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Economic Analysis of a Rural Basic Access Road Project: The Case of Andhra Pradesh, India

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Rural basic access road projects are expected to yield substantial social benefits, which cannot be properly evaluated using conventional cost-benefit analysis methodology. This note describes the application of cost-effectiveness analysis to supplement cost-benefit analysis in the evaluation and selection of road works for financing under a Bank rural road project in the State of Andhra Pradesh, India.

INTRODUCTION

Rural road projects that aim to improve basic road accessibility from villages to markets and social services are expected to yield not only savings in vehicle operating cost (VOC) and road user travel time cost (TTC), but also substantial social values in the form of broadened socioeconomic opportunities for the rural population. As most rural access roads have very low traffic volumes, the social values generated from the improvement of basic access are often a more important item of project benefits than the direct road user cost savings. Due to the difficulties in quantifying the social values in monetary terms, the road cost-benefit analysis methodology that quantifies road user benefits mainly as VOC and TTC savings is unsuitable for evaluating rural basic access road projects. Alternative methodologies should be adopted. This note describes an application of cost-effectiveness analysis (CEA) to supplement cost-benefit analysis (CBA) in the evaluation and selection of road works for financing under a Bank rural road project in the State of Andhra Pradesh, India. An overview of the project is provided in a separate Infrastructure Note (Transport No. RT-4, January 2000).

AN OVERVIEW OF THE ECONOMIC ANALYSIS

The project area includes three selected poor rural districts, Adilabad, Karimnagar, and Warangal, with a total population of 6.8 million. The rural road network has a total length of 15,000 km, most of which are in poor condition. Almost 60% of the network are tracks and earth roads, 10% gravel, and 30% water bound macadam (WBM). Neither tracks nor earth roads are all-weather passable. Both gravel and WBM roads can be all-weather passable, but many of them do not meet the all-weather standard due to broken or missing cross drainage facilities. The project is proposed to improve the rural road network to at least basic, all-weather passable standard. The role of economic analysis is to assist the design, prioritization, and selection of road works for financing under the project.

The demand for network investment greatly exceeds the budget available under the project. It is necessary to focus on the improvement of a core network that would ensure a minimum connectivity for *each* village to a nearby main road or a market center. The core network is identified through a rural road master planning process.[1] The links in the core network that do not meet the basic all-weather standard are identified as candidate roads for improvement. The economic analysis is applied only to these candidate roads.

The road works for the candidate roads fall into two major categories: (a) *basic accessibility works*, including the upgrading of tracks/earth roads to gravel or WBM roads, and all minor and major cross drainage works on existing gravel and WBM roads; and (b) *black-topping works* on existing earth, gravel, and WBM roads. The basic accessibility works are considered as a valuable instrument for poverty reduction, and thus are given first priority. Black-topping is primarily for economic reasons. When traffic volume (especially motor vehicle traffic) on an unpaved road reaches a certain level, it is more economical to pave the road than maintain the unpaved road to all-

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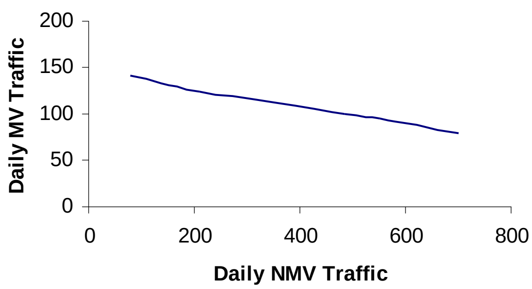
[1] For details on the rural road master planning process, see Infrastructure Notes, Transport No. RT-4, January 2000.

weather condition. Economic justification is required for all black-topping works.

Both CBA and CEA methodologies are used for this project. CBA is applied mainly to the black-topping works. A simple spreadsheet CBA program (shown in the Appendix) based on the conventional road CBA methodology is first used to determine minimum traffic thresholds, which are defined as the combinations of motor vehicle (MV) and non-motorized vehicle (NMV) traffic levels at which black-topping would be justified at the minimum economic rate of return (ERR) of 12%. The thresholds are shown as MV/NMV combinations along the curve in Figure 1. All candidate roads with traffic levels around and above the thresholds are evaluated individually using the spreadsheet CBA program, and the ERRs are estimated. The candidate roads with traffic levels significantly below the thresholds are dropped from the list of black-topping works, but are considered for upgrading to basic access standard and evaluated in the category of basic accessibility works.

Figure 1. Minimum Traffic Thresholds for Rural Road Paving



CEA is applied to the selection of basic accessibility road works. All roads proposed for basic accessibility work are ranked by a simple cost-effectiveness measure—the number of population benefited with basic access per lakh rupees (roughly equivalent to US$2,500) of expenditure. The road works for financing under the project are selected from the top of the ranking list. Economic efficiency is considered through an emphasis on the least-cost design of road works. Based on the available budget, moreover, a maximum amount of 2,000 rupees (or US$50) per person is identified as the brake-off point, above which road works would not be financed.

The economic analysis produces a list of basic accessibility road works ranked by cost-effectiveness and a list of black-topping works ranked by ERR. It should be noted that the application of CBA and CEA in this project does not deal with the optimal allocation of budget between the two categories of road works; the allocation is decided through a stakeholder participatory process. Based on the budget allocation, about 1,700 km of rural roads are selected for financing to basic accessibility standard, with cost-effectiveness ratio ranging from US$14 to US$50 outlay per person served. A further total of 1,300 km of roads are selected for black-topping. Their ERRs range from 12 to 90 percent with an overall ERR of 24%. A total of two million rural population are expected to benefit from the project.

VILLAGE AND HOUSEHOLD TRANSPORT SURVEY

The application of CEA for basic accessibility works is supported by an assessment of the likely impact of basic road access on the welfare of rural households. The data for the assessment are obtained from a small-scale rural household and village transport survey conducted for 40 sampled villages in the project area. For each sampled village, 10 households are randomly selected for the household level survey. The survey results are summarized in Table 1, which reveal significant differences in selected socioeconomic indicators between villages connected with all-weather access road and those unconnected. According to household interviews in the unconnected villages, the poor road condition, seasonal road closure, lack of motorized access, and the high cost of freight delivery are among the major

Table 1. A Summary of Rural Household Survey Results: Villages Connected with All-Weather Access Road vs. Villages Unconnected, 1997

Indicators	Connected	Unconnected
Household income (US$/yr)	700	275
Literacy rate		
Male	51%	40%
Female	35%	22%
Total	43%	32%
Avg. distance traveled (km)		
for fertilizer	11	19
for seeds	11	19
for pesticides	9	16
Transport cost (US$/tkm)		
Fertilizer by bullock cart	0.13	0.33
Seeds by bullock cart	0.10	0.26
Fertilizer by lorry	0.16	0.25
Seeds by lorry	0.08	0.11
Avg. distance to school (km)		
Primary education	0.2	0.2
Secondary education	2.5	18.0

problems of village accessibility. Moreover, road closure during the rainy season causes produce spoilage, delay of freight delivery, labor unemployed, and lower school attendance. When asked what impacts are expected from the improvement of roads, most households in villages both connected and unconnected with all-weather access roads respond with predictions of more seasonal work taken outside villages, higher intensity of cultivation, and expansion of cultivated land. The survey results provide strong empirical evidence to support the social and economic justifications for the provision of basic all-weather access to villages.

THE SPREADSHEET CBA PROGRAM

The spreadsheet CBA program, shown in the Appendix, is designed specifically for the evaluation of rural road black-topping works. It has a conceptual structure similar to that of the HDM model, but is much simplified for rural road evaluation. The program consists of five panels. The first is used to record the road data and economic input parameters. The value of travel time is estimated using the rural per capita income data from the project area. The annual traffic growth rate is predicted based on the area’s population and per capita income trends. The second panel contains engineering unit cost data obtained from the field. The third panel presents the estimated unit VOCs and travel speeds by both road type and vehicle type. The average road surface condition for each type of road in the project area is measured by a range of international roughness index (IRI).[2] The unit VOC data for motor vehicles are obtained from the empirical VOC-IRI relationships estimated for a Bank financed state highway project in Andhra Pradesh, and extended to cover the worse IRI levels typically found on the rural road network. Average travel speed on each type of road surface is estimated by local engineers based on field experience. The VOC-IRI relationships for bullock cart and bicycle are estimated using the NMV basic cost data (Table 2) collected from the field and the empirical relationships developed by recent studies in South Asia.[3]

[2] While the appropriateness of using IRI for rural road project evaluation remains debatable, for this particular project, it is judged appropriate by the project team, given the substantial differences in roughness found among different types of rural road and the relative uniformity within each type of rural road in the area.

[3] (1) Padeco (1996), Non-Motorized Transport (NMT) Modeling in HDM-4, Draft Final Report for Transport Division of the World Bank. (2) World Bank (1996), Bangladesh: Second Rural Roads and Markets Improvement and Maintenance Project: Project Implementation Document No. 15: Economic Appraisal of FRB Roads, South Asia Regional Office, World Bank.

The fourth panel calculates savings in VOC and value of travel time (VOT) for the users of each mode. Finally, the bottom panel calculates the economic cost and benefit streams over the project life, the net present value (NPV), and the ERR.

Table 2. NMV Basic Cost Data, 1997

Item	Unit	Bullock Cart	Bicycle
Vehicle price	US$	62.5	30.0
Price of a pair of ox	US$	312.5	n.a.
Annual cost of feeding the ox	US$/pair	150.0	n.a.
Annualized maintenance cost	US$	75.0	5.0
Vehicle depreciation	US$/yr.	12.5	5.0 (a)
Annual average usage	km	2,400	1,000
Average year of life	years	5	10
Average VOC per km	**US$**	**0.13**	**0.01**

Note: (a) annual depreciation for the first 3 years.

LESSONS LEARNED

1. Where the provision of basic road access is mainly for social equity reasons, cost-effectiveness analysis can be used to evaluate or highlight the impact of the project, and economic efficiency can be considered implicitly through an emphasis on the least-cost design to achieve the project objectives.

2. The economic analysis described here requires systematic data collection. This particular experience may not be transferable to other rural road projects. However, one important lesson learned from this experience is that data collection at low cost can be possible with the active participation of the client in the preparation of the project.

3. Where systematic data do not exist or are costly to collect, effort should be made to at least establish a transport/poverty profile through a small scale household survey, and to collect traffic data on the proposed rural roads.

4. While the methods used in this project help ensure the application of economic criteria, they do not deal with the optimal allocation of budget between the two categories of road works. This allocation may be decided through a stakeholder participatory process.

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Appendix: Cost-Benefit Analysis Program for Rural Road Paving Project

(The parameters shown here are for presentation purpose only, and may not be transferable to other projects.)

District name:	**Warangal**	Road name:	**PWD to Chilpoor**
Division name:	**Warangal**	Road No.:	**L101**
Road length (km):	**15**	Population served:	**12,000**
Current road type (enter 0 for earth, 1 for gravel, 2 for WBM)	**2**	No. of minor CD/km:	**0.5**
		Major CD (m/km):	**1.0**
Value of travel time (US$/hr)	**0.06**	Annual traffic growth rate	**5%**
Annual per capital income growth	**3%**	Standard Conversion Factor	**0.90**

Capital Cost ('000 US$/km)	Financial	Economic	Annualized Maint Cost ('000 US$/km)	Financial	Economic
Formation	5.00	4.50	Earth	0.55	0.50
Gravel (when available on site)	5.00	4.50	Gravel	0.68	0.61
WBM (each layer)	6.25	5.63	WBM	0.88	0.79
Blacktop	7.50	6.75	Blacktop	0.93	0.83
Minor CD ('000 US$/each)	5.00	4.50			
Major CD ('000 US$/m)	3.75	3.38			

	Unit VOC by Road Type (US$/km)				Travel Speed by Road Type (Min./km)			
	Earth	Gravel	WBM	BT	Earth	Gravel	WBM	BT
Vehicle Type	IRI=14-18	IRI=9-11	IRI=9-11	IRI=5-7	IRI=14-18	IRI=9-11	IRI=9-11	IRI=5-7
Buses	0.303	0.250	0.245	0.225	2.4	1.7	1.7	1.2
Mini buses	0.170	0.123	0.118	0.100	2.4	1.7	1.7	1.2
Cars/Jeeps	0.170	0.123	0.118	0.100	2.4	1.7	1.7	1.2
Trucks	0.343	0.280	0.268	0.240	2.4	1.7	1.7	1.2
Tractor Trailors	0.250	0.225	0.200	0.150	3.0	2.0	2.0	1.5
LCV/Tempo	0.170	0.123	0.118	0.100	2.4	1.7	1.7	1.2
Three wheelers	0.075	0.063	0.050	0.038	2.4	1.7	1.7	1.2
Two wheelers	0.063	0.038	0.038	0.025	2.4	1.7	1.7	1.2
Bullock carts	0.147	0.129	0.118	0.115	20.0	15.0	15.0	15.0
Bicycles	0.010	0.008	0.008	0.006	7.5	7.0	7.0	6.5
Pedestrains	n.a.	n.a.	n.a.	n.a.	17.0	16.0	16.0	15.5

	Base yr.	Avg. Veh.	VOC(US$/km)		Speed (Min./km)		Savings (US$/km)	
Vehicle Type	Traffic	Occup.	w/o. Proj	w. Proj.	w/o. Proj	w. Proj.	VOC	VOT
Buses	**20**	35	0.25	0.23	1.70	1.20	0.40	0.36
Mini buses	**16**	10	0.12	0.10	1.70	1.20	0.28	0.08
Cars/Jeeps	**40**	4	0.12	0.10	1.70	1.20	0.70	0.08
Trucks	**24**	0	0.27	0.24	1.70	1.20	0.66	0.00
Tractor Trailors	**22**	5	0.20	0.15	2.00	1.50	1.10	0.06
LCV/Tempo	**37**	1	0.12	0.10	1.70	1.20	0.65	0.02
Three wheelers	**32**	3	0.05	0.04	1.70	1.20	0.40	0.05
Two wheelers	**68**	1.5	0.04	0.03	1.70	1.20	0.85	0.05
Bullock carts	**60**	1.5	0.12	0.12	15.00	15.00	0.15	0.00
Bicycles	**320**	1	0.01	0.01	7.00	6.50	0.56	0.17
Pedestrians	**680**	1	n.a.	n.a.	16.00	15.50	n.a.	0.35
MVs (2 2w = 1 MV)	225				Annual sum (325 days/year) =		1868	400
NMVs	380							

Year	Traffic Growth	Capital Cost	Maint. Cost	VOC Savings	VOT Savings	Net Benefit
		(All in thousand US$)				
1998	**5%**	20.25	0.045	1.87	0.40	-18.03
1999	5%		0.045	1.96	0.43	2.35
2000	5%		0.045	2.06	0.47	2.48
2001	5%		0.045	2.16	0.51	2.62
2002	5%		0.045	2.27	0.55	2.77
2003	5%		0.045	2.38	0.59	2.93
2004	5%		0.045	2.50	0.64	3.10
2005	5%		0.045	2.63	0.69	3.28
2006	5%	6.75	0.045	2.76	0.75	-3.29
2007	5%		0.045	2.90	0.81	3.66
2008	5%		0.045	3.04	0.88	3.87
2009	5%		0.045	3.19	0.95	4.10
2010	5%		0.045	3.35	1.03	4.33
2011	5%		0.045	3.52	1.11	4.59
2012	5%		0.045	3.70	1.20	4.85
2013	5%		0.045	3.88	1.30	5.13
NPV						0.81
ERR						12.8%