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The screening of rural road projects in Indonesia: an analysis of stakeholder decision-making criteria

Doni Widiantono
Postgraduate Research Student, UNSW

John Black
Professor of Transport Engineering, UNSW

Abstract:

Institutions are the arrangements for the production, distribution and consumption of a service. One set of arrangements with which this paper is concerned relates to governments in the public provision of local roads in Indonesia, which account for 80% of total road length. The current 5-year Development Plan aims over the next 25 years to connect more than 66,000 villages into a network of rural roads. The institutional challenge is to get the process right of screening, monitoring and evaluating local roads.

Research has been conducted into this planning and evaluation cycle with an aim to improve current methods. "Bottom up" planning and prescreening criteria are currently used and these institutional arrangements are described. Our approach is to apply multi-attribute decision methods to allow decision makers to set priorities amongst competing projects. A questionnaire survey has been administered to the seven major institutions (30% response rate) across all provinces to establish views (n=118) on the rank order of road attributes such as economic, social or environmental factors, to measure the degree of commonality in response and to determine the weights to attach to each attribute. Similarities and differences by institutional response and region are based on statistical analyses of the data. Based on these findings we construct multi-attribute utility functions for each attribute separately and suggest such a model is sufficiently robust for application across Indonesia in the screening of local roads. A computer program has been written and a hypothetical example is presented.

Contact author:

Doni J Widiantono
Postgraduate Research Student
School of Civil & Environmental Engineering
University of New South Wales
SYDNEY NSW 2052

Telephone: (02) 9385 5036 Fax: (02) 9385 6139
Email: j.black@unsw.edu.au

Introduction

The economy of Indonesia, with a land area of 1.9 million sq. km. and a population of some 200 million people, has been growing consistently at about 6 percent per annum until the recent economic crisis when GDP declined by 8.5 per cent in the first quarter of 1998. Investment in the Indonesian transport sector has been an important part of a strategy to help foster the attainment of growth. In its successive 5-year Development Plans (*Pembangunan Jangka Panjang Tahap II*) the Government of Indonesia has devoted significant resources to improving transport infrastructure with emphasis on promoting economic growth and regional development. The most important issue under the plan is how to improve the road network, particularly for under-developed regions, so that there are no more isolated villages. Connecting more than 66,000 villages into the road network within the next 25 years in a huge developmental task. The Government is faced with a huge number of proposed rural roads that clearly exceeds the financial capability of implementation.

A simple, and technically adequate, screening method is therefore needed to determine priority rankings of rural road projects. Conducting a full social cost-benefit analysis, or a detailed feasibility study, for each individual road project is impractical from a resource point of view (manpower and money), and not fully commensurate with the relatively small capital investment (less than Rp.500 million) needed for such roads. This paper proposes a multi-attribute decision method (Keeney and Raiffa 1976, Zeleny 1982) to solve the problem, by calculating a weighted sum of the value of attributes (decision variables). The projects are then ranked accordingly to their utility scores. Furthermore, a cut-off point is determined by using a budget constraint. Attributes employed in this method include economic, technical, socio-political, and environmental aspects, and any other plausible attributes defined by decision makers. Similar work had been undertaken by (Carnemark, Biderman and Bovet 1983 annex 3) who exploited a weighted rating technique for economic activity, social service, social and economic welfare and some environmental impact criteria.

The originality of our paper is that it identifies the appropriate variables used in decision making for rural road projects in Indonesia by surveying the key stakeholders in the technical, political and community spheres. Respondents to a questionnaire survey administered through the Indonesian Institute of Road Engineering nominated the decision attributes and assigned weights to each main category and their sub-categories. This has not been attempted before in Indonesia. Based on the analyses of these data an appropriate, and robust, model has been formulated for determining the level of priority of Indonesian rural road projects subject to various aspects (economic, technical, socio-political, and environmental). The paper also outlines how the multi-attribute decision model, with its utility functions calibrated, is translated into computer code. The computer model is applied to determine the priority rankings based on representative, although hypothetical, data for 10 rural roads

Road Transport System in Indonesia

Before explaining the survey of key decision makers it is necessary to explain the institutional arrangements for road and bridge infrastructure as ten government agencies are involved in Indonesia. It is also necessary to outline road funding to establish the relative importance of rural road development in Indonesia. Finally, current approaches to screening road proposals are outlined.

Institutional Arrangements

A brief introduction to government structures and road administration is given to establish the context for rural road planning. Furthermore, we need to establish the key stakeholder groups involved in rural road appraisal. Indonesia has four main levels of government : National (Central Government); Provincial (Level I Government); *Kabupaten*/District or *Kotamadya*/Municipal (Level II Government); and *Kecamatan*/Sub-districts (Level III Government). Currently, there are 27 provinces in Indonesia, including three special regions (Jakarta, Yogyakarta, and Aceh), and these are headed by Governors. These provinces are divided into several *Kabupatens* and *Kotamadyas* (municipalities) which are headed by *Bupati* and *Walikota,* respectively. Under these *Kabupatens* and *Kotamadyas* there are several *Kecamatans*, each of them directed by a *Camat.* Furthermore, the *Kecamatans* are divided into *Kelurahan/desa* (which are simply villages), headed by a *Lurah* (a government official) in an urban area, or a *Kepala Desa* (not a government official) in a rural area (Sajogyo and Wiradi 1985 pp12-13).

At the provincial level, most of the central government ministries have branch offices called *Kantor Wilayah* (KANWIL). These KANWILs are staffed and operated by the Central Government, although they have to co-operate with the Governor of the province. The heads of these KANWIL are representatives of the ministers in the provinces. They are mainly concerned with administrative matters. Beside these KANWILs, there are also local offices called *Kantor Dinas* (DINAS), which are similar to Central Government ministries, except that they are under the Governor's authority. At the kabupaten or kotamadya level, offices which deal with local operational affairs are also called DINAS but they are under the authority of *Bupati/Walikota* (Mayor).

The road transport system accommodates more than 50% of medium and long-distance freight transport and almost 90% of passenger transport movements (Biro Pusat Statistik, 1993). Administratively, roads in Indonesia can be classified into two different types, *Jalan Umum* (public roads) and *Jalan Khusus* (specific roads). Public roads may include road networks that can be categorised as public properties, while specific roads are roads which are built for special purposes, or are privately owned. There are several organisations at the different levels of government which are involved in administering roads in Indonesia: each has a distinct responsibility and role in the system. Some roles overlap slightly. The institutional arrangements for roads and bridges in Indonesia involve 10 agencies. Their major roles are also summarised in Table 1

Table 1 Indonesian governmental institutions and their roles in road administration

Institution	Major Roles
Direktorat Jenderal Perhubungan Darat (Directorate General of Land Transport)	General planning, regulation and development of land transport system; regulating and supervising the land transport services, such as public transit, coaches, service stations, vehicle manufacturers and railways; law enforcement, (operating weigh bridges, controlling public vehicle quality) and registration.
Direktorat Jenderal Bina Marga (Directorate General of Highways, Ministry of Public Works)	Primary role in planning, constructing and maintaining the public road infrastructure especially national roads and bridges; standards of construction; technical advice to the public works offices, either at provincial or kabupaten levels, and to offices in other departments.
Dinas Pekerjaan Umum Propinsi (Provincial Office for Public Works)	Plan and implement the construction and maintenance of provincial infrastructure, including roads and bridges
Dinas Pekerjaan Umun, Kabupaten (District Office for Public Works)	Planning and implementation of the development of kabupaten infrastructure, including roads and bridges.
Direktorat Jenderal Pembangunan Daerah (Directorate General of Regional Development, Ministry of Home Affairs)	Regulate and monitor the non-technical aspects of central government grant programs (INPRES) to the lower governments. In terms of road development, responsibilities for constructing and maintaining village roads, and providing access to the remote areas by opening new roads connecting to the nearest developed area; receives technical advice from *Bina Marga* regarding planning, development and maintenance of roads and bridges in kabupaten and village levels.
Ministry of Transmigration	In road-related matters, provides access to new transmigration areas and after a period of time, hands over responsibilities to the Directorate General of Regional Development, Ministry of Home Affairs.
Badan Perencanaan Pembangunan Nasional – BAPPENAS (National Development Planning Board)	Determines the priority and annual budgeting for all development projects in all sectors in Indonesia, including transport and roads.
Badan Perencanaan Pembangunan Daerah – BAPPEDA (Regional Development Planning Board)	Planning bureaus in either provincial or *kabupaten* level
PT. Jasa Marga (Indonesian Highway Corporation)	Administering and managing the development of toll roads.
Puslitbang Jalan PU (Institute of Road Engineering)	Research agency in Ministry of Public Works studying roads and traffic engineering to support the Directorate General of Highways.

Road Funding

In terms of road length, the local roads are the most important (Directorate General of Highways 1993). In 1991, there were about 233,000 kilometres of road in Indonesia. About 80 percent served local traffic, only 5 and 15 per cent served arterial and collector traffic, respectively. Provincial roads are mainly collector roads (about 90% of them), whereas all *kabupaten* roads served local traffic. The average expenditure for the local road subsector is about 20 per cent of the national development budget (Biro Pusat Statistik 1993). The total length of *kabupaten* roads is 210,000 km. Most of these roads are in poor condition because of lack of maintenance, low institutional capabilities, and limited sources of funds. About one third of the road expenditure is on *kabupaten* roads: upgrading village and transmigration roads.

The program is driven by the stated objective of BAPPENAS to have 55 per cent of planned/network completed by the end of the fifth 5-year Development Plan (REPELITA V). The uses of the road development budget varied across different levels of government. Road betterment and bridge replacement of district/*kabupaten* roads are usually financed by *INPRES Peningkatan Jalan Kabupaten* (IPJK). The local government development budgets – APBD Tk I (Provincal Government through Dinas PU Propinsi) and APBD Tk II (District Government through Dinas PU Kabupaten – are used for maintaining provincial and *kabupaten* roads, respectively. Indonesia has a total of 243 *kabupatens* or rural districts. They vary greatly in the population and size, but, on the average, a *kabupaten* has a population of 0.7 million and a land area of 4,000 square kilometres (Biro Pusat Statistik 1993).

Screening Procedures for Rural Road Projects

There is no specific procedure for screening rural road projects in Indonesia. Most of the decisions are made in an intuitive, or in a speculative, manner. Decision makers' practical experiences tend to dominate. Nevertheless, there is a general procedure of assessing projects following a "bottom-up" planning mechanism. Screening on cost per population or cost per cultivated area are used as general rule of thumb for establishing priorities amongst competing projects. A bottom-up planning mechanism is made possible under the Act on Village Government of 1979 where in every village, there may be a Village Council (*Lembaga Musyawarah Desa*) and a Village Self-Reliance Organisation (*Lembaga Ketahanan Masyarakat Desa*). The latter is an informal unit made up of all local leaders with the Village Head (*Kepala Desa*) as its chairperson.

The LKMDs are expected to come up with proposals on types of needed projects in which part of the costs will be borne by the community. These proposals are then discussed at the *Camat* office together with representatives of other LKMDs. The selected proposals are submitted to be discussed at the *Bupati* office (*Rakorbang*). Once some of the proposed projects have been accepted by this higher committee, the task of implementing the project in each village is again left to the LKMD. For *kabupaten* roads, the mechanism is slightly different. Every financial year, the local public works office has to submit a list of proposed projects (*Daftar Usulan Proyek* –

DUP) based on their local needs. These DUPs are then discussed at the *Rakorbang* at the higher level (Province and National levels) The approved projects (called a DIP) are then assigned to each *kabupaten*.

Survey Design

The main objective of the survey was to obtain reliable information on how decisions about rural road projects are made in Indonesia. The survey tried to identify what the decision attributes are and how they are weighted in a form of a utility function. It also tried to identify the level of risks perceived by the decision makers when making road investments (although this part of the study is not reported in this paper)

Target Population and Sample

A questionnaire survey method was employed because: the location of respondents are scattered over wide geographical areas and provinces in Indonesia; the technique is relatively easy to conduct with limited manpower; the information needed can be clearly defined; and the questions can be designed to be self explanatory. The target population was the decision makers who were either directly or indirectly involved in the decision-making process of any rural road project in Indonesia. Those decision makers can be categorised into one of three groups.

Planners and Engineers: Who decide about the design and planning of the proposed projects. This category includes engineers in BAPPEDA Tk II, Directorate General of Highways, *Dinas PU Kabupaten*, and from some engineering consultancy companies

Executives: Who determine the final decisions or who conduct the operational stages of rural or regional development programs. These might be engineers or executives in *BAPPEDA Tingkat II* (regional planning bureau), *Biro BANGDA* (Regional Development Bureau) under the Ministry of Home Affairs, and engineers in *Dinas PU Kabupaten*.

Community representatives : Who are involved in the proposing stage of the project, the transport operators, and other road users who benefit from the project (beneficiaries). They may be members of *DPRD Tk. II* (House of Representatives in District level), *LKMDs* (Community Representatives in village level), *KUDs* (Local Cooperation Units), or *LSMs* (non government organisation)

The target sample was distributed by three geographical areas amongst 26 provinces (Jakarta is excluded)

West Indonesia: Covers 13 provinces in the area of Java, Bali, and Sumatra. This region has characteristics of relatively high GDP, high population density, and more developed and established rural areas. Included in this region are Aceh, North Sumatra, West Sumatra, South Sumatra, Jambi, Lampung, Bengkulu, West Java, Central Java, East Java, Special District Yogyakarta, and Bali.

Central Indonesia: Includes 8 provinces in Kalimantan, and Sulawesi. Within this region; there is a moderate level of GDP, medium population density and a mix of developed and less-developed remote areas Included in this region are West Kalimantan, East Kalimantan, Central Kalimantan, South Kalimantan, North Sulawesi, Central Sulawesi, South East Sulawesi, and South Sulawesi.

East Indonesia: Comprises of 5 provinces in Nusa Tenggara, Maluku and Irian Jaya. In these most eastern islands of Indonesia, the population is scattered among vast areas. A considerable number of remote areas and difficult topographical terrain are the distinguishable charracteristics of this region. Included in this region are West Nusa Tenggara, East Nusa Tenggara, East Timor, Maluku and Irian Jaya.

Other factors that are distinguishable, and included in the survey, account for different types of rural road projects (e.g. *kabupaten* roads, village roads, and other feeder roads) and the relative geographical location of projects (e.g remote or non-remote areas).

From the 243 *kabupatens* (rural districts) five kabupatens were taken as samples from each province. From every *kabupaten* there were at least 3 respondents contacted, including a planner, an executive and a community representative. Another 10 respondents were selected from Directorate General Bina Marga, Directorate General Regional Development (Bangda), and engineering consultants. The design for the sample sizes of each stratum and category can be observed in Table 2.

Table 2 Sample size by province and respondents group

Region	Province	Respondent Group			Total
		Planners	Executives	Community	
West Indonesia	13	65	65	65	195
Central Indonesia	8	40	40	40	120
East Indonesia	5	25	25	25	75
Other (DGBM, DGRD & Consultants)		10	0	0	10
Total	26	140	130	130	400

Questionnaire Design

The questionnaire used in this study was designed in English then translated into Indonesian. Questions are grouped into three: (i) general questions; (ii) multi-attribute decision-making questions; and (iii) risk analysis questions. The questions are designed to avoid misunderstanding or misinterpretation made by the respondents. There are a total 24 questions with, 5, 15 and 4 questions in section (i), (ii), and (iii), respectively. Most are open questions.

The 5 general questions established: the institution in which the respondents works or represents; the type of road project (*kabupaten* road, village road, or other feeder road);

the type of area (well developed, moderately developed, or remote area); and the location.

Questions in the multi-attribute decision-making section are designed to find out what are the decision attributes taken into account by different groups of respondent. It also determines how they set the ranking of importance as well as the distribution of weightings, amongst attributes. The four broad attributes are economic, technical, socio-political, and environmental. Specific attributes in the economic group include project costs, project benefits, farm productivity, ratio of cultivable area, economic indicators (IRR/NPV/B-C ratio) and other attributes that can possibly be grouped into economic. The technical attributes are the proposed road length, estimated traffic, terrain difficulties, bearing capacity, number of people served, or any other attribute that could be included into this technical group. Socio-political attributes are market accessibility, community welfare, employment generation, and access to either tourism or mining locations. The environmental attributes are accidents, community severance, change in land value, noise and air pollution, and change in land use. The third section is on about risk evaluation. Respondents are asked to state how accurate they can estimate the attributes in the above four broad groups using three distinct levels of accuracy: 1=High; 3=Medium; and 5=Low, or the two intermediate values (2 and 4 on the scale).

Pilot Survey

A pilot survey was conducted in 1995 on 28 participants from BAPPEDA Tk. II (Regional Development Planning Body) attending a Course on Regional Development Planning Techniques and Management, conducted by the University of New South Wales. Most of the provinces in Indonesia were represented. Comments and notes were obtained on the pilot survey. Suggestions on some technical aspects and administration matters of the questionnaire survey were taken into account in the final questionnaire design.

Survey

The mailing of 370 letters and questionnaires was conducted during the second week of March, 1995. A cut-off date for processing the questionnaire responses was set at 20th April, 1995. In order to increase the response rate the following additional features accompanied the questionnaire: a covering letter from the relevant authority - Director of the Institute of Road Engineering, Ministry of Public Works, Government of Indonesia; a covering letter from the School of Civil and Environmental Engineering, University of New South Wales, that outlined the research objectives; and prepaid returning envelopes. Reminder letters were sent.

Response Rate

The overall response rate was satisfactory for this kind of survey with 118 (32 per cent) of questionnaires being returned before the cut-off date. Of this total, 116 (31 per cent)

were valid, with only 2 unusable because of incomplete answers. The highest response was received from *DPUK (Kabupaten* office for public works) which constitute about 39% of total responses, followed by *BAPPEDA* (36%), *DPRD* (18%), Consultants (6%) and *IRE* (1%). All but one province responded to the survey There were 17 returns that were unidentifiable in terms of the province. Of the total records, DKI was among the provinces with the highest response rate (67%) followed by Central Java, West Java, Central Sulawesi and Bali which returned 60, 42, 41 and 40 per cent, respectively, of the mailed questionnaires Provinces in the western region gave better responses by returning 35% of the mailed questionnaires, compared to the central region (28%) and east Indonesia (17%). In terms of role of the stakeholder groups, planners gave a better response (44%) when compare to their colleagues in the executive and community groups - a 30% and a 12.5% response rate, respectively

Hypotheses and Analysis

Hypotheses are stated in the form of statements showing that there is no statistical difference between the preferences from one group of respondents to the other (Table 3). There are three groups of respondents' role (planners, executives, and community), three groups of respondents' origin (west, central, and east), two groups of concerned area (developed and remote), and two groups of road types (*kabupaten* and village road).

Statistical analyses were undertaken to see whether each hypothesis should be accepted or rejected. A summary of the analyses is given in Table 4. Various techniques of analyses were used because there are three different kinds of data: data about determining attributes; data regarding rankings; and data on direct weightings. For data on determining attributes, analysis was done to see whether different proportions of respondents answering *yes* and *no* were observed in deciding the inclusion of an attribute. Analysis was undertaken to measure levels of aggreement within each group on ranking data. With the weighting data, analyses were undertaken to see whether the same means were observed between groups of respondents.

Various comparisons were made across different categorisations of respondents. The comparisons were intended to see whether the responses had been influenced by role of respondents, their region of origin, the type of area concerned, and the type of road concerned. Three different roles of respondents were considered: planners, executives and community. Regions of origin were differentiated into western, central or eastern part of Indonesia. The types of area concerned comprised of two, developed and remote area. While *kabupaten* (district) road and village road were the two types of road concerned.

The detailed statistical analyses undertaken by Widiantono (1995) confirm that there are no significant differences in the preferences of decision variables reported by the categorisation of respondents. With this important finding in mind it is therefore appropriate and worthwhile to develop a model in a general form which is applicable

Table 3 Hypotheses tested based on the survey

Attribute	Working Hypotheses
Group	1. The groups attributes taken into account by all respondents are not significantly different. 2. The ranking of attributes set by all respondents are not significantly different. 3. The weighting of attributes assigned by all respondents are not significantly different.
Economic	1. The attributes taken into account by all respondents are not significantly different. 2. The ranking of attributes set by all respondents are not significantly different. 3. The weighting of attributes assigned by all respondents are not significantly different.
Technical	1. The attributes taken into account by all respondents are not significantly different. 2. The ranking of attributes set by all respondents are not significantly different. 3. The weighting of attributes assigned by all respondents are not significantly different.
Socio-political	1. The attributes taken into account by all respondents are not significantly different. 2. The ranking of attributes set by all respondents are not significantly different. 3. The weighting of attributes assigned by all respondents are not significantly different.
Environmental	1. The attributes taken into account by all respondents are not significantly different. 2. The ranking of attributes set by all respondents are not significantly different. 3. The weighting of attributes assigned by all respondents are not significantly different.

Table 4 Summary of statistical methods of data analysis

Data	Type	Analysis	Statistical Test
Determining attribute	Nominal	Comparing proportions between various groups of respondents	Chi-square test
Ranking	Ordinal	Measuring aggreement within groups	Kendall's coefficient of concordant and Chi-square
Weighting	Interval	Comparing means of weighting between groups of respondents	ANOVA

for any rural road project in Indonesia. However, we caution the model's suitability on Irian Jaya where the survey response rate was low.

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Development of Multi-objective and Multi-Attribute Utility Models

This model development simply translates figures, either in the form of direct weights or ranks determined by the survey instrument, as the coefficients of utility functions in multi-objective models.

Multi-objective Utility Model

Four broad appraisal criteria have been found to be important in rural road planning in Indonesia – economic, technical, socio-political and environmental. These are later broken down into several more specific sub-attributes. The relative importance, or power, of each, as determined from the survey by the decision makers responses to questions, is presented in Table 5. In addition to the four aspects the "remoteness" of the area in which the project might be constructed is considered as a fifth aspect because it was frequently mentioned as an important factor by the decision makers In contrast to the other four aspects it is measured qualitatively by determining whether the area is categorised as a remote area or not. If the area is categorised as remote it is given a score of 100, otherwise 0. The ranks are transformed into their expected values using a technique suggested by Rietveld (1982) It is then desirable to have a combined power of both direct and ranked weights, by adding them up and dividing them by two.

Table 5 Power of aspects associated with a multi-objective utility model for rural roads in Indonesia

Aspect	Direct Weight	Ranks	Weight based on ranks	Combined Power
Economic	0.33	1	0.45	0.39
Technical	0.25	2	0.26	0.26
Socio-political	0.22	3	0.16	0.19
Environmental	0.16	4	0.09	0.12
Remoteness	0.04	5	0.04	0.04

The utility models for the five appraisal criteria are then written as:

a. Direct Weights

$$U = 0.33\, u_1(x_1) + 0.25\, u_2(x_2) + 0.22\, u_3(x_3) + 0.16\, u_4(x_4) + 0.04\, u_5(x_5)$$

b. Based on Ranks

$$U = 0.45\, u_1(x_1) + 0.26\, u_2(x_2) + 0.16\, u_3(x_3) + 0.09\, u_4(x_4) + 0.04\, u_5(x_5)$$

c. Combined

$$U = 0.39\, u_1(x_1) + 0.26\, u_2(x_2) + 0.19\, u_3(x_3) + 0.12\, u_4(x_4) + 0.04\, u_5(x_5)$$

Where:

U = utility score of any single project;
$u_1(x_1)$ = utility score of economic aspect;
$u_2(x_2)$ = utility score of technical aspect;
$u_3(x_3)$ = utility score of socio-political aspect;

$u_4(x_4)$ = utility score of environmental aspect; and
$u_5(x_5)$ = score of "remoteness" (remote area = 100, developed area = 0).

For the six sub-attributes of the economic criterion a similar procedure is applied. Results from the survey allow the relative importance of the attributes – called the "strength" of the attribute (Table 6) – to be established.

Table 6 Strength of economic attributes

Aspect	Direct Weight	Ranks	Weight based on ranks	Combined Power
Costs	0.30	1	0.41	0.36
Benefits	0.18	3	0.15	0.16
Productivity	0.20	2	0.25	0.22
Cultivatable area	0.12	5	0.06	0.09
Economic indicators	0.17	4	0.10	0.14
Other	0.03	6	0.03	0.03

In utility form, the models for the economic attributes are written as:

a. Based on Direct Weights

$$u_1(x_1) = 0.30\,x_{11} + 0.18\,x_{12} + 0.20\,x_{13} + 0.12\,x_{14} + 0.17\,x_{15} + 0.03\,x_{16}$$

b. Based on Ranks

$$u_1(x_1) = 0.41\,x_{11} + 0.15\,x_{12} + 0.25\,x_{13} + 0.06\,x_{14} + 0.10\,x_{15} + 0.03\,x_{16}$$

c. Combined Strength

$$u_1(x_1) = 0.36\,x_{11} + 0.16\,x_{12} + 0.22\,x_{13} + 0.09\,x_{14} + 0.14\,x_{15} + 0.03\,x_{16}$$

Where:

$u_1(x_1)$ = utility score of economic aspect;
x_{11} = normalised score of cost attribute;
x_{12} = normalised score of benefits attribute;
x_{13} = normalised score of productivity attribute;
x_{14} = normalised score of cultivable area attribute;
x_{15} = normalised score of economic indicators attribute; and
x_{16} = normalised score of other attribute.

Having set out the functional form of the multi-objective utility models for either direct weights, ranking or a combination of the two based on economic, technical, socio-political, environmental and remoteness criteria, and the functional forms for the sub-set of economic attributes, it remains straightforward to do the same for the remaining criteria. The relative strengths of the technical, socio-political and environmental factors are given in Appendix A, Tables A1 to A3, recpectively.

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Model Application

An application of the models is demonstrated using a hypothetical but real-world-like, example. A computer program written in Turbo PASCAL was developed for the calculations. The development project scenario is formulated as follows

A rural development proposal prepared by local government in Indonesia includes a plan to construct and upgrade 7 kabupaten roads and 3 village roads. The total length of roads to be built is 93 km. With the construction costs per km ranging between Rp. 75 million to Rp. 140 million. Since the budget for the road sub-sector program is not more than Rp. 5000 million, it is desirable in the prescreening stage to identify a combination of projects which are likely to be feasible within the budget constraint. As an additional constraint, any proposal with a road length less than or equal to 2 km (which lies within the area of influence of other existing roads) is excluded automatically from the analysis.

The practical information to obtain and the preparation of this input data for the model is explained by Widiantono (1995) and Directorate General of Highways (1991, 1994). The input data for the 10 road proposals are summarised in Table 7

Table 7 Input data matrix of rural road projects (hypothetical)

Attributes	Project									
	A	B	C	D	E	F	G	H	I	J
Costs, M Rp./km	100	120	95	110	75	130	140	80	85	105
Benefits, M Rp./year	10	12	10	12	9	11	13	13	9	14
Productivity, ton/ha/year	7	8	6	5	7	8	5	5	6	7
Cultivable, ha/km^2	28	30	25	26	25	35	34	15	20	25
IRR, %	12	10	11	13	8	13	12	9	10	15
Length, km	12	10	8	2	11	15	9	10	11	5
Traffic, veh/day	350	400	200	375	150	420	450	120	100	300
Terrain, m/km	35	40	55	45	70	40	50	55	60	35
CBR, %	6	7	8	5	4	5	6	7	5	6
Pop, Served, persons	1500	2800	1800	2000	1700	2500	1200	1000	1250	1600
Accessibility, farm, market	60	70	56	70	64	80	50	46	72	66
Welfare, people, facilities	3000	5600	3500	4000	3800	4800	2500	2100	2250	3200
Employment, people, jobs	150	250	225	200	175	250	300	75	80	300
Tourism, yes/no	yes	no	no	yes	yes	no	no	yes	no	no
Mining, yes/no	yes	no	yes	no	yes	no	yes	yes	yes	no
Other interest, yes/no	no	no	no	no	no	no	no	no	no	no
Accidents, accidents/year	008	008	003	005	003	013	008	002	002	003
Severance, H-M-L*	L	M	H	M	M	M	H	L	M	H
Land value, H-M-L	L	H	M	L	H	L	H	H	M	H
Pollution, H-M-L	M	M	H	L	H	H	M	L	M	H
Land use, % ratio	6	10	7	8	9	8	10	5	6	7
Isolatedness, yes/no	no	no	no	no	yes	no	no	yes	yes	no

* L = low; M = medium; H = high

Table 8 gives the output of the computer program. Project D is excluded automatically from the analysis since it has a road length 2 km. Since the available budget is only Rp. 5000 million, we cut the list off after project A. From the figures in the table if we were

to maximise the economic objective, the best five projects would be : E, J, H, I and A. Alternatively, if we optimise the selection based on the technical score the projects are: B, J, F, G and A. Different results are obtained for socio-political and environmental objectives. It is clear that the objectives conflict. The model is structured to compromise these conflicting objectives by optimising the generalised utility score. Thus, the decision implication in this approach is to include the following projects into the program and conduct a further in-depth study (a feasibility study or an environmental impact assessment should that be required under legislation) for each of them: Project B; Project E; Project J; Project H; and Project A.

Table 8 Ranking of priority of the proposed projects

Rank No.	Project Name	Score					Cumulative Budget
		Economic	Technical	Socio-pol.	Envl/tal	Overall	
1	B	67.73	85.46	74.80	76.68	72.06	1200.0
2	E	82.31	41.12	78.08	80.36	71.44	2025.0
3	J	78.61	77.36	61.39	66.21	70.41	2550.0
4	H	77.19	43.75	56.27	86.55	66.73	3350.0
5	A	74.50	67.31	70.48	50.88	66.05	4550.0
6	C	72.70	61.51	64.59	57.26	63.55	5310.0
7	F	65.15	72.67	73.17	36.95	62.52	7260.0
8	I	74.63	38.40	54.34	68.55	61.75	8195.0
9	G	52.67	71.93	60.50	68.83	59.01	9455.0

Note: --- budget cut-off constraint

Conclusions

The paper has described the analysis method, the interpretation of results, the development of models as well as the application of the model of the decision making framework for rural road projects in Indonesia. The statistical analysis of the questionnaire data obtained from 116 decision makers in Indonesia came up with the conclusion that there is no significant differences in the preferences of attributes amongst the various groupings of respondents. This finding leads to the possibility of using a general model for every rural road project across Indonesia without introducing undue bias. Most of the decision makers think that they can estimate the decision variables with a satisfactory level of accuracy, and this adds confidence to a general multi-attribute model being applied in practice.

Using a hypothetical example, the application of the model to the real world has been demonstrated. Although the procedure is quite simple, a computer program had been developed in Pascal to facilitate the calculations. For any specified rural road budget constraint, projects are ranked according to their performance in meeting the economic, technical, socio-political and environmental attributes. In Indonesia road engineering practice, the magnitude of the development task requires more rigorous methods for the initial screening of projects to ensure economic efficiency, environmental compatibility and social equity. The methods developed in this research project were applied by Bina Marga as part of their planning responsibilities.

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71.44	2025.0
70.41	2550.0
56.73	3350.0
56.05	4550.0
53.55	5310.0
52.52	7260.0
51.75	8195.0
59.01	9455.0

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Appendix A

Table A1 Strength of technical attributes

Aspect	Direct Weight	Ranks	Weight based on ranks	Combined Power
Road length	0.20	3	0.15	0.18
Traffic volume	0.24	1	0.41	0.32
Terrain rise/fall	0.16	4	0.10	0.13
Tonnage capacity	0.14	5	0.06	0.10
Pop. Served	0.23	2	0.25	0.24
Other	0.03	6	0.03	0.03

Table A2 Strength of socio-political attributes

Aspect	Direct Weight	Ranks	Weight based on ranks	Combined Power
Accessibillity	0.27	2	0.25	0.26
Welfare	0.28	1	0.41	0.34
Employment	0.16	3	0.15	0.16
Tourism	0.13	4	0.10	0.11
Mining/Industries	0.12	5	0.06	0.09
Other	0.04	6	0.03	0.04

Table A3 Strength of environmental attributes

Aspect	Direct Weight	Ranks	Weight based on ranks	Combined Power
Accidents	0.23	2	0.25	0.24
Severance	0.21	4	0.10	0.16
Land-value	0.19	3	0.15	0.17
Pollution	0.11	5	0.06	0.08
Landuse change	0.22	1	0.41	0.31
Other	0.04	6	0.03	0.04

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