BENEFICIARY SURVEY—RURAL ROADS SECTOR II INVESTMENT PROGRAM (PROJECT 4) IN THE STATE OF ASSAM—DIFFERENCE IN DIFFERENCES

A. Background

1. The Prime Minister's Rural Roads Program—*Pradhan Mantri Gram Sadak Yojana* (PMGSY)—was launched in December 2000 to improve accessibility in rural areas by providing all-weather roads to every rural habitation in India with a minimum population of 500 in the plains and 250 in hill states, tribal districts, and desert areas. The Ministry of Rural Development was the designated lead ministry for the implementation of PMGSY and the National Rural Roads Development Agency, an organ of the ministry, provided technical support. The Asian Development Bank (ADB) supported a portion of the PMGSY.

2. The PMGSY envisages the strengthening of existing but dilapidated road surfaces, or stabilizing and upgrading unpaved surfaces and cart tracks, with a granular sub-base and a water-bound-macadam base course finished with a suitable, frequently bituminous, surface course.[1] Appropriately designed cross drainage works including pipe culverts and box culverts, are incorporated within the design to ensure unimpeded flow of watercourses running across the alignment of the road. Road furniture, including signboards providing technical specifications and details of the contracts awarded, cautionary signs, and kilometer stones, are to be installed.

3. The comprehensive impact of road networks may not be captured by traditional measures such as cost–benefit analyses or through the internal rate of return, since returns on rural road investments are more social, derivative, and distributed over time and space. Moreover, educational attainment and income and expenditure patterns are dynamic and evolve over the life cycle of the residents. Rural roads in developing countries are also known to impact men and women commuters differently.[2] Other exogenous variables such as nearer consumer credit, better schools and hospitals, and improved and cost-effective warehousing facilities, may influence outcomes that can be mistakenly attributed to the roads themselves. Benefits delivered by rural roads tend to be systematically underestimated by standalone spot-assessments and overestimated in the absence of a credible benchmark or a robust counter-factual baseline.

4. This report reviews the socioeconomic benefits delivered by PMGSY roads built in the north-eastern Indian state of Assam.

B. Collaboration with a Local University

5. To implement the socioeconomic impact survey, the survey team needed to understand the local culture and systems. The Independent Evaluation Department (IED) established collaboration mechanism with Gauhati University because the survey required local knowledge and advice to (i) design a questionnaire format and a survey implementation plan, (ii) select road sections and control groups, and (iii) communicate with local people in their own language.

[1] Roads funded by PMGSY are built in accordance with technical specifications laid down by the Indian Roads Congress.

[2] S.R. Khandker, Z. Bakht, B.K. Koolwal. 2006. The Poverty Impact of Rural Roads: Evidence from Bangladesh. *World Bank Policy Research Working Paper.* No. 3875, pp. 1 – 34.

6. The collaboration included not only implementation of the assessment but also knowledge sharing:

(i) Socioeconomic impact assessment
   (a) Enumeration and analysis of the questionnaire. The university faculty and nine students validated the survey instruments, undertook a field survey of about 400 respondents, analyzed responses, and submitted a written report in English.
   (b) Focus group discussions. The university faculty moderated 10 focus group discussions, analyzed discussions, and submitted a written report in English.

(ii) Knowledge sharing on the evaluation
   (a) The university and IED exchanged knowledge on the evaluation, and presented the results of the socioeconomic impact assessment at evaluation workshops and seminars.
   (b) The university and IED replicated the acquired skills and knowledge in other evaluation studies.

C. Methodology

7. A socioeconomic survey using a structured questionnaire was carried out to estimate the benefits delivered by rural roads built between 2009 and 2013 and specifically roads covered by the Rural Roads Sector II Investment Program Subproject 4.[3] Project villages (beneficiaries) were selected and villages excluded from the project roads were also selected as control groups. A before-and-after comparison of welfare outcomes between project and control villages was undertaken. Data relating to conditions prevailing prior to road construction were drawn from respondents' memories and from published sources. This comparison of welfare outcomes between project and control villages forms the basis of the "difference-in-difference" estimate. The incremental impact of the PMGSY road infrastructure was to be evaluated in terms of the difference between relevant outcomes for the two sets of habitations across the two points in time.

8. The evolution in perceived welfare over the period 2009–2016 among residents of project villages, estimated from survey responses is difference–a. The evolution in perceived welfare among the control villages over the same time period is difference–b. The difference between "difference-a" and "difference-b" provides the estimate of the incremental benefits delivered by the project road. For instance, in Assam, a mobile hospital visiting a village once over an average time-span of 3 months is "not a long-term solution, but it's better than no health care at all."[4] It is assumed that both project and control settlements faced similar constraints relating to health care and physical access in 2008. Access to the mobile hospital, infrequent as the visits might be, facilitated by the project road, could serve to improve health outcomes among project village residents (while leaving residents of control habitations untouched) and may eventually lead to a statistically significant difference in economic standing between the two groups of villages.

9. The beneficiary survey was designed to adopt a participatory approach, with a total of about 400 respondent residents, split in approximately equal numbers into beneficiaries and nonbeneficiaries. The quantitative data from the questionnaire survey was validated against subjective and more elaborate inputs received during structured focus group discussions. The road sections for the survey were selected based on (i) length, (ii) population, and (iii) economic activity. Responses to 230 questionnaires were completed within the 16 project-influenced villages identified for the survey. In addition, the survey team gathered responses to 189 questionnaires from the control areas. Against a target of 400 questionnaire responses from approximately 10 project and 10 control villages, as originally proposed, the survey gathered 419 questionnaire responses (net) from 16 project villages and 21 control areas.

---

[3] ADB. 2009. *Rural Roads Sector II Investment Program - Tranche 4.* Manila.
[4] N. Alcoba. 2009. Hitting the Road to Alleviate India's Rural Doctor Shortage. *Canadian Medical Association Journal (CMAJ).* 180:10. pp. E34 – 36.

10. The survey design had assumed that the control group respondents who would serve as a baseline proxy would be chosen from settlements that did not meet the PMGSY criteria for road connectivity. The survey compared the responses from control villages and project villages. It was observed that certain clusters within select project villages were isolated and removed from the project road by over 300 meters, providing a more proximate counter-factual case. In general, project village respondents were selected at random from residents living on the edge of the road itself (a road's zone of influence is defined as direct access to the road from the resident's doorstep), while control village respondents were to be identified from nearby settlements as well as from removed and relatively isolated clusters. The difference-in-difference is expected to eliminate outcomes that might have materialized independently of the intervention. Additionally, the interviews sought to gather data relating to the socioeconomic status prevailing in 2008 (drawn from respondents' memories), and to compare it with the present day, thereby eliminating the short-term effects from the intervention, such as temporary employment generated during construction.

11. The net impact of the road intervention is estimated as follows:

Step 1: The difference in values of the outcome variables after and before the intervention for the beneficiaries is computed. This gives the gross evolution in the variables correlated with beneficiary selection and the road infrastructure intervention.

Step 2: The difference in values of the outcome variables after and before the intervention for the nonbeneficiaries is computed. This gives the counter-factual scenario for the evolution in the underlying variables correlated with beneficiary selection and the intervention.

Step 3: The difference between the pre-intervention difference in outcomes and the post-intervention difference is computed, providing a reasonable estimate of the net impact of the intervention on the beneficiaries.

12. Focus group discussions were carried out. Participants in the discussions were residents with similar educational backgrounds and life experience, falling within broadly defined socioeconomic criteria and age groups. The discussions sought to explore subliminal messages, opinions, and experiences related to related roads.

13. A total of 10 focus group discussions, one each in the six districts of Baksa, Barpeta, Chirang, Kamrup (Rural), Sonitpur, and Udalguri and two each in Darrang and Kokrajhar districts were organized, to supplement the questionnaire survey and to gather qualitative information and perceptions relating to the roads themselves, and to the benefits delivered by the roads.

D. Site Selection

14. The project envisaged the construction of 916.77 kilometers (km) of rural roads broken into 274 road sections, spread across 11 districts as laid out in Table 1. By June 2014, the project had completed the construction of 914.27km.[5] Survey respondents were selected from eight districts hosting 260 road sections with a total length of 858.65 km.

[5] ADB. 2014. *Completion Report: Rural Roads Sector II Investment Program in India*. Manila.

Table 1: Distribution of Project Roads by District

District	Road Length (kilometer)	Share (%)
Baksa[a]	211.1	23.0
Barpeta[a]	134.5	14.7
Bongaigaon	12.5	1.4
Chirang[a]	83.4	9.1
Darrang[a]	118.8	13.0
Dhubri	43.5	4.7
Kamrup Rural[a]	53.8	5.9
Kokrajhar[a]	121.7	13.3
Nalbari	2.2	0.2
Sonitpur[a]	98.3	10.7
Udalguri[a]	37.0	4.0
Total	**916.8**	**100.0**

[a] Districts selected for the survey.
Source: Asian Development Bank Independent Evaluation Department.

15. The selection of the sample road sections was based on the following:

(i) **Road section length.** The minimum road section length of the project roads was 0.78 km and the maximum was 12.89 km. The average length was 3.303 km, and a standard deviation of 1.833 km. In all, 104 road sections were above the average length, and 156 below. Of the 260 road sections, 203 fell within one standard deviation on either side of the mean (1.47 km–5.14 km). The lower and upper bounds for the first short-list of project villages were respectively set at 1.0 km and 5.0 km, with the average length targeted to be as close as possible to the population average of 3.3 km.

(ii) **Project village population**. The average population of a project village based on the 2001 population was 1,427 persons, increasing to 1,624 in 2011,[6] growth of 13.8% over a 10-year period. Since 2001, the PGMSY has been using population as a screening criterion for road-eligibility by aiming to have a sample average comparable to the population average.

(iii) **Literacy rate**. The average literacy rate across the population of 260 project villages was 59.1%, with a range of 11.1%–85.1%, a standard deviation of 15.6%. The test sample was designed to include villages with varying levels of literacy, broadly defined as "low" (any value lower than mean minus 1-standard). Few other relevant socioeconomic details were available within the census datasets.

(iv) **Economic activity.** The principal economic activities within each project district were sericulture, horticulture including tea and vegetable cultivation, and mainstream agriculture including paddy farming, sugarcane cultivation, and poultry farming. Where village production data were available, attempts were made to identify villages that would truly represent the district concerned.

16. Initially, 26 road sections were selected (10% sample size based on total number of road sections) with the characteristics presented in Table 2. A second step selection was carried out to select 16 sample villages that were actively engaged in vegetable cultivation (Darrang), betel nut and *Eri* silk production (Baksa), silk weaving (Kamrup-Rural), tea, paddy and sugarcane cultivation (Sonitpur), bamboo, poultry, piggery and fishery (Barpeta), and tea cultivation (Udalguri). Annex 1 lists the 16 villages surveyed with relevant demographic and economic screening criteria.

[6] http://www.censusindia.gov.in/2011census/population_enumeration.html3.0

Table 2: Characteristics of Sample and All Project Roads

Item	All Project Roads	Sample Project Roads
Road length (kilometers)	3.3	3.0
Population (number of people)	1,427	1,477

Source: Asian Development Bank Independent Evaluation Department.

E. Survey Implementation

17. The survey team gathered responses to 189 questionnaires (net of incomplete entries) from among the control habitations and 230 questionnaires from project villages. As against a target of 400 questionnaire responses from approximately 10 project and 10 control villages, as originally proposed, the survey completed 419 questionnaire responses (net) from 16 project villages and 21 control areas.

F. Data and Analysis

18. Of the 230 project beneficiary respondents, 49 (21.3%) confirmed that they were consulted before and/or during project construction, Table 3.1). Of the 49 consulted, 31 (13.5% of the total) confirmed that they had conveyed their expectations from the new road. More than 51% of the respondents were not aware and close to 99% did not know who was responsible for conducting the consultation.

Table 3.1: Beneficiary Consultation

Item	Frequency	Proportion (%)
Before Construction	37	16.1
During Implementation	12	5.2
Not Consulted	62	27.0
Don't Know	119	51.7
Grand Total	**230**	**100.0**
Did you convey your needs?		
No	33	14.4
Yes	31	13.5
Don't Know	166	72.2
Grand Total	**230**	**100.0**
Consultation Method		
Don't Know	184	80.0
Meeting at Community	34	14.8
Meeting at Municipality Office	1	0.4
One-to-One Consultation	11	4.8
Grand Total	**230**	**100.0**
Facilitation of consultation		
Don't Know	227	98.7
One-to-One Consultation	1	0.4
Government Officers from this Town	2	0.9
Grand Total	**230**	**100.0**

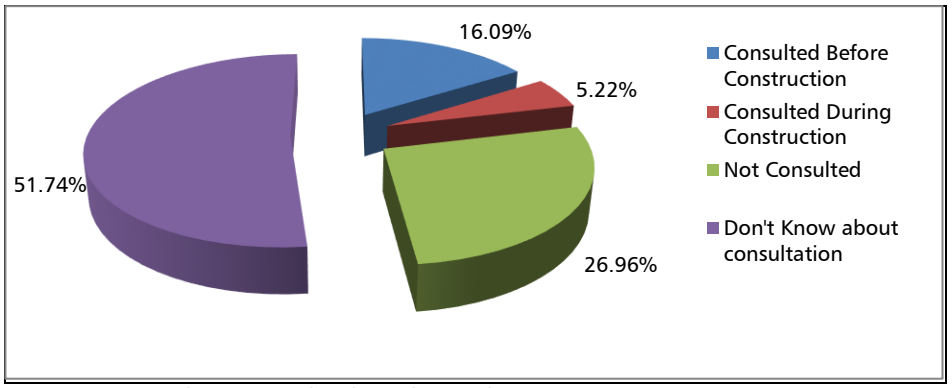
Asian Development Bank Independent Evaluation Department.

Table 3.2: Beneficiary Consultation, by Gender

Consultation Before and During Implementation	Gender		
	Female	Male	Total
Before [1]	6	31	37
During Implementation [2]	6	6	12
Don't Know [88]	40	79	119
No [0]	25	37	62
Total	**77**	**153**	**230**
Did You convey your needs?			
Yes [1]	7	24	31
No [0]	14	19	33
Don't Know [88]	56	110	166
Total	**77**	**153**	**230**
Consultation method			
Meeting at Community [1]	9	25	34
Meeting at Municipality office [2]	1		1
One-to-One Consultation [3]	2	9	11
Don't Know [88]	65	119	184
Total	**77**	**153**	**230**
Facilitation of Consultation			
Government Officers from this Town [2]		2	2
One-to-One consultation [3]		1	1
Don't Know [88]	77	150	227
Total	**77**	**153**	**230**
Did inputs reflect in design and/or implementation?			
Don't Know [88]	63	120	183
No [0]	6	19	25
Yes [1]	8	14	22
Total	**77**	**153**	**230**

Source: Asian Development Bank Independent Evaluation Department.

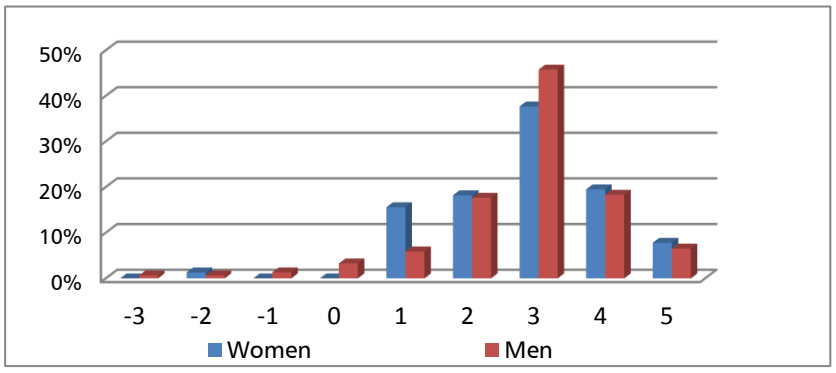
Figure 1: Consultation during Project Implementation



Source: Asian Development Bank Independent Evaluation Department.

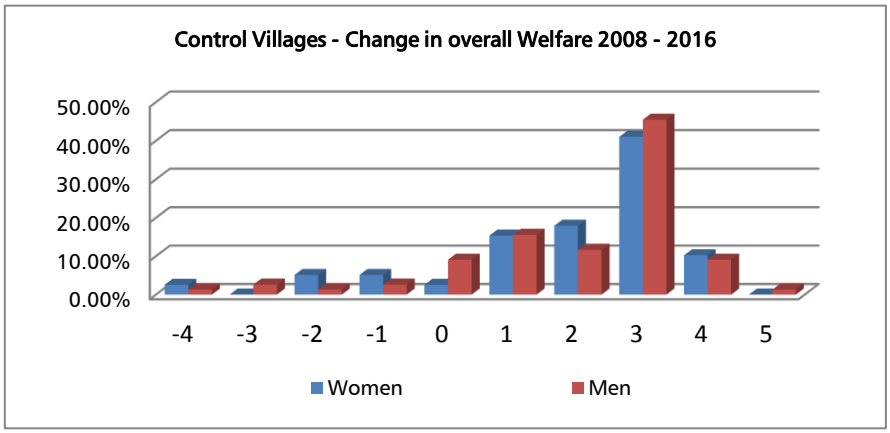
19. **Overall welfare.** More than 98% of female and more than 94% of male respondents confirmed that the project road had contributed positively to their wellbeing. Only 5 of the 230 project beneficiaries reported that their wellbeing had diminished subsequent to project construction, with over 98% confirming that the project road had contributed positively to their lives. For the control group, 11 of the 189 respondents (5.8%) reported a negative change in wellbeing.

Figure 2.1: Change in Welfare due to Project Road in Project Villages, by Gender



Source: Asian Development Bank Independent Evaluation Department.

Figure 2.2: Change in Welfare due to Project Road in Control Villages, by Gender



Source: Asian Development Bank Independent Evaluation Department.

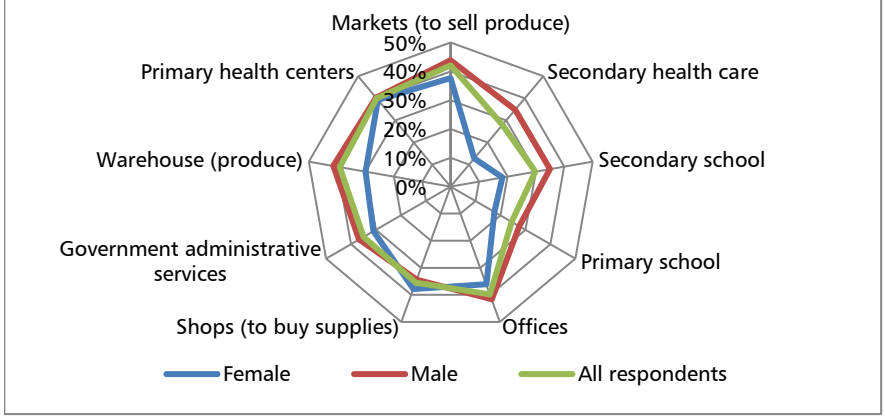
20. **Travel time saving**. Among project beneficiaries, 97% of the women and 95% of men interviewed reported that access to education had improved. Of 195 respondents, 77 (39.5%) respondents reported no change in time taken to reach the school; 54 (27.7%) respondents reported a reduction of 13% (2 minutes) to 46.7% (7 minutes); and 64 (32.8%) respondents reported lowering of travel times between 50% (up to 30 minutes) to 85.7% (5 minutes after road construction, compared with 35 minutes previously). The results are presented in Table 4. Similar perceptions relating to the access to various facilities expressed by residents of project villages, and the estimated reduction in travel times, are represented in Figure 3.

Table 4: Change in Travel Time to Various Facilities, by Gender (%)

Decrease in Time taken	Female	Male	All Respondents
Markets (to sell produce)	38	44	42
Secondary Health Care	13	35	28
Secondary School	18	35	30
Primary School	18	27	24
Offices	36	42	40
Shops (to buy supplies)	38	34	35
Government Administrative Services	31	37	35
Warehouse (produce)	30	41	39
Primary Health Centers	39	40	40

Source: Asian Development Bank Independent Evaluation Department.

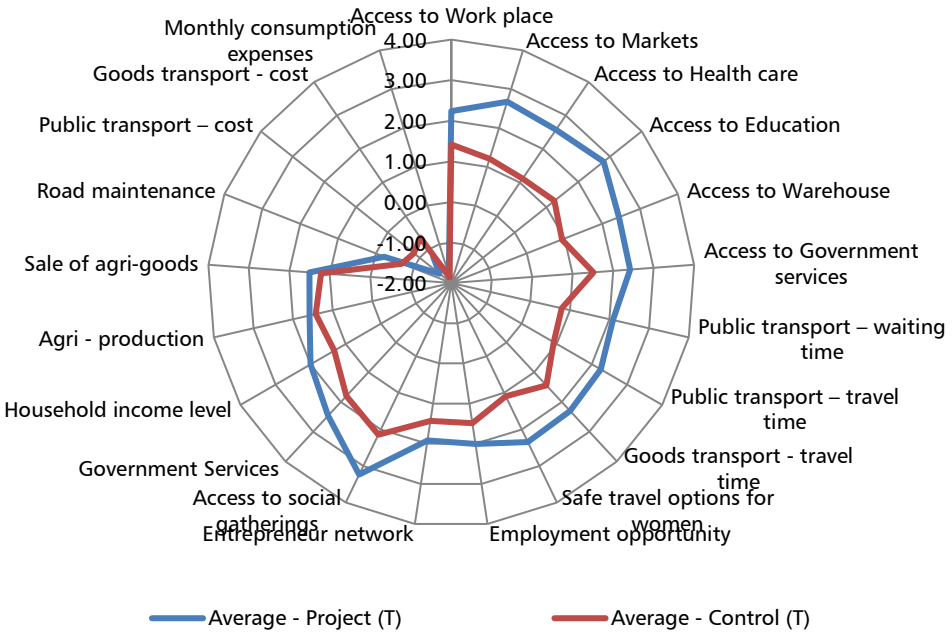
Figure 3: Change in Time Taken to Access Various Facilities



Source: Asian Development Bank Independent Evaluation Department.

21. Project roads have enhanced access to markets, education, and government services and have contributed to the provision of safe travel options for women. They also have enhanced opportunities for employment and for entrepreneurs to network better; the benefits accruing across the eight districts (consolidated) and the benefits disaggregated by district are depicted in figures 4, 5, and 6. In doing so, project roads appear to have had little influence on enhancing agricultural output or on selling agricultural produce. Control group residents also report positive changes in access to services and facilities and to economic opportunity, although these are not comparable in magnitude to the benefits that were delivered to project-influenced villages.

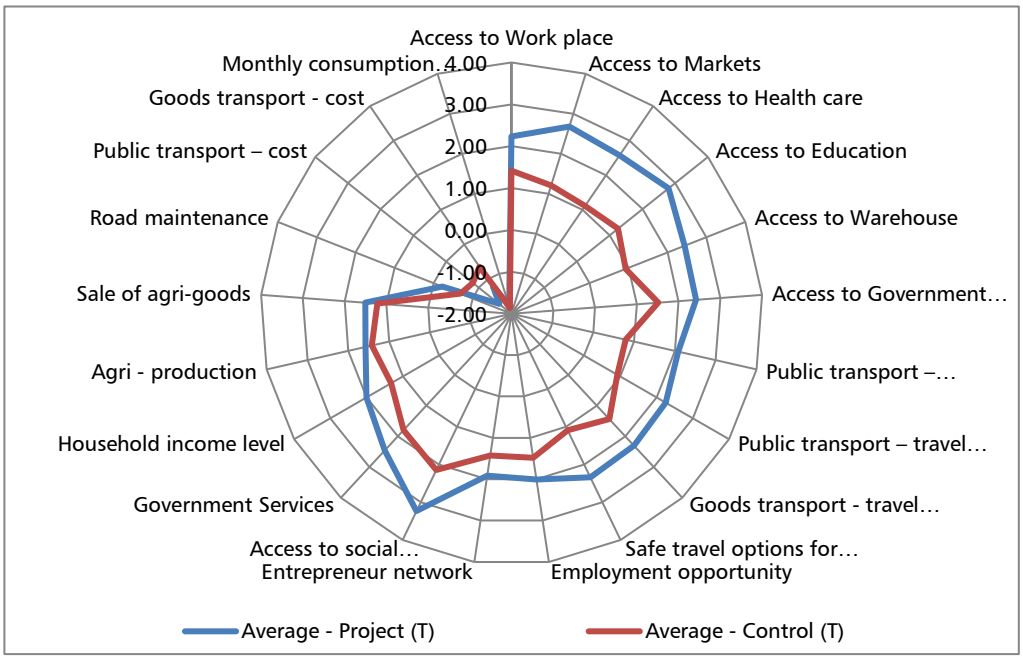
Figure 4: Benefits from Road Project: Beneficiaries and Control Group



Source: Asian Development Bank Independent Evaluation Department.

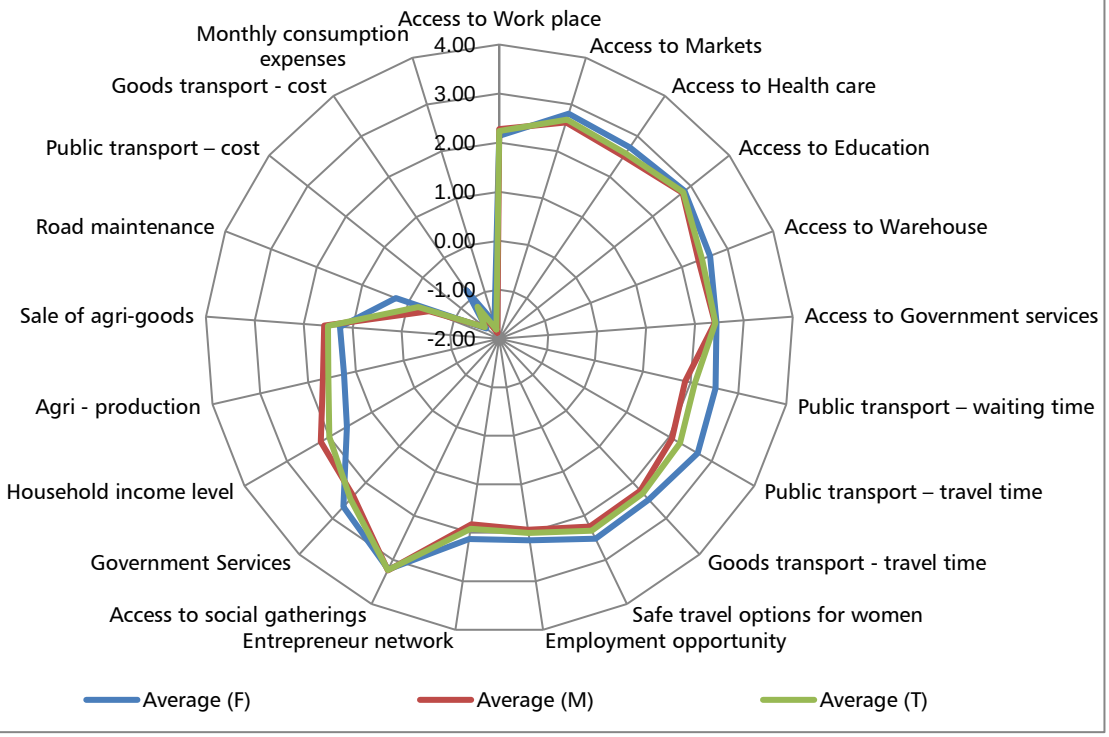
22. Project roads have enhanced access to markets, education, government services and other facilities, and have contributed to the provision of safe travel options for women. As shown in Figure 5, project roads have also enhanced opportunities for employment and networking. Project roads appear to have had little influence on enhancing agricultural output or on selling such produce.

Figure 5.1: Comparison of Benefits between Project and Control Villages All Respondents, by Gender



Source: Independent Evaluation Mission.

Figure 5.2: Benefits from Project Roads, Eight Districts of Assam

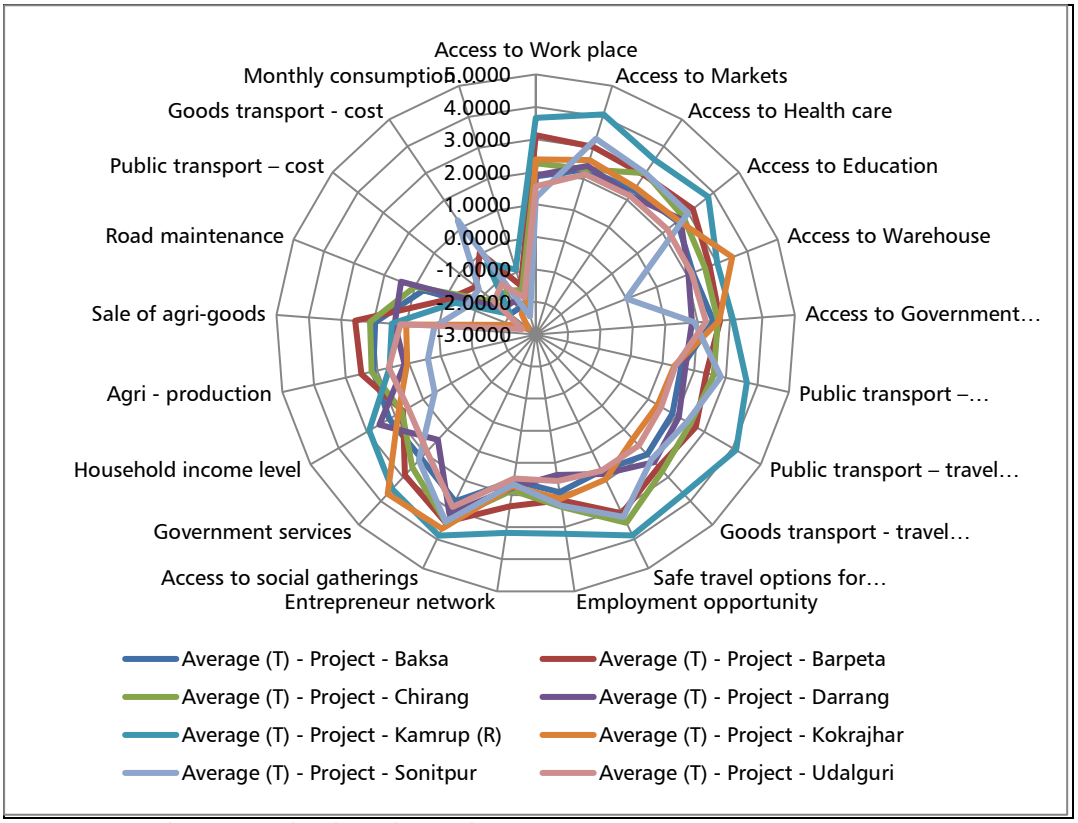


Source: Asian Development Bank Independent Evaluation Department.

23. The project roads had improved access to various destinations by improving the quality of the transport made available to residents, they had facilitated social convergence, and they had supported higher education and encouraged economic activity. Respondents had previously used bicycles or had travelled on foot.

24. Of the 230 respondents drawn from project–influenced villages, 59% (69% for the control group) believed that there had been no change in the availability or price of agricultural land, while over 13% (8% for the control group) believed that prices had risen in tandem with project implementation, and with the opening up of additional lands for cultivation.

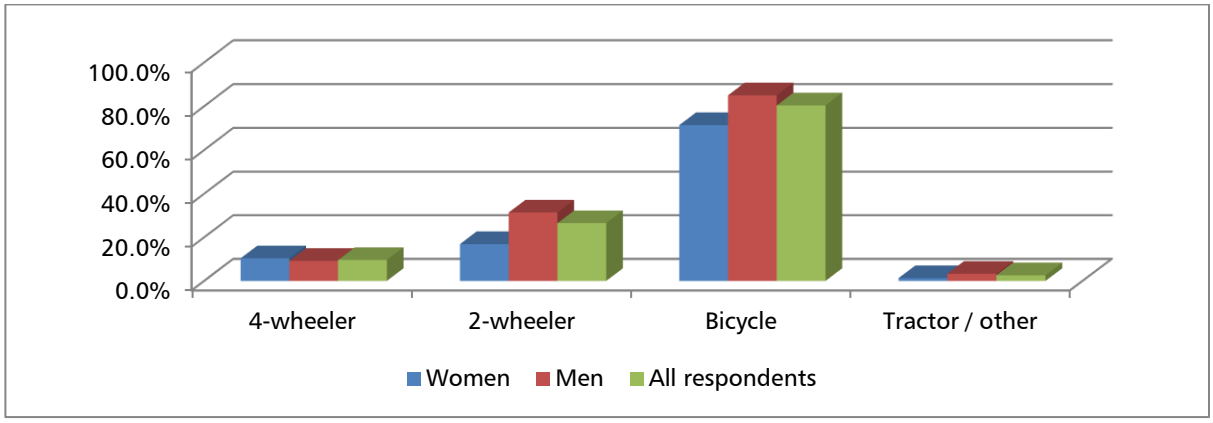
Figure 6: Benefits of Project Roads to Project Villages



Source: Asian Development Bank Independent Evaluation Department.

25. Among the 230 project village respondents from the project villages, 9.6% confirmed the purchase of a four-wheeler, in most cases a passenger car, while 26.50% confirmed the purchase of a two-wheeler. Of all the persons surveyed, 85% of men surveyed and 80.40% of all persons surveyed confirmed the purchase of a bicycle motivated by road construction (Figure 7).

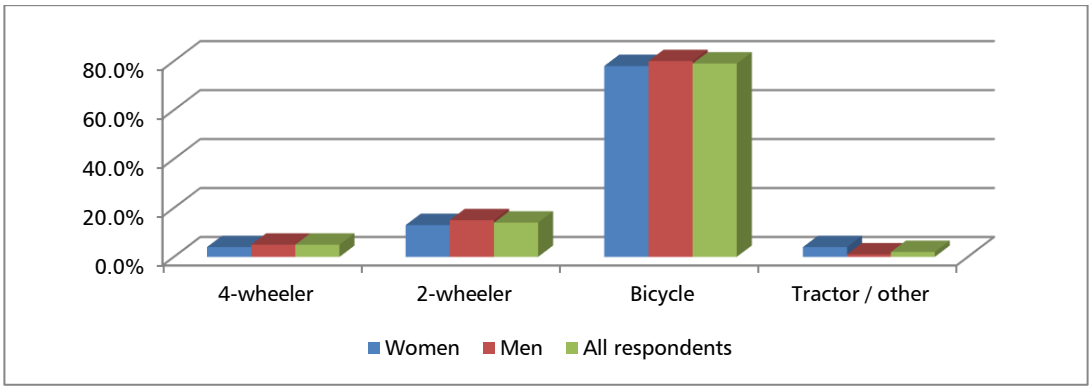
Figure 7: Purchase of Transport Assets Among Project Village Respondents, by Gender



Source: Asian Development Bank Independent Evaluation Department.

26. Among the 189 respondents from the control villages, 5.0% confirmed the purchase of a four-wheeler (a passenger car), while 14% confirmed the purchase of a two-wheeler. Of the men surveyed, 80% confirmed the purchase of a bicycle in recent years, while for all persons surveyed it was 79% (Figure 8).

Figure 8: Purchase of Transport Assets Among Control Village Respondents by Gender



Source: Asian Development Bank Independent Evaluation Department.

Table 5.1: Purchase of Transport Assets by Project Village Respondents by Gender (%)

Asset	Female	Male	All Respondents
Four-Wheeler	10	9	10
Two-Wheeler	17	31	26
Bicycle	71	85	80
Tractor and/or other	1	3	3

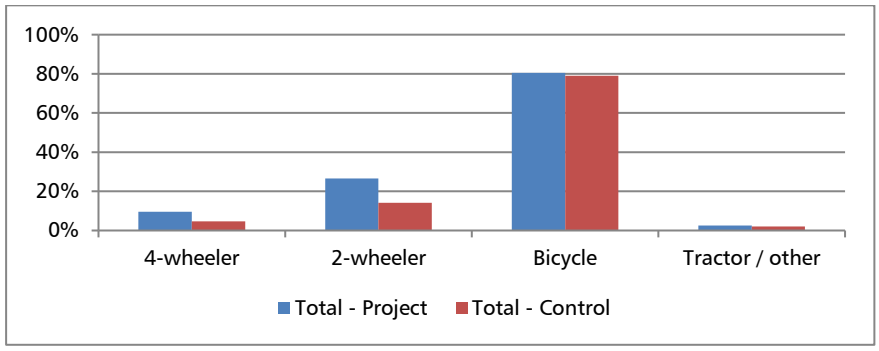
Source: Asian Development Bank Independent Evaluation Department.

Table 5.2: Purchase of Transport Assets by Control Village Respondents by Gender (%)

Asset	Female	Male	All Respondents
Four-Wheeler	4	5	5
Two-Wheeler	13	15	14
Bicycle	78	80	79
Tractor and/or Other	4	1	2

Source: Asian Development Bank Independent Evaluation Department.

Figure 9: Purchase of Transport Assets, Project and Control Villages



Source: Asian Development Bank Independent Evaluation Department.

27. Project roads had motivated the purchase of motorized two-wheelers and four-wheelers among the residents of the project villages and also facilitated the launch of public transport services. Bicycles were still largely used by both groups of respondents, and in approximately equal numbers among men and women, as detailed in Tables 5 and 6.

Table 6: Perceived Benefits from Road Project

	Project Beneficiaries			Control Group		
	Female	Male	Total	Female	Male	Total
Purchase of Transport Assets						
Four-wheeler	10	9	10	4	5	5
Two-wheeler	17	31	26	13	15	14
Bicycle	71	85.	80	78	80	79
Tractor/Other	1	3	3	4	1	2
Availability of Agricultural Land						
Decrease	4	3	4	3	4	4
No Change	6	4	5	12	10	11
Increase	90	93	92	84	86	85
Price of Agricultural Land						
Decrease	36	25	28	26	21	22
No Change	60	59	59	70	69	69
Increase	4	16	13	4	10	8

Source: Asian Development Bank Independent Evaluation Department.

28. Respondents drawn from project villages believed that their influence within their respective households and within their communities had risen following road construction (Table 7). Women reported marginally greater increases in influence within the households as well as within the community. Women also reported a marginally greater increase in mobilizing women's groups than men and in their negotiating power with their respective employers.

29. Responses were collected on a three-point scale: 1 meant respondent influence was worse than before, 2 meant influence remained the same, and 3 meant there had been an increase in influence. All the average figures presented in Table 7 below are over 2.0, confirming a positive change in influence within the household, the community, at employment and within social networks.

Table 7: Perceptions Relating to Empowerment, by Gender

Impact on Person	Female	Men	Total
Bargaining Power within Household	2.6129	2.5075	2.5408
Bargaining Power within Community	2.6290	2.5075	2.5459
Bargaining Power with Employer	2.5932	2.4656	2.5053
Mobilization of Women Groups	2.7903	2.6617	2.7026

Source: Asian Development Bank Independent Evaluation Department.

30. Out of 230 respondents, 59% drawn from project–influenced villages believed that there had been no change in the availability or price of agricultural land, while over 13% believed that prices had risen in tandem with project implementation (Table 8), and with the opening up additional lands for cultivation. Of the control group, 22% mentioned a decrease in land availability, 69% mentioned no change.

Table 8: Perceptions Related to Availability of Agricultural Land, by Gender

Response	Project Villages (%)		
	Female	Male	Total
Decrease	4.4	3.2	3.6
No Change	5.9	4.0	4.7
Increase	89.7	92.8	91.7
	Control Villages (%)		
	Female	Male	Total
Decrease	3.6	3.7	3.7
No Change	12.7	10.2	11.0
Increase	83.6	86.1	85.3

Source: Asian Development Bank Independent Evaluation Department.

31. Close to 41% of the respondents confirmed an increase in the availability of agricultural inputs, and 86.5% confirmed an increase in prices of such inputs. Close to 85% of respondents confirmed an increase in the availability of consumer goods (control group: 87.6%), while 96.5% reported an increase in the prices of consumer goods (control group: 92.5%). Data relating to the perceived change in prices of land, as perceived by men, women and the surveyed population and segregated between project and control villages, are presented in Table 9.

Table 9: Perceptions Relating to Prices of Agricultural Land, by Gender

	Project Villages (%)		
	Female	Male	Total
Decrease	35.6	24.8	27.7
No Change	60.0	58.7	59.0
Increase	4.4	16.5	13.2
	Control Villages (%)		
	Female	Male	Total
Decrease	26.1	20.8	22.5
No Change	69.6	68.8	69.0
Increase	4.4	10.4	8.4

Source: Asian Development Bank Independent Evaluation Department.

G. Difference-in-Difference Valuation

32. The difference-in-difference methodology is used here as a pilot approach to assess its applicability in impact studies that generate repeated cross-section data and outcomes for two groups for two time periods. One group is the treatment group, in this case the beneficiaries of project roads, and the other the control group. The methodology removes biases in comparisons between the treatment and control groups that could be systematically different changes that have nothing to do with the project.

33. The rural road is visualized as providing residents with a series of "real" options that could be exercised multiple times each day. Such patterns could be repeated over several years, overlapping with the useful life of the road ("nested options"). Residents aged 5–20 years, for instance, might exercise the option to access educational institutions 5–6 days a week, while middle-aged residents might focus on access to employment. Likewise, all residents, jointly and severally, gain from better access to health care and from curtailing the spread of communicable diseases. More generally, improved health and higher educational attainment should eventually translate into economic outcomes, reflected in increased incomes and expenses.

34. With a view to adequately capturing the real world paradigm, while ensuring that a robust internal solution can be found, a structurally simple real option model is developed. In essence, the rural roads provide a continuous stream of nested options that could be exercised at any time during the option contract, and could be exercised repeatedly. To simplify computations, the principal economic activity among the respondents is modeled and the revenue streams mapped over the span of a fiscal year. If the project road offers farmers the option of growing three crops of paddy each year, the annual revenues from paddy cultivation, net of transportation costs, are considered the payoffs from exercising the option. The dispersion in anticipated year-end revenues and the tenure of the contract determine the price that a resident would, hypothetically, be willing to pay for acquiring the option ("the option price").

35. In phase 1 of the computation, the real option valuation methodology is employed to model the road as an underlying asset that delivers tangible benefits to residents who exercise the option to reap benefits repeatedly across several years, with the tenure defined by the useful life of the road. The option price computed is analogous to procuring a ticket to future income streams, notionally paid for at the commencement of road construction.

36. The notional willingness to pay (WTP) is estimated by computing the perceived change in incomes across time for both groups and the differences in perceptions of wellbeing. Fiscal year (FY) 2009 was used as the base year and FY2016 was used as the end year.

37. In phase 2 of the computation, economic and social returns are estimated in proportion to the sanctioned project cost for each road section. The incremental earning by residents of the project-influenced-village is attributed to the project road and is presumed to account for the economic return. The residual value is assumed to represent the social returns on the capital investment.

38. Intuitively, if residents anticipate low (absolute values) and uncertain returns (high standard deviation of returns), the price paid to earn such returns would be low. However, if the projected returns appear attractive and relatively stable, the willingness-to-pay to access such returns would be higher (the classic risk–return relationship). The value delivered by the roads does not necessarily emanate from higher incomes—the roads could also serve to reduce uncertainty in economic outcomes.

39. The model specifies that, consequent to road construction, beneficiary-village residents acquired the option to grow three crops of paddy, and to derive the resulting cash-flow (this assumption was derived from the survey). The options are exercised over useful life of the road.

40. Road construction under the project was initiated in the fourth quarter (Q4) 2009 and was completed by Q3 2013. For the purpose of illustration, and to represent all the sample project roads adequately, the premiums payable on options-to-derive-year-end-revenues are computed for FY2012 through FY2016 (by which time, many of the roads would require substantial overhaul and renovation, involving sizable investment).

41. The (net) payoffs from the economic activity facilitated by the project road, i.e., growing three crops of paddy during a fiscal year, are posited as a proxy measure of the economic benefits derived by the beneficiaries, while the algebraic summation of the prices of the options to derive such (incremental) future pay-offs are modeled as a proxy for the *notional* willingness-to-pay for the rural road.

42. The model design visualizes (i) a median resident from a beneficiary village, (ii) stationed in time coinciding with the commencement of the road project, (iii) being made a promise of receiving discrete year-end revenue amounts drawn from within a range of incremental values. The payoffs, net of earning by corresponding control villages, are linked to market prices, dispersion in land holding within the respondent group, transportation costs, and other relevant variables.

43. The beneficiary is pictured as being informed of the possibility of drawing such revenues consecutively for multiple accounting periods, with each such payoff drawn from within a range of incremental revenue estimates. The notional willingness-to-pay for such a hypothetical option is presumed to represent the beneficiary's perceived value of the road. The price of such an option with a fixed tenure is computed using the Black–Scholes option valuation model.[7]

44. The valuation of an option to call an underlying asset (in this case a cash-flow stream made possible by road construction) is computed using the standard and universally applied Black–Scholes formula:

$$\mathrm{C}(\mathrm{S},\mathrm{t}) = \mathrm{N}(\mathrm{d}_1)\mathrm{S} + \mathrm{N}(\mathrm{d}_1)\mathrm{K}\mathrm{e}^{-\mathrm{r}(\mathrm{T}-\mathrm{t})}$$

Where,
$\mathrm{C}(\mathrm{S},\mathrm{t})$ is the price of the option at time t = the amount a resident household believes is the value of the road in terms of the present value of future incremental cash-flows the road helps generate:

$$\mathrm{d}_1 = \frac{1}{\sigma\sqrt{T-t}}\left[\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)(T - t)\right],$$

$$d_2 = d_1 - \sigma\sqrt{T-t}$$

Where:

(i) $\mathrm{N}(*)$ = cumulative distribution function of the standard normal distribution, as defined by the "bell" curve with 99% of the projected values lying within 3 standard deviation measures on either side of the mean;
(ii) (T – t) = the time to maturity, (time between commencement of project and survey);
(iii) S = the spot price of the underlying, in this case, the median income (net of transportation cost) of the villagers *before* project implementation;
(iv) K = is the strike price (interchangeably used with the exercise price) for the option, median income (net of transportation cost) *after* project implementation;
(v) r = the risk-free rate for the economy (relevant to the situation on hand), rate of return that a resident would get by depositing savings in commercial bank;

[7] Black Fischer and Myron Scholes. 1973. The Pricing of Options and Corporate Liabilities. *Journal of Political Economy.* Vol. 81, No. 3. May–June.

(vi) σ is the volatility of the returns of the underlying asset (a measure of risk), in this case, the standard deviation of the prices of paddy for each district was calculated for a period of 10 years (2003 to 2013) based on available data.[8]

45. The model assumes the following:

(i) In 2009, control and project settlements were identical in every respect.
(ii) In July 2016, all other (exogenous) variables such as teacher attendance at schools and physician and medicine availability at health centers are presumed to impact the residents of project-influenced villages and the corresponding control habitations in exactly the same manner.
(iii) The construction of the project road during the intervening period is therefore assumed to represent the sole difference between the two clusters.
(iv) The control habitations are assumed to represent the counter-factual scenario for the project village; in other words, had the project road not been built in the intervening period, at the time of the present assessment, the project village would be indistinguishable from the control habitation.
(v) Baseline crop yield and revenue per unit of land area are presumed to apply equally to both project and control villages. Respondents were not in a position to recall year-2009 yields and market prices. These values are gathered from statistical tables published by the government of Assam.

46. For phase 1 of the computation: (i) the increase in net revenue for Chapaguri (project village) was computed at 37.75% and for Goybari (control village) at 24.36%, and (ii) the estimated increases in income represent a premium of 13.4% correlated with road project implementation.

47. For phase 2: social and economic returns from project investment: (i) the growth in net income for the median project village resident is 37.8%; (ii) the growth in net income for the median control village resident is 24.4%, and (iii) the incremental revenue growth is 13.4%.

H. Calculation, Results, and Validation

48. A detailed application of the real option valuation for district Chirang is explained in the succeeding paragraphs. The villages considered and their characteristics are given below:

District	Chirang
Project Village	Chapaguri
Control Village	Goybari
Length of Project Road	4.0 kilometers
Sanctioned Cost	₹59,244,000
Population (2001)	2,043 persons
Population (2011)	2,868 persons
Population (2008)	2,621 persons (by linear interpolation)
Population (2008)	596 households (~4.4 persons/household)
Economic Activity Analyzed	Paddy cultivation
Annual Paddy yield (FY07–FY08)	0.750 ton/*bigha*[9] (2.206 ton/acre)
Expected Revenue yield (FY07–FY08)	₹5,338 /*bigha* (₹15,701/acre)
Sample Size (project beneficiaries)	16

[8] Directorate of Economics and Statistics, Assam. *State / District Wise Area, Production, Price and Value of Ten Major Crops in Assam From 2003-04 to 2012-13*. pp. 32/126, 42/126 and 52/126.
[9] 1 *bigha* = 0.338 acre. Footnote 8.

Sample Size (Control)[10]	6
Risk–Free Interest Rate Applied	6.0%

49. The double difference estimates for phase 1 of the computation are as follows:

(i) Reported land holdings varied between 0.25 *bigha* and 22.00 *bigha* in the project village and 0.50 *bigha* to 20.00 *bigha* for the control village.
(ii) The variation in income over the period April 2009–March 2016 is projected based on responses to survey question no. 5(a): responses ranged from negative 40% to positive 60% for both the project and control villages.
(iii) Base date (FY2009) costs associated with transporting agricultural produce for both the project and control villages were quoted at ₹100 per metric ton (1,000 kilograms).
(iv) The variation in transportation cost over the period April 2009–March 2016 is projected based on responses to survey question no. 2(e): responses ranged from negative 60% to positive 80% for the project village and negative 60% and 0% (which means stayed the same) for the control village.
(v) The average respondent's baseline income (FY2008) for the project village was estimated at ₹25,858. The average respondent's baseline income (FY2008) for the control village was estimated at ₹52,940.[11] This is a curious case where the control village was much "better off" to start with but fell behind over the years since the project road was constructed.
(vi) Based on the perception of evolution or change reported during the survey interviews, average present day income (FY2016) was estimated at ₹35,584 (project village) and ₹65,930 (control village).
(vii) Baseline transportation cost (FY2008) reported by the average respondent stood at ₹363 (project village) and ₹744 (control village).
(viii) Present day transportation cost per ton of paddy (FY2016) based on variance-perception reported in response to survey question 2(e) is estimated at ₹466 (project village) and at ₹1,021 (control village).
(ix) Baseline average revenue (FY2008) accruing to farmers *net* of transportation costs was estimated at ₹25,495 (project village) and at ₹52,198 (control village).
(x) Present day average revenue (FY2016) accruing to farmers net of transportation costs was estimated at ₹35,118 (project village) and at ₹64,908 (control village).
(xi) Incomes in both project and control villages have risen between FY2009 and FY2016, but incomes in the project village have risen more rapidly, overlapping with project road construction and utilization.
(xii) Increase in net revenue for Chapaguri (project village) was computed at 37.75% and for Goybari (control village) at 24.36%.
(xiii) The estimated increases in income represent a premium of 13.39% correlated with road project implementation ("double-difference estimate").

50. The estimated social and economic returns from project investment for the phase 2 computation are as follows:

(i) The median farmer in Chapaguri earned ₹10,677 in FY2008.[12] This is used as a proxy for the spot value (time t = 0) of income.
(ii) Income dispersion is computed by growing FY2008 incomes by 13.39% to represent future states of the world from the median farmer's perspective. The median of the projected range of values (₹12,107 in FY2016) is adopted as the exercise price (strike price) for the option contract expiring in March 2016.

[10] This corresponds to a sample size of 11 respondents per village, which is comparable to the population average.
[11] It was reported that Goybari, which served as the control village, received the title of *adarsh gram* (ideal village) by the Assam government in 2007. This report was not independently verified by the authors.
[12] Footnote 8.

(iii) The Black–Scholes option valuation formula was applied to estimate the price of the option with the following input parameters and values: t = 0 (FY2008); spot price: ₹10,677, t = 0 8 (FY2016); exercise price: ₹12,107; risk free interest rate: 6%; call option value computed: ₹4,046.

(iv) At the time of project commencement, the median farmer is presumed to acquire the option to earn the incremental revenue (relative to the control village). The option to earn the incremental revenue can be exercised each year after construction of the road. The cumulative option value for the exercise between years 2012 and 2016 is estimated at ₹9.99 million, representing 16.87% of the sanctioned project cost, a proxy for the economic value of the road.

(v) When a terminal value at three times the option price estimated for year 2016 is included, the economic value of the road rises to 37.22% of the sanctioned project cost. The social value of the investment therefore is estimated at 62.78%. Table 10 contains the details of the real option valuation for Chapaguri village in Chirang District.

Table 10: Phase 1 Difference in Difference Computation

		Project Village		Control Village	
Parameter	**Unit**	FY2007–FY2008 (Before)	FY2015–FY2016 (After)	FY2007–FY2008 (Before)	FY2015–FY2016 (After)
Land Holding	*bigha*	0.25 – 22	0.25 – 22	0.5 – 20	0.5 – 20
Average Baseline Income	₹	25,858		52,940	
Income Variance	%		-40% to +60%		-40% to +60%
Average Estimated Income	₹		35,584		65,930
Transportation Cost	₹/ton	100		100	
Transportation Cost	₹	363		744	
Transportation Cost Variance	%		-60% to +80%		-60% to 0%
Transportation Cost Estimated	₹		466		1,021
Baseline Net Income	₹	25,495		52,198	
Average Income Estimated	₹		35,118		64,908
Difference–a (growth in net income for the median project village resident)					
		(₹35,118–₹25,495)/₹25,495 = 37.75%			
Difference–b (growth in net income for the median control village resident)					
			(₹64,908–₹52,198)/₹52,198 =		24.36%
Incremental Revenue Growth ("Double Difference Value")					**13.39%**

FY = fiscal year.
Source: Asian Development Bank Independent Evaluation Department.

I. Conclusion

51. Rural roads built under the PMGSY have been truly transformational when they are adequately maintained. Numbers of school-going children rose, children recorded better attendance at school, and parents were more confident that their wards were secure on their way to and from school. Avenues for higher education and employment opened up. Ambulance services were now available in places where hitherto residents requiring medical assistance had to be carried on the shoulder or moved on animal-drawn carts. Wholesalers had started visiting the villages to collect agricultural produce directly from the farmers.

52. Yet the most significant contributions from the roads may be more intangible. Residents felt part of a larger social ecosystem. The roads have helped to shore up their self-esteem, both through physical manifestations such as cleaner school uniforms, and through symbolic representations as being addressed by more charitable nicknames. Residents appear to view the roads less as stand-alone physical assets with

intrinsic value and more as instruments providing access to wider opportunity sets in education and employment. Statistical data corroborate the significance attached to accessing educational institutions and workplaces, and eventual economic outcomes including increases in employment opportunity and income.

53. Maintenance of road surfaces, boards and signage, culverts and railings has left a lot to be desired across locations. This is reflected in the low (women) and negative (men) scores awarded for road maintenance, across villages. Worse, maintenance has contributed little to the improvements in quality of life for the residents of the project-influenced villages. Men participating in the focus group discussions attributed the deterioration to the use of inferior material, inadequate customization of road design to the local weather conditions, insufficient camber on the straight sections and banking on the curves, and ineffective supervision during construction.[13] Women participating in the focus group discussions were more utilitarian in their views, and merely wished for the roads to be maintained by the persons concerned to ensure round-the-year accessibility. Across districts, residents unanimously expressed the need for street lights to enhance safety, the construction of channels to drain storm water, and, above all, more intensive user consultation and involvement in the design and implementation of rural road projects.

54. Inadequate maintenance and the seasonal unavailability of the project roads owing to flooding withdraw some of the options originally made available to the residents, diminishing the perceived value of the roads. Contractor accountability, especially with regard to maintenance of the road surface and the road furniture need to be strengthened to ensure year-round availability of the road. The economic returns on road projects could be enhanced if such availability were to be assured and secondary income-generating opportunities, such as agriculture tourism were to be explored.[14]

55. The average economic returns from project road construction across the 15 road sections modeled are estimated at 60.14%. The social returns are assumed to account for the residual cost (39.86%). Ignoring the two outliers—Kendukona village (four control observations) and Chola-gaon (four project village observations) —provides a revised average economic return estimate of 52% of project construction cost. The economic returns from 10 project roads with only positive difference-in-difference estimates amounted to 45.50%, with social returns presumed to justify the residual 54.50% of the investment.

[13] "A distress study that was carried out on the four rural roads of Assam which were opened to traffic between January 2009 and January 2010 revealed their pavement condition index ratings at the time of the study to be from fair to satisfactory." T. L. Ryntathiang. 2011. Pavement Condition Index as a Tool for Assessing the Rural Road Pavements: A Case Study of the Assam Rural Roads. *Indian Highways.* 39:10, Indian Roads Congress, PP. 41 – 57.

[14] C. Goswami and M. Bhattacharyya. 2014. Rural Non-Farm Employment in Assam: A Gender-Based Analysis. *Space and Culture, India*, 2:1, pp. 14–23.