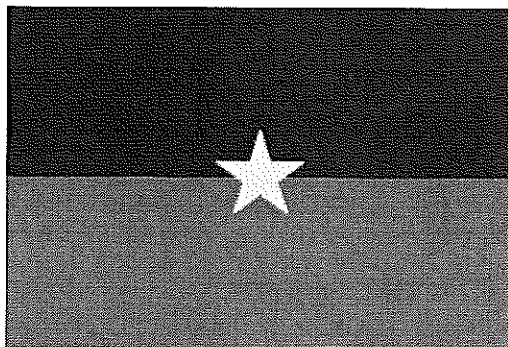# Evaluation Design Report
Impact of the Roads Project

Burkina Faso

March 2012

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CHAPTER 1. INTRODUCTION

Burkina Faso is one of the poorest countries in the world with 44.8 percent of the population living below the national poverty line as of the year 2006 (UN Data). The UNDP's 2007/08 Human Development Index (HDI) places Burkina Faso in 176th position out of 177 countries. Agriculture constitutes 30 percent of the country's GDP, with cotton being the main export commodity and driver of economic growth. In recent years (1997-2006), the average GDP growth rate has been around 5.9 percent (AfDB/OECD Report 2008).

Research has shown that the inadequacy of basic infrastructure facilities 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. Roads are argued to be 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]

To address the concerns that poor road conditions may have hindered economic growth in Burkina Faso, the government of Burkina Faso and the Millennium Challenge Corporation (MCC) entered into a Compact Agreement which includes funds for a road rehabilitation project. Using funds from this compact, MCC is supporting the rehabilitation of three primary roads and several rural roads in three provinces. This road rehabilitation project is expected to 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.[2]

IMPAQ International was selected by MCC to conduct a rigorous evaluation of the impact of MCC road improvement projects in Burkina Faso 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 MCC's 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 Burkina Faso impact evaluation will be compared with the results from a concurrent impact evaluation of a similar roads project in Sénégal.

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[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] 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

On July 14, 2008, the Millennium Challenge Corporation entered into a $480.9 million Compact Agreement with the government of Burkina Faso. To effectively manage the work of this compact, an autonomous body was established on March 12, 2008 by the Government of Burkina Faso, the Millennium Challenge Account (MCA-BF). The compact in Burkina Faso entered into force in July 2009, initiating the five-year timeline for project implementation. The funds from this compact are to be strategically invested in the following four projects:

- Rural Land Governance Project
- Agriculture Development Project
- Roads Rehabilitation Project
- Burkinabe Response to Improve Girls' Chances to Succeed (BRIGHT 2) Schools Project

To produce rigorous evidence about the effectiveness of these projects and inform future poverty alleviation programs and strategies, the compact incorporated Monitoring and Evaluation as a key function in the program implementation mechanism. IMPAQ International was selected to perform a rigorous impact evaluation of the Roads Rehabilitation Project. The overall goal of this project is to enhance access to markets through investments in the road network.

Burkina Faso's Poverty Reduction Strategy identifies lack of appropriate road infrastructures as major constraint to economic growth. By improving access to roads, reducing transportation costs and travel time, road infrastructural investments are expected to stimulate market activity, affect input and output prices, foster economic linkages to markets thereby enhancing agricultural production and other income-earning opportunities. In addition, these investments can also facilitate access to social service facilities, like schools and health centers, contributing to increase the social and human capital of the populations touched by these interventions.

To improve an inadequate road network system, compact funds will be used for upgrading both primary and rural road segments to appropriate functional standards. In particular, three primary roads segments will be rehabilitated in the center-western part of Burkina Faso, for a total of 271 kilometers (Exhibit 1).

- Dédougou-Nouna-Forniere du Mali (145 km);
- Banfora Sindou (50 km);
- Sabou-Koudougou-Didyr (76 km).

Exhibit 1: Primary Roads to be Rehabilitated by MCC

Burkina Faso - Primary Roads

Legend

Province

Population / Area

☐ Low (149300 - 411400)

▨ Medium (411500 - 763400)

▨ High (763500 - 1539000)

▮ Very High (1540000 - 8305000)

▬▬▬ Primary Road Sections to be rehabilitated by MCC
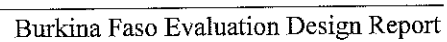
The Dédougou-Nouna-Forniere road segments span the provinces of Mouhoun and Kossi (*Boucle du Mouhoun* region). The total population of these provinces was about 600,000 in 2009, and is one of the poorest areas in the country. The road segment connecting Didyr and Sabou passes through the provinces of Sanguie and Boulkiemde (in the *Centre-Ouest* region) with a 2009 population of about 800,000. The Sindou-Banfora primary road is located between the provinces of Léraba and Comoé, which together compose the *Cascades* region. The population of the area was about 590,000 in 2009. The poverty incidence is somewhat lower than the national average in the Centre-Ouest and Cascades regions, but these areas are still plagued by higher than average infant and neonatal mortality rates and low alphabetization rates.[3]

The regions spanned by the three primary roads to be rehabilitated contribute significantly to the agricultural production of the entire country; for example, about 35% of national cereal production comes from these regions. Despite the agricultural importance of these regions, there is a lack of adequate road network in these regions (there are only about 500 km of paved roads across the three regions- slightly less than 18 percent of the national total).[4]

In three rural areas in southwestern Burkina Faso (including the Provinces of Léraba, Comoé and Kénédougou), fourteen rural roads segments (for a total of 151 km) will be rehabilitated with compact funds (see Exhibit 2 for location of these provinces). Currently, some rural roads in these provinces exist only in the form of rural tracks. Selected rural roads will be upgraded to appropriate rural road standards to provide accessibility to national roads. These improvements are expected to help connect the local populations to major national urban markets.

The proposed roads project interventions have the potential to unlock agricultural (and non-agricultural) economic capacities and resources, thereby contributing to the amelioration of the poor living standards. The impact evaluation will attempt to estimate the effectiveness of the interventions on achieving this goal. In the next section we describe in more detail the potential mechanism through which road sector interventions can contribute to economic growth and poverty reduction. A description of these mechanisms is important to assess whether, how, and to what extent planned interventions achieve the target goals. The conceptual model will thus guide the design of our evaluation.

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[3] According to the data collected through the last survey on household living conditions in 2003 (EBCVM- *Enquête burkinabé sur les conditions de vie des ménages*).

[4] Sources : Direction générale des routes, Direction générale des transports terrestres et maritimes.

Exhibit 2: Rural Roads to be Rehabilitated by MCC

Burkina Faso - Rural Roads

Legend

☐ Provinces in which the rural roads to be rehabilitated by MCC are located
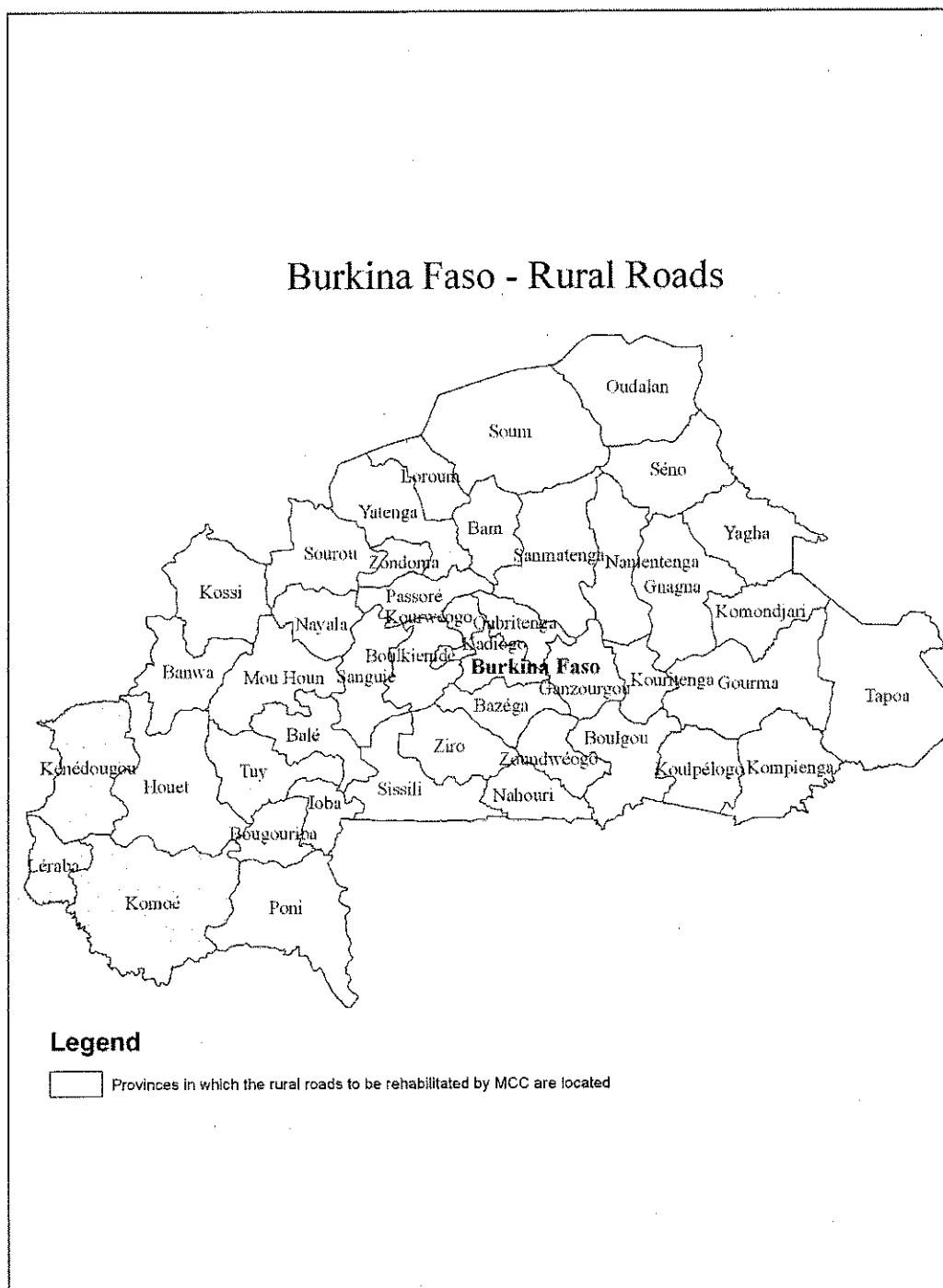
1.2 Conceptual Model

The overall long term goal of the compact is to reduce poverty and enhance economic growth. Improvement in road infrastructure has been suggested as one approach to advance this goal. Exhibit 3 shows potential causal pathways through which road improvements may lead to poverty reduction. The model consists of two parts:

(1) road rehabilitation implementation, and
(2) outcomes of the project.

Exhibit 3: A Conceptual Model for Road Rehabilitation Projects
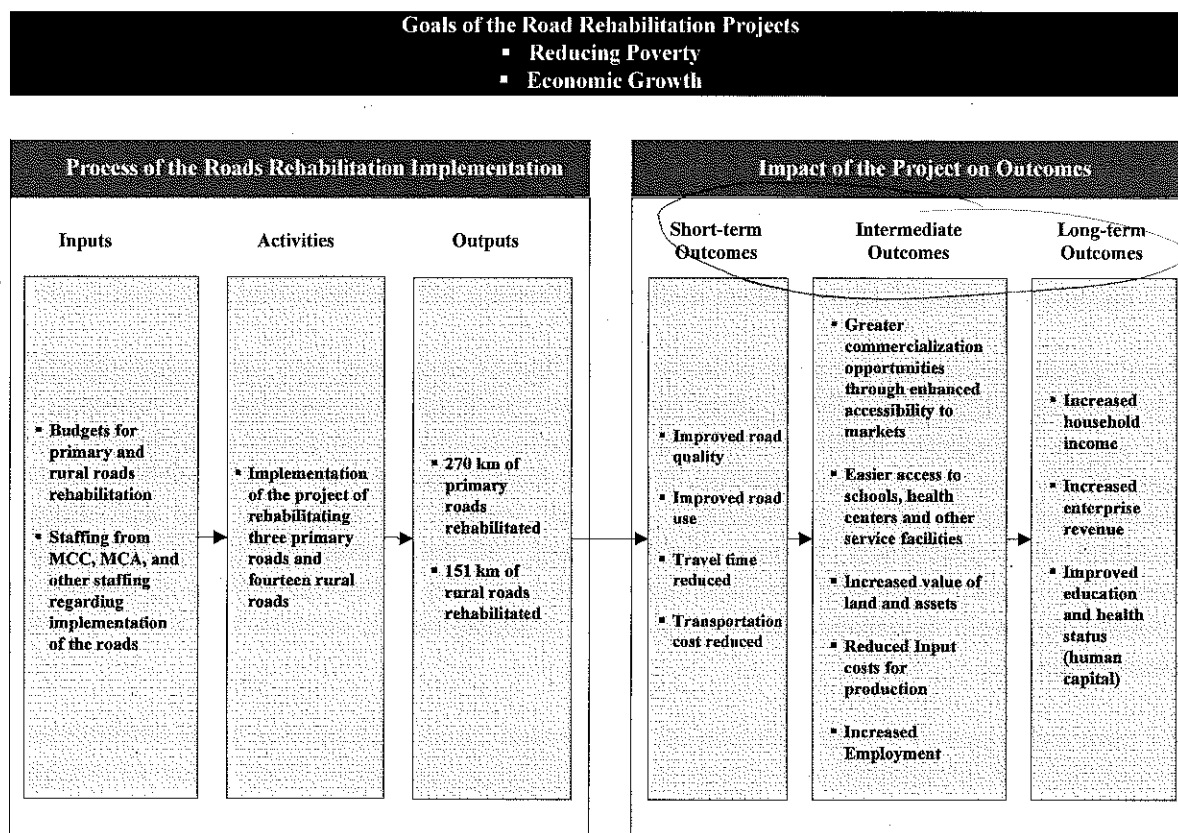
The project implementation includes inputs, activities, and outputs. Inputs refer to the resources needed to rehabilitate the roads; activities are the actions taken to implement the road rehabilitation; and outputs are the resulting rehabilitated road segments. Project outcomes are contingent on behavioral changes by program beneficiaries. In other words, outcomes depend on the changes in the behavior of beneficiaries as a result of the road rehabilitation. We will measure changes in beneficiary behaviors and the results of these behavioral changes in the impact evaluation.

The first three columns of Exhibit 3 show the process of the road rehabilitation implementation. Inputs include budgets and staffing for the implementation of the roads rehabilitation. These

inputs are used to perform two main *activities*: (1) the rehabilitation of three primary roads, and (2) the rehabilitation of fourteen rural roads. These improvements are expected to yield 270 km of functional primary roads and 151 km of functional rural roads in the West and South-West part of the country (*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 Exhibit 3 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.

To the extent that these interventions improve access to the roads, the first direct measurable outcome that would likely be observed in the short-run is a greater use of the roads (increased frequency and increased distance traveled) and a reduction in travel time and transportation costs (*short-term outcomes*). For example, families may be able to use a road that was previously not easily accessible, change transportation methods, or reduce vehicle operating costs and so on.

In turn, greater access to the road is expected to unlock economic and social opportunities of households and individuals living close to the road (*intermediate outcomes*). There may be a better access to markets where to buy and sell products. It may be easier and cheaper to find inputs needed for production activities for both formal enterprises and household informal economic activities. Road construction can also impact the value of land and assets of households and enterprises. Shorter distances and reduced travel time may also improve employment opportunities of individual household members, allow enterprises to expand their businesses, as well as provide better access to schools, health centers and other important infrastructures.

Long term outcomes of the intervention include greater household income from employment or increased enterprise revenues and greater human capital accumulation from better schooling and access to health care. Increased economic opportunities and improvements in human capital can serve as engine to economic growth and poverty reduction, if sustained over time.

Based on the logic model described above, 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? *tricky to capture*

- 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

The proposed impact evaluation will focus on how the MCC funded road improvements affect households and enterprises in Burkina Faso. In this section, we describe our plan to evaluate the impact of the rehabilitation projects. We begin by restating the main research questions. 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 Burkina Faso to address several 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 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 access 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 the enterprises 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 questions from the enterprise survey.

Research Question 5: What is the ex-post Economic Rate of Return of the Burkina Faso 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-BF) we will use the impact evaluation results to calculate 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 the road rehabilitation affects the probability of going to school differently for boys and girls.

Research Question 7: How do the 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 Burkina Faso.

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 accurately measure program impacts, we would like to observe the outcome of interest (Y) for each individual i in two situations:

1) when the individual receives the intervention (*treatment status Y_{1i}*), and
2) when the individual does 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:

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

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).

The appropriate selection of the treatment group is only part of the challenge. We must also identify the 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 4.

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[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 4: Illustration of Selection of Treatment and Comparison Areas
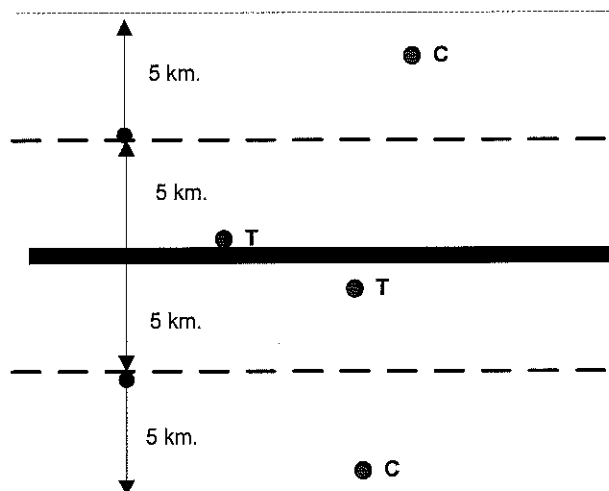
The rationale of this design is that units (households and enterprises) that are close to the road are likely to be affected by the road (Ts), while those that are farther away may not be affected (Cs). This design assumes that the comparison group units (i.e., units farther from the road) are similar 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 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.

The selection of comparison roads in Burkina Faso is based on the recommendation made by MCA-BF for both, primary and rural roads. Two road segments were recommended as comparison roads for each of the three primary roads to be rehabilitated. About ten road segments were suggested as comparison roads for each of the provinces where rural roads will be rehabilitated (Comoé, Léraba and Kénédougou). There are multiple rural roads to be rehabilitated in each of the three provinces: six in Comoé, four in Léraba and four in Kénédougou. We selected appropriate comparison roads based on:

- the length and location of the comparison road,
- its distance from the treatment road, and
- the similarity of the road to the treatment road in terms of the local population, economic activity, and level of road degradation.

For the primary roads, we chose comparison road segments that are not adjacent to the intervention road segments. For each primary road we selected one comparison road; thus, in total we will evaluate three treatment and three comparison road segments.

A total of 14 rural roads are scheduled to be rehabilitated in the three provinces. To measure the impact of the rural roads rehabilitation, we selected one rural road in each province as a treatment road. To select comparison roads for these three treatment roads, MCA-BF assisted in identifying comparable comparison roads. The choice of comparison road segments was based on the similarity of road length and distance to the primary intervention roads. Exhibit 5 shows the selected treatment and comparison roads for each primary and rural road segment that will be evaluated in the project.

Exhibit 5: Selection of Comparison Roads for Primary and Rural Road Segments

	Treatment Roads	Length (km)	Comparison Roads	Length (km)
Primary Road Segments				
	Dédougou- Nouna- Djibasso- frontière du Mali (RN14)	145	Tougan- Ouahigouya	94
	Banfora- Sindou (RD 21)	50	Mangodara- Niangoloko	170
	Koudougou- Didyr (RN13/RN21)[6]	55	Ouessa -Léo	81
Rural Road Segments				
Provinces				
Comoé	Moussodougou- Diamon	15	Koutoura – Goéra	8
			Panga-Gouéra	10
Léraba	Ouleni- Tenakourou	14.2	Loumana – Kangoura	11
	Sokouraba- Tourni	9.2	Kankalaba – Niantonon	12
Kénédougou	Toussiana- Tapako- Kourinion	26.7	N'dorola- Kodora	25

The population characteristics along each treatment and correspondent comparison road segment will be compared as a first step in the analysis. While the comparison segments were selected to be similar, we will verify if our selection resulted in comparable populations. To the extent that the populations differ on demographic and economic characteristics, we will employ sample matching techniques. We will assess whether matching would be best conducted following enumeration of the population (pre-matching) or after the baseline data is collected (post-matching).

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

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[6] MCC will rehabilitate the segment Sabou-Koudougou- Didyr (RN13/RN21) of a total extension of 76 km. However, the presence of confounding factors between Sabou-Koudougou prevents the team of performing a rigorous evaluation of the entire segment to be rehabilitated.

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 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.[7]

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 in (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 Burkina Faso.

2.3   Other Analyses

2.3.1   Cost-Benefit Analysis

Our analysis of the road projects in Burkina Faso 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-BF 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?

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[7] 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).

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

2.3.3 Cost-Effectiveness Analysis

worthwhile ?

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.[8] 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 Burkina Faso.

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:

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

- 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?

Because it is difficult to address these questions using quantitative data, we will gather qualitative data from households, firms, and other key stakeholders in Burkina Faso 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 baseline and 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.

In this section, we describe the empirical models that we will use to estimate the impact of the Burkina Faso 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 the primary roads 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 Burkina Faso, 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:[9]

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

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

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[9] 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.

There are potential differences between households and enterprises benefited from primary roads rehabilitation and households and enterprises benefited from improvements in rural road segments. Thus, we will explore the existence of differential effects across the two types of roads by estimating the econometric models described above separately for each type of road rehabilitation.

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

Total [% of Total]	Treatment Group N [%]	Comparison Group N [%]	Difference 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 (A)	Follow-up Mean (B)	Mean Difference (C= B-A)	Baseline Mean (D)	Follow-up Mean (E)	Mean Difference (F= E-D)	Impact Estimates (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			

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 Burkina Faso 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.[10] 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.[11] 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.[12]

Note that the benefit magnitude information is available only for the primary roads, not for the rural roads. Exhibit 9 shows the present value of benefit stream as share of annual consumption (%) by primary road segment.

Exhibit 9: Present Value of Benefit Stream as Share of Annual Consumption (%)

Road Segment		Present Value of Benefit Streems as share of Annual Consumption
Primary Roads		
	Sindou-Banfora	8%
	Sabou-Koudougou-Didyr	9%
	Dedougou-Nouna-Mali Border	27%

Source: Beneficiary Analysis from the MCC

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[10] 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.

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

[12] 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.

As indicted in Exhibit 10, using the least restrictive criteria for the power and test size in Exhibit 10, with 80% power and a 5% significant level, we need at least 3,734 households in each of the treatment and comparison groups for the three primary roads.[13] Previously, with limited information on the expected benefits from the roads project, we obtained sample size of 3469 using similar power analysis. Using the most recent information on the expected benefits from the MCC Beneficairy Analysis, we updated the sample size. Given the lack of precision in some of the parameters that enter the sample size calculations and the similarity of the estimates obtained using updated data, we feel that it is not critical to adjust the sample size arrangements that have already been made with MCA-BF and the survey firm.

Exhibit 10: Sample Size Requirement

	Power		
	80%	**90%**	**95%**
Significance Level = 0.1%			
Sample Size	8121	9943	11585
Significance Level = 1%			
Sample Size	5555	7078	8474
Significance Level = 5%			
Sample Size	3734	4998	6182

It should be noted that the proposed sample size for Burkina Faso roads evaluation are close to the sample size used for other MCC roads projects. For example, the Georgia project included 3382 households, Tanzania for 3000 households and El Salvador for 5388 households, (BenYishay and Tunstall, 2010).

Regarding the sample size for rural roads, we did not use rigorous statistical analysis to calculate the sample size for the rural roads for various reasons. First, for the rural roads, ERRs have not been calculated, which is essential for calculating the target effect size of the road rehabilitation project. Second, there are only a limited number of households living along the rural roads. Considering these factors as well as budgetary concern of the survey consultant, we arrived at 600 for the treatment group and 600 for comparison group for rural roads.

Only a small number of enterprises are available along the roads, compared to households. We are in the process of determining the sample size of enterprises using tax registry information in the cities along the roads of our interest that MCA-Burkina Faso provided us. A consensus with MCA-Burkina Faso is that due to the small number of the enterprises located along the rural

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[13] These calculations assume a two-tailed t-test. See Appendix A for details on the sample size calculations.

roads from the list, we will collect enterprise samples *only from the primary roads*. The exact sample size for enterprise surveys is to be determined.

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 might need larger sample sizes. However, there is a trade-off between the statistical rigor we can attain for the evaluation purpose and the budgetary constraints that MCA-Burkina Faso faces. Therefore, it is important to work in close collaboration with MCA-Burkina Faso and MCC to reach a conclusion on the 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.

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 road, level 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 its 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 11 we summarize the main categories of variables we need to capture household and enterprise outcomes. We are in the process of developing survey questionnaires based on the variables needed for impact evaluation in cooperation with MCA-Burkina Faso and MCC.

Exhibit 11: 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	

Successful implementation of this project requires the simultaneous implementation and management of several activities as well as close coordination with MCA-BF survey contractors. For organizational and quality control purposes, we have organized the project into two 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 12 below.

Exhibit 12: Project Tasks and Subtasks

Task 1: Evaluation Design and Planning

    1.1. Project Kick-off and Initial Burkina Faso 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 13, 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 Burkina Faso 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 for both the primary and rural roads.

Data and document review. IMPAQ is reviewing data about the people and enterprises near the primary and rural roads to be rehabilitated 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 the survey contractor.

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-BF to coordinate the development and testing of Questionnaires.

2.2 Baseline Data Collection
MCA-BF has contracted with a survey organization to collect the baseline survey. IMPAQ will continue to work with MCA-BF 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-BF 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 assist in collecting 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-BF 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-BF 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-Burkina Faso 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 in 2015. IMPAQ will convene a meeting with MCA-BF and MCC to review comments and suggests. A final report incorporating all comments will be submitted within two months of this meeting.

Exhibit 13: Project Gantt Chart

Tasks	2011	2012	2013	2014	2015
	J-M A-J J-S O-D	J-M A-J J-S O-D	J-M A-J J-S O-D	J-M A-J J-S O-D	J-M A-J J-S O-D
Task 1. Evaluation Design and Planning					
1.1 Project Kick-Off and Initial Burkina Faso Visit					
1.2 Confirmation of Treatment and Control Groups					
– Data and Document Review					
– Identifying Units to Sample, Interview and Analyze					
1.3 Evaluation Design Report					
Draft and Final Reports					
Task 2. Quarterly Report and Briefing Materials					
2.1 Support and Development of Questionnaires					
2.2 Baseline Data Collection					
2.3 Baseline Data Processing					
2.4 Baseline Analysis					
Draft and Final Interim Reports					
2.5 Monitoring Project Activities					
2.6 Collection of Cost Data					
2.7 Follow-up Data Collection					
2.8 Follow-up Data Processing					
2.9 Final Impact Evaluation Report					
Draft and Final Evaluation Reports					

KEY: △ Draft Report ▲ Final Report

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 Burkina-Faso, (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

One potential challenge to successfully carrying out our proposed evaluation design will be to monitor the progress of the road rehabilitation projects and to be prepared to respond to any unexpected deviations from the implementation schedule. Because infrastructure projects take some time to complete, unforeseen circumstances outside the control of the stakeholders involved in implementing the project can necessitate changes to the work schedule or other components of the implementation. If the actual implementation of the project varies drastically from what was originally planned, the deviation may threaten the impact evaluation. But this is not necessarily the case. Many times, evaluation plans can be modified to account for such changes through various technical adjustments. During the course of the roads project, we will maintain close communication with MCC-BF so that we maintain an up-to-date awareness of the progress of the roads projects. To the extent that the actual project implementation differs from the planned implementation, we will be able to quickly identify steps that may help ensure that we will still be able to provide MCC-BF with reliable impact estimates.

6.2 Next Steps

We are currently working with MCC Burkina-Faso to develop and test the survey instruments and to begin more detailed planning regarding the implementation of the survey.

Once data collection has begun, we will stay in close contact with the survey contractor to verify that data collection is going smoothly. Should there be any need for our assistance, we will be ready to work with the survey contractor to provide whatever technical assistance or guidance may be required.

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The sample size calculations are based on the STATA command "sampsi", which provides an estimate of the sample size required for comparing outcomes of two groups. The syntax for command "sampsi" is:

$$\text{sampsi} \quad A\ B, \text{sd1}(C)\ \text{sd2}(D)\ p(\textbf{power})\ a(\textbf{significance level}).$$

Since we use a difference-in-differences approach, we compare *the before and after changes of outcomes (e.g. consumption)* 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 consumption between baseline and follow-up periods in *the treatment group*

    We derived this parameter from the following components:

    (1) **Consumption growth without intervention** can be calculated from the national average consumption per capita from the MCC Beneficiary Analysis, $804, and the income growth rate of 2008 from the World Bank, 5.0%. We estimate that the consumption will increase by approximately $222.1 ($= 804 \times (1.05)^5 - 804$).

    (2) **Consumption growth attributed to the intervention (Estimated benefits from the road project):** Using the present value of benefit stream as share of annual consumption and the national average consumption per capita from the Beneficiary Analysis, we estimate that for the first 5 years approximately,$16.1, $18.1 and $54.3 of benefits would be generated from **Sindou-Banfora, Sabou-Koudougou-Didyr, and Dedougou-Nouna-Mali Border, respectively.**[14]

    A = $238.2 (= $222.1 + $16.1) for Sindou-Banfora
    = $240.2 (= $222.1 + $18.1) for Sabou-Koudougou-Didyr
    = $276.4 (= $222.1 + $54.3) for Dedougou-Nouna-Mali Border

- **B:** an estimated average difference of per capita consumption 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 consumption growth without intervention, the first component of A.

    B = $222.1

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

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[14] 16.1=804*0.08/4, 18.1=804*0.09/4. and 54.3=804*0.27/4

The Table 7 in the Kazianga and Udry (2004) suggests a relation between standard deviation (SD) of consumption and SD of changes in consumption.[15] The SD of consumption changes is similar to that of consumption in magnitude. Assuming that SD is about 20 percent of the national average annual per capita consumption, we use $160 for the SD of the consumption 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 = $160

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

The SD of consumption 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 consumption distribution. Thus, we use $200 for the SD of consumption changes in the comparison group.

D = $200

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 $(1-\alpha/2)$ quantile of the normal distribution, and $\mu_1 = A$, $\mu_2 = B$, $\sigma_1 = C$, $\sigma_2 = D$, and $r = n_2 / n_1$ is the ratio of sample sizes.16

- **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.

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[15] 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 consumption, such as the mean and standard deviation of annual consumption.

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