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MILLENNIUM CHALLENGE ACCOUNT SENEGAL

Evaluation Design Report
Impact of the Roads Project

Sénégal

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CHAPTER 1. INTRODUCTION

Basic infrastructure facilities are public goods and their inadequacy is a significant cause of failure among poor nations (Warr 2005). In recent years, roads have been extensively championed as poverty alleviation instruments by the World Bank and donor institutions and are argued a key to raising living standards in poor rural areas. By reducing isolation, better roads reduce vulnerability and dampen income variability (Van de Walle and Cratty 2002).[1]

According to a report published by the World Bank in September 2011 on Senegal's infrastructure, despite the good economic performance of the past decade (2005 GDP growth rate of 5.6 percent)[2], Senegal still remains a poor country. As of the year 2005, 50.8 percent of the population lived below the national poverty line with the highest incidence of poverty in rural areas.

To address the concerns that poor road conditions (only 29.3 percent of the total roads were paved as of 2003 - World Development Indicators) have hindered economic growth in Senegal, the government of Senegal is implementing a road rehabilitation project using funds from the Millennium Challenge Corporation (MCC). By rehabilitating selected national roads, MCC will improve access to domestic and international markets. In addition, communities along the rehabilitated roads will have improved access to important services such as schools and hospitals.[3]

IMPAQ International was selected by MCC to conduct a rigorous evaluation of the impact of MCC road improvement projects in Sénégal on individuals, households, and enterprises. The impact evaluation will evaluate the impact on beneficiaries as a result of:

- improved access to agricultural markets;
- improved access to basic social services; and
- reduced transportation costs.

The project will also update estimates of Economic Rates of Return (ERR), measure the cost-effectiveness of the interventions, identify factors that precluded achievement of the roads project's goals, assess key distributional impacts across key social groups (e.g., gender, age, economic status), identify unintended consequences of the project (if any), and ascertain prospects for the long-term sustainability of impacts. Finally, the results from the Sénégal impact evaluation will be compared with the results from the impact evaluation of the roads project in Burkina Faso.

[1] Jalan and Ravallion (1998) in a study of rural China find that higher density of roads in an area lowered the probability that households in that area will be poor.
[2] World Bank World Development Indicators (http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG accessed January 5th, 2012).
[3] Van de Walle and Cratty (2002) found that in a Vietnam road rehabilitation project, the time needed to reach the closest hospital in case of a serious injury declined by three-quarters of an hour.

1.1 Background and Objective

The Millennium Challenge Corporation (MCC) is an independent U.S. foreign aid agency whose mission is to achieve poverty reduction through economic growth by partnering with governments of low income countries in the implementation of effective development programs. Grants are awarded to countries committed to good governance and sound policies.

MCC signed a 5-year, $540 million compact with the Republic of Sénégal in September 2009. To effectively manage the work of this compact, an autonomous body has been established by the Republic of Sénégal, the Millennium Challenge Account in Sénégal (MCA-S). The MCC Compact is designed to reduce poverty and support economic growth by unlocking the country's agricultural productivity and expanding access to markets and services through infrastructure investments. Two major projects are currently being implemented:

- The National Road #2 (RN2) and National Road #6 (RN6) Rehabilitation Project, which aims at increasing access to markets and services with a view to reducing transportation time and costs.
- The Irrigation and Water Resources Management Project, which has the objective of increasing agricultural productivity by extending and improving the quality of irrigation in northern Sénégal.

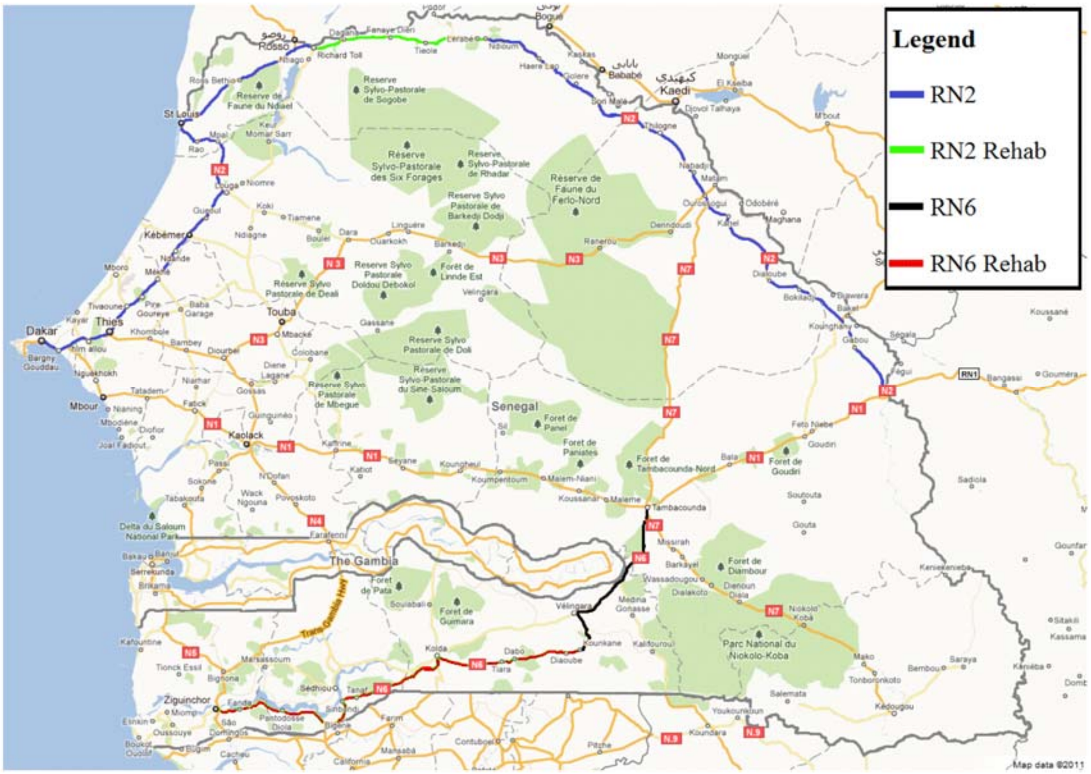
The Roads Rehabilitation Project (RRP) is designed to increase beneficiaries' access to domestic and international markets by improving the quality of roads and reducing travel time and costs. Improving these two national roads is also expected to facilitate the transportation of manufactured goods, minerals, and agricultural products. To achieve these goals, the RRP will implement the following:

- Rehabilitation activities (strengthening, widening, and replacing associated structures) of RN2 over a distance of 120 km from Richard-Toll to Ndioum; and constructing a new 150-m bridge over a river.
- Rehabilitation activities (strengthening, widening, and replacing associated structures) of RN6 over a distance of approximately 260 km from Ziguinchor to Kounkané.

The rehabilitation of RN2 is expected to benefit some 21,000 households, or 250,000 people, over the next 20 years. Currently there are about 9,290 households, or 111,500 people, residing within a 5-km radius, on either side along the RN2. Meanwhile, the RN6 activity is expected to affect some 102,000 households, or about 1.1 million people, over the next 20 years. Currently there is a population of about 44,000 households, or 474,000 people, along the road.[4] As indicated in Exhibit 1, RN2 serves the northern provinces of Sénégal, while RN6 serves the southern province of Sénégal (Casamance).

[4] Compact with Sénégal, http://www.mcc.gov/documents/agreements/compact-Sénégal.pdf

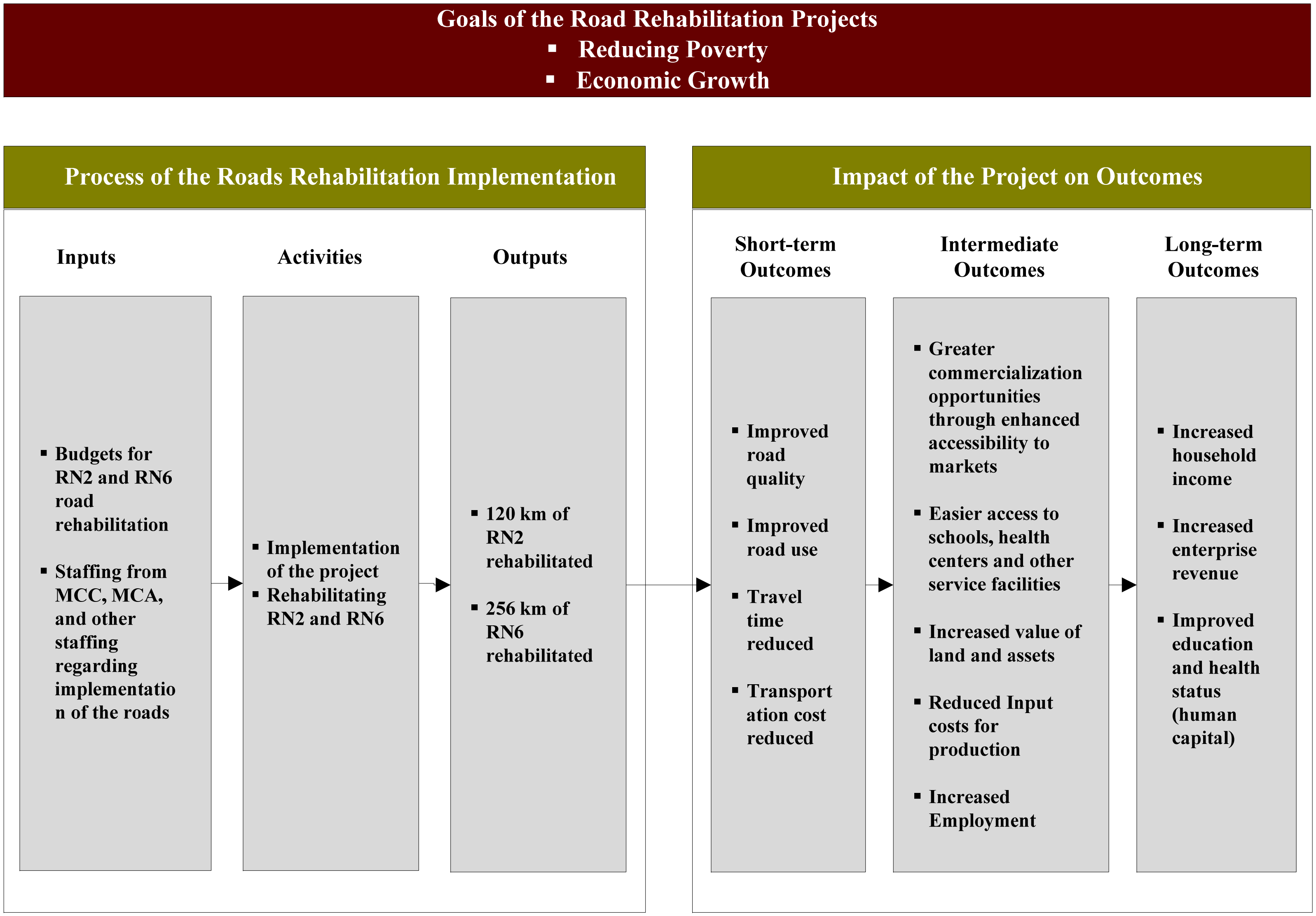
Exhibit 1: Map of Sénégal RN2 and RN6 Roads for Rehabilitation



1.2 Conceptual Model

The long-term goal of the compact is to reduce poverty and enhance economic growth. Investments in road infrastructure can serve as a mean to achieve the goal. In Exhibit 2, we present a logic model that illustrates potential causal pathways through which road rehabilitation projects may lead to poverty reduction. The model consists of two parts: (1) the implementation process and (2) the impacts of the project on outcomes.

Exhibit 2: Conceptual Model for Roads Rehabilitation Project



The first three columns of Exhibit 2 show the process of the road rehabilitation implementation. Resources of the projects include budgets and staffing for the implementation of the roads rehabilitation (*Inputs*). Using the resources, implementers rehabilitate the road segment of RN 2 and RN6 under the supervision of MCC and MCA (*Activities*). The byproduct of the activities performed is the rehabilitated roads: 120km and 256 km of rehabilitated RN2 and RN6 road segments, respectively (*Outputs*). Note that unexpected delay in the implementation may happen due to various environment factors, such as extreme weather and civil unrest that may prevent timely rehabilitation of the roads. There may be other factors that affect the road rehabilitation project. For example, there could be cost over-runs (*inputs*) that reduce the length of roads that end up being rehabilitated (*outputs*), thus, affecting fewer beneficiaries than planned (*outcomes*). The next three columns of the exhibit show the impact evaluation outcomes of the road rehabilitation project. Some outcomes may be realized immediately upon completion of the project, while others may take long to materialize.

The last three columns of Exhibit 2 depict the impact of the project on outcomes. Once the road rehabilitation implementation is complete, the time and cost required to travel to a certain destination via the rehabilitated roads will be reduced. Also, the targeted road segments will be improved in quality and thus will be used more frequently. These outcomes are expected to be realized shortly after the completion of the roads (*short-term outcomes*).

The completion of the road rehabilitation is also expected to unlock economic and social opportunities of households and individuals using the road (*intermediate outcomes*). For example, there may be a better access to markets to buy and sell products. It may also be easier and cheaper to find inputs needed for production activities for both formal enterprises and household informal economic activities. Due to the reduced time and cost of travel on the rehabilitated roads, households can enjoy easier access to basic facilities, such as schools and health centers. Furthermore, there may be more employment opportunities due to increased demand in markets accessible via the improved roads. In addition, the values of land and assets along the rehabilitated roads are expected to rise, as the demand for the road use rises. Other intermediate outcomes include increased employment and improved access to social services such as schools and health centers.

Long-term outcomes include higher earnings and enterprise revenues. Long-term outcomes also include increased economic opportunities and better levels of human capital and health status. These outcomes can then serve as long-term engines to economic growth and poverty reduction, if sustained over time.

Based on the logic model, we can address the following key research questions:

- What is the impact of the road rehabilitation project on the improvement of the road quality and reliability?
- Has there been reduction in the travel time and cost? If so, how much?
- Has there been increased accessibility to the nearest market due to the improved road quality? If so, how much?
- Do children go to school more often than before the project implementation?
- Do households experience enhanced health outcomes due to potential increased visit to health center due to reduced travel time and/or cost?

- Does the impact on the outcomes vary by gender, age and income group?
- Have enterprises experienced reduced input costs for production due to the reduced travel time and costs from the road rehabilitation?
- Do enterprises enjoy greater revenues due to the project?

These questions will be addressed further in the next section as we discuss the evaluation methodology.

CHAPTER 2. EVALUATION DESIGN

IMPAQ International was selected by MCC to conduct a rigorous impact evaluation of road improvement projects in Sénégal. The evaluation will focus on how the road improvements affected households, and enterprises in Sénégal. In this section, we describe our plan to evaluate the impact of the rehabilitation projects. IMPAQ will conduct a series of analyses that will provide a comprehensive assessment of the impact of the road projects. We begin by restating the main research questions that the evaluation seeks to answer. Next, we describe our approach for estimating the project's impact on outcomes of interest. Then we describe the analyses that complement this evaluation including a cost-benefit analysis, a gender and subgroup analysis, a cost-effectiveness analysis, and an analysis of unintended consequences.

2.1 Key Research Questions

This study will use data collected from a sample of households and enterprises in Sénégal to address key research questions about the impact of the road projects:

Research Question 1: Did the road projects reduce the travel time and costs to households/enterprises living near the rehabilitated roads?

To address this question we will use data collected from households and enterprises focusing on the travel time and costs to reach primary services, markets, schools and health centers. These are the outcomes that are expected to be affected by the rehabilitation activities in the short term as direct results of improved road conditions.

Research Question 2: Did the road projects lead to increased work opportunities for employment and income among beneficiary households?

In this question we investigate whether the availability of roads upgraded to functional standards unlock economic opportunities for households and enterprises near the rehabilitated roads. We will use the employment and income information from the household survey data to assess if the road improvements led to greater employment and income.

Research Question 3: Did the road projects lead to increased access to health and education services?

Aside from the direct economic impacts in terms of income and employment, other *social* opportunities can be unlocked through the project. For example improved roads may make it easier for children to go to schools; this could translate into higher educational attainment. Information about access to education and other services will be collected for each household member and will be used to evaluate this issue.

Research Question 4: Did the project affect business opportunities and enterprise revenues?

Economic activities of enterprises can be directly affected by the improved roads as a result of better access to the markets where they sell their products. Also, enterprises will be able to obtain raw materials and inputs at better prices and reduce their transportation costs. On the other hand, enterprises may suffer during the rehabilitation activities due to the disruption caused by the road rehabilitation. These effects will be investigated using specific question from the enterprise survey.

Research Question 5: What is the ex-post Economic Rate of Return of the Sénégal road projects?

An important component in the decision of the project investments is to investigate whether the project is warranted based on a comparison of its costs and benefits. The results obtained from the impact evaluation allow us to measure the benefits (accrued to households and enterprises) of the road rehabilitation project. Together with estimates of the costs of the interventions (provided by MCA-S) we will use the impact evaluation results to update the ex-post economic rates or returns (ERR). Then we will compare the ex-post ERRs with the ex-ante ERRs originally used for the compact investment decisions.

Research Question 6: How are the benefits of the projects distributed among subgroups of the population, such as gender, age and income?

In answering this question we will investigate whether the benefits of the project accrue differently to different sub-groups. Specifically, we will disaggregate results by gender and socioeconomic status. For example, we will investigate whether the road rehabilitation impacts employment opportunities differently for males and females, or whether it affects the probability of going to school differently for boys and girls.

Research Question 7: How do the long-term impacts of the road projects per dollar invested compare to other typical infrastructure investments?

To answer this question, we will compare the effects per dollar invested in the road project with comparable effects of other infrastructure investments. Specifically, we will conduct an in-depth literature review of similar infrastructure investment projects in other developing countries. Once we have gathered the data regarding outcomes, we will investigate building a simulation model that can use these outcomes as inputs to forecast different possible scenarios of long-term benefits to be accrued by the road projects in Sénégal.

2.2 Impact Evaluation

Impact evaluation focuses on answering the question of how the implementation of the program affected beneficiaries. In principle, to be able to correctly account for this we would like to be able to record the outcome of interest (Y) from each individual *i* in two situations:

1) when they receive the intervention (*treatment status* Y_{1i}), and
2) when they do not receive the intervention (*control status* Y_{0i}).

The average of the differences in these outcomes over all the beneficiaries of the program — $E(Y_{1i} - Y_{0i})$ — provides an estimate of the average impact of the program on the outcome of interest. Unfortunately, as with all interventions, we can only observe the beneficiaries of the program under the scenario in which they receive the intervention.

Evaluations can only rely on the observation of individuals who do not benefit from the program to measure the outcome of interest in the absence of the program. A comparison of the outcomes of beneficiaries and non-beneficiaries provides an estimate of the average impact of the program. However, this simple comparison presents a potential complication if beneficiaries and non-beneficiaries have different characteristics related to the outcome of interest. This problem is referred to as *selection bias*, which is illustrated by the following equation:

$$E[Y_i|D_i = 1] - E[Y_i|D_i = 0] = \big[E[Y_{1i}|D_i = 1] - E[Y_{0i}|D_i = 1]\big] + \big[E[Y_{0i}|D_i = 1] - E[Y_{0i}|D_i = 0]\big]$$

In the equation, D_i is an indicator of whether person *i* receives the program. The left hand side of the equation indicates the observed average outcome difference between beneficiaries and non-beneficiaries. The first bracketed term on the right hand side of the equation denotes the average effect of the program on the beneficiaries. The second bracketed term on the right hand side is the difference in outcomes, in the absence of the program, between beneficiaries and non-beneficiaries. This second term represents the selection bias. For example, if farmers who are typically more productive tend to be closer to the road being rehabilitated, then this term will be positive, implying that comparing mean outcomes for beneficiaries and non-beneficiaries will overestimate the true impact of the program.

2.2.1 Evaluation Approaches

A straightforward way to address the problem of selection bias is to randomly assign road segments to treatment and control groups. Random assignment, also called experimental design, helps ensure that the treatment status (D_i above) is independent of the characteristics of the units being assigned. This implies that the second bracketed term on the right hand side of the equation above is equal to zero, and comparing the outcomes of beneficiaries (treatment group) and non-beneficiaries (control group) provides an estimate of the effect of the program.

Impact evaluations of road improvement programs rarely use experimental design to evaluate program impacts. In an experimental design, road segments would need to be randomly assigned to either a treatment group (i.e., selected for rehabilitation) or to a control group (selected not to be rehabilitated). Such a design is rarely used because the selection of segments to be rehabilitated is typically based on a variety of factors, including the economic rate of return, political factors, social factors, environmental factors, etc. In the absence of random assignment, estimating the impact of a particular program becomes more complicated due to the selection bias problem described above.

When random assignment methods are not feasible, researchers generally turn to what are called quasi-experimental methods. In a quasi-experimental approach, program impacts are estimated by comparing treatment group outcomes with outcomes from a comparison group. To ensure accurate results in a quasi-experimental evaluation, the comparison group must be chosen to be as similar as possible to the program group on all characteristics that might affect the outcomes. Thus, the main challenge of quasi-experimental impact evaluations is to address the selection bias noted above by identifying a comparison group that is as similar as possible to the program group.

One quasi-experimental approach that is often used to assess rural infrastructure projects is difference-in-differences (DID). DID models essentially compare the pre- and post-intervention change in outcomes among the treatment group to the pre- and post-intervention change in outcomes among the comparison group. In some contexts, however, outcome changes depend on initial conditions and lead to biased DID impact estimates (Jalan and Ravallion, 1998, 2002). Ravallion and Chen (2005) take into account differences in initial conditions and use a DID model combined with propensity score matching (DID-PSM) to evaluate the impact of construction of rural roads and piped water supply systems in China. Mu and van de Walle (2009) and van de Walle and Cratty (2002) also use DID-PSM to assess the impact of rural road rehabilitation projects in Vietnam.

An alternative approach that has been suggested in the context of MCC road projects is dose-response approach. This approach estimates the impact of the program according to the degree of the intensity of treatment, using continuous treatment variables (Imbens 2000, Behrman, Cheng and Todd, 2004, Hirano and Imbens 2004).[5] In this framework, it is the intensity of treatment that varies and there is no formal comparison group (no group receives zero treatment). Such a dose-response approach was used to evaluate the impact of a single integrated road network MCC project in Honduras. The method involves estimating the change in travel time/cost associated with road improvements and modeling the change in an outcome variable of interest as a function of the change in travel time/cost and other relevant characteristics. In this model, the "treatment" variable is continuous rather than dichotomous.

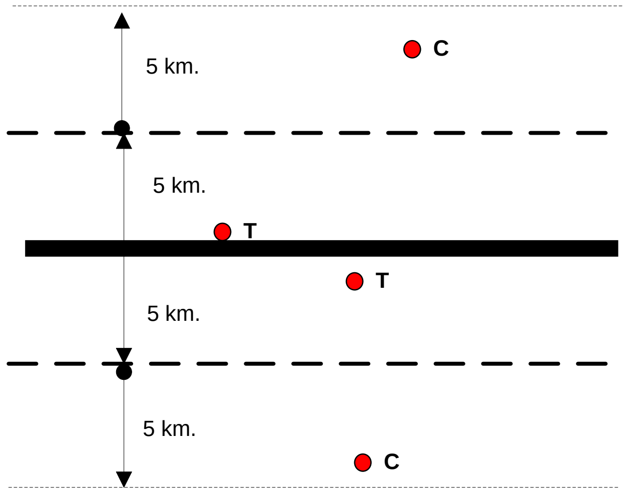
2.2.2 Evaluation Design Alternatives

In a road rehabilitation project, households and enterprises located near the rehabilitated road are typically considered the treatment group members since they are most affected by the road improvements. The treatment group is therefore often selected from among all households and enterprises located within a set distance from the rehabilitated road. For example, one approach that has been proposed is to select a sample of individuals and enterprises located within 5 km of the rehabilitated road as the treatment group. An alternative approach may be to use the households living within a specific walking time to the road (e.g., 30 minutes walking time).
In this study, however, the problem is complicated by the fact that the MCC Sénégal Compact also includes two major components in the vicinity of RN2: (1) road rehabilitation and (2) irrigation. Thus, some households located a short distance from the rehabilitated segments of RN2 may be affected by both the road rehabilitation project and the irrigation project. In the discussion below, we ignore the presence of the irrigation project in the vicinity of the RN2 rehabilitation segment. We will revisit this issue after the evaluation approach for the irrigation project is confirmed.

The appropriate selection of the treatment group is only part of the challenge. We must also identify the counterfactual (i.e., comparison group). One approach that has been suggested is to identify a comparison group that is located farther from the rehabilitated road than is the treatment group (say, between 5 and 10 km). This is illustrated in Exhibit 3.

[5] For example, Behrman, Cheng and Todd (2004) developed a generalized matching estimator to control for nonrandom selectivity issues in their study to evaluate a preschool enrichment program. Hirano and Imbens (2004) also develop a generalized propensity score matching technique for use when the treatment variable is continuous.

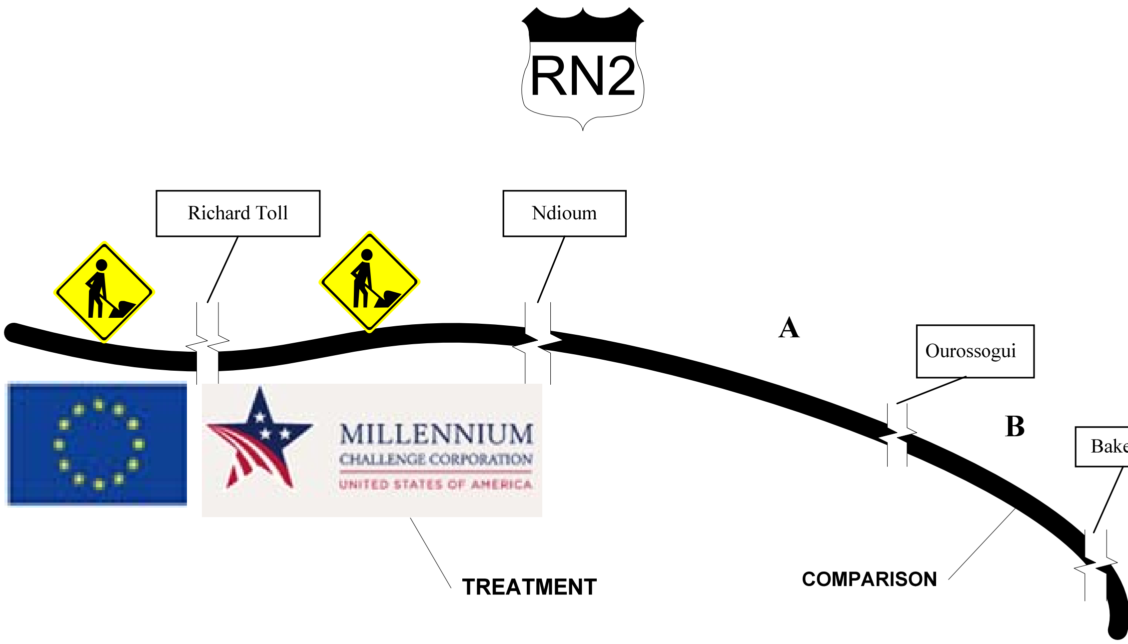
Exhibit 3: Illustration of Selection of Treatment and Comparison Areas



The rationale of this design is that units (households and enterprises) that are close to the road are likely to be affected by the road (Ts), while those that are farther away may not be affected (Cs). This design assumes that the comparison group units (i.e., units farther from the road) are similar to those located near the road. This assumption, however, is problematic since those units that chose to locate farther from the road may not need the benefits that an improved road may provide. As a result, selecting Ts and Cs based on distance (or access) from the road may not be appropriate since the two groups are different on important characteristics.

A better design would be one where both the Ts and the Cs are near a national road that, at baseline, has similar characteristics (level of degradation, economic conditions, etc.). In the current study, the Ts would be households and enterprises that are near a rehabilitated road, while the Cs would be near a similar road that is not scheduled to be rehabilitated in the near future. This design is illustrated in Exhibit 4.

Exhibit 4: Treatment and Comparison Areas for National Road 2



As indicated in Exhibit 4, the leftmost section of RN2 is being rehabilitated by the European Union (EU). The next section of the road (120 km) is being rehabilitated with MCC funding. This area represents the treatment area where the program group will be selected. One option is to select the adjacent segment of RN2 (segment A) as the comparison area. This design, however, may be problematic since the rehabilitation of the treatment area is likely to affect outcomes in the comparison area. A better design will be to select segment B as the comparison area. Segment B has been described by government experts and stakeholders as similar in many respects to the MCC rehabilitated area yet far enough away that it is not likely to be influenced by rehabilitation activities in the RN2 treatment area.

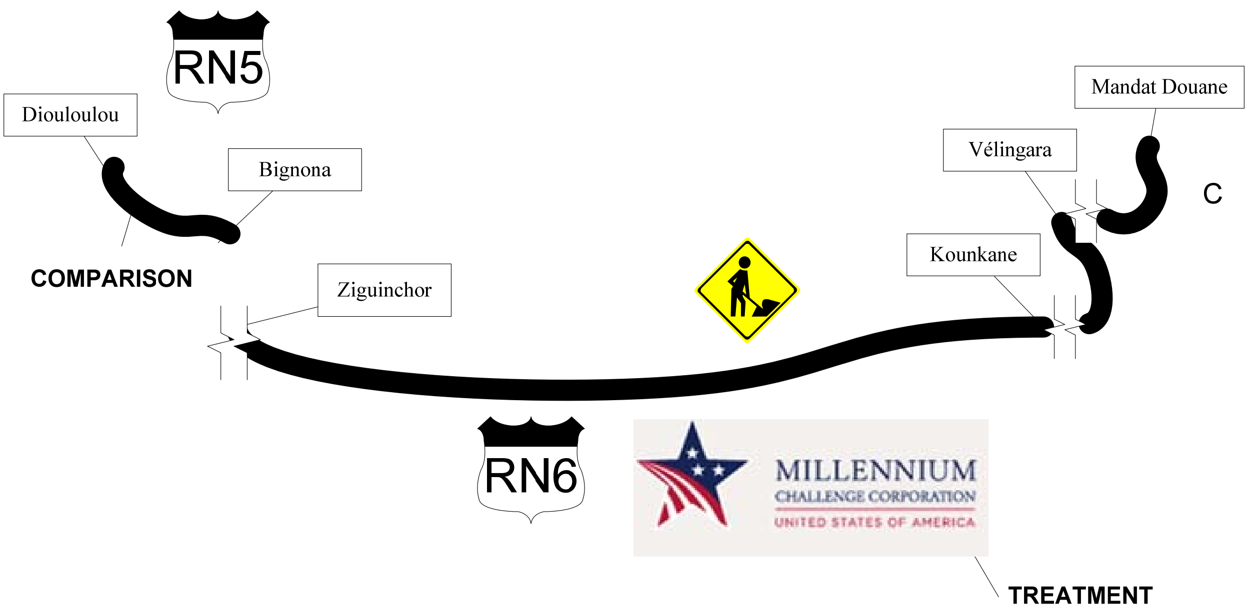
Based on extensive discussions with the experts and stakeholders, a consensus was developed that the far right (eastern-most) segment of RN2 is similar to the treatment segment. Stakeholders agree that the level of road degradation of this segment, and the economic activity and population along this road segments are similar to those of treatment roads. As a result of these similarities and in further discussion with the stakeholders, we reached a consensus to use the road segments from Orossogui to Bakel as our comparison road to identify the counterfactual.

We use the same approach for evaluating the impact of the road rehabilitation for RN6. As indicated in Exhibit 5, the RN6 road is located in the southern part of Sénégal, where conditions differ significantly from those in the northern part. RN6 provides a link between the largest villages of the Casamance and the rest of Sénégal (the Casamance region is separated from the rest of Sénégal by The Gambia). The MCC road rehabilitation area runs from Ziguinchor to Kounkane.

Identifying a comparison road segment for RN6 is difficult due to the substantial variation in the level of degradation of different segments of RN6. One possibility that has been discussed with stakeholders is the potential of using the same comparison area for the rehabilitated RN2 segment as the control area for RN6. However, the consensus of stakeholders is that conditions along RN6 are sufficiently different from the conditions along RN2 that the control area selected for RN2 may not be appropriate to serve as the comparison area for the RN6 rehabilitation area.

We considered using the area toward Tambacounda, east of Kounkane (Exhibit 5 Segment C), as a comparison group. However, this road segment was rejected as a comparison area since it is likely that this segment will be rehabilitated in the near future. After review of several potential comparison areas, the researchers and MCA-S agreed that the most appropriate comparison road segment is not on RN6, but rather on RN5 (the Diouloulou-Bignona segment). We have requested summary statistics for census tracts along the RN6 treatment area and similar summary statistics for the proposed RN5 comparison area. These statistics will be compared to confirm the choice of a comparison road segment for RN6.

Exhibit 5: Treatment and Comparison Areas for National Road 6



2.2.3 Proposed Estimation Method

Following careful review of the alternative quasi-experimental evaluation approaches, we propose to use difference-in-differences (DID) for measuring program impacts of the roads project. We will also consider combining the DID approach with propensity score matching (DID-PSM).

In the DID-PSM approach, once the treatment group is identified and selected, each treatment group member is matched with one or more individuals from a pool of individuals who did not receive the treatment. This matching process creates a comparison group that is similar to the treatment group in many observable characteristics. The effect of the program is then measured by the difference in outcomes before and after the program intervention for (a) the group that benefited from the intervention, or a treatment group, and (b) a similar group that did not benefit from the intervention, or a comparison group. The value added from DID-PSM is contingent on the assessment of the baseline characteristics of the treatment and control group samples. If the baseline characteristics are similar and few differences exist between the treatment and control samples, we will use DID alone. If there are significant differences between the two samples on a number of baseline characteristics, we will combine DID with PSM.[6]

In addition to the DID and DID-PSM we will explore the use of a dose-response approach that has been proposed for evaluating MCA road rehabilitation projects in other countries (e.g., Honduras). At this point, however, it does not appear that there is sufficient data (e.g., digitized maps of the areas in the study) to be able to implement this approach. Nonetheless, we will explore this technique further and assess the availability of digitized maps in Sénégal.

2.3 Other Analyses

2.3.1 Cost-Benefit Analysis

Our analysis of the road projects in Sénégal will include a cost-benefit analysis, focusing on the Economic Rate of Return (ERR) for the projects. The ERR is the discount rate at which the discounted benefits equal the discounted costs. The IMPAQ team will recalculate the ERRs using data to be collected from the survey and/or from MCA-S on costs (such as vehicle operating costs and travel time). We will compare these costs with the benefits derived from the roads project (e.g., increased income of households and added revenue for enterprises). After updating the ERRs, the team will compare them with the *ex-ante* ERRs used for the compact investment decisions.

2.3.2 Analyses by Gender and Other Subgroups

The IMPAQ team will also conduct the ex-post Beneficiary Analysis (BA) by examining the distribution of benefits by subgroup (e.g., gender and income group). The BA is intended to answer the following questions: (1) How many people are expected to benefit from increased household incomes as a result of the project? (2) What proportion of the beneficiaries is poor? (3) How much on average will each individual beneficiary gain from the project? and (4) For each dollar invested by MCC, how much will be gained by the poor? The data needed to answer these questions include, but are not limited to, the following:

- Beneficiary population

[6] DID-PSM estimators cannot guarantee, however, to completely address the selection bias mentioned earlier. Furthermore, for PSM to reduce bias, it requires that the data include a rich set of variables related to program participation (Smith and Todd, 2005).

- Gender of beneficiaries
- Consumption of beneficiaries
- Income of beneficiaries
- Vehicle operation costs
- Travel time/costs
- Administrative costs

2.3.3 Cost-Effectiveness Analysis

The cost-effectiveness analysis (CEA) compares the cost of interventions with their intended impacts. We note that the implementation of CEA is challenging. Prior research reveals the difficulty of estimating the long-term benefits of road rehabilitation projects within 3–4 years after the projects are completed.[7] For this analysis, we will compare the effects per dollar invested with the effects of other typical transportation infrastructure investments. Specifically, we will conduct an in-depth literature review that will provide information regarding patterns of development observed in other developing countries where similar projects have been implemented. Once we have gathered the data regarding outcomes during the initial years, we plan to build a simulation model that uses these outcomes and the patterns described in the literature as inputs to forecast different possible scenarios of long-term benefits to be accrued by the road projects in Sénégal.

2.3.4 Unintended Consequences

Even the most carefully thought-out and well-planned program may face unforeseen obstacles or produce unintended side effects when ultimately implemented. For example, a roads project that allows a business to reach more customers may adversely affect the environment through increased pollution as the firm expands its output. Similarly, reduced transportation times and costs may lead to increased competition for jobs as labor markets may attract job-seekers from greater distances. Reduced transportation times and costs might also induce some households to relocate. Finally, the road rehabilitation may cause temporary hardships for some households and enterprises during the construction phase. Indeed, the construction may cause some businesses to fail as well as some households to move out of the area. These and other positive and negative unintended consequences will be evaluated in the evaluation of the roads project.

We will address the following questions:

- Were there any unintended consequences of the road projects? If so, why did they occur?
- Who was affected by any unintended consequences?
- Could any negative unintended consequences have been mitigated? How?

[7] Conversely, Khandker et al. (2011) find that the benefits of a road project in Bangladesh attenuated over time for some groups.

Because it is difficult to address these questions using quantitative data, we will gather qualitative data from households, firms, and other key stakeholders in Sénégal to answer these questions. We will collect these qualitative data during the process of monitoring the progress of the road rehabilitation projects via telephone or electronic communications with relevant stakeholders. Another possibility for collecting information that could shed light on any unintended consequences of the project would be to include one or more open-ended response questions as part of the follow-up surveys. Such questions could ask households and firms for any comments they may have on how the road projects have influenced their lives. If it is feasible to include these types of questions in the survey, then the text gathered from the responses will be organized and analyzed for emerging themes using NVivo, an innovative qualitative data analysis software program that we have used in other projects to efficiently organize and analyze qualitative data.

CHAPTER 3. ANALYSIS PLAN

In this section, we describe the empirical models that we will use to estimate the impact of the Sénégal road projects. We also discuss how to estimate the impacts by subgroup. Our analysis plans are based on the assumption that we will use a quasi-experimental approach that involves surveying a random sample of households and businesses from treatment and comparison areas as discussed in the previous section.

We expect the road project to affect households and businesses by reducing travel times and travel costs. For example, the improvements to RN2 and RN6 should make the upgraded portions of road less affected by weather conditions like heavy rain, and should make the roads less demanding on vehicles. We expect that these reductions in travel times and travel costs will affect households by:

- Providing more opportunities for employment
- Increasing access to a wider range of businesses
- Lowering prices of goods and services due to increased competition by businesses
- Increasing access to health services
- Increasing access to education and school attendance
- Increasing land values

Similarly, we expect the road project to affect businesses near the rehabilitated road, by:

- Lowering transportation expenses
- Increasing access to customers
- Increasing access to labor

Evaluating the impact of the road project will involve estimating the effects of the project on all of these household and business outcomes.

3.1 Impact Analysis

To estimate the impacts of the road projects in Sénégal, we will specify econometric models that will compare how outcomes for economic agents (household and enterprises) served by project roads changed over time, relative to changes in outcomes for economic agents in the comparison group. This approach is captured by a multivariate DID regression:[8]

$$\text{Outcome} = \alpha + \beta T + \gamma F + \delta(T \cdot F) + \lambda X + \varepsilon$$

The left-hand side of the equation is the outcome variable of interest. The variables on the right-hand side include:

[8] Our impact analysis approach is based on the DID model because we anticipate obtaining data from treatment areas and a comparable group of households. Nonetheless, we will explore the value of expanding this approach to include DID-PSM (see section 2.2.3).

- A dummy variable T which equals 1 if the observation is in the treatment group and zero otherwise. The estimate of β captures the group effect. In other words, T controls for any differences in the outcome variable that are associated with being in the treatment group.

- A dummy variable F which equals 1 in the follow-up year and zero in the baseline year. The estimate of γ captures the time effect. In other words, F controls for any changes in the outcome variable that occur over time and are common for treatment and comparison group members.

- An interaction term $(T \cdot F)$ which equals 1 if the observation is in the treatment group *and* in the follow-up year and zero otherwise (i.e., for comparison group members in both the baseline and follow-up years, and for the treatment group in the baseline year). The estimate of δ captures the impact of the roads project on the outcome variable—this is the parameter of interest.

- A vector X of other relevant explanatory variables that may be related to the outcome of interest and will help control for baseline household or business characteristics. At a minimum, for household models, X will include the education, gender, and age of the household head. Including these explanatory variables will reduce the amount of unexplained variation in the outcome variable, thereby increasing the accuracy of our parameter estimates.

For each regression model, we will estimate: the parameters α, β, γ, δ, and the elements of the vector λ. All else equal, positive parameter estimates will indicate that the corresponding right-hand side variable is associated with an increase in the outcome measure. Likewise, negative parameter estimates will indicate a negative association. We will use t-tests to measure the statistical significance of the parameter estimates. Where we find statistically significant differences, we can be confident that the corresponding right-hand side variable has an effect on the outcome variable.

3.2 Impacts on Subgroups

In addition to the main impact analyses described above, we will examine whether the impacts of the road projects differed by subgroup, with subgroups defined by household characteristics such as gender and income. To do so, we will modify the basic regression model above to include terms that capture potential subgroup effects. More specifically, for the subgroup analyses, our regression models will be of the form:

$$\text{Outcome} = \alpha + \beta T + \gamma F + \xi S + \delta_1(T \cdot F) + \delta_2(T \cdot S) + \delta_3(F \cdot S) + \delta_4(T \cdot F \cdot S) + \lambda X + \varepsilon$$

As before, the left-hand side variable is the outcome of interest. Many of the right-hand side variables are the same as in the basic regression model. Explanatory variables added for the subgroup models include:

- A dummy variable S which equals 1 if the observation is in the subgroup and zero otherwise. The estimate of ξ accounts for differences in outcomes that are associated with being in the subgroup of interest.

- An interaction term $(T \cdot S)$ which equals 1 if the observation is in the treatment group *and* the subgroup of interest and zero otherwise. The estimate of δ_2 captures the incremental treatment group effect for observations in the subgroup.

- An interaction term $(F \cdot S)$ which equals 1 if the observation is in the follow-up period *and* the subgroup of interest and zero otherwise. The estimate of δ_3 captures the incremental time effect for observations in the subgroup.

- An interaction term $(T \cdot F \cdot S)$ which equals 1 if the observation is in the treatment group, in the follow-up period, and in the subgroup of interest. The estimate of δ_4 captures the potential differential effect of the road project for the subgroup—this is the parameter of interest.

For the subgroup models, we will estimate not only the parameters α, β, γ, and the elements of the vector λ, but also the parameters ξ, δ_1, δ_2, δ_3, and δ_4. In these models, the expected outcome for individuals in the subgroup is equal to the expected outcome for non-subgroup individuals plus: 1) a subgroup effect (ξ), 2) an incremental treatment group effect (δ_2), 3) an incremental time effect (δ_3), and 4) the incremental effect of the road projects (δ_4). Thus, our estimate of δ_4 will indicate whether the impact of the road project is different for the subgroup of interest. If δ_4 is positive, then the program has a greater impact on the outcome for the subgroup, all else equal. Likewise, if δ_4 is negative, then the program has a smaller effect on the outcome for the subgroup. We will use a t-test to evaluate whether our estimate of δ_4 is statistically significant. If so, then we can be confident that the impact of the program is indeed different for the subgroup of interest.

3.3 Presentation of Analysis

Results from the analysis will be presented in an evaluation report using data from the baseline and follow-up interviews. The evaluation report will include a description of the evaluation approach, results from the qualitative analysis, and results from the quantitative impact analysis. The results of the analysis will be presented in a variety of formats, including charts and tables. Exhibit 6 provides the table structure for sample characteristics, Exhibit 7 presents the structure for impact results, and Exhibit 8 presents the structure for impact coefficients.

Exhibit 6: Sample Characteristics

	Treatment Group	Comparison Group	Difference
Total [% of Total]	**N [%]**	**N[%]**	**Statistical Significance***
Men			
Women			
Age: Less than 15 yrs			
Age: 15-24 yrs			
Age: 25-34 yrs			
Age: 35-44 yrs			
Age: 45-54 yrs			
Age: 55+ yrs			

Exhibit 7: Impact Estimates

	Treatment Group			Comparison Group			Program IMPACT		
	Baseline Mean	Follow-up Mean	Mean Difference	Baseline Mean	Follow-up Mean	Mean Difference	Impact Estimates		
	(A)	**(B)**	**(C= B-A)**	**(D)**	**(E)**	**(F= E-D)**	**(C-F)**	**t-test**	**p-value**
Household									
Income									
Enterprise									
Revenue									
Notes: * p<0.05; **p<0.01; ***p<0.001.									

Exhibit 8: Impact Estimate Coefficients

	Treatment Group Coefficient (SE)	**Control Group** Coefficient (SE)	***Difference*** Coefficient (SE)
Likelihood of employment			
Monthly Income			

CHAPTER 4. SURVEY SAMPLING CONSIDERATIONS

Once the evaluation design method is determined, data need to be collected to be applied to the method. For a rigorous impact evaluation of the MCC Sénégal road rehabilitation project, it is essential to establish appropriate size of samples from households and enterprises and determine well-defined variables for survey questionnaires that address all the research questions that the evaluation is aiming to answer. In this section, we describe our proposed sample size and minimum variables needed for the impact evaluation.

4.1 Sample Size Calculation

We use statistical power analysis to calculate the minimum sample size required to detect an effect of a given size. Identifying an appropriate sample size for our impact evaluation depends on various factors, including a desired effect size, target power, and significance level.[9] For the desired effect size, we use information on the magnitude of benefits from the Beneficiary Analysis provided by MCC. The *power* of a statistical test is the probability of detecting a true effect when it exists. The significance level (or test size) is the probability of falsely detecting an effect when it does not exist.[10] We calculate the minimum sample sizes required to detect an effect of a given size for each of combinations of the most commonly used powers and sizes of a test.[11]

Our proposed sample sizes are calculated using the STATA command "sampsi" which provides an estimate of the sample size required for comparing outcomes of two groups.
The syntax for the "sampsi" command is:

sampsi **A B**, sd1(**C**) sd2(**D**) p(**power**) a(**significance level**).

The command uses the following formula,

$$n_2 = \frac{(\sigma_1^2 + \sigma_2^2 / r)(z_{1-\alpha/2} + z_{1-\beta})^2}{(\mu_1 - \mu_2)^2}$$

$$n_2 = rn_1$$

where α is the significance level, $1-\beta$ is the power, $z_{1-\alpha/2}$ is the $(1\text{-}\alpha/2)$ quantile of the normal distribution, and $r = n_2/n_1$ is the ratio of sample sizes.[12]

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[9] The effect size for the difference-in-difference analysis can be defined as the mean difference between the differences of an outcome in a treatment group from baseline to follow-up time point and the differences of an outcome in a control group for the same period. By dividing the effect size by the combined standard deviation from both groups, we obtain the standardized effect size to be used for the power analysis.

[10] The most commonly used significance levels are 5%, 1%, and 0.1%.

[11] A power analysis is either retrospective or prospective. A prospective analysis is often used to determine the required sample size to achieve the target statistical power given effect size and test size, while a retrospective analysis computes the statistical power of a test given sample size, effect size, and test size. Since we wish to obtain desired sample size, we take the prospective approach in this section.

[12] We used 1:1 for the ratio of treatment group sample to comparison group sample.

Since we use a difference-in-differences approach, we compare *the before and after changes of outcomes (e.g. income)* between the treatment group and the comparison group. For the sampsi command, we need the following inputs:

- **A:** an estimated average difference of per capita income between baseline and follow-up periods in *the treatment group*

  We derived this parameter from the following components:

  (1) **Income growth without intervention** can be calculated from the per capita GNI and the income growth rate. For the per capita GNI, we use $820 in the ERR calculation spreadsheet from the MCC. For the income growth rate (annual %), we use 2.2% in 2009 from the World Bank. Using the per capita GNI of $820 and the 2.2% of annual income growth rate, we estimate that the income will increase by approximately $\$94.3\ (= 820 \times (1.022)^5 - 820)$.

  (2) **Income growth attributed to the intervention (Estimated benefits from the road project):** Using the present value of benefit stream as share of annual income of about 10% and the per capita GNI of $820 in the ERR spreadsheet from MCC, we estimate that approximately $\$20\ (\approx 820 \times 0.1 \div 4)$ of benefits is expected to be generated from the road project per household for the first 5 years.

  A = $114.3 (= $94.3 + $20)

- **B:** an estimated average difference of per capita income between baseline and follow-up period in *the comparison group*

  Since there is no impact from the intervention in the comparison group, this is equal to the income growth without intervention, the first component of A.

  B = $94.3

- **C:** an estimated standard deviation (SD) of the differences of per capita income between baseline and follow-up in the treatment group

  The Table 2 in the Kazianga and Udry (2004) suggests a relation between standard deviation (SD) of income and SD of changes in income.[13] The SD of income changes is similar to that of income in magnitude. Assuming that SD is about 20 percent of the per capita GNI, we use $150 for the SD of the income changes. ***This assumption is to take into account the budget constraint of data collection***. If the SD increases, the required sample size increases even more, as shown in the formula below.

  C = $150

[13] This information is hard to obtain. We did our best to use a reasonable estimate for this. For an accurate calculation of minimum required sample size, we need more information on summary statistics of income, such as the mean and standard deviation of annual incomes.

- **D:** an estimated standard deviation of the differences of per capita income between baseline and follow-up in the comparison group

  The SD of income in the comparison group is expected to be larger than in the treatment group, assuming that the intervention would help reduce the inequality in the income distribution. Thus, we use $200 for the SD of income changes in the comparison group.

  D = $200

- **Power:** The most commonly used power is 80%, 90%, and 95%. In our sample size calculation, we used 80%. Increasing the power will increase minimum required sample size.

- **Significance level**: The most commonly used significance level is 5%, 1%, and 0.1%. In our sample size calculation, we used 5%. Decreasing the significance level will increase the minimum required sample size.

Exhibit 9 presents estimated required sample sizes for the combination of power and significance level.[14]

Exhibit 9: Sample Size Requirement

	Power		
	80%	**90%**	**95%**
Significance Level = 0.1%			
Sample Size	2668	3267	3806
Significance Level = 1%			
Sample Size	1825	2325	2784
Significance Level = 5%			
Sample Size	1227	1642	2031

As indicted in Exhibit 9, using the least restrictive criteria for the power and test size (80% power and a 5% significant level), we need at least 1,227 households in each of the treatment and comparison groups.[15] Thus, the minimum total household sample size is 4,908 (=1227*4). Since we are uncertain about the number of enterprises along the treatment and comparison roads, we propose a survey sample of about 600 enterprises. As already mentioned, this is the minimum required sample size for the least restrictive assumption for power and test size. For more robust results, we would need larger sample sizes. However, given the trade-off between the statistical

[14] These calculations assume a two-tailed t-test.

[15] The same approach can be used to obtain desired sample sizes for treatment and control groups for RN6, and the same method could be used to calculate the minimum required sample size for enterprises. In this case, the outcomes of interest would be the realized profits at baseline and the expected profits at the follow-up period. However, in discussion with MCA, we concluded not to use the power analysis for enterprise mainly because there are not sufficiently large number of enterprises that touch the roads.

rigor and the budgetary constraints that MCA-S faces, we have selected the smallest sample size consistent with a rigorous impact evaluation. We will continue to work in close collaboration with MCA-S and MCC to reach a consensus on the survey sample size.

4.2 Minimum Variables Needed

In order to implement the evaluation design described in the previous sections, we need to collect data on both households and enterprises. These data should be collected from the sample of treatment and comparison group households/enterprises at baseline (i.e., prior to the road rehabilitation) and again in the follow-up period. Since the effects of a road rehabilitation project may not be realized immediately following the completion of the road it is important to allow a sufficient time period to evaluate the impacts of the road improvements. Each of the baseline and follow-up data will be collected three times to consider three different seasons.

To estimate the impacts of the road rehabilitation activities on households, household survey data will be collected during in-person interviews from households living along the treatment and comparison roads through a repeated cross section, where a different set of households will be collected at the baseline and follow-up. We will ask questions about income and expenditures, access to primary services, use of the national road, output and commercialization of agricultural production. Other general measure of well-being that may be affected by the road rehabilitation activities includes value of land and other properties. The baseline survey will gather information on key background characteristics, like gender and age of each of the household members. These background characteristics will be used to identify population sub-groups that may differentially affected by the new economic opportunities unlocked by the road rehabilitation activities.

There is also need for a separate questionnaire and data collection effort for enterprises. This enterprise data collection effort is essential to gain a full picture of the impact of the road rehabilitation. The survey will gather information on type of enterprise activities, quantity of goods produced and commercialized, costs relate to the commercialization of goods and purchase of raw materials, size of the enterprises in terms of employee and other capital equipments, revenues and use of the road. The purpose of these questions is to capture how enterprise business economic activities are affected by the road rehabilitation projects.

In Exhibit 10 we summarize the main categories of variables we need to capture household and enterprise outcomes. The survey questionnaires to collect the variables needed for the impact evaluations will be developed in close cooperation with MCA-S, ANSD, and MCC.

Exhibit 10: Categories of Data to be Collected in the Surveys

Variables Descriptions	
Households	**Enterprises**
Household identification and geographic location	**Type of enterprise**
Household members and their characteristics	
Relationship to household head	**Services provided**
Household Members' Age	
Household Members' Gender	**Number of employees**
Household Members' Education	
Marital status	**Vehicles owned/used**
Household size	
Employment and earnings	**Quantity of goods produced**
Employment status	
Primary source of income	**Raw materials used**
Household access to basic infrastructures (market, school, health center etc…)	
Distance to Service/Infrastructure	**Enterprise transportation costs**
Means of Access to Service/Infrastructure	
Travel Time to Service/Infrastructure	**Commercialization of production**
Cost of Travel to Service/Infrastructure	
Household expenditures by category	**Enterprise revenues**
Household income by source	
Value of land and houses	**Utilization of the road**
Transportation	
Type of Vehicle Owned/Used	
Operating Cost of Vehicles	
Use of Public Transportation	
Use of primary/rural road	
Purpose of Travel on Primary /Rural Road	
Frequency of Use of Primary /Rural Road	
Means of Access to Primary /Rural Road	
Travel Time to the Primary /Rural Road	
Cost of Travel to Primary /Rural Road	
Household economic activities	
Main economic activity of the household	
Amounts of agricultural goods produced	
Amounts of agricultural goods commercialized	

CHAPTER 5. TIMELINE AND WORKPLAN

Successful implementation of this project requires the simultaneous implementation and management of several activities as well as close coordination with MCA-S and the survey contractors. For organizational and quality control purposes, we have organized the project into 2 major tasks, each with several subtasks. Some of the tasks have been completed or are currently in progress. The tasks and subtasks are outlined in Exhibit 11 below.

Exhibit 11: Project Tasks and Subtasks

Task 1: Evaluation Design and Planning
1.1. Project Kick-off and Initial Sénégal Visit 1.2. Confirmation of Treatment and Control Groups 1.3. Evaluation Design Report
Task 2: Evaluation Implementation, Data Collection Support, Data Analysis and Reporting
2.1. Support Development and Testing of Questionnaires 2.2. Baseline Data Collection (by the survey firm) 2.3. Baseline Data Processing 2.4. Baseline Analysis with Interim Report 2.5. Monitoring Project Activities 2.6. Collection of Cost Data 2.7. Follow-up Data Collection (by the survey firm) 2.8. Follow-up Data Processing 2.9. Final Impact Evaluation Report

In Exhibit 12, we provide an overview of the work plan for carrying out the evaluation, including activities performed under each task and subtask. Specifically, the table provides task and subtask start and end dates, project milestones, and deliverables. Our proposed timeline depends heavily on the realization of the road rehabilitation activities. Currently, the final impact evaluation is planned for 2015. Below, we provide a brief description of each task.

Task 1- Evaluation Design and Planning

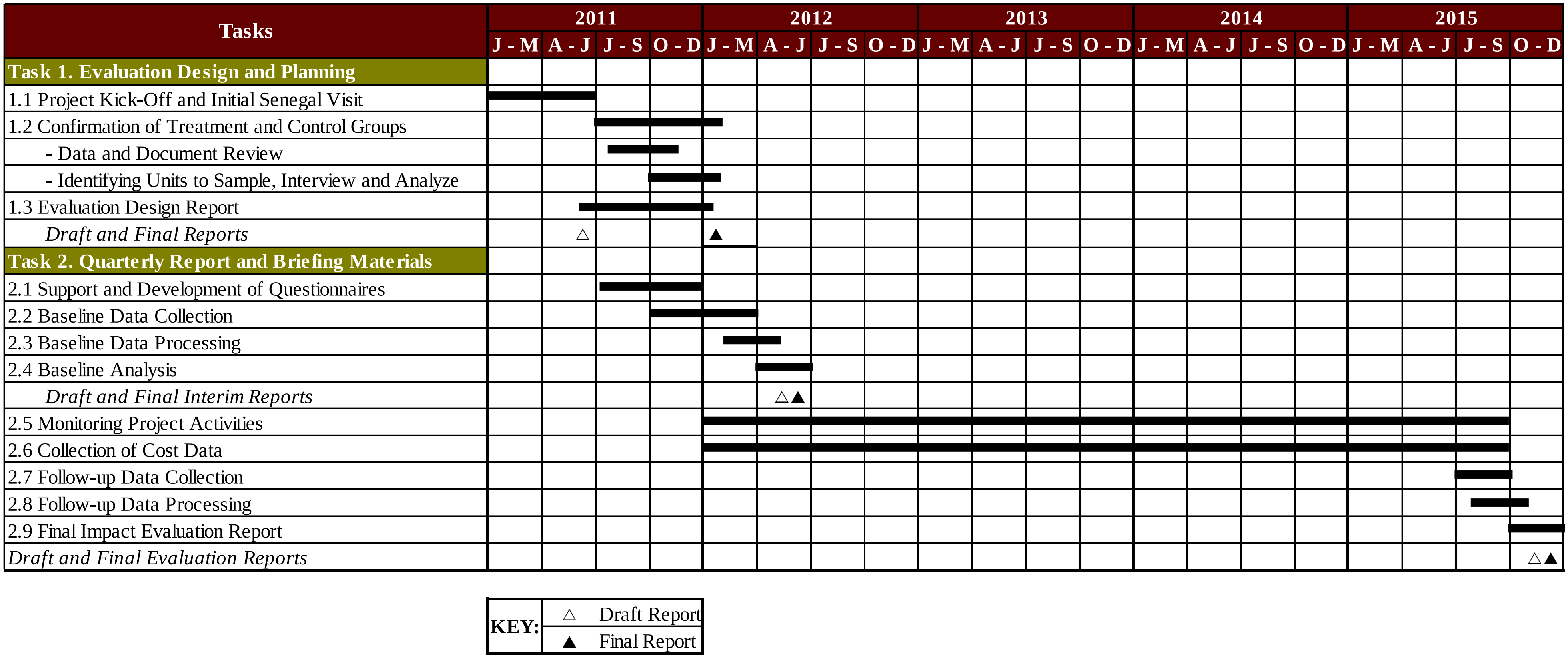
1.1 Project Kickoff and Initial Sénégal Visit

The Project Kick-off meeting was conducted on January 12, 2011, convening Washington MCC Monitoring and Evaluation Staff and the IMPAQ Team.

1.2 Confirmation of Treatment and Control Groups

The IMPAQ team is reviewing the selection of treatment and control groups along both RN2 and RN6.

Exhibit 12: Project Gantt Chart



Data and document review. IMPAQ is reviewing data about the people and enterprises near RN2 and RN6 as well as data for the selected comparison roads. The purpose of this activity is to confirm that characteristics of both groups are similar.

Identifying units to sample, interview, and analyze. IMPAQ has shared an initial sampling plan to be implemented by ANSD.

1.3 Completing Evaluation Design Report

IMPAQ is currently in the process of completing a draft of the Evaluation Design Report.

Task 2 - Evaluation Implementation, Data Collection Support, Data Analysis and Reporting

2.1 Support Development and Testing of Questionnaires

IMPAQ will continue to work with MCA-S to coordinate the development and Testing of Questionnaires by ANSD contractors and consultants.

2.2 Baseline Data Collection

MCA-S has contracted ANSD to collect the baseline survey. IMPAQ will continue to work with MCA-S advising on data collection tasks including comparison group data collection sites, sample size and power calculations.

2.3 Baseline Data Processing

IMPAQ anticipates that baseline data collection will be completed by the end of the first quarter of 2012. During and after completion of the data collection period, IMPAQ will work closely with MCA-S and the survey contractor to review the quality of data; confirm the quality of key variables; analyze whether the baseline data show the expected similarity in characteristics of treatment and comparison areas; identify potential errors to be resolved; and propose methods to address any errors.

2.4 Baseline Analysis with Interim Report

IMPAQ will analyze baseline data and develop a draft interim report.

2.5 Monitoring Project Activities

Throughout the baseline data collection period IMPAQ will continuously monitor project activities.

2.6 Collection of Cost Data

IMPAQ will continuously collect cost data to be used for calculating Economic Rates of Return, Beneficiary Analysis, and Cost Effectiveness Analysis.

2.7 Follow-up Data Collection

As with the Baseline Data Collection, IMPAQ will work with MCA-S and the contracted survey firm to complete the follow-up surveys during the third quarter of 2015.

2.8 Follow-up Data Processing

IMPAQ will also continue to work with the survey firm and MCA-S to clean the survey data during and after the data collection period.

2.9 Final Impact Evaluation Report

IMPAQ will analyze the follow-up survey data and cost data beginning the third quarter of 2015 through the fourth quarter of 2015. The report will include a variety of tables and figures with descriptive statistics. However, the focus of the report will be on the impact estimates of the MCC-Sénégal roads project and their statistical significance. This will include recalculation of ERR rates, a Beneficiary Analysis, and a Cost Effectiveness Analysis. Contextual narratives will be provided for all analyses. A draft final report will be delivered at the beginning of the fourth quarter of 2015. IMPAQ will convene a meeting with MCA-S and MCC to review comments and suggests. A final report incorporating all comments will be submitted within two months of this meeting.

CHAPTER 6. CONCLUSION

In this evaluation design report, we have: (1) described the main research questions that we will answer for the MCC roads project in Sénégal, (2) discussed various methods used to estimate the impacts of road projects, (3) presented our preferred evaluation approach, (4) explained the econometric models we will use to estimate project impacts—both overall and for subgroups, and (5) presented how the results will be presented in the final impact evaluation report. Despite having a robust plan for conducting the impact evaluation, the realities of the implementation of the road projects may require some flexibility with regard to various aspects of the evaluation design. We are prepared to remain flexible throughout the project implementation and to make adjustments where appropriate.

6.1 Challenges and Suggestions

The primary challenge to successfully carrying out our proposed evaluation design is the selection of an appropriate comparison area. At present, our discussions with MCC and MCA-S stakeholders have led to a consensus regarding an appropriate comparison area. Nonetheless, we need additional data to ensure that the treatment and comparison areas are similar along observable dimensions.

Even if we find that the treatment and comparison areas are comparable, there will be challenges in selecting the samples and achieving an adequate response rate. We believe that ANSD has the experience and capacity to be successful in collecting the required survey data and providing IMPAQ a clean data set with adequate documentation. We will work closely with ANSD to help ensure that the data collection process is implemented successfully.

The timing and duration of the road construction is a variable which we cannot control. In order to observe an impact after the completion of the road construction, there must be a sufficient observation period following the completion of construction. Since impacts of road rehabilitation projects may not materialize for some time, if the road rehabilitation is delayed, the analysis may only be able to measure the short-term and intermediate impacts of the project.

6.2 Next Steps

We are currently working with MCC and MCA-S stakeholders to determine appropriate sample sizes for the data collection effort. The next task will be to work with the survey contractor to develop and test the survey instruments and to begin more detailed planning regarding the implementation of the survey.

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