2016 Simplified Methodology for Economic Appraisal of Road-Transportation Projects in the Kurdistan Region

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1. PROLOGUE AND OVERVIEW

In the context of public policy, governments face the problem of allocating scarce resources (natural, human and capital) among infinite uses, to satisfy certain needs and with the goal of obtaining the maximum social and economic benefit. On the other hand, standardization and systematization of public investment processes have demonstrated important advantages in terms of increasing the profitability and productivity of public investment. In general, developing economies should allocate their scarce resources to the most productive investments. The public investment projects financed through increases in tax revenue or foreign debt should generate increased economic benefits to justify its implementation.

From this perspective, the purpose of this simplified transportation methodology is to assist Kurdistan Regional Government (KRG) agencies involved in the selection of new roads for construction and in maintenance projects for the existing network.

These guidelines are intended for different types of user in KRG. They serve as a technical reference for public sector authorities who are responsible for making public-sector investment decisions. This group shall include public officials (project evaluators) within the Ministry of Planning, Ministry of Finance, line ministries (LMs), departments and agencies (DAs), public enterprises (PEs) and all others institutions involved in the formulation, evaluation and implementation of public investment projects.

The structure and issues addressed in this methodology took into account international best practices and the review of textbooks and methodological guides from different countries and international organizations.

The document is divided into five chapters. Chapter 2 describes the scope of projects involved in the improvement of the transportation network in Kurdistan. The analysis will cover two processes: i) road-project preparation; ii) allocating funds to select projects for road maintenance and new road construction.

Chapter 3 lays out the analytical framework for this simplified methodology. This chapter familiarizes the project sponsor and project analyst with the basic concepts of financial and economic analysis of roads.

Chapter 4 is devoted to project preparation and analysis. An integrated financial, economic and uncertainty analysis must be carried out for new routes on the network in order to compare the alternative roads, and rank them according to their economic net benefits. This is what we call the module approach.

Chapter 5 lays out the basic concepts for allocating the limited budgetary funds between the construction of new roads and the maintenance of the existing network. This chapter helps to establish an economically sound balance between rival spending alternatives.

Finally, Chapter 6 presents final comments. It is important to note that the proposed methodology is fully aligned with the methodology used for the Highway Design and Maintenance Standard Model, the software designed to be used to perform lifecycle economic evaluation of road construction projects across the world.
2. INTRODUCTION

Evaluation tools are essential for making decisions related to project selection (to ensure the highest return). Comparing the total costs (investment and operation) of a project with its benefits allows a judgment to be made on the true contribution of that project to the wealth of the country.

Many developing countries show a shortage of modern procedures and techniques to provide the requisite efficiency in the process of selecting public investment projects (PIPs) for implementation. Provision of the basic infrastructure facilities such as roads, water, electricity, education and telecommunication – among others – are the key to the development of a country, and are fundamental for the creation of a strong private sector.

In this context, the proper evaluation of previous initiatives is essential in avoiding past mistakes and to enable us to learn from experience. Project evaluation allows the:

i) Identification of those criteria for investment policies that maximize social welfare;
ii) Cessation of "bad" projects and promote those whose are "good";
iii) Definition of the public or private sector implementation of the project;
iv) Establishment of agreements for desirable cost recovery;
v) Assessment of their impact on the environment, regional development and poverty, among other things.

2.1. Scope of Project Appraisal

The existence of a formal tool for project appraisal provides a framework to guide the efforts of government systems (which tend to run projects, which is good!), preventing the society as a whole from being harmed (which is bad!). Project appraisal allows us to answer the following questions: “What is the aim of the project? What happens if the project is implemented or not? Is the project the best alternative? Does the project have separable components? Who benefits and who pays the costs of the project? Which stakeholders may affect the investment decision or the performance of the project? Is the project financially sustainable (feasible)? What is the environmental impact of the project? What are the sources and magnitudes of the risks? Does the project contribute to economic growth? Is the project a source of political risk? And finally, to answer the big question: Is the project the most desirable relative to others competing for the same budget?” (Belli, P. et al, 2001).

The investment appraisal phase of PIPs is to ensure the economic feasibility and sustainability of projects over time. The utilitarian approach and applied welfare economics provide a conceptual framework to estimate the goodness of public policies in terms of social welfare and thus to answer the above questions. To estimate the contribution of the projects, it is then necessary to identify, measure and assess their costs and benefits. Identification of costs and benefits is to determine, qualitatively, the positive and negative impacts generated by the project.

Appraisal of PIPs using either the cost–benefit analysis (CBA) or cost-effectiveness analysis (CEA) approach will allow the direction of scarce economic resources toward the most productive investments and will provide for the sustainable long-run economic growth of the Kurdistan Region.
2.2. Scope of Proposal Methodology

The objective of this document is to provide a uniform pattern to prepare, assess and evaluate intercity (also called interurban) transportation projects. Intercity Transportation Sector includes all those national, regional and communal roads linking cities, towns and rural areas. In addition, it includes access to productive areas, tourism, neighbors, etc.

This methodology is aimed at allowing the economic profitability of road projects of the following type to be determined:

**Projects that increase road capacity**
Projects that increase the vehicle capacity of a highway, for example:
- Construction of third lanes.
- Construction of secondary roads for trucks.

**Projects that improve road quality**
Projects that improve the quality of existing service through changes in road geometry. For example:
- Reduction of the curvature of the path.
- Decreased slopes in the road.
- Construction of an alternative way.
- Construction of a tunnel that avoids a slope.

Projects that improve the quality of existing service through changes in the road surface (better quality). For example:
- Paving of a gravel road.
- Improvement of a dirt road.

Included are projects that partially or completely renovate the road surface, including the basic works required. For example:
- Resetting the concrete surface.
- Recoating with asphalt mix.
- Resetting the surface on a gravel road.

**Construction of new roads**
Projects that incorporate areas with accessibility problems. For example:
- Construction of access roads.
- Construction of border crossings.

Normally, conservation of existing roads does not require economic evaluation, because these activities are planned and considered in the original project appraisal. However, this methodology can support the analysis of conservation policies.

Activities to conserve roads should include all those actions that are intended to prevent the rapid deterioration of the road surface, deferring its replacement. These actions are applied to the same surface as related works, for example:
- Replacement of concrete slabs.
- Patching on asphalt.
- Re-profiling of a folder gravel or dirt.
- Re-taping of holes.
- Sealing of joints.
- Conservation and improvement of drainage works.
- Conservation of bridges.
3. ANALYTICAL FRAMEWORK

One of the objectives of project evaluation is to ensure that a project makes efficient use of a country’s scarce resources. Economic analysis provides a methodological framework for estimating economic benefits and costs. The benefit is measured by the net present value (NPV) of the incremental net economic benefits. Only if NPV is positive can a project claim to reallocate resources efficiently.

3.1. Incrementality of Projects

One of the key problems of project appraisal is ensuring that the project’s benefits and costs are being measured on an incremental basis. When conducting a project appraisal, it is important to conceptualize two states of nature: the one that includes the project (with-project situation) and the one that does not include the project (without-project situation). The costs and benefits of the “without” situation should be subtracted from the costs and benefits of the “with” project situation to derive the incremental resource-flow statement.

An important element in the appraisal is to ensure that the “without” situation is properly defined. The “without” project situation does not mean that nothing is done to the current situation (if a road construction is not undertaken). Even without a major rehabilitation of that particular road-link, there will be some regular maintenance performed on the road. In other words, the “without” project situation should still be technically optimized in order to be compared to the “with” project situation. A simple before-and-after comparison would not be able to avoid this pitfall.

3.2. Economic Benefits

The approach undertaken in this manual is called the Integrated Project Analysis (IPA), developed by Prof. Glenn Jenkins and Prof. Arnold Harberger, which is the most advanced methodology for modeling investment projects. This approach estimates the impact of the project from various perspectives in one integrated model; effects on private investor, government tax revenues, fiscal expenditures, consumers, and the environment are quantified and estimated in one integrated simulation model. IPA uses financial, economic and risk analyses of a potential investment project within a single consistent model.

From the economic point of view, transportation is a "good" and as such is governed by market laws: there is a demand, which reflects the willingness to pay for travel, and there is a supply, which represents the cost incurred for making such trips. This situation is shown in Figure N°3.1. The traffic volume is measured by annual average daily traffic (AADT, the number of trips) and is performed per unit of time; it is measured between a source-destination pair.

The costs incurred by users are called generalized travel cost, GTC, which mainly depends on the valuation of time spent on the trip and on the operating costs of vehicles (fuel, tires, etc.).

Both curves are expressed in private terms, i.e. at market prices. The 0ABTV₀ area, under the demand curve D, represents the willingness to pay (the total benefit received by road users).

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The cost perceived by the user that is incorporated into a route is the GTC, so it is also known as financial marginal travel cost, FMgTC. Since the GTC is the perceived cost by each road user, it will also be equal to the Economic Average Travel Cost, EATC.

The GTC is the addition of Vehicle Operation Costs and the Economic Value Time, which is considered a cost in transportation projects.

**Reduction in Vehicle Operating Costs**

Vehicle Operating Costs (VOC) represent the costs incurred by road users in terms of inputs consumption: gasoline and oil, wear-and-tear on tires, repair and maintenance expenses. All these inputs are combined into the definition of VOC and as a consequence of road improvement they will decline:

- Road geometry.
- Type and surface status.
- Types of vehicle; volume, composition and distribution of vehicles.
- Economic price of inputs.

For each type of vehicle formulator the following cost items must be calculated:

- Fuel consumption.
- Lubricants/oil consumption.
- Tire consumption.
- Parts consumption.
- Maintenance cost per hours of consumption.
- Vehicle depreciation.

These costs will depend on the types of user: normal traffic, diverted traffic and newly-generated traffic.

“Normal traffic” corresponds to road users who will travel on the road even without road improvement. Incremental VOC savings are estimated by comparing the total VOC...
“without” project with the proposed road improvement VOC. This annual financial VOC savings must then be converted into economic values to reflect the value of the resources saved for the economic analysis as a whole.

The total amount of such savings depends on the traffic volume and the vehicle composition on the route. It will depend also on the degree of surface improvement. In the case of a dirt or gravel road upgrading to a tarred surface, the value of VOC savings is likely to be substantial, as graphically presented in Figure N°3.2. Note that figure represents not only VOC reduction but also a combination of VOC and time costs incurred by road users.

“Diverted traffic” corresponds to users that change their route, keeping their origin and final destination. For diverted traffic, the benefits are measured by the difference between the total VOC on the alternative route against the total VOC on the upgraded road. To estimate their benefit, it is necessary to know what the alternative routes are in terms of distance and surface condition. In the absence of improved roads, “diverted” users are not willing to incur the current GTC, but they are willing to incur the new GTC measured as the sum of the value of time, VOC and toll rate (if any). Figure N°3.2 illustrates this.

**Figure N°3.2: Reduction of Total User Costs for Existing and New Traffic**

Source: international best practices.

Line D in Figure N°3.2 represents the demand function by vehicles. The vertical axis denotes the price (cost) that each successive unit of traffic would be willing to pay, per vehicle-km, for traveling over the road. This price should be interpreted as the maximum total cost per vehicle-km that one unit of traffic would be willing to bear in order for it to travel on the road. With the unimproved road, the cost per vehicle-mile is E, and the traffic level is TV₀, including all those traffic units willing to bear costs of C₀ or more. Under the improvement, costs will fall to A and traffic volume will now expand to TV₁. The net benefit to “normal” traffic is described by rectangle AEFTV₀, which is simply the difference between total VOC plus the time costs “with” and “without” the project.

The gross benefits received by incremental traffic are measured by TV₀FGTV₁, but the costs they perceive are TV₀BGTVDV₁. Therefore, the triangle BFG measures their net benefit for a particular period of time. It is evident from the diagram that they do not receive as much net
benefit as the existing traffic as some reductions in costs are necessary to induce them to travel on the improved road.

“Newly-generated traffic” corresponds to those new users that start a new trip between an origin and destination point. The reduction in the cost of using the improved road resulting from lower vehicle operating costs and faster travel (time savings) will induce more road journeys. The additional (newly-generated) road users are not willing to incur the current (without-project) generalized cost, but they are willing to incur the new GTC measured as the sum of the value of time, VOC and a toll rate (if any). The benefit to the generated users is also measured based on a half of the per-unit GTC reduction, since this type of traffic would not be materialized without this reduction. Referring to Figure N°3.2, if the additional traffic is entirely of the “newly-generated” type, with a volume $TV_{17}V_0$, then its per-unit value of benefits is equal to $\frac{1}{2}(E-A)$.

The actual increase in traffic as a result of lower transportation costs depends on the elasticity of demand for transportation services, which in turn depends on the elasticity of demand for the individual commodities involved. The traffic model that provides traffic forecasts should incorporate these factors in order to generate a series of “diverted” and “newly-generated” traffic.

**Travel Time Savings**

The magnitude of time savings depends on traffic volumes, average effective speeds, economic value of time for users of vehicles and economic opportunity cost of commercial vehicles. Valuation of time savings requires measuring the average speeds traveled on the road before and after road improvement. At some point, the speed on the road will become negatively related to the traffic volume due to congestion. Time savings should be projected for the future period.

“Normal” Traffic. For passengers and tourists that are classed under “normal traffic”, the improved road allows their vehicles to travel at a higher speed than the speed they can travel on the existing road; as a result, they will save time. The economic value of time is typically linked to the wage rates of unskilled, semi-skilled and skilled labor in the country/region. Once the average occupancy is established for each vehicle type, the analyst can estimate the value of time savings, depending on the vehicles’ rate of use (the number of passengers by type of vehicle).

“Diverted” and “Generated” Passenger Traffic. Typically, the value of time savings per additional vehicle-km traveled for “diverted” and “newly-generated” passenger traffic is taken as only one half of the value of time savings for “normal” traffic.

“Diverted” and “Generated” Freight Traffic. There are few approaches to estimating the value of time savings for cargo transportation. Ideally, the analyst should know what commodities are being transported on the road, as well as their volumes and destinations. This would facilitate an estimation of a delay cost as measured through the willingness to pay for a faster delivery.

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Valuation of time savings by different types of vehicle requires a substantial volume of survey information, often specific to the particular road segment in question.

**Savings of Maintenance Expenditures**

The construction costs of a tarred surface are typically justified by its lower annual maintenance costs as compared to a gravel-type surface. Savings of maintenance expenditures are estimated as the difference between the projected expenditures over the periods covered by the analysis of the existing road (“without” situation) minus the projected expenditures on an improved road (“with” situation). The resulting annual financial savings must then be converted into economic values to measure the real economic value of resources being conserved.

Most road improvement projects or new roads will affect the pattern of traffic on other roads that are complementary or substitutes to the road being improved. The traffic volume will increase on complimentary roads because people will use these roads in order either to access or to exit the improved road. It would be normal for road maintenance requirements to rise to a certain extent on these roads as their traffic increases. This rise in the annual road maintenance costs should be included in the costs associated with the road improvement project. The opposite situation arises in the case of substitute roads. The net change in the maintenance cost on substitute roads should be included as a benefit or cost in the appraisal of the road improvement project.

Figure N°3.3 shows the GTC curve for a section of the road network; it is assumed that this curve does not change the effect of the project, as the road remains standard. The project produces a shift in the demand curve from D to D' because of the diverted (or transferred) users to the improved road. If there is a distortion in this section (for example, congestion), reduced traffic will lead to an indirect benefit of the project.

**Figure N°3.3: Positive Indirect Benefits on a Substitute Road**

![GTC curve](image)

*Source: international best practices.*

On the other hand, sections of a complementary road will increase their traffic, as shown in Figure N°3.4. In this case, the existence of a distortion, such as congestion, will cause a
negative indirect benefit of the project (equivalent to a cost, but considered one of its benefits, because the benefit of the project is the sum of these parts).

Figure N°3.4: Negative Indirect Benefit on a Complementary Road

Source: international best practices.

Summary of Direct and Indirect Benefits

The economic benefit of the project is the sum of its direct and indirect benefits, i.e. the following shaded areas:

- Area AEFB in Figure N°3.2 corresponds to the release of resources or increase in consumer surplus associated with normal traffic on the improved road.
- Area FBG in Figure N°3.2 corresponds to the increase in consumer surplus associated with diverted (transferred) and newly-generated traffic in the improved section of the road.
- Area HKLJ in Figure N°3.3 corresponds to the increase in consumer surplus associated with normal traffic on substitute or alternate paths due to reduced congestion.
- Area LMJ in Figure N°3.3 corresponds to the increase in consumer surplus associated with the traffic that deviates and is transferred to the road that the project improves; this increase is determined by the excess-reducing congestion to the point where the user decides to change route.
- Areas RSTU and TWU in Figure N°3.4 should be considered negative as they correspond to costs.

Accident Reduction

An improved road is an important factor in reducing the number and degree of accidents, but there are a number of other influential aspects determining accident rate: width and geometric alignment of the road, congestion, volume of slow traffic, effectiveness of law enforcement, vehicles’ mechanical condition, and driver behavior. As a result, road improvement per se may not automatically imply a substantial reduction in the rate and severity of accidents. A detailed assessment is needed for each particular road in question before final conclusions are derived.
Two main steps must be taken to assess the magnitude of accident reduction. Firstly, the rate of traffic accident “with” and “without” the proposed improvement must be established. The rate is typically expressed as number of accidents per million vehicle-kilometers. Secondly, the value of accident reduction must be estimated. Typically, three types of damages are considered: property damage, cargo damage, and injuries and fatality. The value of property and cargo damage is easily appraised, but the assessment of injury and fatalities will require putting a value on human life or on forgone earnings over remaining years of life.

**Externalities**

It is appropriate, in the analysis of any project from the point of view of society as a whole, to take into account external or indirect benefits and costs, for example, whether, owing to the existence of a road project, more or less unskilled labors were to be employed in the area. Indirect benefits are measured by the excess of the amount these workers were paid over the minimum amount they would be willing to work for. The value of these indirect benefits is attributed as an additional benefit to the project.

### 3.3. Economic Costs

In order to receive the benefits of the project, it is necessary to incur some costs. Obviously, the most important costs are related to road improvement: construction, maintenance, conservation and future replenishments. However, the project can produce effects in stretches where no construction work is carried out (for example, alternative roads that will require less investment in maintenance or roads that will postpone future replacements to the surface). This is one of the subject addressed when considering the benefits by savings of maintenance expenditures.

In practice, what is commonly done is to determine the total resources that would be needed each year to maintain the technical standard of the sections belonging to the project (including alternative and complementary ways). The cost of the project is given by the additional amount of resources required in the *with project* situation compared with that in the *without project* situation.

In addition, project costs should include interference causing traffic construction (diversions, arrests, complaints, etc.). To assume that during project execution the road continues its normal operation (and therefore no additional operating costs and travel time are produced) may not reflect reality. It should be noted that in most cases, the additional costs incurred by users during project execution will be insignificant (it is common for users to have to wait in line). Costs shall be clearly defined, and the type of interference and additional travel costs that users will incur compared to the situation without interference clearly indicated.

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4. PROJECT PREPARATION AND ANALYSIS

For optimal allocation of public resources, the process of economic evaluation of projects should ensure the correct selection of projects. This process should start with the identification and analysis of the problem situation: a bad coverage of a service, a bad service delivery, lack of assets, lost opportunities for improvement, among other factors. The definition and evaluation of a range of alternatives that may provide solutions to the problem must follow, ending with the selection of the alternative that maximizes social welfare.

In the context of public sector investment, a project may be viewed as an instrument for achieving the planning objectives and development goals of a country or a region, available to planners and policy-makers. Often, a project may be considered a series of activities and tasks with a specific objective, to be completed within certain specifications and a given timeframe. Usually, it will also have funding limitations, consume resources and may be evaluated as an independent unit. It may be possible to break down a project into various components, but they cannot be operated independently and each one cannot fulfill a purpose without the other.

4.1. The Project Lifecycle

The project lifecycle is the process by which an idea is transformed into a concrete solution through the analysis of alternatives and the choice of the most profitable alternative from the economic point of view. Every project has certain phases in its development and implementation. These phases are very useful in planning a project, as they provide a framework for budgeting, resource allocation, the schedule of project milestones in implementation and the establishment of a monitoring system. The purpose is to provide a basis for organizing the project to establish resource requirements, and to set up the management system that will ultimately guide project activities.

Although the exact division of a project’s life into its different phases is somewhat sector specific, the project lifecycle phases may be broadly placed in different steps. Figure No. 4.1 shows the project lifecycle.

As the project moves through its lifecycle, the focus of managerial activities shifts from planning to operating and controlling activities. It should be emphasized that these phases only represent a natural order in which projects are planned and carried out. Also, none of these phases becomes really final until the project approaches its termination stage.
To obtain more details on the project cycle, please review the following document: “Simplified Methodology for Economic Appraisal of Public Investment Projects in the Kurdistan Region of Iraq”.

4.2. The Project Background

The pre-investment phase is a gradual process of developing project ideas, following the project lifecycle until an appraisal conclusion is reached. This corresponds to the process of preparing the necessary studies and analysis for the identification, preparation and evaluation of the project that can solve the problem or meet the needs that triggered it, so reducing the degree of uncertainty on investment decisions.

**Idea and Project Profile Definition**

The project profile requires a rigorous identification process, which implies undertaking the identification of gaps in the economy and the definition of investment priorities for the public sector. A typical description of a problem requires a definition of:

1. The area of influence of the project;
2. The target population; and
3. The present and projected demand, supply, and deficit of the service to be provided by the project.

The purpose in a project profile analysis is for the sector, promoting a given investment initiative, to answer the various questions in terms of base-case optimization, alternative projects, redefinitions, etc.

The sponsoring agency must first clearly identify the problem that gives rise to the idea of a given project. After that, the problem must be framed as a negative state affecting a population, and not as the “lack of a solution”. In any situation that is analyzed, several
problems can be distinguished; however, it is necessary to focus on the root problem, establishing the causes that originate it and the effects it produces.

Areas of Interest: Study and Influence Area

The **Study Area** is defined after the geographical analysis and gives a context to the problem being studied. It also delivers the limits for analysis. The **Influence Area** corresponds to the point at which the problem directly affects the population and at which alternative solutions should be considered. Typically, the influence area is a subset of the study area, but there are also situations in which the study area and area of influence are equivalent.

The project file should include:

- The project name.
- Region and governorate of the affected road network. It is convenient to present a map or location scheme, clearly highlighting the section of the road network that the promoting agency wants to address.
- Define the problem to be solved.

Referring to the source of information, data could be addressed from:

- The Roads Department at the Ministry of Public Works.
- The Investment Department at the Ministry of Planning.
- The Project Department at the Ministry of Transport.
- Others.

**Affected and Target Population**

Inside the Influence Area analysis, the recognition and description of the **affected and target population** is critical to understanding the current situation and to finding solutions to problems.

For the purposes of identification, it is recommended that efforts be concentrated on the identification of the affected population. To do this, information about their social and economic, demographic and cultural characteristics must be collected. Also, it is necessary to forecast the growth of the affected population in the project evaluation horizon.

Project preparation should include a diagnosis of the current situation, which is necessary to address the following issues:

- Current supply infrastructure. Each section should include the following:
  - Length in kilometers.
  - Geometrical characteristics of the layout.
  - Characteristics of the cross section of the road (number of tracks, width of the road, etc.).
  - Features on surface.
  - Description of bridges, berm (road shoulder), drainage system, etc.
Identification and Description of Alternative Solutions

To identify possible solutions, the first thing is to visualize the expected situation once the central problem is solved; this provides strategies for action and, therefore, the set of alternatives to be analyzed.

It is recommended that the analysis of alternatives be carried out in the pre-feasibility studies, using the modules approach (developed in the next section). As the sponsoring agency is involved in the details of the study, the chance of choosing the best alternative for solving the problem is higher.

The project file should describe all the alternatives that provide solutions to the traffic problem while being technically feasible to perform. Information on alternative solutions should include the following:

- Roads with different design speeds.
- Different surfaces, such as gravel, asphalt double treatment, asphalt concrete and concrete.
- Different sizes of project, in order to determine the optimal size, if applicable.
- Different times at which to begin the project, in order to determine the optimal time investment for each.

Pre-feasibility studies may rule out some alternative solutions as a result of considering findings at the profile level. At times, alternative solutions may be ruled out for technical, institutional or other reasons, in addition to economic reasons.

One of the alternative solutions to be considered in project appraisal for all types of problem is what is known as the "optimization of the base-case situation". The sponsoring agency must take it into account in the comparison of alternatives.

Optimizing the Base-Case Situation and the Concept of Incremental Analysis

One of the important concepts when defining a project is to ensure that project benefits and costs are being measured on an incremental basis. An investment opportunity entails incremental net benefit flows that occur over and above what would have been there in the absence of that investment. In application to public investments, this means that one should carefully identify the benefits and costs that are only associated with the project in question.

The optimization of the without-project situation should always be considered as an alternative solution, especially in the case of brown-field projects (or incremental projects). Optimization investments apply to all low-cost measures that can improve the current situation, partially or completely eliminating the problem. In this case, it allows for improvements without the need for a fully-fledged project, which involves many financial resources.

If, after the evaluation of the optimized base-case situation, the conclusion is that there is no solution to the given problem, it will be necessary to evaluate other alternative solutions, considering the optimized “Without Project” situation as a base-case situation. It is from this starting point that the project promoter should measure the incremental benefits and costs of each alternative, and then, choose the most profitable alternative from the economic point of
view. *It should be remembered that the evaluation of projects is always a comparison between different alternatives (including, of course, doing nothing!).*

The without-project situation corresponds to the optimized current situation, which is determined by executing works under feasible and cost-effective investment or management measures to improve the operating conditions of the road. Often, it is not necessary to economically assess these investments; they emerge as obviously profitable. For example, if the promoting agency wants to evaluate the possibility of repaving a road that is full of holes, the without-project situation would be the same surface, keeping the clogged holes.

As another example, in the case of roads with waterlogging problems (because of poor drainage), the base-case situation should not be considered among the without-project solutions to this problem, because it is not feasible to maintain the road under those conditions.

*It should be noted that if there is not a cost-effective alternative solution, the project sponsor must run the above optimization.*

**Traffic (Demand) Module**

This module examines the volume of traffic by the type of vehicle. The function of this module is not only to assess current traffic but to undertake the more difficult task of forecasting the future traffic on the route. Additional assessment should be made to measure the effects on the alternative and complement routes and modes of transportation.

To determinate the economic viability of a road project it is necessary to perform the following:

- To determine the tranches (sections) of vehicle network that will be affected by the project.
- To determine traffic flows to be used on those sections in the without-project situation and for the entire period of analysis.
- To determine the GTC for each vehicle in the without-project situation and for the entire period of analysis.
- To determine the investments required in the without-project situation for the entire period of analysis, including both infrastructure investments and conservation.
- To reassign traffic flows taking into account the new features of the network in the with-project situation. It should be noted that the total number of trips will be the same in the with- and without-project situation, because it is assumed that there is no generated traffic.
- To determine the GTC and investment for the with-project situation.
- To determine the benefit for each year of the analysis period, which is calculated as the difference between the GTC on the without- and with-project situations.
- To determine the total investment (including all sections) for each year of the analysis period for with- and without-project situations.
- To determine the costs for each year as the difference between investments in with- and without-project situations.

When there is generated traffic it will be necessary to analyze the markets that generate them, because the benefits are perceived primarily in those. For example, a path of penetration will require analyzing markets such as forestry, livestock, tourism, etc.
**Current Demand.** The demand for a road is determined by the flow of vehicles passing through it. The vehicular flow path is represented by AADT\(^5\), i.e. the number of vehicles every day, in both directions, on average during the year.

The existing level of traffic is obtained either from mechanical or manual traffic count by the types of vehicle. Ideally, it would be preferable to differentiate vehicles into several types, such as cars, light, medium and heavy buses, and light, medium, heavy and articulated trucks.

Prefeasibility studies also require vehicle counts on the ground, in order to determine the relationship between measurements for each stretch of road and measurements at the transit point census representative. This requires that the latter measurement be performed simultaneously. Traffic information should include the following:

- A map showing the area covered by the project, the location of the chosen census points and location of the vehicle-count ground.
- A table showing, for census points, the most accurate traffic information available.
- A table showing the traffic obtained in the field.
- A relationship between the transit of each section and its associated census point.

**Traffic Forecast “With” and “Without” New Road/Upgrading.** A projection of future traffic volumes typically incorporates the following factors: growth in population; growth of economic activity and income; number and magnitude of new mining, tourism and agriculture projects in area; public sector initiatives such as expansion of hospitals/health centers, schools, police stations; the physical condition of road sections, the degree of congestion, and so on. Models based on linear and past traffic growth functions (often linked to some parameters of general economic activity in the region) may do a reasonable forecasting job.

The number of trips to be held in the future on the road network is difficult to predict. One alternative is to assume that the historical trend of traffic growth will be maintained in the future; another alternative is to analyze each production sector to discover the trend in associated traffic growth. For example, in a study of forest roads, historical traffic was projected by an exponential function. In cases where the exponential function is not representative, it is recommended that three levels of traffic are independently estimated, associated with the zero year of the analysis, the last year of the analysis period, and any intermediate. For the other years, the promoting agency can make linear interpolations. However, it must always be verified that historical information is homogeneous.

The following recommendations are for those projects where the need to analyze "activity systems" becomes evident, i.e. for each sector independently:

- Use census data source/destination.
- Conduct a specific analysis of those activities that are relevant, to estimate their impact on current or future traffic flow.
- Estimate the development of each sector through simple and clear criteria; it is not necessary to complicate the analysis. For example, the growth of traffic access ports is linked to the capacity of port operation and existing expansion options.

\(^5\) Annual Average Daily Traffic.
A computerized model of regional traffic flow is needed to make reliable forecasts of future traffic volumes. These forecasts have to account for all relevant factors affecting the growth and direction of passenger and cargo traffic. The output of this model will be time series of expected traffic volume by types of vehicle. Typically, such computerized models are able to generate several scenarios from the “worst” to the “best” case. These series will be the basis of the “without” financial and economic analysis. Similarly, annual traffic flows in the “with” road project scenario could be simulated by types of vehicle.

To determine operating costs and travel time savings is recommended to use the *Highway Maintenance and Design Model* (HDM). The HDM is a software application that has been developed by the World Bank, the Asian Development Bank, the Department for International Development of the United Kingdom, the National Road Administration of Sweden and the Transport and Road Research Laboratory. This application is a simulation model of the lifecycle of behavior on roads, considering the relation between the atmosphere and transit within a national or regional economy. This model allows the composition and structure of the GTC to be determined. The model provides detailed results based on the data supplied by users.

**Reassignment in flows.** In projects that do not generate traffic, the number of trips made must be equal in with- and without-project situation, for any year of the analysis period. However, the AADT of each section of road will differ as the distribution of trips by purpose of the project changes (for example, the existence of traffic diverted and transferred).

The new balance must be estimated for each alternative solution independently; and it depends on the quality of travel services offered by each of the alternative routes. Most commonly, it is assumed that the new equilibrium is achieved by matching the GTC between different alternative routes.

**Engineering Module**

Once traffic forecasts are formulated in terms of the expected traffic load, design of the road sections should be prepared. The blueprints of road width, drainage, surface strength, passes, and bridges along all sections are prepared. The outputs of the engineering module are the design plans for all road elements, and the estimated costs of their construction. Expected future maintenance, periodic, and rehabilitation costs are estimated using previous information from the provincial network and expected traffic levels.

As an example, in a *tarred road* is usual to follow these rules: *Routine maintenance* should be performed every year; *intermediate maintenance* should be performed every 5 years; *periodic maintenance* should be performed every 10 years. In the case of a *gravel road*, *blading* should be performed every year; the *wearing course* should be performed every 2 years; a *heavy regravel* should be performed every 5 years.

**Environmental Module**

Several projects have a negative impact on the environment that may affect a group of people in the society adversely. This is an externality generated by the project and is not reflected in the private costs of the project. Failure to consider these actions in the ex-ante evaluation of

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the project may lead to the selection of an alternative that is not necessarily the most profitable in economic terms.

In this context, any road development should basically avoid spoiling the environment. The modern construction methods attempt to minimize such negative interactions; however, even the presence of the road and its traffic movement is likely to pose a danger to the remaining flora and fauna. If road improvement is thought to cause a substantial degree of harm, a proper environmental assessment should be made on the nature and extent of this damage. In cases of substantial pollution, the design phase may re-consider the direction of the problematic segment and, perhaps, re-route it elsewhere.

If redirection is neither possible nor technically feasible, then it is important to estimate the amount of environmental damage caused by this road improvement project. The environmental assessment team may be able to produce an estimate of the damage in monetary terms.

**Financial Module**

Financial analysis assesses the impact of a project on the financial costs and funding of the organization that makes the decision to carry it out. This type of analysis requires the construction of cash flows based on different points of view. For example, if the project does not yield private investors a sufficient return to be attractive to them, a related function of financial analysis is to measure the minimum amount of public assistance that would be needed to induce private investors to undertake the investment.

Project implementation involves the use of resources to build, install, upgrade and/or equip infrastructure, facilities or other investments. The financial analysis of a project helps to determine the financial sustainability of the project and its overall success. But an important question arises immediately. Why a financial appraisal for a public sector project? It may appear that the financial appraisal of a project is only of interest to a private investor who wishes to determine the net financial gain (or loss) resulting from an investment project. From a country’s point of view, a project will increase the country’s net wealth if it has net positive economic returns. Conversely, a project that yields negative economic returns should not be undertaken as it would lower the net wealth of society as a whole.

This module provides the first integration of the financial and technical variables estimated in the demand, technical and manpower modules. A cash-flow profile of the project is constructed that identifies all the receipts and expenditures that are expected to occur during the lifetime of the project.

**Financial Expenditures**

For toll-free roads, the cash flow profile will only include initial investment costs, regular and periodic maintenance expenditures, and rehabilitation costs. Since road users are not charged for their passage, no financial receipts are expected. All these outlays will be borne by the sponsoring agency and will be incurred during the lifespan of the project, typically 20 years. This cash-flow profile will belong to the “with” project situation.

Another set of expenditure outlays must be estimated for the “without” road improvement situation. It will include entire regular and periodic maintenance expenditures and the rehabilitation costs of the existing road if no improvement is done to it beyond maintenance.
This situation does not automatically mean that there is “no spending”; nor does it imply a “minimum maintenance” strategy. What this profile really means is that this road will be maintained in a proper physical condition, according to the overall network maintenance strategy plan.

Data Requirements

The condition of a road link is typically assessed through a number of criteria: cracks, pothole, patching, rutting. At least two summary measures of physical condition need to be stated: International Roughness Index (IRI), and Visual Condition Index (VCI).

The role of this database is to provide decision-makers and engineers with up-to-date information about the condition of the provincial road network. The database might also contain information about the deterioration of certain roads and suggest possible treatment options. In short, the database is a tool that helps to identify roads for upgrading and rehabilitation.

The following financial data is needed to conduct a financial analysis in order to determine the financial viability of a new road link/upgrade:

a. Construction, regular maintenance, and rehabilitation costs for the “without” situation.

b. Construction, regular maintenance, and rehabilitation costs for the “with” situation.

c. Types of Vehicle:
   o Car
   o Pickup
   o Bus
   o Light Truck
   o Medium Truck
   o Heavy Truck

d. Existing and future “normal” traffic volume by type of vehicle for the “without” situation.

e. Forecasts of “diverted” and “generated” traffic by type of vehicle for the “with” situation.

f. Forecasts of user charges by type of vehicle (in the case of a toll-road).

g. Financial discount rate (in real terms).

h. Period of analysis.

i. Initial calendar year.

Data requirements in (a) and (b) can be reasonably estimated. The existing traffic load can be easily estimated. The forecast of future traffic flows “without” and “with” project, items (d) and (e), must be generated by the analyst with the aid of traffic-flow software.
Likewise, the forecasts of user charges by type of vehicle, item (g), could be developed. The appropriate discount rate, item (h), will be the Weighted Average Cost of Capital (WACC) if the owner of the enterprise is a private owner. In the case of a public road, the appropriate discount rate will be the target financial rate of return (net of inflation) set by the government.

Period of analysis (i) is the time over which benefits and costs are compared. An analysis period of 20 years is recommended. Initial calendar year (j) is the first year of the analysis period. Also note that the last year of the analysis should be reserved to reflect the residual value of the road and other project assets.

Real Versus Nominal Prices

One of the core concepts of the financial modeling is tied up with the differentiation between the “nominal” and “real” prices. “Nominal” prices are easily observed in the marketplace while the underlying “real” prices are not. The difference between the two accounts for the movement in the general price level over time.

The nominal price of an item is its real price plus the cumulative effect of inflation. In fact, any year could be defined as the base as long as the whole analysis consistently uses that particular year as a reference point. If the “real” value of a good or service is constant over time, i.e., forces of demand and supply do not alter its relative price, then in order to project a “nominal” price of a good or service into future periods the analyst needs to know the inflation rate(s).

To simplify the financial analysis, the analyst might use only “real” costs of construction and maintenance. If the real cost of a commodity or service changes, for any reason other than inflation, the projected future nominal cost will also adjust.

Incremental Financial Cash Flow

Once the amount and timing of financial expenditures for both “without” and “with” project situations are established, the analyst can finally derive an incremental financial cash flow. The costs of routine, intermediate, and periodic maintenance are computed for X-km length of road, and are also timed according to engineering standards.

Thus, the incremental financial cash flow of this road improvement project is derived by subtracting each and every value of the “with” project situation from the corresponding values of the “without” project situation. Any positive result implies that cost savings will be achieved, while a negative figure means that additional costs will be imposed on the economy.

Economic Module

Economic analysis is similar to financial analysis in the sense that it also measures changes in the wealth generated by a project. However, economic analysis is concerned with society as a whole and not only with the welfare of the owners of the project. Here, the starting point

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for economic analysis is the incremental expected net cash flows to total capital from the financial analysis.

At this stage, all the benefits generated by the project to society are recognized. The sponsoring agency should consider not only those benefits that are generated in the same market services or products (direct benefits) but the benefits generated in a related market (secondary and indirect benefits and positive externalities). Similarly, all the costs should be recognized, considering the direct costs plus the costs imposed on the rest of society (secondary and indirect costs and negative externalities).

Market distortions refer to externalities like taxes, subsidies, trade tariffs, price controls, monopoly markets, environmental impacts (such as pollution or congestion), and open access or common property situations. Also, it is necessary to take into account externalities in the price of capital (discount rate), in the price of foreign exchange (because of trade distortions and controls in foreign exchange markets), and in the labor market (where the financial wage rate may be different from the economic price of labor).

In this module the project is being examined from the entire economy's point of view to determine whether or not its implementation will improve the economic welfare of the region or governorate. An economic appraisal is of exactly the same nature as financial analysis is, except that now the benefits and costs are measured from the point of view of the whole country or the region. Instead of relying on market prices to measure the economic cost of expenditures, the economic analysis estimates the economic prices of goods and services, foreign exchange, cost of capital and labor. The true economic values of costs and benefits are not accurately reflected in market prices in the presence of various market distortions such as import tariffs, value-added taxes, subsidies, minimum wages, and price controls.

To undertake economic appraisal, the first step is to convert all financial expenditures into their corresponding economic costs. This implies that all taxes, subsidies, market imperfections, impact of foreign exchange premium, and labor market distortions must be removed from financial expenditures to arrive at economic costs. Secondly, the benefit items must be estimated in terms of their magnitude and timing over the duration of the project. These include maintenance costs savings, vehicle operating costs savings, and time savings.

In practical terms, the incremental economic resource-flow statement consists of two parts: economic benefits and economic costs. Ideally, on the benefit side, five types of benefit should be counted: i) a change in resource costs on maintenance by the roads agency; ii) reduction in vehicle operating costs for road users due to improved road surface; iii) time savings for road users, including cargo, due to an increase in the average speed of vehicles; iv) possible reduction in the costs of accidents; and v) other externalities.

Conversion of Financial Expenditures into Economic Costs

Economic prices account for the real resources consumed or produced by a project and hence exclude tariffs, taxes or subsidies, as these are the financial transfers between consumers, producers and the government all within the same economy. An economic conversion factor (CF) is the ratio of the economic price of a commodity to its financial price.

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8 A road project does not necessarily imply a reduction of maintenance expenditures. Upgrade of the road surface and/or road expansion might lead to an increase in the required road maintenance expense.
Market distortions drive a wedge between financial and economic prices of goods and services\(^9\). The concept of the conversion factor, defined as the ratio of the economic price to the financial price, is a handy way to express the relationship between the economic and financial values of the same commodity or service. Hence, the economic price of any commodity can be determined by multiplying the CF for that commodity by its financial price:

\[
CF = \frac{\text{Economic Cost}}{\text{Financial Cost}}
\]

\[
\text{Economic Cost} = \text{Financial Cost} \times CF
\]

Practically, the procedure of transforming financial expenditures into their economic equivalents is very straightforward once all conversion factors have been estimated. The financial expenditure savings are derived from the incremental financial cash-flow profile, and are simply an annual summation of maintenance costs, grouped by type of maintenance activity.

If there are no distortions in the supply and demand market of a commodity, the CF will simply be 1 because the economic and financial prices are the same. If the market for foreign exchange is distorted, the market exchange rate (Em) or the official exchange rate (OER) will not accurately reflect the economic value of a unit of foreign exchange in relation to the domestic currency. Thus, it is essential to make an adjustment for the divergence between the market or official price of foreign exchange and its economic price, also referred to as the Economic Exchange Rate (Ee) or sometimes as the Shadow Exchange Rate (SER).

**Data and Economic Parameters**

As was mentioned above, there are three types of benefit that could reasonably be estimated from road improvement:

- Reduction in vehicle operating costs for road users, due to improved road surface.
- Time savings for road users, due to the increase in the average speed of vehicles.
- Reduction in resource costs on maintenance by different agencies.

In addition to financial data requirements, the following set of additional data and economic parameters are needed to conduct the economic analysis:

- Economic conversion factors for all construction, maintenance, and rehabilitation costs (in order to estimate corresponding economic costs).
- VOC of existing and future traffic volume by type of vehicle for the “without” situation.
- VOC of the diverted and newly/generated traffic by type of vehicle for the “with” situation.
- Detailed composition of traffic by vehicle type, and average speeds “with” and “without” road improvement.

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• Average occupancy of vehicles and cargo content.
• Average value of time for passengers and cargo.
• Economic discount rate (in real terms).

Economic conversion factors are required to estimate the economic costs of road construction, maintenance, and rehabilitation expenditures. It is suggested that a database of economic conversion factors for all commodities under harmonized tax system (HST) be developed, organized into a single database\(^\text{10}\). To arrive at the economic costs of road-related expenditures, the analyst should examine the outlays on domestically produced inputs, imported inputs, cost of services (i.e. design, supervision, etc.), and cost of labor by skill\(^\text{11}\).

The economic cost of foreign exchange (Foreign Exchange Premium, or FEP) is extensively used in the calculation of economic conversion factors. FEP represents the difference between the market value and the economic value of foreign exchange\(^\text{12}\).

Labor markets of many developing countries are characterized by high rates of unemployment of unskilled labor and close-to-full employment of skilled labor, and are generally highly regulated, unionized and distorted. In such a situation, the wage rate paid by a project for a particular skill or occupation will usually be significantly different from its economic opportunity cost.

The vehicle operating costs by type of vehicle are estimated from traffic forecasts for “without” and “with” project with the help of appropriate road management software. The resulting product is a set of annual time-series on VOC by type of vehicle. The next step is to take the difference between the VOC “without” and “with” project by type of vehicle; discount the resulting differentials to the beginning year of analysis in order to estimate a total present value (PV) of VOC cost-savings, i.e. economic benefit.

The parameters are typically derived from an actual road survey, which can help establish the composition of road users on a particular section, average speeds, and their average occupancy. The average speed is the function of the type of road surface, as well as congestion on the road.

The value of time for passengers and tourists is usually linked to wages of skilled, semi-skilled and unskilled labor in the region. The value of time-savings for cargo is a function of delay costs, and may require an additional investigation for the particular commodities in question.

\(^{10}\) It is suggested that user-friendly online-based software be used for the database. The software should have open access and be available to analysts, including private companies and international bilateral agencies and development institutions. An example of an open-access database can be found at [http://rwanda-csef.minecofin.gov.rw](http://rwanda-csef.minecofin.gov.rw). The conceptual framework and actual estimation procedures are presented in “Cost–Benefit Analysis for Investment Decisions”, Chapter 10 and Chapter 11.


The Economic Opportunity Cost of Capital (EOCK) is the appropriate discount rate to use when estimating the economic NPV of a road project.\(^\text{13}\)

Investment decisions are fundamentally different from consumption decisions because the former have a time dimension. For example, land and capital equipment are purchased at one point in time, and they are expected to generate net cash flows, or net economic benefits, over a number of subsequent years. To determine whether the investment is worthwhile, it is necessary to compare benefits and costs, which occur in different time periods.

From the point of view of the economy, the funds are generally drawn from three sources. First, funds that would have been invested in other investment activities and have now been displaced by the project (the cost of these funds would be the return that would have been earned on the alternative investments that are now foregone). Second, funds come from different categories of saver in the economy who postpone their consumption in the expectation of getting a return on their savings (the cost of this part of the funds is the cost of postponing consumption, and this is reflected in the interest rate that the savers earn). Finally, some funds may be coming from abroad, that is from foreign savers (the cost of these funds would be the marginal cost of foreign borrowing). The EOCK will simply be a weighted average of the costs of funds from the three sources outlined above: rate of return on postponed investments, the rate of interest on domestic savings, and the marginal cost of additional foreign capital inflows.

This hurdle rate applies not only to investments financed solely with public funds but for the economic evaluation of joint public–private ventures and pure private investments. For developing countries, the 12 percent EOCK is generally adopted if a more accurate estimate is not available.

**Uncertainty (Risk) Analysis Module**

Generally, when evaluating investment projects, it is assumed that the variables used have a deterministic character. However, there are a number of variables in all infrastructure investment projects that do not behave this way. There are variables whose value cannot be accurately predicted, but there is some uncertainty in their estimation.

A traditional cash-flow analysis assumes single (deterministic) values for all of the variables. The outcome of that analysis is a point-estimate of a project’s indicators, as NPV or its IRR, and a decision on whether to accept a project is made on that basis. More realistically, however, we know that values for most project variables are subject to change and are difficult to predict. While the past values of a particular variable are known with certainty, predicting future values is a different matter. It is more likely to forecast the correct range of future values for a variable rather than its exact value. Given that there are probabilities attached to the possible values of a variable in a given range, there is a good chance that the value that occurs will be other than the one we have chosen.

Uncertainty and its consequences are very significant issues in road appraisal because the project costs and returns are spread over time. Estimates of time and vehicle operating cost

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\(^\text{13}\) The theoretical arguments have been developed by Harberger, A.C., “On Measuring the Social Opportunity Cost of Public Funds”, in *Project Evaluation – Collected Papers* (Chicago: the University of Chicago, 1972).
savings are tentative due to uncertainty in traffic forecasts. In turn, this makes the outcome of projects uncertain.

Typically, the analysts use three types of analysis to deal with uncertainty: sensitivity tests, scenario analysis, and Monte-Carlo risk analysis. For a road improvement project, the minimum requirements in terms of risk assessment are sensitivity tests and scenario analysis for the parameters of cost items, assumptions of traffic forecasts, and valuation of benefits.

Sensitivity Analysis

Appraisal of transportation-road construction projects involve some degree of uncertainty. Appraisal analysts simply do not know with certainty what will happen in the future. Sensitivity analysis is a way of testing how sensitive a project’s outcomes (whether cash flows, economic NPV, gains and losses to different groups in the economy) are to changes in the value of one parameter at a time. Sensitivity analysis is typically conducted to identify the impact of input variables on the economic outcomes of a project. Sensitivity analysis is often referred to as “what if” analysis, because it allows the analyst to answer questions, such as “What would happen to the NPV if a variable were to change by a certain amount or percentage?” To conduct this analysis, it helps if the spreadsheets are organized in a systematic way starting with the table of parameters that can be easily adjusted.

- **Construction Costs Overruns.** This test measures the response of the economic NPV to an unexpected escalation of road construction costs, keeping all other project parameters constant. Road users are not affected by unexpected cost escalations of road construction since the cost is covering by the government. In the range from -5% to +25%, the total economic NPV is moderately sensitive to changes in initial construction costs.

- **Traffic Growth Rate.** This test measures the project’s performance under various traffic volume levels, as a factor of expected future traffic growth rate. The value of benefits accruing to owners of light and heavy vehicles varies with the rate of traffic growth. It is implicitly assumed that a higher traffic level does not result in an increased frequency and cost of road maintenance, and that is why the PV of the net benefits accruing to the government remains constant.

- **Maintenance Costs Savings Factor.** This factor adjusts all the maintenance resource savings over a range from -50% to 0% in order to assess the sensitivity of the NPV to the overall value of maintenance savings.

- **VOC Savings Factor.** A range of -50% to 0% for this factor has been tested. The response of NPV is directly related to the overall level of VOC savings.

- **Time Savings Factor.** This test examines the elasticity of the NPV to changes in the total value of time savings in a range of -50% to 0%.

Scenario Analysis

A one-at-a-time testing of variables is not realistic to account for the interrelationships between variables. Scenario analysis recognizes these interrelationships by allowing to simultaneously after a number of variables.
Scenario analysis allows for interrelationships between variables, it usually does not take into account the probabilities associated with each scenario. Probabilities could be assigned, but they are likely to be highly subjective and could be biased either in favor or against a project. Scenarios are based on a set of parameters, values of which are pre-defined by the analyst. There could be a number of scenarios, built on the “base” scenario but ranging from the “worst” to the “best”. Even under the worst set of circumstances, the project has a marginal negative (close to the break-even) NPV, which suggests that the proposed road improvement is indeed a robust project. Obviously, the “worst” and “best” scenarios are two extremes that are very unlikely to happen in practice.

The main limitation of this method is that it does not allow the probability of occurrence of each of the proposed scenarios to be represented, so that while delivering as much information as the sensitivity analysis (considering the correlation between different variables), it cannot be enough, since the number of variables and values for each that can be tested is limited.

What sensitivity tests and scenario analysis lack the capacity to embrace is the probabilistic expression of a project’s returns. The two extreme sets of conditions formulated in the “worst” and “best” scenarios are unlikely to occur, and most of the time some combination of parameters within the vicinity of the “base” scenario will materialize. The chance that the values of project outcomes will materialize exactly as estimated is practically zero. In order to look at the project returns from a probabilistic point of view, the analyst should undertake a Monte Carlo simulation.

4.3. Final Comments

The project lifecycle and its phases play a key role in the success of a project. In these phases, information is gathered and the necessary studies for the identification, formulation and appraisal of the project are done. The studies reduce the degree of uncertainty about the investment decisions, thus allocating fiscal resources efficiently.

Given the importance of these phases, a series of recommendations and obligations to ensure that the project is formulated correctly is listed below:

1. The definition of the problem is essential in determining possible alternative solutions. Framing the problem as the lack of a good or service leads invariably to a unique solution and prevents the analysis of more than one alternative to the root problem.

2. It is necessary to understand that a problem in itself is not a project. A project comprises courses of action that arise from a given problem and provides a rational response to the problem.

3. When doing the diagnostic of the current situation, it is helpful to set a baseline for comparisons and benchmarking. This is essential for the ex-post evaluation of the project, which aims to verify whether the project has been a real solution to the problem.

4. The optimization of the base case (or without the project) should always be considered as one of the alternative solutions to the problem.

5. Always more than one alternative should be analyzed as a solution to the problem.
6. For the calculation of benefits and costs of each alternative, the situation “without project” or “optimized base case” should be considered the baseline for comparisons, thus avoiding over- or underestimation of benefits or costs.

7. It is recommended that the analysis of project alternatives be performed in the pre-feasibility study, as this involves looking at each alternative in greater detail and therefore increases the probability of choosing the best alternative to solve the problem. A modular analysis for each alternative is recommended.

Finally, it should be noted that financial and economic analyses represent a guide for decision makers and do not represent a decision in themselves. The evaluation approaches proposed above are just an input to the policy process that projects undergo.
5. PROJECT EVALUATION

The financial and economic attractiveness of a project is determined by the net present value of its incremental net cash or resource flows. The NPV criterion is widely accepted by accountants, financial analysts, and economists as the only one that yields correct project choices in almost all circumstances. However, some investors have frequently relied upon other criteria such as a project’s internal rate of return and the benefit–cost ratio.

The incremental net economic resource flow is the difference between total benefits and total costs, on a year-by-year basis. It is a summary profile of the road project. The values of the resulting annual net economic flow are then discounted to the initial year of analysis at the EOCK to compute an economic Net Present Value (NPV) of the project. If the economic NPV of the project is greater than zero, the project is potentially worthwhile to implement. This implies that the project would generate more net economic benefits than if the resources had been used elsewhere in the economy. On the other hand, if the NPV is less than zero, the project should be rejected on the grounds that the resources invested could be utilized better by the capital market.

When selecting among several alternatives, the economic NPV criteria makes it possible to choose the best combination of roads. Alternative road projects with the highest NPVs should be selected first to maximize the net economic benefits over time.

5.1. Evaluation Period

To evaluate a project, a period of analysis is required. This evaluation horizon will depend on the particular characteristics of the project. However, there are some recommendations to facilitate determining what it should be.

- If there are several alternative solutions, a single analysis period must be set, for comparison purposes. A shorter period of analysis may be required to determine the profitability associated with the initial investment if the most convenient alternative is chosen.

- It is recommended that a period equal to the life of the most important or representative aspects of the project work be chosen as an analysis period. For example, if the project is to evaluate the paving of a gravel road, the pavement life will be used, even if the drainage works or earthworks are longer-lasting.

- In the case that the most important work has a very long shelf life, such as bridges or tunnels, it is desirable to reduce the period of analysis, for example, to 20 years.

On completing the analysis period, some works are left with a surplus of life. This is to be incorporated into the residual economic value of the project and is considered to be a benefit received during the last year of analysis.

5.2. The Net Present Value Criteria

The NPV is the algebraic sum of the present values of the incremental expected positive and negative net cash flows over a project’s anticipated lifetime. If this sum is equal to zero,
investors can expect to recover their incremental investment and to earn a rate of return on their capital equal to the private discount rate used to compute present values\textsuperscript{14}.

A NPV greater than zero means that investors can expect not only to recover their capital investment and to earn a rate of return equal to the discount rate but to receive an addition to their real net worth equal to the positive amount of the NPV. Only projects with positive NPVs are going to be beneficial and hence attractive to private investors. They are unlikely to pursue a project with a negative NPV unless there are strategic reasons.

The formula for computing the NPV of expected incremental net cash flows over n time periods with annual discounting is:

\[
NPV = \sum_{t=0}^{n} \frac{CF_t}{(1+r)^t}
\]

Where:

The incremental net cash flows (\(CF_t\)) could be negative, zero, or positive.

\(r\) is the discount rate equal to the cost of capital.

Sigma sign (\(\sum\)) is the symbol of summation.

The NPV formula can be written out in its component present values of the annual net cash flows, as follows:

\[
NPV = C_0 + \frac{CF_1}{1+r} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n}
\]

The net present value criterion can be stated in the form of a set of decision rules.

Decision Rule 1: Do not accept any project unless it generates a positive NPV when discounted by a discount rate equal to the opportunity cost of the funds.

Decision Rule 2: To maximize net worth, choose among the various projects, or scenarios of projects, the one with the highest NPV. If investment is subject to a budget constraint, choose the package of projects that maximizes the NPV of the fixed budget.

Decision Rule 3: When there is no budget constraint and when a choice must be made between two or more mutually exclusive projects, e.g. projects being considered for the same building site, investors who seek to maximize net worth should select the project with the highest NPV.

These rules follow from the definition of the NPV, namely the algebraic sum of the present values of the incremental expected positive and negative net cash flows over a project’s anticipated lifetime.

\textsuperscript{14} The recovery of the invested capital is anticipated when \(NPV \geq 0\) because the incremental capital expenditures are included in the initial negative net cash flows.
5.3. The Internal Rate of Return Criteria

By definition, the internal rate of return (IRR) is the discount rate ($\rho$) that sets the NPV = 0 in the following equation:

$$\sum_{j=1}^{n} \frac{CF_j}{(1 + \rho)^j} - I_0 = 0$$

Where:

$CF_j =$ the incremental net cash flow in year $j$ to total, or equity, capital,

$I =$ the initial investment,

$\rho =$ the IRR. We have to solve for $\rho$.

This definition is consistent with the meaning of a zero NPV as explained in the previous section, namely that investors recover their invested capital and earn a rate of return equal to the discount rate, which is the IRR. The internal rate of return criterion can be stated in the form of a set of decision rules.

Decision Rule 1: Do not accept any project unless its IRR is greater than the opportunity cost of the funds (accept project if $\rho > r$, the opportunity cost of capital; otherwise, reject). The opportunity cost of capital is measured by the cost of funds or the expected rate of return offered by other assets equivalent in risk to the project being evaluated.

Decision Rule 2: When a choice must be made between two or more mutually exclusive projects, investors should select the project with the higher, or highest, IRR.

5.4. Cost of Postponing Project Criteria

The cost of delaying the project (Cost of Postponing the Project, CPP) can be expressed as a fraction of the initial investment required by the project.

$$CPP = \frac{\Delta NPV}{I_0}$$

For those road projects that only have savings in operating costs and travel time, it is easy to calculate the cost of delaying the project (CPP). In this case, if the execution of the road is delayed one year, it incurs a cost equal to the profit of the first year of project operation ($B_Z$). The benefit to postpone by one year the initial investment is the initial CAPEX multiple by EOCK. The expression is:

$$CPP = \frac{1}{I_0} \left[ \frac{B_Z}{(1+r)^2} - \frac{I_0 * r}{(1+r)^2} \right]$$

Where:

CPP is the cost of delaying the project, expressed as a fraction of the initial investment.

$B_Z$ is the benefit for the first year of project operation.

$Z$ is the number of years from when the initial investment was made.
$I_0$ is the initial investment.

$r$ is the economic discount rate.

Since the first year of investment corresponds to the year zero, the year "$z" is the year when the project is put into operation (and therefore is the year when the first benefit is obtained).

The expression of CPP is based on some assumptions, such as that the initial investment will not change if the project is delayed; second, that the benefits are not significantly dependent on the time of investment; third, that the external additional travel costs (inconvenience, delays, detours, etc.) resulting from the execution of the project are negligible.

The optimum time to run the investment is the one that maximizes the NPV. If the cost of delaying the project (CPP) is negative, it means that the NPV increases with this postponement, and therefore this is not the optimal year to start project execution.

For road projects is reasonable to assume that the benefits (Bi) will increase over time and therefore that the cost of delaying the project, CPP, will also grow over time. The optimal year to run the investment will be one in which the CPP is greater than or equal to zero.

5.5. Final Comments

For roads owned and operated by the government, no financial revenues from road users accrue to the government, and it should be clear that the financial NPV is, in most cases, simply the present value of the costs of building and maintaining the road during a period of time. As a result, the financial NPV for such a road will be negative, representing the requirement for funds to finance the project.

If it is a private-sector project such as a public–private partnership (PPP) and the financial NPV of the project is greater than zero, the project is potentially worthwhile for the private investor to implement. But if the financial NPV turns out to be negative, private investor(s) might find it better to shift their investment elsewhere, to other projects, where they will earn the minimum required return.
6. FINAL COMMENTS

This document is a simplified tool to technically guide the process of project formulation and project evaluation for transportation-road projects. Therefore, and because it is a technical document, the methodology does not describe roles and administrative responsibilities in the public investment process. This description must be part of the rules and procedures of the PIM system.

Project evaluation is a tool for decision-making that allows the determination of the suitability of society to invest in various initiatives when resources are scarce. Usually, this "convenience" is understood from the economic point of view as a measurement of the costs and benefits of competing projects, leading to the prioritizing of those projects whose expected economic benefits are the highest.

Comparing the total costs (investment and operation) of a project with its benefits allows public authorities to decide if that project has the potential to make a real contribution to the wealth of the country. Thus, project evaluation allows them to: i) Identify the criteria for investment policies that maximize social welfare; ii) stop the "bad projects" and promote those that are "good"; iii) define whether the public or private sector should implement the project; iv) estimate the fiscal impact of the project; v) establish agreements for desirable cost recovery; and vi) assess their impact on the environment, regional development and poverty, among other things.

It is often argued that all road improvements stimulate economic development. The truth is that some do stimulate it while others do not. It is the task of the project analyst to establish whether this particular road project will spur on economic development in the area.

In order to consider this road upgrading as groundbreaking in terms of economic potential, three conditions must be met simultaneously:

- The economic development would not have taken place in any circumstance without this road improvement.
- The resources used in the new development would have been under-utilized or remained unused.
- The economic activity stimulated does not replace any other activity that would have taken place otherwise.

Often, the proposed road improvement is not the only requirement to unlock the economic potential of a particular area. Other basic factors of production must be ensured in order to make the best use of available resources. In a very specific case, when all conditions are effectively satisfied and the road upgrade is the only barrier to pass, the valuation of road benefits should be linked to the net value of additional output. Of course, vehicle-operation cost savings for the traffic from the project must be excluded to avoid double counting of the benefits of developing the road.
7. REFERENCES


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