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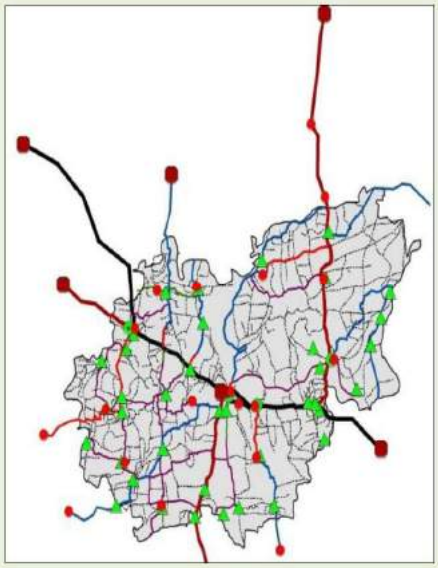
Planning and Prioritisation of Rural Roads in Bangladesh

Final Report – Volume 1



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Mr. Md. Mashrur Rahman using
LGED's GIS Database

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Acronyms, units and currencies

AADT	Average Annual Daily Traffic
AHP	Analytic Hierarch Process
APS	Agricultural Product Surplus
BC	Bituminous Concrete
BDT	Bangladesh Taka
BRTC	Bureau of Research Testing and Consultancy (at BUET)
BUET	Bangladesh University of Engineering and Technology
CARE	A non-profit public charity
CBA	Cost Benefit Analysis
CC	Cement Concrete
CVD	Commercial Vehicles per Day
DURP	Department of Urban and Regional Planning
EIRR	Economic Internal Rate of Return
FRB	Feeder Road Type B
GBP	Great Britain Pound
GIS	Geographical Information System
GoB	Government of Bangladesh
HBB	Herring Bone Bond (brick pavement)
HDM	Highway Design and Maintenance Model
HQ	Head Quarters
LGED	Local Government Engineering Department
LGI	Local Government Institution
IRAP	Integrated Rural Accessibility Planning
IRI	International Roughness Index
MCA	Multi-Criteria Analysis
MST	Minimal Spanning Tree
NH	National Highway
NMT	Non-motorised Transport
NPV	Net Present Value
PCU	Passenger Car Unit
PHF	Peak Hour Factor
PMGSY	Prime Ministers Rural Roads Scheme (in India)
RCC	Reinforced Cement Concrete
RDBMS	Road Database Management System
ReCAP	Research for Community Access Partnership
RED	Roads Economic Decision Model
RHD	Roads and Highways Department
RPPM	Rural Road Planning and Prioritisation Model
RSDMS	Road and Structure Database Management System
RR1	Rural Road Type 1
SCF	Shadow Price Conversion Factor
SDG	Sustainable Development Goals (of the United Nations)
SFYP	Seventh Five Year Plan
TTCS	Travel Time Cost Saving
ToR	Terms of Reference
ToT	Training of Trainers
UCS	User Cost Saving
VOCS	Vehicle Operating Cost Saving
VPD	Vehicles per day
WG	Working Group

Terminologies

Analytic Hierarchy Process (AHP)	An analytical procedure to determine the relative importance of a number of criteria or factors considering the opinion of experts.
Cost Benefit Analysis (CBA)	A procedure for evaluating the desirability of a project by comparing its total benefits with total costs. Results may be expressed in many ways including Economic Internal Rate of Return (EIRR), Net Present Value (NPV), and Benefit Cost Ratio (BCR).
Earth Road	An unpaved road with bare earth surface made from the soil of the land surface through which it passes; generally built on a raised embankment; commonly known in Bangladesh as “Kutcha rasta”. LGED usually uses the term ‘‘Earthen Road’’ for such roads.
Multi-Criteria Analysis (MCA)	A procedure for appraising the total effect of a number of criteria or factors considering their relative importance.
Passenger Car Unit (PCU)	is an equivalence measure of the impact that a transport mode has on traffic flow compared to a single standard passenger car.

Contents

Executive summary

Introduction

There are about 353,000 km of rural roads in Bangladesh. The Local Government Engineering Department (LGED) in collaboration with Local Government Institutions (LGIs) manage all rural roads in the country. The rural roads connect some 87,000 villages with Zila, Upazila and Union HQs and other important market centres, as well as the National and Regional Highways and Zila roads managed by the Roads and Highways Department (RHD).

As of September 2017, about 97,000 km of rural roads are paved; the rest are undeveloped earth roads. Many Upazila and Union roads or parts of them are still unpaved. The Government has a policy to improve such Upazila and Union roads. Also, many villages are yet to be connected by an all-weather road.

LGED spends a considerable amount of resources for the development of rural roads. There is a need to develop a planning and prioritisation methodology for the development and maintenance of rural roads on a sustainable basis. Such a methodology also can enhance the planning and decision-making capacity in LGED.

The main objectives of this study include:

- development of a methodology on planning and prioritisation of rural roads;
- development of an application tool (software) to implement the methodology; and
- production of a user manual and training of 15 professionals to use the application tool.

This report provides the details of the planning and prioritisation methodology and discusses the results generated by the application tool for the pilot district Tangail.

Methodology for planning and prioritisation of rural roads

The methodology has two major components. The first component follows a network approach to rural road planning focussing on access and connectivity; and the second component involves prioritisation of road development based on the outcomes of Cost Benefit Analysis (CBA) and Multi-Criteria Analysis (MCA). Both the components include local stakeholders' participation. The methodology was generalised, as much as possible, to make it applicable in other districts.

Government policies and objectives, similar to national programmes in other countries, were considered to develop core networks of rural roads at the upazila and union levels. The core networks can enhance rural accessibility and ensure connectivity within an upazila and its neighbouring upazilas. All Upazila and Union roads, some important Village roads and national roads under RHD, if any, form the core network in an upazila. In the prioritisation scheme, roads in the core networks were given additional importance for their development. The market/activity centres form the nodes, and RHD roads, Upazila and Union roads and selected village roads connecting them are the links of the core network.

Prioritisation methodologies were developed for three types of road development works namely, improvement, further improvement (upgrading of an existing paved road) and maintenance of rural roads. The definitions of these three terms are as follows:

Improvement

- converting an earth road to a paved road i.e., from earth to Bituminous Concrete (BC)/ Reinforced Cement Concrete (RCC) in an existing alignment;
- converting a partly paved road to a fully paved road; and
- converting a Herring Bone Bond (HBB) road to a fully paved road.

Further improvement/Upgrading

- improvement of road geometric standards, raising of embankment and widening of pavement and/or road crest and raising of road embankments of an existing road.

Maintenance

- maintenance of an already paved or partly paved road (BC, RCC or HBB).

The methodology considers priority appraisal of all rural roads in an upazila for their development and/or maintenance. For this study, maintenance is considered only for paved and partly paved roads. The maintenance of unpaved rural roads generally is undertaken by LGIs under other programmes of the government according to needs.

Two appraisal methodologies namely, CBA and MCA were developed for the study. A simplified CBA methodology was developed to estimate the economic benefits of road development considering the availability of data mainly from the road database of LGED and data from LGED and other secondary sources. The CBA model estimates Economic Internal Rate of Return (EIRR) values for roads that require improvement or further improvement/upgrading.

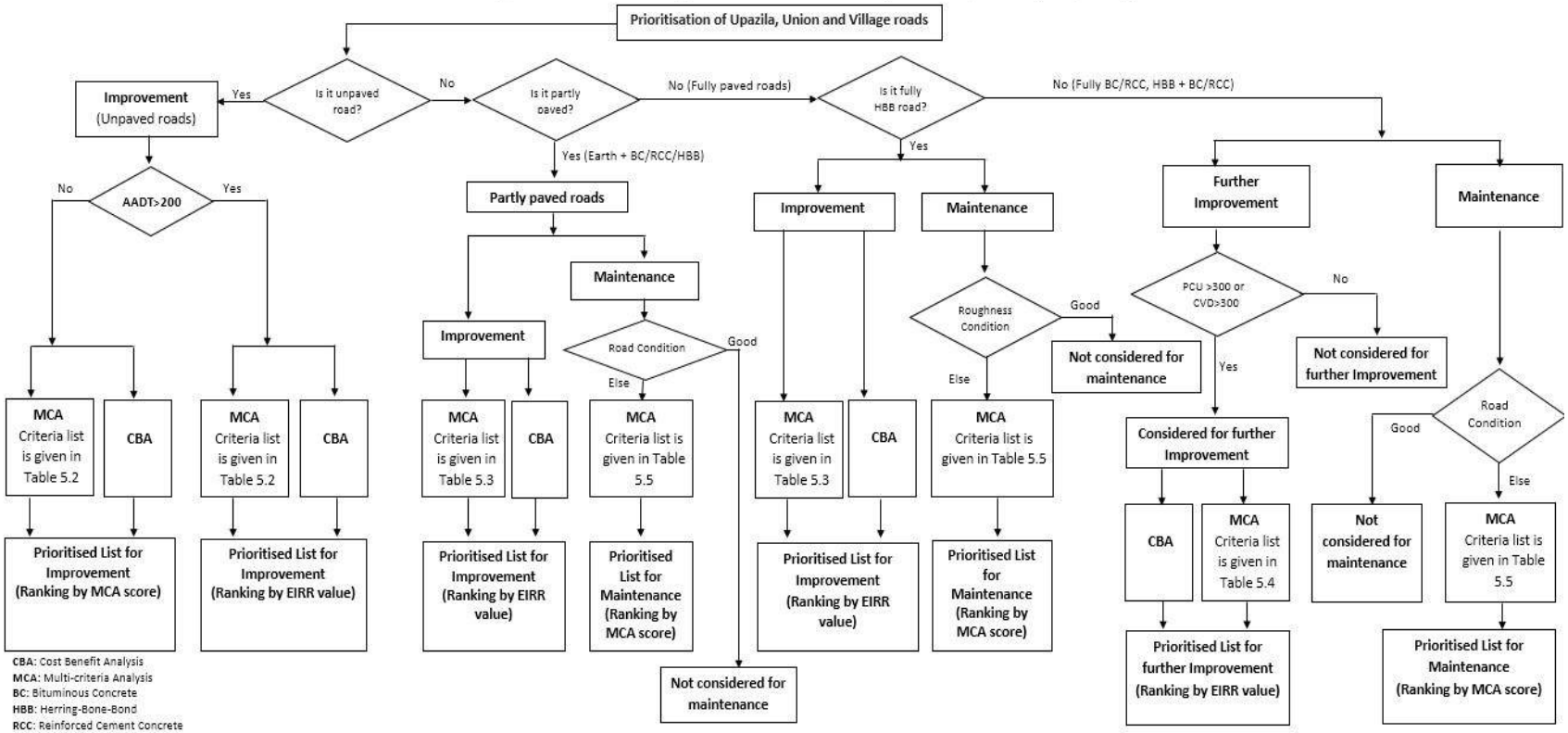
An MCA procedure was developed to consider the access and connectivity benefits of rural roads which are not well reflected in CBA, especially for very low-volume roads. The criteria considered for MCA include, among others, traffic volume, number and types of socio-economic facilities, growth centre and rural markets served, connectivity and local priority.

The applicable criteria for each of type of road development were selected from among a list of potential criteria by conducting an Analytic Hierarchy Process (AHP) survey among the stakeholders including experts and LGED officials. The selected criteria were reviewed and agreed by the Working Group (WG) at a meeting. The same AHP technique was used to determine the relative importance or weights of the selected criteria. Finally, the selected criteria and their weights were reviewed by LGED officials including members of the WG, discussed and agreed.

The MCA results complement the CBA results (EIRR values), especially for low volume roads. A high MCA score of a road reflecting its significant access benefits may also justify its priority for development even if the EIRR value is low.

The selection of roads for different types of development follows the decision tree in Figure 1. It also shows whether MCA scores or CBA results (EIRR values) are used to generate priority lists of roads for each type of development. The priority ranking for improvement and further improvement/upgrading of roads are based on their EIRR values except for low volume earth roads. MCA scores are used for priority ranking of low volume earth roads and priority for periodic road maintenance.

Figure 1: Decision tree showing selection of roads for development and priority ranking



The methodology has the following important features. It considers government strategies and policy objectives related to rural roads. The policy objectives focussing on rural access are used to generate core road networks, which can enhance rural access and ensure intra- and inter-upazila accessibility.

All types of road development works undertaken by LGED are considered within a single planning framework following a consistent approach to appraisal of priority.

The methodology combines the top-down and bottom-up approaches to planning. The organisation of local workshops is an important element of the methodology. Local stakeholders validate the core network. They can also define local priorities considering Sustainable Development Goals (SDG) 9.1 target set by LGED and other local priorities, identify potential roads for further improvement/ upgrading and evaluate the connectivity status of the roads in the core networks.

The planning and prioritisation application tool (software)

A web-based application tool, Rural Road Planning and Prioritisation Model (RPPM), was developed to implement the methodology. The application tool has been implemented on the Geographical Information System (GIS) portal of LGED. Its integration with the GIS portal facilitates mapping and generating road priority outputs from the web platform. RPPM can generate core road networks at the upazila and union levels, and appraise the priority of rural roads for their development including their ranking based on CBA and/or MCA outcomes.

Considering its representativeness, Tangail was selected as the pilot district to test the methodology and working of RPPM. The methodology was applied in 12 upazilas of the district. RPPM calculated MCA scores and EIRR values as expected.

The successful application of the methodology for the pilot district validated its applicability and the working of RPPM. The methodology can be applied to other districts of Bangladesh and RPPM can be used to generate core networks and priority lists for road improvement and maintenance.

RPPM uses data mainly from the databases of LGED. However, two new tables are required to be added to the road database for use by RPPM. The first table contains some additional data on connectivity and local priority. These data are required for MCA. The second table contains values of vehicle operating cost (VOC), travel time cost (TTC), speed, average occupancy and Passenger Car Unit (PCU) values by vehicle type, which are required for undertaking CBA. Before running the application for another district, these two additional tables will have to be created and added to the road database for that district. The data values in the first table are to be collected by organising local workshops. The second table will be the same for other districts.

LGED maintains two databases: the road (and structure) database - RSDMS and the GIS database. These two databases are not fully integrated. If they are fully integrated, the wealth of information available in them may be effectively used in undertaking many useful interactive analyses relevant to rural road development and other development purposes. Some other government departments may also benefit from such analyses in preparing their development plans. Although it may require considerable amount of time, resources and efforts to integrate the two databases, it would be worth considering such investment given its huge potential use in development planning.

1 Introduction

1.1. Background and context of the study

The majority of the people of Bangladesh lives in rural areas. There are some 87,000 villages, 4,553 unions, 491 upazilas (sub-districts) and 64 zilas (districts) in the country. A network of about 353,000 km of rural roads connects the villages with union, upazila and zila headquarters, important market centres and national roads and highways. There are three types of rural roads: Upazila Road, Union Road and Village Road (types A and B). According to their definitions, all rural roads are officially categorised into one of these road types.

The Local Government Engineering Department (LGED) in collaboration with Local Government Institutions (LGIs) manage all rural roads which form more than 94% of total roads in the country. There about 63,244 km of type B Village roads that are less than 2 km in length. The Government has transferred the responsibility of managing these roads to LGIs. The Roads and Highways Department (RHD), the national highway authority of Bangladesh, manages a network of national roads and highways of about 21,500 km.

Table 1.1 shows the current status of rural roads in Bangladesh. Bangladesh has a relatively high density of rural roads of about 2.53 km/sq. km; for example, the national average of road density in the Philippines is 0.62 km/sq. km. However, the major part of the network (about 72%) comprises of undeveloped earth roads; many of them have 'gaps' where bridges/culverts are required to be built. The shares of road length by broad types are shown in Figure 1.1.

Table 1.1: Status of rural roads in Bangladesh (as of September 2017)

Rural road type	Number of road				Road length by surface type (km)				Total number (km)
	Fully paved (BC)	Fully paved other	Partly paved	Earth road	Earth road	Flexible pavement (BC)	Brick paved	Rigid pavement CC/RCC	
Upazila Road	2,713	544	1,347	177	6,618	28,103	2,095	703	4,781 (37,519)
Union Road	2,094	789	3,881	1,259	17,902	19,086	4,026	667	8,023 (41,680)
VR Type A	4,474	2,685	11,654	29,056	98,575	19,169	8,683	1,001	47,869 (127,427)
VR Type B	3,031	2,832	9,392	74,750	132,958	7,089	5,690	579	90,005 (146,316)
Total	12,312	6,850	26,274	105,678	256,051	73,447	20,494	2,951	150,678 (352,943)

Source: Road and Structure Database Management System (RSDMS), LGED.

Notes: VR = Village Road; BC=Bituminous Concrete; CC=Cement Concrete; RCC: Reinforced Cement Concrete. The figures in the last column correspond to the figures mentioned in the Government's Gazette notification No. 11469 of 29 October 2017.

Fig 1.1(a): Share of road length in km by road type

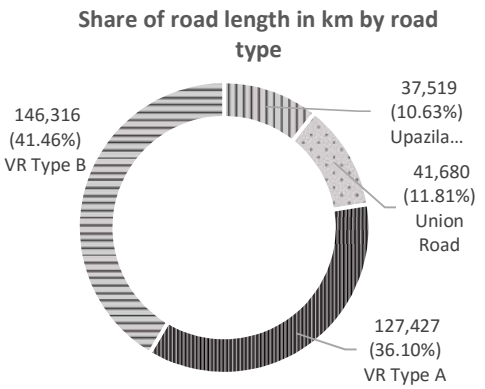
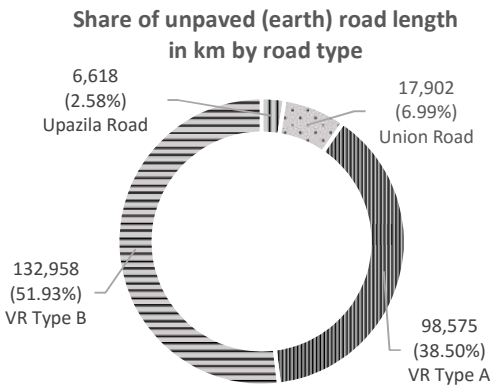


Fig 1.1(b): Share of unpaved (earth) road length in km by road type



Source: Based on data from RSDMS, LGED

The transport demand for passenger and goods has increased manifold over the years due to consistent growth of the national economy between 6 - 7% per year. Consequently, many rural roads, originally built for low volume light traffic, are found inadequate and substandard to cope with the growth of traffic.

LGED spends a considerable amount of resources for the improvement and maintenance of rural roads. It has already developed a network of about 76,000 km of paved roads and about 20,000 km of brick paved roads which may be paved in the near future. Further development should be selective based on a planning and prioritisation methodology so that the road network can enhance rural accessibility at all levels and be sustained and properly maintained over a longer term.

1.2. Objectives of the research study

The main purpose of this research study is to develop a planning and prioritisation methodology to identify rural roads that should be prioritised for development and maintenance to enhance rural accessibility and connectivity with the greater region.

The main objectives of this study are:

- development of a methodology on planning and prioritisation of rural roads;
- development of an application tool (software) to implement the methodology; and
- production of a user manual and training of 15 professionals to use the tool.

The prioritisation methodology should not be based solely on the traditional economic appraisal of roads. Other important criteria such as, connectivity with higher order roads, benefits from improved access to socio-economic facilities and other factors which can contribute to people's welfare should also be considered.

The methodology to be developed should be generalised, as much as possible, to be applicable to all over Bangladesh. The methodology should be simple and easy to use and must not require any vast amount of additional data collection. They should be integrated with the existing databases of LGED so that visualisation of the prioritisation results may be possible. Considering its representativeness, Tangail was selected as the pilot district to test the methodology.

It is expected that the outcomes of the research study will enhance the decision-making capacity in LGED regarding selection of rural roads for development and maintenance.

1.3. Scope of the report

The study started on 7 April 2016. An inception report was submitted on 5 May 2016. The First Stakeholder Workshop was held in August 2016. In the following six months the Project team developed a methodology for the study and conducted field studies in the pilot district. After that a web-based application tool Rural Road Planning and Prioritisation Model (RPPM) was developed and implemented.

This report provides the details of the planning and prioritisation methodology and discusses the results generated by RPPM for the pilot district.

1.4. Organisation and contents of the report

The report is organised in two volumes. Volume 1 presents the main text of the report including an executive summary, the planning and prioritisation methodology and discussion on results. There are eight chapters in this volume. Chapter 1 provides the background, objectives, and deliverables and milestones of the project. Chapter 2 is on the major phases and management of the project. Chapter 3 provides a review of methodologies on rural road planning and road development programme in Bangladesh and other countries. Chapter 4 is on the study area. The details of the planning and appraisal methodology developed for the study is presented in Chapter 5. Chapter 6 is on local level workshops. Chapter 7 discusses the results; and finally, Chapter 8 presents some conclusions and recommendations.

Volume 2 contains annexures, reports of local workshops in 12 upazilas of the pilot district, and outputs generated by the application tool for 12 upazilas of Tangail.

2 Major phases and management of the project

This chapter outlines the major phases of the work and how the project was conducted and managed.

2.1. Main phases of the work

2.1.1. Conceptualisation of the study

Consultation meetings were held with LGED officials at Dhaka and field offices and other stakeholders to have a better understanding about LGED's requirements, government policies and objectives, current appraisal practices, and availability of relevant data and information. All meeting reports and officials met are available in Annex D and Annex E of Volume 2. The consultation meetings helped the project team to develop a preliminary methodology for planning and prioritisation of rural roads.

The project team also made a field visit to know more about the work of LGED in the context of the project, how data was collected by LGED, and availability of data and to collect some information.

2.1.2. Developing a methodology to meet the requirements of LGED

There were two main challenges in developing a methodology for the research study. The first one was to decide a priority appraisal procedure(s) for different types of road development works undertaken by LGED. The other challenge was that the methodology should be centred on the idea of developing an application tool that is easy to use, makes best use of the available data from the existing databases and can enhance decision making capacity in LGED. The steps followed to develop a methodology included:

- review of current appraisal practices in Bangladesh and other countries;
- feedback from meetings/workshops and consultation with LGED officials;
- understanding the Road and GIS databases of LGED;
- feedback on the draft methodology; and
- suggestions, guidance and advice received from the Working Group (WG) meetings.

The project team also considered the technical details of how the proposed computer program could be implemented as a web-based application tool.

2.1.3. Preparing the details of the methodology and data collection

A major task was to prepare the details of the methodology so that a computer program could be developed. This included the development of an overall algorithm and details of calculation to derive the required appraisal results. Data requirements for the computer program were established after deciding the details of the appraisal methodologies and considering the availability of data from the road database and other secondary sources.

Survey instruments were designed to collect data for the appraisal methodologies. A meeting was organised with Upazila Engineers in Tangail to discuss the survey instruments and organisation of local workshops. Following which, surveys among LGED officials at the headquarters and field offices, experts and local stakeholders were held. Local workshops were conducted in 12 upazilas of the pilot district to collect additional data, and to test and implement the methodology. The details of the local workshops are presented in Chapter 6. The survey instrument is shown in Annex G, Volume 2.

2.1.4. Preliminary program development

A computer program was developed to implement the planning and appraisal methodology. Each module of the program was tested separately to verify the outputs by comparing results with spreadsheet generated outputs. A review of the preliminary outputs was undertaken by LGED officials. Changes in the program and format of outputs were made considering the feedback from LGED.

2.1.5. Refinement, finalisation and implementation of the computer program

After refinement of the program it was implemented on the GIS portal of LGED as a web-based application tool. The WG and other LGED officials reviewed the results generated by the program and working of the application tool on the portal. Further changes were made to some user interfaces of the computer program, format of outputs and graphics of maps considering their suggestions.

2.2. Project implementation arrangement

The Department of Urban and Regional Planning (DURP) took the main responsibility in implementing the project. DURP in collaboration with the Departments of Civil Engineering and Computer Science and Engineering at BUET, and LGED have implemented the project. LGED provided direct support to the project team in undertaking field studies in the pilot district.

DURP prepared an overall work plan and monitored the progress of project implementation. It was also responsible for overall coordination and implementation of all project activities including liaison with LGED and other stakeholders, and organisation of local workshops. Designated counterparts at BUET and LGED facilitated coordination in organising project activities including organisation of meetings. Informal consultation groups were established at DURP and LGED to exchange information, and work out details on matters, as required.

Besides the scheduled workshops and meetings, extensive consultations were held with LGED experts, policy makers and other stakeholders to receive their opinion and feedback at different stages of project implementation including finalisation of the methodology and the computer program.

2.3. Monitoring the progress of implementation and quality assurance

DURP prepared an overall work plan, taking into account the identified risks and monitored the progress of project implementation.

LGED established a WG to ensure the quality of project outputs and assist in the implementation process. The WG provided overall guidance and assistance in implementation of the project, considered the intermediate outputs especially the proposed methodology and outputs and gave necessary advice to the project team as required. The project team also received feedback on initial outputs from senior officials of LGED which helped to finalise the computer program.

2.4. Risk management

Several risks were identified in implementing the project. The major risks were related to development and implementation of the application tool in time. The other risks were related to delays in field work due to natural hazards or other reasons. Appropriate mitigation measures were considered for all risks. To minimise the risk of computer program development, additional advisory services were considered to review the concept and structure of the program, and its linkage with the GIS web portal

of LGED. Furthermore, the program was developed module by module and each module was tested before developing the next one. The work plan considered the field work schedule at times when the risks of natural hazards were low and LGED officials were available.

3 Planning and prioritisation methodologies in Bangladesh and other developing countries

3.1. Introduction

Rural road development has been a major focus of rural development for many decades. In the 1950s and 1960s, rural infrastructure development, particularly rural roads, was taken as the starting point of economic development in many developing countries. In recent times, some countries have introduced more broad-based programmes to extend basic infrastructure such as rural roads, irrigation and water supply, soil conservation and social facilities in remote and poverty-stricken areas. Bangladesh, India, Malaysia, Nepal, Pakistan, the Philippines, Sri Lanka and Thailand have all introduced such programmes.

Research studies have considered different approaches in addressing the planning, policy and methodological issues concerning the definition, identification, selection and evaluation of rural roads. The national programmes in countries also differ in their approaches to selection and appraisal of rural roads for making investment decisions. This chapter presents a review of such approaches and considers some useful considerations from such reviews to develop a planning and prioritisation methodology for rural roads in Bangladesh.

3.2. Broad categories of planning and prioritisation methodologies

A literature review on rural road planning in developing countries reveals that such methodologies may be grouped into five broad categories.

1) MCA (also known as Prioritisation Ranking, or PR, techniques).
2) Economic analysis (Cost Benefit analysis also referred to as Benefit Cost analysis).
3) Participatory approaches.
4) Network planning models based on optimisation techniques.
5) Hybrid methodologies - combination of multiple methodologies on road planning.

In the context of the present study, these five broad categories are discussed below.

3.2.1. Multi Criteria Analysis (MCA)

MCA or Prioritisation ranking (PR) techniques of rural roads have been widely used for the selection of rural road projects in many countries. The ranking of projects is based on a set of criteria reflecting policy or social objectives of the government. Such criteria may or may not include cost variables but may include criteria such as population served, improvement of access to markets and services, impacts on natural systems, traffic volume, social and economic welfare etc. After selection of factors, their relative weights are established. The use of AHP is common for the establishment of relative weights of the criteria. Finally, the priority score of each road project is calculated by summing the product of the normalised value of each criterion by its weight.

Many good examples on application of MCA can be found in the literature, for example, ESCAP (1979), Greenstein and Bonjack (1983), UNCHS (1985), Lebo and Schelling (2001), Hine et al. (2003), Bhandari et al. (2014), and Philippine Rural Development Project (2015, pp. 11-13).

The MCA methodology is used to rank rural road investments, and is typically applied when traffic volumes are too low to apply the conventional CBA but there is a strong belief that there will be important social benefits from improvement of access and connectivity.

It is important to note here that in addition to such benefits, there are impacts of road investment on socio-economic development, or the so-called indirect and induced benefits. Alternative impact assessment methods may be used to assess such benefits. This can be supported by additional data collection methods through which the proposed impact of rural road investments can be estimated and measured by obtaining views from communities with respect to the expected impact on socio-economic conditions on communities. A study by Ahmed and Hossain (1990) in Bangladesh is a good example for such impact assessment.

Generally, indicators used in MCA implicitly reflect economic and subjective evaluations (Lebo and Schelling, 2001). If the weights and factors are decided upon and allocated in a participatory way, MCA has the potential to be a participatory planning method (see discussions below on participatory approach). The MCA methodology should not be applied without consultation with the concerned users and stakeholders. The outcome of the MCA methodology can become non-transparent, especially if too many factors are considered and a complicated formula applied to determine an index value or priority score. Therefore, as suggested by Lebo and Schelling (2001), if adopted, this method should be kept simple, transparent, and participatory.

Despite all the advantages of MCA, its main caveat is the inability to compare the benefits with respect to the costs. In order to address this problem, Gühnemann et al. (2012) developed an integrated approach where they combined CBA and MCA for effectively evaluating road development projects. With this approach the strengths of both methods are retained.

3.2.2. Economic analysis (Cost Benefit Analysis)

The application of CBA has been widely adopted in analysing the merits of road investment projects in both developed and developing countries including Bangladesh. CBA has been popular among the decision makers as it provides a systematic framework to evaluate costs and benefits of a project. In short, CBA identifies and estimates in monetary terms costs and benefits of a project during its (economic) lifetime, discounts them to a reference point in time (generally the present year), and compares to see if the summation of the Net Present Value of Benefits (NPVB) exceed the summation of Net Present Value of Costs (NPVC). The commonly applied assessment criteria for project selection include, Benefit Cost Ratio, Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, etc.

There are several approaches to estimate the benefits of road development. The User Cost Saving (UCS), Vehicle Operating Cost Saving (VOCS) and Travel Time Cost Saving (TTCS), and Agricultural Product Surplus Method (APS) are among such conventional approaches. However, in recent years, the most commonly applied CBA methodology follows the VOCS and TTCS approach. This approach has also been applied in Bangladesh for many road infrastructural development projects (for example, PRMIMP-II, RDP, TRIDP, RDP-24, RIIP-I and RTIP).

Due primarily to its wide application and popularity among decision makers, several computer based CBA models have been developed to provide a harmonised approach to economic evaluation of road projects. One of the most well-known such model is the Highway Design and Maintenance Standards Model (HDM) developed by the World Bank. Based on the outcome of large field studies and earlier empirical research, a comprehensive model known as HDM-III was introduced in 1980s. However, this model had many limitations and became outdated because of change in vehicle operating cost as vehicle technology had improved dramatically after 1980. It was recognised that vehicle operating costs could be much less than those predicted by HDM-III models.

HDM4 was developed to address the limitations of the HDM-III model. HDM4 may be used as the primary tool for the analysis, planning, management and appraisal of road maintenance, improvements and investment decisions. However, HDM4 has also limitations for its use as a tool for rural road planning and development. Although HDM4 is customised for low volume unpaved roads, many authors and practitioners dispute its effectiveness for the economic evaluation of such roads. The model also requires data inputs which may be impractical to collect for rural roads (Archondo-Callao, 2004).

The World Bank developed a separate economic evaluation model, the Roads Economic Decision (RED) model, suitable for the characteristics and needs of low volume rural roads. The model is adapted for low-volume unpaved roads, with traffic volumes between around 50 and 300 vehicles per day. The model performs an economic evaluation of road investment options using the consumer surplus approach and is customised to the characteristics of low-volume roads such as the high uncertainty of the assessment of the model inputs (Archondo-Callao, 2004).

Despite its popularity and wide application, CBA has many serious limitations which are well documented in the literature. The conversion of nonmonetary costs and benefits into monetary values is not without controversy. Another major criticism is that CBA is essentially an economic efficiency criterion; it does not consider equity or fails to capture government's policy objectives, for example, social and economic wellbeing of people. There are also other difficulties in applying CBA; some of these include, obtaining reliable information on costs, estimating the costs and benefits of externalities, limitations in demand forecasting, and accounting for the impacts outside the geographical scope of the project. Also, the CBA methodology may not be suitable for low-volume rural/village roads. Due to low base demand typical CBA analysis for such roads may not produce results that may be used for investment decisions.

However, as mentioned in the previous section on MCA, CBA may also be combined with other methodologies to overcome some of its limitations as well as to make the methodology more appropriate in a given context, for example, the Second Phase of Rural Roads Markets Improvement and Maintenance Project (RRMIMP-II) in Bangladesh which was implemented in 21 districts of the country (LGRDC, 2002). More details are provided in section 3.3.

3.2.3. Participatory approaches

Participatory approaches to planning increases the likelihood that actions taken or services provided by public agencies more adequately reflect the needs of people. Public participation is understood as a process in which all concerned stakeholders including the beneficiaries and affected people are involved in decision-making about development works. Considering the merits of such approaches models have been developed for planning of infrastructure facilities and various public services. In the context of rural infrastructure development probably the most well-known is the Integrated Rural Accessibility Planning (IRAP) methodology developed by the International Labour Organisation (ILO).

IRAP is an area-based planning process to identify the actual access needs of the local communities and define and prioritise interventions to improve access. Interventions to either improve rural mobility (such as roads, bridges and tracks) or improve the distribution of facilities and services (such as water supplies, schools and health centres). The whole process is participatory and involves the local communities and local government officials representing the different sectors.

Further details of the model can be found in Donnges (2001) and elsewhere. The IRAP methodology has been applied in the Philippines and many other countries for village level accessibility planning. Sarkar and Dash (2011) developed a modified version of IRAP and applied it in India. The major

limitation of the participatory approach to planning is that it requires an institutional setting to apply the approach. In the absence of such an institutional setting, as in the case of Bangladesh, there is little chance of executing such approach or implement the outcome of any such exercise. These approaches are more suitable in situations where local level planning is fully institutionalised within local bodies.

3.2.4. Network planning models based on optimisation techniques

CBA and Prioritisation Ranking (PR) or MCA techniques may not be always suitable for the selection of rural road projects. In both the cases there is an implicit assumption of project independence. However, this assumption may not be valid especially in the early stage of rural road network development. A particular road (or link) in the network may not get priority for development considering its own merits but could be a vital link of the network. Without its development the network as a whole may only be partially functional and therefore of limited utility to the people. In other words, the functional utility of many roads in the network and the network as whole are dependent on this particular road of lesser priority.

Researchers have applied some network development models such as the Minimum Spanning Tree (MST) and other network development models (which are based on Graph Theory) to address this issue of independence. In short, an optimum network of roads is identified by applying the MST model which minimises the total length of the road network in connecting all villages with the nearest market/service centre by linking the village directly with that centre, or to another village which is already connected to such a centre, or to an existing road link which in turn serve as a link to a centre. Good examples of network development models in rural areas of Bangladesh and Nepal can be found in Oudheusden and Khan (1987) and Shrestha et al. (2013).

The major limitation of such models is that if the network is already developed more than the basic minimal network to connect all market/service centres, as would be the case in most parts of Bangladesh, such models do not work well. Another limitation is that because of their analytical sophistication, usually it may not be easy to apply such models in, or generalise for all situations.

3.2.5. Hybrid methodologies – Combination of multiple methodologies

All of the broad categories of methodologies discussed above have their weaknesses as well as advantages over the other categories. In many respect, the suitability of these methodologies also depends on the context or situation. In order to overcome their methodological weaknesses, especially in a given context, often a combination of methodologies has been suggested by researchers. For example, Guhnemann et al. (2012) combined MCA and CBA to capture the best of both. In another example, Shrestha (2003) in his methodology for district road network planning and prioritisation in Nepal has used a network planning model, CBA, and a prioritisation index based on four criteria (agricultural potential, interaction, accessibility and environmental impact).

Another strand of work found in the literature is the application of GIS-based models incorporating accessibility planning. For example, Singh (2010) developed a methodology for rural road network planning model for developing countries. The model is based on the concept of accessibility and was applied in Paithan Taluka, India. An index of accessibility was designed which evaluated various rural road link options for their efficiency in accessing the missing functions in the unconnected settlements. A GIS-based technique for the analysis of alignment of new road link options was developed which considered the topographic and land use characteristics of the area. This approach offered maximum benefit to the unconnected settlements in terms of access to various facilities or the main road network.

3.3. Planning and prioritisation of rural roads in Bangladesh: current practice

In the past, simple appraisal methodologies were developed for several donor-funded projects for the estimation of benefits of road improvement in the project areas. For example, an appraisal methodology was developed to prioritise Feeder Road type Bs (FRB[1]) and important Rural Road RR1s[2] for improvement and maintenance under the Second Phase of Rural Roads Markets Improvement and Maintenance Project (RRMIMP-II) which was implemented in 21 districts of Bangladesh (LGED, 2002). The consultants identified six factors important for prioritisation of roads. However, due to the limitations of data, finally two criteria were used for prioritisation: community ranking and Benefit-Cost Ratio. A common limitation of these methodologies was that they were developed for particular projects and was not considered for the whole country.

The current Guidelines for Rural Roads and Culverts Maintenance (LGRDC, 2013) provides LGED a good policy support in maintaining its infrastructures and assets throughout the country. It provides a checklist for considerations while prioritising maintenance requirements. Higher priority is given for periodic maintenance, higher order roads, donor funded roads, roads having higher traffic volume and bus routes, continuous and uninterrupted link providing roads, roads providing accessibility to more growth centres, villages, and service/activity centres.

LGED has developed a road database. The database maintains detailed information on road inventory including type of road, road length, surface type and condition, traffic counts by mode on market and non-market days etc.; types of socio-economic facilities along a road and many other information. LGED has developed a computer-based priority ranking model for road maintenance and is currently used for the prioritisation of road maintenance work. The model considers a number of criteria including some from the above-mentioned Guidelines. It uses data from the road database. Table 3.1 provides examples of some of the criteria and their weights used by the model. LGED has also developed a GIS database and is currently developing some application tools to make use of the GIS database.

[1] FRB stands for Feeder Road (Type B), which has been renamed as Upazila Road.

[2] RR1 stands for Rural Road (Type 1), which has been renamed as Union Road.

Table 3.1: Criteria and their weights used by the road maintenance priority model

Criteria	Description	Weight
Road type	Upazila road	12
Surface type	Fully BC	12
Gaps	Major gaps	3
Traffic volume	CVD 300+	100
Market	Growth centre	12
	Rural market	6
Hospitals	Upazila/union health complex	6
Social centres	Union *Parishad* office	9
	Other public centre	3
Educational institutions	College	9
	Secondary school	6
	Primary school/madrasa*	3
**Madrasa*: An educational institution with primary focus on the study of Islamic Theology and Religious Law		

Source: RSDMS, LGED
Note: Only a few criteria are shown as examples.

3.4. Rural road development programme in other developing Asian countries

Many countries in Asia have implemented impressive rural road development programmes. In India, for example, a rural roads programme, the Prime Ministers Rural Roads Scheme (PMGSY), was launched as a 100 per cent Centrally Sponsored Scheme, with the objective of boosting rural connectivity. The aim of the scheme was to provide habitations with a population of 1,000 and above, as well as those with a population of 500 and above, with all-weather roads. In hilly/desert/ tribal areas, its aim was to link habitations with populations of 250 and above. During the Tenth Five Year Plan (2002-2007), 88% of the targeted habitations were connected (GOI, 2008). A manual prepared by the National Rural Roads Development Agency (NRRDA, 2005) provides the operational details of the PMGSY programme.

The programme has several innovative features which include: first that it is financed from a small dedicated levy on diesel fuel; second, that the engineering design and construction standards are set by the central Government; and third, that physical and financial implementation of the scheme is done through a centralised computer system. In an evaluation undertaken by the Planning Commission of India it was observed that PMGSY had succeeded in providing connectivity to some of the most deserving habitations (Government of India, 2008). In 2007, PMGSY was folded into the *Bharat Nirman* programme. This is a more broad-based programme that includes all rural infrastructure development including rural roads. With respect to rural roads, it aimed to connect all 1,000-plus habitations in rural areas (500-plus in hilly and tribal areas) by 2012.

The Gama Neguma programme in Sri Lanka is designed to achieve island wide economic development through the creation of economically prosperous villages. The programme was launched in 2006 in 119 Grama Niladhari divisions and will ultimately cover all of the 14,034 divisions. Under the

programme, 3,354 km of roads and bridges were built in 2008 at a cost of 7,058 million Sri Lanka rupees (Government of Sri Lanka, 2008).

The Philippines is implementing an Intensified Building-Up of Infrastructure and Logistics for Development (I- BUILD) programme to develop a network of climate-resilient rural infrastructure and facilities which include farm to market roads and bridges and other infrastructures (Philippines Rural Development Project, 2015). I-BUILD is centrally managed and funded with the support of the World Bank, and is implemented in direct collaboration with the Local Government Units (LGUs). The proponent LGUs, among other things, must be willing and capable to contribute to funding requirements and have the technical capability to plan and implement projects.

The actual project selection and implementation is done by the LGUs. There are a few general and some specific criteria for project selection. However, as funds available may not be sufficient to implement all such selected projects, a set of specific prioritisation criteria is applied for the ranking and final selection of projects.

In China, about 2 million kilometres of roads classified as rural were constructed during the period 1996-2004. A feature of the interventions in China is that they provide not only transport infrastructure but also transport services. The road development strategy envisages that regular bus services will serve no less than 95 percent of villages by 2010 and all villages by 2020.

China has established a sustainable road maintenance programme. In the Asia-pacific region, China has a high rate of rural road maintenance, with an estimated 90 per cent of rural roads are currently being maintained. It has established an institutional setup involving financial and implementation arrangements and responsibilities at different tiers of the government for proper maintenance of rural roads (Hongye, 2012).

3.5. Observations and conclusions related to developing a methodology for the present study

Several conclusions can be drawn that can be useful in developing a planning and prioritisation methodology for rural road development in Bangladesh. The national programmes of road development generally are based on some broad criteria that can be applied all over the country to develop a rural road network. The main purpose of developing such a network is to provide access to all habitations of a sizable population by an all-weather road. The actual selection of projects is based on the outcome of some form of economic or other types of appraisal model.

CBA has been popular among the decision makers in Bangladesh. For being a preferred choice among the decision makers in government, a simplified CBA model based on limited data for the appraisal of rural roads may be considered. It is also noted that the development of a simplified CBA methodology for the evaluation of rural roads is a strategy stated in the Seventh Five Year Plan of Bangladesh. However, a large number of rural roads in Bangladesh are low-volume roads and mainly used by pedestrians. Typical CBA analysis for such roads may not produce results that may be used for investment decisions. The application of some form of MCA would be more appropriate in such a situation.

Besides the choice of a suitable appraisal methodology, there are other considerations that may also need to be considered while developing a suitable methodology. Many villages in Bangladesh are not connected by all-weather roads. Further development of roads should be based on some criteria so that a network is developed that can enhance access to all villages and ensure connectivity with higher

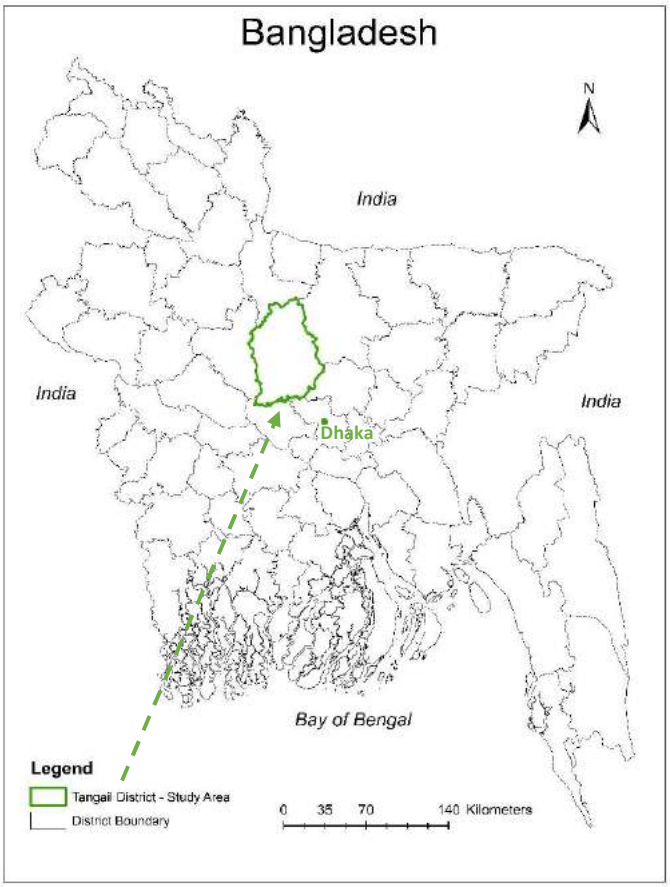
order centres. Some broad criteria, similar to national programmes in other countries and SDG 9.1 target can be considered to develop rural road networks. Fortunately, such national level broad policies are already in place that may be considered to develop rural road networks in Bangladesh.

4. Tangail district: The study area

4.1. An overview of the district

Tangail district was selected as the study area for piloting the methodology. It is 13th largest district of Bangladesh by area and 5th largest by population. Figure 4.1 shows location of the district in Bangladesh.

Figure 4.1: Map of Bangladesh showing location of Tangail



Source: LGED

The city of Tangail is located about 86 km North-west of Dhaka. The district is crisscrossed by different types of roads. National Highway 4 (NH 4), which passes through this district, connects Dhaka with the North-western part of Bangladesh through the Bangabandhu Bridge over the river Jamuna.

As per BBS (2011), the population of Tangail district was 3,605,083 of which around 85% people lived in rural areas. Tangail district consists of 12 upazilas, namely Basail, Bhuapur, Delduar, Dhanbari, Ghatail, Gopalpur, Kalihati, Madhupur, Mirzapur, Nagarpur, Sakhipur, and Tangail Sadar. Ghatail is the largest upazila by area and Tangail Sadar is the largest upazila by population. Although Tangail Sadar appears to be the most densely populated upazila, most of the economic establishments are located in Kalihati upazila followed by Nagarpur and Mirzapur upazilas.

4.2. Growth centres, educational and other facilities in Tangail district

There are several growth centres, markets (locally known as *hat* or *bazaar*) and other activity centres in the district. Table 4.1 shows the number of market centres and other activity centres in the district.

Table 4.1: Number of growth centres, educational and other facilities in Tangail district

Facilities	Number	Facilities	Number
Growth centre	77	Homeopathy college	1
Market	457	*Madrasas**	202
Government primary schools	941	Technical university	1
Non-government primary schools	395	Nursing institutes	2
Community primary schools	146	Polytechnic institute	1
NGO operated schools	1,304	Medical assistant training school	1
Junior schools	40	Police academy	1
Satellite schools	86	Teachers' training school	1
Government high schools	5	Mosque	5,763
Non-government high schools	341	Temple	759
Government colleges	5	Church	56
Non-government colleges	48	Fuel Filling station	44
University colleges	3	Fire station	2
Textile engineering colleges	2	Police station	23
Medical college	1	Cyber café	9
Law college	1	Flood and Cyclone Shelter	18
* *Madrasa*: An educational institution with primary focus on the study of Islamic Theology and Religious Law			

Source: BBS, 2012; BBS 2013

4.3. Rural roads in Tangail

The total length of rural roads in Tangail is about 8,250 km. The road density in the district (2.42 km/sq km) is slightly higher than the national average (2.39 km/sq km). However, there is wide variation of road density by upazila. The highest road density is in Nagarpur (3.17 km/sq km) and the lowest is in Tangail Sadar (1.55 km/sq km).

Figure 4.2 (a) depicts that Village roads (VR), with a split of 41% and 33% between VR Type A and VR Type B, constitute the highest share of roads in the district followed by Union roads (about 14%) and Upazila roads (about 11%). This is essentially complemented by figure 4.2 (b) which portrays the fact that most of the roads of Tangail district, about 78% of the entire network, are earth roads. Of the total earth roads, the shares of Upazila and Union roads are 3.49% and 10.2%, respectively. The share of paved roads dominates only for Upazila roads (about 74%) followed by Union roads (about 41%). About 12% of VR Type A and 4% of VR Type B roads are paved.

Figure 4.2 (a): Share of road length (km) by road type

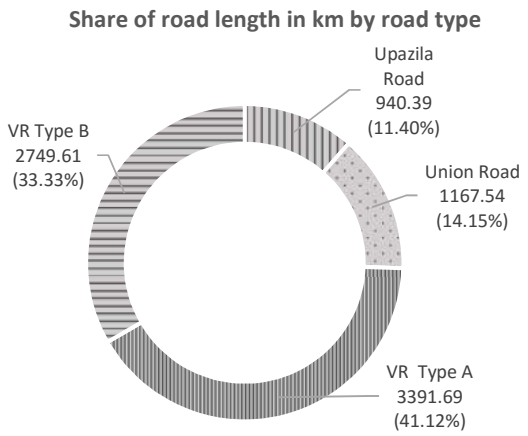
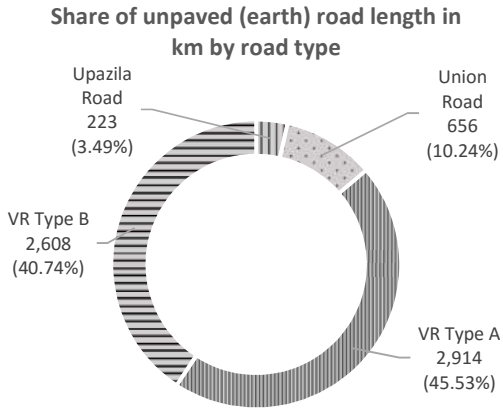


Figure 4.2 (b): Share of unpaved (earth) road length (km) by road type



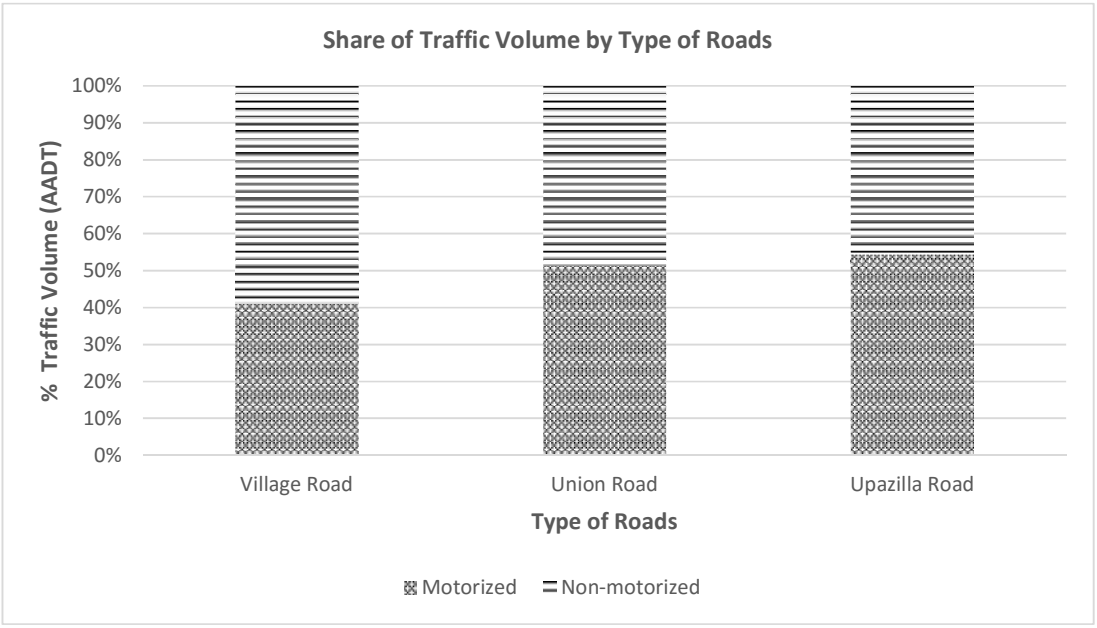
Source: Based on information from RSDMS, LGED

4.4. Traffic volume

Figure 4.3 shows the share of traffic volume, with a split between motorised and non-motorised traffic, for different types of roads. It is evident that traffic composition is similar for all types of roads with slight predominance of motorised traffic on Upazila and Union roads (more than 50% of the traffic volume). However, 60% of traffic on village roads are non-motorised.

Motorised traffic volume is lower in Village roads compared to Union roads and Upazila roads. As the average annual daily traffic (AADT) volume exceeds 500, the distribution of motorised traffic volume leans more towards Union and Upazila roads. Less than fifty rural roads in the district are experiencing relatively high-volume of traffic (AADT > 600).

Figure 4.3: Share of traffic volume by type of roads in Tangail



Source: Based on AADT data in RSDMS, LGED

5. Methodology for planning and prioritisation of rural roads

5.1. Introduction

The Project team developed a methodology for planning and prioritisation of rural roads. The details of the methodology, as applied in the pilot district, are discussed in this chapter.

In developing the methodology, the following matters were considered.

- Government objectives, current policies and strategies as stated in official documents.
- Guidance and advice of the Working Group established for the project.
- Comments and suggestions received at the First Stakeholders Workshop.
- Consultation meetings with concerned LGED officials at the HQs and field offices.
- Observation and conclusion distilled from the literature review.
- The current prioritisation practices of LGED, methodologies applied in previous studies.
- Data available in LGED's database and from other secondary sources; and avoidance of primary data collection unless essential.

5.2. Road categories and types of road development

An upazila may have different types of roads – National and Regional Highways and Zila roads managed by RHD; and Upazila, Union and Village roads managed by LGED. However, for the purpose of the present study only the roads managed by LGED have been considered.

Following initial discussion with LGED officials, it was decided at a Working Group meeting that methodologies on prioritisation would be developed for three types of road development works namely, improvement, further improvement/upgrading and maintenance of rural roads. The definitions of these three terms are as follows:

Improvement

- Converting an earth road to a paved road i.e., from earth to BC/RCC in an existing alignment.
- Converting a partly paved road to a fully paved road.
- Converting an HBB road to a fully paved road.

Further improvement/Upgrading

- Improvement of road geometric standards, raising of embankment and widening of pavement and/or crest of an existing paved road.

Maintenance

- Maintenance of a paved road (BC, RC or HBB).

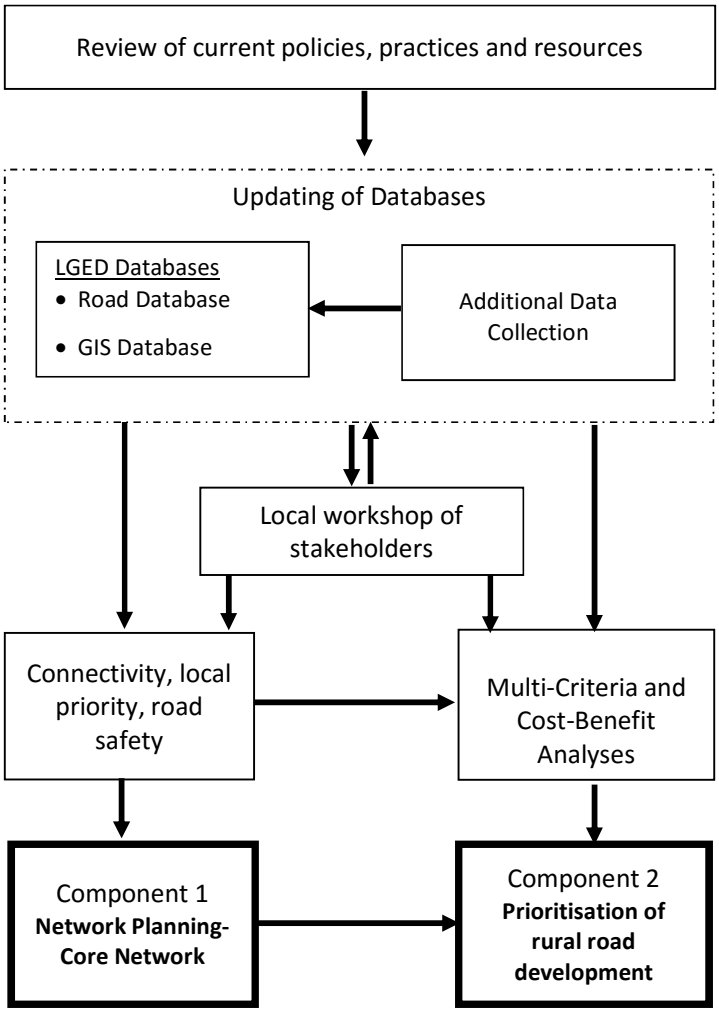
5.3. Major components of the methodology for the study

The methodology has two major components. The first component follows a network approach to road planning; and the second component involves prioritisation of road development based on a set of physical, economic, social and other criteria (Figure 5.1). Both the components include the provision of local stakeholders' participation.

All the designated Upazila and Union roads along with the national roads, if any, form the core network in an Upazila. The core network also includes roads that crosses the geographical boundary of an

Upazila to connect an activity centre or a national road in a neighbouring Upazila. In the prioritisation scheme, all such roads have been given additional importance as together they form a network vital to maintain inter- and intra-Upazila transport connectivity. The activity centres form the nodes and Upazila and Union roads connecting them are the links of the core network.

Figure 5.1: Schematic diagram showing overall approach to planning and prioritisation of rural roads



The core road network has two components: upazila-level core network, and union-level core network. The upazila core road network serves upazila-wise access needs and ensures connectivity with the neighbouring greater region/rest of the country. The union core network serves union-wise and inter-village access needs and ensures connectivity with other areas of the same and neighbouring upazila(s).

The prioritisation component of the methodology considers physical, economic, social and some other aspects. A set of prioritisation criteria for the assessment of costs, benefits, and social and environmental considerations were selected. The selected criteria included road construction costs,

direct benefits to road users, improved accessibility to markets and social infrastructure facilities, connectivity, if the road can be used in all seasons, and other local priority of special nature.

Further details on these two components of the methodology are presented below.

5.4. Network planning - Defining the core road network and identification of priority road development needs

The preliminary core road networks were developed from the data available in LGED's databases. Some of the roads in the upazila connect an upazila with other upazilas and important activity centres within the upazila. The RHD Roads (if any) and Upazila roads are vital for ensuring connectivity of an upazila with the greater region/rest of the country. Union roads are also important as they connect Union HQs with Upazila HQs, Growth Centres or local rural markets. Therefore, all RHD Roads, Upazila Roads and Union Roads were included in the core network. However, some village roads providing access to a large number of socio economic facilities and rural markets are also important for addressing the union-wise access needs. In summary, the preliminary core network comprises:

- All RHD Roads (considered as given roads).
- All upazila roads that connect to national and regional highways of RHD, zila and upazila headquarters and other higher order national centres, and railway and steamer stations.
- All upazila roads that directly connect to growth centres in an upazila or a neighbouring upazila, zila roads of RHD, and that crosses the geographical boundary of an upazila to connect an important centre or a national highway or zila road in a neighbouring upazila.
- All union roads that directly connect to upazila and union headquarters, important market centres in the same or neighbouring upazila, and zila roads.
- Other union roads.
- Some village roads by which a large number of socio-economic facilities (schools, clinics, small industries, shops, rural markets etc.) are located.

5.4.1. Validation of the preliminary core road networks

Local workshops attended by the local leaders, officials and other stakeholders were organised one in each of the 12 upazilas of the pilot district. Further details about the organisation of local workshops are provided in Chapter 6. The local workshops, among others, had two major objectives:

- Validation of the preliminary upazila and union core road networks, and
- Identification of roads according to their level of local priority for development.

The workshop participants scrutinised the preliminary upazila and union core road networks presented to them. This was done to ensure that no important road that should be part of the core networks was left out. For example, roads that connects an important activity centre (GC/RM/*Ghat*/Station or any other important economic/agricultural/industrial or other establishment) or links of the already identified core network with higher order roads were included in the core network. Some village roads having many facilities by them were also considered for inclusion in the core network. In this process, the preliminarily defined core networks were finalised at the local workshops. The activity centres (Upazila and Union Headquarters, growth centres, rural markets) form the nodes, and upazila and union roads connecting them are the links of the core network. Reports of the local workshops are provided in Annex F, volume 2.

5.4.2. Connectivity and local priority for development

Connectivity of roads was identified as an important criterion for their prioritisation. Accordingly, connectivity was included as a criterion for road prioritisation assessment by MCA (discussed later in the section; see Tables 5.2-5.5). Roads in the core network which provide higher order connectivity get a higher score for priority. Upazila roads that directly connect to national and regional highways of RHD, zila and upazila headquarters provide the highest order connectivity because they connect the entire upazila with the greater region and rest of the country. Other Upazila roads that connect one growth centre to another growth centre, Union roads and the village roads selected as part of core networks get the priority scores according to their respective order of connectivity as shown in Table 5.1.

Table 5.1: Level of connectivity of roads and their assigned scores

Level of connectivity	Road	Score
Part of core networks	Upazila roads that directly connect to national and regional highways of RHD, zila and upazila headquarters	100
	All other Upazila Roads	80
	Union Roads that connect upazila headquarters	50
	All other Union Roads	40
	Village roads that are part of core network	35
Not part of core networks	Village roads those are not part of core network	0

The workshop participants also identified the roads according to their level of priority for development. This is termed as 'local priority' which is one of the assessment criteria for MCA for road prioritisation. In addition, the local stakeholders also identified some roads from among the upazila and union roads which may need further improvement/upgrading in terms of geometric standards such as road width and/or pavement strengthening on a priority basis. The stakeholders also discussed and suggested what type of "improvement" measures may be needed for such prioritised roads. Although collection of these suggestions was not necessary for the present study, this was undertaken with a view to assist the local LGED offices. The suggestions may be considered while undertaking detail design for such prioritised roads when funding becomes available.

5.5. Prioritisation of rural roads development

The prioritisation methodologies on improvement, further improvement/upgrading and maintenance of rural roads cover all three types of rural roads namely, Upazila Road, Union Road and Village Road. The type of development depends on road type, surface type, road condition and traffic volume.

The methodology, in general, has a capacity to consider the appraisal outcomes though both the Cost Benefit Analysis (CBA) and MCA. However, due to practical issues prioritisation for periodic maintenance of roads and prioritisation for improvement of low volume earth roads are done only based on MCA. It should also be mentioned here that the software (RPPM), developed based on the methodology, shows ranking of roads based for prioritisation. However, depending on road surface type and type of development works (i.e. improvement, further improvement/ upgrading or maintenance) ranking of roads in output tables are shown based either on MCA or CBA (EIRR) (See section 7.1 for details).

MCA is done using a selected set of socio-economic criteria. The selected criteria include traffic volume, access to markets and social infrastructure facilities, connectivity, local priority of special nature including the criterion set by LGED to meet SDG 9.1 target and a few other factors. The selection of criteria for MCA, however, depends on the type of development and category of road. Considering their relevance, separate sets of criteria are used for each type of development.

In addition to MCA, CBA has been considered to assess the economic merits of road development. However, CBA is not applied for prioritisation of road maintenance. An already paved road requires maintenance anyway. Only MCA scores has been considered for prioritisation of road maintenance. CBA results in terms of EIRR values and MCA scores are shown for all roads. As preferred by LGED, other than for low traffic volume earth roads, the priority ranking order is based on EIRR values; priority ranking order for low volume earth roads is based on their MCA scores.

The flow diagram in Figure 5.2 shows how a road is selected (from among the roads in the road database) for a particular type of road development. There are specific criteria for the selection of a road for each category of development. These criteria have been chosen so that they can be used by a computer program to select the appropriate assessment methodology for all roads. For example, if data shows that a road is partly paved, it may be considered for both improvement and maintenance. For improvement, priority assessment will be done by both CBA and MCA. Priority assessment for its maintenance is done by MCA if International Roughness Index (IRI) value is greater than 6; otherwise not considered for maintenance. There are four broad groups of prioritisation analysis as mentioned below:

1) Unpaved earth roads for improvement (converting into paved roads)
   a. High traffic volume (AADT > 200)
   b. Low traffic volume
2) Partly paved roads
   a. Improvement (paving the unpaved part)
   b. Maintenance (IRI value or road condition assessed by visual inspection)
3) Fully HBB
   a. Improvement (converting into BC/CC/RCC)
   b. Maintenance (road condition assessed by visual inspection)
4) Fully paved roads
   a. Further improvement/upgrading (for roads with peak hour PCU > 290 or Commercial Vehicles per day (CVD) > 300 VPD)
   b. Maintenance (IRI value or road condition assessed by visual inspection)

Prioritisation analysis is undertaken for each of the above 8 sub-categories of roads by applying CBA and/or MCA. Further details on these analyses are provided hereafter.

5.5.1. Prioritisation for improvement of rural roads

All unpaved or earth roads are considered for development under the category “improvement”. Also included in this category are the partly paved roads that are to be fully paved and HBB roads that need to be upgraded into BC or RCC roads. The local situation would determine the appropriate type of improvement. For example, in “haor” areas and some coastal areas, where roads may remain submerged for a considerable time, RCC may be right type of pavement. For unpaved roads, low volume roads need to be considered separately from higher volume roads for prioritisation. The majority of the traffic on low volume earth roads consist of pedestrians and non-motorised Traffic.

The benefits due to lower transportation cost resulting from the development of the roads would be small but many of them may provide considerable access benefits to the people.

AADT volume is proposed to identify low volume earth roads from high volume ones. A cut-off value of AADT was determined after undertaking CBA of earth roads with different traffic volumes. An AADT value of 200 was considered the cut-off value as CBA analysis under AADT 200 was not found appropriate for the purpose of prioritisation. For such roads, prioritisation is based on MCA scores. It may be noted here that the RED software developed by the World Bank also suggested such an approach. Although CBA results were not used in this study for prioritisation for low volume roads, the analysis was undertaken because of interest in LGED.

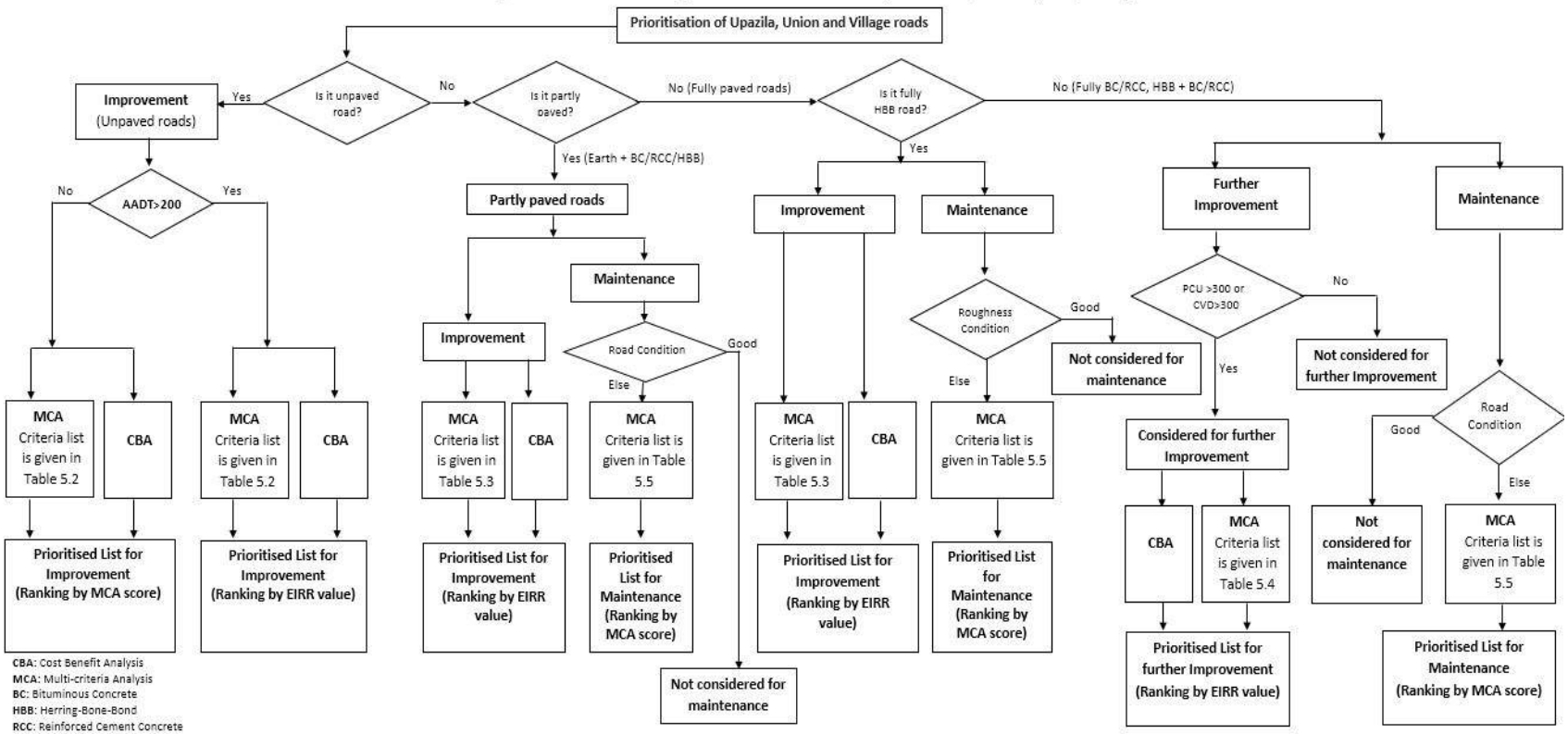
For the improvement of high volume earth roads both MCA and CBA were undertaken. A set of socio-economic criteria were considered in MCA. The criteria used in the MCA for road improvement are listed in section 5.6 (Tables 5.2 and 5.3). The details on the CBA are provided in Section 5.7. The prioritisation of such roads are based on CBA results.

5.5.2. Prioritisation for further improvement/upgrading of rural roads

Roads which are already paved but requires upgrading in terms of geometric standards (widening, for example) or pavement strengthening due to changes in traffic volume and/or their composition (considerable increase in number of heavy vehicle, for example) are considered under this category of development. The methodology considers paved roads with more than peak hour PCU of 290 or 300 CVD for further improvement/upgrading. It may be noted here that these values are also consistent with the LGED's current road design standards.

MCA in conjunction with Cost Benefit Analysis (CBA) has been used for the prioritisation of further improvement/upgrading of roads. The MCA for further improvement/upgrading are based on socio-economic and other criteria (similar to earlier described MCAs for road improvement) along with other criteria which include traffic volume (AADT), road geometry, surface type (BC or RCC) and road category (UZR, UNR or VR). The prioritisation criteria used in MCA for further improvement/ upgrading of roads are provided in Table 5.4.

Figure 5.2: Decision tree showing selection of roads for development and priority ranking



5.5.3. Prioritisation for periodic maintenance of rural roads

The roughness condition of a road is considered to determine if it needs periodic maintenance. The IRI value, if available, has been used to determine the condition of paved roads (RCC and BC roads) and partly paved roads (where periodic maintenance of only the paved segments are necessary). A road is considered for maintenance only if its IRI value is greater than 6 (Figure 5.2). If IRI values are not available, the qualitative assessment information available in the road database (RSDMS) based on visual inspection of road conditions are used. The qualitative assessment is based on the number of potholes, cracks, depression and edge failure, and ravelled and rutting conditions observed during visual inspection. The data on these items are collected and included in the road database by LGED.

The appraisal for prioritisation of road maintenance is based on the outcome of an MCA. The MCA considers a set of criteria which include traffic volume (AADT), last maintenance year, road surface type, as well as some socio-economic and other factors. The choice of these criteria follows the current practices of LGED and the Guidelines for Rural Roads and Culverts Maintenance prepared by the Ministry of Local Government, Rural Development and Cooperatives (LGRDC, 2013). Based on the MCA scores, maintenance priority lists are generated for Upazila, Union and Village roads. The prioritisation criteria considered in MCA are given in Table 5.5.

5.6. Multi-Criteria Analysis

MCA forms an important part of the prioritisation methodology. An MCA or an MCA and CBA have been used for the appraisal of prioritisation. Initially a set of criteria, reflecting policy and social objectives of rural road development, was identified considering LGED's current practice (see section 3.3 in chapter 3), views of experts and literature review. A survey was conducted among the stakeholders (including LGED officials) to identify the potential criteria from among this initial list (see, first stakeholders meeting report). After further discussion with LGED officials and other experts, these potential criteria were considered by the WG at a meeting and were finalised (Tables 5.2 through 5.5). The selected criteria include variables such as access to markets and services, connectivity, traffic volume, social and economic factors, etc.

After selection of the MCA criteria, their relative weights were established. The AHP technique, which is commonly used for the establishment of relative weights of factors, was used for this purpose. A survey instrument was designed and a survey was conducted among the experts and LGED officials at the HQs and field offices to determine the relative weights of the selected criteria for their use in MCAs. More details are provided in section 5.6.1. The weights were reviewed by LGED officials including members of the Working Group, discussed and finally agreed. The survey instrument is shown in Annex G, Volume 2.

Finally, the priority score or index value of each road was calculated by summing the product of the actual value of each criterion (the actual value was standardised) by its relative weight. This section outlines the criteria that were considered for undertaking the MCAs for each type of road development.

Table 5.2: List of selected criteria for improvement of unpaved roads

	Criteria	Description	Unit of measurement
1.	Traffic volume	• Average Annual Daily Traffic (AADT)	AADT
2.	Facilities served	• Education Institutes, Health facilities, Industries, other public centres etc.	Number of facilities
3.	Growth centres (GC)/Rural markets (RM) served	• Hats and Bazars (rural markets) served by the roads	Number of GC/RM
4.	Connectivity to higher roads and other centres	• Upazila level connectivity* • Union level connectivity**	Connectivity score as provided in Table 5.1
5.	Local priority	• Priority given by local representatives	• High priority (3) • Medium priority (2) • Low priority (1)

*If a road or its connectivity is important from the perspective of the entire upazila
**If a road or its connectivity is important only at the context of the union

Table 5.3: List of criteria for improvement of partly paved and HBB roads

	Criteria	Description	Unit of measurement
1.	Traffic volume	• Average Annual Daily Traffic	AADT
2.	Surface type	• BC + HBB + Other fully paved • Fully HBB/Other paved • BC + HBB + Other + Earth	Percentage of paved segment
3.	Road type	• UZR will be given the highest priority, followed by UNR and then village roads (VR)	UZR>UNR>VR
4.	Road Safety	• If road safety is an issue	Yes/No
5.	Facilities served	• Education Institutes, Health facilities, Industries, other public centres etc.	Number of facilities
6.	Growth centres (GC)/Rural markets (RM) served	• Hats and Bazars are termed as GC and RM	Number of GC/RM
7.	Connectivity to higher roads and other centres	• Upazila level connectivity • Union level connectivity	Connectivity score as provided in Table 5.1
8.	Local priority	• Priority given by local representatives	• High priority (3) • Medium priority (2) • Low priority (1)

Table 5.4: List of criteria for further improvement/upgrading of roads

	Criteria	Description	Unit of measurement
1.	Traffic volume	• Average Annual of Daily Commercial Traffic will be considered	AADT
2.	Road type	• UZR will be given the highest priority, followed by UNR and then village roads (VR)	UZR>UNR>VR
3.	Road safety	• If road safety is an issue	Yes/No
4.	Facilities served	• Education Institutes, Health facilities, Industries, other public centres etc.	Number of facilities
5.	Growth centres (GC)/Rural markets (RM) served	• Hats and Bazars are termed as GC and RM	Number of GC/RM
6.	Connectivity to higher roads and other centres	• Upazila level connectivity • Union level connectivity	Connectivity score as provided in Table 5.1
7.	Local priority	• Priority given by local representatives	• High priority (3) • Medium priority (2) • Low priority (1)

Table 5.5: List of criteria for periodic maintenance of roads

	Criteria	Description	Unit of measurement
1.	Traffic volume	• Average Annual of Daily Commercial Traffic will be considered	AADT
2.	Last maintenance year	• Roads with long gaps of maintenance are prioritised	Number of years
3.	Surface type	• Current pavement type will determine nature of improvement (HBB to BC or increasing width)	Percentage of paved segment
4.	Road type	• UZR will be given the highest priority, followed by UNR and then village roads (VR).	UZR>UNR>VR
5.	Facilities served	• Education Institutes, Health facilities, Industries, Other public centres will be considered as the important facilities	Number of facilities
6.	Growth centres (GC)/Rural markets (RM)	• Hats and Bazars are termed as GC and RM	Number of GC/RM
7.	Connectivity to Higher Roads and other centres	• Upazila level connectivity • Union level connectivity	Connectivity score as provided in Table 5.1
8.	Bus route	• Presence of bus route along the road	Yes/No

5.6.1 MCA Weighting framework

Ten different criteria are used for MCA. Since the weights of these criteria are not the same they were determined using AHP method. Two MCA criteria namely 'facilities served' and 'growth centre/market served' have multiple sub-criteria. For example, the value of MCA criterion 'facilities served' depends on the number and relative importance/weight of different educational, health and other facilities present along a road. Similarly, the value of MCA criterion 'growth centre/market served' depends on the number and importance/weights of growth centre and rural market. Since the importance/weights of these sub-criteria are not the same, those weights were determined using the Reed-Muench Median Threshold Method (Section 5.6.1.2).

5.6.1.1 Weights of the selected MCA criteria

Determining the relative weights of the selected criteria is important for MCA since all criteria do not bear the same level of importance. The more the importance of a criterion, the higher is its weight. As already mentioned, the AHP technique has been used to determine the relative weights of a selected set of criteria. The criteria were evaluated by pairwise comparison method. Selected LGED officials, experts and other stakeholders actively participated in the AHP survey. The consistency of the replies was checked by considering the consistency index (CI) value. The survey responses from an individual that met the acceptable level of consistency (less than 20%) were used to calculate the final weights. Table 5.6 shows the selected criteria and their weights determined by AHP analysis for each type of road development.

Table 5.6: List of criteria and their weights determined by AHP analysis

MCA criteria	Improvement of unpaved roads	Improvement of partly paved and HBB roads	Further improvement/ upgrading of roads	Maintenance of roads
Traffic volume	7.95	20.00	21.84	15.05
Facilities served*	18.65	15.00	9.54	14.85
Growth centre/ Market served	29.20	13.58	17.91	12.70
Connectivity	35.80	21.07	20.07	19.65
Local priority	8.40	5.97	14.93	N/A
Surface type	N/A	5.86	N/A	7.80
Road type	N/A	11.83	7.86	14.15
Road safety	N/A	6.69	7.84	N/A
Bus route	N/A	N/A	N/A	11.50
Last maintenance year	N/A	N/A	N/A	4.30
Total	100.00	100.00	100.00	100.00

Source: Results of AHP application by the project team.
Notes: All values are expressed in percent. N/A = Not applicable.
*A full list of the facilities and their relative weights determined by the Reed-Muench Median Threshold Population Method are provided in Table 5.7

5.6.1.2 Weights of the facilities and growth centres/markets

Fifteen different types of facilities and two types of market centres have been considered in MCA. All facilities do not have the same level of importance, some are of higher order than others. The order of importance of a facility depends on its level of influence. For the present study, the level of influence of a particular facility was determined by the Reed-Muench 'Median Threshold Population' method (Haggett and Gunawardena, 1964). The higher threshold population of a facility means a higher level of importance and therefore a higher value was assigned as the weight of that particular facility. For example, the median threshold populations of a primary school or a community clinic shows that their influence area is limited to only a particular village, while the influence areas of a college or a health centre are much larger and they serve a much larger population. Accordingly, facilities such as college, health care centre and other facilities serving a much larger population were given higher weights compared to primary school or other facilities serving much less population. Table 5.7 shows the weights of different types of facilities considered in MCAs. The methodology followed to estimate population threshold is provided in Annex H, Volume 2.

The score of a road for facilities served was found by summing the products of number of facilities along the road by the corresponding weights of the facilities as shown in Table 5.7.

Table 5.7 Assigned weights of socio-economic facilities

Types of facilities		Weight of the facility
Educational facilities	Primary school	1
	Secondary school	3
	High madrasa	6
	College	9
Health facilities	Community clinic/ FWC	1
	Union health centre	6
	Upazila health centre	9
	Non-govt. Hospital	9
	Private clinic	9
Other facilities	Small industry	1
	Medium industry	3
	Large industry	6
	Cyclone shelter	1
	Cyclone shelter cum school	1
	Other Public centre	3
Growth centres/Market centres	Growth centre	6
	Rural market	1

Source: Determined by using the Reed-Muench Median Threshold Population method by the research team

5.6.2 MCA scoring

The actual values of the selected criteria are in different units of measurement. In order to allow for their addition, the actual value of each criterion was standardised on a scale of 0 to 100. The MCA score for a road is calculated by multiplying standardised values and weights together and summed into a combined score as follows:

$$I = \sum (w_i \times x_i)$$

I = Combined score, w_i= Relative weight of criteria *i*, x_i= *Standardised score of criteria i*

5.7 Cost benefit analysis

The results of CBA can be an important consideration for making a road project investment decision. The CBA of this study is based on calculation of economic internal rate of return (EIRR). It uses a standard analytical framework of EIRR to calculate economic return for different types of road improvement activities. The CBA (EIRR) methodology follows the VOCS and TTCS approach. It considers the benefits of road improvement by estimating savings in vehicle operating costs and travel time cost against the costs of road improvement and regular and periodic maintenance.

Since the road users are the immediate beneficiaries of an improved road, it was necessary to obtain information on the prevailing traffic and its characteristics to estimate road user benefits. Data on the following items were used in CBA to estimate user benefits.

- AADT
- Composition of traffic.
- Travel purpose and passenger occupancy in vehicles.
- Vehicle operating speeds and costs by road roughness condition.
- Value of time of passengers.

Data on the first two items were available from the road database. Information on the remaining three items were used from a study undertaken by GTZ for LGED (GTZ 2009).

5.7.1 Projection of future traffic volume

Traffic volume is an important variable in the CBA analysis. As such, the projection of future traffic volume is an important task. The current AADT and CVD values by type of vehicle were available from the LGED's road database. The volume of traffic on "hat" (market) and "non- hat" days varies significantly. For use in CBA, the weighted average of AADTs on hat (assuming two days in a week) and non-hat days (5 days in a week) was considered.

The growth factor method was used to project future traffic volumes of roads. The growth factor was estimated using trend analysis of traffic growth on rural roads in recent years. It is likely that the growth rates may vary by district/locality depending on type of economic development in the surrounding areas. Traffic growth rates in different situations were examined and the generalised rates of traffic growth were estimated. For the present study, 6% growth for normal traffic and another 6% growth for generated traffic were used for traffic projection. However, it is unlikely that such high traffic growth rates (total 12% a year) would be sustained over a long period of time. Beyond 10 years, it is unlikely that there would be any significant generated traffic growth as most new developments (for example, increase in agricultural and manufacturing outputs; new socio-economic

facilities, houses, shops and factories built) within the service area of a road would have taken place by then. Some other studies had used similar assumptions. As in other studies, 20 years of economic life for a road has been used.

5.7.2 Estimation of costs and benefits through CBA (EIRR)

The cost components in the CBA (EIRR) analysis includes updated standard construction and maintenance costs for different categories of roads[3] and road structures as currently being used by LGED in Tangail. Appropriate shadow factors for labour and material costs and current tax rates were applied to calculate the economic costs of road construction and maintenance (Table 5.8). Similar to traffic growth factor, the values of cost variables are also configurable in the software. They can be changed for other districts, if needed, and in the future when the costs may change.

The benefits of road improvement are estimated from lower vehicle operating costs (VOCs) and savings in travel time cost (TTCS). The Vehicle Operating Cost (VOC) varies by type of vehicle and according to the road surface condition of a road. The amount of such benefits for each type of vehicle have been estimated considering road surface conditions "before" and "after" road improvement.

Table 5.8: Standard parameter values used in CBA (EIRR calculation)

Parameter		Value
Construction cost per km (12ft/3.75m pavement width), Taka		8,000,000
Routine maintenance cost per km (12ft/3.75m pavement width), Taka		500,000
Periodic maintenance Cost per km (12ft/3.75m pavement width), Taka		1,500,000
Annual cost increment		12%
Salvage value (% of original construction cost)		25%
Tax rate		11.50%
Economic life (years)		20
Shadow price factor (to calculate economic cost)	Weighted average Shadow Price Conversion Factor (SCF) for construction cost (labour and material)	0.88
	Weighted average SCF for maintenance cost (labour and material)	0.84

Source: LGED (internal communication with the project team)
Note: All costs in the table are in 2017 Taka value.

With the increase of traffic over the years, the savings in travel time would decrease as the average travel speed would gradually fall. In less than 10 years the volume of traffic on many rural roads is expected to double and may exceed the present capacity of roads. Consequently, beyond 10 years, it is unlikely that there would be any significant savings in travel time. Therefore, for the purpose of this study, after 10 years no additional benefit from savings in travel time has been considered.

[3] LGED has established design and construction standards based on defined traffic volumes.

The improvement of road surface condition results in higher speed and thereby reduce travel time. The benefits from reduction in travel time or in other words savings in travel time have been estimated and used in the analysis. Standard values of VOCs by vehicle type, average speed of travel under different road surface condition, and value of time savings for both passengers and vehicles have been considered from a study undertaken by GTZ for LGED (GTZ, 2009) as shown in table 5.9. It may be mentioned here that in determining the average passenger time saving values the GTZ study considered the split between work and non-work trips. The parameter values taken from the GTZ study were converted into current prices by using the consumer price index or CPI value. All parameter values (VOC, TTS, etc.) used in CBA are given in Table 5.9.

For this study, benefits from any potential increase in agricultural production have not been considered for two main reasons. First, road improvement is a necessary condition but not sufficient to generate new development/production activities. Any potential increase in agricultural production (or any other type of economic activity) cannot be solely attributed to improvement of road. Other complementary interventions (such as investment for increase in production, development of transport services and logistics) may also be necessary. Second, the demand for transport is primarily a derived demand, meaning that the benefits from improved transport are passed through to prices for products and factors. Separate consideration of such benefits would have led to double counting of benefits. Since additional production/ economic activities produces "generated traffic", benefits from which have already been considered in the analysis.

5.7.3 Strength and limitation of the adopted CBA methodology

The CBA methodology developed for the purpose of this study is a simplified one. It does not require collection of a vast amount of data for individual roads. The methodology is based on unit cost/standard values, for example, unit construction and maintenance costs and standard conversion factors for shadow pricing to estimate economic costs. It is important to mention here that an average upazila has some 400-600 rural roads. It is not practical to collect/estimate specific data for such a large number of roads to undertake CBAs. The methodology, therefore, mainly relies on data available from the road database, and LGED and other secondary sources. However, the adopted methodology follows the standard procedures in estimating economic costs and benefits of road improvement as far as practical.

5.8 Salient features of the methodology and conclusions

There are several important features of the methodology. The main ones are as follows:

- There is a significant research component in developing the methodology. Many parameter values for use in CBA and MCA, and in a computer program to apply the methodology were established through research.
- The conventional approach to network planning focuses on traffic flow. The main purpose is to minimise travel time and/or travel distance or maximise traffic flow capacity. However, the network planning approach adopted for the present study focuses on connectivity to ensure local accessibility and connectivity with the greater region.
- LGED undertakes three types of rural road development activities: improvement, further improvement/upgrading and maintenance. All of these activities are considered within a single planning framework based on priority appraisal of roads following a consistent approach.
- The methodology is centred on the idea of developing a software that is easy to use, makes best use of the available data from the database and can enhance decision making in LGED.

The methodology has been generalised, as far as practical, for its application in other districts of Bangladesh. The assigned weights for the criteria used in MCA would also be applicable for other districts as they were not determined by considering the opinions of stakeholders only from Tangail; the opinion of concerned LGED officials having worked in many other districts and other experts were also considered in determining the weights. However, with further improvement of connectivity, accessibility and rural transport services, stakeholders' perception on relative importance of the criteria as well as the relevant criteria for MCA may change. The list of selected criteria and their relative weights may need to be reviewed in 3-5 years time.

Some of the major considerations in developing the methodology were as follows: additional data collection should be kept as minimum as possible; the methodology should be practical and user friendly; and it should serve the requirements of LGED. The methodology meets these requirements.

The methodology also meets the strong demand of local stakeholders for their involvement in the planning and prioritisation process. It allows their participation in the process through local workshops. The local workshops complement the technical process and can ensure transparency in planning and prioritisation process of future road development works undertaken by LGED.

Table 5.9: Vehicle operating cost and speed by road surface condition, passenger time cost, average occupancy and PCU factor by type of vehicle

Vehicle ID	Vehicle Name	VOC_ Good (IRI less than or equal to 6)	VOC_ Fair (IRI between 6-8)	VOC_ Poor (IRI between 8-10)	VOC_ Bad (IRI greater than 10)	Speed_ Good (IRI less than or equal to 6)	Speed_ Fair (IRI between 6-8)	Speed_ Poor (IRI between 8-10	Speed_ Bad (IRI greater than 10)	TTS	Average Occupancy (persons)	PCU_ Factor
1	Motorcycle	3.65	3.69	3.71	4.14	79.00	67.00	62.00	44.00	22.90	2.00	0.30
2	Tempo	5.65	5.73	6.51	6.95	0.00	0.00	0.00	0.00	16.40	10.29	1.00
3	Car	19.49	19.66	21.14	26.20	81.00	77.00	66.00	44.00	30.90	3.52	1.00
4	Delivery	13.45	14.09	15.97	19.30	0.00	0.00	0.00	0.00	27.36	3.48	1.00
5	Minibus	34.12	34.39	37.10	48.26	69.00	68.00	62.00	43.00	17.60	35.38	3.00
6	Medium Truck	26.39	26.85	29.10	36.31	59.00	57.00	52.00	40.00	32.36	3.24	3.60
7	Bicycle	1.97	2.03	2.38	3.34	N/A	N/A	N/A	N/A	12.28	1.22	0.30
8	Animal Cart	9.68	10.21	11.29	15.81	N/A	N/A	N/A	N/A	0.00	0.00	4.00
9	Rickshaw	2.86	3.06	3.86	5.54	N/A	N/A	N/A	N/A	12.28	2.32	1.00
10	Rickshaw Van	2.86	3.06	3.86	5.54	N/A	N/A	N/A	N/A	12.28	6.99	1.00
11	Small Truck	13.45	14.09	15.97	19.30	67.00	65.00	59.00	43.00	27.36	3.48	3.60
12	Large Bus	81.63	81.48	85.78	93.48	73.00	70.00	59.00	39.00	17.60	46.59	3.00
13	Light Bus	18.27	18.35	19.68	25.14	69.00	68.00	62.00	44.00	17.60	16.18	3.00
14	Utility	19.32	19.43	22.85	30.46	82.00	77.00	65.00	43.00	30.90	6.97	1.00
15	Auto-rickshaw	5.65	5.73	6.51	6.95	48.00	47.00	44.00	36.00	16.40	4.00	1.00

Source: Extracted from GTZ (2009).

Notes: VOC values are in Taka (Bangladesh currency); Speed values are in km per hour; and TTS values are in Taka per hour per passenger.

6 Local level workshops

6.1 Introduction

The Local Level Workshops had an important role in implementation of the methodology. The feedbacks received from the workshops organized in twelve upazilas of Tangail district were crucial to validate the core networks and collect additional data that were required to run the software developed.

Objectives of organising the local level workshops were as follows:

- to facilitate participation of local leaders and other stakeholders in rural road planning and prioritisation process;
- to validate the core network by the local stakeholders and identify village roads, if any, had the merits to be part of the core network;
- to identify the local priority of rural roads in the upazila; and
- to collect information on further improvement/upgrading of the identified roads.

The local level workshops complemented the technical process of planning. They also helped to show transparency in the decision-making process, ensure local ownership of the output and overcome the limitations of data available in the databases.

6.2 Organisation of the local level workshops

A date for the workshop in each upazila was fixed in consultation with LGED officials at the Headquarters and field offices, the concerned Upazila Chairman and the Upazila Nirbahi Officer (UNO). The Upazila Engineer was appraised in advance the purpose and tasks to be undertaken at the workshop and logistics support required. In consultation with Upazila Chairman, the Upazila Engineer invited the participants for the workshop.

Before the start of the workshop, the Upazila Chairman and UNO were explained the purpose and tasks to be undertaken at the workshop. Meanwhile, the venue was prepared and the programme started after the arrival of participants. It took about three hours to complete each of the workshops.

All materials were prepared in advance and made available to the participants at the workshop. The workshop was conducted in the local language. Due care and considerations were made in conducting the workshop so that the participants could freely discuss and undertake the tasks.

6.3 Participants of the local level workshops

Participants included the elected local leaders, government officials, informed persons and representatives of interest groups. Invitations for participation at the workshop were sent to the local Member of Parliament (MP), Upazila *Parishad* Chairmen, Vice Chairmen (particularly Women Vice Chairmen), Union *Parishad* Chairmen and members (particularly women members), Upazila Nirbahi Officers (UNO), Executive Engineer of LGED at Tangail, Officer-in-Charge of the local Police Station, officials of the upazila administration, members of Nagorik Committee (local chapter of a national citizens right organisation) and others. On an average, twenty to twenty five participants were present in the workshops.

6.4 Activities undertaken at the workshop

The workshop was conducted in two sessions. In the first session, after inauguration by the Upazila Chairman, a presentation was made to explain the purpose of the workshop and tasks to be undertaken.

The concept of Core Network was explained and the participants were shown the preliminary core network of the upazila on an A0 size printed map. They were given A4 size printed copies of the core network maps and separate lists of roads in the networks. Core network maps for the upazila and unions were printed separately and were distributed to them.

In the second session, the first task was verification of core network. Verification of core road network in the union was done by the chairmen and members of respective unions. The Upazila Chairman, Vice Chairman and members of the Upazila Parishad did the same tasks for upazila roads. Upazila Engineer and his staff helped the participants to complete the tasks.

The proposed changes by the elected officials (inclusion or deletion of some roads particularly village roads) to the upazila and union core networks were discussed. The other stakeholders including LGED staff further examined the proposals. Finally, all or some of the proposals were accepted on the basis of consensus of the stakeholders and validation of the core networks were completed.

After validation of the core network, local priority ranking for each of the roads in the upazila was collected. Upazila Chairman and Vice Chairmen were given the list of all Upazila and Union roads in the Upazila; the Union *Parishad* Chairmen and members were given the list of village roads in their respective unions. They ranked the roads according to their perceived priority of development (3 for highest, 2 for Medium and 1 for lowest priority). Participants put local priority values based on local factors. However, considering SDG target 9.1, particularly rural access index 9.1.1, they were requested to keep in mind connecting all the villages with population more than 500.

The final task was to identify any paved Upazila or Union road that may need further improvement/ upgrading considering traffic and other conditions. After identification of such roads, if any, participants also suggested improvement measures (widening, raising elevation, alignment straightening, pavement strengthening etc.) that might be considered for such roads.

6.5 Workshop materials distributed

The following workshop materials were used/distributed to conduct the local workshops:

- Printed copies of updated list of union wise list of Village roads.
- Printed copies of list of Upazila and Union roads.
- Printed copies of core network maps for upazila on A0 size and A4 size paper.
- Printed copies of core network maps for each union.

Upazila and Union *Parishad* chairmen were requested in advance to bring their official stamps. They signed and stamped the prioritised list of roads and maps of the validated core networks.

6.6 Logistics needed

A venue with modest sitting (and writing) arrangements for at least thirty persons were required. Upazila *Parishad* Meeting Room or the *Muktijodhdha* Auditorium of the upazila was used to conduct the workshops. Where computer and projector facilities were available, presentations were made by using such facilities. Prior arrangements were also made to hang large size maps of core networks and

banner for the programme. The availability of alternative power supply arrangements and printing and photocopying facilities were useful at some upazilas.

6.7 Outcome of the local level workshop

The following were the main outcome of the workshop:

- verified upazila and union core road networks;
- identified upazila, union and village roads that have local priorities for development;
- identified roads that may need further improvement/upgrading; and
- local inputs and data necessary for CBA and MCA analyses.

The outcomes were used to update the road database.

6.8 Challenges faced

In most cases the workshops were held smoothly. However, problems arose when stakeholders had difficulties in locating roads of their interest in the list provided. It happened either due to difficulties in reading maps or absence of that road in the database. They were helped them to find the roads. In cases when the road was not in the list, the Upazila Engineer took note for its inclusion in the road database at the time of next updating.

7 Discussion on outputs generated by RPPM

7.1 Introduction

A web-based application tool RPPM, was developed to implement the planning and prioritisation methodology discussed in Chapter 5. It works in the web platform of LGED and can return output data in both tabular (report) and graphical (map) form. A user with access to the Internet can use the application tool by logging into the GIS portal of LGED. A separate user manual has been developed with the details of the software, its subsystems and data requirements that shows how a user can use the tool to generate outputs.

RPPM uses data mainly from the two databases of LGED. However, two new tables were added to the existing road database for use by RPPM. At present RPPM can produce outputs for 12 upazilas of the pilot district Tangail. After collection of some additional data (discussed in the user manual) and their inclusion in the road database for other districts, RPPM may be applied to generate similar outputs for other districts of Bangladesh. This chapter presents the RPPM generated results for the pilot district and a discussion on them.

RPPM can produce the following outputs:

- core networks for the upazila;
- eight separate priority lists (output tables) by type of road development and type of road surface;
- priority score table with basic information, details of priority scores, and CBA and MCA results of a road; and
- maps showing prioritised roads on an upazila map.

The eight priority lists produced by RPPM are shown in Table 7.1. It also shows whether MCA score or EIRR value of a road is used for its priority ranking in each list.

The priority score table for a road has the following information:

- road code and road name;
- road surface condition, AADT and CVD values;
- total road length, road type, surface type, connectivity;
- MCA scores for facilities;
- evaluation score including EIRR and MCA scores;
- priority ranking considering EIRR or MCA as may be applicable.

Following the current practice in LGED, RPPM makes priority ranking for road maintenance by MCA score. In other cases of road development, except for low volume earth roads, the priority ranking is based on EIRR values (Table 7.1). The priority ranking of low volume earth roads is based on their MCA scores.

It may also be noted, for many low volume village roads it was not possible to estimate the low (negative) EIRR values as the undiscounted post investment cash flow was less than the investment cost.

Table 7.1: Priority lists produced by RPPM

Priority list	Type of road development	Surface type	Output tables in RPPM	
			Shows values of	Ranking of roads is based on
1	Improvement	Low traffic volume earth road	MCA	MCA
2		High traffic volume earth road	MCA and CBA (EIRR)	CBA (EIRR)
3		Partially paved road	MCA and CBA (EIRR)	CBA (EIRR)
4		Fully HBB road	MCA and CBA (EIRR)	CBA (EIRR)
5	Maintenance	Partially paved road	MCA	MCA
6		Fully HBB road	MCA	MCA
7		Fully paved road	MCA	MCA
8	Further improvement/ upgrading	Fully paved (Full BC/RCC, HBB + BC/RCC)	MCA & CBA (EIRR)	CBA (EIRR)

7.2 Core road network

RPPM can generate core road network for each upazila. RPPM generated maps of the core road networks of the pilot district are provided in Annex I, volume 2. The maps reveal that the core road network of the district is almost unbroken if one considers the RHD roads in the network. In some upazilas (for example Gopalpur, Bhuapur and Mirzapur) there is scope for expanding the core network to improve rural accessibility. The number of roads in the core network varies from 13 (Bhuapur and Dhanbari) to 40 (Kalihati). However, the number of roads depends neither on the size nor on the road density of the upazila. The core network of Tangail district has 80 upazila roads and 170 union roads. The list of roads forming the core road network of each of the upazila of Tangail district is given in Annex J, Volume 2. There is no other type of road in the core network. But it should be borne in mind that, roads maintained by RHD have been identified as RHD roads but no name was given. Due to absence of data, RPPM could not identify whether RHD roads are national or regional highways.

7.3 Improvement of roads

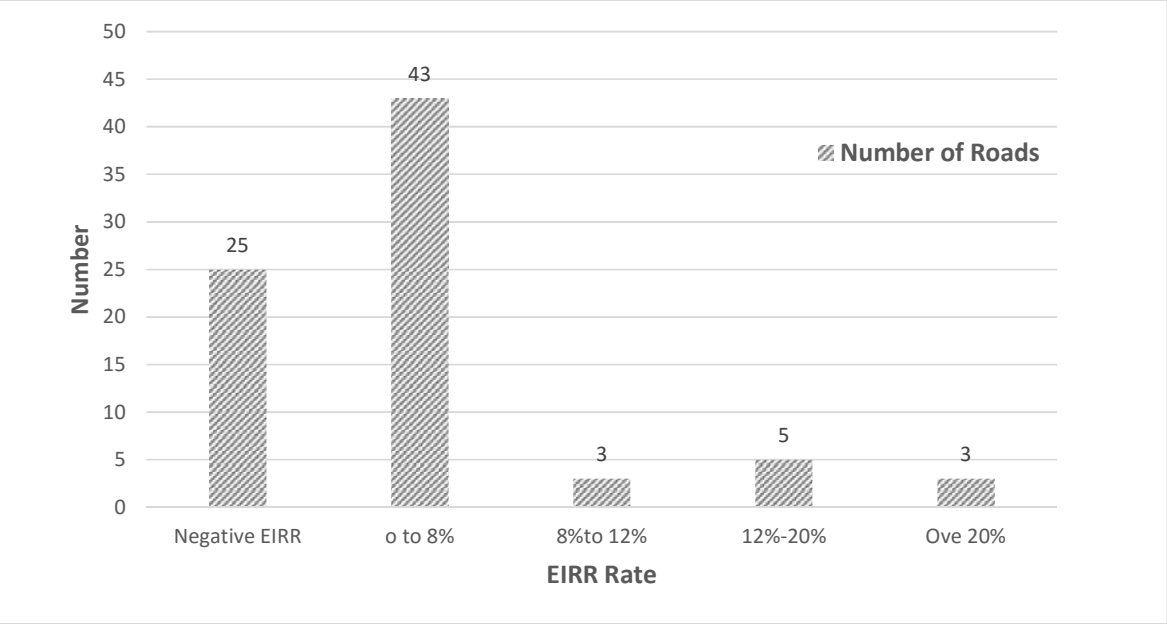
RPPM generated four tables for improvement of roads for each of the 12 upazilas of Tangail. The generated outputs of roads requiring improvement are provided in Annex K1 – Annex K4, Volume 2. Each table provides the prioritised list for a particular type of road surface.

Considering traffic volume, two types of earth roads were considered for improvement. Roads with AADT values over 200 were considered as high volume earth road and roads with AADT values 200 or less as low volume earth roads. It was not possible for LGED to collect traffic count data for all earth roads. The AADT value of roads for which traffic count data was not available was stored as none (0) in the database. So, for some roads the priority ranking for improvement may change if AADT data were available for all roads. It is found that most of the low volume earth roads of Tangail have MCA score less than 20. There are only 90 roads which have MCA scores over 20. It may be mentioned here that of these 90 roads, AADT values for 10 roads were not available. Of these 10 roads, eight were located in Ghatail upazila. Basail-Ishorgonj GC via Borni kishory Road is the highest ranked low volume earth road of the district. This is an upazila road which connects Ishorgonj GC with Basail-Sunna GC road. Except Delduar upazila, the top three low volume earth roads in 11 other upazilas have a MCA

score over 20. Table 7.2 provides the top 20 low volume earth roads which needed improvement in the district.

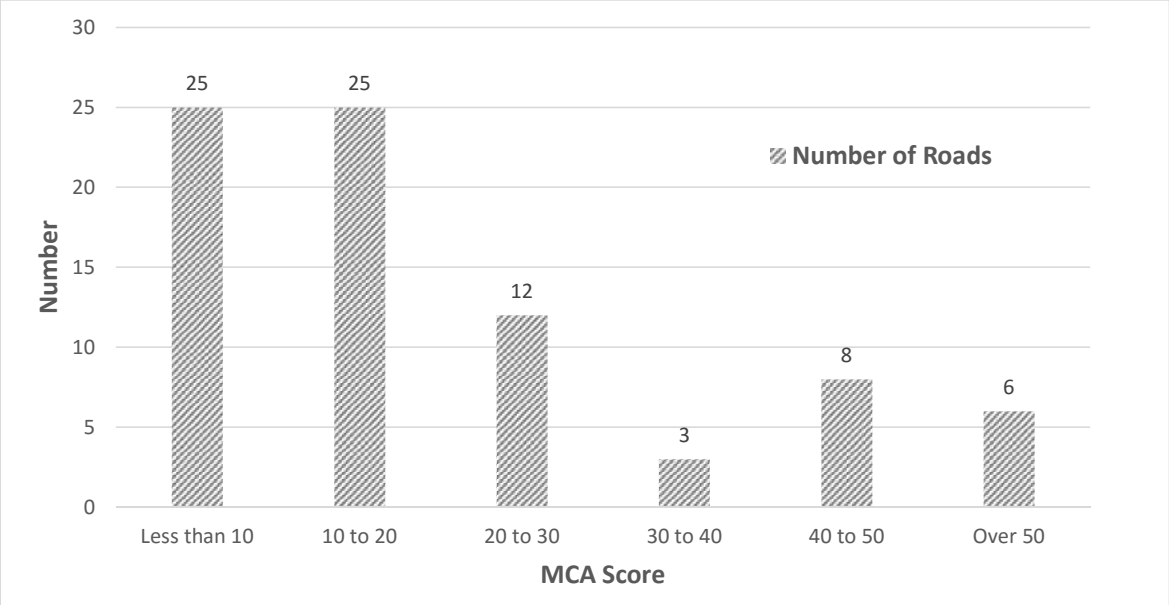
There are 79 earth roads with AADT value over 200. For these roads both EIRR values and MCA scores were calculated. Table 7.3 provides the top 20 high traffic volume earth roads which needed improvement in the district. Deuli UP Office (Silimpur)-Bangrail Road in Delduar Upazila is the highest ranked earth road with high volume of traffic. The road has an EIRR value of 33.94%. It may be mentioned here that all upazilas did not have earth roads with high traffic volume. Seven upazilas (Basail, Delduar,Kalihati, Mirzapur, Nagarpur, Shakhipur and Tanagail Sadar) have high traffic volume earth roads. If the generally accepted 12% is considered as the cut-off value for EIRR only eight roads could be selected. Most of the roads have an EIRR value below 8% (Figure 7.1a). Although some roads have high MCA scores (there are six roads which have an MCA score over 50), most of the roads have an MCA score below 20 (Figure 7.1b). It is observed that many roads with less than 12% EIRR value can have high MCA scores. This implies that such roads have significant access benefits and that the selection of roads for improvement may not always be based on their EIRR values, their MCA scores may also be considered.

Figure 7.1a: Distribution of roads for improvement (high volume earth road) by EIRR value



Source: Based on data generated by RPP

Figure 7.1b: Distribution of roads for improvement (high volume earth road) by MCA score



Source: Based on data generated by RPPM

Compared to earth roads, the partially paved roads draw much higher traffic volume. The AADT value for most of these roads is above 300; many of them also have considerable number of commercial vehicular traffic. As the AADT value for all partially paved roads were not available, the ranking order of some of the roads, as shown in Table 7.4 may get changed if AADT value for all roads were available. It was found that Nagarpur H.Q-Daragram GC via sanka bazaar of Nagarpur upazila was the highest ranked partially paved road. This is also one of the longest roads of Tangail district. About half of its length is paved. It also had the highest AADT value among all the partially paved roads in the district. If a 12% EIRR value is considered for investment, 56 partially paved roads can be considered for improvement.

Similar to high traffic volume earth roads, some partially paved roads also have a negative EIRR value. Table 7.4 provides the list of top 20 partially paved roads in Tangail. Some upazilas (for example, Tangail Sadar and Mirzapur) do not have any road in the top 20. MCA scores for most of these top ranked roads are high. There are more than 50 partially paved roads in Tangail with an MCA score of over 50.

The Bonki Gramin Bank R&H - Bonki Mirza Chala Road of Shakhipur was the top ranked HBB road which needed improvement. There were only nine partially paved HBB roads and most of them had an EIRR value of 0%. The top ranked Bonki Gramin Bank R&H - Bonki Mirza Chala Road had an EIRR below 8.5%. These roads also had relatively low MCA scores (the highest being about 17).

7.4 Maintenance of paved and partially paved roads

RPPM made the priority ranking order of paved roads for maintenance based on their MCA scores. This was in line with the current practice in LGED. As mentioned earlier, earth roads were not considered for maintenance. The generated outputs showing priority ranking for road maintenance are provided in Annex K5 to Annex K7, Volume 2.

70 partially paved roads needed maintenance. Compared to partially paved roads considered for improvement, these roads had higher MCA scores. Figure 7.2a provides a graphical representation of the distribution of MCA scores of partially paved roads requiring maintenance. The top ranked Nagarpur H.Q-Daragram GC via Sanka Bazaar road for maintenance was also the top ranked partially paved road for improvement. It may be mentioned here that of the top 20 partially paved roads for maintenance in the district (Table 7.5), nine roads were also listed among the top 20 roads for improvement in the district.

Kuripara Simarpar to Masidpur Road in Mirzapur Upazila was the only HBB road that met the criteria for maintenance; other roads did not require maintenance.

There were 94 fully paved roads which met the criteria for maintenance. As expected, these roads had heavy volume of traffic (in terms of both AADT and CVD). These roads also had high MCA scores. Figure 7.2b provides the distribution of MCA scores for paved roads requiring maintenance. For maintenance, the Sakhipur-Sagardighi via Barochowna Road in Shakhipur Upazila was the top ranked paved road in the district. Table 7.6 reveals that of the top 20 paved roads requiring maintenance five are in Kalihati upazila and four in Ghatail Upazila. On the other hand, no paved roads from Dhanbari, Mirzapur and Tangail Sadar were in the top 20 list of paved roads requiring maintenance.

Table 7.2: Top 20 low volume earth roads selected for improvement in Tangail

Ranking	Road Code	Road Name	Upazila	AADT	CVD	Length in km	MCA Score
1	393092010	Basail-Ishorgonj GC via Bornikishory Road.	Basail	131	7	3.43	70.81
2	393763016	Nagarpur-Shahbatpur UP road niaNagarpur Govt. College	Nagarpur	200	0	3.00	57.26
3	393234018	Delduar Bazar-DelduarElasin Road	Delduar	134	13	0.50	41.96
4	393384055	Jamtail-JhawailFerryghat	Gopalpur	9	0	2.55	40.66
5	393964072	Keramjani-HadiraU.P.office via Pankata Bazar road	Dhonbari	59	0	5.00	37.73
6	393765034	Shahjanipucca road at Shajhani High School via Atapara Primary School JamunaGhat	Nagarpur	131	0	2.62	34.76
7	393575018	Dhalpur-Malka road Capri	Modhupur	40	0	3.85	33.88
8	393764078	Tangail-Aricha road at BRCK office to Shahbatpur road.	Nagarpur	128	0	2.00	33.71
9	393853009	Kalia UP office-Debraj Bazar Rd	Shakhipur	24	0	6.00	33.16
10	393194068	Shailkol hat-Lakhipur road	Bhuapur	4	0	2.10	32.89
11	393194022	Amula-Changtapara road	Bhuapur	4	0	4.00	32.89
12	393283007	Guiagomvir (Makrai Bazar)-Soankhola Bazar (Sandhanpur UP office) Road	Ghatail	0	0	5.00	31.95
13	393665011	Jamurki-Dubail Rd	Mirzapur	48	0	2.10	31.46
14	393665035	Zamurki High school to Dobail road	Mirzapur	57	0	1.50	31.15
15	393764065	Khorshed Market to Bharrah GC road via Bir-salil	Nagarpur	178	0	2.50	30.97
16	393764084	Chandakmadrasha to Subantalimadrasha via Agdhiguliabazaar	Nagarpur	135	0	4.20	30.89
17	393854025	Kalidash-Borachala via Raja Bari road	Shakhipur	77	0	10.75	30.65
18	393384056	JhawailBagdibari-Darisaya P/School	Gopalpur	71	0	2.27	30.63
19	393765066	Singdair bazar-south Taluknagar road.	Nagarpur	22	0	1.50	30.30
20	393194064	NiklaDoripara Based House-KhorakChanmunshi House road*	Bhuapur	4	0	2.40	30.19

Source: Compiled from list generated by RPPM

Table 7.3: Top 20 high volume earth roads selected for improvement in Tangail

Ranking	Rd Code	Rd Name	Upazila	AADT	CVD	Length in km	EIRR %	MCA Score
1	393233004	Deuli UP office (Silimpur)-Bangrail Road	Delduar	1004	80	3.95	33.95	47.20
2	393473003	Bangra U.P.-Sahadebpur Bazar Road	Kalihati	892	47	2.10	24.09	43.44
3	393953011	Bashakhanpur Bazar-Hugra UP via Beguntola Bazar	TangailSadar	811	50	9.00	20.93	33.87
4	393234029	Babupur-Bangrail	Delduar	492	70	2.45	19.34	11.66
5	393233008	Deoli Up Office-Elasin GCC Road Via Shalpabatia	Delduar	740	12	3.49	16.73	44.77
6	393093011	Kanchanpur UP Office-Patherghata hat via Tarabari Road.	Basail	434	48	8.70	14.63	28.61
7	393092009	Ishorgonj GC-Sunna GC Road.	Basail	388	30	3.00	14.39	75.87
8	393663015	Warshi R&H road to Warshi UP road	Mirzapur	679	70	3.00	13.17	21.84
9	393953006	Baghil-Aynapur Road	TangailSadar	505	74	5.73	10.04	44.36
10	393473014	Elanga U.P.-Nardahi Bazar road	Kalihati	540	11	5.00	8.97	60.87
11	393093008	Basail-Kanchanpur UP office Road.	Basail	344	48	3.92	8.07	41.30
12	393234001	Putiajani-Meruaghona Rd	Delduar	414	17	2.50	6.48	16.35
13	393853015	Mahanandapur Bazar-Baheratail UP via HarangaChala Rd	Shakhipur	267	4	7.60	6.06	47.26
14	393093014	Fulkihat(Janjania)-Kawaljani UP via Badiajan.	Basail	238	10	4.00	5.76	28.74
15	393234026	Deoli hat to jhunkai hat Road	Delduar	293	14	1.00	4.91	8.89
16	393473015	Kokdahara U.P.-Balla U.P. Road	Kalihati	547	0	3.00	4.77	41.00
17	393472014	Jamuna Bridge-Torabgonj G.C. road	Kalihati	507	21	3.70	4.51	57.81
18	393094024	Karatia-Saysata via Sonalia Road.	Basail	202	19	2.70	2.76	5.54
19	393234039	Natiapara-Basail Road	Delduar	221	28	0.70	2.70	16.81
20	393473017	Shahadebpur U.P.(Pouzan)-Bhukta bazar Road	Kalihati	434	17	4.25	2.61	33.22

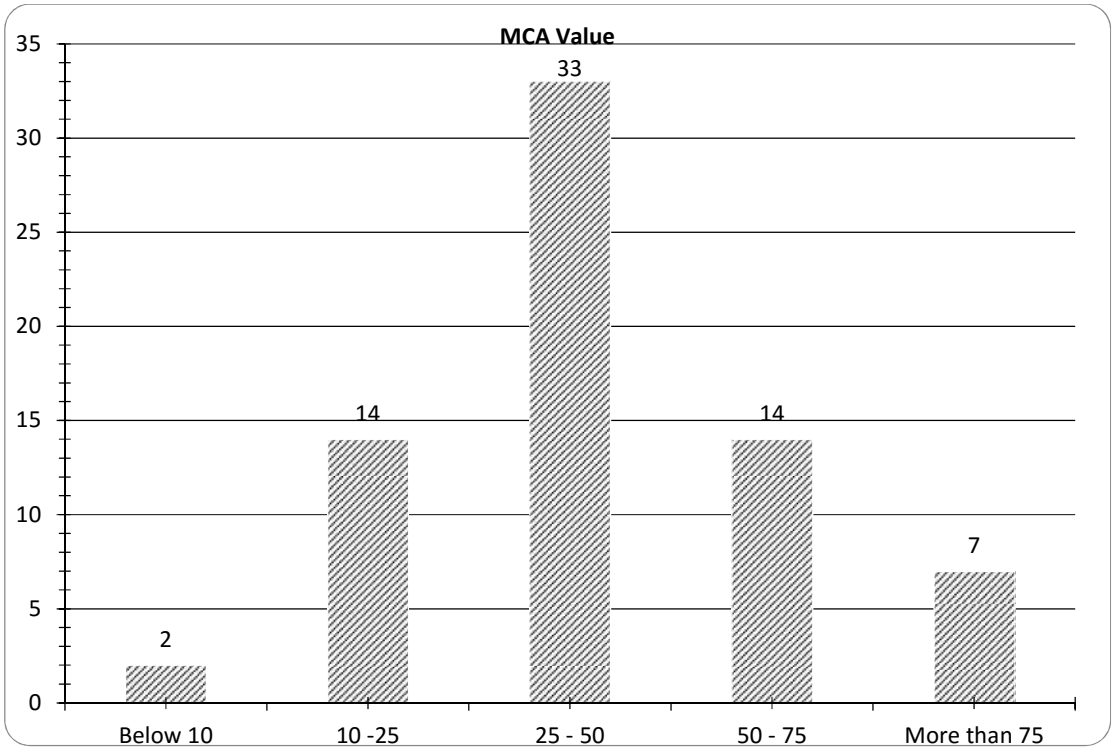
Source: Compiled from list generated by RPPM

Table 7.4: Top 20 partially paved roads selected for improvement in Tangail

Ranking	Road Code	Road Name	Upazila	AADT	CVD	Length in km	EIRR %	MCA Score
1	393762007	Nagarpur H.Q-Daragram GC via sanka bazar	Nagarpur	2348	45	10.55	73.55	85.97
2	393852004	Sakhipur - Suruj GC Road via Salgrampur,TejpurFerryghat.	Shakhipur	1666	186	11.60	71.27	79.68
3	393853014	Shakhipur (Banki)-TatuliarChala via Futanir Bazar road	Shakhipur	1467	292	4.20	68.62	56.19
4	393472002	Bhandeshwar G.C-Balla G.C. Road	Kalihati	843	200	4.65	52.73	77.61
5	393283001	Moghalpara Bazar-Singuria Bazar via Dighulkandi, Anehola UP Office Rd.	Ghatail	1258	304	12.37	50.66	55.72
6	393853010	Berbari Bazar-Boheratoil UP via NakshalaBetua	Shakhipur	942	111	10.15	46.50	39.85
7	393093016	Basail (Andirapara)-Habla UP Office via BalinaVoirpara Road.	Basail	1130	233	8.10	45.23	48.59
8	393762003	Nagarpur-Mirzapur Road Via Mokna	Nagarpur	1352	190	15.78	44.51	78.98
9	393282004	Porabari-Angarkhola-Garo Bazar Rd.	Ghatail	1244	158	21.25	41.96	82.89
10	393474060	Kalihati(Haripur) - Nagbari U.P. Road via Bhandeshwar G.C.	Kalihati	813	29	6.00	40.70	33.63
11	393853002	Hatibanda UP (Taktarchala)-Bazail Bazar	Shakhipur	813	90	9.45	37.25	59.57
12	393853001	Jadabpur UP (Nalua)-salda Bazar road via beltoil	Shakhipur	694	121	14.01	34.49	60.75
13	393572011	Birtibari R&H (ModhupurUpazila) - Dhanbari GC via Zagirachala Road	Madhupur	618	149	9.07	32.81	40.95
14	393232006	Tangail-Aricha R&H Road to Lowhati GCC Road.	Delduar	832	113	9.87	32.31	73.39
15	393093005	Kashil UP Office-Bilpara hat via Kashil High School.	Basail	1024	137	5.50	31.84	44.02
16	393854027	Kalidash-Beltoil road	Shakhipur	399	127	4.00	30.40	17.52
17	393093001	Basail-Kawaljani UP via Maizkhara.	Basail	901	52	7.51	30.39	53.15
18	393233002	Baoikhula Bazar-Nallapara hat via Dubail UP office, Bathuli hat, Fultara Hat Road	Delduar	1113	139	16.13	29.74	48.15
19	393853006	Shakhipur (Mojib College) to Solanga via Isadighi Bazar PatherChowrasta	Shakhipur	617	68	17.05	29.34	52.03
20	393093009	Kashil UP-Nayerhat via Balia Road.	Basail	607	224	6.66	29.27	36.55

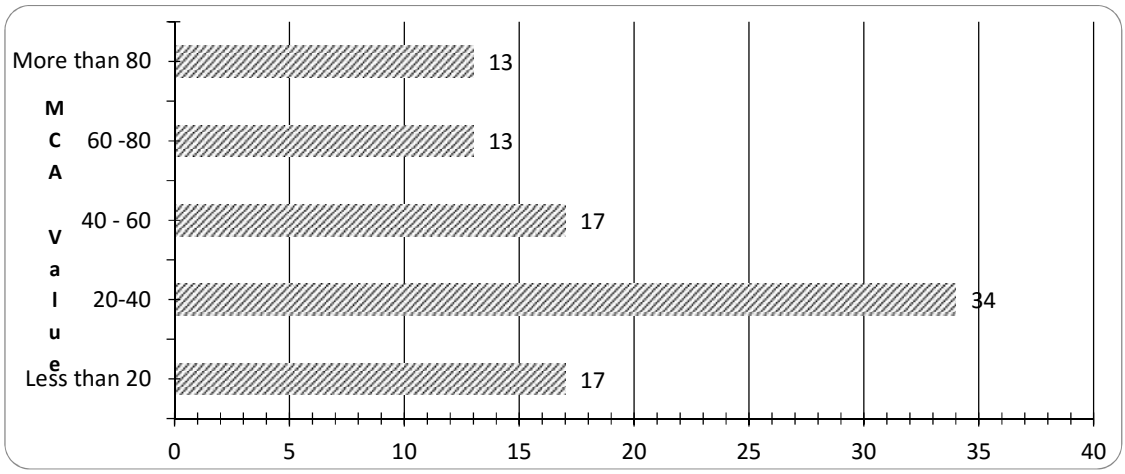
Source: Compiled from list generated by RPPM

Figure 7.2a: Distribution of MCA score for partially paved road selected for maintenance



Source: Developed using information generated by RPPM

Figure 7.2b: Distribution of MCA score for paved road selected for periodic maintenance



Source: Developed using information generated by RPPM

Table 7.5: Top 20 partially paved roads selected for maintenance in Tangail

Ranking	Road Code	Road Name	Upazila	AADT	CVD	Length in km	MCA Score
1	393762007	Nagarpur H.Q-Daragram GC via sanka bazaar*	Nagarpur	2348	45	10.55	88.47
2	393662005	DeohataDhantara G C road	Mirzapur	829	167	8.80	86.52
3	393092004	Basail-Natiapara GC via Bilpara Road.	Basail	648	117	9.66	84.53
4	393472002	Bhandeshwar G.C-Balla G.C. Road*	Kalihati	843	200	4.65	80.90
5	393232006	Tangail-Aricha R&H Road to Lowhati GCC Road*	Delduar	832	113	9.87	80.43
6	393092005	Basail-Sunna GC Road.	Basail	720	137	5.68	80.42
7	393472001	Kalihati (Dhunail)-Shayahat-Hatia JBA Road	Kalihati	813	48	10.00	77.02
8	393762006	Nagarpur HQ-Louhati GC Via Khamardhalla Road	Nagarpur	767	68	8.70	71.77
9	393853002	Hatibanda UP (Taktarchala)-Bazail Bazar*	Shakhipur	813	90	9.45	66.57
10	393093002	Kashil UP Office-Aisara Bazar via Janjania.	Basail	906	100	11.86	64.51
11	393093001	Basail-Kawaljani UP via Maizkhara.*	Basail	901	52	7.51	63.65
12	393853003	Hatibanda UP (Taktarchala)-Koratali Ferry Ghat via KamaliaChala Bazar	Shakhipur	690	53	7.25	62.96
13	393283001	Moghalpara Bazar-Singuria Bazar via Dighulkandi, Anehola UP Office Rd*.	Shakhipur	1258	304	12.37	62.32
14	393853014	Shakhipur (Banki)-TatuliarChala via Futanir Bazar road*	Shakhipur	1467	292	4.20	61.88
15	393473007	KalihatiUpazila-Narandia U.P. Road	Kalihati	541	26	9.90	55.24
16	393572011	Birtibari R&H (ModhupurUpazila) - Dhanbari GC via Zagirachala Road*	Madhupur	618	149	9.07	54.82
17	393473006	Rampur Bhashani G.C.-Fulki U.P. road	Kalihati	588	39	3.30	53.15
18	393473020	Nagbari U.P. - Kawalzani U.P. Road via Ratangonj Bazar	Kalihati	1068	65	7.20	52.77
19	393473005	Paikara U.P(Singutia)-Pouli Bazar Road via Mohela	Kalihati	629	22	5.70	51.64
20	393093005	Kashil UP Office-Bilpara hat via Kashil High School*	Basail	1024	137	5.50	51.39

Source: Compiled from list generated by RPPM

Note: Roads marked with * are also in the prioritised list of top 20 partially paved roads for improvement

Table 7.6: Top 20 paved roads selected for maintenance in Tangail

Ranking	Road Code	Road Name	Upazila	AADT	CVD	Length in km	MCA Score
1	393852001	Sakhipur-Sagardighi via Barochowna Road	Shakhipur	1675	561	14.66	95.74
2	393282002	Sakhipur-Garo Bazar Road	Ghatail	2188	900	15.26	92.67
3	393472010	Kalihati RHW-Barachowna G.C. Road	Kalihati	2396	660	10.42	90.81
4	393282003	Hamidpur-Deopara Road	Ghatail	1643	478	11.25	88.59
5	393852009	Barachowna-Kalihati via Chakpara	Shakhipur	1385	369	11.00	88.47
6	393092001	Basail-Kanchanpur GC Road.	Basail	582	79	3.70	87.97
7	393852002	Sakhipur-Kalidash Road	Shakhipur	779	193	5.74	87.17
8	393282001	Ghatail-Jamuria-Bhuapur Road	Ghatail	1486	307	11.33	86.07
9	393382008	Darisoya-Bhenglabazaar	Gopalpur	380	46	3.25	84.67
10	393282010	Makrai-Deopara Road	Ghatail	1275	193	7.65	83.72
11	393472016	Balla G.C.-Baharatail GC via Ratangonj Bazar Road	Kalihati	1042	75	3.15	82.80
12	393762005	Lauhati GC-Saturia HQ Road	Nagarpur	1742	250	13.00	82.16
13	393232002	Lauhati-Pakulla Rd	Delduar	1732	212	3.62	80.85
14	393382002	Gopalpur-Bhengula	Gopalpur	816	172	4.00	79.20
15	393472009	Zokerchar JBA-Nikrail G.C. Road	Kalihati	1468	77	2.00	78.77
16	393472013	Shaya G.C.-Shialkol G.C. Road	Kalihati	577	28	2.71	78.20
17	393473001	Narandia-Salla Road	Kalihati	1066	33	8.00	77.20
18	393572005	Raktipara-Chapri Road	MadhupurP	375	72	7.50	74.94
19	393382010	Bhengula-Pingna	Gopalpur	330	20	1.75	74.80
20	393762004	TangailAricha R&H at Khorshed Market-Bharra Bazar Via Arrah	Nagarpur	545	46	3.55	73.32

Source: Compiled from list generated by RPPM

7.5 Further improvement/upgrading of roads

Sometime it becomes necessary to improve the road geometric standards, to raise the embankment and to widen pavement and/or road crest and to raise road embankments of an existing road. The road surface may be fully paved, partially paved or HBB. RPPM generates a single list for all kind of road surface for further improvement/upgrading. Generated output of roads requiring further improvement/upgrading are provided in Annex K8, Volume 2. From the data, it was found that only 21 roads needed further improvement/upgrading. All upazilas of the district did not have roads which needed further improvement/upgrading. It was found that nine roads had an EIRR over 12%, in fact their EIRR values were above 40%. As expected, almost all of them had a high MCA score. Table 7.7 provides the top 10 roads which needed further improvement/upgrading in the district.

Table 7.7: Top 10 ranked roads considered for further improvement/upgrading in Tangail

Ranking	Upazila Name	Road Code	Road Name	EIRR %	MCA Score
1	**Mirzapur**	393662001	Pakulla-Lawhati Road Via Bhabkhanda Bazar	82.49	67.12
2	**Nagarpur**	393762005	Lauhati GC-Saturia HQ Road	71.44	61.70
3	**Tangail-S**	393952008	Tangail-Basail Via Vatkura Road	70.88	30.08
4	**Ghatail**	393282003	Hamidpur-Deopara Road	68.13	86.99
5	**Tangail-S**	393952004	Karatia-Silimpur Road	65.72	75.24
6	**Ghatail**	393282001	Ghatail-Jamuria-Bhuapur Road	63.86	89.92
7	**Tangail-S**	393953001	Tangail-Kakua Bazar via Dhalanshibpur Bazar, Kakua UP Road	45.66	55.05
8	**Ghatail**	393282008	Dhalapara-Chapri Road	45.15	79.85
9	**Shakhipur**	393852006	Sakhipur-Dhalapara via Mohanandapur Road	40.73	75.52
10	**Ghatail**	393282002	Sakhipur-Garo Bazar Road	0	96.10

Source: Compiled from list generated by RPPM

7.6 Conclusion

The RPPM generated outputs reveal that there are many roads in the district that may be considered for improvement, further improvement/upgrading and maintenance. However, the generated lists by upazila should not be viewed in isolation. It is also necessary to look from the district perspective as well as in the context of core network development. A link of a core network may not be ranked high considering its EIRR value but may be vital for improving accessibility of an area as a whole. Such a link should have priority for development or maintenance as the case may be. There may be cases where deserving roads may be prioritised low in one upazila with higher EIRR and MCA values than roads of another upazila which may be prioritised high with lower EIRR and MCA value. The decision may be based on other considerations. As the primary objective of rural road development is improvement of accessibility, which is better reflected in MCA scores, roads that have somewhat lower EIRR values than the cut-off rate but have high MCA scores may be given priority for development. In conclusion, the generated outputs are to assist in decision-making, the actual decision should be based on the overall context.

8 Summary, conclusions and recommendations

Rural roads have a vital role in rural development in developing countries. Often, rural road development is considered as an entry point to rural poverty alleviation. As found in many evaluation studies on rural roads in Bangladesh, the development of rural roads has contributed immensely to the social and economic development of rural people and transformation of the rural economy in Bangladesh.

LGED has already developed a vast network of rural roads in Bangladesh including about 76,000 km of paved roads and about 20,000 km of brick paved roads which may be paved in near future. It is important that the selection of roads for improvement from a large number of roads is undertaken through an optimal selection process. This is necessary for the effective utilisation of available resources. Any further development of roads should be selective and based on some criteria so that the network can be sustained and properly maintained over a longer term. Therefore, there was a need to develop a planning and prioritisation methodology for the development, upgrading and maintenance of rural roads.

The project team in collaboration with LGED officials has developed a practical methodology to fulfil this need of future rural road development through a rational selection process. The methodology considers a set of social, economic and access and connectivity related criteria to prioritise three types of road development work undertaken by LGED. The methodology was successfully implemented in the pilot district of Tangail.

The project team has also developed and implemented a web-based road planning and prioritisation application tool RPPM to implement the methodology in the pilot district. RPPM uses data mainly from the two databases of LGED. However, two new tables were added to the road database for use by RPPM. The first table contained some additional data on connectivity and local priority gathered from local workshops. These data were required for MCA. The second table contained values of VOC, TTS, speed, average occupancy and PCU values by vehicle type, which were required for undertaking CBA.

At present RPPM can produce outputs for 12 upazilas of the pilot district Tangail. RPPM may also be applied to generate similar outputs for other districts of Bangladesh. However, before running the application for another district, the two additional tables mentioned above will have to be created and added to the existing road database for that district. The data values in the first table are to be collected by organising local workshops. The details on the data and how they may be collected are provided in a separate RPPM user Manual. The second table, however, will be the same for other districts.

In developing the methodology, a number of challenges were faced. Some observations, suggestions, recommendations and conclusions are outlined in this chapter for their consideration by LGED.

Currently LGED maintains two databases namely the road database and the GIS database. These two databases are not fully integrated. There is a wealth of information in these two databases which could be effectively used in undertaking many useful interactive analyses relevant to rural road development and other development purposes. An integrated database system has the potential of becoming a valuable resource for LGED as well as other government departments, for example, government departments related to primary and mass education, secondary education and health service. Once an integrated database is available, useful analyses are possible even from within the GIS platform without requiring a custom-made program. Although it may require considerable

amount of time, resources and efforts to integrate the two databases, it would be worth considering given its potential use.

The limitations in displaying all features of the outputs produced by the planning and prioritisation software on a map are due to this problem of the two databases. Once this integration problem can be resolved, these limitations can be overcome and interesting and interactive displays of outputs of interest to policy-makers can be produced.

It is advisable that the road database, especially data on traffic volume, be updated. Consideration may be given to update the database on a regular basis, say every three years. Both the CBA and MCA analyses use traffic data. While developing the software, it was noticed that the CBA results, as expected, were sensitive to traffic volume data.

There are some 500-700 rural roads in a typical upazila. It would not be practical to undertake traffic volume studies for long hours on all roads. Consideration may be given to develop a practical methodology to estimate traffic counts and composition on each type of road based on traffic counts for limited hours on representative roads for each type of road and their surface conditions. As village roads are mostly used by pedestrians, it would be very useful if pedestrian counts, especially on village roads, can also be included in the survey.

The future projection of traffic is very important for CBA. While the project has considered the results of available studies on traffic growth and used rational rates for the growth of normal and generated traffic, any detailed growth rates by road type were not available. It is unlikely that traffic grows at similar rates for all types of roads and for all types of vehicles. Traffic growth may also vary by localities and other factors.

This problem needs to be addressed to make CBA results more robust. It is understood that only a limited number of roads are considered for improvement in a year. Traffic counts can be undertaken for before and after situations. Ex-post project traffic counts may be done for 5 consecutive years for a sample of roads. Traffic counts will also be necessary on some other selective roads outside the influence area of the project road to establish the normal traffic growth in that area. The availability of such traffic count data would help to establish reliable traffic growth rates by type of road as well as by district.

For many low volume village roads it was not possible to estimate the low (negative) EIRR values for the fact that undiscounted post investment cash flow was less than the investment cost. It is therefore recommended that MCA scores may be used for priority ranking of low volume village roads. The village roads are mostly used by pedestrians. If pedestrian traffic counts are available, pedestrian traffic volume may be included in MCAs as a criterion. The results of MCAs then can better reflect the actual use of low volume village roads. The inclusion of pedestrian traffic counts in the road database, especially for village roads, is suggested. The availability of pedestrian traffic data and its inclusion in MCA can make the results of such analyses, especially priority ranking, more robust and representative.

With further improvement of connectivity, accessibility and rural transport services, stakeholders' perception on relative importance of the selected MCA criteria as well as the list of criteria may change. It is recommended that the list of selected criteria and their relative weights may be reviewed in 3-5 years time to see if they were still valid.

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