,682.65	253,172,442.22

Source: Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

APPENDIX 5: AVERAGE FUEL ECONOMY OF MAJOR VEHICLE CATEGORIES

Vehicle Type	MPG Gasoline	MPG Diesel	VMT Source
Refuse Truck	2.5	**2.8**	C
Transit Bus	3.3	**3.6**	B
Class 8 Truck	5.3	**5.8**	A
School Bus	6.3	**7.0**	D
Delivery Truck	6.6	**7.3**	A
Para. Shuttle	7.7	**8.5**	B
Police	**10.7**	11.8	E
Light Truck	**17.2**	19.0	A
Light-Duty Vehicle	**21.6**	23.9	A
Car	**23.4**	25.9	A
Motorcycle	**43.5**	48.2	A

Source: Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

APPENDIX 6: TOLL STATION REVENUE STREAM.

Year	Number	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Trucks
2016		2952673.654	4793129.43	11254585.68	2577520.798	35985250.41
2017		3252665.297	5426781.14	12650604.48	2970850.472	40436675.91
2018		3317718.603	5535316.763	12903616.57	3030267.482	41245409.43
2019		3384072.976	5646023.098	13161688.91	3090872.831	42070317.62
2020		3451754.435	5758943.56	13424922.68	3152690.288	42911723.97
2021		3520789.524	5874122.432	13693421.14	3215744.094	43769958.45
2022		3591205.314	5991604.88	13967289.56	3280058.975	44645357.62
2023		3663029.42	6111436.978	14246635.35	3345660.155	45538264.77
2024		3736290.009	6233665.717	14531568.06	3412573.358	46449030.07
2025		3811015.809	6358339.032	14822199.42	3480824.825	47378010.67
2026		3887236.125	6485505.812	15118643.41	3550441.322	48325570.88
2027		3964980.848	6615215.929	15421016.28	3621450.148	49292082.3
2028		4044280.465	6747520.247	15729436.6	3693879.151	50277923.95
2029		4125166.074	6882470.652	16044025.33	3767756.734	51283482.42
2030		4207669.395	7020120.065	16364905.84	3843111.869	52309152.07
2031		4291822.783	7160522.466	16692203.96	3919974.106	53355335.11
2032		4377659.239	7303732.916	17026048.04	3998373.588	54422441.82
2033		4465212.424	7449807.574	17366569	4078341.06	55510890.65
2034		4554516.672	7598803.726	17713900.38	4159907.881	56621108.47
2035		4645607.006	7750779.8	18068178.39	4243106.039	57753530.63
2036		4738519.146	7905795.396	18429541.95	4327968.16	58908601.25
2037		4833289.529	8063911.304	18798132.79	4414527.523	60086773.27
2038		4929955.319	8225189.53	19174095.45	4502818.073	61288508.74
2039		5028554.426	8389693.321	19557577.36	4592874.435	62514278.91
2040		5129125.514	8557487.187	19948728.9	4684731.924	63764564.49
2041		5231708.025	8728636.931	20347703.48	4778426.562	65039855.78

Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

APPENDIX 7: TIME SAVINGS: ANNUAL LABOR/TYPE OF VEHICLES LES ANGLAIS BRIDGE

	Number	Motorcycles	Private Cars	Passenger Cars	Passenger Buses	Trucks	Cargo Trucks
2011	160212	28583.45	87243.6	387008.7	264867.6	229971.5	31424677
2012	163416.2	29155.12	88988.47	394748.8	270165	234570.9	32053171
2013	166684.6	29738.22	90768.24	402643.8	275568.3	239262.4	32694234
2014	170018.3	30332.98	92583.6	410696.7	281079.7	244047.6	33348119
2015	173418.6	30939.64	94435.27	418910.6	286701.2	248928.6	34015081
2016	176887	31558.44	96323.98	427288.8	292435.3	253907.1	34695383
2017	243573.4	40076.06	136076.9	591427.6	434003.2	355681.5	48602447
2018	248444.9	40877.58	138798.4	603256.1	442683.2	362795.2	49574495
2019	253413.8	41695.13	141574.4	615321.2	451536.9	370051.1	50565985
2020	258482	42529.03	144405.9	627627.7	460567.7	377452.1	51577305
2021	263651.7	43379.61	147294	640180.2	469779	385001.1	52608851
2022	268924.7	44247.21	150239.9	652983.8	479174.6	392701.2	53661028
2023	274303.2	45132.15	153244.7	666043.5	488758.1	400555.2	54734249
2024	279789.3	46034.79	156309.6	679364.4	498533.2	408566.3	55828934
2025	285385	46955.49	159435.8	692951.7	508503.9	416737.6	56945512
2026	291092.7	47894.6	162624.5	706810.7	518674	425072.4	58084423
2027	296914.6	48852.49	165877	720946.9	529047.5	433573.8	59246111
2028	302852.9	49829.54	169194.5	735365.9	539628.4	442245.3	60431033
2029	308910	50826.13	172578.4	750073.2	550421	451090.2	61639654
2030	315088.2	51842.66	176030	765074.6	561429.4	460112	62872447

2031	321389.9	52879.51	179550.6	780376.1	572658	469314.2	64129896
2032	327817.7	53937.1	183141.6	795983.6	584111.1	478700.5	65412494
2033	334374.1	55015.84	186804.4	811903.3	595793.4	488274.5	66720744
2034	341061.5	56116.16	190540.5	828141.4	607709.2	498040	68055159
2035	347882.8	57238.48	194351.3	844704.2	619863.4	508000.8	69416262
2036	354840.4	58383.25	198238.3	861598.3	632260.7	518160.8	70804587
2037	361937.2	59550.91	202203.1	878830.3	644905.9	528524.1	72220679
2038	369176	60741.93	206247.2	896406.9	657804	539094.5	73665092
2039	376559.5	61956.77	210372.1	914335	670960.1	549876.4	75138394
2040	384090.7	63195.91	214579.5	932621.7	684379.3	560874	76641162
2041	391772.5	64459.83	218871.1	951274.1	698066.9	572091.4	78173985
2042	399608	65749.02	223248.6	970299.6	712028.2	583533.3	79737465
2043	407600.1	67064	227713.5	989705.6	726268.8	595203.9	81332214
2044	415752.1	68405.28	232267.8	1009500	740794.2	607108	82958859
2045	424067.2	69773.39	236913.2	1029690	755610	619250.2	84618036
2046	432548.5	71168.86	241651.4	1050284	770722.3	631635.2	86310397
2047	441199.5	72592.23	246484.4	1071289	786136.7	644267.9	88036604

Source: Excel spreadsheet of the cost-benefit analysis of the intervention Construction of National Road No. 5 and the Bridge on the Les Anglais River: Cost-Benefit Analysis of these Road Infrastructures" for the Haïti Priorise project, December 10, 2016

Haiti faces some of the most acute social and economic development challenges in the world. Despite an influx of aid in the aftermath of the 2010 earthquake, growth and progress continue to be minimal, at best. With so many actors and the wide breadth of challenges from food security and clean water access to health, education, environmental degradation, and infrastructure, what should the top priorities be for policy makers, international donors, NGOs and businesses? With limited resources and time, it is crucial that focus is informed by what will do the most good for each gourde spent. The Haïti Priorise project will work with stakeholders across the country to find, analyze, rank and disseminate the best solutions for the country. We engage Haitans from all parts of society, through readers of newspapers, along with NGOs, decision makers, sector experts and businesses to propose the best solutions. We have commissioned some of the best economists from Haiti and the world to calculate the social, environmental and economic costs and benefits of these proposals. This research will help set priorities for the country through a nationwide conversation about what the smart - and not-so-smart - solutions are for Haiti's future.

Haïti Priorise

Un plan de **développement** alternatif

For more information visit www.HaitiPriorise.com

COPENHAGEN CONSENSUS CENTER

Copenhagen Consensus Center is a think tank that investigates and publishes the best policies and investment opportunities based on social good (measured in dollars, but also incorporating e.g. welfare, health and environmental protection) for every dollar spent. The Copenhagen Consensus was conceived to address a fundamental, but overlooked topic in international development: In a world with limited budgets and attention spans, we need to find effective ways to do the most good for the most people. The Copenhagen Consensus works with 300+ of the world's top economists including 7 Nobel Laureates to prioritize solutions to the world's biggest problems, on the basis of data and cost-benefit analysis.