A METHODOLOGY FOR EVALUATION OF RURAL ROADS IN THE CONTEXT OF DEVELOPMENT

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Despite a good rate of national growth, rural poverty is on the rise in many developing countries. Transportation, particularly roads, is perceived as an important component of rural development. In an effort to impart a more valid basis for selection among investments, an evaluation framework capable of accounting for the various socio-economic objectives of the rural development effort in the assessment of rural transport projects is formulated and preliminarily tested. A potentially appropriate set of developmental objectives is identified, and possible measures proposed. Utility assessment techniques are suggested for developing decision maker's preference functions, and ultimately scaling project contributions to the criteria. These scaled measures of the criteria for each project are then incorporated into a single value structure as a basis for project ranking and thus decision making. Depending upon the decision maker's access to information and articulation of his preferences among the criteria, equal or cardinal weights may be directly assigned to the criteria, or an ordinal ranking of them may be done and an upper or lower bound decision rule used. The ranking of the projects varies with the approach. The proposed appraisal framework is seen as a simple but valuable tool in the project selection stage where a decision maker faces an array of potential projects and needs some means for evaluating their relative worths. Although a case study has been carried out, testing under actual field conditions remains to be done. Moreover, this is a first step effort, and certain refinements are needed.

1. Introduction

1.1 Rural Development and Transportation

Despite a good rate of national growth in many developing countries in the past decade, rural poverty is increasing, and the number of people living on the margin of existence is rising. It is estimated that some 80 percent of the three-quarters of a billion poor in developing countries live in the rural areas. Moreover, the rural population is growing at a rate of some 2 percent per year in spite of rural migration to urban centers (1).

It has been asserted that through rural development many of the sufferings of this large number of rural poor may be allevaited. As stated in the World Bank's sector policy paper (1), the basic objectives of rural development might be defined as: productivity improvement; employment and income generation for target groups; and provision of minimum acceptable levels of food, shelter, education, and health. The fuller development of the existing resources, the building of infrastructure such as transport and irrigation works, the introduction of improved technology for existing agriculture or new crops, and the creation of new types of institutions and organizations are some of the tasks lying ahead.

Transportation, particularly roads, has been perceived as an especially important component of rural development, in terms of stimulating local development, providing access to social services, and generally serving to integrate the rural population into the overall economy. Trends in recent years have been increasingly away from investments in the primary road network and toward greater emphasis on the rural feeder and penetration roads. Moreover, there has been an increased tendency to regard even these low volume roads as but one of several possible investments competing for scarce resources, the emphasis thus being placed increasingly on integrated rural development.

Evaluation of feeder road projects, therefore, cannot be done in isolation; rather, all complementary activities must also be taken into account. Moreover, such projects cannot be justified in the standard user savings framework. Project evaluation must encompass the social, political, economic, and technical implications of the road itself and of its connection with other projects in the integrated development package.

1.2 Multi-Objective Analysis and Appraisal of Rural Road Projects

Single objective analysis techniques traditionally used in evaluation of road projects, like savings in user costs, producer and consumer surplus, and change in national income, are incapable of taking into consideration the spectrum of objectives relevant to the rural development effort. The emerging method of project evaluation, multi-objective analysis, incorporates both economic and non-economic objectives into an evaluation framework. Much has been written concerning multi-objective analysis in recent years by researchers in such diverse fields as management, engineering, and psychology. Friesz and Evans (2) propose four categories into which most of the prevailing methodologies can be classified.

Under Category 1, each attribute is valued in terms of some common reference attribute, standardly termed a numeraire. The many dimensions or attributes characterizing a project may thus be collapsed into one dimension. The project's value is proportional to the total amount of the numeraire it exhibits; that is, the project with the largest numeraire is optimal. The techniques of category 1 are the more traditional benefit-cost analysis methodologies, like UNIDO (3) and Little and Mirrlees (4), the unifying characteristic being the single numeraire, for which they are referred to as the aggregate method of multi-objective analysis. Through the use of social pricing more than a single objective can be implicitly considered, as, for example, the growth objective in the case of UNIDO (3) and the equity objective in that of Squire and van der Tak(5). Non-economic objectives may also be considered through the use of metric conversions, although these are typically difficult to determine.

Under Category 2, the full set of attributes is not expressible in terms of a single numeraire, but sufficient consensus exists among the users/decision makers that a utility function can be defined to express their level of satisfaction with each alternative. The project with the highest utility level is optimal. For the techniques of category 2, the element of subjectivity still exists, but the value judgments are explicitly articulated by the appropriate elected or appointed official, rather than implied by the metric conversions. Keeney and Raiffa(6), in fact, have developed specialized techniques for determining the appropriate mathematical form of the utility function depending on the relationships among the attributes.

Under Category 3, neither the single numeraire nor adequate consensus exists to define a single utility. This may occur for one of two reasons: (1) there are several statistically distinct groups of users in the user population, each with a distinct utility function; or (2) an individual user group may have multiple objectives or measures of utility against which the projects must be compared, but they may be uncertain as to their relative importance. A single optimal project cannot, therefore, generally be determined; rather, the original list of alternatives might be narrowed to a set of efficient or non-inferior projects, with the final choice being made outside any analytic framework.

Finally, under Category 4, an iterative analytic process is used to arrive at a best compromise under a situation of multiple objectives or utility functions. That is: (1) the most efficient consequence of selected assumptions concerning the relative importance of each objective are presented; (2) a new set of assumptions is derived through inputs from the parties involved; (3) the associated efficient consequences are displayed; and (4) further iterations take place until a final decision is reached.

Turning to the problem at hand, feeder road appraisal can be visualized as a choice of many small projects, where each project has several important selection criteria, each measure is expressed in its own units, and the set of projects to be implemented is selected from a much larger set. In the case of Kenya in the Fall of 1974, for example, a program to improve some 12,000 km of minor and secondary roads out of a possible 30,000 km was being planned, and a second program to upgrade some 16,000 km of low class rural roads to all-weather roads out of a theoretically possible total of 100,000 km of unclassified roads was being investigated.

The situations characterized by categories 3 and 4 are realistic representations of scenarios in developed countries where there are numerous parties involved, each with its own interests and capabilities and each desiring participation in the decision process. In the context of the rural development effort and for the purposes of this research, it may be assumed that there is a universal commitment to the achievement of certain accepted goals; that is, that a single set of social preferences can be articulated with the help of the appropriate decision maker, who might be, for example, the director of the road authority or Minister of Public Works. In view of this assumption and the characterization of the rural road situation given above, it appears that the rural road appraisal problem falls into category 2.

It is thus proposed to focus this paper on structuring a multi-criteria appraisal framework for rural road projects along the lines of techniques discussed under category 2. The development of this framework in Section 2 centers around four activities: (1) identification and measurement of potential criteria to be included in the evaluation; (2) assessment of the decision maker's preference function for each of these criteria, and ultimately scaling the measures of the criteria; (3) combination of the criterion measures for each project to form an explicit value structure as a basis for decision making; and (4) testing and implementation of the proposed methodology in some case studies. The appraisal methodology proposed is seen as a simple but valuable tool in the project selection stage.

2. A Proposed Framework for Socio-Economic Evaluation of Rural Road Projects

2.1 Identification and Measurement of the Criteria

Five criteria have been selected for the framework for appraisal of rural road projects in socio-economic terms. These include: (1) economic benefits, (2) economic costs, (3) distribution, (4) accessibility to social services, and (5) employment. Contributions to these criteria to be included are those resulting from provision of the feeder road and its complementary investments. These represent one possible set of criteria, and are not intended to be a universal representation of the accounting of socio-economic objectives of rural development activities. It is the decision maker in the particular case who must be satisfied with the set of criteria. The appraisal framework structured here is independent of changes in the criteria and in their number.

Economic criteria have traditionally been used in the approaisal of transport projects, and their measurement is widely known and well documented (e.g., 7,8,9). Economic benefits may be measured in terms, for example, of user cost savings, producer and consumer surplus, or increase in national income. Sole use of the first measure is cautioned against since its application assumes that most benefits stem from savings on normal traffic and development benefits are of negligible importance; in feeder road projects the opposite is generally true. The second measure, producer and consumer surplus, although conceptually attractive is difficult in practice due to its requirement of forecasts of approximate demand and supply functions. This leaves the national income measure, a good approximation being induced agricultural production sinced induced economic activity in rural areas, at least initially, will be largely in the agricultural sector. The difference in the present expected value of agricultural activity in the case of project implementation and in that of the no-project alternative is thus the suggested measure for economic benefits.

The value of this induced agricultural production depends on a variety of factors, including the nature of government extension help, receptiveness of farmers to new ideas, availability of cultivatable land and adequate climatic and resource requirements, and existence of a market for the goods in conjunction with sufficiently attractive farmgate prices. Various mathematical models, including linear programming, aggregate regression analysis, and disaggregate behavioral modeling approaches, have been formulated as potential means of forecasting economic benefits of roads (e.g., 10,11,12). Alternatively, induced economic activity as well as measures of other project criteria might be predicted on a project-by-project basis by a specially selected team of interdisciplinary experts, consisting of agricultural economists, sociologists, engineers, and anthropologists, among others. These various forecasting techniques merit further discussion and research, selection among them being a function of the availability of data, transferability of approaches, and biases of the decision-making authority. For the purposes of this paper, the parameters that might be tabulated and used by an appraisal team in assessing the value of each of the five criteria are indicated. Table 1 illustrates a possible set of parameters for determining the expected value of agricultural activity on a yearly basis for each crop and each group of farmers; combining these over the life of the project and comparing this with the no-project alternative yields a predicted value of induced agricultural production.

As observed above, economic benefits occur over time. For project appraisal purposes, it is convenient to present them at discrete intervals, such as yearly, and to aggregate these over the life of the project to a single value, such as present value, using an appropriate discount rate. Alternative means of incorporating temporal considerations are possible, and the debate over discount rates is an active one, but is beyond the scope of this paper.

Expenditures related to the construction and maintenance of the road and to any complementary investments as a part of the development package constitute economic costs. In addition to initial road construction costs, these might include costs associated with maintenance and upgrading over the life of the road; building, staffing, and operating complementary health and educational facilities; and changes in agricultural activities such as extension workers, seeds, tools, and fertilizers. For economic costs, like economic benefits, time must be taken into consideration.

Explicit accounting of the distribution of economic benefits among project beneficiaries has long been recognized as an important aspect of the appraisal of feeder road projects. Alleviation of poverty among the poorest has repeatedly been cited as a primary goal of rural development. Prediction of the small farmers' share of induced agricultural production is, however, hard to make. The use of a proxy measure is proposed, a promising candidate being the cultivatable land owned by the relevant income group(s).

This appears to be a reasonably measurable proxy and reliable representation of the distribution of benefits to the target population. Its usefulness is illustrated by the following two extreme cases: (1) the affected community consists of 500 persons, all of whom presently exist on income levels below that of the target income group; some 750 hectares of cultivatable land is to be opened up and planted, and ownership distributed evenly among the population; and (2) the affected community consists of 300 persons, of whom some 270 are peasants either farming at a subsistance level or working for the five rich families of the community who own/control almost all of the cultivatable land; although induced agricultural production is expected to be large, the subsistence group's share is expected to be negligible. At the same time, use of this measure necessarily entails certain restrictive assumptions such as: cultivatable land owned by the target group is generally less than ten hectares per family, economic conditions of perfect competition exist, average productivity of the land is uniform, and share of economic benefits is proportional to land ownership.

Project implementation may affect accessibility to social services through improved transport and thus easier or new access to existing services, and through complementary investments and thus provision of new service facilities. These may be mobile or permanent facilities. Decisions pertaining to such alternatives are presumably made in the design stage during the formulation of the set of projects to be evaluated; in the appraisal stage, then, the objective is to assess each project's contribution to this criterion.

Using accessibility to health services as an example, five levels of service might be considered: local mid-wives (H1), visiting trained nurses (H2), permanent trained nurses (H3), visiting health clinic (H4), and permanent health clinic (H5). Assuming no deterioration in services as a consequence of the project, Table 2 indicates the possible changes that might occur and their associated utilities on a scale of 0 to 10. Assuming the utility of change to be the same across the affected populace, accessibility to health services can be quantified by multiplying the appropriate figure in Table 2 by the number of people affected. Accessibility to educational facilities might be similarly measured, four possible levels being: none, general, vocational, and adult education. Assuming these to be primary indicators of social services and of equal importance, their sum may be used as a measure of accessibility to social services. This is admittedly a rather simplistic approach; consideration of the distance and timing associated with each change as well as other social services might be incorporated as well.

Table 1: Assessment of Expected Agricultural Production Crop: Year:

Type of Group of Farmers[1]	Cultivatable Areas[2] A	"Old" Average Yield[3] Y_0	"New" Average Yield[4] Y_1	Predicted Average Unit Market Price P_1	FROR to Farmer[5]	Demand Conditions	Other Relevant Parameters[6]	Probability of New Cultivation[7] Pr	Expected Value $[Pr \times P_1 \times Y_1 \times A + (1-Pr) \times P_1 \times Y_0 \times A]$

[1] Grouping might be based on land ownership, for example.
[2] Includes land currently uncultivated and idle, as well as that under cultivation.
[3] Before project implementation.
[4] A predicted figure, after project implementation.
[5] Financial rate of return.
[6] E.g., risk aversion characteristics of farmers, which might decrease over project life.
[7] A likely rather subjective assessment dependent, for example, on the three previous columns.

Table 2. Assessment of the Utility of Change in Health Services

Type of Change	Subjective Assessment of Medical Experts
No Change	0
H1 to H2	2
H1 to H3	5
H1 to H4	7
H1 to H5	10
H2 to H3	3
H2 to H4	5
H2 to H5	8
H3 to H4	2
H3 to H5	5
H4 to H5	3

Consideration of employment in project appraisal raises the question of whether it should be treated as an end or as a means to meeting other ends or objectives. Kessing (13) argues that employment must be treated as a separate objective as generation of employment does not emerge naturally from the pursuit of traditional macroeconomic objectives, while UNIDO (3) argues that it is a means associated with the redistribution objective. Additional arguments to consider employment as a separate measure include its being an indicator of the mobilization of labor, an important condition for rural development, and a measure of relative labor intensity among projects.

Man-days of employment associated with project implementation throughout its life are suggested as the measure. Included in this is employment resulting directly from construction and maintenance activities as well as that expected from increased agricultural activity. Employment of extension workers and other government employees should not be included as it is assumed they would otherwise be employed elsewhere; moreover, interest in employment is primarily from the viewpoint of mobilization of the local labor. Although employment occurs over time, as do economic benefits and costs, its value is assumed constant, and no discounting is proposed. Possible refinements in this measure might include distinction between short and long-term employment and checks on expected labor availability over time relative to its planned use.

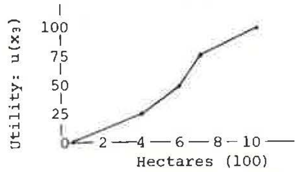
2.2 Scaling of the Criteria

Each criterion is measured in its own units: (1) economic benefits and costs in monetary terms, (2) distribution in hectares, (3) accessibility to social services in ATSS units, and (4) employment in man-days. At this point, the decision maker needs to be brought in to assist in transforming the spectrum of physical measures for each criterion into utility or psychological value terms.

Various utility assessment techniques might be applicable. In the first, the category technique, a number of discrete categories are specified for a particular criterion, and the decision maker assigns each project to one of these based on its contribution to that criterion; numerical worths can then be determined for each category, but the result is rather approximate. The second technique, the gamble, consists of lotteries constructed by varying the level of the measure or the probabilities of occurrence until the decision maker is indifferent between the lottery and a certainty equivalent; this tends to be a somewhat complicated and confusing, as well as time-consuming, technique. A third approach, the direct technique, is the most straightforward, requiring the decision maker to assign numerical values to the various levels of attainment of a particular measure. This can be done in two ways: (1) anchor one extreme point of the measure, and compare all of its other values to this; or (2) anchor the two extreme values of the measure, specify a few intermediate points, and use linear interpolation to complete the preference function.

The direct technique is generally the more attractive, and is used in the hypothetical testing of the appraisal framework in Section 2.4. A sample of its use in constructing the preference function for the third criterion, distribution, is given in Figure 1. In actual practice, the final selection of the utility assessment technique depends on the preferences of the decision maker and the topic of the assessment. Additional techniques are also available should one of these not seem appropriate.

Figure 1. Distribution Preference (Utility) Function



The measure of distribution arising from all projects under consideration ranges from 20 to 1,000 hectares. 600 hectares has been anticipated as the "50" point, 400 as the "25" point, and 720 as the "75" point. The distribution preference function is therefore:

$$u(x_3) = \begin{cases} 0.0658\, x_3 - 1.316 & 20 \le x_3 \le 400 \\ 0.125\, x_3 - 25 & 400 \le x_3 \le 600 \\ 0.208\, x_3 - 75 & 600 \le x_3 \le 720 \\ 0.0893\, x_3 - 10.7 & 720 \le x_3 \le 1{,}000 \end{cases}$$

2.3 Ranking of the Projects

Having identified the criteria of interest, delineated measures by which contributions to them might be assessed, and presented techniques for deriving the preference or utility function for each (i.e., scaling the physical measures), the final step in the formulation of the appraisal framework is combining the measures of the five criteria for each project into a single value structure by which the projects might be ranked. Completion of the analysis depends upon the decision maker's articulation of his preferences among the various criteria. Three scenarios are proposed: articulation of equal, cardinal, or ordinal weights for the criteria.

Implicit in the equal weights alternative, actually a subset of the cardinal weights case, is the assumption that all criteria are of equal importance. Thus, the projects are ranked by the value of the sum of the utilities over all criteria:

$$WVUC_1 = \sum_{i=1}^{n} \frac{u(x_i)}{n} \qquad (1)$$

$u(x_i)$ is the utility function of criteria i, with n being the number of criteria.

If the criteria are truly equally important according to the best-knowledge of the decision maker, the analysis can proceed directly, using the above formulation with no further input from the decision maker.

The cardinal weights approach allows for differences in the relative importance of the various criteria, and assumes that explicit weights can be assigned to each. Projects are, therefore, ranked according to the weighted sum of the utilities over all criteria:

$$WVUC_2 = \sum_{i=1}^{n} \frac{w_i u(x_i)}{\sum_i w_i} \qquad (2)$$

w_i is the explicit weight on criteria i.

To complete the analysis using this formulation, articulation of the cardinal weights must be elicited from the decision maker. In practice this often proves to be difficult due to conceptual problems in explicitly assigning the correct social weights and to political sensitivity issues.

In cases where the decision maker cannot or is unwilling to specify cardinal weights, the ordinal weights approach might be used in ranking the projects. Application of this alternative requires the decision maker to designate an ordinal ranking of the criteria reflecting their relative importance. Given this and utilizing concepts of linear programming, the analysis can be completed. The formulation discussed below is that initially developed by Cannon and Kmietowicz (14) for application to decision-making under uncertainty; further details of its derivation for application here are given by Chew (12).

As a first step, given an ordered set of criteria, the set of utility functions of the various criteria, and a set of projects, an upper and lower bound on the weighted score of each project can be determined based on that order of criteria. This can be formalized as two linear programming problems:

$$\text{Maximize (Minimize) } WVUC_3 = \sum_{i=1}^{n} w_i u(x_i) \qquad (3)$$

$$\text{Subject to: } \sum_{i=1}^{n} w_i = 1 \qquad (4)$$

$$w_i - w_{i+1} \geq 0 \quad (i = 1,\ldots,n-1) \qquad (5)$$

this reflects the ordering of the criteria

$$w_i \geq 0 \quad (i = 1,\ldots,n) \qquad (6)$$

That is, any set of cardinal weights which obeys the specified ordering will have a weighted score somewhere between these upper (maximum) and lower (minimum) bounds for each project.

Through the application of a couple transformations, two parameters and, thus, two possible decision rules, termed maximax and maximin, emerge for ranking the projects. Under the maximax decision rule, the projects are ranked according to the maximum weighted value of the criteria, or in other words, the highest score they can attain given the ordering of the criteria:

$$WVUC_3^{max} = \text{MAX} \sum_{j=1}^{i} \frac{u(x_j)}{i} \quad (i = 1,\ldots,n) \qquad (7)$$

Under the maximin decision rule, the projects are ranked according to the minimum weighted value of the criteria, or in other words, the lowest score they can attain given the ordering of the criteria:

$$WVUC_3^{min} = \text{MIN} \sum_{j=1}^{i} \frac{u(x_j)}{i} \quad (i = 1,\ldots,n) \qquad (8)$$

The ranking of projects produced by the maximax decision rule is of a more optimistic/less conservative nature. That is, if a situation arises in which the contribution to the most preferred criterion is exceptionally good relative to that to any of the other criteria which might be exceptionally poor, the maximax rule cannot take the latter into account. If this inability to account for an exceptionally poor measure is not a critical issue, as long as there exist more preferred criteria with exceptionally good measures, then use of the maximax rule may be justified. The maximin decision rule is, on the other hand, more conservative/less optimistic in nature. That is, the occurrence of an exceptionally poor criterion measure is taken into account by this decision rule, but it, in turn, is less able to reflect the occurrence of an exceptionally good one. If the ability to account for an exceptionally poor criterion measure is critical, as illustrated by the analogy of "a chain is as strong as its weakest link," then use of the maximin decision rule may be justified. One further limitation of both decision rules is that the set of projects are not ranked according to a single set of weights since that which maximizes (minimizes) one project will, in general, not be the same as that maximizing (minimizing) another. Finally, if the information is available and believed correct, use of equal or cardinal weighting techniques for ranking projects may be most appropriate.

2.4 Application/Testing of the Methodology

A hypothetical case study involving 36 alternative projects was designed to demonstrate the application of the overall appraisal framework (see Chew (12) for details). A typical project might be as follows:

> A 20-kilometer feeder road is proposed to join a small agricultural community of 600 persons to a small provincial market town served by a good secondary road. At present an earth trail, not passable by motor vehicles, exists and is mainly used for walking or transport by pack animals to the nearby town where the peasants may go to sell agricultural surplus and purchase consumer goods. The community appears to have rather suitable conditions (e.g., physical, ecological, demographic) for agricultural development.
>
> As part of a regional development effort, a package of investment projects has been proposed by the design team, including: upgrading the trail to a gravel road; agricultural extension services directed toward improving existing production, increasing the land under cultivation, and introducing a new crop, cocoa; establishing a health clinic in the community; and providing general education.
>
> The community has 109 families, of which 5 are relatively rich and own 45-50 hectares of land each, 34 own 2-10 hectares per family, and 70 are landless (50 renting a total of 100 hectares from the rich for subsistence farming, and 20 working for the rich families). Present production consists of cassava, rice, and maize, with a bit of livestock, on 405 hectares of land; an additional 113 hectares of cultivatable land is idle. It is proposed to bring this land under cultivation with a cash crop, cocoa, as well as an additional 70 hectares of nearby government land, the latter to be allotted to the 70 landless families. The target population is 104 families who currently own 278 hectares of land which will be increased to 348 hectares by the project....

Based on such information, contributions to the criteria were identified and measured as discussed in Section 2.1. This represents just one of the myriad possible scenarios for feeder road projects. Corresponding measures for the other 35 projects could similarly be determined; in the case at hand, a spectrum of plausible measures was simply developed. Using the utility assessment techniques of Section 2.2, preference functions were developed for each criterion, and utility values assessed for each project's contributions. The values developed and used in the case study are given in Table 3. These were then combined for each project, and used in ranking the projects as outlined in Section 2.3. The three mechanisms for the decision maker's articulation of preferences concerning the various criteria were tested under one or more sets of assumptions: (1) the equal weights alternative; (2) the cardinal weights alternative with the same order of criteria but three sets of weights; and (3) the ordinal weights alternative with the criteria in the same order as and in different orders from the cardinal weights approach, under maximax and maximin decision rules. Table 4 summarizes the various ranking techniques tried; Table 5 shows the alternative rankings of the set of projects thus achieved.

The ranking of projects by means of the equal weights assumption ($WVUC_1$) depends on their relative performance with regard to each criterion and in total. Projects ranked at the top tend to be uniformly good (e.g., Project 16), or relatively good in two or more criteria and not too bad in those remaining (e.g., Projects 14,13); those near the bottom tend to be uniformly poor (e.g.,Project 3), or relatively poor in several criteria and maybe even quite good in one or two (e.g.,Projects 19,20). Such generalizations must be treated with caution, however, as the ranking of projects is highly dependent on the particular set of projects. Moreover, assigning 36 separate rankings may be somewhat deceptive in that certain projects may be rather close in the numerical values underlying their rankings (e.g., projects ranked 5 to 14 are within 7%) and may thus be relatively equally desirable, at least for a first glance. It is, therefore, recommended that the WVUC values be viewed in conjunction with the rankings (see Chew(12)). Nevertheless, the strength of this appraisal framework is as a mechanism for sorting and ordering a large number of projects, and thereby selection of a group of potentially appropriate projects for further and more detailed inspection. These general comments pertain to all three ranking techniques.

The ranking of a particular project, when cardinal weights are specified ($WVUC_2$) depends on both the relative weights on the individual criteria and the project's performance relative to that of others in the set. $WVUC_2^3$'s behavior is rather similar to that of $WVUC_1$, as the weights on the criteria are nearly uniform. $WVUC_2^1$ and $WVUC_2^3$ show rather different rankings, however, as both their sets of weights favor the first criterion, $WVUC_2^3$ more so than $WVUC_2^1$. In the case of $WVUC_2^1$, for example, projects with a reasonably high measure on the first one or two criteria and maybe not so high on the others tend to rank high (e.g.,Projects 5,4), while those with a reasonably low measure on the first criterion and still relatively high on the others tend to rank low(e.g.,Project 30). Distinct differences exist in the rankings obtained from $WVUC_2^1$ and $WVUC_2^3$, as exemplified by Projects 17 and 22, differences in the emphasis on the second criterion being important here.

The ranking of projects under the ordinal weights assumption ($WVUC_3$) depends on the decision rule used, the ordering of the criteria, and the relative performance of the projects in the set. The five top-ranked projects under $WVUC_3^{max}1$ demonstrate the less conservative nature of the maximax decision rule in that the contribution of the most preferred criterion, economic benefits, overshadows those of all other criteria; Project 4 is an extreme example. Once contributions to the less preferred criteria become larger than that to the most preferred criterion, however, these begin to exert some influence, as in the case of Project 14. The conservativeness of the maximin decision rule is evident in the lowering of Project 4's ranking under $WVUC_3^{min}1$, and in the low ranks of Projects 19 and 20. The observation that the ordinal rankings under $WVUC_2$, $WVUC_3^{max}1$, and $WVUC_3^{min}1$ are the same is valid, but one cannot then proceed to assume that the rankings will also be similar, as demonstrated by Table 5. Some similarities exist as in the top-ranked projects, but striking differences also exist as in the case of Project 22. There is, within the specification of cardinal weights ($WVUC_2$), an almost infinite number of specifications which parallel the ordinal ranking of $WVUC_3^1$ but result in different rankings of the projects. The second ($WVUC_3^2$) and third ($WVUC_3^3$) sets of figures in the ordinal weights case demonstrate the sensitivity of project rankings to the preferential ordering of the criteria.

In order to better understand the use and implications of the various decision rules, the behavior of three projects across these alternatives is traced. The movement of Project 4 is particularly interesting as a result of its extremes in attainment of the various criteria: the highest possible utility score for the economic benefits criterion and lowest for the distributional one, with moderate to low scores on the remaining criteria. Thus, when equal weights ($WVUC_1$) or nearly equal cardinal weights ($WVUC_2^2$) are specified, it ranks around number 20. When cardinal weights with relatively higher weight on economic benefits and lower on distributional effects ($WVUC_2^1$) are applied, Project 4 moves up to position 3, and then up to number 1 when the extremes in the weights are made greater yet ($WVUC_2^3$). The more/less conservative natures of the maximax and maximin decision rules are well depicted by Project 4's behavior. It ranks number 1 with $WVUC_3^{max}1$ which has economic benefits as the most preferred criterion, and number 7 with $WVUC_3^{min}1$. When top priority is given to distributional effects, Project 4 drops to ranks 29 and 36, respectively, under $WVUC_3^{max}2$ and $WVUC_3^{min}2$. In the case of $WVUC_3^{max}3$ and $WVUC_3^{min}3$, the respective ranking is 16 and25 since its performance with respect to the preferred criterion is relatively poor.

The performance of Project 22 with respect to three of the five criteria is good (economic costs and employment) to excellent (distribution), and with respect to the remaining two is relatively poor. It ranks first for $WVUC_3^2$ which places distributional effects at the top. Its score on economic benefits is rather poor, and thus it ranks low, around 20, under $WVUC_2^3$ which puts nearly all its emphasis on this criterion, and under $WVUC_3^{min}1$ for which this criterion is most preferred. Its generally favorable performance with regard to the other criteria bring its rank up to 7 for $WVUC_3^{max}1$, and up into the range of 2 to 11 for the other ranking schemes.

Project 3's performance is relatively poor with regard to all the criteria. Correspondingly, it ranks rather low for all decision rules, although it tends to rise a bit when the maximin decision rule($WVUC_3^{min}$) is used because of its uniformly poor performance without any extreme lows in its utility scores.

The ranking of the alternative projects in the hypothetical case study naturally varies with the decision rule used because different value judgements and amounts of information have been provided in each case. It is not possible to suggest definitively which decision rule is the "best and only one". Its selection is most appropriately made on a case-by-case basis taking into account, for example, the nature of the projects involved and their expected contributions to development, the socio-political environment within which the planning is being done, and the type of value judgements the decision maker can and is willing to make. Adequate understanding by the analyst and proper education of the decision maker concerning the properties and implications of the various decision rules are essential to successful implementation of the proposed framework for project appraisal.

3. Summary, Conclusions and Recommendations

3.1 Summary and Conclusions

The plight of the rural poor in developing countries is a problem needing immediate attention today. Rural development is a formidable and multi-faceted problem which developing countries and lending agencies are finally beginning to face. Transportation is recognized as a necessary but insufficient ingredient in this process. Evaluation of rural road

Table 3. Utility of the Criteria Measures, $u(x_i)$

Project Number	Economic Benefits	Economic Costs	Distribution	Employment	Accessibility to Social Services
1	34.09	61.82	21.58	83.04	42.79
2	30.22	17.66	54.79	100.00	52.03
3	15.69	37.91	20.13	13.17	33.28
4	100.00	31.26	0.00	45.23	20.21
5	90.43	72.67	0.99	24.48	10.21
6	73.88	58.90	1.25	28.90	14.99
7	41.35	55.67	27.63	88.02	31.26
8	34.62	80.23	40.13	73.81	27.04
9	20.77	81.81	56.46	46.26	15.61
10	11.15	82.26	75.00	16.42	32.14
11	30.22	77.86	12.04	43.94	24.53
12	39.43	59.87	11.58	58.79	19.14
13	41.35	38.40	82.14	89.39	71.45
14	36.17	31.67	95.80	90.49	88.25
15	29.44	44.46	76.07	58.27	52.56
16	77.14	48.64	54.38	52.41	40.36
17	79.93	2.76	29.00	33.07	27.01
18	19.81	94.99	12.17	75.49	11.88
19	3.30	95.85	5.46	0.00	5.13
20	0.00	100.00	11.18	1.61	0.00
21	44.45	84.08	0.33	31.85	14.50
22	30.39	69.78	100.00	45.97	27.03
23	63.84	0.00	52.50	68.12	45.21
24	48.30	13.61	41.00	57.81	100.00
25	21.16	50.00	70.83	9.68	17.80
26	25.00	67.04	27.50	46.50	22.63
27	53.93	38.55	50.00	67.18	38.75
28	29.81	29.55	82.14	60.93	51.25
29	6.73	67.06	87.68	31.85	27.00
30	13.36	50.00	54.58	37.90	43.75
31	60.31	47.73	40.38	56.25	45.00
32	37.52	38.40	37.75	81.24	51.29
33	32.98	8.14	11.97	46.37	57.50
34	27.21	72.74	24.47	51.87	6.38
35	30.77	34.93	15.26	58.12	45.38
36	35.83	28.26	9.14	46.40	41.18

Note: For all criteria except economic costs, the lowest attainment is assigned a utility of 0, and the highest 100; the situation is reversed for economic costs where the highest cost is assigned a utility of 0, and the lowest 100.

Table 4. Decision Rules Used in the Case Study

$WVUC_1$: equal weights on the critera
$WVUC_2$: cardinal weights on the critera

Weights, w_i:

Rule:	w_1	w_2	w_3	w_4	w_5
$WVUC_2^1$	0.50	0.20	0.15	0.10	0.05
$WVUC_2^2$	0.22	0.21	0.20	0.19	0.18
$WVUC_2^3$	0.90	0.04	0.03	0.02	0.01

$WVUC_3$: ordinal ranking of the criteria

Rule:	Weighted Value of Criteria:	Preferential Ordering of Criteria, x_i:
$WVUC_3^{max_1}$	maximum	$x_1 > x_2 > x_3 > x_4 > x_5$
$WVUC_3^{min_1}$	minimum	$x_1 > x_2 > x_3 > x_4 > x_5$
$WVUC_3^{max_2}$	maximum	$x_3 > x_2 > x_1 > x_4 > x_5$
$WVUC_3^{min_2}$	minimum	$x_3 > x_2 > x_1 > x_4 > x_5$
$WVUC_3^{max_3}$	maximum	$x_2 > x_1 > x_3 > x_4 > x_5$
$WVUC_3^{min_3}$	minimum	$x_2 > x_1 > x_3 > x_4 > x_5$

where: > means "is preferred to"

i = 1 - economic benefits
2 - economic costs
3 - distribution
4 - employment
5 - accessibility to social services

Table 5. A Summary Comparison of Project Rankings Using Different Decision Rules

	Equal Weights:	Cardinal Weights:			Ordinal Ranking:					
Rank	$WVUC_1$	$WVUC_2^1$	$WVUC_2^2$	$WVUC_2^3$	$WVUC_3^{max_1}$	$WVUC_3^{min_1}$	$WVUC_3^{max_2}$	$WVUC_3^{min_2}$	$WVUC_3^{max_3}$	$WVUC_3^{min_3}$
1	14	16	14	4	4	16	22	22	20	8
2	13	5	13	5	5	31	14	14	19	22
3	22	4	16	16	17	27	29	13	18	16
4	16	31	22	17	16	7	28	16	21	31
5	15	13	15	6	6	13	13	15	10	9
6	24	6	8	23	14	5	10	28	9	10
7	8	14	24	31	22	4	15	27	5	18
8	2	27	31	27	13	32	25	9	8	7
9	28	22	28	24	21	6	9	29	11	5
10	31	17	27	21	23	21	8	10	34	1
11	27	23	2	13	31	12	16	31	22	27
12	32	8	7	7	8	8	20	8	14	13
13	7	7	32	12	18	17	2	30	29	32
14	1	24	1	14	10	1	5	32	26	26
15	23	15	23	32	11	14	30	2	6	11
16	9	1	9	8	27	23	18	25	4	12
17	29	21	29	1	29	24	7	7	13	15
18	10	32	10	36	7	22	23	26	16	29
19	18	28	18	22	9	11	27	24	1	34
20	30	9	5	15	15	28	24	23	12	6
21	5	12	4	28	24	15	31	34	7	21
22	4	2	30	2	2	34	19	1	31	25
23	12	11	12	33	28	35	1	3	27	30
24	26	18	11	11	1	26	32	17	15	14
25	11	34	26	35	20	36	34	35	24	4
26	35	10	34	34	34	2	26	18	2	28
27	34	26	6	26	12	25	11	11	28	35
28	6	29	35	9	19	9	6	12	30	36
29	21	25	21	18	32	18	4	20	25	20
30	17	35	17	25	25	33	21	33	32	19
31	25	36	25	30	26	3	12	36	23	3
32	36	30	36	3	30	30	17	19	17	2
33	33	33	33	10	35	10	35	6	3	24
34	3	19	3	29	36	29	36	5	35	33
35	20	20	20	19	33	19	33	21	36	17
36	19	3	19	20	3	20	3	4	33	23

projects, therefore, must begin to incorporate complementary investments in the development package, and to look at these projects from a socio-economic perspective.

The multi-criteria appraisal framework proposed above has been formulated in response to such concerns. A potentially appropriate set of developmental objectives is suggested, as well as possible means by which a project's contribution to these objectives might be assessed. These include traditional economic benefits and costs as well as distributional effects, accessibility to social services, and employment generation. This list is by no means inclusive; findings of further research may suggest new criteria as well as new means of measuring those currently of concern. The appraisal framework itself is independent of possible changes in the criteria and of addition of new ones. As the measures for each criterion are delineated in their own physical units, the direct or a similar utility assessment technique is suggested for developing preference functions for each criterion, and ultimately scaling the contributions of the projects.

The final step in the formulation of the appraisal framework is combining the scaled measures of the various criteria for each project into a single value structure as a basis for decision making. This requires articulation of the decision maker's preferences among the various criteria, for which three hypotheses are postulated. It is imperative that the decision maker be informed as to the implications and demands of these scenarios. Equal and cardinal weight assignments, for example, require the most information, but they also give the most reliable responses provided the weights are correct; ordinal ranking, onthe other hand, is generally easier for the decision maker, but the maximax decision rule tends to be aggressive in ranking projects, and the maximin to be conservative. No definitive statement as to the appropriate decision rule can be made, other than that the selection of the approach is specific to the situation and cases under review, and is constrained by the available information and value judgments.

As a general conclusion, it has been demonstrated that it is conceptually possible to structure and implement a multi-criteria appraisal framework to account for the various socio-economic objectives of the rural development effort in the evaluation of rural transport projects. It appears that such a framework will be highly applicable in the developing country context, particularly in light of the large volume of resources anticipated to be allocated to rural development in the near future. The real strength of this appraisal framework is expected to be in sorting and ordering a large number of projects, for selection of a smaller group of potentially appropriate projects to be subjected to more detailed inspection.

3.2 Recommendations

The framework has been formulated at a conceptual level, and although a case study has been carried out to illustrate its implementation, it remains to be tested under actual field conditions. Some of the measures that have been advocated, for example, have yet to be collected by any appraisal effort. Such field testing of the framework constitutes the first recommendation for further action. In this way, policy makers' and other users' acceptance of the ideas and methods proposed can also be assessed.

Secondly, the multi-criteria appraisal framework proposed in this paper is a "first step" effort, and some refinements are clearly needed. Although the criteria are reasonably straightforward, for example, more research is needed on their predictive measurement. Use of land ownership by the target income group as a proxy for tracing distributional effects entails some restrictive assumptions, which might be removed through the structuring of a new measure, for example.

Finally, this research effort has focused only on the appraisal problem. Two other problem areas -- the design and implementation stages -- need further study, and are suggested as a third area for future consideration. Thus, for example, the design problem needs to be investigated as a multi-objective problem; identification of projects is a particularly critical step in the process, as the projects ultimately selected for implementation can only be as good as the best of those available.

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