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Independent Evaluation ADB

Evaluation Approach

Special Evaluation Study on Poverty Impacts Evaluation of Road Projects in Bangladesh

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I. RATIONALE

1. ADB evaluates its progress against the corporate results framework. The corporate results framework forms the basis of the annual Development Effectiveness Review (DEfR), a tool to measure ADB's contribution to development in Asia and the Pacific. The DEfR presents a scorecard evaluating ADB's performance of core sector outcomes and outputs, along with ADB's operational and institutional effectiveness. The review of sector performance in the results framework (Level 2) largely relies on evaluation results in the project completion and performance evaluation reports. However, few project completion or performance evaluations do reliable assessment on whether a project achieved its intended outcomes, due to resource and methodological constraints. Impact evaluation of ADB projects in this proposed study will equip projects with practical tools to evaluate their impacts and outcomes, and thereby heighten the relevance of the results framework.

2. Roads have been championed by ADB[1] as instruments for achieving inclusive growth, one of three pillars of Strategy 2020. The rationale is that rural poor households can better exploit agricultural and non-agricultural opportunities to employ labor and capital more efficiently. Yet despite such a general consensus on the importance of roads for development and poverty reduction, there is surprisingly little hard evidence on the size and nature of their benefits especially to the poor, leaving knowledge gaps as to how the spurred opportunities associated with improved roads have actually filtered into the development outcomes for the rural poor.

3. The proposed impact evaluation study will assess the development outcome of selected road projects in Bangladesh, provide evidence of poverty impacts of road interventions, and fill in the knowledge gap. It will use impact evaluation methods based on statistical and econometric analyses of quantitative data from household and community level surveys, both existing and to be conducted by the study. The counterfactuals will be drawn from comparable non-participants areas. For additional insights on non-quantifiable variables and study robustness, it will collect qualitative information and integrate it into the quantitative analyses.

[1] Transport is a main sector in ADB portfolio: it has accounted for 27% of ADB lending during 2005–2009. Some 70% of ADB transport lending is for roads. Transport projects have performed well: Some 92% of transport projects were rated successful or better.

II. EXISTING WORK ON IMPACTS OF ROADS

A. Road Impacts – Key Characteristics

4. It is widely perceived that by reducing transport costs, improved roads generate market activities, affect input and output prices, and foster economic linkages that enhance agricultural production, alter land use, crop intensity and other production decisions, and stimulate off-farm diversification, income-earning opportunities, and migration. Improved roads also enhance social outcomes, by facilitating access to social service facilities.

5. Because of such interactive and dynamic natures of impacts of roads, however, evaluating impacts poses serious challenges. Most impacts are indirect and conditional on interactions with the geographic, community and household characteristics of its placement. The placement of road intervention is determined endogenously, which confounds inferences from comparisons of places with road investments versus places without. Impacts may also be distributional, felt across multiple outcomes over a long time. Highlighted below are key issues on evaluation.

- **Derived and conditional benefits:** Numerous factors may interact with a road project in determining what impacts it has on its surroundings. The nature and extent of impacts depend on interactions with other investments, other infrastructure and characteristics of where the roads are located.

- **Non experimental design**: In evaluating impacts of road interventions, it is not possible to construct treatment and control groups through experimental design.

- **Unobserved heterogeneity:** Road projects were not randomly placed at all. Factors that have mattered to projects' placement might have in turn influenced their outcomes, too. Understanding potential sources of heterogeneity is critical to collecting right data and choosing right methodologies for estimating unbiased results.

- **Dispersed effects**: Road effects are geographically dispersed. Through various linkages, an improved road could conceivably have community-wide impacts as well as impacts that may extend beyond the community the road links up to. As such, defining a project area is not simple. Determining comparison areas is also tricky since they should be close enough to the project area and yet sufficiently distant to avoid being contaminated by spillovers effects. Project areas are often defined as villages that a road passes through but under this definition data collected in project areas do not allow an investigation of impacts that might have had spillover to neighboring areas.

- **Distributional, time variant impacts**: Impacts of a road intervention vary across groups in the project area; while some gain from better roads, there can be losers from road projects. If roads lead to higher land values there may be a higher tendency towards land concentration and landlessness. Those with greater initial land, education, wealth or influence will be better able to take advantage of the changes. Distribution of current and future earning opportunities may widen. Common property resources may be reduced which may hurt the poor the most. With cheaper goods coming in, traditional job may be displaced. Distributional impacts may also change over time with even initial losers eventually benefiting.

- **Long time to emerge**: While intermediate impacts occur relatively quickly, the full impacts usually emerge over time. If impact evaluation doesn't allow sufficient time for linkages to play themselves out, it could under- or over-estimate net impacts. But, the more time one allows for impacts to emerge, the more the evaluation needs to contend with potential attrition in the data.[2]

6. Road improvement itself would not automatically generate intended outcomes. There are various prerequisites for roads to impact the poor. For a new road to enhance mobility, people must have access to means of transport along the road (e.g. bicycles, motorcycles, buses). For impacts to be felt on input and output prices there must be some means of freight transport and local production for which external demand exists. For the road to have social impacts there must be functioning health and education facilities in its vicinity (Hettige 2005).

B. Existing Findings

7. Methodological constraints and data limitations, combined with inherent complexities, have made it very difficult to precisely quantify impacts of roads. A drawback in previous studies was that they did not have appropriate control groups ('non-randomization') — a main huddle of quantitative designs in setting up the counterfactual. Using quasi-experimental design, they selected comparison areas in the vicinity of the project areas. The chosen comparison areas were assumed to share many of the characteristics as the project areas. However, in reality, no one could assure that these are a good comparison group on *a priori* grounds. Their resultant findings were often vulnerable to unobserved factors.

8. Using advanced econometric techniques to overcome such drawbacks to estimation and data collection, recent studies have improved their results.[3] They presented various channels through which roads have influenced development. Improved roads helped create opportunities for economic growth and poverty reduction through a range of mechanisms (Lokshin and Yemtsov 2005; van de Walle and Cratty 2005). Roads reduced transportation costs and the costs of consumption and production of goods and services (BIDS 2004). With easier access to markets and technology, improved roads expand farm and nonfarm production through increased availability of relevant inputs and lower input costs (Khandker 2009; Binswanger, Khandker, and Rosenzweig 1993; Levy 1996) as well as growth in rural enterprises (Lokshin and Yemtsov 2005) and local markets development (Mu and van de Walle 2008). At the household level, road development contributed to higher productivity and demand for labor (Leinbach 1983), and improved education and health, including for women and girls (Bryceson and Howe 1993; Levy 1996). Studies also suggested that household consumption seemed to be boosted as a result of increased household income. van de Valle (2008) provides an excellent summary of ex-post impact evaluation studies.

9. Using participatory rural assessment and focus group discussions with focus on specific livelihood aspects of rural poor households, Hettige (2005) illustrated how rural road development affected the poor's daily activities and livelihood and found the conditions that are conducive or not conducive to poverty reduction. She pointed out that benefits from new economic activities generated by improved roads were not necessarily trickled down to the poor. Due to farm-gate price rigidity or land ownership structure, for example, higher crop productivity

[2] It confounds exogenous shocks and spillover effects such as related or unrelated other investment programs in the control or treatment areas that make it harder to assess the impacts of the original road project.

[3] To construct comparison groups, they used various ways such as a rigorous propensity scores matching method, double difference, double difference combined with propensity score matching, double difference combined with instrumental variables, and dynamic panel data models with quasi-experimental natures.

after road improvement was not followed by income increases for poor or wage farmers. Better roads helped create more non-farm job opportunities outside their vicinity but whether such boosted employment chances were really passed onto the poor was questionable since most rural poor people were often very reluctant to take any risks in search of employment. On the other hand, the non-poor who had access to capital were found to be in a better position to take advantages from new additional economic opportunities.

III. ROAD DEVELOPMENT IN BANGLADESH

A. Road Sector

10. **Sector Performance:** In 2003, the transport system in Bangladesh comprised about 140,000 kilometers (km) of roads, 2,700 km of railroads, 5,970 km of waterways, two major seaports, and seven airports.[4] The primary road network connecting national and regional roads and district roads comprised 20,800 km,[5] while the secondary roads totaled 115,000 km. National and regional roads and district roads are administered by the Roads and Highways Department (RHD) within the Ministry of Communications. Secondary roads are administered by the Local Government Engineering Department (LGED) within the local government division. The performance of the road sector consistently improved in the past decades, with an extension of the road network and demand for road transport that persistently increased at 8% or higher. Roads have become the principal mode of transport.[6]

11. **National Land Transport Policy (NLTP):** The Government developed the NLTP in 2002, under which the road sector has been planned and managed by two principles: promoting greater private sector participation and fostering the "user-pays" concept for services. RHD, responsible for 20,800 km of primary roads, accomplished its mission, completing the five strategic road corridors with the assistance of aid agencies. Responding to evolving natures of road network, RHD adjusted its focus from construction to maintenance. The road subsector roadmap for 2003-2008 identified institutional and policy reform elements in NLTP: (i) integration of transport policy, planning, and appraisal within MOC; (ii) updating of legislation; (iii) private sector participation in highway development; (iv) modernization and strengthening of RHD; (v) privatization of RHD's plant and equipment workshops; (vi) road maintenance and funding; and (vii) a road subsector master plan.

12. **District Roads**: The Poverty Reduction Partnership Agreement[7] identified roads as one of the most important tools to reduce poverty. In line with the Agreement, the road subsector strategy focused on (i) accelerating pro-poor economic growth, e.g., by providing farmers with access to markets and inputs; (ii) reducing obstacles to social service delivery and providing access to vulnerable groups; (iii) facilitating popular participation by facilitating travel; and (iv) conducting road sector operations with greater public scrutiny and introducing more objective and transparent approaches to resource allocation, especially for road maintenance. Type-A feeder road, which most rural farmers relied on to access markets or social facilities, was usually in poor condition.

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[4] ADB. 2003. *Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People's Republic of Bangladesh for the Road Maintenance and Improvement II Project*. Manila.

[5] The primary road network comprises 3,086 km of national roads, 1,751 km of regional roads, and 15,962 km of district roads. District roads are the ones connecting national and regional roads.

[6] The modal share of transport has gradually shifted in favor of roads. From 1975 to 1997 the modal share of road transport rose from 54% to 73% for passenger traffic, and from 35% to 63% for freight.

[7] It was signed in April 2000.

B. ADB Assistances

13. ADB has provided 23 loans, totaling about $1.88 billion, to Bangladesh road subsector, focusing on the completion of the five strategic transport corridors. About 96% of national and regional roads are paved. Until 2003, only 65% of the district roads, which were paved connected rural remote areas. As a result, many rural poor farmers, who resided in rural remote areas, were often excluded from economic opportunities and had very limited access to markets, education, and health facilities. Developing a road network, which would integrate rural, isolated areas into economic centers, has received a developmental priority from 2003.

IV. PROPOSED IMPACT EVALUATION

A. Objectives and Scope of Evaluation

14. ADB loans to the road subsector in Bangladesh have aimed at reducing poverty[8] by improving access to local communities and linking them to the major road networks. The objective of this study is to evaluate ex-post impacts of ADB-financed road projects in Bangladesh. The study will (i) measure impacts that are attributed to the projects in achieving the intended impacts and outcomes; (ii) help improve ADB's operational effectiveness at the project level; and (iii) enhance the relevance of ADB corporate results framework.

15. Key evaluation questions will be:

(i) Did road projects influence poverty in Bangladesh?
(ii) What outcome indicators were good proxies for project impacts?
(iii) What indicators should be in project design and monitoring framework and measured periodically during a project cycle?

Based on outcomes of projects' ex-post impact evaluation, a set of enhanced indicators will be suggested for the design and monitoring framework, which will help measure impacts of future projects systematically over a full project cycle.

16. The study will be undertaken in three steps: diagnostic work, field work and data work, and analytical work.

- **Diagnostic work** will (i) review previous studies, (ii) identify characteristics and stylized facts in project areas and presenting hypotheses for evaluation, (iii) finalize analytical methodologies, and (iv) prepare fieldwork. Preparing fieldwork includes selecting study areas, making survey framework (survey design, sampling size, questionnaires), and setting up data collection strategy.

- **Fieldwork and data work** will (i) compile secondary data suitable for the study (household income and expenditure surveys, annual statistics, road inventory etc.); (ii) conduct household- and community- surveys, key informant interviews, and focus group discussions; and (iii) establish data set for qualitative and quantitative analyses.

[8] The study will use the poverty line defined by the Bangladesh Bureau of Statistics (the level of per capita income or consumption, at which the members of a household can be expected to meet their basic food consumption needs, i.e. to meet their calorie intake requirements as well as some essential nonfood consumption. As precursory work, field work is being arranged to develop poverty profile and socioeconomic characteristics of the project areas.

- **Analytical work** will, through qualitative and quantitative analyses, quantify impacts on poverty and draw insights for project design and evaluation framework. Qualitative analysis will outline plausible storylines of how the poor's livelihood is connected to road improvement, and present a set of effective indicators for the project design and monitoring framework. Quantitative analysis will (i) estimate econometric models, (ii) test robustness, and (iii) assess estimation results.

B. Proposed Projects of Impact Evaluation

17. The 33 ADB loans to Bangladesh, totaling $ 2.45 billion, comprise 23 loans to road, seven to railway, and three to water subsector. The proposed study considers the following four completed projects of evaluation:

- Loan 1708: southwest road network project to improve five sections of national highway (approval of 1999, loan amount of $ 89 million, implementation over 2001~2006);
- Loan 1789: road maintenance project to construct four sections of national highway (approval of 2000, loan amount of $ 68 million, implementation over 2002~2009);
- Loan 1920: road network improvement and maintenance project to improve 127 km of type-A feeder roads in Mymensingh and Rangpur (approval of 2002, loan amount of $ 35 million, implementation over 2007~2011);
- Loan 2021:road network improvement and maintenance II project to improve 142 km of district roads in Dhaka, Mymensingh, Rangpur, and Chittagong (approval of 2003, loan amount of $ 82 million, implementation over 2008~2011).

18. The above projects were selected by their implementation period and likelihood of data availability. They, like any other road projects, aimed at promoting economic growth and poverty reduction in the project area, by providing better and safer access to income and employment opportunities. The projects were designed to improve physical and non-physical components of road infrastructure for more efficient transport network in the project areas.

19. The first two projects (Loans 1708 and 1789) were rated successful, relevant, effective, efficient, and less than likely sustainable in their project completion reports.[9] The remaining two projects (Loans 1920 and 2021) were just completed and thus their project completion reports are not available. However, these two projects are included in this study, considering they were the loans to Bangladesh that explicitly targeted the rural poor areas for first time aiming at poverty reduction. The project areas—the northwest and the central north regions in Bangladesh where the level of poverty incidence was among the highest—were expected to have significant developmental impact not only nationwide but also subregion-wide in the medium term, from improved regional and feeder roads. Project information is in Appendix 1.

C. Evaluation Methodology – Econometric Analysis

20. The study will evaluate ex-post impacts of the projects by estimating their impacts on poverty using econometric methodologies used in two existing studies (Khandker, Bakht, and Koolwal 2005; and Lokshin and Yemtsov, 2005): a double differenced reduced-form equation and propensity score-matched double difference comparisons. The methodologies employed in these studies are found to be appropriate to overcome methodological constraints and data

[9] ADB. 2009. *Project Completion Report: Road Maintenance and Improvement Project (Loans 1789-BAN and 1790-BAN)*. Manila. ADB. 2007. *Project Completion Report: Southwest Road Network Development Project (Loan 1708-BAN [SF]).* Manila.

limitation the proposed study faces. A reduced form equation model allows complex interactions among various factors affecting the role of road in income, productivity, and poverty. A propensity score-matched difference-in-difference method helps overcome problems arising from non-randomization. The use of different tools will ensure effective cross-checking and validation through triangulation of findings for study robustness.

1. Estimation of Reduced-form Equation of Household Income[10]

21. A model is designed to allow the outcomes to be influenced by agroclimatic and other community endowments as well as agricultural opportunities of a village/community. Observed and unobserved characteristics affect input and output markets, public investments in infrastructure such as roads, and government pricing, interest, and public spending decisions.

22. Household outcomes are assumed to be influenced by input and output markets, infrastructure, and government policy. Likewise, infrastructural investments also affect these input and output markets. Government policymaking in credit and other markets (for crops such as paddy, for example) can also influence household outcomes directly and indirectly via the input and output markets as well as infrastructural investments. A semi-logarithmic reduced-form income equation, conditional on road investment, can be written as:

$$\ln Y_{ijt} = \alpha H_{ijt} + \beta V_{jt} + \gamma R_{jt} + \mu_j + \eta_i + \varepsilon_{ijt}^{\ y} \qquad (1)$$

where *i* denotes i^{th} household, *j* denotes j^{th} village. *Yijt* is a per capita income of i^{th} household in j^{th} village at time *t*, *H* is a set of observed household characteristics, *R* is an indicator of road projects, *V* represents observed non-road village-level characteristics, μ is unobserved village-specific heterogeneity, η represents unobserved household characteristics, and ε is a vector of idiosyncratic errors distributed across households. Similar equations can be written for other outcomes such as prices (*P*) and institutional factors (*I*) that are influenced by road improvement.

23. Since household income is also a function of input and output prices as well as institutional factors, road investment has a direct effect on household income as well as an indirect effect through prices and institutions. Total effect may be decomposed as: $\ln Y_{ij} / \ln R_j = \ln Y_{ij} / R_j + (\ln Y_{ijk} / P_{jk})(\ln P_{jk} / R_j) + (\ln Y_{ijk} / I_{jl})(\ln I_{jl} / R_j)$

24. From the model road improvement will affect the household through changes in three mechanisms: (i) transportation costs as well as input and output prices; (ii) labor supply, as well as farm and non-farm production; and (iii) household outcomes such as earnings, consumption, and schooling.

25. Time variations are also included in the outcomes and explanatory variables to control for both household and community heterogeneity in estimation that might have affected estimates of a road investment. When the road project is in effect, t = 1 and otherwise, t=0.

26. Household level characteristics that are often unobserved to the researcher are socioeconomic culture, habit, preference, risk taking, behaviors, and ability. Community level characteristics are agro-climatic and other community endowments, agricultural opportunities, socioeconomic culture, and religious or tribal background. To control for the sources of heterogeneities (i.e. unobserved time-invariant village and household characteristics), taking the

[10] Khandker, Bakht, and Koolwal (2005) estimated impacts of rural road projects financed by the World Bank in Bangladesh on rural household income and other rural household outcomes. This study will follow their work.

difference of equation (1) over the two points of time we obtain equation (2). Estimating the coefficients in equation (2) will measure impacts of road improvement.

$$Y_{ij} = \alpha \quad H_{ij} + \beta \quad V_j + \gamma \quad R_j + \quad \varepsilon_{ij} \qquad (2)$$

27. Using equation (2), a difference-indifference equation for the two project (T) and control (C) villages can be written as follow:

$$[\ Y_{ij}^{T} \ - \ Y_{ij}^{C}\ ] = \alpha\ [\ H_{ij}^{T} \ - \ H_{ij}^{C}\ ] + \beta\ [\ V_{ij}^{T} \ - \ V_{ij}^{C}\ ] + \gamma \quad (3)$$

The road impact is to be captured by a coefficient, γ. Since in the case of quasi experiment survey design, the expected values of the first two bracketed terms on the right-hand-side will lead to a bias, the differences between the time-varying observed variables (*H* and *V)* need to be controlled for in regression.

28. The outcomes of interest include variables such as per capita income, household transport expenses,[11] fertilizer price, agricultural wage, agricultural output and price indices, labor supply, and schooling. Explanatory variables may include: road project (binary), household head's gender (binary), household head's age, household head's education years, maximum schooling years of adult in household, village having electricity (binary), number of grocery and fertilizer shops in district, percentage of irrigated land in village, and household owning land.

29. For each road section, project and control areas will be selected. For project areas, one or two villages each for roadside and off-road will be selected. For control areas, one each roadside and remote villages will be selected. The selected roadside villages should indicate the immediate influence areas of road intervention and remote villages should similar to the roadside villages and be at least 2 km away from the project road or other paved roads. Sufficient number of households will be selected from each study village using a stratified random sampling procedure. [12] Surveys will collect information on general household characteristics, education, healthcare treatment, wage and self-employment, credit activities, assets, income, consumption, marriage, fertility, community characteristics, and transportation.

2. Scoring Matched Difference-in-Difference[13]

30. While the above method is expected to demonstrate insightful internal influencing mechanisms, it may also face criticisms on the quasi-experimental approach to select control villages. Thus, the study will stretch its methodology out to employing a propensity scoring matched difference-in-difference comparisons.

31. Outcome measure I_{it} for a project in i^{th} village at date t is defined as:

$$I_{it} = I_{it}^{*} + G_{it}^{I}\ D_i \qquad (4)$$

[11] Household transport costs that include costs incurred while going to such places as the market center, school, and nearest health facility.

[12] The exact sample size will be determined based on the findings of the diagnostic fieldwork that is being carried out.

[13] Impact evaluation of projects, especially those which targeted specific communities and areas, requires particular attention to evaluation techniques and good quality data. Lokshin and Yemtsov (2005) evaluated economic benefits of road interventions using a propensity score–matched double difference method. This paper will follow their approach for estimation of road impacts [Lokshin Michael and Ruslan Yemtsov. 2005. *The World Bank Economic Review*, vol 19, no. 2, pp. 311-333].

where I_{it}* is the outcome for a village if the project is not implemented, and G_{it}^{I} is the gain to village *i* from an outcome attributable to a project. Then the estimate of the average impact of the project on a treatment village (dummy variable $D_i=1$) can be decomposed as:[14]

$$E\,(I_{it} \mid D_i=1) - E\,(I_{it} \mid D_i=0) \equiv E\,(I_{it}^* \mid D_i=1) + E\,(G_{i1}^{I} \mid D_i=1) - E\,(I_{it}^* \mid D_i=0) \quad (5)$$

With a few assumptions, the following equation can be drawn.

$$E\,[(I_{i1} - I_{i1}^*) - (I_{i0} - I_{i0}^*) \mid D_i=1\,] = E\,[G_{i1}^{I} \mid D_i=1\,] \quad (6)$$

If the outcomes in period 0 are not correlated with project placement, this equation will estimate the mean changes in outcomes for the treatment villages.

32. This study will use a matched difference-in-difference method, which combines propensity score–matching and difference-in-difference methods. The propensity score measures the probability that a project is implemented in a village as a function of that village's observed pre-intervention characteristics.[15] Villages with projects (the treatment group) are matched with villages without projects (the control group) on the basis of the propensity score. This matching will remove the selection bias due to the observed differences between treatment and control villages. Then the difference-in-difference method will be applied to correct for possible bias due to the differences in time-invariant unobserved characteristics between the two groups. To evaluate the impact of the project, the changes in outcome measures will be compared between matched villages from the treatment and control groups.

33. Outcome indicators of interest may include:

- Household-level indicators: sales of agricultural products, female nonfarm employment, nonagricultural employment, household transport expenditures per capita, travel time to markets, etc.
- Village-level indicators: time to district capital, barter trade, and small enterprises.

34. The following village-level characteristics, but not limited to, shall be considered to compute a propensity: total population, if internally displaced person in the village, agriculture only, experienced flood, mountainous (hilly) area, distance to district center, distance to market, rail, main road, number of schools, clinic, number of enterprises, police station, post office, shops, restaurant, proportion of households with phone, proportion of households with toilet, unreliable electric power supply, proportion of households with piped water, proportion of buildings with wooden walls, proportion of buildings with dirt floors, and roadside trade.

3. Data

35. To capture the broad sphere of impacts, the study will use available secondary information and also collect primary data from household surveys, key informant interviews, participatory rural assessments, and feedback from workshops. These tools will be used sequentially, each intending to inform the next phase and cumulatively to validate the data. The qualitative information will be fed into a framework that is to capture not only project outcomes but also factors that might have affected the impacts.

[14] The estimation bias amounts to $E\,(I_{it}^* \mid D_i=1) - E\,(I_{it}^* \mid D_i=0)$.

[15] This may require a large sample size since it may be difficult to find matched villages with the project village. A sufficient number of samples will be drawn.

36. **Secondary Data:** For a pre-matching of prospective comparison areas or information on the history of community trajectories to control for selection bias, the study will draw on existing data sources. Among the main sources are the Household Income Expenditure Survey (HIES) and Bangladesh Statistical Year Book. The Bangladesh Bureau of Statistics (BBS) publishes the Community Report every five years (at the zila level). The Community Report contains socioeconomic information of a community itself as well as micro information at the village- and ward- levels. The study will also draw extensively on commune-level data from the reports of 2000, 2005, and 2010 for the zilas included in the study to construct the baseline data as well as select control areas.

37. **Primary data** will be collected by structured sample surveys of households. Household level information will be complemented by village-level information and interviews with key informants from service agencies, focus group discussions, and supplementary secondary data analysis.[16] Survey will include various categories of beneficiaries of the projects.[17] A variety of information will be collected on general household characteristics, education, healthcare treatment, wage and self-employment, credit activities, assets, income, consumption, marriage, and fertility. In addition, information on community characteristics and transportation will also be collected.[18]

4. Fieldwork and Survey

38. The proposed evaluation study will evaluate impacts of the following sections implemented under ADB loans.

(i) Primary road sections under Loan 1789:
- Feni-Chittagong, section 1 (25.44 km, $7.47 million)
- Feni-Chittagong, section 2 (22.50 km, $9.87 million)
- Chittagong Port access road (13.58 km, $11.09 million)

(ii) Secondary road sections (type-A feeder roads) under Loan 1920:
- Mymenshingh-Namdail (Section 1) (20 km, $7.38 million, contract no 1)
- Mymenshingh-Namdail (Section 2) (28 km, $12.87 million, contract no 2)
- Jamalpur-Dewanganj (41 km, $7.0 million, contract no. 3)
- Mithapukur-Madhyapara (24 km) and Saidpur-Parbatipur (15 km) ($9.64 million, contract no. 4)
- Thakurgaon-Ranisankail (36 km, $ 9.93 million, contract no. 5)

[16] Qualitative data from unstructured interviews will be gathered, which would be very useful for interpreting and understanding the underlying and intermediate processes that would explain final impacts, as well as help formulate a design and content of quantitative survey instruments.

[17] The categories of beneficiaries not limited to include labor contracting societies, transport owners and workers, farmers, traders, passengers, road maintenance group, members of management of the growth centers, project affected persons, and jetty operators.

[18] **Household-level survey** will collect information including: household per capita income, years in school, literacy, number of household members (female and male), livestock holding, main crops farming, indebtedness (amount of debt), landholding structure, wage farming, sales of agricultural products, female off-farm employment, nonagricultural employment, number of livestock, number of days working, ethnicity, religion, medical expenses, education expenses, transportation expenditure, field of employment activity, type of housing structure, toilet facility, and source of drinking water. **Community-level survey** will collect information including: health, road transport services providers, water availability, other infrastructure, children enrolled in school, school enrollment rate, incidence of waterborne diseases, time to district capital and markets, road condition, railroad and main highway, small enterprises, new water sources, piped water in the household, hours of piped water supply, roadside shops and vendors, proportion of household with phone, proportion of household with toilet, unreliable electric power supply, proportion of household with piped water, built with wooden (dirt) walls (floors), experienced disaster (flood).

(iii) Primary road sections under Loan 1708:

- Dhaka-Mawa (31.25 km, $2.35 million)
- Mawa-Bhanga (22.76 km, $18.27 million)
- Bhanga-Bhatiapara (37.6 km, $19.87 million)
- Bhatiapara-Mollahat (41.82 km, $18.41 million)
- Mollahat-Noapara (28.96 km, $14.42 million)

(iv) Secondary road sections under Loan 2021:

- Bhaluka-Kishoreganj road (45.4 km, contract no. 1)
- Parbatipur-Madyapara road (44.0 km, contract no. 3)
- Boda-Nilphamari road (52.6 km, contract no.3)

39. Study areas—project areas and control areas—will be selected for each project. About 100 villages will be selected as project areas for each section and then corresponding control villages will be selected using a score matching.

Study Areas

	Areas	Districts
Loan 1789	Southeast	Comilla, Feni, Chittagong
Loan 1708	Southwest	Dhaka, Munishiganj, Faridpur, Gopalganj, Bagerhat
Loan 1920	Northeast, Northwest	Mymensingh, Jamalpur, Rangpur, Dinajpur, Thakurgaon
Loan 2021	Northeast, Northwest, Southeast	Mymensingh, Koshoreganj, Panchagarh, Dinajpur, Nilphamari,Chittagong

D. Staffing and Scheduling

40. The study will be conducted by an IED evaluation team comprising a principal evaluation specialist/Team Leader, a senior evaluation specialist, a national evaluation officer, and an evaluation assistant. The IED team will be assisted by a team of consultants comprising an international socioeconomic and poverty impact evaluation specialist, an international evaluation econometrician, a national research analyst, a national statistics assistant, and two national socioeconomic and poverty impact specialists.

41. The study will be carried out from October 2012 to September 2013:

Activity	**Schedule**
• Study concept clearance	4 Sept 2012
• One stop meeting	25 Oct 2012
• Evaluation approach paper approval	15 Nov 2012
• Commencement	November 2012
Diagnosis work	I November - IV December 2012
Fieldwork	IV November 2012 ~ IV Apr 2013
Data work	I January ~ IV May 2013
Econometric analysis	IV February ~ IV June 2013
• Draft report for peer review	II July 2013
• Interdepartmental review	II Aug 2013

- Report approval by DG, IED — II September 2013
- DEC discussion — IV September 2013

Appendixes:

1. Project Profile: Design and Technical Standards
2. Information in the Household Income and Expenditure Surveys and Community Report
3. Econometric Analyses

Project Profile: Design and Technical Standards

A. Loan 1708: Southwest Road Network Project

1. The project was to improve five sections of national highway: (i) 53.9 km of roads along the Dhaka-Mawa-Bhanga route; (ii) construct 38.0 km of roads from Bhanga to Bhatiapara; (iii) construct and rehabilite 73.6 km along the Bhatiapara-Gopalganj-Town Noapara route; and (iv) construct a 450 m bridge over the Anal Khan River.

- Dhaka-Mawa (31.25 km, $2.35 million, contract no.1)
- Mawa-Bhanga (22.76 km, $18.27 million, contract no.2)
- Bhanga-Bhatiapara (37.6 km, $19.87 million, contract no.3)
- Bhatiapara-Mollahat (41.82 km, $18.41 million, contract no.4)
- Mollahat-Noapara (28.96 km, $14.42 million, contract no.5)

2. The existing roads along Dhaka-Town Noapara, which were seal coated on the top of brick aggregate base course, were deteriorated and did not satisfy international standards in alignment, cross section, and pavement structure. About 60 percent of the sections were improved along the current alignment, including widening, reconstruction, and raising the embankment based on the past 20-year flood records. The remaining portions were to be realigned or newly constructed.

B. Loan 1789/1790: Road Network Improvement Project

3. The project included (i) overlay and widening of the Chandina, Comilla, and Feni bypasses (52 km) of the Dhaka-Chittagong highway; (ii) upgrading and widening of the Feni-Chittagong section (47 km); (iii) construction of Chittagong Port Access Road (13.6 km). The structures were designed in accordance with acceptable international standards. AASHTO[1] HS20 loading (equivalent to a trailer truck of 36 tons) was adopted and the return period of 20 years was considered for drainage structures.

4. Seven bridges and 23 culverts in total will be newly constructed. Seven bridges and 36 culverts in total required rehabilitation.

Table 1: Details of Roads for Improvement

Item	Chandina, Comilla, Feni	Feni-Chittagong	Feni- Chittagong	Chittagong Port Access
Length (km)	51.7	24.4	22.5	12.4
Pavement width	7.3 m traffic lanes	7.3 m traffic lanes	7.3 m traffic lanes	7.3 m traffic lanes
	3 m shoulders	3 m shoulders	3 m shoulders	2.4 m shoulders
Shoulder width	2.45 m for each	2.45 m for each	2.45 m for each	2.45 m for each
	(1.5 m paved)	(1.5 m paved)	(1.5 m paved)	(1.2 m paved)
Improvement Type				
New Construction (km)		5.9	6	12.4
Reconstruction (km)		9.7	11	
Overlay (km)	51.7	8.8	5.5	
Pavement (typical)				
Bituminous Wearing Course (mm)	40	50	50	50
Bituminous Binder Course	60 (9.7 km)	80	80	80

[1] AASHTO denotes American Association of State Highway and Transportation Officials.

(mm)				
Asphalt Upper Base (mm)		120	120	120
Aggregate Lower Base (mm)		200	200	200
Aggregate Subbase (mm)		250	250	250
Improved Subgrade (mm)		300	300	300
Construction Cost ($ million)	24.1	18.7	20.8	22

Source: ADB. 2000. *Report and Recommendation of the President to the Board of Directors on Proposed Loans to the People's Republic of Bangladesh for the Road Maintenance and Improvement Project*. Manila.

C. Loan 1920: Road Maintenance and Development Project

5. The projects aimed at helping the Government achieve poverty reduction through economic growth by improving transport efficiency and strengthening integrated road networks effectively linking national, regional, and feeder roads. Intended outcomes were (i) improved subnational roads to provide rural farmers with better access to markets, social services, and employment opportunities; (ii) secured Government resources for periodic road maintenance; (iii) promoted private sector participation in road maintenance; and (iv) improved road safety. Intended outputs included (i) 47 km of regional roads reconstructed and 127 km of type A feeder roads reconstructed; (ii) periodic road maintenance supported of 400 km of roads; (iii) routine road maintenance supported through performance-based contracts; (iv) road safety in accident-prone areas or black spots; and (v) consulting services.

6. In addition to the 47 km regional road in Mymensingh-Nandail, the Project was to improve 127 km of type-A feeder roads in Mymensingh region and in Rangpur region:

- Muktagacha-Chechua (10 km, contract no 1)
- Jamalpur-Dewanganj (41 km, contract no. 3)
- Mithapukur-Madhyapara (24 km, contract no. 4)
- Saidpur-Parbatipur (15 km, contract no. 4)
- Thakurgaon-Ranisankail (37 km, contract no. 5)

7. The districts of the project areas measured about 35,000 km^2 accommodating more than 31 million people and about 4,500 km of national, regional, and type-A feeder roads. Type-A feeder roads comprised more than 76% of the total length of roads. Industrial activities in the project areas were low compared with those in other regions of the country, particularly Dhaka, Chittagong, Jessore, and Khulna. Each project district had an industrial estate of Bangladesh Small and Cottage Industries Corporation, where small and medium-size industrial enterprises were set up. Total employment in the industrial activities in the project district was estimated at 100,000 in 1996/1997. Outside the estates, small and cottage industries such as rice milling, timber processing, furniture making, food processing, and hand loom weaving were popular.

Table 2: Details of Preliminary Design of Roads

Item	Mymensingh Region			Rangpur Region		
	Mymensingh-Nandail	Muktagacha-Chechua	Jamalpur-Dewanganj	Mithapukur-Madhyapara	Thakurgaon-Ranisankail	Saidpur-Parbatipur
Length (km)	47	10	41	24	37	15
No of lanes	2 lanes	2 lanes	2 lanes	2 lanes	2 lanes	2 lanes
Pavement width						
Current	5.5 m traffic lane	5.5 m traffic lane	3.65 m traffic lane	5.5 m traffic lane	3.65 m traffic lane	3.65 m-5.5 m traffic lane
Design	5.5 m traffic	5.5 m traffic	3.65 m traffic	5.5 m traffic	3.65 m traffic	5.5 m traffic lane

	lane	lane	lane	lane	lane	
Shoulder width						
Current	1.81 m each, no pavement	1.22 m each, no pavement	1.28 m each, no pavement	1.48 m each, no pavement	1.72 m each, no pavement	1.9 m each, no pavement
Design	3.35 m each, 1.5 m paved	2.95 m each, 2.0 m paved	2.45 m each, 1.5 m paved	2.45 m each, 1.5 m paved	2.45 m each, 1.5 m paved	2.45 m each, 1.5 m paved
Improvement Type: all reconstruction						
Pavement (typical)						
Bituminous Surface Dressing (mm)			15-20		15-20	
Asphalt Concrete (mm)	125	100		125		125
Aggregate Base (mm)	275	250	225	250	225	250
Aggregate Subbase (mm)	275	250	250	250	250	200
Improved Subgrade(mm)	300	300	300	200	250	200
Construction Cost ($ million)	31.9	4	13.5	11	11.1	8.1

Source: ADB. 2002. *Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People's Republic of Bangladesh for the Road Network Improvement and Maintenance Project*. Manila.

D. Loan 2021: Road Maintenance and Development II Project

8. The project aimed at helping the Government achieve poverty reduction through economic growth by improving transport efficiency and strengthening integrated road networks. Intended outputs included: (i) reconstruction of 15 km regional road in Nandail-Kishoreganj, (ii) reconstruction of 45.4 km district road in the Bhaluka-Kishoreganj road, and (iii) reconstruction of 44.0 km district road in the Parbatipur-Madyapara improving 57.0 km national road in Panchaghar-Banglabandh, 52.6 km district road in the Boda-Nilphamari, 26.2 km of national roads in Chittagong-Dohazari, and 3.2 km of national roads in Kaliakoir Bypass.

9. The roads sections to be improved were constructed with sand seal surfacing or thin bituminous carpeting over brick macadam base, which have deteriorated and did not satisfy international standards in alignment, cross section, and pavement structure. The suggested improvements were full reconstruction following the current alignment but including widening and correcting substandard curves, and construction of bypasses to avoid densely inhabited market places.

Table 3: Details of Preliminary Design of Roads

Item	Mymensingh Region			Rangpur Region			Chittagong
	Bhaluka-Kishoreganj	Nandail-Kishoreganj	Kaliakoir Bypass	Panghagarh-Bangladandh	Parbatipur-Madhyapara	Boda-Nilphamari	Chittagong-Dohazari
Length (km)	45.4	15	3.2	57	44	52.6	26.2
Number of Lanes	2 lanes	2 lanes	2 lanes	2 lanes	2 lanes	2 lanes	2 lanes
Pavement width							
Current	3.5-5.5 m traffic lane	5.5 m traffic lane		3.2-7.3 m traffic lane	5.5 m traffic lane	3.2-5.5 m traffic lane	5.5 -7.3 m traffic lane
Design	5.5 m traffic lane	5.5 m traffic lane	7.3 m traffic lane	7.3 m traffic lane	5.5 m traffic lane	5.5 m traffic lane	7.3 m traffic lane
Shoulder width							
Current	1.27 m	1.805 m		1.28 - 2.75 m	1.5 m each,	1.295 -	1.25 -2.45

	each, no pavement	each, no pavement		each	no pavement	1.38 m each, no pavement	m each
Design	3.35 m each, 1.5 m paved	3.35 m each, 1.5 m paved	2.45 m each, 1.5 paved	2.75 m each, 1.5 m paved	2.45 m each, 1.5 m paved	2.45 m each, 1.5 m paved	2.45 m each, 1.5 m paved
Improvement Type	Reconstruction		New Construction	Reconstruction			
Pavement (typical)							
Asphalt Concrete (mm)	100	100	120	100	125	100	120
Aggregate Base (mm)	275	275	330	250	250	250	330
Aggregate Subbase (mm)	275	275	225	300	250	200	225
Improved Subgrade (mm)	300	300	300	500	200	200	300
Construction Cost ($ million)	34.1	8.2	6.9	12.9	22.1	23.5	14.2

Source: ADB. 2003. *Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the People's Republic of Bangladesh for the Road Maintenance and Improvement II Project*. Manila

E. Overall Standards

10. The road sections to be improved were traditionally constructed with sand seal surfacing or thin bituminous carpeting over brick macadam base, which deteriorated and did not satisfy international standards in alignment, cross section, and pavement structure. The suggested improvements are full reconstruction following the current alignment, but including widening and correcting substandard curves.

11. Bridges and drainage structures were designed in accordance with acceptable international standards. AASHTO HS2O loading (equivalent to a trailer truck of 36 tons) was adopted and the return period of 20 years was considered for drainage structures.

12. Cross sections were developed from traffic projections for motorized and nonmotorized traffic, and the terrain. The cross section consisted of motorized traffic lanes of 3.65 m, for district roads, with two surfaced shoulders of 1.5 m. A feature that added to the overall cost but was considered necessary for safety and traffic flow efficiency is surfaced shoulders along the length of each project road. The shoulders were to provide space for nonmotorized and slow motorized traffic as well as space for vehicle repairs, tire replacement, or mechanical breakdown, without disturbing traffic flow or posing high traffic safety risks.

13. The pavements were designed in accordance with accepted international standards and procedures for a 20-year life, with provision for overlays during or at the end of 10 years to cover the serviceability loss and extend the life to 20 years while maintaining international roughness index at the recommended level. The designs was based on traffic counts and traffic projections (for capacity), and axle-load surveys and projections (for structural capacity). The pavement structure consisted typically of an improved subgrade, a granular subbase of brick aggregate, a base of stone aggregate, asphaltic concrete surfacing (base course and wearing course), or double bituminous surface dressing. Roughness values for the completed pavements, expressed in international roughness index terms, should be 2.0–2.5.

Information contained in Household Income and Expenditure Surveys and Community Report

I. Household Income and Expenditure Surveys

- Total sample household
- total household (million),
- Average household size (in million)
- no of household by no of earner (in million)
- Housing structure (head of households) roof material (%)
- Housing structure (head of households) wall material (%)
- Source of drinking water (%), electricity (%)
- Toilet facilities (%)
- Mai occupation (%)
- School enrollment (lower poverty line)
- Type of school attended
- Income accruing to: (taka per household per month), Income (taka per month)
- Expenditure (taka per month)
- Share of food on expenditure
- Food intake (gram per capita per day)
- Incidence of poverty
- Incidence of poverty and literacy of head of household
- Poverty incidence and sex of head of household
- Poverty incidence and age of head of household
- Percent of household receiving benefit from Social Safety Nets Programme
- Percent of household reporting migration
- Average amount of loan taken per HH
- Percent of household who faced any kind of crisis
- Percent of disabled person
- Disability: Intensity of difficulty (%)

II. Community Report

- Area, Households, Population, Density by Residence and Community
- Distribution of Households and Population by Sex, Sex Ratio, Residence and Community
- Percentage Distribution of General Households by Size, Average Size, Residence and Community
- Percentage Distribution of Population by Age Groups, Residence and Community
- Percentage Distribution of Population aged 10 years and above by Sex, Marital Status, Residence and Community
- Distribution of Population aged 7 years and above by Literacy, Sex, Residence and Community
- Distribution of Population aged 3-14 years by Age Groups, School Attendance, Sex, Residence and Community
- Distribution of Population aged 15-29 years by Age Groups, School attendance, Sex, Residence and Community

- Percentage Distribution of Population by Type of Disability, Residence and Community
- Distribution of Population aged 7 years and above not attending School by Employment Status, Sex, Residence and Community
- Distribution of Population aged 7 years and above not attending school but Employed by Field of Activity, Sex, Residence and Community
- Distribution of Ethnic Households, Population by Sex, Residence and Community
- Distribution of Population by Religion, Residence and Community
- Percentage Distribution of General Households by Type of Structure, Toilet Facility, Residence and Community
- Distribution of General Households by Source of Drinking Water, Electricity Connection and Housing Tenancy Status, by Residence and Community

Econometric Analyses

1. The study will evaluate ex-post impacts of the projects by estimating their impacts on poverty using econometric techniques. To overcome methodological constraints and data limitations in estimation, the study will employ various econometric approaches: a double differenced reduced-form equation and propensity score-matched double difference comparisons. These two approaches, which efficiently controlled for biases arising from time-invariant unobservable community characteristics, are considered to be appropriate to be used for this study. A reduced form equation model allows complex interactions among various factors affecting the role of road in income, productivity, and poverty. A propensity score-matched difference-in-difference method helps overcome problems with non-randomization. The use of different tools will ensure effective cross-checking and validation through triangulation of findings for study robustness.

1. Estimation of Reduced-form Equation of Household Income[1]

(i) Model

2. A model is designed to allow the outcomes to be influenced by agroclimatic and other community endowments as well as agricultural opportunities of a village/community. Observed and unobserved characteristics affect input and output markets, public investments in infrastructure such as roads, and government pricing, interest, and public spending decisions.

3. Household outcomes are assumed to be influenced by input and output markets, infrastructure, and government policy. Likewise, infrastructural investments also affect these input and output markets. Government policymaking in credit and other markets (for crops such as paddy, for example) can also influence household outcomes directly and indirectly via the input and output markets as well as infrastructural investments. A semi-logarithmic reduced-form income equation, conditional on road investment, can be written as:

$$\ln Y_{ijt} = \alpha H_{ijt} + \beta V_{jt} + \gamma R_{jt} + \mu_j + \eta_i + \varepsilon_{ijt}^{\ y} \qquad (1)$$

where *i* denotes i^{th} household, *j* denotes j^{th} village. *Yijt* is a per capita income of i^{th} household in j^{th} village at time *t*, *H* is a set of observed household characteristics, *R* is an indicator of road projects, *V* represents observed non-road village-level characteristics, μ is unobserved village-specific heterogeneity, η represents unobserved household characteristics, and ε is a vector of idiosyncratic errors distributed across households. Similar equations can be written for other outcomes such as prices (*P*) and institutional infrastructure (*I*) that are influenced by road improvement.

4. Since income is also a function of input and output prices (*P*) as well as institutional infrastructure (*I*), road investment has a direct effect on household consumption as well as an indirect effect through prices and institutions. Thus, the total effect of road investment can be decomposed as:

$$\ln Y_{ij} / \ln R_j = \ln Y_{ij} / R_j + (\ln Y_{ijk} / P_{jk})(\ln P_{jk} / R_j) + (\ln Y_{ijk} / I_{jl})(\ln I_{jl} / R_j)$$

[1] Khandker, Bakht, and Koolwal (2005) estimated impacts of rural road projects financed by the World Bank in Bangladesh on rural household income and other rural household outcomes. This study will follow their work.

where dY/dR is a total derivative of an effect of road on outcomes, $\partial Y/\partial R$ is a partial effect of road, $\partial P/\partial R$ is a partial effect of road on price and similar intervening factors, and $\partial I/\partial R$ is a partial effect of road on institutional factors.[2]

5. Assuming unobserved community characteristics are time-invariant, a panel regression with fixed community effects can control for such heterogeneity. To allow before-and-after comparison of outcomes, let t=1 if the road program is in effect, and t=0 otherwise.[3] To control for household-level unobserved heterogeneity, which cannot be removed by village-level fixed effects due to quasi experimental approach, a household-level panel with household fixed effects is introduced in equation (a). This will allow difference-in-difference comparison before and after between project and comparison groups.

6. Taking the difference over the two-year period of study, one would obtain the following difference equation, where the sources of endogeneity (i.e. the unobserved village and household characteristics, and assuming that these characteristics do not change over time) are dropped out. In this case, the simple OLS can be applied to the following differenced equation to estimate unbiased effect of road development

$$Y_{ij} = \alpha \quad H_{ij} + \beta \quad V_j + \gamma \quad R_j + \quad \varepsilon_{ij} \qquad (2)$$

(ii) Selection of Study Villages and Data

7. The outcomes of interest include variables such as per capita expenditure, household transport expenses,[4] fertilizer price, male agricultural wage, agricultural output and price indices, labor supply (by gender), and schooling (by gender). Explanatory variables may include: road project (binary), household head's gender (binary), household head's age, household head's education years, maximum schooling years of adult in household (each for male and female), village having electricity (binary), number of grocery and fertilizer shops in district, percentage of irrigated village land, and household land owning (in acres).

8. In both project and control road areas, one roadside village was selected for each road project. The selected roadside villages indicate the immediate influence areas of road intervention. In addition, one remote village was selected for each of the sample roads to assess the decay effects of road development. The remote villages were similar to the roadside villages and were chosen such that they were at least 2 kilometers away from the study or any other paved road. About 50 households were selected from each study village using a stratified random sampling procedure. Both surveys collected a variety of information on general household characteristics, education, healthcare treatment, wage and self-employment, credit activities, assets, income, consumption, marriage, and fertility. Additionally, information on community characteristics and transportation was also collected. The outcomes of interest include variables such as household transport expenses, fertilizer price, male agricultural wage, agricultural output and price indices, and household outcomes such as per capita expenditure, male and female labor supply, and boys' and girls' schooling.

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[2] Thus, changes are measured at i^{th} household in village j, for the k^{th} type of intervening price factors, and I^{th} type of institutional factors.

[3] Underlying assumption is that project villages (i.e. placement of road project) are selected randomly.

[4] Household transport costs that include costs incurred while going to such places as the market center, school, and nearest health facility.

9. Road improvement will affect households through three mechanisms: (i) transportation costs as well as input and output prices; (ii) labor supply, as well as farm and non-farm production; and (iii) household outcomes such as earnings, consumption, and schooling.

10. Household transport costs will include costs only incurred while going to such places as the market center, school, and nearest health facility. For input and output prices — such as fertilizer (urea) price, daily agricultural wage for men, as well as agricultural output and price indices, we will use the Laspeyres quantity and price indices for agricultural production [Computational procedures are in Kandkher et.al (2005)].

11. The agricultural commodities entering the indices will include potato, wheat, as well as high-yielding variety (HYV) Boro paddy, HYV Aman, and local and HYV Aus. Since the study will cover only a base and a follow-up year, the base year indices for both aggregate price and output indices will be equal to one. All values will be measured in real terms, adjusted by the consumer price index of the base year of each survey.

12. Finally, we consider household and individual outcomes such as annual total per capita expenditure, male and female labor supply, and boys' and girls' schooling. Labor supply is measured as the total number of hours in the last month worked by all men and women in household, and schooling is the percentage of school-aged boys and girls (5-17 years of age) who attended school in the year of the survey. The estimates are done separately for each project.

(iii) Returns to Road Improvement

13. Using equation (2), a difference-indifference equation for the two project (T) and control (*C*) villages can be written as follow:

$$[\ Y_{ij}^{T} - Y_{ij}^{C}\ ] = \alpha\ [\ H_{ij}^{T} - H_{ij}^{C}\ ] + \beta\ [\ V_{ij}^{T} - V_{ij}^{C}\ ] + \gamma \qquad (3)$$

The road impact is to be captured by a coefficient, γ, in equation (3). Since in the case of quasi experiment survey design, the expected values of the first two bracketed terms on the right-hand-side will lead to a bias, the differences between the time-varying observed variables (*H* and *V)* need to be controlled for in regression.

14. The equation with household fixed-effects is in semi-logarithmic form for all outcome variables except for schooling, which is measured by a percentage of school-aged children in school for each household. The intervening policy variable is a road investment indicator (1 if road project villages in year 1, and 0 otherwise).

15. Project villages include both roadside and off-road villages, while control villages include both nearby and remote villages from the road. Thus, the coefficient γ will measure a proportionate change in the outcome (e.g., household per capita consumption) from a road improvement. The effect of a road project can be expressed by differentiating (2) with respect to *R*, where *R=1* for project villages and γ can be estimated from equation (2):

$$(1/Y_{ijt})\ \partial\ \Delta Y_{ijt} / \partial\ \Delta R_{jt} = \gamma$$

2. Scoring Matched Difference-in-Difference[5]

16. While the above method is expected to demonstrate insightful internal influencing mechanisms, it may also face criticisms on the quasi-experimental approach to select control villages. Thus, the study will stretch its methodology out to employing a propensity scoring matched difference-in-difference comparisons.

17. Outcome measure I_{it} for a project in i^{th} village at date t is defined as:

$$I_{it} = I_{it}^* + G_{it}^I D_i \qquad (1)$$

where I_{it}^* is the outcome for a village if the project is not implemented, and G_{it}^I is the gain to village i from an outcome attributable to a project. Then the estimate of the average impact of the project on a treatment village (dummy variable $D_i=1$) can be decomposed as:

$$E(I_{it} \mid D_i=1) - E(I_{it} \mid D_i=0) \equiv E(I_{it}^* \mid D_i=1) + E(G_{i1}^I \mid D_i=1) - E(I_{it}^* \mid D_i=0) \quad (2)$$

From equation (2) the estimation bias amounts to

$$E(I_{it}^* \mid D_i=1) - E(I_{it}^* \mid D_i=0) \qquad (3)$$

The cross-sectional propensity score method assumes that conditional on a set of observed characteristics X,[6]

$$E(I_{it}^* \mid D_i=1, X) = E(I_{it}^* \mid D_i=0, X)$$

18. Thus, the cross-sectional propensity score method produces an unbiased estimate of the project effect if project placement is based purely on a village's observed characteristics. However, some unobserved characteristics of the village that are correlated with project outcomes might also be correlated with project placement. This correlation can introduce bias in the estimation of project impact.[7]

19. If the pre-intervention differences between treatment and control villages are assumed to be the result of time-invariant unobserved factors, the difference-in-difference method can be used to correct for possible bias. The pre-project difference in outcomes may be subtracted from the post-project differences for the same villages.

20. The underlying assumption in this method is that the time trend in the control group is an adequate proxy for the time trend that would have occurred in the treatment group in the absence of an intervention, or

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[5] Impact evaluation of projects, especially those which targeted specific communities and areas, requires particular attention to evaluation techniques and good quality data. Lokshin and Yemtsov (2005) evaluated economic benefits of road interventions using a propensity score–matched double difference method. This paper will follow their approach for estimation of road impacts [Lokshin Michael and Ruslan Yemtsov. 2005. *The World Bank Economic Review*, vol 19, no. 2, pp. 311-333].

[6] An estimation bias, $E(I_{it}^* \mid D_i=1) - E(I_{it}^* \mid D_i=0)$, will be no bias in a simple comparison of the means between treatment and control villages if the terms of equation 3 are equal.

[7] For example, an active parent group might lobby the village authorities to pursue a school rehabilitation project. This same group of active parents might then become involved in the education process and positively affect school outcomes for their children. If the evaluation does not take into account the differences in parental activity between treatment and control villages, the effectiveness of the school project will be overestimated.

$$E\ (I_{i1}^{*} - I_{i0}^{*} \mid D_i = 1,\ X) = E\ (I_{i1}^{*} - I_{i0}^{*} \mid D_i = 0,\ X) \qquad (3\text{-i})$$

The mean difference in difference for the outcome is estimated by taking the expectation of equation 1 over all N sample villages using equation (3-i):

$$E\ [(I_{i1} - I_{i1}^{*}) - (I_{i0} - I_{i0}^{*}) \mid D_i = 1\ ] = E\ [G_{i1}^{I} \mid D_i = 1\ ] \qquad (4)$$

If the outcomes in period 0 are not correlated with project placement, equation (6) estimates the mean changes in outcomes for the treatment villages.

21. A matched difference-in-difference method will be used, which combines propensity score–matching and difference-in-difference methods. The propensity score measures the probability that a project is implemented in a village as a function of that village's observed pre-intervention characteristics. Villages with projects (the treatment group) are matched with villages without projects (the control group) on the basis of the propensity score. This matching will remove the selection bias due to the observed differences between treatment and control villages. Then the difference-in difference method will be applied to correct for possible bias due to the differences in time-invariant unobserved characteristics between the two groups. To evaluate the impact of the project, the changes in outcome measures are compared between matched villages from the treatment and control groups.

22. Outcome Indicators of interest include:

- Household-level indicators: time for ambulance to arrive, sales of agricultural products, female nonfarm employment, nonagricultural employment, household transport expenditures per capita.
- Village-level indicators: time to district capital, barter trade, small enterprises, subjective assessment of road condition (bad), commercialization, road transport services (jetty operators), railroad and/or main highway, proportion of household with piped water, built with wooden (dirt) walls (floors), and experienced disaster (flood).

23. **Control Groups** will be established using the following information, but not limited to: School project, road project, water project, total population, if internally displaced person in the village, agriculture only, experienced disaster, experienced flood, Mountainous (hilly) area, distance to district center, distance to market, rail road, main highway (primary road), paved road, number of schools, number of large enterprises, Small enterprise, police station, post office, shops, restaurant, proportion of households with a phone, proportion of households with a toilet, unreliable electric power supply, proportion of households with piped water, proportion of buildings with wooden walls, proportion of buildings with dirt floors, trade by the roadside.