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TITLE: Estimation of socio-economic impact of rural access roads estimated from household survey data

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Abstract

Socio-economic data from a household survey were used in combination with basic road condition information to obtain relationships between type and volume of travel by rural dwellers, disaggregated by transport mode, journey purpose and season. Relationships were derived which could be used to predict the effects of different interventions on rural travel patterns. These relationships can be input to traditional ex-ante cost-benefit analyses and to study the impact of road improvements on different types of road user or different socio-economic groups within the community.

Using this model, the overall economic internal rate of return on road investments made by Commune-Sangkat Councils in Cambodia was estimated to be 25%. However, this estimate fell to 6% if it were assumed that no routine maintenance of the roads (only periodic rehabilitation) would be carried out. About 90% of the benefits were estimated to accrue to residents of rural communes (rather than to urban-based transporters). The spread of benefits between users of different vehicle types was roughly proportionate, from which it is inferred that the benefits are spread equitably and that the poor are not excluded from the project benefits.

The data used for this research had the weakness that the data on road conditions was obtained from interviews with village key informants and not verified by actual physical observations of the roads. If the model were refined by using a combination of engineering assessments of road condition and well designed household surveys, a practical tool for predicting and evaluating the impacts of a range of rural transport interventions could be developed.

Introduction

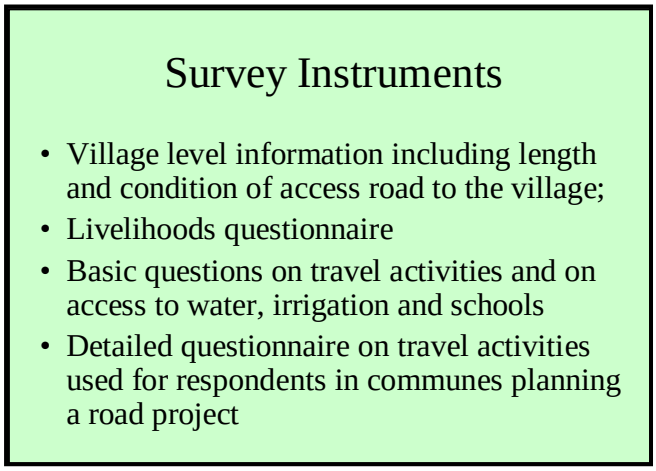
Conventional cost-benefit analysis of road investments is based upon traffic counts (1). However, these are expensive relative to the cost of rural roads and may be unreliable if traffic is subject to high seasonal variability. Traffic counts are of little use for ex-ante appraisal if the road is in such poor condition that there is no traffic to count. The alternative approach is to predict the level and type of road use based on socio-economic data about the population served by the road.

In 2003 Seila Task Force Secretariat commissioned a Socio-Economic Baseline Survey to collect data on indicators which were expected to be sensitive to the impact of small scale infrastructure investments, in particular rural roads, water supplies, school buildings and small scale irrigation promoted by decentralised local authorities (Commune Councils) with finance from the Commune Fund mechanism.

The survey was undertaken by Helmers and Wallgren (2). Data were collected in 960 household interviews and 56 village key informant surveys in 15 communes in Kampong Cham, Battambang and Takeo. The villages and communes were selected according to the types of Commune Fund infrastructure investments that were proposed to be implemented in 2003; thus five of these communes were "road project communes" whilst four were planning water supply projects, four were planning irrigation projects, and the remaining two had other project types. In each commune, two villages with access to the proposed project outputs and two villages without such access were sampled.

Household interviews consisted of a detailed questionnaire on household livelihoods and social indicators and four basic question sets on access to and use of roads, water supplies, irrigation and schools respectively. According to the type of project proposed in the commune, a more detailed questionnaire was substituted for the basic question set; i.e. in a commune proposing a road project, the detailed questions related to travel and transport activities were used instead of the basic questions.

Data collected in this survey were used to develop an economic model predicting the impact of road interventions on levels and implicit costs of travel activities by rural people (3). This present paper summarises the work undertaken so far and reviews further work needed to develop this model into a practical tool for appraisal and evaluation of investments in the sub-tertiary rural road network.



Findings on travel patterns.

The Baseline Survey (2) collected data on rural people's travel patterns under two main categories, one being agriculture and natural resource exploitation and the other on market and social. Respondents were asked about the number and length of journeys made by members of their household for each type of journey, in wet season and in dry season, and by means of transport. Journeys were subdivided into on-road and off-road segments.

The following table summarises the findings of the survey on quantity, type and season of travel by rural households.

Table 1: Household Travel Patterns

Season, gender and travel type	Purpose of Journey		
	Agriculture and natural resources	Market and social	Total
Wet Season person-km/year	1,229	743	1,972
Dry Season person-km/year	500	805	1,305
Total person-km/year	1,730	1,548	3,277
Women %	26%	47%	36%
Men %	59%	45%	52%
Children %	16%	8%	12%
On Road %	25%	66%	45%
Off Road %	75%	34%	55%

Not all travel by rural people is on rural roads. Many journeys, particularly journeys by foot or ox-cart for agriculture or natural resource management purposes, are across fields or by informal paths. The questionnaire differentiated between "on road" and "off road" parts of each journey. Conversely, some journeys, for example to seek wage earning opportunities, may be principally by the national and provincial highway network and the portion on village roads may be only a small part of these journeys. The survey did not differentiate directly between village road travel and highway travel.

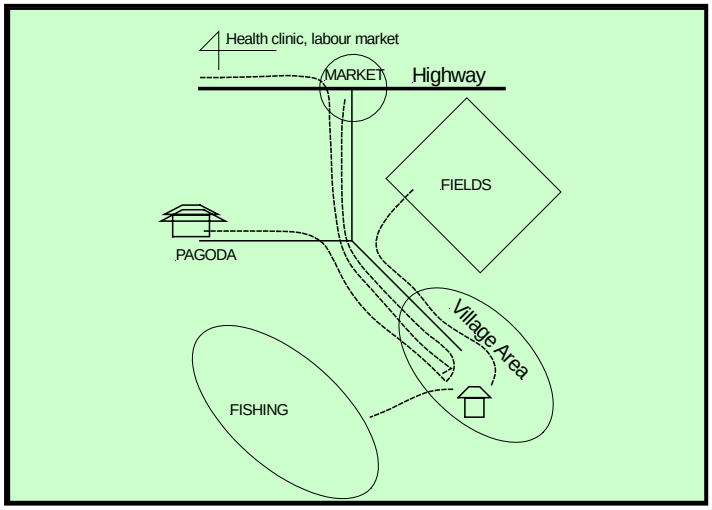


Table 2: Means of transport used for each type of journey

	Agriculture		Non-Agriculture		All Travel
	WS	DS	WS	DS	
Foot	43%	14%	12%	10%	22%
Bicycle	30%	43%	16%	34%	28%
Ox Cart	22%	32%	4%	28%	19%
Motorcycle	4%	10%	32%	26%	17%
Boat	0%	0%	3%	0%	1%
Car	0%	1%	19%	0%	7%
Other	0%	0%	14%	2%	5%

Means of transport used also varied markedly by season. Bicycle was the predominant mode of transport overall, followed by walking, ox cart and motorcycle. Four-wheeled motor vehicles accounted for only about 7% of all reported travel. Further analysis showed that

this was predominantly for long distance journeys and cars accounted for only about 1% of travel by rural people on village roads.

An interesting apparent finding was that more use of motorised transport (cars and motorcycles) was reported for the wet season than for the dry season. This may be because of the difficulty of using bicycles on very poor roads.

Data from traffic counts conducted by the Ministry of Rural Development (4,5) showed a somewhat higher proportion of motorised traffic on roads upgraded under Commune Fund financing. It was interpreted that the difference was accounted for by vehicles based outside the commune but engaged in business in the commune. Villagers cited the increased number of traders traveling to the village to buy crops as one of the major benefits of road improvements (2).

About 60% of all village roads (the main access road to each village) were said to be in poor condition and in need of major repairs, with only 23% of all roads said to be in good condition (2).

The following table summarises average distances cited to different facilities. based on village key informant data.

Table 3: Village Access to Economic and Social Facilities

Facility	% of villages with the facility located in the village	% of villages with the facility located elsewhere in the commune	Average travel distance to the facility (km)
Commune Centre			3.3
Market for buying goods	9%	27%	8.3
Market for selling products	29%	20%	7.9
Labour Market (Dry Season)	25%	13%	57.8
Labour Market (Wet Season)	39%	14%	47.1
Health Clinic	14%	29%	9.9

Relating travel patterns to road conditions.

The data obtained from the Baseline Survey were examined for relationships between road condition and quantity of travel on village roads in different categories. Travel on highways or other roads outside the commune was eliminated by taking the length of the village access road as a maximum for any journey.

For journeys for non-agricultural purposes it proved possible to determine statistically significant relationships of the form:

$$V_{S,M} = B_0 + B_1.X_1 + B_2.X_2 + B_3.X_3 + B_4.X_4 + B_5.X_5$$

- V = volume of travel in person-km per household
- B_0 = a constant
- B_1, B_2 etc. = coefficients estimated by linear regression
- S = season
- M = means of transport
- X_2 = distance to market
- X_3 = length of journey on good road
- X_4 = length of journey on poor road
- X_5 = length of journey on bad road

However, for journeys related to agriculture and natural resource exploitation, the number of journeys and means of transport did not appear to be related to the condition of the village road. This is not surprising as the "on-road" part of these journeys is only about 25% of the total and so the road condition will have less influence on whether a journey is made, and by what means.

Economic Analysis

An *ex-post* economic analysis was undertaken of a set of pattern road projects, representing the roads sector output of the Commune Sangkat Fund in 2003. The same techniques could in principle be applied to either *ex-ante* appraisal or *ex-post* evaluation of a single project road.

The data input to the analysis comprised:

- the length and condition of village road linking a number of villages to a central destination (conceived of as the commune centre, market, or link to a highway);
- the expected condition of the road after upgrading part of the road or constructing new structures;
- Predicted traffic profile and volumes, derived from the relationships described above;
- Data on vehicle travel speeds and operating costs, depending on road condition;
- A general value for rural people's time.

The valuation of rural people's time is a critical issue in economic evaluation of rural road investments. Some authors (e.g. Gittinger, 5) have contended that as the rural populations are generally under-employed they do not have the opportunity to use the time saved for any economic purpose; in this view small savings of time have no economic value. However, other studies have shown that rural people themselves put a high implicit value on time saved (6). Rural Cambodians have diverse livelihoods and share their time between a wide range of economic activities and domestic tasks; therefore time saved in travel can be used in any of a number of productive or necessary alternative activities such as agriculture, natural resource exploitation, domestic labour or paid labour (Chan and Acharya, 7 and 8; Helmers, 9).

Following this latter view, an approximate value was obtained from figures for total average household income presented by Chan and Acharya (8). Assuming that a typical household would spend the equivalent of about 10,500 adult person-hours per year in economic and domestic tasks, a value of US$0.066 per hour was obtained. Following Gwyllim (10) children's time was assumed to be worth half the adult amount.

Motorcycle drivers were assumed to be working and earning the equivalent of the unskilled labour wage of around $0.13 per hour, while car drivers were assumed to earn a semi-skilled wage of around $0.31 per hour.

For analysis, the output of the Commune-Sangkat Fund projects in 2003 was considered as equivalent to a set of "pattern projects," each with four beneficiary villages. Village A represents a central village with a market and direct access to a highway, so villagers use the village road frequently but for short journeys. Villages B and C are located at greater distances along the project road. Village D is not located on the project road, but residents use the project road to access the market. Populations, distances and road conditions were adjusted to represent the average conditions found in the survey.

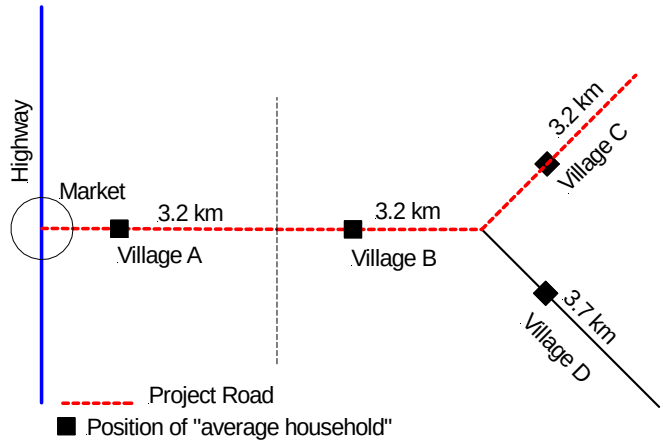


Table 4: Comparison Of Pattern Projects with CS Fund Road Projects 2003

	Actual	Pattern projects
Number of contracts	817	551
Number of villages with outputs	1,654	1,653
Number of beneficiary villages	2,423	2,224
Number of beneficiary households	401,722	401,891
Average length of village road (km)	3.7	3.4
Poor road in village (km)	0.6	0.5
Bad road in village (km)	2.2	1.9
Average distance to market (km)	5.2	5.3
Length of earth road constructed (km)	440	441
Length of laterite road constructed (km)	722	720
Number of culverts constructed	2,010	2,011
Number of bridges constructed	163	163
Value of all outputs	US$4,259,637.68	US$4,259,224.55

Results of Economic Analysis

Economic cost-benefit of the model resulted in a calculated economic internal rate of return of 25% for the CS Fund road projects. This compares well with the generally accepted minimum value of 12%. However, this rate of return will only be achieved if adequate routine maintenance is carried out. The model was also analysed on the assumption of no routine maintenance, but periodic rehabilitation. On this assumption the calculated internal rate of return fell to a sub-acceptable 6%.

The equivalent financial present value of the benefits from the investments was calculated, with a discount rate of 25% to reflect the high cost of money in the rural economy. The average benefit was calculated to be equivalent to about US$6.43 per household. This would fall to US$4.44 per household if no routine maintenance is carried out. If the cost of

routine maintenance (but not the construction costs) were paid by the households, the net present value of the benefit to each household would be US$5.43.

Table 5: Summary of Results of Economic Analysis

	With routine maintenance	Periodic Rehabilitation
Economic Internal Rate of Return (EIRR)	25%	6%
Financial Present Value per household	US$6.43	US$4.44
Financial Present Value per household if households have to pay maintenance or periodic rehabilitation costs	US$5.43	US$2.51

The model allowed the spread of benefits between different villages, and different types of road user to be determined. The following table summarises the results of this analysis.

Table 6: Distribution Of Benefits of Road Projects

Distribution of discounted value of benefit stream		
Source of benefit	Traffic of local origin	Incoming traffic
1. Origin of traffic		
Share of total benefit	84%	16%
2. By village		
Village A (market and highway access)	34%	-
Village B (intermediate village)	25%	-
Village C (distant village on project road)	19%	-
Village D (distant village off project road)	21%	-
3. By transport means		
Pedestrians	30%	-
Bicycle	37%	-
Ox-carts	4%	-
Motorcycle	24%	14%
Cars	5%	86%
4. By journey type		
Journeys to outside village (non-agriculture)	65%	-
Internal journeys (Agriculture and natural resource)	35%	-
5. By season		
Wet season	52%	52%
Dry season	48%	48%
6. By type of cost saving		
Value of traveler's time	53%	21%
Wage savings	15%	26%
Vehicle fixed costs	22%	53%
Vehicle operating costs	11%	0%
Refer also to Annex 1Table A1.20		

"Village A" the centrally located village in the model, appears to capture more of the benefits than the outlying villages, in this model. Presumably this is because with shorter journey lengths the residents make more frequent use of the road.

Abut two-thirds of the benefits were gained by pedestrians and cyclists, with car traffic (meaning any kind of four-wheeled motor vehicle) accounting for only 5% of the benefits to local traffic but 86% of the benefits to incoming traffic.

About 65% of the benefits to local traffic are for journeys for non-agricultural purposes. Benefits are spread evenly between dry season and wet season. About half the total benefit from the project is in the form of time savings for local people. Savings in vehicle operating costs are not important in this model, but this reflects the assumption that per-kilometre operating costs of the types of vehicle operated on rural roads, will not vary much with road condition.

These detailed findings are sensitive to assumptions made in constructing the model and are presented here as examples of the type of information that can be extracted from a model of this kind. Further work would be needed to validate these assumptions and to calibrate the model, as discussed below. However, it is considered that the broad findings are valid and it is reasonable to draw general conclusions about the impact of low level access improvements on the rural economy.

Implications.

It is considered that the following general implications can be derived from the study:

1. Small, scattered investments in access improvements on village access roads result in real economic gains, with estimated internal rates of return similar to those calculated for other types of public infrastructure investment;
2. Because most journeys by rural people are short and confined to the local area, connection to the highway network may not be necessary for economic viability. Spot improvements are economically worthwhile provided that the reduction in travel costs and value time saved is greater than the cost of the investment. However, rural people cite the generation of incoming traffic, particularly produce buyers, as a key benefit of road investments (2). Connectivity enhances economic value, but should not become a reason for denying investments to areas already disadvantaged by poor access.
3. Investment in the lowest levels of the road network spreads the benefits of the investment very broadly. CS Fund investments in rural road improvements from the start of Fund operations in 2002 until 2004 totaled about $US 13.6 million dollars. About 6,000 villages, representing 43% of the villages and 46% of the households in Cambodia, benefited from these investments. This fits well with recommendations for generating broad based growth and reducing poverty (11).
4. The analysis presented above does not determine directly how much of the benefit went to poor households. However, as the majority of the benefit is calculated to be gained by travelers on foot and by bicycle, it is considered a reasonable inference that the rural poor gain significantly from these projects.

Further Development

Further work is needed to develop a consistent and reliable model for estimating the impacts of rural access road investments.

One difficulty encountered was in the interpretation of information about village road lengths and condition derived from key informant interviews. In any follow-up research this should be replaced by simple physical surveys using consistent indicators.

Household interviews would then refer more specifically to a defined length of road, and enquiries about the use made of that road by the household members, for journeys for different purposes, seasons and modes of transport.

The model needs calibration by traffic counts conducted on the same roads. Based on the work described above, it is expected that the volume of motorised traffic will be underestimated by reference to household surveys alone, and the difference will be accounted for largely by incoming traffic.

Further analysis should focus on relative amounts of benefit gained by different groups within the population, including women and the poorest households. The relationship between benefits gained and contributions made to the projects, in the form of time spent in planning meetings and participatory monitoring, and direct financial contributions, should also be investigated.

With this work carried out, a model can be developed which will estimate with acceptable reliability the traffic volumes, economic benefits and distribution of benefits expected from proposed investments in rural access roads. The data required for appraisal would be:

- the location of each village served in relation to facilities such as markets and highway access;
- the population of the villages;
- the pre-existing condition of the road according to simple, consistent indicators;
- the extent to which the village inhabitants use the road to access each type of facility, for example in the form “X% of journeys to market use that road.”

All except the last data can be obtained from maps, databases (e.g. the Commune Database of the Ministry of Planning) or simple physical survey. Data on uses of the road by the local population could be obtained from key informant or group interview.

Commune-Sangkat Fund projects are identified and prioritised through a participatory planning process which has very little analytical content at present. It is not reasonable to expect Commune Councils to conduct economic analyses, or to understand the results of these analyses presented in conventional terms. However, it is possible that a simple tool, based on underlying economic and poverty alleviation criteria, could be developed to help Commune Councils to select projects. Results should be presented in a format designed to facilitate understanding and decision-making by the local authorities. For example, formats such as “Road A has greater economic benefits, but Road B will benefit more poor people;” or, “Road C will benefit people cycling to the fields during the wet season, but Road D is more likely to encourage traders to come to the village” would be easily understood by most councilors and would allow for better informed exercise of discretion.

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