ASSESSMENT OF RURAL TRANSPORT ACCESSIBILITY IN BANGLADESH

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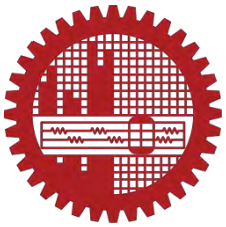
MASTER OF SCIENCE IN CIVIL ENGINEERING
(TRANSPORTATION)



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ASSESSMENT OF RURAL TRANSPORT ACCESSIBILITY IN BANGLADESH

A Thesis Submitted by

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A thesis submitted to the Department of Civil Engineering, Bangladesh University of Engineering and Technology, Dhaka, in Partial Fulfillment of the Requirements for the Degree of

Masters of Science in Civil Engineering
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DEPARTMENT OF CIVIL ENGINEERING
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The Thesis Titled **"Assessment of Rural Transport Accessibility in Bangladesh"**, submitted by: **Md. Aminul Islam**, Roll No: 0412042451P, Session: April/2012; has been accepted as satisfactory in partial fulfillment of the requirement for the degree of **Master of Science in Civil Engineering (Transportation)** on **19, April, 2017.**

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Md. Aminul Islam
April 19, 2017

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ABSTRACT

This research paper has been prepared to estimate rural transport accessibility index to help decision makers integrate transport interventions into poverty reduction programs and to develop the relationships between rural accessibility improvement and socio-economic parameters of Bangladesh.

In order to achieve the objectives of this research, at first road transport network of Bangladesh was collected from Roads and Highways Department (RHD) and Local Government Engineering Department (LGED). The district administrative area boundary was collected from LGED. Then the demographic and socio-economic data of sixty-four (64) districts of Bangladesh was collected from Bangladesh Bureau of Statistics (BBS). The road network and administrative boundary data are in the form of GIS environment. The districts demographic statistics are in the form of tabular data.

After collecting the data, the analyses were done using GIS software and Microsoft Excel Analysis Toolpack (e.g. Data Analysis Tool, Data Solver Tool). Rural Transport Accessibility was estimated by ArcGIS-ArcMap. From the analysis, rural transport accessibility index of sixty-four (64) districts of Bangladesh has been estimated considering only the paved road transport (motorable all the year round) network across the country. Then the estimated accessibility value has been compared with the poverty incidence and with other socio-economic parameters to establish a relation among them. At the bottom line, a district ranking was prepared to prioritize the budget allocation in physical infrastructure that will seek help the policy maker to foster poverty free and equitable development vision of Bangladesh.

Moreover, Data Envelopment Analysis (DEA) and Correlation Analysis were carried out to establish the priority ranking setting the target to minimize the objective function (in this case poverty incidence) and to investigate the correlation (if exists any) among the accessibility to the poverty incidence and socio-economic parameters.

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LIST OF ACRONYMS AND ABBREVIATION

ADP	Annual Development Programme
AI	Accessibility Indicator
BBS	Bureau of Statistics
BR	Bangladesh Railway
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
ESRI	Environmental System Research Institute
GDP	Gross Domestic Product
GIS	Geographical Information System
GRG	Generalized Reduces Gradient
HCR	Head Count Ratio
HIES	Household Income and Expenditure Survey
HQ	Head Quarter
IDA	International Development Association
ILO	International Labour Organization
IMT	Intermediate Means of Transport
IRAP	Integrated Rural Accessibility Planning
IWT	Inland Water Transport
LCC	Lambert Conformal Conic
LGED	Local Government Engineering Department
LP	Linear Programing
LPL	Lower Poverty Line
MDG	Millennium Development Goals
MT	Motorized Transport
NGO	Non-Government Organization
NLP	Non-Linear Programming
NLTP	National Land Transport Policy
NMT	Non-Motorized Transport
RAI	Rural Transport Accessibility Index
RHD	Roads and Highways Department
RMMS	Road Maintenance Management System
RMP	Road Master Plan
RMS	Result Measurement System
SDG	Sustainable Development Goals
SE	Socio-Economic
UPL	Upper Poverty Line

CHAPTER-1

INTRODUCTION

Chapter One
INTRODUCTION

1.1 General

In this research report, Rural Transport Accessibility Index (RAI) will be estimated and try to establish a relationship between RAI, Poverty and Socio-Economic Parameters. The importance of transport accessibility and its contribution to poverty reduction is imperative. Transport access has direct impact on poverty reduction and upliftment of peoples' life style. "Poverty Reduction" is Bangladesh Government's overarching objective. In this urge, two questions come in mind sensibly, ***"what are incidence of poverty?"*** and **"how to reduce these incidence of poverty?"**

This report entails to address these issues only in the perspective of transport accessibility.

Poverty has many root causes. While it is primarily related to very low incomes, it is manifested in many dimensions, especially malnutrition, ill health and illiteracy. Attempts to alleviate poverty basically follow two broad approaches: direct and indirect. The indirect approach relies on economic growth to generate income earning opportunities for the poor, while the direct approach targets assistance to the poor for their specific basic needs, especially food, health care and education.

For Economic Growth-

To avail the income earning opportunities, say for employment, people need to go some places where he or she can works – so for this need to go – there is a need of means – i.e. transport.

For Food-

None community in the world produce all the foods what he needs on daily basis to satisfy the demand of food. Every times he or she needs some items of foods need to buy from market – so there is need of means – i.e. transport through which he or she can go to nearby market and that particular foods came from other place to his or her nearby market.

For Health care-

Say for instance there are sufficient good health clinics, good doctor and equipment in rural units. But, it is necessary and sufficient condition to have a good transport network to avail the health care services in the clinics.

For Education-

As in the case of health care, there are sufficient good school buildings, good teachers in the rural villages but no transport network. How people would avail the education. So it is necessary and sufficient condition to have a good transport network to go to school.

Therefore, both the approaches to poverty reduction require adequate means of moving people and goods, transport development becomes a crucial complementary factor in the process of poverty alleviation.

For Agricultural Input

For agricultural production, the farmers need modern argi-equipment, pesticides, fertilizer, and high productive seeds because agriculture is the single largest producing sector of Bangladesh. It contributes to the economy is about 17.22% to the total Gross Domestic Product (GDP) of the country (*source: BBS Year Book-2014*). This sector also accommodates around 45.6% of total labour force. GDP growth rate of Bangladesh mainly depends on the performance of the agriculture sector. So, in order to have a smooth supply and availability of these argo-input it is one of the necessary and sufficient condition to have the accessibility to the area by transport network.

For Social Bonding

Peoples in rural areas not having the mobility become isolated to visit their near and dear ones to maintain the social bonding. By meeting and seeing with their relatives, people acquire mental satisfaction and peace. It is also tradition of people in general, in particular the rural women to visit their ancestral house and relatives. By visiting they become invigorate and have metal peace. But the areas not having accessibility can‘t exploit the opportunity of social bonding.

To overcome these stumbling blocks in rural areas, this study has been taken. This study addresses this question by reviewing the rural transport access through which low income groups can be assisted to overcome poverty. The study recommendations also suggest the ways to increase the mobility in rural areas through guiding the policy maker to allocate due resources to enhance the accessibility through understanding the effect or gravity of not having transport access.

1.2 Background of the Study

This section briefly describes the characteristics of rural transport accessibility and travel patterns in terms of trip purpose, factors affecting the extent of travel and goods/load carrying and modes of transport.

Travel and transport are related to needs of access to facilities or services and movement of goods. These can be broadly broken down into four categories: ***daily subsistence, economic, improvement of human capital and other social and business purposes.***

Physical isolation is a strong contributor to poverty. People without reliable transport accessibility to social and economic activities/services are poorer than those with reliable access facilities. Problems of access are particularly severe in rural areas of Bangladesh. The great majority of the population of Bangladesh, roughly 85 percent, is living in rural areas without reliable access to transport. The measurement of rural access is very important aspect to understand the peoples‘ isolation and rural access index one of the yardstick which provides a consistent basis for estimating the proportion of the rural population which has adequate access to the transport system. On the other hand, findings of relationship between accessibility improvement and socio-economic parameters are to help understand the gravity to allocate resources.

A country‘s ability to unleash its economic potential is closely linked to the efficiency of its transport system. Transport is an integral part of daily subsistence and economic and social activities. That is especially true for the poor: poor households transport their food and need transport services to get to markets, jobs, and health clinics. The likelihood that the children of poor families-especially daughters-will go to primary and secondary schools is much higher if there are reliable and affordable transport services. Better transport can also facilitate the participation of the poor in social and political process. In countries that lack an effective transportation system, poor people are unable to accumulate the human, physical, financial, and social assets to break out of poverty cycle. A well-defined and effective transport policy must be an integral part of every countries overall poverty reduction strategy.

This rural accessibility index and relationship measurement seek to help decision makers to integrate transport interventions into poverty reduction programs because transport has a pervasive influence across a country‘s economy and its social fabric, it is hard to trace and measure the ultimate impact of transport interventions on the welfare of poor households. But we do know that improvements in transport have the greatest impact on poor people when other sectoral interventions are also adequately in place and that without good transport many sectoral interventions may be ineffective.

1.3 Objective of the Study

The overall objective of this research project is to compute rural accessibility index to help decision makers integrate transport interventions into poverty reduction programs and to develop the relationships between rural accessibility improvement and socio-economic parameters of Bangladesh. The specific objectives as following:

- *Summarizes the understanding of the links between poverty and transport access;*
- *Measuring the rural access index and poverty incidence;*
- *Develop a relationship between access and poverty;*
- *Spatial maps on accessibility index; and*
- *Suggests avenues to the policy makers to prioritize the resource allocation based on accessibility map.*

1.4 Study Area and Scope of Work

1.4.1 Study Area and Road Network

The scope of area under this thesis study is the spatial area of Bangladesh, whose geographical area extends from 20º 34´ to 26º 38´ North and 88º 01´ to 92º 41´ East. To measure the Rural Transport Accessibility Index (RAI), it is taken into consideration the administrative area of District of Bangladesh, where there are 64 Districts under 8 Divisional areas that comprise Bangladesh as shown in Figure 1-1.

RAI is calculated providing the all season road network of Bangladesh consists of Roads and Highways Department (RHD) and Local Government Engineering Department (LGED) national wide road network. Accessibility Index is calculated based on the RHD and LGED all weather road network of Bangladesh. The RAI has been calculated for the year of 2011 to compare with the poverty situation of Bangladesh.

Table 1-1: RHD Network with Surface Type

RHD – All Season Road Network	Length (km)	Surface Type	
		Paved (km)	Unpaved (km)
National Highway	3790.86	3428.34	362.54
Regional Highway	4206.12	3716.81	489.31
Zila Road	13095.16	9013.82	4081.34
Total RHD	21,092.14	16,158.97	4933.19

Source: *RHD Road Maintenance Management System (RMMS) database, (www.rhd.gov.bd)*

Table 1-2: LGED Network with Surface Type

LGED – All Season Road Network	Length (km)	Surface Type	
		Paved (km)	Unpaved (km)
Upazila Road	37,334.86	29,797.33	7,537.53
Union Road	44,202.03	22,478.31	21,723.72
Village Road (Type-A&B)	2,22,842.42	31,027.77	191814.65
Total LGED	3,04,379.31	83,303.41	2,21,075.90

Source: LGED Road Database (www.lged.gov.bd)

The RAI will be compared to poverty and other socio-economic values to explore the association among them and also analyze the reflection of accessibility on poverty and socio-economic statistics. Total Area of Bangladesh is 1,47,570.12 square kilometer out of which 1,24,455.96 square kilometer area is treated as accessible through all season road round the year. The underlying proposition adopted in this study is that the number of rural people who live within two kilometers (typically equivalent to a walk of 20-25 minutes) buffer area of all-season road.

Table 1-3: Accessibility Status over Spatial Area of Bangladesh

	Area (km^2)	Access Area Ratio in Percent	Less/Non Accessible Area
Bangladesh (including water river/water bodies)	1,47,570.12	57.41%	42.59%
Land Area	1,24,455.96	68.07%	31.93%
Access Area by all Season Road (2 km buffer area)	84,719.02		

Source: BBS and this Study

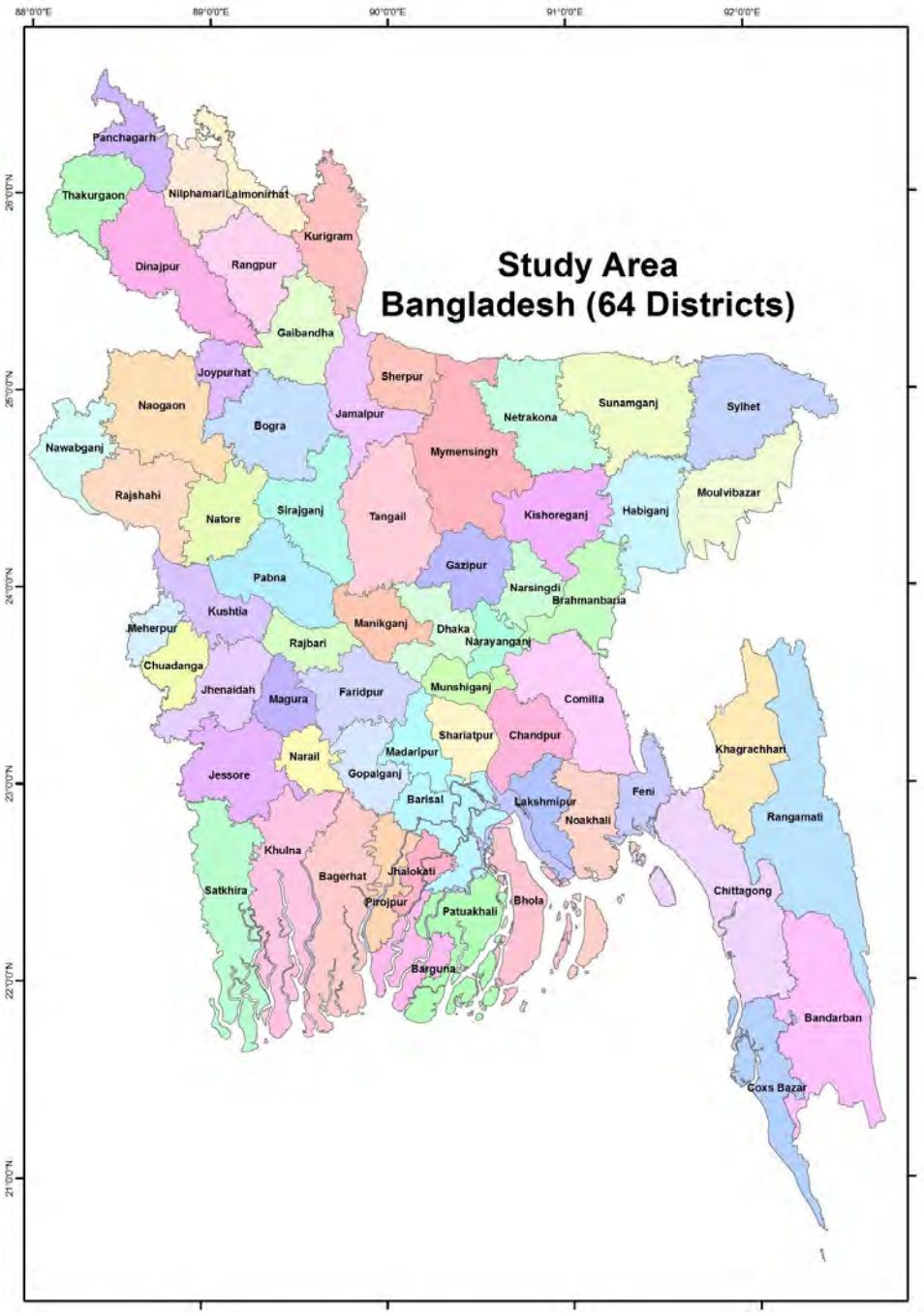


Figure 1-1: Study Area

Source: Map prepared under this study

1.4.2 Demographic Data

District wise population of Bangladesh has been used in this thesis study. Then the District's people are subdivided into rural and urban population to distinguish the urban people who are better accessible than that of the rural population. Furthermore to attain the objectives of the study, population characteristics in the form of poverty incidence has been used. For all these data sources have been collected from Bangladesh Bureau of Statistics (BBS).

1.4.3 Spatial Data

In this thesis study to assess the Rural Transport Accessibility Index (RAI) various spatial data has been used to perform analysis in ESRI ArcGIS-ArcMap environment. To do the analyses in this ESRI GIS environment, the following kinds of spatial data are used:

Road Network Data (line/arc data – GIS data)

RHD Road Network – GIS shape file

LGED Road Network – GIS shape file

Administrative Data – GIS shape file

Administrative Boundary (National, District level) – line/arc data – vector form

Administrative Polygon – polygon data – GIS shape file

It will be used the Lambert Conformal Conical (LCC) Projection System for all the spatial data.

1.5 Organization of the Report

This dissertation is part of post graduate study of Masters of Science in Engineering (M.Sc. Engineering) in Transportation program at Bangladesh University of Engineering and Technology (BUET), Session April-2012 accomplished by the author. This research study report comprises of five (05) chapters. The report's structural organization is shown in Figure 1-2 and the synopsis of each chapter is presented below:

Chapter 1 includes background and objectives of the study. It also presents the study area and scope of the work done under the thesis study. The importance and its implication in the practical life of this thesis outcome are also presented in the first chapter.

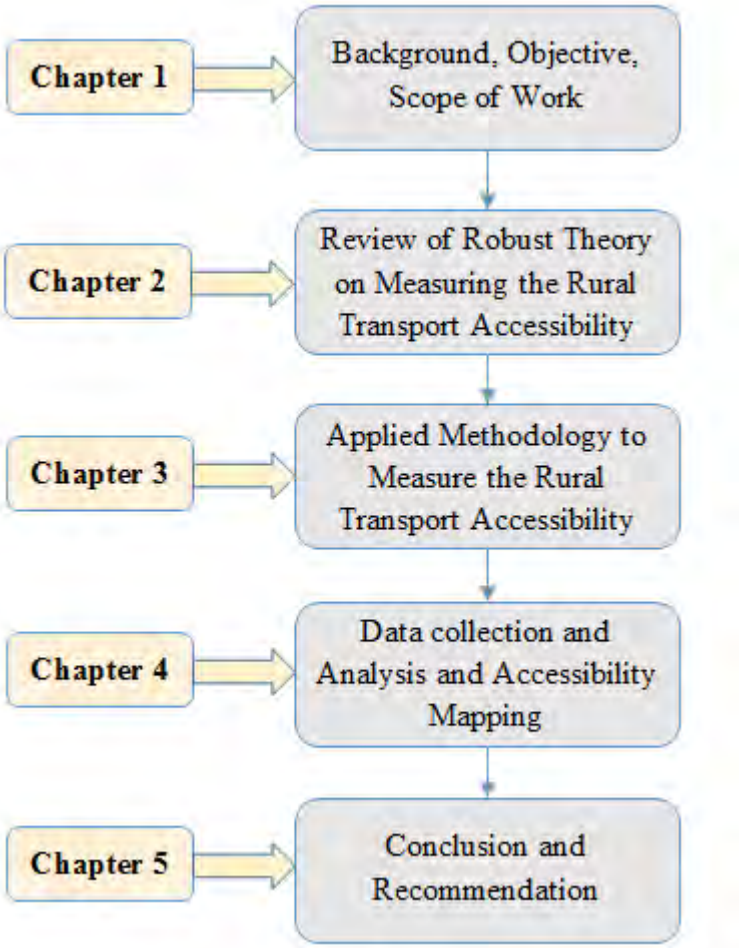
Chapter 2 delineates reviewing the literature pertinent to the topics. In this chapter it is critically reviewed the previous study reports on National and International in particular on the ambit of Rural Transport Accessibility measurement.

Chapter 3 chalked out the methodologies contemplated to furnish the study.

Chapter 4 represents and lays out the data collection and analysis, which is the most important chapter to substantiate the study report.

Chapter 5, the final part of this study report, draws out the recommendation and conclusion made by the student which are rudiments of Chapter 4 and as well the study outcome.

Figure 1-2: Flow Chart of the Organization of the Study



Source: this study

1.6 Overview

In this chapter background, objectives, study area & scope of the study are elucidated and also organization of the thesis is depicted. In the next chapter literature reviewed related to Rural Transport Accessibility in Bangladesh and other developing countries is elaborated. Most importantly in next chapter, the theoretical basis and its implication of rural transport accessibility which is globally accepted indicator to bring down the poverty is reviewed.

CHAPTER 2

LITERATURE REVIEW

Chapter Two
LITERATURE REVIEW

2.1 Introduction

This section describes literature review and theoretical basis to measure the Rural Transport Accessibility Index (RAI), one of several Transport Headline Indicators endorsed by the World Bank Transport Sector Board in 2003. The index has been adopted for the Results Measurement System (RMS)[1] of the 14th round of the International Development Association (IDA-14) which was launched in July, 2005. The Index has developed with a view that it identifies an important priority for poverty reduction strategies in view of the established links between physical isolation and poverty. This provides stronger linkage to the Millennium Development Goals (MDG) and in recent time to Sustainable Development Goals (SDG) to better assesses the contribution of domestic and foreign assistance to the sustainable development of the countries.

Bangladesh Government emphasizes the importance of rural infrastructure development of the country. Bangladesh Transport sector is not equally and widely distributed in all Districts. In order to maintain nonbiased development, it has to be identified a key diagnostic measures which have particular significant for the sector in contributing to the wider development process. These are considered to be headline transport indicators.
The Rural Transport Accessibility Index (RAI) provides a consistent basis for estimating the proportion of the rural population which has adequate access to the transport system. It can help to inform policies and strategies which ensure that the rewards of development are distributed more equitably to the rural population.

2.2 General Understanding about Transport Accessibility

2.2.1 Definition and Importance of Access

Accessibility" and **Mobility**" are two terms that are often used in transport planning processes, but sometimes confusion is created by the way these terms are used. Mobility refers to the ease with which a person can move about [2]. It relates to the person's physical fitness, availability of different modes of transport, and the resources available to the person concerned (Jones, 1975). Mobility is also dependent on the individual's other personal attributes (e.g. a mother with young children would be considered less mobile than a woman without small children).

On the other hand, accessibility is defined as the opportunity that an individual or type of person at any given location possesses to take part in a particular activity or a set of activities (Jones, 1981). The concept of access has been applied to regional and rural

[1] The RMS involves measuring a set of indicators, which captures key aspects of the development of 81 countries which receive IDA concessional assistance (IDA, 2004).

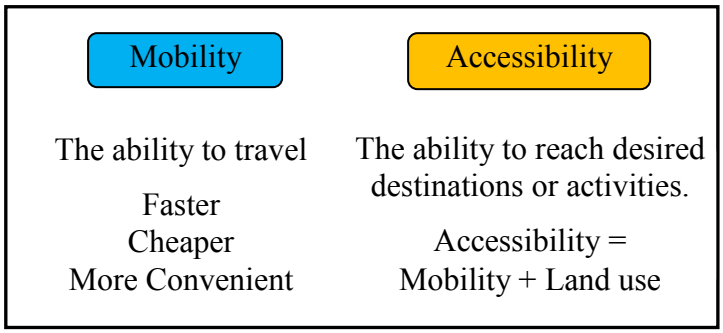
planning for some years now and a considerable body of literature exists on this subject. It is widely accepted that accessibility has three elements:

- *the location of the individual*
- *the location of the supply, service or facility to which the individual needs access*
- *the link to bring the two together*

The objective of bringing the individual to the location of the supply, service or facility to which the individual needs access can be achieved by: (i) moving the individual physically to the facility (mobility of the individual); (ii) taking the facility closer to the individual (relocation of the facility); and (iii) a combination of (i) and (ii) which reduces physical movement of the individual and the use of the transport system. Therefore, any interventions to improve access involve one or more of the above.

Mobility and accessibility are the two fundamental benefits transportation is meant to provide. They are related but slightly different. Mobility is defined as the ability to travel. Mobility is improved by making travel faster, cheaper, and more convenient.

Accessibility is defined as the ability to reach desired destinations or activities.
Accessibility can be viewed as a combination of mobility and land use patterns. Accessibility can be improved in the following ways:



- *Transportation investments that improve mobility*
- *More compact land use patterns that locate origins and destinations closer together.*

People do not travel for its own sake, but to engage in activities, such as employment and education. For this reason, accessibility is more important than mobility.

2.2.2 Importance of Rural Transport Accessibility

Transport has direct impacts on the personal wellbeing of all income groups. It is generally accepted that access to at least minimal infrastructure services is one of the essential components of personal wellbeing [3]. Improvements in transport not only provide people with more convenient access to a broad range of socio-economic opportunities, but also have strong income effects by lowering transport cost and hence the prices of consumer goods and services. In these ways, transport exerts a pervasive contribution to the improvement in personal wellbeing. Understanding these impacts is especially important in assessing transport‘s direct contribution to poverty reduction.

Transport‘s impact on personal wellbeing may be best assessed by examining closely how transport affects people‘s daily activities. People make trips to workplace, to school, to health clinics, to sell & buy the products and to the locations of social services. In rural

areas, where people have better access the farmers can sell and buy the products at reasonable and competitive price. These marginalized people can avail better education and health services. If we think another way that income is the dominant determinant of individual travel behavior, more trips per person, longer average trip distance, and faster and more comfortable modes of transport are all linked to rising incomes. As incomes moves up, people are able to afford access to more facilities & opportunities and more social interactions. So it‘s a one-way process if the people have better access they can earn more and be more wellbeing.

For the rural poor people, the lack of affordable access deprives them of the ability to take advantage of better market access and even of very basic health, education and social services. Reliable access to schools and health services for the poor contributes directly to build their adroit human capital, which is a key factor in sustainable poverty alleviation.

Accessibility for the poor in rural areas of Bangladesh is inadequate. For example, the rural poor often have extremely limited mobility beyond their immediate settlement due to geographical isolation and the high cost of motorized transport. As a result, the poor are not able to take advantage of market opportunities, such as seasonal work, agricultural products beyond their settlements. Moreover, an adequate accessibility reduces food prices and the risks of famine by facilitating the movement of food from surplus to deficit areas. For farmers in general, improved rural accessibility can also ease the introduction of improved farming practices and the transition from subsistence farming to cash crops and a market economy. Accessibility improvements also lower the costs of inputs such as fertilizer. Reliable access (all-weather passability) to input and output markets can stimulate higher cash-crop farming production and more stable incomes, and enable the poor to improve their disaster risks. Rural transport improvement can benefit urban populations as well. For example, by lowering the cost of rural (and rural to urban) transport, a reduction in food prices for the urban poor can be achieved. So accessibility plays a critical role to alleviate poverty and to acts as catalyst to improve human development.

2.2.3 Poverty and Isolation

Physical isolation is a strong contributor to poverty [1]. Populations without reliable access to social and economic services are poorer than those with reliable access. Problems of access are particularly severe in those rural areas which are distant from roads that carry motorized transport services on a regular basis. Roughly 80 percent populations are rural dwellers of Bangladesh (BBS, 2005). On the basis of current values of RAI it is estimated that about 100 million rural dwellers in Bangladesh, are without reliable transport access. The large majority of these people are poor as defined for the MDGs. The lack of reliable transport systems in Bangladesh, mainly in rural areas, has compelled household members to spend significant time traveling in order to meet basic needs. Usually this time burden is distributed inequitably within the household. In this case, women were particularly overburdened, taking responsibility for about 80 percent of the time cost.

It is generally accepted that isolation is one of the key causes of poverty [1]. However, a reduction of isolation (i.e. improvement of access) will not necessarily contribute directly to poverty reduction as poverty has many dimensions and lack of access is just one of them. Making a provision to improve access to basic facilities and services (e.g. health, water, sanitation etc.) in subsistence economies will only provide a foundation for development. Improvements of access to the wider economic and socio-economic facilities (e.g. markets) will play a catalytic role in the poverty reduction process.

Table 2-1 identifies the key items to which rural people require access including the factors that are directly and indirectly related to the access (I. T. Transport, 1999). Edmonds (1998) discusses this issue more elaborately.

Table 2-1: Access and Poverty

	Factors Related to Access	**Other Factors**
Employment	Physical Access to job location Lack of Transport Services	Lack of job opportunities
Farm/Land	Distance/Time to fields	Size of Holdings Cultivable Land Population Density
Information	No Radio No Telephone Poor Postal Services	Lack of Extension works
Credit	Location of Credit Facility	Poor Banking Services Strict Credit Regulations
Health Service	Lack of Health Centers Poor Access Lack of Transport Services	Limited Personnel Lack of Medicine
Water	Lack of Irrigation	Distance of Supply Lack of wells
Energy	Limited Electricity	Distance to Source
Market	Poor Transport Facilities Poor Location	Poor Marketing System
Transport	Poor Transport Services Lack of Roads Limited Number of Vehicles	Lack of sufficient investment in Transport Sector
Education	Location of Education Institution Lack of Access	Lack of Efficient Teachers Limited Educational Tools

Source: A Synthesis Paper on Rural Transport and Accessibility, Ron Dennis, ILO

2.2.4 Rural Transport Accessibility Index and MDG/SDG

Transport is not specifically identified in Millennium Development Goal targets, but it makes key contributions to achieving many of the Goals—underpinning pro-poor growth and improving social inclusion. It is evident that poor people recognize isolation as a major contributor to their poverty and marginalization. In practice, improving access to

transport for rural men and women in low income countries like Bangladesh is considered essential to promote rural development, to increase uptake of human development services (educational and health), to facilitate inclusion of different ethnic and other groups, to improve employment opportunities, and to stimulate growth for poverty reduction. The rapid introduction of the highway network did play a part, but the much shorter lengths of rural roads (Zila, Upazila, Union and Village) made an even more important contribution to growth and poverty reduction, achieving about four times greater benefit/cost ratio than did the highways. Improved transport contributes not only through enabling better access to services and opportunities, but also by lowering the transport costs incurred in delivering and/or accessing such services and opportunities.

2.2.5 Equity and Development

The Rural Access Index also helps to address the issue of equity which is an increasing focus of the international development community. The World Development Report (World Bank 2005) explores the relationship between equity and development strategy and makes the issue of equity central to ―poverty-reducing" development [1]. A previous World Development Report points out that the affordable access to services is especially low in many of the poorest countries, with poor people needing to travel much further to reach basic services such as health and education, than richer people in the same country (World Bank 2003) As an example, the rural children from the poorest access to transport need to travel more than five times farther than the children in the richest access to reach the nearest primary school and health centers.

2.2.6 Impacts of Rural Transport Accessibility

Improvement in rural access has differing impacts on various sections of the population. In particular, the socioeconomic impact of increased access differs by gender, by age groups, by different caste/ethnic groups, and by income. For example, improved access potentially increases men's migration, and may result to increased workload on women in the farm and household. Similarly, improved motor access brings consumption goods nearer to households, but affects rural artisans and those residents whose livelihoods depend upon pottering. For policy makers, this underlines that transport interventions often need to be coupled with complementary policies if all socially and economically disadvantaged households are also to reap the benefits of improved access.

2.2.7 Conceptual Shifts

The Rural Access Index helps to address the issues mentioned above by changing the way the outputs of investment in the rural transport sector are measured. The shift in the form of measurement is threefold—what to measure, where to measure and how to define what is being measured [1]. The indicators which have been generally used to report progress in the transport sector have been based on characteristics of the road network such as the length or density of different categories of roads (paved and gravel roads, urban, feeder roads and national highways, etc.). Such measures do not give a clear picture of the

transport access level available to the rural population since they do not relate the provision of transport facilities to the location of the target population. Thus the first important conceptual shift has been to measure the accessibility of the target population to the road network, rather than simply some aspect of network size.

Corresponding to this has been the second conceptual shift, which is in the measurement units used to study the impacts of changes in transport infrastructure. Thus, rather than focusing on an administrative unit and assuming that all households within the unit have the same level of access to the transport network, the definition of RAI enables more detailed measurement - that is, at the household level. This approach can capture how access to transport services relates to household characteristics.

The third shift is that the definition of the index provides a common international basis for understanding rural access as it relates to transport.

Further, by providing information on rural residents' differential access to the all-season road network, the RAI helps planners to devise policies and programs to meet specific rural access objectives. RAI thus provides an objective basis for governments to set transport sector goals, and to establish investment priorities for improving rural access.

2.2.8 Definition of RAI

In practice the RAI measures the number of rural people who live within two kilometers (typically equivalent to a walk of 20-25 minutes) of an all-season road as a proportion of the total rural population. An "all-season road" is a road that is motorable all year round by the prevailing means of rural transport (typically a pick-up or a truck which does not have four-wheel-drive) [1]. Occasional interruptions of short duration during inclement weather (e.g. heavy rainfall) are accepted, particularly on lightly trafficked roads.

$$RAI = \frac{No\ of\ Rural\ People\ with\ Access}{Total\ Population} \times 100$$

Some sections of the population (the elderly, the disabled or those carrying heavy burdens) may find that even distances of less than one kilometer present a significant barrier to access, particularly under extreme conditions of terrain or climate. On the other hand, in many remote situations (such as the hills of Rangamati and Bandarban or remote areas of rural area of Bangladesh) people may be accustomed to walking many kilometers in order to reach formal transport services. Alternatively, they may manage without using such transport at all. The choice of two kilometers as the defining distance for 'adequate access' is a compromise between these extremes. This establishes a consistent definition of the Index, enabling comparison and aggregation (on the basis of population weight) of the values for target populations.

The specific emphasis given to roads in the definition of the index reflects the importance of road transport for improving rural access for the great majority of rural people in lowest income countries. In these situations, where another mode, such as water transport

is dominant the definition can be modified to reflect that. If this is done, then the fact should be explicitly recorded against the resulting RAI value.

2.2.9 Factors Affecting Accessibility

Accessibility is concerned with location of facilities, methods of travel and transporting goods to or from these facilities and the routes on which travel and transport take place [4]. These issues are discussed in this chapter under four headings:

i. Location of facilities
ii. Infrastructure
iii. Means of Transport
iv. Transport Services

Following four sections below reviews the particular factor and how it affects access.

2.2.9.1 Location of Facilities

The facilities to which rural households require access and their location is the key issue in defining access needs. In some cases, facilities may be fixed by the physical environment, for instance natural sources of water such as springs and rivers. In other cases, there may be constrained freedom in selecting location, for instance markets, grinding mills, schools, health clinics etc. Even where locations are fixed there may options for improving access, for instance piping water to a more central supply source rather than improving access paths of tracks to the natural source.

Effective location or relocation of facilities improves access by reducing the distance and/or time that household travel to reach the facility. It is one of a number of non-transport interventions which are suggested in the basic need is defined as improving access rather than improving infrastructure or means of transport. The aim is to reduce the need to travel rather than making travel easier. Other possible options to improve access are:

- Development of village-based system of secondary level education with the provision of adequate accessibility
- Provision of preventive health care services in the villages by travelling health care workers, thus reducing the need for households to travel to health clinics.
- Provision of village growth centres/bazaars so that rural households needs less effort and travel to market their production

Interventions such as relocation of facilities or development of infrastructure can be particularly effective to improve the accessibility of the community, usually at no cost to the household. They may especially benefit lower-income households that cannot afford a means of transport by reducing walking distances.

2.2.9.2 Infrastructure

One of the most obvious constraints on access to rural areas is the poor condition or even some cases, the absence of infrastructure. By infrastructure in this context is meant roads, tracks, paths and their associated bridges and other forms of cross drainage works. For villages not located on a major highway, the principal means of access is along roads-usually un-surfaced –paths and tracks.

In India 40% of villages in the 1000 to 1500 population range were reported to not have direct access to any standard of road, and 58% people did not have access to an all-weather road. More than 78% of Bangladeshi villages are below 1000 population and therefore road access can be assumed to be worse than this for most small villages. In India 22% of villages are not provided with even earthen road access; they are connected to larger villages, and thence to the road network, only by footpaths. There are many countries that are poorer and thus may be presumed to have more severe rural access problems than Bangladesh and India.

In rural areas of Bangladesh, the overall condition of the road network is not satisfactory mainly due to inadequate road maintenance. To improve this situation, government road authorities have been underscored to focus on the rehabilitation and routine & periodic maintenance. Rural people are mostly reliant for access on rural roads which are largely un-engineered and mostly not maintained. Rough and narrow roads not only increase travel time and cost, but also prevent or discourage their use by transport operators due to accidents or damaging their vehicles.

The major problem with rural infrastructure is that the government facing fund constraint to build new paved i.e. all weather road and to maintain the existing one to let it ridable.
The rural access program should be undertaken to provide improved access to high agricultural potential areas of the country. These roads were built labor intensively using local paid labor and subsequently maintained using some of the same labor force. Although not built for high speed traffic, this network of small roads provides reliable, year-round access.

The economic return for local infrastructure construction tends to be high, particularly when opening up access to an underprivileged area. Studies in Ghana showed that it was 140 times more beneficial to bring vehicular access 5 km closer to a village previously dependent on head loading than to carry out the improvement to 5 km of a road which already permitted vehicular access. Because the investment costs of building rural infrastructure are relatively low and the benefits from change in access relatively high, it is not usual to demonstrate such high benefit/cost ratios.

2.2.9.3 Means of Transport

The predominant mode of transport in rural areas particularly for ~~–in~~ternal" trips is walking carrying loads on head, back or shoulders. Typically, 60 to 70% trips are by walking [4]. In an Indonesian Study 90% of trips were by walking accounting for 38% of

distance travelled, and even in the Indian Study where vehicles were widely used, 67% of trips of less than 2 km were by walking [4]. The load that can be carried is typically 25 to 30 kg so that multi-trips are necessary for many activities such as for buying daily needs from hat/bazaars and transporting crops, these imposes severe burdens in time and effort on rural household.

The transport burden can be substantially reduced by use of even simple vehicles. For example, a bicycle can move three times the load that can be carried for the same input of time and effort. However, vehicles tend to be used only if they can be seen to pay for themselves and are generally only introduced when the movement of produce for marketing becomes unmanageable by human porterage.

Rural transport comprises mainly short trips (less than 2 to 5 km) in and around the village, carrying relatively small loads, often on earthen roads. Few conventional motorized vehicles are available in rural areas, and in any case a combination of low incomes and limited infrastructure make them largely unaffordable and unsuitable. Improvements in means of transport for rural households therefore lie in the lower-cost range of what are termed ~~"i~~ntermediate means of transport, IMT" i.e. intermediate between human porterage and conventional motorized vehicles. This situation seems likely to continue for the foreseeable future for most rural communities.

Details of the range of IMT are shown in Table 2-2. They range from animal driven cart to single-axle laden vehicles which cost about 25% of the cost of a pick-up. The initial costs shown are considered typical average costs of reasonable quality devices but will vary from country to country depending on such factors as availability and cost of materials, cost of labor and government policy on import components and items such as bicycles and motorcycles. The main variations in initial cots will be for items which are made locally. For instance, in particularly poor areas where rickshaw van or indigenous vehicle may be made at very low cost from wood and scrap materials. An ox-drawn cart using a scrap car axle costs around BDT 8,000 to 10,000 in rural areas of Bangladesh.

Although affordability, and therefore initial cost, is usually a ruling criterion in the selection of an IMT, operating costs should also be considered because of their effect on net income received from marketing of produce and on the ability of the owner to afford repairs and to keep the IMT operational. The latter factor can be a serious problem for farmers since their income tends to be concentrated in the period following harvest so that if breakdowns occur at other times of the year the IMT may be out of operation for many months. This showed up in household surveys in Bangladesh where 30 to 40% of bicycles were out of services because of the high cost of spare parts and repairs.

Table 2-2: Range of Intermediate Means of Transport

Mode of Transport	Typical Load (kg)	Average Speed (km/hr)	Daily Range (km)	Transport Capacity (ton km/hr)	Typical Initial Cost (BDT)
Human Carrying	25-30	4 to 5	8-10	0.12	-
Rickshaw Van	90	8 to 10	12-15	0.31	50
Ox-Cart	200	5-7	10-12	0.70	100-120
Bicycle	40	10-12	12 -15	0.50	80-100

Source: Rural Transport and Accessibility, ILO Report by Ron Dennis

2.2.9.4 Role of IMT in Improving Rural Access

The main advantage of IMT is in reducing the time and effort involved in rural travel and transport as compared with human porterage [4]. Bicycle, Rickshaw Van, Ox-Cart improve access by greatly reducing the number of trips needed to transport agricultural crops or other materials thus releasing substantial blocks of time which can be used in other activities. The potential time savings are clearly shown in Table 2-3. Consequently, they also provide a large increase in load carrying capacity which may encourage households to extend cultivation and production of crops.

Table 2-3: Estimates of Operating Costs of IMT

Mode	Life (yr.)	Depreciation ($/yr.)	Operating Cost for 500 hrs. per year ($)			Cost of transporting 100 tonne.km per year ($)		
			Running	Total	Per ton.km	Time Taken (hr.)	Vehicle Operating Cost	Vehicle plus labor Cost
Human Carrying	-	-	-	-	-	835	-	-
Handcart	15	9.90	10.00	19.90	0.057	140	12.70	30.20
Bicycle & Trailer	10	30.20	48.00	78.20	0.150	84	38.30	48.80
Ox-drawn Sledge	2	5.70	30.00	35.70	0.110	160	15.30	35.30
Ox-Cart	15	39.40	75.00	114.40	0.082	36	44.80	49.30
Single-axle Tractor Trailer	10	488.00	550.00	1038.0	0.260	12.5	502.00	503.50

Source: Rural Transport and Accessibility, ILO Report by Ron Dennis

Notes:

1. Depreciation is based on interest rate of 10%
2. Running costs comprise maintenance costs for vehicles and animals plus fuel costs in the case of the single-axle tractor.
3. The operating cost per ton.km is based on the IMT operating at full capacity. The same assumption is made in calculating the time needed to transport the equivalent of 100 tonne.km
4. The vehicle operating cost to transport 100 tonne.km is based on annual depreciation plus a proportion of the running cost for 500 hours per year, assuming the latter is linearly proportional to time taken.
5. Labour cost is based on time taken costed at $1 per 8 hr day.
6. Annual maintenance costs for vehicles are based on field experience or where this is not available, 15% of initial cost.

In case of bicycles, improved access is also achieved through greater speeds which reduce travel times and make longer trips feasible. The latter is particularly important in providing access to work opportunities, health facilities and more distant markets.

The main role of IMT is in transporting agricultural inputs and production in and around the village, grain to the mill and produce to markets and collection points that are within a reasonable distance. Although they could often be used to save considerable time in subsistence activities such as collecting water and firewood, their use in these activities is limited.

Although the potential role of IMT in improving rural accessibility is clear to see, much of the evidence of actual benefits is circumstantial. For example, the suggestion discussed in section 2.5 that time saving from use of IMT has enabled households to produce surplus crops for marketing. The benefits are also indicated by the fact that many rural households are prepared to invest several months of income in purchasing IMT, presumably because of the economic benefits they gain from improved access to markets and other facilities.

2.2.9.5 Transport Services

Transport services involve the movement of passengers and goods for a fee by an operator working as a business or employer of a business. They normally operate on popular routes where traffic levels are high enough for the services to be economical, for instance linking villages to markets or a rural growth center. However, some of the lower-capacity modes, such as bicycles or motorcycles-based vehicles are able to provide for more individual needs of a more door to door service. These modes may also be suitable for providing a village transport service, linking the village with a range of facilities.

Transport services are particularly important for providing access to ~~–e~~xternal" facilities. The transport modes used therefore need to be suitable for longer distance trips than the generally non-motorized modes used for short ~~–in~~ternal" transport. A range of available modes is compared in terms of operating cost per passenger km (p.km) and operating cost per tonne km (t.km).

2.2.9.6 The "Access" Role of Transport Services

Access to village markets/Growth centers is essential for agricultural development. The major demand and hence best price, for agricultural production, where people tend to sell or buy their respective demands. Also farmers that grow cash crops need access to markets. Lack of effective transport services significantly constraint the opportunities that households can gain from access to these facilities, imposing service penalties through lengthy travel times, substantially restricting the volume of production that can be transported and sometimes forcing farmers to sell at low prices to traders at the farm gate. For example, in rural areas where transport services are quite limited, farmers often sell to the whole sale traders who buy up production in the hat/bazaars.

The benefits of transport services in providing good access to markets is amply demonstrated by the advantages of living close to major growth centres or main roads. Farmers in these areas can often earn considerably in excess of average incomes. An added advantage is that persons can commute on transport services from these areas into

the urban center for non-agricultural work thus further raising the general level of incomes in the area which has low flow-on benefits to the community.

The availability of effective transport services is particularly important for marketing perishable goods such as vegetables, fruits, fish, etc. These goods are needs to be transported in time as fast as possible to avoid the damage. Sometimes in the west and south-west region of Bangladesh, the goods laden trucks are get struck in ferry-ghats due to long tail-back, in this situation the traders are not able to reach in the capital due time and have to incur loss due to damage.

In addition, to providing access to markets and work opportunities, transport services are needed to provide access to health, education, jobs and social facilities. As outlines in Chapter-1 some basic health care is available at village level but doctors and hospitals are generally located in the urban centres, so that access may involve trips up to 25 to 50 km and sometimes even upto 100 km or more. Primary education is widely available at village level, but secondary education tends to be available at larger distances. Therefore, motorized transport services operating down to village level and linking up with main bus routes may provide potential to significantly improve access to health, education, and socials facilities.

2.3 Review of Previous Research and Study on Rural Transport in Bangladesh

Very few studies and researches were done on rural transport, in particular the rural transport accessibility and its quantitative measurement to understand the actual status of the rural population within the reach of accessibility coverage, thereby taking into account this status to take investment priority plan or initiative to improve the accessibility coverage. In the next following sections, I have tried to describe some of the available research or study reports outcomes regarding the rural transport.

2.3.1 Transport System in Bangladesh: Issues and Options for Sustainable Development [6]

2.3.1.1 Background of the Research Report

This research report was done by S.M. Sohel Mahmud, Mohammad Wahidur Rahman and Shahnewaz Hasanat-E- Rabbi. The purpose of that report was to describe the rural transport characteristics and its consequent mobility and to identify policy issues for sustainable rural transport development.

2.3.1.2 Outcome and Recommendation of the Report

In the report, it identified ten (10) steps towards more sustainable people centered Transport, the ten steps are: accessibility for all, social equity, ecological sustainability, health & safety, public participation & transparency, economy & low cost, information & analysis, advocacy, capacity building, and networking.

Concerning about the accessibility for all, the report underscored to provide access to the contacts, services and goods that we all need in an equitable, low-cost and low-impact way. It further mention that transport policy should not fall into the trap of seeing mobility as an end in its own right and of simply promoting more and more vehicle movement at higher and higher speeds. Accessibility planning aims to ensure that destinations remain within easy reach and seeks to maintain the viability of diverse and plentiful transport choices, particularly non-motorized transport, public transport and paratransit.

The report investigate about the economic benefits of sustainable transportation like, Attracts New Business, Generates sales, Encourages local circulation of money, Stimulates retail trade, Offers cost effective services, Encourages high value land use, Increases productivity, Reduces transportation costs, Enables economic development, Reduces infrastructure costs, Creates Jobs.

2.3.1.3 Action for Sustainable Development

In this research report it is recommended the actions needed to foster the sustainable development, where the main and foremost action is ―Access". Access to people, places, goods and services is important to the social and economic wellbeing of communities.

2.3.1.4 Critical Review of the Report

In this report it is rightly mentioned that ―Accessibility" is the key for sustainable development but it is not only the means to achieve this. However, in this report there are no directions or guidelines how to improve this accessibility in particular the rural transport accessibility. So without enhancing the rural accessibility it is not possible to attain sustainable development since 79% population [*source: 2011 Census Report, Bangladesh Bureau of Statistics*] of the total population of Bangladesh are living in rural areas.

Furthermore, in this report it is only subjective discussions on access and its importance in the way to sustainable development, but no objective or quantitative discussions in this report to make an urge in the mind of the policy maker to emphasize the rural accessibility improvement by allocating more resources in order to poverty alleviation.

2.3.2 Integrated Rural Accessibility Planning in Bangladesh [7]

2.3.2.1 Background of the Study

This research was conducted by A K Farhad Ahmed, Masters Student, Transport Systems Center, University of South Australia, M A P Taylor, Professor of Civil Engineering & Director, Transport Systems Centre, University of South Australia and Steve Carpetis, Transportation Specialist (Retired), World Bank. The paper examines the rural transport accessibility and Transport Services impact of non-motorized transport (NMT) on rural households' activity-travel patterns in Bangladesh.

The authors also examined the access to essential facilities by rural residents and adequate, reliable, and economic means of transport is pre-requisite for the overall rural development. The author is aiming to provide a better basis for policy formulation and assessment in rural transport planning in Bangladesh.

2.3.2.2 Research Findings and Recommendations

In the research, the rural villagers of southern part of Bangladesh were surveyed regarding the times spent for travel for different activities by them. Four villages namely Manthana, Dhaperkathi, Guria, and Gangber, of spatially different accessibility levels were selected for interview. The interview was done in pre and post intervention to get changing scenario travel pattern.

It was found that the activity travel time spent by the Dhaperkathi villagers is more than that of Manthana villagers; on the other hand, it is almost same of the Guria and Gangber village as represented in the Table 2-4 below. The reason behind that Manthana is most accessible, Dhaperkathi is least accessible and both Guria and Gangber have similar level of access to necessary facilities.

Table 2-4: Activity Travel Pattern (Hour/Person/Day)

	Dhaparkathi			Guria			Manthana			Gangber		
	Male	Female	Overall	Male	Female	Overall	Male	Female	Overall	Male	Female	Overall
Education	2.3	1.2	1.7	1.2	1.1	1.2	1.2	1.1	1.1	1.1	0.8	0.9
School/Leisure	2.9	2.9	2.9	3.0	2.4	2.7	3.2	3.9	3.5	3.2	5.0	4.0
Domestic Task	1.8	5.0	3.6	3.1	7.4	5.3	1.1	6.8	3.9	0.6	6.1	3.2
Eating	1.5	1.7	1.6	1.4	1.8	1.6	0.7	0.6	0.7	0.7	0.7	0.7
Personal Care	1.2	1.5	1.4	1.4	1.1	1.2	1.0	1.0	1.0	0.9	1.1	1.0
Shopping/Marketing	4.0	1.9	2.8	2.6	0.6	1.6	5.2	1.2	3.3	6.1	0.8	3.0
Travel	0.8	0.2	0.5	1.2	0.2	0.7	0.9	0.3	0.6	1.8	0.4	1.2
Sleeping	7.1	7.3	7.2	7.7	7.2	7.4	9.1	8.6	8.4	8.3	9.0	8.6
Total	24	24	24	24	24	24	24	24	24	24	24	24

Source: Journal of the Eastern Asia Society for Transportation Studies, Vol.1, No.3, Autumn 1995

The authors found that household activity travel time were changed after the introduction of the intervention. Considering the access time the households which responded positively were marginally less accessible compared to average households. A summary of changes in time allocations to different activities is presented in Figure 2-1. It shows that total travel time would be reduced by 10.29% after the intervention. The percentage re-allocation of the overall saved time is shown in Figure 2-2. It is to be noticed that about 44%, 27%, and l8%, of the time saved from mainly (96% of the total time saved) would be reallocated for work, domestic task and social/leisure respectively.

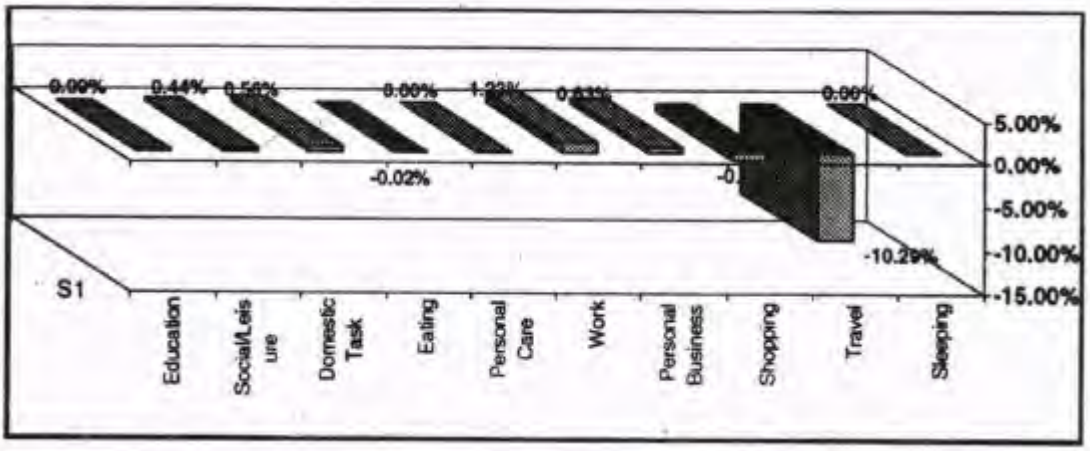


Figure 2-1: Change in Time Allocation after Introduction of Intervention

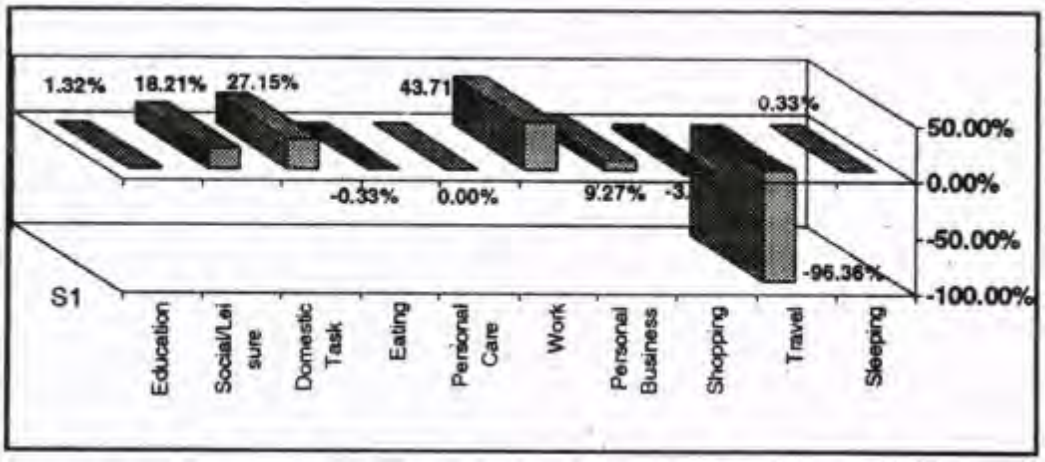


Figure 2-2: Re-Allocation of Saved Time After Introduction of Intervention

Source: Journal of the Eastern Asia Society for Transportation Studies, Vol.1, No.3, Autumn 1995

The authors found that work related activity time in Dhaperkathi was significantly less than Gangber and that of Manthana was significantly less than that of Guria and Gangber. It was also found that the cash income from agriculture and business of Manthana and Gangber were substantially higher than Dhaperkathi and Guria. Hence it can be concluded that the more the households are engaged in commercial activities through improved access (commercial farming or other activity) the more total time they spend on work.

2.3.2.3 Research Outcome and Recommendation

Any intervention to increase the mobility of the rural population would engage more in commercial activities and to social services – result is the uplifted the household status in all respect. Rural population of Bangladesh would tend to spend the time saved from the transport intervention for productive purposes.

2.3.2.4 Critical Review of the Report

In this report, four villages of Barisal District in Bakerganj area were taken as study purpose to observe the household status due to change in rural accessibility after

intervention. The authors also compared the access time required by the villagers of the four villages and how access time changes over the activities over improvement of accessibility. The authors however presented in the report the status of accessibility only in subjective (literal language) but not presented any subjective measure (with some numerical value). They have also shown the intervention as hypothetically and after that intervention the evidence of accessibility improvement mentioned by merely theoretical representation but no subjective measurement. Therefore the author‘s aiming to provide a better basis for policy formulation and assessment in rural transport planning in Bangladesh didn‘t truly reflected.

2.4 Review of International Research and Study on Rural Transport

In International arena many research and study were done on rural transport, transport accessibility. Besides the international countries study, international organizations like World Bank, Asian Development Bank have also carried out study and research on rural transport accessibility. There are many approaches were adopted to measure the accessibility index. In this report I would like to review some of the reports, its findings, recommendations and importance to use or understand the rural transport accessibility in our national perspective.

A case study was carried out (Prof. Ashoke K. Sarkar and M.A. M Mashiri) in South Africa titled as ―Quantification of Accessibility Levels of Rural Areas" [8] in order to help government policy makers to make transportation investment decisions. Accordingly, in three rural areas, namely Galashen, Lemonside, Millbank, Miltonduff and Udney, the transportation needs of the communities were determined and the ability of those communities to pay assessed. Based on the results of the study, it was suggested that there was a need to strengthen local participation in problem definition and solution, to develop infrastructure on an incremental basis to accord with needs and funding levels, to institute network optimization and to set up a special funding allocation.

A study was carried out (Mohammed Dalil Essakali) in Pakistan titled on ―Rural Access and Mobility in Pakistan" [9] to present a number of policy options to improve basic access and promote the mobility of Pakistan‘s rural population in support of the Government‘s Poverty Reduction Strategy. The current state of rural accessibility and mobility are examined together with their effect on both the social and economic dimensions of rural poverty. It should also be of interest to policy makers in other countries concerned with how rural transport policy may be developed to meet the Sustainable Development Goals.

2.4.1 Quantification of Accessibility Levels of Rural Areas: A Case Study in the Northern Province of South Africa [8]

2.4.1.1 Background of the Case Study

The case study was done getting a sense of urge that lack of mobility and accessibility of goods and people at the local level is a major factor impending the integration of rural

communities into the national economy. In this case study a methodology to quantify the overall accessibility level of rural communities has been suggested. However, the methodology aids policy and decision maker to quantify and compare accessibility levels of different locations with a view of arriving at sustainable solutions and investment priorities.

Transportation is a vital component of economic development, social progress and quality of life of rural population. The inadequacy of transportation infrastructure can dramatically reduce agricultural production and market opportunities and make population suffer from reduced cultural and social contacts as well as limiting business and employment opportunities. The aim of the study was to quantify and prioritize the present overall accessibility levels of rural areas and to determine the travel needs of rural communities.

2.4.1.2 Methodology Adopted in the Study

In the study, it was quantified the accessibility levels of five villages of South Africa and presented the impacts of poor accessibility on the residents economic and social life. The accessibility was quantified using the following formula;

$$Overall\ Accessibility\ Level\ (OAL) = \sum_{i=1}^{N} W_i V_i$$

Where:

N = Number of basic activities required by individuals in the study area as obtained by interviewing the villagers.

W_i = importance (weight) associated with the accessibility to the i-th activity.

Vi = present level of accessibility to the i-th activity.

Then the OAL is expressed in a scale of 0 to 1, where OAL value close to 1 indicates high level of accessibility, whereas that close to 0 indicates very poor level of accessibility. This would enable policy decisions to be made on the kind of measures to be taken to increase the OAL of individual areas.

2.4.1.3 Impact of Poor Accessibility on the Residents

The poor transport accessibility levels affect the willingness of the villagers to travel further to improve their living conditions. The majority of the respondents indicated that they would like to travel further. On the question of how the ability to travel further would help, the respondents had multiple choice among three reasons, namely take product/service to bigger market, commute to work and undergo further education. The major reason sighted that better accessibility levels enable to increase the income levels by taking the products/services in bigger market, better accessibility level would give the chance to commute to work at far off places, and better accessibility level would help to undergo further education.

2.4.1.4 Identification of Measures to Increase the Accessibility Levels of the Villages

The methodology developed in this study helps to suggest the measures to be to increase the overall accessibility of study area. It would be appropriate if the activities are considered one by one in descending order of their weights. To increase the satisfaction level is to provide better accessibility to water sources, which can be achieved by providing a few more water points or by providing better transport facilities to the existing water points. Better transport facilities may be provided by better roads and provision of motorized or non-motorized vehicles. Accessibility levels to school are poor in the study areas. Thus there is a need to increase the accessibility levels to schools in all the villages. In this way, it is possible to identify the necessities in the villages against all the activities. The methodology helps the policy and decision makers to numerically calculate the extent of improvement measures necessary against each activity to provide a certain level of overall accessibility to the villages.

2.4.1.5 Outcome and Recommendation of the Study

The technique used in the study for the quantification of accessibility levels based on responses from the villagers on the importance of activities and the satisfactions on the existing infrastructure and services helps to identify the problems and prioritize them. This helps the local level partners to suggest alternative interventions to increase the accessibility level in the selected villages or a group of villages. The method ensures the participation of the local people in the planning process. However the effectiveness of the method will largely depend on the sampling method used during data collection process.

2.4.1.6 Critical Review and Remarks of the Study Report

In this report it was quantified the accessibility level based on activity of village people‘s daily needs to survive. In order to calculate the accessibility level, it was not directly consider the transport access rather the transport used as a perception factor to recognize the accessibility level of the human lives activity. For instance, if in an area there are no schools, hospital or clinic, market place, etc. or the location of these facilities are more distant then the accessibility level of that area will be poor, therefore to increase the accessibility level if it would be construct new roads, but eventually it would cast any substantial positive impact on peoples life, as the facilities are at far away without having any affordable means of transport.

2.4.2 Rural Access and Mobility in Pakistan [9]

2.4.2.1 Background of the Study

Rural areas in Pakistan are home of 100 million people or two thirds of the total population. One in every five rural communities does not have access to an all-weather motorable road, and three in every ten communities have no transport service available. A large proportion of rural Pakistan lacks motorized access to markets, basic services, as

well as physical, social and political opportunities. Poor people and poor communities in rural Pakistan are least likely to have access to transport infrastructure and services. At the same time, low accessibility to roads and transport services are associated with lower human development outcomes.

2.4.2.2 Methodology Adopted in the Study

Road accessibility indicators used in this study are derived from the Pakistan Integrated Household Survey (PIHS) data. The PIHS community survey had three questions relating to road access: (i) Is there a motorable road access to village? If the answer is yes, then (ii) is it accessible during all months? And (iii) what is the type of the road: metaled, paved/bricks/stones, unpaved or other type. Access to transport services is also measured using PIHS, where a question on the availability of a transport service in the village was included in the community survey.

2.4.2.3 The Critical Role of Rural Transport in Human Development Performance

Poor accessibility is associated with lower human development indices. For instance, in case of net primary enrollment rate and literacy rate, the difference between villages endowed with all-weather motorable roads and those without this type of access is particularly high for females. Good accessibility is also associated with better health outcomes, for example, from the significantly higher rates of pre-natal consultation, immunization coverage, contraceptive prevalence, and births assisted by killed attendant in villages with all-weather motorable road access. These facts may somewhat overstate the relationship between poor accessibility and social issues – particularly gender associated problems as stated in Table 2-5.

Table 2-5: Human Development Indicators and Road Access

Indicator	Villages with all-weather motorable roads	Villages without all-weather motorable roads
Girls Net Primary School Enrollment Rate	41%	27%
Boys et Primary School Enrollment Rate	56%	49%
Females Literacy Rate (10 years and above)	23%	13%
Males Literacy Rate (10 years and above)	53%	44%
Immunization Coverage (fully immunized 12-23 months based on recall and record)	54%	46%
Contraceptive Prevalence Rate (% of married women of age 15-49 who ever used contraception)	19%	12%
Pre-Natal Consultation	28%	14%
Births Assisted by skilled attendant	58%	39%
Births at Home	85%	91%
Post-natal Consultation	7%	5%

Source: Rural Access and Mobility in Pakistan, Policy Note by Moh. Dalil Essakail, Dec, 2005

2.4.2.4 Socioeconomic Influence of Rural Accessibility

However, the association between human development performance and transport access is broadly consistent. Research conducted by the World Bank on the impacts of rural roads on human development achievements has documented the link between the availability of road access and gender gaps in education and health outcomes. For example, a survey of a rural roads improvement program in four areas in Morocco found that women and girls benefited especially from providing all-weather road access. The new roads also made travel to schools safer, encouraging parents to send their daughters to school. Primary school enrollment in the study area improved significantly and at the same time rural road access improvements in the study areas more than doubled visits to hospitals and primary health care centers.

2.4.2.5 Key Recommendations of the Study

The report outlines a few key options and offers recommendations for further discussion and Government consideration. *Policy and strategy formulation* – consistent with the Government‘s overall plan to improve rural roads should recognize that any sustainable approach has to be owned by the beneficiaries. *Institutions, ownership, responsibility and financing* – improve the current institutional arrangements for ownership, management and financing of rural transport system. *Funding* – mobilize additional resources and allocate funding more cost-effectively by targeting investments in ways that more directly benefit the poor. *Cross-sectoral linkages* – to implement development programs in rural areas that reduce the need to travel. *Intermediate means of transport* – promote the use NMT to reduce the workload associated with basic household needs, especially for women, and improve key paths and tracks.

2.4.2.6 Critical Review on the Report

In this report it was quantified the accessibility in aggregate level in rural Pakistan. The approach used to calculate accessibility in this report was comprehensive and well represented. It has been presented the association and the role of rural transport accessibility in Human Development Indicators. It has been found that poor accessibility is associated with lower human development indices. The research also showed the socioeconomic influence of rural roads. It also identified the challenges to expanding accessibility and improving mobility in rural Pakistan. The report fabulously recommended the ways out to improve the Pakistan‘s rural accessibility.

However, the accessibility shown in the report as aggregate level, so it may be difficult to make priority of road improvement projects in rural areas. It also didn‘t show any direct impacts of accessibility to poverty reduction.

2.4.3 Improving Access in Rural Areas – Guidelines for Integrated Rural Accessibility Planning [10]

2.4.3.1 Background of the Report

These guidelines were developed in early 1990s, describing the Integrated Rural Accessibility Planning (IRAP) process designed for improving access in rural areas by International Labour Organization (ILO). The IRAP consists of a set of tools to identify and prioritize investments in rural areas in a participatory manner. These investments, mainly in infrastructure, improve the access of rural populations to social and economic goods, services and facilities that satisfy basic needs. This can be done either by facilitating access to services through transport; or locating the services closer to the people by improving local infrastructure IRAP is complemented by a capacity building process to enable policy makers to identify ―access-poor" communities and emphasize resource & budget allocation.

2.4.3.2 Improving Rural Access

Interventions to improve access often cut across different sectors. This contributes to the difficulty of defining the meaning of the word ―Access". It certainly is a comprehensive concept. The term access in fact comprises three elements: physical access, social access, & economic access. Physical access relates to distance & travel. How far people have to travel to reach certain locations? How easy or how difficult is this journey? Physical access is usually improved by the provision of physical infrastructure. Although it needs to be reiterated that infrastructure by itself does not improve access. Culture, customs and responsibilities determine social access. A village school may exist but parents may decide to not send their daughters to school since education is perceived to be of no importance for girls. Access to primary education is therefore limited for these girls for social reasons.

Economic access relates to the ability to pay. Health services may be nearby but the cost of examination and treatment may prevent poorer families from benefitting from these ―accessible" services. These guidelines deal with physical access. A lack of physical access deprives people of opportunities to improve and sustain their level of living. Physical access, hereinafter referred to as access, is determined by two factors: ―mobility", reflecting the ease or difficulty in travelling to a specific location and ―proximity", reflecting the distribution of goods, facilities and services. The access needs of rural people can be grouped in three broad categories:

The access needs for rural people can be grouped into three broad categories: (i) those associated with basic needs such as food, water, firewood; (ii) those associated with the social welfare aspects of rural life such as health and education; and (iii) those associated with the economic welfare aspects. Access can be improved in three fundamental and complementary ways: (i) through a better siting of basic facilities and services that rural

need to use (food, water supplies, health centers, markets); (ii) through improving the mobility of rural people so that they can travel faster, easier, more convenient and less expensive (rural roads, tracks, trails, footbridge, water ways); and (iii) through promoting and stimulating in use of communication technology so that rural people have improved access to information related to health, education and market prices (rural telephones, email, & internet connection).

The first is a ―non-transport intervention" while the second is a ―transport-intervention". A specific approach seems necessary in rural areas, one that effectively addresses rural access problems and reduces isolation and alleviates poverty. More emphasis is to be given to the development of an integrated approach that simultaneously improves the rural and feeder road network and the distribution of facilities and services. This approach has been developed by ILO and is called ―Integrated Rural Accessibility Planning" or ―IRAP".

2.4.3.3 Process to Improve the Rural Access

The IRAP developed a sequential step approach to improve the rural access can be briefly described as follows:

Steps 1 and 2: Data collection and processing:

The first step is to carry out a situation analysis that identifies access problems in target areas regarding the mobility of the population and the location of services and facilities. Local communities, organizations (government and NGOs) and individuals are involved in this process in terms of providing the information needed. Local enumerators are trained to carry out the survey and to process the data. Data comprises secondary data (population, agriculture outputs, etc.) and primary data. At the village level, primary data is collected on time taken and the manner in which households obtain access to services and facilities. The collected data is processed and analyzed, which results in the identification of demand-oriented access or transport needs in the target areas.

Step 3: Preparation of Accessibility Profiles, Indicators and Maps:

The access profile of a target area covers a set of basic information on both locations of services and facilities and the difficulties that people have in gaining access to them. For each sector, accessibility indicators (AI) are calculated. The indicators are calculated by relating the number of households in a target area to the difficulty of reaching facilities and services. Different indicators are used in different countries. In addition, based on the gathered information, accessibility maps are prepared in order to have a better visual presentation of access profiles in target areas and to compare alternative solutions to access problems.

Step 4: Prioritization:

The larger the value of AI, the worse is the access problem. The target areas are ranked and prioritized accordingly. The target area with the worst access indicator in a particular sector gets the highest priority for access interventions in that sector.

Step 5 and 6: Data Validation and Defining Targets and Objectives

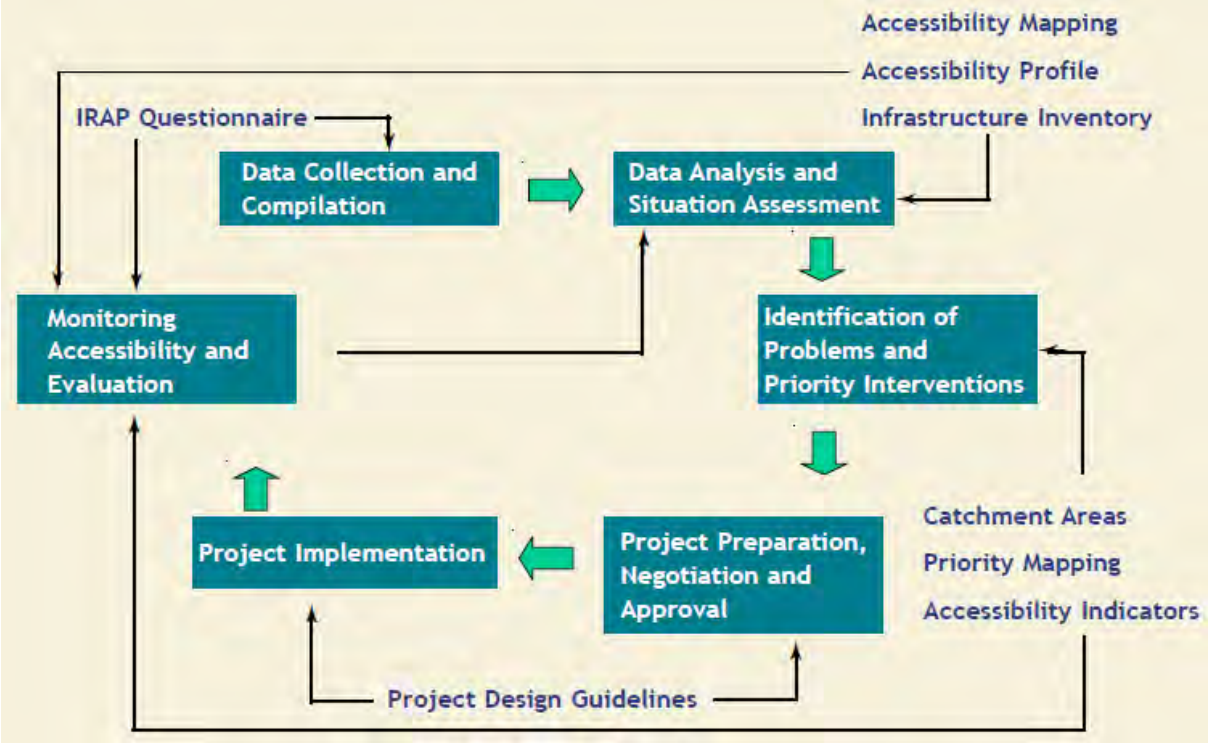
The access profiles will be presented and the data validated in a workshop with representatives of local authorities, organizations and communities. During the workshop the sectoral objectives for access improvements will be defined. Where national targets exist, these will be used to define overall objectives, e.g. all households in an area should have direct access to potable water, not exceeding a distance of 500 meters, all year around. Targets should be realistic and attainable, based on the available resources.

Step 7: Project Identification

The results of the above mentioned workshop contribute to identification of a set of interventions or projects which would most effectively reduce the time and effort involved in obtaining access to supplies, services and facilities. These interventions are related to transport (rural transport infrastructure, low cost means of transport or transport services) and non-transport services (e.g. better distribution or the most appropriate locations of services).

Step 8: Implementation, Monitoring and Evaluation

The identified projects are then considered and integrated into the overall local development planning system for implementation, monitoring and evaluation. The target communities and organizations are, preferably, not only involved in planning but also contribute to implementation and maintenance of what has been planned.



Source: Improving Access in Rural Areas, Guidelines for Integrated Rural Accessibility Planning, by Chris Donnges, International Labour Organization, 2003

2.4.3.4 Critical Review of the Report

This guideline explicitly describe about how to develop rural accessibility and practical process in details. The report presented the every steps of the process in detail with filed data of Asian countries, namely Philippines, Cambodia, Laos, India, Nepal and Indonesia. However, in this guideline there is no approach to relate the accessibility with poverty level of rural areas that may influence and persuade the policy makers to allocate budgets for intervention in transport infrastructure. Because it is obvious to need political will and support to successfully implement a project.

In this report, it will relate the accessibility level with the poverty level of an area and will presented by charts and maps for better understanding for the policy makers. The representations will cast a spell to the politicians as their overarching goal is to reduce poverty. So it will gain political will to allocate more budget to implement new projects to improve accessibility.

2.5 Observations from the Review of Literature

The studies carried out on the accessibility of rural areas in South Africa had considered the access to basic facilities, such as schools, clinics/hospitals, market places and social service points with giving a weights in a scale of ~~0~~ to 1". However, recognition of the actual accessibility needs of rural populations leads to the identification of factors that affect their satisfaction: e.g. the location and distance of services and facilities, the infrastructure used to reach facilities, means of transport and availability of transport services. Thus, it is necessary to look closer at the access needs and priorities of the rural

population and to develop a coordinated, integrated set of interventions to meet its access needs. This requires an integrated rural accessibility planning methodology derived from the accessibility concept.

The Integrated Rural Accessibility Planning (IRAP) process is a product of such an approach and has been used successfully in a number of countries, including a few in Southern Africa. However, to make the IRAP method a more convenient tool for the local level decision makers in South Africa, it would be appropriate if the accessibility levels of each settlement in an area could be quantified in the form of indices based on the availability of facilities and services in the surroundings and the importance put on those facilities by the residents. This would help to identify the most inaccessible areas and prioritize them on the basis of an accessibility index. Cost-effective remedial measures could then be suggested to increase the accessibility levels.

2.6 Existing Transport Policy in Bangladesh

2.6.1 National Land Transport Policy (NLTP) [11]

The National Land Transport Policy (NLTP) [11] - was approved by the cabinet on 26th April 2004, in the light of the Bangladesh Government pledge to establish a transport system which is cheap, modern, technology dependable, environment friendly and acceptable in the light of globalization.

One of the goals of the policy is to ~~"~~poverty alleviation"- the transport will be highlighted within the overall planning and program of the government so that lower income groups also can enjoy the outcome of development.

The policy 4.9 of NLTP states that ***~~"~~Increased access to transport and services in rural areas***" and article 4.9.1 states that paved connections between all the economic growth centres and the country's road network will be provided.

2.6.2 Road Master Plan (RMP) [12]

In pursuance of NLTP, the Road Master Plan has been developed by the Roads and Highways Department (RHD) under the Ministry of Road Transport and Bridges. It was prepared intending to be served as a guiding document for road sector investment priority program and approved by the government in June 2009.

The approved Road Sector Policy states that the Zila road network will be rehabilitated over the next ten years in order to achieve minimum accessibilities level on all Zila roads. The criteria for taking up Zila roads project are based on roads which serve the highest concentrations of poverty have been treated as priorities for rehabilitation. *The priorities for Zila road improvements will be based on analysis of socio-economic indicators.*

The impact of this RMP guidelines set forth that will ultimately connect 469 Upazila Headquarters by paved access roads to the main road network. The minimum accessibility level as defined in the RMP that the Planning Commission requires that all

growth centres, Upazila headquarters, land and sea ports should have all weather year round vehicular access. The RMP therefore takes this as its minimum accessibility target. To achieve this target and meet the strategic objectives in the most efficient manner, the RMP has defined three Priority Levels.

The first priority level was set-out as to make sure that the roads that provide a direct connection between an Upazila Headquarter, Land or Sea Port and the nearest major town and / or Highway meet the all-weather vehicular access.

The second priority level was set-out based on the road condition (IRI value good to fair condition) to ensure the riding quality to meet the minimum accessibility level.

The third priority level based on the socio-economic prioritization approach is a proxy evaluation that aims for investments to reach the most people, the most poor people and the most social and economic facilities that each Zila road serves. The socio-economic indicators used are:

- Population density
- Poverty density
- Density of social facilities (education, health, community, religious)
- Density of economic facilities (markets, industry, agricultural production, animal husbandry, natural resources, etc.)

Based on these four indicators, a socio-economic (SE) score is calculated for each Upazila or Thana, higher the value indicates good socio-economic condition and lower the value indicates inferior economic-condition. An average socio-economic score is then calculated for each road by multiplying the length of the road in each Upazila or Thana by its SE score for each section of road and then dividing it by the total road length. This socio-economic score is then used to rank individual roads within the Priority Level 2 – Road Condition categories.

2.6.3 Perspective Plan (2010-2021) [13]

The perspective plan of Bangladesh (2010-2021): Making Vision 2021 a reality is a strategic articulation of the development vision, mission, and goals of the Government in achieving a prosperous Bangladesh grounded in political & economic freedoms a reality in 2021.

The Perspective Plan provides the road map for accelerated growth and lays down broad approaches for eradication of poverty, inequality, and human deprivation. Specific strategies and the task of implementation will be articulated.

The long-term goals of the perspective plan with respect to rural roads are (i) *to provide all-weather access* to all growth centres, all union parishad complexes, most rural markets and other rural service delivery centres, and (ii) *to improve rural accessibility* to facilitate

agricultural production and marketing. The strategies may be adoption of a Rural Road Master Plan and Maintenance Plan with priority accorded on maintenance over new construction, and more involvement of LGIs in ensuring utilization and maintenance of constructed facilities.

2.6.4 Seventh Five Year Plan (2016-2020) – Accelerating Growth, Empowering Citizens [14]

The Seventh Five Year Plan was structured to attain equitable access to education, healthcare, rule of law and employment opportunity. The overall goal is to realize the Government Vision 2021-envision a country where all citizens enjoy a quality of life assured with basic healthcare and adequate nutrition.

The strategies of the plan stressed the need to develop rural transport infrastructure. Rural transport is critical to socio-economic development and poverty reduction. An improved road communication system reduces road user costs of production and thus facilitates socio-economic development of the country. It contributes to the reduction of poverty by creating job opportunities for all, including women, increasing the mobility of working people and facilitating the distribution of capital and consumption of goods. Moreover, it contributes to the expansion of regional balance and creation of investment opportunity, all of which are conducive to economic growth and poverty reduction. Furthermore, it supports human resources development through improved access to education and healthcare services.

2.6.5 Observation from the Review of the Existing Transport Policy in Bangladesh

It has been observed from the review of the existing policy guidelines in Bangladesh that policy to improve the rural transport accessibility has been set-out in the NLTP and under this policy guideline other plans are structured emphasizing the need to improve rural transport accessibility.

2.7 Transport "the missing link" in the MDGs and SDGs [15]

Despite the indispensable influence of mobility and access issues on almost all aspects of development, the Sustainable Development Goals (SDGs) make no explicit reference to transport. In the transport sector we have become accustomed to describing transport as the _missing link' in the SDGs, the _critical catalyst' that was overlooked when the 17-Goals and 169 targets were set-out in Transforming Our World: the 2030 Agenda for Sustainable Development Goals on 25-27 September 2015 at a meeting at the United Nations Headquarters in New York, which is built upon the achievements of the Million Development Goals (MDG) of 8-Goals were drawn up by the United Nations in 2000. In the years since, we have generated a wealth of evidence to articulate the relationship between transport and poverty and to justify our role in achieving the SDGs. What has this achieved, and as we pass the half way mark to the 2015 SDG deadline, how should we move forward?

2.7.1 A Critical Catalyst

The need for improved mobility and access for poor communities is implicit in the timely and affordable delivery of basic public services, the facilitation of economic growth through national, regional and international trade, the empowerment of vulnerable groups, and in establishing links with the market economy and information society. If we examine each of the goals in this context then the cross-sectoral importance of transport becomes clear:

2.7.2 Goal 1: End Poverty in all forms everywhere and Goal 2: End Hunger, Achieve Food Security and Improved Nutrition and Promote Sustainable Agriculture

Three quarters of the world's chronically hungry people in rural areas, so enabling poor farmers to grow more food is an effective means of reducing hunger and poverty. Investments in improved transport infrastructure and services can be effective in-

- *lowering the farming input prices,*
- *increasing agricultural production, and*
- *reducing the monopoly power of agricultural traders by facilitating access to markets.*

Food security is also determined by purchasing power and therefore by the level and location of employment opportunities. Transport investments not only facilitate access to employment but also provide employment, for example through labour-based infrastructure construction and the operation of transport services.

In rural areas with improved accessibility and mobility, the poor households are able to sell his/her firm or domestic yield product (say paddy, jute, vegetables, eggs, milk, coconut etc.) after meeting his/her family consumption to the market at good price and can earn money for his/her family well-being.

2.7.3 Goal 3: Ensure Healthy Lives and Promote Well-Being for all at all ages

More than 60% of rural people live more than on an average eight kilometers from a healthcare facility center (Govt. Upazila Health Complex/District Sadar Hospital) and there is a clear association between infant, child and maternal mortality rates and distances to healthcare services. Improvements in mobility have shown measurable impacts such as a rise in the immunization of children. Factors that are conducive to good maternal and child health such as antenatal and postpartum care, birth in the presence of a skilled attendant and the availability of emergency obstetric services, are compromised by distances to referral health services and limited, inappropriate and expensive transport services. Long, slow journeys act as a deterrent to healthcare seeking behaviour by enforcing breaks in subsistence activities and loss of wages. Meanwhile, the poor handling and positioning of patients, particularly pregnant women, during transportation can lead to critical secondary injuries.

On the other side, assume it has health complex within the reach of the rural people, but if the accessibility and mobility is not good then it very difficult to go to hospital in time and the doctors or health care giving employees are not willing and even some cases they remain absent to their work place.

Therefore, the problem remains in vicious-cycle and without appropriate transport accessibility this could not be overcome.

2.7.4 Goal 4: Ensure Inclusive and Equitable Quality Education and Promote Lifelong Learning Opportunities for all

Getting to school in rural areas is costly in time, efforts and money. Drop-out rates are high and attracting and retaining quality teaching staff in rural schools is difficult. The distance between home and school, the lack of appropriate, affordable infrastructure and transport services to make the journey, and the time required to do so, are all constraints to this goal. Improved mobility can also relieve heavy domestic workloads that are a barrier to attendance, particularly for girls.

2.7.5 Goal 5: Achieve Gender Equality and Empower all Women and Girls

Women often carry a heavier burden in terms of time and effort spent on transport. They have less access and control over resources and fewer opportunities than men to use transport technologies. By focusing more investment on the infrastructure and services used by and appropriate to women, their time poverty can be dramatically reduced. Improved mobility empowers women to take more control over their lives by increasing their access to markets, their exposure to education and information, their opportunities to participate in income generation, community and political activities, and by improving equality in gender relations.

2.7.6 Goal 6: Ensure Availability and Sustainable Management of Water and Sanitation for All

Availability of water means availability of safe drinking water for all. In fact in rural areas where there are no pipe water supply networks, instead in case of rural areas of Bangladesh there are deep tube wells at some distance interval which is the only source of safe drinking water for rural peoples. The people have other source of water; say for example river, canal, ponds, water bodies (haor/beel/lake) but which is not safe for drinking. Therefore for safe drinking water people have to fetch water from his/her nearest location of deep tube well – so people have to have transport accessibility. It is rational to mention that people in hilly (Chittagong, Bandarban, Rangamati, Khagrachhari) and haor (Sylhet, Sunamganj, Habiganj, Moulivibazar, Kishoreganj, Netrokona) areas of Bangladesh has to spent a substantial time and effort to collect safe dringking water due to lack of sufficient transport access to the source of safe drinking water. In bottom line, it is imperative to have a good accessibility to ensure availability of water and sanitation for all.

Goal 7: Ensure Access to Affordable, Reliable, Sustainable, and Modern Energy for All – it is independent to transport accessibility.

2.7.7 Goal 8: Promote Sustained, Inclusive, and Sustainable Economic Growth, Full and Productive Employment and Decent Work for All and Goal 10: Reduce Inequality within and Among Countries

To foster sustain, inclusive and sustainable economic growth and employment for all in accordance with national circumstances, it is imperative to have transport accessibility for all. On the other hand to reduce inequality by 2030 by empowering and promoting the social, economic and political inclusion irrespective of age, sex, disability, race, ethnicity, origin, religion or other status, it is also imperative to have equitable transport accessibility to all and without it the attainment of the targets is not possible. To get access to employment, social, economic and political activities by all, it is have to have transport accessibility.

2.7.8 Goal 13: Take Urgent Action to Combat Climate Change and it Impacts

Climate change and Environmental degradation has a much greater impact on the livelihoods of the poor by increasing their vulnerability to natural and manmade disasters. Transport has a poor environmental record: greenhouse gas emissions, noise pollution, deforestation and contribution to urban sprawl. Yet transport also provides huge potential for minimizing its externalities and developing environmentally sustainable technologies, for example green roads in Nepal and the rising popularity of bio-fuels. The promotion of more sustainable public transport and non-motorized vehicles and the development of traditional waterways can all contribute to a greener tomorrow.

2.7.9 Goal 16: Promote Peaceful and Inclusive Societies for Sustainable Development, Provide Access to Justice for all and Build Effective, Accountable and Inclusive Institutions at All Levels

Transport provides the links between rural areas and the outside world. It forges a life-link between rural communities and their markets, puts isolated people in touch with their representatives, sustains important social networks and in general, helps to empower communities and individuals by delivering freedom of movement. By providing and sustaining access opportunities, transport can be a key catalyst for a global partnership for development.

2.7.10 The Challenge

The oversight of transport within the SDGs as well in MDGs has created a significant challenge for the sector. As donor priorities have shifted to align with the Goals some bi-laterals are choosing to move away from transport altogether and if this continues we can expect to see the sector left in the hands of the bigger multi-laterals. The impact of this could be the prioritization of large-scale road-focused investments over the smaller scale transport initiatives that are more likely to benefit poor communities. This will also result

in a weaker voice for the grassroots as a consequence of lost support to international and national NGOs and networks that currently rely upon the shorter lead times and willingness of the bi-laterals to support smaller scale initiatives (Werner 2007).

2.7.11 Moving Forward

World leaders embark to set goals and target to attain by 2030 deadline for achieving the SDGs, it is time for the transport sector to consolidate a more pro-active cross-sectoral role and to address our own internal challenges in realizing a pro-poor agenda. Although current transport rhetoric looks beyond an exclusive focus on roads to a more integrated approach encompassing low cost means of transport and the optimal location of services to suit local needs, this rhetoric is still not matched by practice on the ground.

A paucity of reliable and comprehensive travel data is one of the weak links between policy intention and the actual delivery of solutions. Participants in consultations carried out as part of the World Bank‘s Transport Results Initiative have called for the inclusion of household travel information as part of regular national surveys. Examples include the 2004 Nairobi Urban Household Travel Patterns Survey, which revealed that transport accounted for over 10% of expenditure for at least 68% of households in the city. Also the 2005 South Africa National Household Travel Study, which recorded transport difficulties for approximately 82% of rural households.

We need to further refine and scrutinize the transport and poverty indicators that we have developed. Do they fully reflect the complexities of improving access and mobility for poor communities? For example the Rural Transport Accessibility Index (RAI), one of the most established headline indicators, endorsed by the World Bank, defines rural access in terms of the percentage of a population within 2 kilometers of an all season road. Does distance alone sufficiently capture issues of affordability, availability and reliability of transport services, or even the differential time burdens encountered due to various terrains, or climate patterns, for example increased difficulties during the rainy season? How do we measure and mitigate against less recognized obstacles to mobility such as personal security for women, men and children?

To truly fulfill its role as a critical catalyst for the delivery of the SDGs it is clear that the transport sector has a lot of work to do. We need to use the coming years to allocate more resources in transport sector in the Annual Development Program (ADP) budget that will support the implementation of rural roads. We need to establish clear mechanisms that will ensure that due emphasis and attention are given in transport sector. For these, I in this thesis research study want to frame a framework of rural transport accessibility indicator and its consequence to rural community in particular to the poverty situation. Ultimately we need to close the gap between our own rhetoric and the harsh reality of poor access and mobility that is still experienced by the rural communities of Bangladesh and by other developing countries every day.

2.8 Need for an Integrated Approach

Chapter 1 has outlined the characteristics of rural travel and transport and identified the primary or basic need as access of rural households to facilities for subsistence, economic, health, education and social and business requirements. In this Chapter (section 2.10) has discussed the factors which affect the level of access that households have to these facilities, namely: location of the facility, infrastructure providing access to the facility, means of transport and transport services. This chapter discusses the inter-action of these factors and, because of the strong inter-relationships, the need for an integrated approach to accessibility planning.

2.8.1 Inter-Action of Factors which Affect Access

The level of access to a facility is primarily measured by the average time needed to travel to the facility. However, if a means of transport is used then the cost of travelling to the facility might also be included, particularly if transport of goods for economic reasons is involved. Level of access would then be judged by some compromise between time and cost which acceptable to the household.

The time taken to travel from the homestead to a facility is determined by distance, the nature of the infrastructure and terrain i.e. good, poor, hilly, flat, etc., the means of transport used and to some extent whether a load is carried (this ignores any waiting that might be involved at blockages, ferries, etc.). The same factors will also determine cost but in a more complex manner. The distance to the facility is determined by its location and the infrastructure which is available to provide access. The factors- location of facility, infrastructure and means of transport (or transport services) – are clearly inter-related in determine the level of access to a facility. It is therefore essential that the factors are not considered in isolation in accessibility planning.

2.9 Overview

Many studies and researches on rural accessibility have been carried out in abroad, particularly in the developing countries like South Africa, India, Pakistan, Morocco, etc. But in Bangladesh a few study has been done on quantification of rural transport accessibility. In this backdrop this research topics has been taken to quantify the rural transport accessibility. The methodology used to quantify the rural transport accessibility is described in the next chapter 3.

In this chapter, it has been observed from the literature review and previous studies and researches, internationally and nationally, quantification of rural transport accessibility were done on activity based, distance of facilities, small areas base, aggregate base, etc. In Bangladesh, the accessibility index at the District (64 numbers of administrative areas) was not done ever. Under this research program, I have calculated the rural transport accessibility index, which makes this research unique in this arena of rural transport accessibility.

CHAPTER-3

Research Methodology

Chapter 3
RESEARCH METHODOLOGY

3.1 Introduction

In this chapter, it is presented the overall methodology adapted for the study starting from set out objective, vast and rich literature review data collection, data processing, and the development of recommendation for implementation. However, the next Chapter will focus on the detail analyses and mathematical presentation and accessibility mapping.

Bangladesh, the area of which is 1,47,570 sq. km with a population of 149.77 million [*source: Bangladesh Bureau of Statistics, 2011 population census, website: http://www.bbs.gov.bd*]. Of which only 23.43% people live in urban areas – comprising of the capital Dhaka city including seven other Divisional Headquarters, District Headquarters, Thana/Upazila Headquarters, etc. The remaining 76.57% people are living in rural village areas across the country. These large volumes of people of Bangladesh in village areas are connected with the main stream i.e. economic, business, education, health and other social services centers by rural roads, waterways and railways, whereas many rural areas still not adequately connected by any formal transportation system. In some village areas, still people have to walk through earthen narrow roads to get into access to the main road.

Out of total transport demand in Bangladesh, road transport carries the lion share. So out of this fact, rural roads play a pivotal role to get accessed to work places, markets, business centers, education centers, health centers, and other social services for daily subsistence as well as rural human development. To increase the rural transport accessibility, Bangladesh needs to invest in rural transport. To this end, our policy makers have to feel realize and understand the level of accessibility in order to make a priority list in invest in new physical infrastructure within our budget constraint. In line with this, in this research study it is attempted to quantify the rural transport accessibility index. To achieve this target as set out in the thesis objective, a comprehensive methodology is required.

The next few sections of this chapter describe the methodology adapted in this study to achieve the objectives set forth in Chapter-1. To quantify the rural transport accessibility, first of all to gather information and to collect the current updated rural transport road network (data is in GIS format), then through spatial analysis, it is identified the all-season all-weather road. Then applying the GIS technology and through appropriate mathematical calculation it is found the accessibility index. The detail analyses and mathematical calculation is shown in next chapter for further understanding.

3.2 Selection of Study Area

The scope of area under this research is the spatial area of Bangladesh, whose geographical area extends from 20º 34´ to 26º 38´ North and 88º 01´ to 92º 41´ East. To

quantify the Rural Transport Accessibility Index (RAI), it is taken into consideration the administrative area of sixty four Districts of Bangladesh, where there are 64 Districts under 8 Divisional areas that comprise Bangladesh as shown in Figure 3-1: Study Area.

RAI is calculated providing the all season road network of Bangladesh consists under the jurisdiction of two government organizations namely Roads and Highways Department (RHD) (under ministry of Road Transport and Bridges of Bangladesh People's Republic of Bangladesh) and Local Government Engineering Department (LGED) (under Ministry of Local Government Rural Development & Cooperatives of Bangladesh People's Republic of Bangladesh) national wide road network.

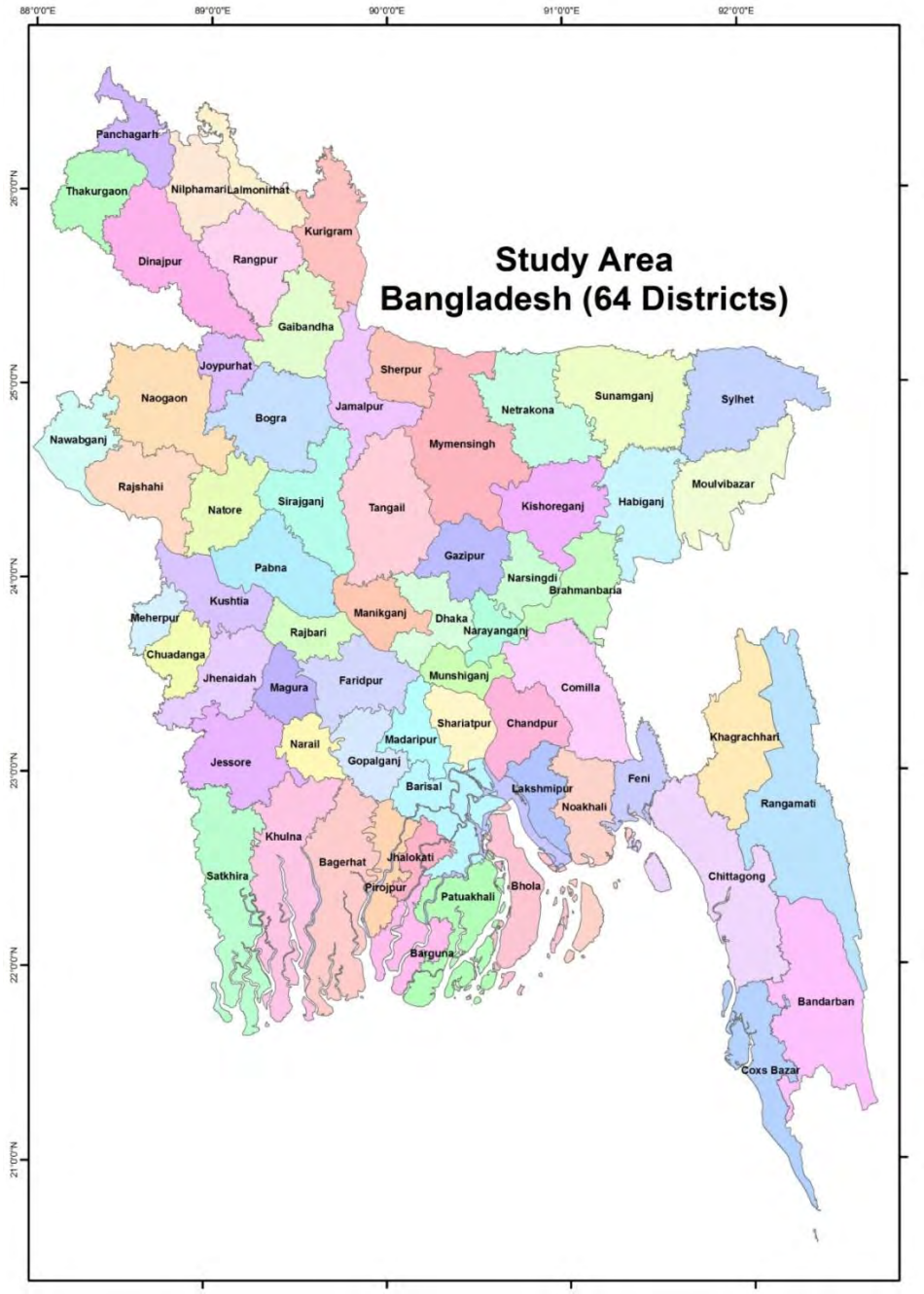


Figure 3-1: Study Area
Source: map prepared under this study

3.3 Technique Used to Estimate Rural Transport Accessibility

In this study geographical information systems (GIS) tools has been used for analyzing physical accessibility, which is highly spatial in nature. GIS allows explicit geographical representation of transportation networks (e.g. roads), with associated properties such as length and surface condition (which affects travel time, or whether passable in all weather). The divisional administrative area is used as the polygon data. The GIS provides functions to determine spatial relationship such as all-weather road which is based on the query made on the type of road (i.e. paved road); and to calculate the buffer area (2 km distance on either side of the road, which is elaborated next in data analysis chapter) treated as accessible area enabling people to quick and easy access to jobs, education, health services and socio-economic activities.

The choice of two (02) kilometers as the defining distance for adequate access is a compromise between two extreme cases. Some sections of the population (the elderly, the disabled or those carrying heavy burdens) may find that even distances of less than one kilometer present a significant barrier to access, particularly under extreme conditions of climate & spatial condition of land areas. On the other hand, in many remote situations (such as the hills of South-Eastern areas of Bangladesh, Nepal or remote areas of Southern areas of Bangladesh and in many African countries) people may be accustomed to walking many kilometers in order to reach formal transport services.

Then the population within the buffer area was calculated assuming that the settlements are uniformly distributed over the district area. RAI is being calculated using the formula as,

$$RAI = \frac{No\ of\ Rural\ People\ with\ Access}{Total\ Population} \times 100$$

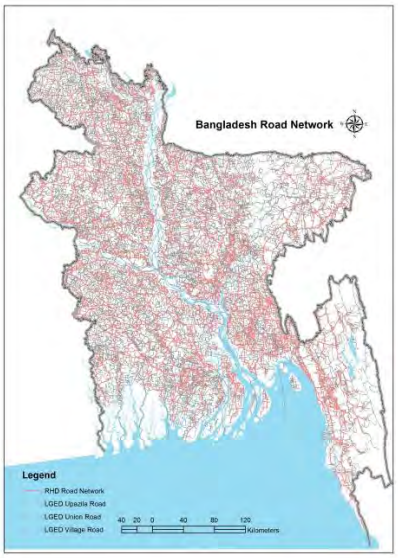
The computed RAI value interpretation is like that the higher value of RAI means higher accessibility and lower RAI value means less accessible through all-weather roads. Further RAI is calculated for two time periods to see the trends of accessibility over the time period and also try to establish a relationship with the poverty incidence. The results of the computation have been displayed on a map and presented also in tables. The Head Count Index (HCI) is the most popular index to apprehend the poverty incidence of Bangladesh has been used to come up with a relationship with the RAI.

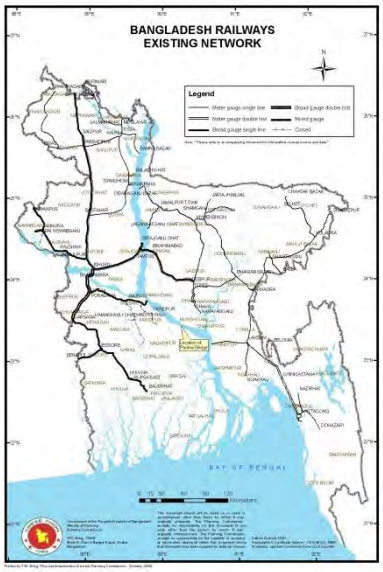
3.4 Rationale to Consider Road Transport only to quantify the Accessibility Index

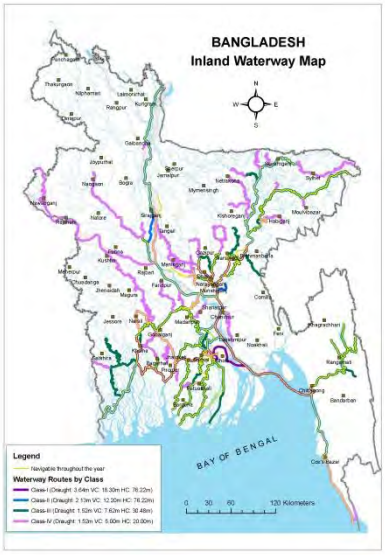
Bangladesh transport system comprises of road, rail and waterways, of which road transport is the dominant mode of transport. Most widely coverage transport network in Bangladesh is road through which almost every Thanas/Upazilas and even Unions are connected with the headquarters. On the other hand, railway network is limited access and not covered even every District of Bangladesh. There are fifteen (15) numbers of Districts are not connected by railway network. People can only access to rail through

total of 507 numbers of stations situated in Bangladesh rail network across the country. Waterway transport system is very limited network which mainly covers the southern part of Bangladesh. It is presented the summary of network of the 3-modes of transport in Bangladesh in the following table.

Table 3-1: Bangladesh Transport Network Summary

<table>
<tr><td colspan="2">Road Transport</td><td>Railway</td><td colspan="2">Waterway</td></tr>
<tr><td>RHD</td><td>Total = 21,092.14 km
Paved = 16,158.968 km</td><td>Total Route = 2,877.10 km
Station = 456 Nos.</td><td colspan="2">Length of Inland Waterways = 24,000 km</td></tr>
<tr><td>LGED</td><td>Total = 3,04,379.31 km
Paved = 83, 303.41 km</td><td></td><td>Length of Navigable Waterways</td><td>Monsoon = 5,968 km
Dry Season = 3,865 km</td></tr>
<tr><td colspan="2">Source: RHD and LGED Database (www.rhd.gov.bd and www.lged.gov.bd)</td><td>Source: Bangladesh Railway website (www.railway.gov.bd)</td><td colspan="2">Source: Bangladesh Government Economic Review 2010 (www.mof.gov.bd)</td></tr>
<tr><td colspan="2"> 

RHD+LGED Road Map</td><td> 

Bangladesh Railway Route Map</td><td colspan="2"> 

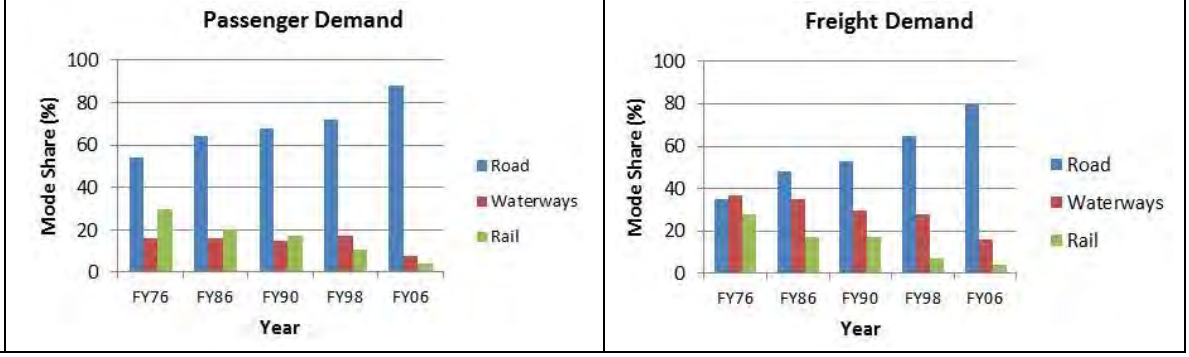
IWT Route Map</td></tr>
</table>

Source (Map preparation): this study

Lion share of country's total transport demand is met by road transport, which emerged as a dominant mode of transport over the years as shown in Table 3-2 below. The share of passenger transport demand provided by road transport increased from 54 percent in 1975 to 88 percent in 2005, while rail declined from 30 to 4 percent and Inland Water Transport (IWT) from 16 to 8 percent over the same time period. A similar change also happened for freight transport demand also.

Table 3-2: Transport Demand and Mode Share

Year	Passenger				Freight			
	Total Passenger-km (billion)	Share (%)			Total Tone-km (billion)	Share (%)		
		Road	IWT	Rail		Road	IWT	Rail
FY76	17	54	16	30	2.6	35	37	28
FY86	35	64	16	20	4.8	48	35	17
FY90	57	68	15	17	6.3	53	30	17
FY98	90	72	17	11	12	65	28	7
FY06	112	88	08	04	20	80	16	4



Source: Bangladesh Economic Review (www.mof.gov.bd)

Therefore, considering the above scenario of area wide coverage network and mode share contribution, road transport network has been chosen to find out the transport accessibility index. For planning purpose, the accessibility index of road transport can exhibit a good proxy to understand the ground information of actual accessibility level of rural areas.

Here, the author would like to keep provision and proposal to further study at Ph.D. level to consider all the transport network (road, rail & waterway) to find the accessibility level and its significant impact on poverty reduction as well as other human development index, like maternal mortality rate, education enrollment rate, infant mortality rate, etc.

3.5 Types of Data and Software Used in this Study

Data used: To estimate the rural transport accessibility index demographic data and spatial data were used. The details of these kinds are presented in Table below:

Table 3-3: Data Types and Sources Used in this Study

Data Types	Data Description	Name of the Organization belongs the Data	Data Collection/Source
Spatial Data	Road Network	RHD, LGED	Secondary
	District Administrative Boundary	RHD, BBS	Secondary
Demographic Data	Population (District wise)	BBS	Secondary
	Urban and Rural Population	BBS	Secondary
Poverty Data	Poverty Indices (District wise)	BBS	Secondary

Source: this study

Software used: Geographical Information System (GIS) software (ESRI ArcGIS-ArcMap Desktop) is used to analyze, interpreting data to understand relationship, and visualize data in the form mapping i.e. accessibility mapping and poverty mapping.

3.6 Data Collection

To accomplish this study, data collections are only done in one ways namely secondary data collection. Secondary data are collected from different organizations, expert suggestions and discussions as explained in the next sections.

3.7 Secondary Data Collection

The major secondary data collections are Bangladesh Road Network under the authorities of Roads and Highways Department (RHD) and Local Government Engineering Department (LGED). The administrative area polygon data is collected at the District level. All these data are in geographical data in shape file format. The poverty data in terms of poverty indices (Head Count Index, HCI) of sixty four Districts of Bangladesh were collected from Bangladesh Bureau of Statistics. Besides these, other secondary data collection comprises official documents, literature review, expert suggestions and discussions. Official documents are collected from Govt. organizations and from internet for literature review presented in chapter-2 in this thesis paper. Expert suggestion and discussions are acquired by personal visit who are adept in realm of transport sector.

3.8 Problems Face-Off during Data Collection

During secondary data collection from different organizations, the following difficulties are faced-off even if the age of pervasive internet networking:

- RHD Road Network Data: (i) updated paved and non-paved road data.
- LGED Road Network Data: (i) lack of precise GIS based road network data with paved and non-paved information.
- Lack of precise data regarding District administrative area and boundary.

3.9 Data Analyses

In the data analysis chapter, the robust analyses were done in ArcGIS-ArcMap environment and in Microsoft Excel Analysis Toolpack. It has been done step wise and systematically with substantial rational and prudent facts to quantify the accessibility index. The population and poverty data used to find out the factual relationship was done in excel spreadsheet. Then the accessibility mapping was prepared in ArcMap leveling the accessibility index value and poverty data to make a good understanding to the policy makers. Summary tables and graphical charts of accessibility and poverty were prepared for Division wise.

3.10 Assumption made to do the Analyses

An assumption was made to do the analyses in this research study for ease of calculation, i.e. the total population of a District is considered as evenly distributed over the total land area of that District. Because the actual location of population settlement is very difficult to find and there is no data available in our country in this regard.

3.11 Summary and flow Chart of Methodology

It is presented in detail in the data analysis chapter-4 to attain the objectives set out in Chapter-1, where the data are collected through secondary source only. The secondary data are collected from different organization and officials belong to these different organizations. The flowchart of the methodology adopted in this research is presented below:

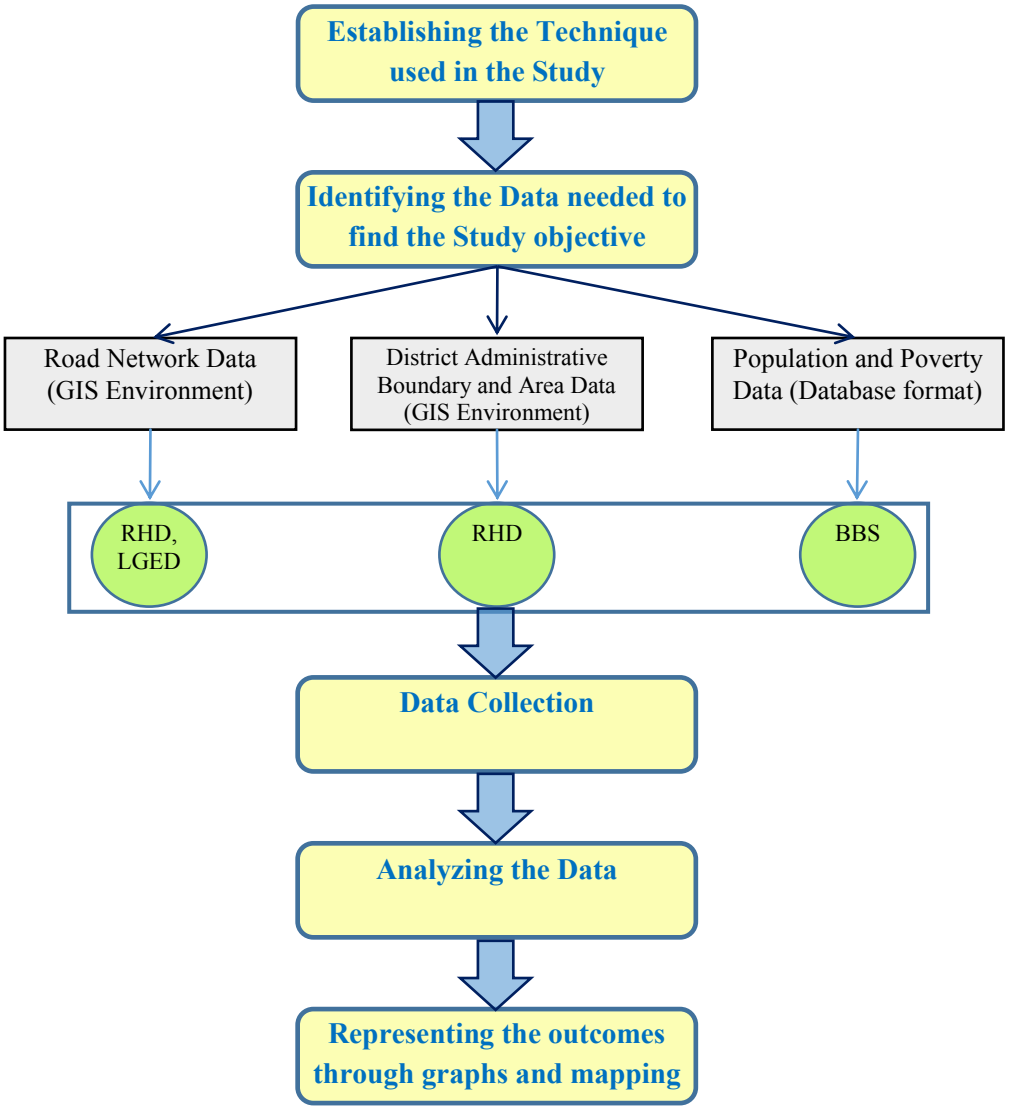


Figure 3-2: Chronology of Methodology for the Study

Source: this study

3.12 Overview

This chapter describes the total analysis procedure of the present study starting from selection of corridors, data collection to problem encountered during data collection, data processing, and the development of framework for analyses. The type of each framework and the components of the skeleton are illustrated briefly to recognize the research pattern correctly. However, the next Chapter will focus on the detail analyses of pavement design parameters in different National Highways of Bangladesh.

CHAPTER 4

Data Collection and Analysis

Chapter-4
DATA COLLECTION AND ANALYSIS

4.1 Introduction

To estimate the Rural Transport Accessibility Index, in this chapter, data collection and robust analyses of these data are presented to attain the objectives set out in chapter 1. Mainly the principle part of this chapter is the assessment of data, which is collected from the secondary sources, is called the –Secondary Data". The secondary data were collected from different organizations of Bangladesh, namely Roads and Highways Department (RHD), Local Government Engineering Department (LGED) and Bangladesh Bureau of Statistics (BBS). In addition to that open source data are used which are relevant and complementary to this study.

This chapter describes data collection and analysis to measure the Rural Access Index (RAI), one of several Transport Headline Indicators endorsed by the World Bank Transport Sector Board in 2003. The index has been adopted for the Results Measurement System (RMS)2 of the 14th round of the International Development Association (IDA-14) which was launched in July, 2005. The Index has been developed with a view that it identifies an important priority for poverty reduction strategies in view of the established links between physical isolation and poverty. This provides stronger linkage to attain the Millennium Development Goals (MDGs) and in recent time to the Sustainable Development Goals (SDGs).

Bangladesh Government emphasizes the importance of rural infrastructure development of the country. However, the rural infrastructure facilities are not equally and widely distributed over the area considering the socio-economic factors. In order to maintain nonbiased development, it has to be identified a key diagnostic measures which have particular significant for the sector in contributing to the wider development process. Stimulating from these notion, this study concept was taken to estimate an index and ranking based on the result which could be a proxy to help the policy makers in budget allocation in rural physical and social infrastructure to address the poverty.

Rural Transport Access Index could provide a consistent basis for estimating the proportion of the rural population which has adequate access to the transport system. It can help to inform policies and strategies which ensure that the rewards of development are distributed more equitably to the rural population.

4.2 Data Collection

In this thesis study, there is no primary data collection. All the data used for the analyses are secondary data, as described as follows:

[2] The RMS involves measuring a set of indicators, which captures key aspects of the development of 81 countries which receive IDA concessional assistance (IDA, 2004).

4.2.1 Road Network Data

To estimate the rural transport accessibility index, road network data across the country are collected. The nationwide rural road network data are under the jurisdiction of Roads and Highways Department (RHD) and Local Government Engineering Department (LGED). Since the analyses has been done in GIS environment, therefore the road network data are collected in GIS shape file format with its attribute road condition data to filter out the all-weather paved road in rural areas.

4.2.1.1 Roads and Highways Department (RHD) – Road Network

The nationwide RHD road network consists of three categories of road, namely National Highway, Regional Highway, and Zila Road. In order to estimate the road transport accessibility index, the roads are selected based on road condition as paved road, regarded as all-weather accessible road.

4.2.1.2 Local Government Engineering Department (LGED) – Road Network

The nationwide LGED road network consists of three categories of road, namely Upazila Road, Union Road, and Village Road. In order to estimate the road transport accessibility index, the roads are then selected based on the pavement surface condition as paved road which are regarded as all-weather accessible road.

4.3 Overall Outline of Data Analysis

In this study, Rural Transport Access Index (RAI) values are estimated using the formula as stated in Chapter 2 of this report. Data fed in the equation are processed in GIS software and in excel spreadsheet. In the next sections, it is first estimated the value of RAI, then prepared Accessibility Mapping and presented data aggregation through charts and graphs. The estimated RAI values then have been tried to find the relational association between the RAI and poverty. It is also tried to find the association with social and socio-economic facilities and eventually perform the data envelopment analysis.

4.4 Selection of Road Network to Estimate the Transport Accessibility Index

In Bangladesh, there are actually six (06) categories of roads as listed in the table below. Two Government organizations are responsible to construct and maintain these roads across the country. The former three (03) categories of higher standard of roads are under the responsibility for and under the jurisdiction of Roads and Highways Department (RHD) and latter three (03) categories of lower standards of roads are under the responsibility for and under the jurisdiction of Local Government Engineering Department (LGED).

Table 4-1: Bangladesh Road Type Definition and Ownership

Sl. No.	Type	Definition	Ownership and Responsibility
1.	National Highway	Highways connecting National Capital with Divisional Headquarters (HQs) or Sea Ports or Land Ports or Asian Highways.	RHD
2.	Regional Highway	Highways connecting District HQs or main river or land ports or with each other not connected by National Highways.	RHD
3.	Zila Road	Roads connecting District HQs with Upazila HQs or Connecting one Upazila HQ to another Upazila HQ by a single main connection with National/Regional highway through shortest distant or route.	RHD
4.	Upazila Road	Roads connecting Upazila HQs with Growth Centers or one Growth Center to another Growth Center by a single main connection or connecting Growth Centers to Higher Road System*, through shortest distance/route	LGED/LGI**
5.	Union Road	Roads connecting Union HQs with Upazila HQs, Growth Centers or local markets or with each other.	LGED/LGI
6.	Village Road	a) Roads connecting Villages with Union HQs, local markets, farms, ghats or with each other; b) Roads within Village.	LGED/LGI

* Higher Road System National Highway, Regional Highway and Zila Roads
** LGI – Local Government Institute
Source: Bangladesh Gazette, 6 November 2003 and Planning Commission, 2007

4.4.1 Roads under Roads and Highways Department

The Roads and Highways Department (RHD) in Bangladesh is responsible for first three higher categories of roads as classified & defined in Table 4-1 and is currently over 21,000 km length of roads across the country. Not all the roads, particularly in the Zila category, are yet fully paved of entire lengths. As in **Table 4-2** and Figure 4-1, it shows that 9,013 km of the total Zila roads are paved, or just under 69% of the entire lengths. Map in Figure 4-2 shows the current RHD network where the green color lines represent the paved road and red color lines represent the unpaved roads. In this study, it is particularly interest in paved roads which are assumed to be accessible all the year rounds in all-weather condition by the rural people to meet their daily needs and activities.

Table 4-2: Road Length under RHD

Road Class	Total Length (km)	Paved Road (km)	Paved Road (%)
National Highway	3790.86	3428.33	90.44%
Regional Highway	4206.12	3716.81	88.37%
Zila Road	13095.16	9013.82	68.83%
Total =	**21,092.14**	**16,158.968**	**76.6% (avg.)**

Source: RMMS Database of RHD (www.rhd.gov.bd)

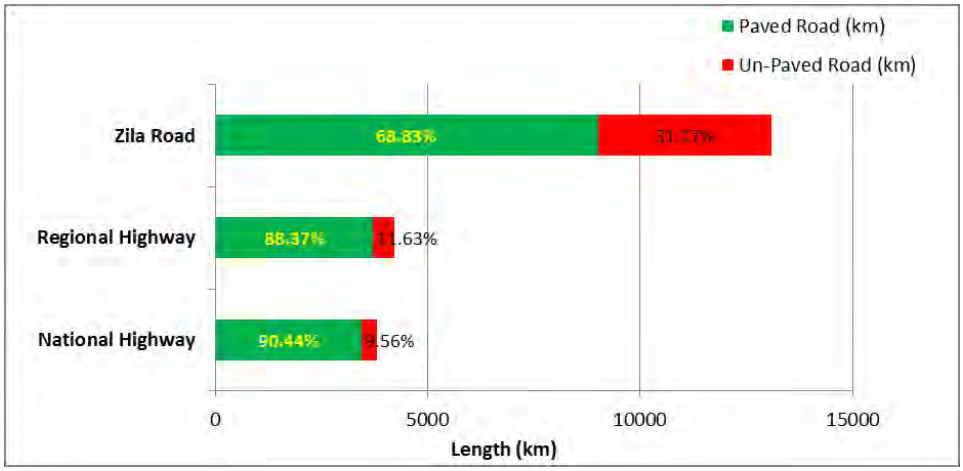


Figure 4-1: Paved and Un-Paved Roads under RHD

Source: RMMS Database of RHD (www.rhd.gov.bd)

In the following figure, the RHD network across the country has been shown where the green color represents the paved road and the red color represents the un-paved road.

Figure 4-2: Nationwide Road Network (Paved and Unpaved) under RHD

Source: prepared under this study

4.4.2 Paved Road under Roads and Highways Department

To estimate the rural transport accessibility index, it has to be found the all-weather accessible road by the year round. In RHD RMMS (Road Maintenance Management System) database, road attribute table of road condition where it is periodically update the road condition. One of the attribute of the road condition is "ISPAVED" and the content of the field is Yes/NO. To find the paved road, this road condition database has been joined to the attribute table to the road network layer. After joining the road condition database, the query has been made on the condition (ISPAVED = Yes) to segregate the paved road only in the ArcGIS-ArcMap view. The only paved roads across the country under RHD are presented in the following map in Figure 4-3.

Figure 4-3: Nationwide Paved (all-weather Accessible) Road under RHD

Source: prepared under this study

4.4.3 Roads under Local Government Engineering Department

The Local Government Engineering Department (LGED) is responsible for lower three categories of roads which are classified and defined in Table 4-1 and currently there are over 3,00,000.00 km length of roads under the jurisdiction of LGED across the country. However, not all the roads, particularly in the Union & Village Road categories, are yet paved the entire coverage lengths. As represented in Table 4-3 and in Figure 4-4, the Upazila roads are around 80% paved, but Union and village roads are about 51% and 14% paved only in respect. In Table 4-3, it is presented the current LGED network across the country.

Table 4-3: Road Length under LGED

Road Class	Total Length (km)	Paved Road (km)	Paved Road (%)
Upazila Road	37,334.86	29,797.33	79.81%
Union Road	44,202.03	22,478.31	50.85%
Village Road	2,22,842.42	31,027.77	13.92%
Total =	**3,04,379.31**	**83,303.41**	**48.19% (avg.)**

Source: LGED Road Database (www.lged.gov.bd)

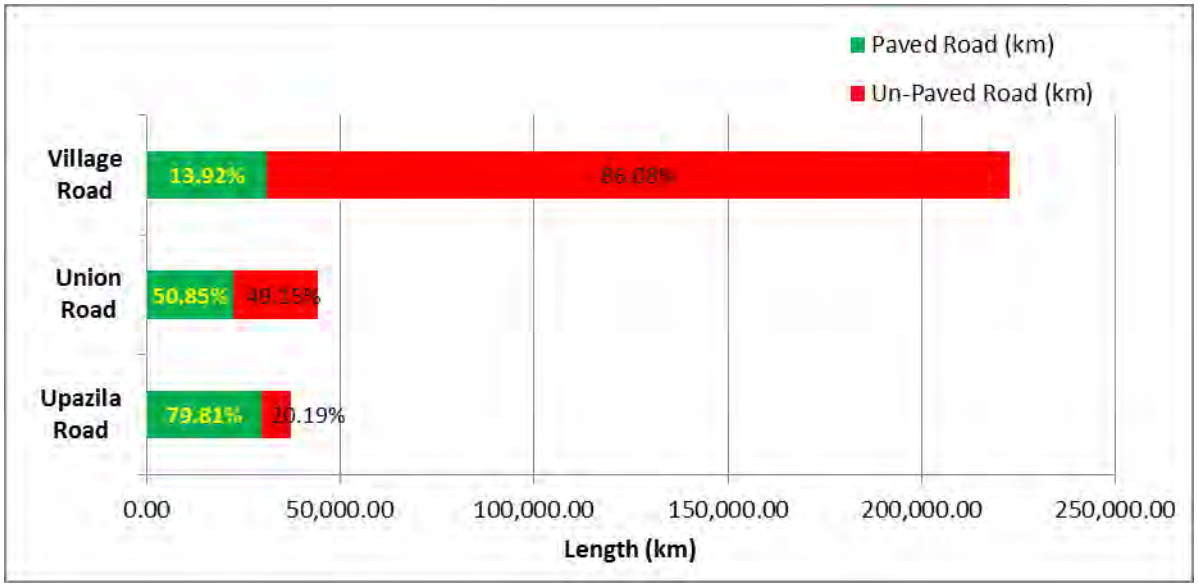


Figure 4-4: Paved and Un-Paved Roads under LGED

Source: LGED Road Database (www.lged.gov.bd)

In the following map in Figure 4-5, the LGED road network across the country has been shown where the orange, pink and ash color represents Upazila, Union and Village roads respectively. From these roads, it will be selected paved roads only to estimate the rural transport accessibility index.

Figure 4-5: LGED Road Network Across the Country
Source: map prepared under this study

4.4.4 Paved Roads under Local Government Engineering Department

In this study, it is in particular interest in the paved road network in rural areas, which are considered as the all-weather passable road all the year round. From the road layer shape file in ArcView GIS environment, in the attribute table of the road it has been made a query builder to select the "Pucca" (ashphalt/concrete) road [rd_cond = "FRB_Pucca"] to segregate the paved road. The following map in the Figure 4-6 it represents the "Pucca" [paved] road.

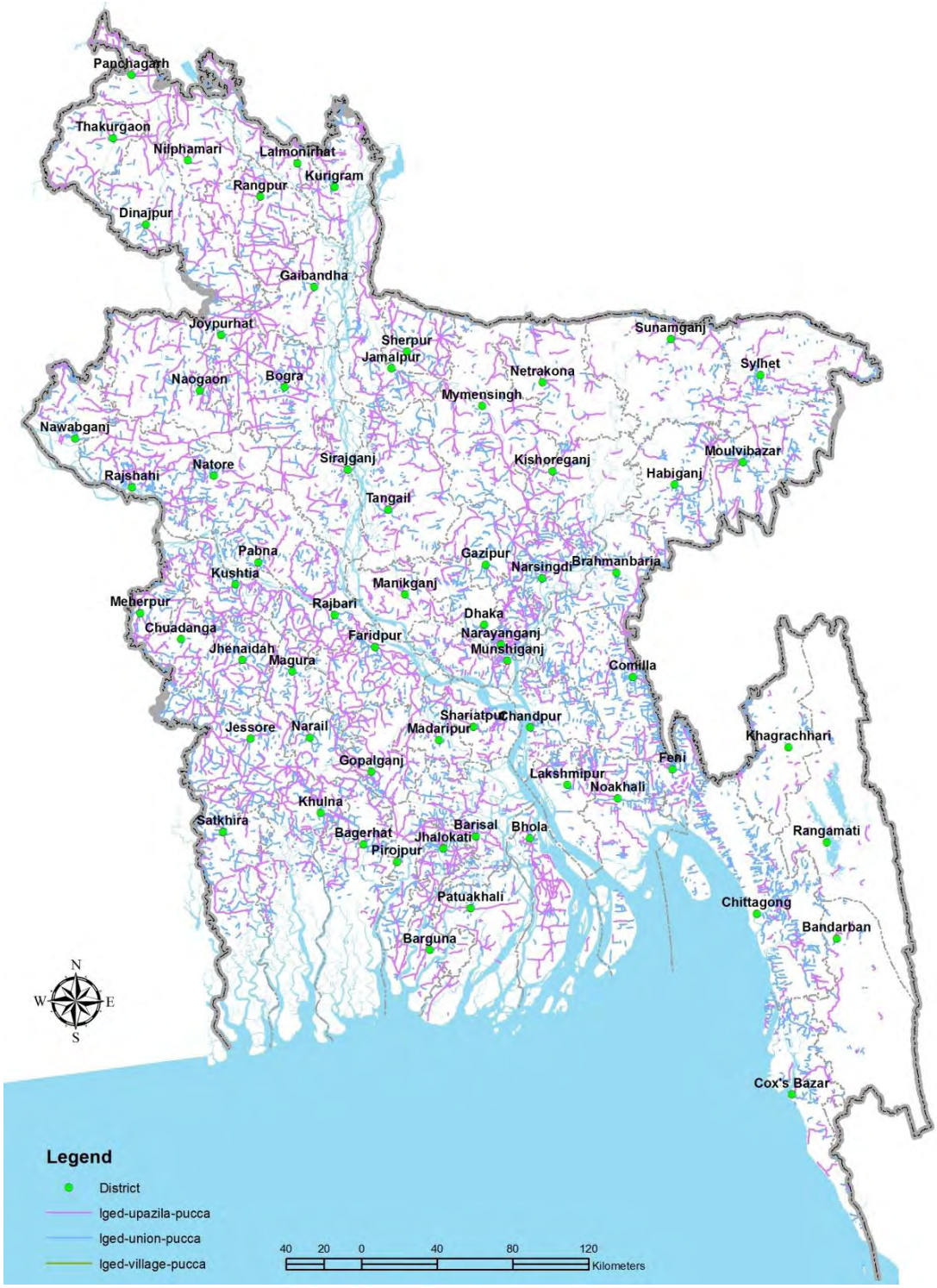


Figure 4-6: Nationwide Paved (all-weather accessible) Road under LGED

Source: map prepared under this study

4.4.5 Combine RHD and LGED Road Network – Paved Road Only

As it is mentioned earlier, RHD and LGED are the two different organizations and are responsible for construction and maintenance of the road network across the country. Now the all-weather accessible roads of different GIS dataset under RHD and LGED are combined using GIS tool. To combine the different data sets, the GIS tool used is called

the ―Merge" tool under the ―Data Management" toolset as described in details in the **Appendix-1**. By combining these different dataset, it has been created a new data set of paved roads as shown in Figure 4-7.

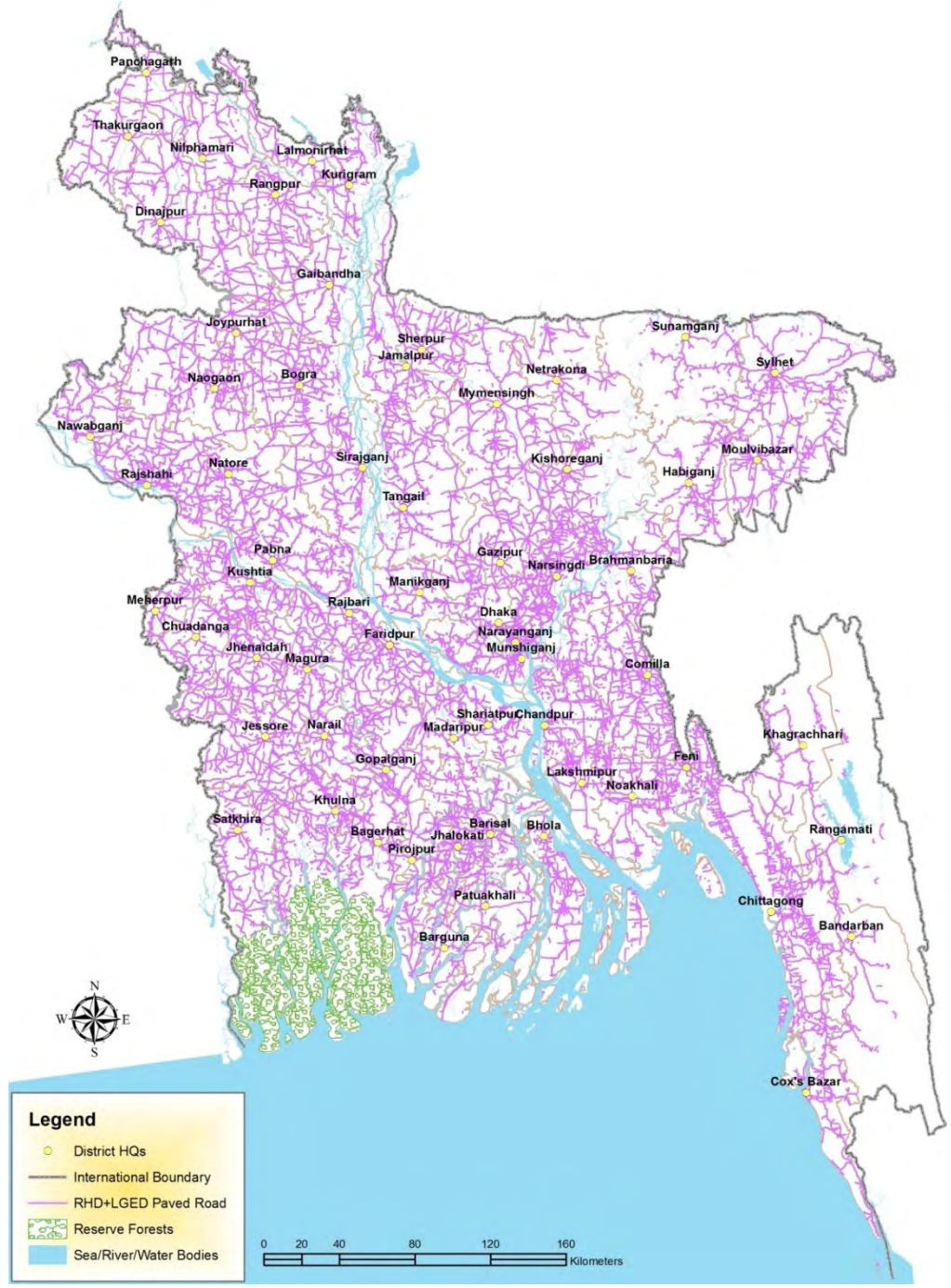


Figure 4-7: Combined (RHD+LGED) Road Network – Paved Road Only (all-weather accessible)

Source: map prepared under this study

4.5 Accessible/Service Coverage Area around the Neighborhood of the All-Weather Road

In practice, the rural transport accessibility index measures the number of rural people who live within two kilometers (typically equivalent to a walk of 20-25 minutes) of an

all-weather all-season road as a proportion of the total rural population. An –all-season road" is a road that is motorable all year round by the prevailing means of rural transport. Occasional interruptions of short duration during inclement weather (e.g. heavy rainfall) are accepted, particularly on lightly trafficked roads.

Some sections of the population (the elderly, the disabled or those carrying heavy burdens) may find that even distances of less than one kilometer present a significant barrier to access, particularly under extreme conditions of terrain or climate. On the other hand, in many remote situations (such as the hills of Rangamati, Khagrachhari and Bandarban districts or remote areas of rural area of Bangladesh) people may be accustomed to walking many kilometers in order to reach formal transport services. Alternatively they may manage without using such transport at all. The choice of two kilometers as the defining distance for _adequate access' is a compromise between these extremes. This establishes a consistent definition of the Index, enabling comparison and aggregation (on the basis of population weight) of the values for target populations.

The specific emphasis given to roads in the definition of the index reflects the importance of road transport for improving rural access for the great majority of rural people in developing countries, like Bangladesh where people per capita income is low. In these situations where another mode, such as water transport is dominant the definition can be modified to reflect that. If this is done, then the fact should be explicitly recorded against the resulting RAI value. The RAI is measured on the basis of the definition given above for every administrative districts area of Bangladesh. The complete estimation procedure is as follows:

Step 1: Clip the RHD+LGED all-weather road by the –District" area polygon

Step 2: Identify the 2 km buffer area on both side of an all-weather road in GIS

Step 3: Using the buffer area clipping the District demographic coverage

Step 4: From clipping coverage, calculate the area under each –District"

Step 5: Calculate the number of population fall within the buffer area

Step 6: Calculate RAI using the formula $RAI = \frac{No\ of\ Rural\ People\ with\ Access}{Total\ Population} \times 100$

For the simplicity of the analysis, here it is given one –District" complete set of steeps followed in this study analysis.

The detail analysis steps have been described in **Appendix-1**.

4.5.1 Estimated Road Transport Accessible Area under each "District"

From the clipping coverage as described in Appendix-1, the accessible area under each –District" are calculated in GIS is to estimate the rural transport accessibility index. This population settlement in this area is believed to have privilege in the sense of accessibility than other population who are far from 2km away off the all-weather road. Population being avail more accessible, can exploit socio-economic opportunity for their

development. The following map shows the accessible area out of the total land area of each District.

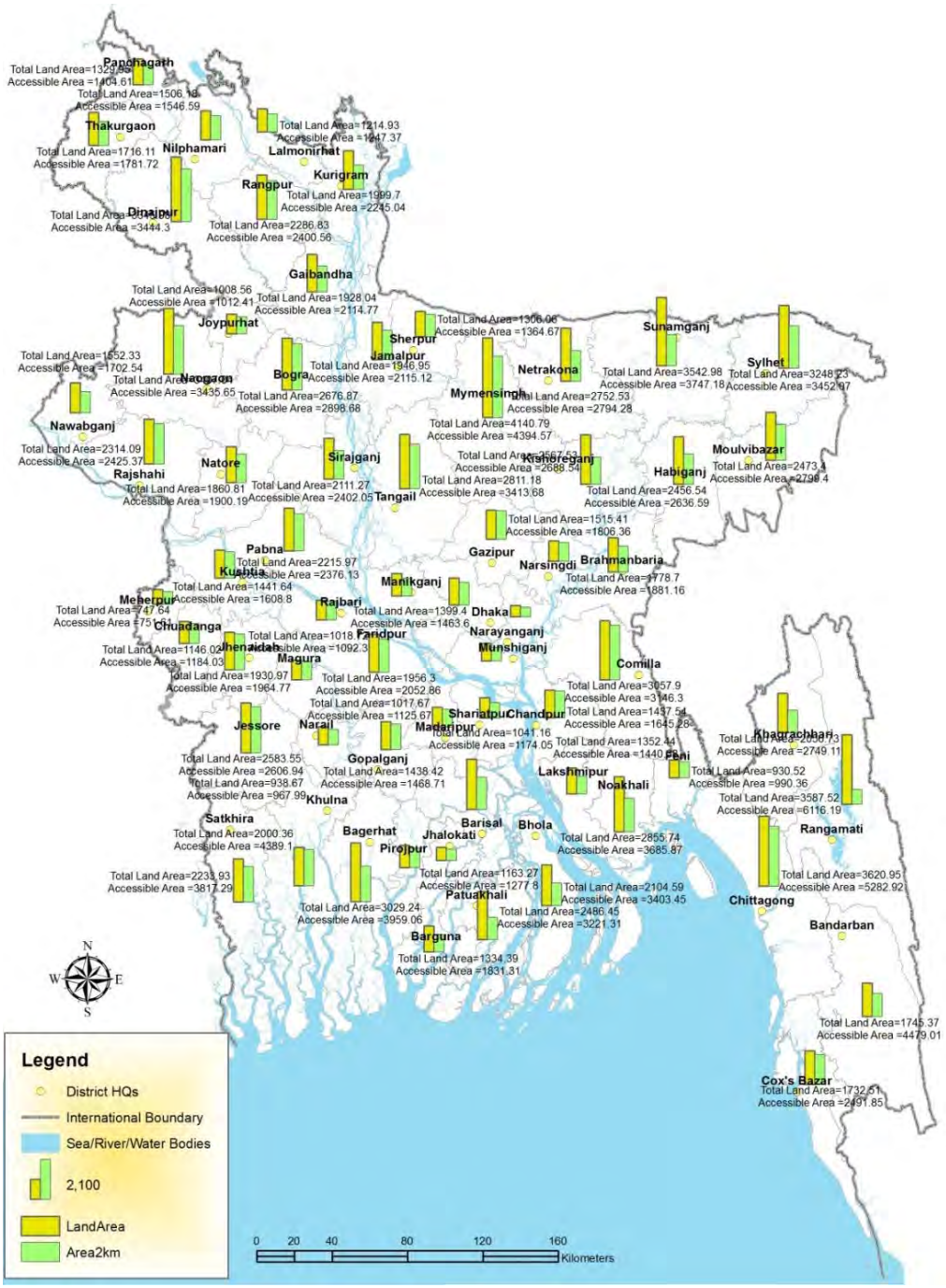


Figure 4-8: Land Area and Estimated Transport Accessible Area under Each District

Source: map prepared under this study

4.5.2 Calculate the Number of Population Settlement Fall within the Accessible Area

After calculating the accessible area around the all-weather accessible road, the next step is to find out the number of population settlement within this area. One assumption has been made here to find out the number of population who are said to be accessed by the

all-weather road. It is assumed that the total populations in each District administrative area are evenly distributed over the land area, though it is not realistic. Since there is no authentic geo-statistical database available regarding the population settlement, therefore this assumption has been made to find the population. The even distribution method is applied here to calculate the number of population settlement within this buffer area. The detail calculations are done in a spreadsheet as presented in the Table 4-4 below.

4.5.3 Estimation of Rural Transport Access Index

To estimate the rural transport accessibility index the following formula has been used. This formula has been developed by the International Development Association (IDA) in its 14th round conference in July 2005. The Index was developed in response to the consensus led by borrowers that it identifies an important priority for poverty reduction strategies in view of the established links between physical isolation and poverty. This provides stronger linkage to the Sustainable Development Goal (SDG) and better assesses the contribution of IDA assistance to the sustainable development of the beneficiary countries. The detail estimation is done in a spreadsheet as presented in the Table 4-4 . Then based on the estimated RAI values, the districts are ranked, where the RAI values are sorted in descending order. Lower the ranking values indicating the better accessibility level and higher the ranking values indicating the worse level of accessibility.

$$RAI = \frac{No\ of\ Rural\ People\ with\ Access}{Total\ Population} \times 100$$

Table 4-4: Detail Estimation of Rural Transport Accessibility Index

District	Area (km2)	Water Area	Reserve Forest	Land Area	Population 2011	Urban Population 2011	Rural Population 2011	Urban Area	Area (km2) within 2km-buffer Area	Rural Population with Access	Rural Population without Access	RAI	Rank
1	*2 (BBS)*	*3 (BBS)*	*4 (BBS)*	*5=(2-3-4)*	*6 (BBS)*	*7 (BBS)*	*8 (BBS)*	*9 (BBS)*	*10 (GIS)*	*11=(8/(5-9))*(10-9)*	*12=(8-11)*	*13=(11/8)*100*	*14*
Barguna	1831	400	97	1334	892781	103094	789687	72	909	523902	368879	66	55
Barisal	2785	160	0	2624	2324310	519016	1805294	172	1682	1111691	1212619	62	60
Bhola	3403	1133	165	2105	1776795	243317	1533478	161	1169	795373	981422	52	67
Jhalokati	707	33	0	674	682669	112003	570666	59	600	501924	180745	88	19
Patuakhali	3221	664	71	2486	1535854	201882	1333972	116	1161	588217	947637	44	69
Pirojpur	1278	106	9	1163	1113257	182631	930626	86	1022	808766	304491	87	20
Barisal Division	13225	2496	342	10387	8325666	1361943	6963723	666	6544	4210701	4114965	60.47	
Bandarban	4479	3	2730	1745	388335	100423	287912	214	1213	187812	200523	65	57
B‘baria	1881	102	0	1779	2840498	448493	2392005	123	1350	1772426	1068072	74	47
Chandpur	1645	208	0	1438	2416018	435724	1980294	161	1394	1912401	503617	97	2
Chittagong	5283	550	1112	3621	7616352	3152629	4463723	451	3099	3728985	3887367	84	29
Comilla	3146	86	2	3058	5387288	840326	4546962	216	2820	4167113	1220175	92	10
Coxs Bazar	2492	161	599	1733	2289990	499011	1790979	148	1551	1586141	703849	89	14
Feni	990	53	7	931	1437371	293742	1143629	93	852	1036618	400753	91	12
Khagrachari	2749	41	652	2057	613917	215808	398109	309	1171	196311	417606	49	68
Lakshmipur	1440	86	2	1352	1729188	262997	1466191	160	916	929780	799408	63	58
Noakhali	3686	493	337	2856	3108083	496700	2611383	203	1736	1509671	1598412	58	64
Rangamati	6116	295	2234	3588	595979	159627	436352	385	768	52182	543797	12	71
Chittagong Division	33908	2077	7676	24156	28423019	6905480	21517539	2462	16871	14291742	14131277	66	
Dhaka	1464	64	0	1399	12043977	9317043	2726934	214	1184	2231849	9812128	82	31
Faridpur	2053	97	0	1956	1912969	271100	1641869	116	1713	1424374	488595	87	22
Gazipur	1806	18	273	1515	3403912	1037574	2366338	173	1488	2317679	1086233	98	1
Gopalganj	1469	30	0	1438	1172415	128705	1043710	72	1329	959794	212621	92	8

District	Area (km2)	Water Area	Reserve Forest	Land Area	Population 2011	Urban Population 2011	Rural Population 2011	Urban Area	Area (km2) within 2km-buffer Area	Rural Population with Access	Rural Population without Access	RAI	Rank
Kishoreganj	2689	121	0	2568	2911907	489030	2422877	155	1408	1258295	1653612	52	66
Madaripur	1126	108	0	1018	1165952	157810	1008142	66	908	891641	274311	88	16
Manikganj	1384	233	0	1151	1392867	128710	1264157	65	917	992341	400526	78	38
Munshiganj	1004	93	0	911	1445660	186106	1259554	38	719	982679	462981	78	39
N‘ganj	684	111	0	573	2948217	988956	1959261	109	503	1666290	1281927	85	27
Narsingdi	1141	78	0	1063	2224944	447645	1777299	110	984	1630429	594515	92	9
Rajbari	1092	74	0	1019	1049778	136042	913736	57	969	866396	183382	95	4
Shariatpur	1174	133	0	1041	1155824	131044	1024780	61	809	781977	373847	76	41
Tangail	3414	93	510	2811	3605083	543785	3061298	237	2317	2473306	1131777	81	34
Dhaka Division	20499	1252	783	18463	36433505	13963550	22469955	1475	15248	18216795	18216710	81	
M‘singh	4395	107	147	4141	5110272	798127	4312145	269	3191	3253910	1856362	75	43
Sherpur	1365	7	52	1306	13583225	188106	13395119	62	1160	11819064	1764161	88	18
Jamalpur	2115	150	18	1947	2292674	387869	1904805	159	1531	1461857	830817	77	40
Netrakona	2794	33	9	2753	2229642	247183	1982459	129	1581	1097261	1132381	55	65
Mymensingh Division	10668	296	226	10146	23215813	1621285	21594528	619	7462	15511663	7704150	72	
Bagerhat	3959	71	858	3029	1476090	195331	1280759	109	1831	755255	720835	59	63
Chuadanga	1184	37	1	1146	1129015	306157	822858	212	1042	730973	398042	89	13
Jessore	2607	23	0	2584	2764547	513552	2250995	140	2375	2058654	705893	91	11
Jhenaidah	1965	34	0	1931	1771304	280192	1491112	147	1848	1421716	349588	95	3
Khulna	4389	361	2028	2000	2318527	777588	1540939	138	1888	1447841	870686	94	6
Kushtia	1609	167	0	1442	1946838	235526	1711312	73	1369	1620016	326822	95	5
Magura	1039	17	0	1022	918419	120414	798005	58	960	746594	171825	94	7
Meherpur	752	4	0	748	655392	83393	571999	48	644	487243	168149	85	26
Narail	968	29	0	939	721668	112352	609316	95	817	521195	200473	86	25
Satkhira	3817	48	1535	2234	1985959	197616	1788343	83	1829	1451515	534444	81	32
Khulna Division	22288	792	4422	17074	15687759	2822121	12865638	1104	14602	10873751	4814008	85	

District	Area (km2)	Water Area	Reserve Forest	Land Area	Population 2011	Urban Population 2011	Rural Population 2011	Urban Area	Area (km2) within 2km-buffer Area	Rural Population with Access	Rural Population without Access	RAI	Rank
Bogra	2899	218	4	2677	3400874	670388	2730486	185	2389	2414572	986302	88	17
Joypurhat	1012	4	0	1009	913768	143910	769858	67	881	665886	247882	86	23
Naogaon	3436	9	20	3407	2600157	275567	2324590	104	2521	1701260	898897	73	48
Natore	1900	33	7	1861	1706673	228008	1478665	111	1504	1177513	529160	80	37
Nawabganj	1703	150	0	1552	1647521	320278	1327243	99	1106	919508	728013	69	51
Pabna	2376	160	0	2216	2523179	387675	2135504	127	1917	1829529	693650	86	24
Rajshahi	2425	97	14	2314	2595197	854619	1740578	374	2092	1540946	1054251	89	15
Sirajganj	2402	291	0	2111	3097489	436577	2660912	126	1497	1837455	1260034	69	52
Rajshahi Division	18153	962	44	17147	18484858	3317022	15167836	1193.04	13906.72	12087267	6397591	80	
Dinajpur	3444	19	79	3346	2990128	453699	2536429	165	2718	2035453	954675	80	35
Gaibandha	2115	187	0	1928	2379255	210524	2168731	80	1348	1488017	891238	69	53
Kurigram	2245	245	0	2000	2069273	326494	1742779	179	1256	1031138	1038135	59	62
Lalmonirhat	1247	32	0	1215	1256099	129209	1126890	60	932	851090	405009	76	42
Nilphamari	1547	28	12	1506	1834231	289974	1544257	127	1259	1267633	566598	82	30
Panchagarh	1405	52	23	1330	987644	95149	892495	61	1013	669454	318190	75	45
Rangpur	2401	98	16	2287	2881086	442713	2438373	99	2000	2118881	762205	87	21
Thakurgaon	1782	61	5	1716	1390042	161309	1228733	101	1239	866063	523979	70	50
Rangpur Division	16184	722	135	15327	15787758	2109071	13678687	872.92	11765.93	10308135	5479623	75	
Habiganj	2637	64	116	2457	2089001	244966	1844035	92	1577	1157781	931220	63	59
Moulvibazar	2799	9	317	2473	1919062	208079	1710983	88	1873	1280060	639002	75	46
Sunamganj	3747	178	26	3543	2467968	256117	2211851	139	1617	960531	1507437	43	70
Sylhet	3452	97	107	3248	3434188	753549	2680639	157	2193	1765340	1668848	66	56
Sylhet Division	12635	347	566	11721	9910219	1462711	8447508	476	7259	5095614	4814605	60	

Source: Data source BBS and analysis under this study

In the table above, column no. 2, 3, 4, 6, 7, 8 and 9 data were collected from Bangladesh Bureau of Statistics (BBS). The column no 10 data are derived from analysis in GIS environment, where actually lies the main analysis part of this thesis report are presented in the following section. Column no. 11, 12, 13 are based on formulas as stated and column no. 14 is the ranking of RAI values. For the analysis, the road networks across the country are used from roads and highways department and local government engineering department. Then the roads are selected based on the criteria of pavement type. The road type-"paved" is considered as the all-weather/all-season passable road.

4.6 Rural Transport Accessibility Index (RAI) Value Interpretation and Presentation

4.6.1 General Interpretation

The RAI value expressed in percentage of the population of a district administrative area who are said to be accessed as per the definition stated in chapter 2, i.e. the number of population within 2km proximity area of an all-weather road to the total population of that district. Higher the RAI value indicates the more population possesses the accessibility to all-weather road. In contrast, lower the RAI value indicates the lesser population possesses the accessibility to all-weather road.

Districts having higher RAI value enabling people of that territory to have accessibility to education, health, market place/growth centres, job place, agricultural input/output and other socio-economic activities make them to avail the opportunity all the year round. As a result the people have privilege to be developed in all terms and thereby get rid out of poverty.

On the other hand, the district having lower RAI value disabling people of that territory to have lesser extent of accessibility to education, health, market place/growth centres, job place, agricultural input/output and other socio-economic activities make them onerous to avail the opportunity all the year round. As a result the people are hindered to be developed in all terms and thereby fall into poverty and poor people locked into deeper hard core poverty.

4.6.2 RAI Values – Presenting by Summaries at National Level

In this study, the land area used for estimation of RAI of an individual District administrative area was obtained by subtracting the river/water area and forest area from the total administrative area. Because this deduced land area – treated the place or area where the people are being living and can be accessed to the social and economic activities. The total land area of Bangladesh is 1,47,570 sq.km where the livable and arable land area is 1,24,422 sq.km. The latter area is used to estimate the transport accessibility in this study.

People living in rural areas should have basic access and this basic access standard must be defined in the rural transport policy for the country. In this study, it has been defined

the basic access as the reliable access available to the mechanized road within 2km of household. Reliable access means all the year round access with exception of limited periods during floods or other natural disasters.

From the RAI estimation result, the value has been summarized by National level and presented in the following Figure 4-9.

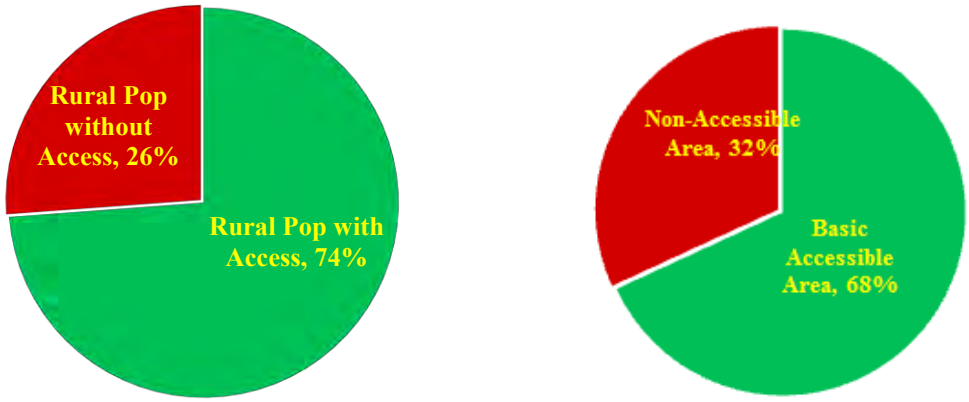


Figure 4-9: Transport Accessible and Non-Accessible Area and Population
Source: this study

From close observation of the above figure it is evident that 68% of total land area of Bangladesh is accessible by all-weather road transport network which provides reliable connectivity to 79% population of Bangladesh connected through ease of access by country wide transport network. This reliable accessibility enables people to have access to health, education, jobs, and agricultural input-output and other socio-economic activities. On the other hand, 32% land area is lack of basic access which corresponds to 21% population of the country and is out of reliable accessibility level by road transport network.

4.6.3 RAI Values – Summaries at Division Wise

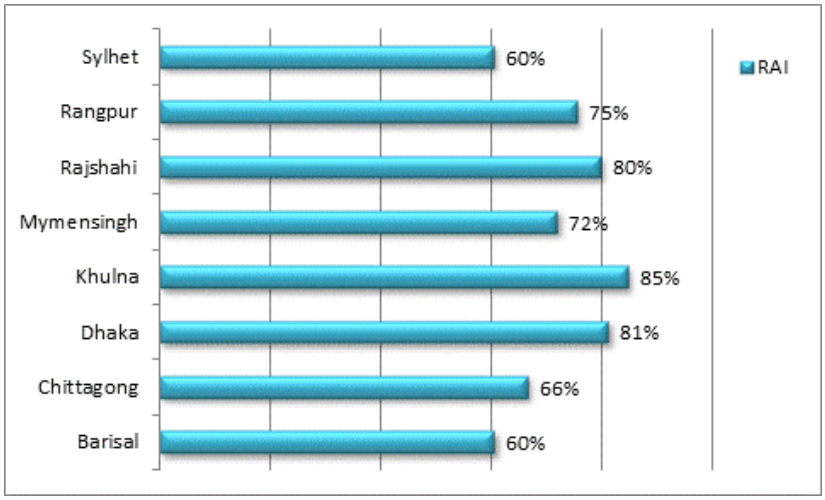
Estimated RAI results for 8 Divisions[3] of Bangladesh represent that on average **74 percent** of rural population have better access to the all-weather road transport network. The graph illustrates the lowest average transport accessibility level in Barisal, Sylhet and Chittagong Divisions, lower than the national average value which is around 60% indicating that 40% rural inhabitants are still out-off better access to all-passable road round the year. As per the geo-spatial condition, Barisal and Sylhet division has more river, canal and haor, baor, beel respectively, and Chittagong division has hilly and reserve forest area, that is why in these divisions have lesser amount of road network and thereby lesser transport accessibility. The graph also illustrates that the higher average transport accessibility level is in Khulna, Dhaka and Rajshahi divisions which is around 85%, indicating that still 15% rural inhabitants are out-off better access to all-passable road round the year.

[3] Dhaka, Chittagong, Rajshahi, Khulna, Sylhet, Barisal, Rangpur, Mymensingh.

Among the eight Divisions of Bangladesh, Sylhet Divisions has the lowest level of transport accessibility value of 60.32 percent, indicates that around 60 percent population in this division are accessible by all-weather road network and 40 percent people are still out of reach by road transport network. From geo-spatial array it can be found that the four districts of this division have a lot of haors, baors and beels. In addition to that, there are reserve forest areas in this division. Out of total 12,635.24 km^2 area of this division water (haor/baor/beel/river) and forest areas are 347.72 km^2 and 566.37 km^2 respectively. In this backdrop, the length of all-weather road is merely 0.22 km/km^2 and 0.28 km/thousand population, therefore the division has lowest average accessibility level.

Table 4-5: RAI Aggregate Values in Eight-Divisions

Division	RAI	Rank
Barisal	60	7
Chittagong	66	6
Dhaka	81	2
Khulna	85	1
Mymensingh	72	5
Rajshahi	80	3
Rangpur	75	4
Sylhet	60	8



Source: this study

In the above table and bar diagram, it can also be seen that the Khulna division has highest level of accessibility value of 84.52 percent, indicates that about 84.5 percent people are accessible by the all-weather road network all the year round and 15.5 percent people are out of reach by road transport network. From statistics it can be found that out of ten districts in this division, three districts namely Bagerhat, Khulna and Satkhira districts have mangrove forest areas of total 4422.58 km^2 (858.49, 2028.22 and 1534.88 km^2 respectively). However, the remaining districts (Chuadanga, Jessore, Jhenaidah, Kushtia, Magura, Meherpur and Narail) geo-spatial tract reveal that these districts land area are fairly level grounds without any reserve forest area and insignificant area of water/river areas. Due to this attributes, it might be the underlying reason to have more road network in this districts that eventually leads to possess better accessibility to road transport accessibility.

4.6.4 Rural Transport Accessibility Index – Map

In Figure 4-10, the map shows the rural transport accessibility index of each District of Bangladesh; the higher the RAI value indicates the better accessibility and lowers the values indicates low accessibility level. In the map color contrast signifies the accessibility level, darker the color signifies higher accessibility level and lighter the

color signifies lower accessibility level. This accessibility mapping was drawn with the intension that it can be easily understandable even for the

Figure 4-10: Bangladesh Rural Accessibility Index (RAI) Mapping

Source: map prepared under this study

In the map above, it is also predominant that some Districts have lower transport accessibility level hindering the people to be connected to the socio-economic services and activities, as a result trapping them into the poverty.

4.7 Comparative Relation between RAI and Poverty

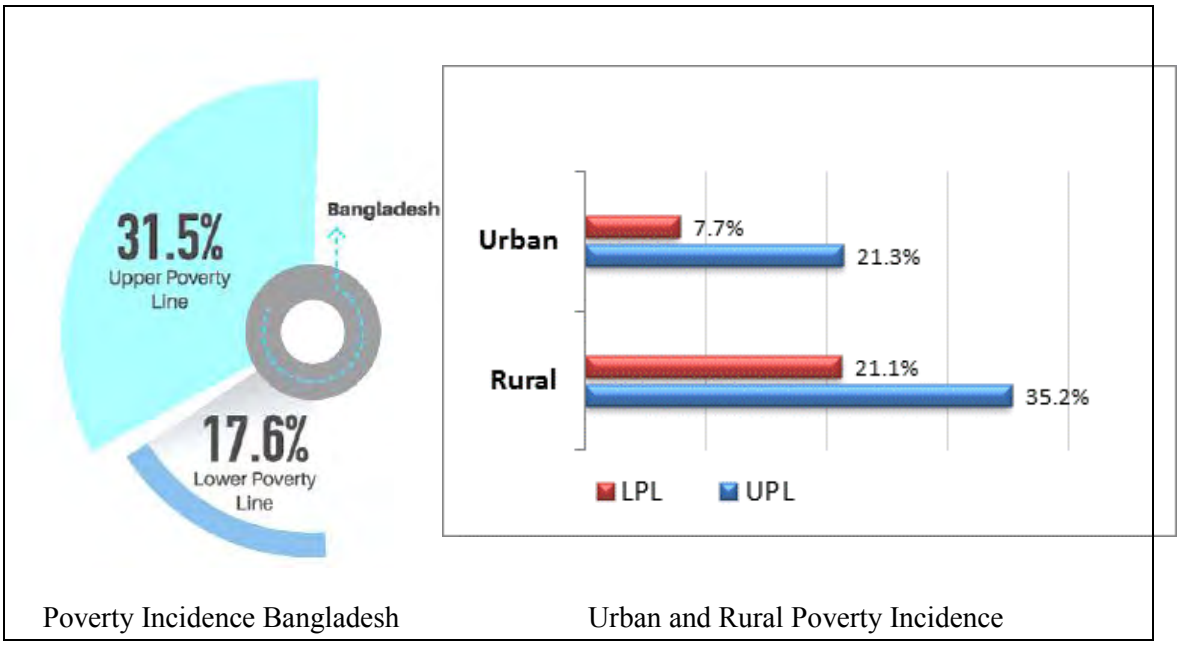
Poverty in Bangladesh are characterized by regional variations, factors such as level of access to education, health facilities, employment opportunities, social amenities/utilities and other physical & social infrastructure provide possible explanations for this. Peoples in rural areas are out of easy accessibility as a result are deprived from the all kinds of economic and social activities and are trapped into poverty. In this section, it has been tried to represent the level of accessibility in each District and its poverty situation.

In this report, Head Count Ratio (HCR) is used which provides the estimation of percentage of people living below the poverty line as a share of total population. The two poverty lines are Lower Poverty Line (LPL) and Upper Poverty Lines (UPL) are used here to do the comparative analysis with the transport accessibility level.

Table 4-6: Poverty Level in Bangladesh (HIES 2010)

HIES 2010	Upper Poverty Line (UPL)	Lower Poverty Line (LPL)
National	31.5%	17.6%
Rural	35.2%	21.1%
Urban	21.3%	7.7%

Source: Key Findings of the Household Income and Expenditure Survey 2010, BBS



Poverty Incidence Bangladesh Urban and Rural Poverty Incidence

Source: Key Findings of the Household Income and Expenditure Survey 2010, BBS

In the following table, it is juxtaposed the estimated rural transport accessibility index (RAI) in percent to the poverty incidence in terms of Upper Poverty Line (UPL) and Lower Poverty Line (LPL) of each 64-Districts of Bangladesh. It is also summarized the value by Division wise (there are 8-Divisions in Bangladesh).

Table 4-7: Rural Transport Access and Poverty Incidence (UPL and LPL)

District	Rural Transport Access Index (RAI) in %	Lower Poverty Line (LPL) in % of HCR	Upper Poverty Line (UPL) in % of HCR
Barisal Division	**60**	**36.2**	**23.7**
Barguna	66	9.8	19.0
Barisal	62	39.9	54.8
Bhola	52	20.4	33.2
Jhalokati	88	26.7	40.5
Patuakhali	44	14.7	25.8
Pirojpur	87	30.9	44.1
Chittagong Division	**66**	**28.7**	**14.7**
Bandarban	65	21.6	40.1
Brahmanbaria	74	15.0	30.0
Chandpur	97	30.3	51.0
Chittagong	84	4.0	11.5
Comilla	92	21.1	37.9
Coxs Bazar	89	16.2	32.7
Feni	91	14.6	25.9
Khagrachhari	49	10.1	25.5
Lakshmipur	63	18.1	31.2
Noakhali	58	3.4	9.6
Rangamati	12	6.8	20.3
Dhaka Division	**81**	**30.8**	**16.8**
Dhaka	82	4.9	15.7
Faridpur	87	19.8	36.3
Gazipur	98	8.2	19.4
Gopalganj	92	26.8	42.7
Kishoreganj	52	16.4	30.3
Madaripur	88	17.4	34.9
Manikganj	78	8.0	18.5
Munshiganj	78	15.6	28.7
Narayanganj	85	10.4	26.1
Narsingdi	92	12.1	23.7
Rajbari	95	25.7	41.9
Shariatpur	76	34.4	52.6
Tangail	81	18.0	29.7
Mymensingh Division	**72**	**46.3**	**28.9**
Mymensingh	75	32.3	50.5
Sherpur	88	29.8	48.4
Jamalpur	77	34.2	51.1

District	Rural Transport Access Index (RAI) in %	Lower Poverty Line (LPL) in % of HCR	Upper Poverty Line (UPL) in % of HCR
Netrakona	55	19.5	35.3
Khulna Division	**85**	**30.3**	**15.4**
Bagerhat	59	24	42.8
Chuadanga	89	10.8	27.7
Jessore	91	18.4	39.0
Jhenaidah	95	10.0	24.7
Khulna	94	21.2	38.8
Kushtia	95	0.8	3.6
Magura	94	25.9	45.4
Meherpur	85	5.1	15.2
Narail	86	7.7	20.0
Satkhira	81	29.7	46.3
Rajshahi Division	**80**	**27.8**	**14.5**
Bogra	88	6.7	16.6
Joypurhat	86	12.9	26.7
Naogaon	73	7.0	16.9
Natore	80	21.3	35.1
Nawabganj	69	12.1	25.3
Pabna	86	16.7	31.5
Rajshahi	89	16.5	31.4
Sirajganj	69	22.7	38.7
Rangpur Division	**75**	**39.9**	**23.5**
Dinajpur	80	21.3	37.9
Gaibandha	69	30.3	48.0
Kurigram	59	44.3	63.7
Lalmonirhat	76	16.7	34.5
Nilphamari	82	18.8	34.8
Panchagarh	75	12.3	26.7
Rangpur	87	30.1	46.2
Thakurgaon	70	13.8	27.0
Sylhet Division	**60.32**	**25.28**	**20.33**
Habiganj	63	20.1	25.3
Moulvibazar	75	21.1	25.7
Sunamganj	43	20.6	26.0
Sylhet	66	19.5	24.1

Source: this study and Household Income and Expenditure Survey (HIES) 2010, BBS

4.7.1 Rural Transport Accessibility Level with Upper Poverty Line (UPL)

In this section, it is presented the comparative analysis between the rural transport accessibility with the upper poverty line. The upper poverty line is estimated by adding together the food and nonfood poverty lines. The moderate poor households are those households whose total expenditures are equal to or less than the upper poverty line. The average national UPL is 31.5% where in rural area this is 35.2% and in urban area the value is 21.3%. It indicates in national average 31.5 percent population is poor, where the values in rural and urban area are 35.2 and 21.3 and others are non-poor.

In the following Table 4-8 and Charts in Figure 4-11 are illustrating the information and significant relationship between rural transport accessibility level and poverty level of those respective areas. The Head Count Ratio (HCR) is used here to understand the poverty level as Upper Poverty Level (UPL) and Lower or Hardcore Poverty Level (LPL). In the graph, it illustrating that higher the transport accessibility level in an area - lower the poverty level in that area.

Table 4-8: RAI Values Compared with Poverty Incidence (UPL)

Division Name	Rural Transport Index (RAI)	Poverty Level HCR (UPL)
Barisal	60	36
Chittagong	66	29
Dhaka	81	31
Khulna	85	30
Mymensingh	72	46
Rajshahi	80	28
Rangpur	75	40
Sylhet	60	25

Source: this study and BBS

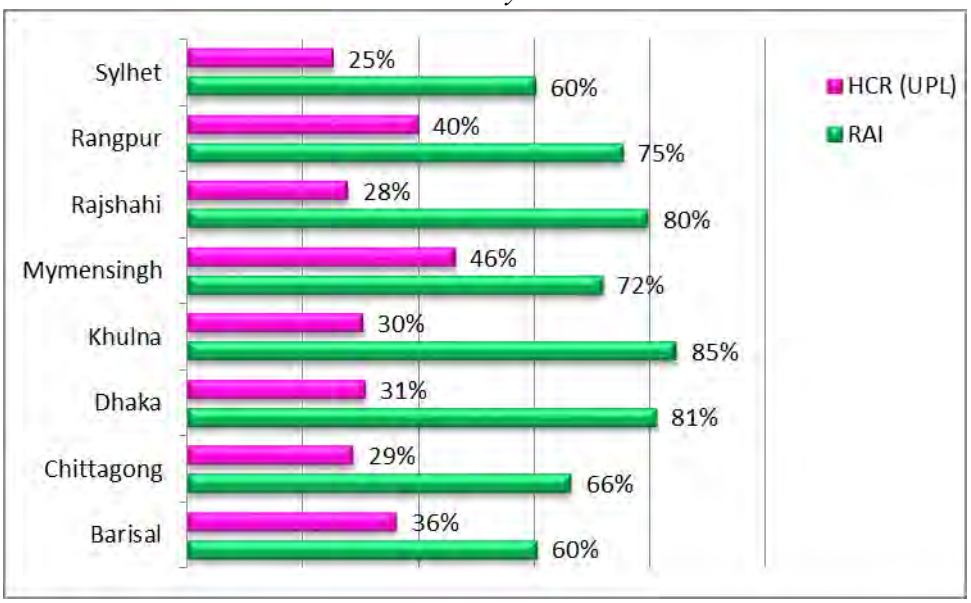


Figure 4-11: Comparison of RAI with Poverty Incidence (UPL) in Eight-Divisions

Source: prepared under this study

From the above observation and illustration, it can be conferred that people of the area who possess higher mobility through higher level of road transport accessibility, enabling people to have access to education and health care facilities, jobs/employment opportunity, socio-economic activities, to get modern agricultural inputs and so on, are less poor. In contrast, the people of the area who possess lower mobility through low level of road transport accessibility, prohibiting people to have access to education and health care facilities, jobs/employment opportunity, socio-economic activities, to get modern agricultural inputs and so on, are poor.

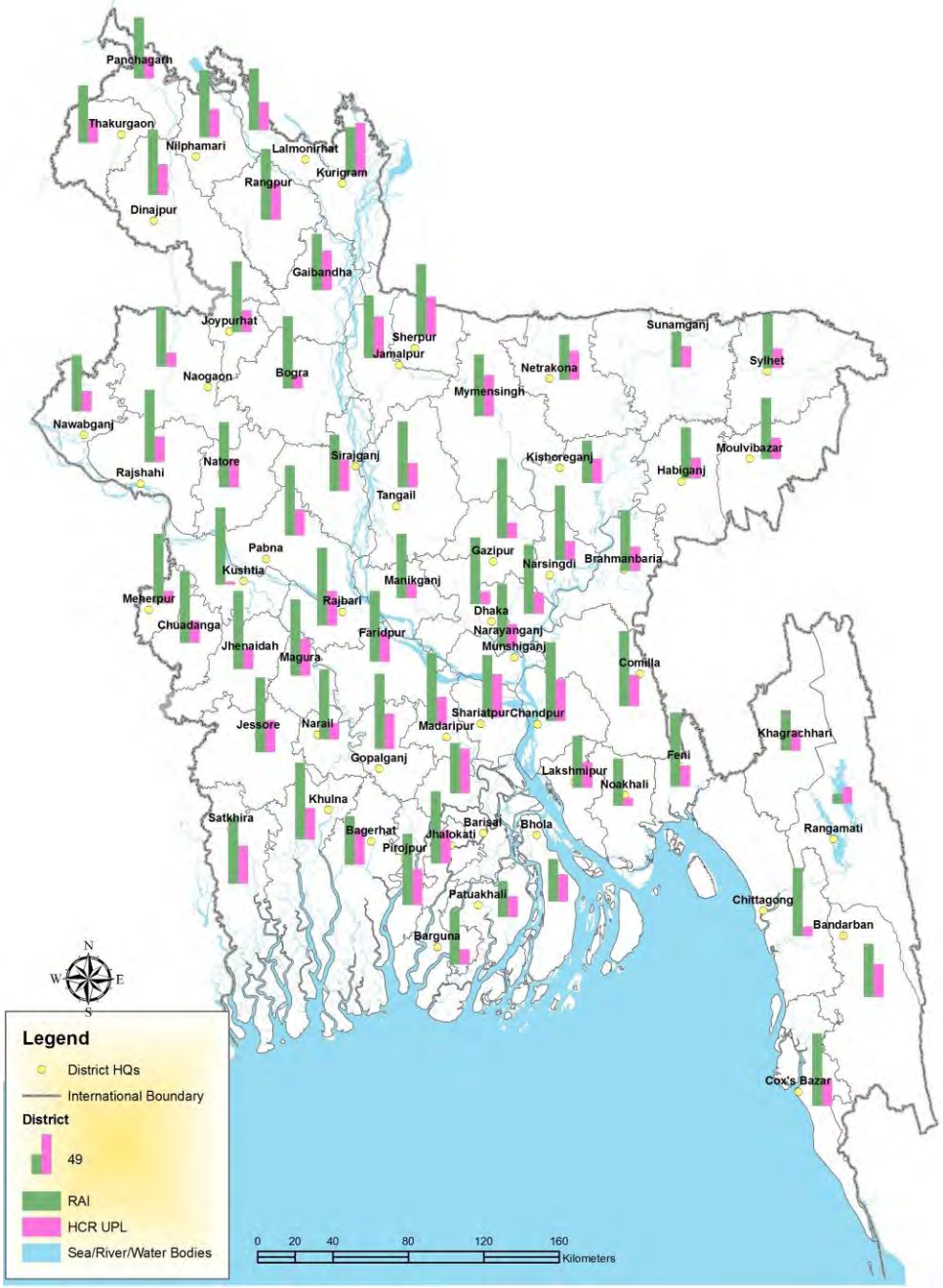


Figure 4-12: RAI with Poverty Incidence (UPL) – District wise
Source: map prepared under this study

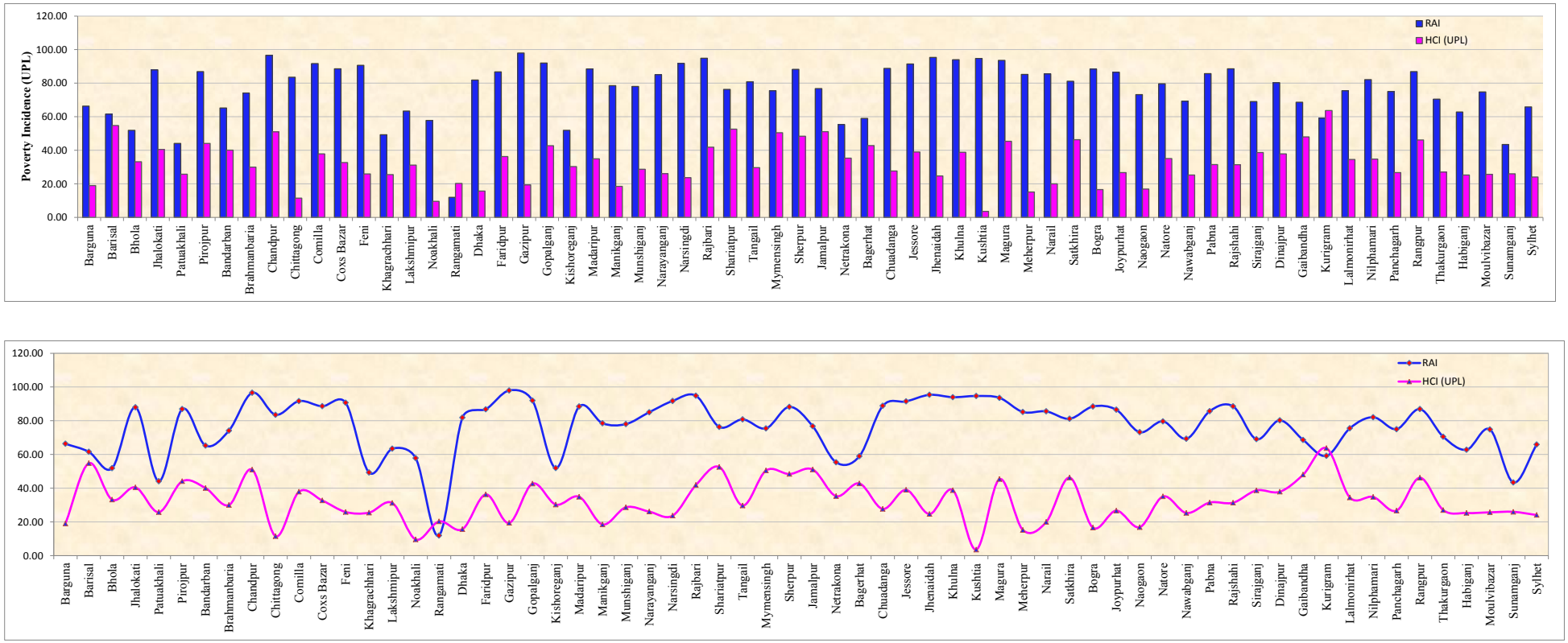


Figure 4-13: RAI with the Corresponding Poverty Incidence [Upper Poverty Line (UPL)] in District wise

Source: this study

4.7.2 Rural Transport Accessibility Level with Lower Poverty Line (LPL)

In this section, it is presented the comparative analysis between the rural transport accessibility with the Lower Poverty Line (LPL). The extreme poor households are those households whose total expenditures on food and nonfood combined are equal to or less than the food poverty line. The average national LPL is 17.6% where in rural area this is 21.1% and in urban area the value is 7.7%. It indicates in national average 17.6 percent population is poor, where the values in rural and urban area are 21.1 and 7.7 and others are non-poor.

The following table and charts are illustrating the information and significant relationship between rural transport accessibility level and poverty level of those respective areas. The Head Count Ratio (HCR) is used here to understand the poverty level as Lower Poverty Level (LPL). In the graph, it illustrating that higher the transport accessibility level-lower the poverty level.

Table 4-9: RAI with Poverty Incidence (LPL) in Eight-Divisions

Division Name	RAI	HCR (LPL)
Barisal	60	24
Chittagong	66	15
Dhaka	81	17
Khulna	85	15
Mymensingh	72	29
Rajshahi	80	14
Rangpur	75	23
Sylhet	60	20

Source: this study

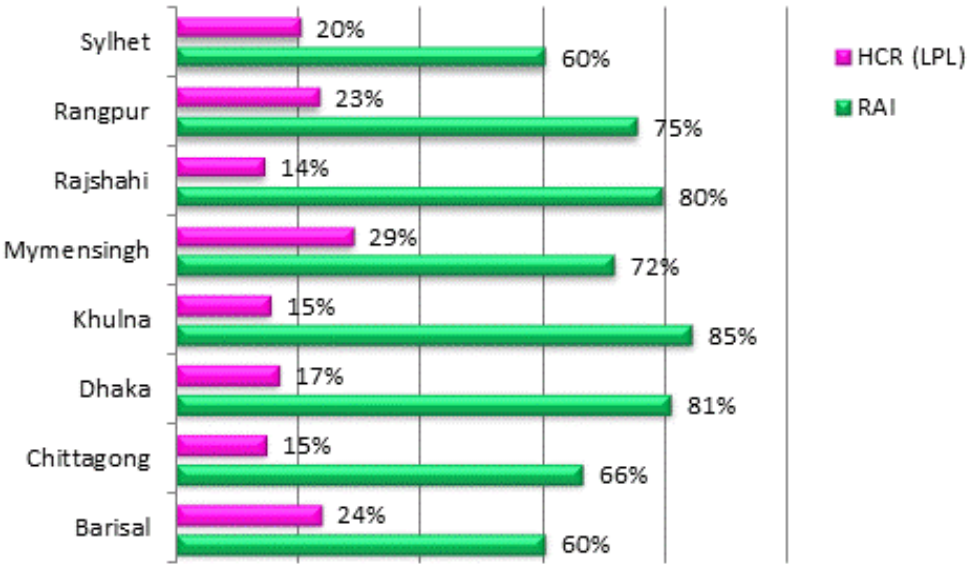


Figure 4-14: Comparison of RAI with Poverty Incidence (LPL) in Eight-Divisions

Source: this study

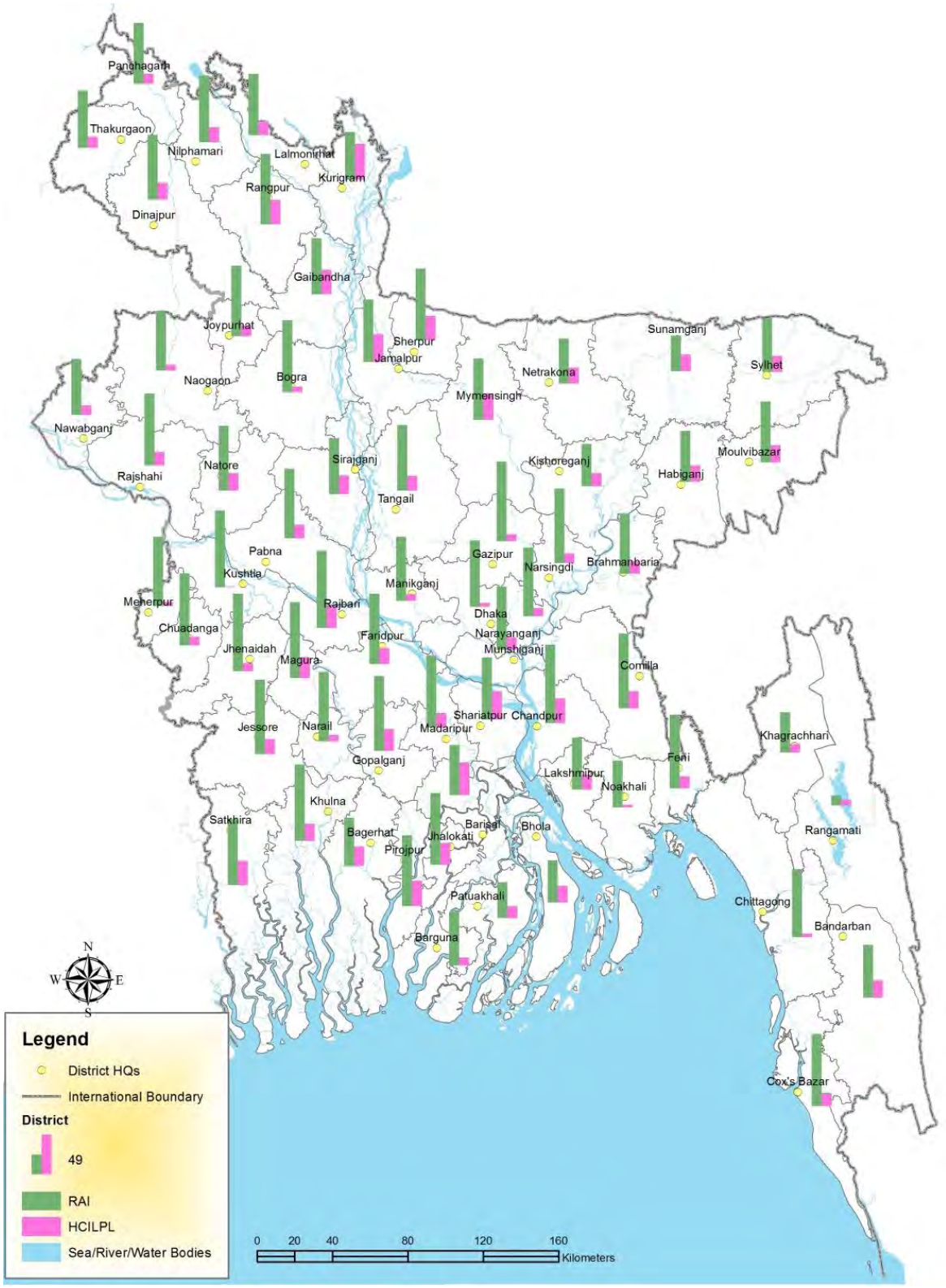


Figure 4-15: RAI Values with Poverty Incidence (LPL) – District wise

Source: map prepared under this study

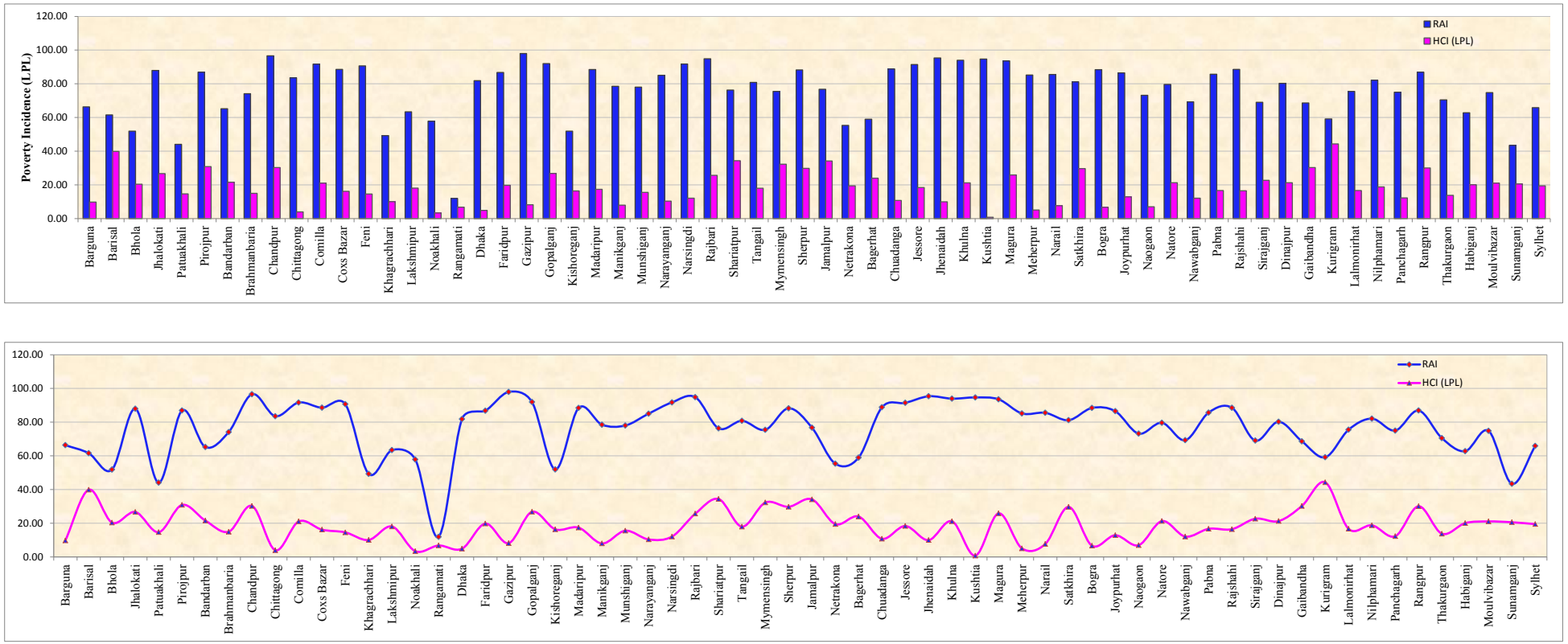


Figure 4-16: RAI with the Corresponding Poverty Incidence [Lower Poverty Line (LPL)] in District wise.

Source: this study and BBS

4.7.3 RAI and Poverty – Observed Association

It is evident from close observations that there is considerable inequality in the level of access amongst the different Districts and a large portion of rural people are excluded from the opportunity of access to education, health, jobs, agriculture inputs, and socio-economic activities. Less accessible people are poorer than the people who have relatively more access to the transport system. Head Count Ratio (HCR), one of the measures of the poverty incidence, shown against the RAI in section 4.7.1 and 4.7.2. From Figure 4-13 and Figure 4-16 it has observed that there is inverse relationship with RAI with poverty (HCR), i.e. where RAI possess low value due to poor access that leads people to high incidence of poverty and where RAI possess higher value due to increased access to transport system that leads people to low poverty incidence i.e. people are better privileged to access to health, education, jobs, agricultural inputs and socio-economic activities than those of low access.

The rural transport accessibility level of 64-Districts of Bangladesh and its corresponding poverty level in terms of upper and lower poverty lines are illustrating through map and graphs to find out the association, if any, between rural transport accessibility level and poverty. The maps (in Figure 4-12 and Figure 4-15) and the bar chart and line diagram (in Figure 4-13 and Figure 4-16) illustrating the rural transport accessibility level and poverty incidence of the corresponding District jurisdictional area.

The general association between Rural Transport Accessibility and Poverty Incidence which is evident from the map and graphs is that the areas which possess higher mobility through higher road transport accessibility are in low poverty incidence and in contrast, the areas which possess lesser mobility through lower road transport accessibility are in high poverty incidence.

From the close observation, it can be found that there are some areas which exhibit the disregard of the general association as described in the above section. For instance, some District areas possess higher level of transport accessibility but also have high poverty incidence (here it is referred to as ~~–~~**Scenario-1**"-will be investigate in the latter section), e.g. Jhalokathi, Chandpur, Shariatpur, Rangpur. On the other hand, there are some areas possess lower level of accessibility and poverty incidence is also low (here it is referred to as ~~–~~**Scenerio-2**"- will be investigate latter section), e.g. Patuakhali, Rangamati, Noakhali and Sunamganj. In these exceptional scenarios, it needs to undergo micro analysis within 2-km (as 2-km buffer area from an all-weather road has been taken to estimate the rural transport accessibility), where it may actually hide the macro problem.

Scenario-1: Transport Accessibility High and Poverty Incidence Also High

There are some areas as shown in Table 4-10, where the estimated value of transport accessibility is higher level, but at the same time the poverty incidence is also high, which should not be the case according to the general association as has been observed from the previous sections. Through micro analysis within the 2-km area of either side of the all-

weather road, it can be explored the problem behind this. As mentioned earlier, Jhalokathi, Chandpur, Shariatpur, Rangpur

Table 4-10: Districts Having RAI High and Poverty also High

District	RAI (%)	HCR (LPL)	HCR (UPL)
Chandpur	97	30	51
Jhalokathi	88	27	41
Shariatpur	76	34	53
Rangpur	87	30	46

Source: this study

District resembles this scenario. As in the case of Chandpur, Jhalakothai and Shariatpur Districts, most of the roads are alongside the canal or low lying area. In the estimation of accessibility index it is presumably assumed that people within 2km distance of either side of the all-weather road have well accessed, but in this District the geo-spatial position of road is not providing the desired level of accessibility. There might have other socio-economic constraints that prohibit people to become entangle with the activities, which will be look into the following section.

From the topographic array in this area it is found that due to widespread canal across the area though the accessibility is high but people can avail the less opportunity to get access to the socio-economic activities, in particular the agricultural input. Another fact is that most of the roads following on one side of the canal, therefore in the estimation of accessibility within 2km buffer area it might have canal which can‘t be accounted due to data limitation. As a result the estimated value of RAI might not represent the actual accessibility level of this district. Because of these facts, as most of the population dependent on agricultural production, they are able to get the modern agricultural inputs and thereby less production, so the poverty rate is high.

In case of Rangpur and Kurigram Districts, are vulnerable to frequent natural disasters. People face catastrophe like cyclones during summer, floods and river-bank erosion in the rainy season, drought in summer, spring and cold wave in winter Moreover, this areas are lacking any significant industrial development, where agriculture is the mainstay of source of employment, which is affected due to natural disaster and weather disfavoring.

Scenario-2: Transport Accessibility Low and Poverty Incidence Also Low

There are some other areas where the estimated value of transport accessibility is lower level but the poverty level of that areas are also low, which should not be the case according to the general association as has been observed from the previous section. In the table below, there are exceptions, like Patuakhali, Khagrachhari, Rangmati, Noakhali and Sunamganj district, where the accessibility level is low but poverty is also low. These exceptions need to closer look into through micro analysis within these areas that may actually reveal the fact that people possess the privileges or opportunity to be accessed to the socio-economic activities and exploit the reap to be well-off.

These Districts are needed to be more emphasized to construct new road infrastructure to increase the rural transport accessibility enabling people to have access to social and economic activities to get rid out of poverty.

Table 4-11: District with Low Transport Accessibility (<60%) and Corresponding Poverty Incidence

District	RAI (%)	HCR (LPL)	HCR (UPL)
Patuakhali	44	15	26
Khagrachhari	49	10	26
Noakhali	58	3	10
Rangamati	12	7	20
Sunamganj	43	21	26

Source: this study

In this section, it is trying to analyze in micro level under the purview of topographic, demographic social and economic statistics to investigate the scenario (here it is under ~~–S~~cenario-2" as stated). The administrative area of Patuakhali district is 3685.87 km2, out of which water and reserve forest areas are 493 km2 and 337.13 km2 respectively, makes the land area 2855.74km2. Within this substantial large area, the all-weather road length is only 350.9km, by which 5,88,217 rural people are having access to all-weather road round the year out of 13,33,972 rural population in this district and the remaining 7,45,755 rural people are out of ease access to all-weather road (refer to Figure 4-17) .

Therefore, from the literature review (Chapter-2) and general phenomenon of data analysis (previous section in this chapter) shows that people having less access are poor, but in this area poverty is low. The underlying reasons behind this might be that people are having access through waterway transport, since in this district there are many rivers and canals and on top of that this district is in coastal belt area. From economic aspect, it is found that besides the fresh water fishing, marine fishing is one of the important source of household income of people of this area. District economy also is dependent on agro-based where 65% household having farming. In bottom line it can be propounded that on top of this road transport accessibility, waterway transport plays a key role in this district contributing less poverty incidence.

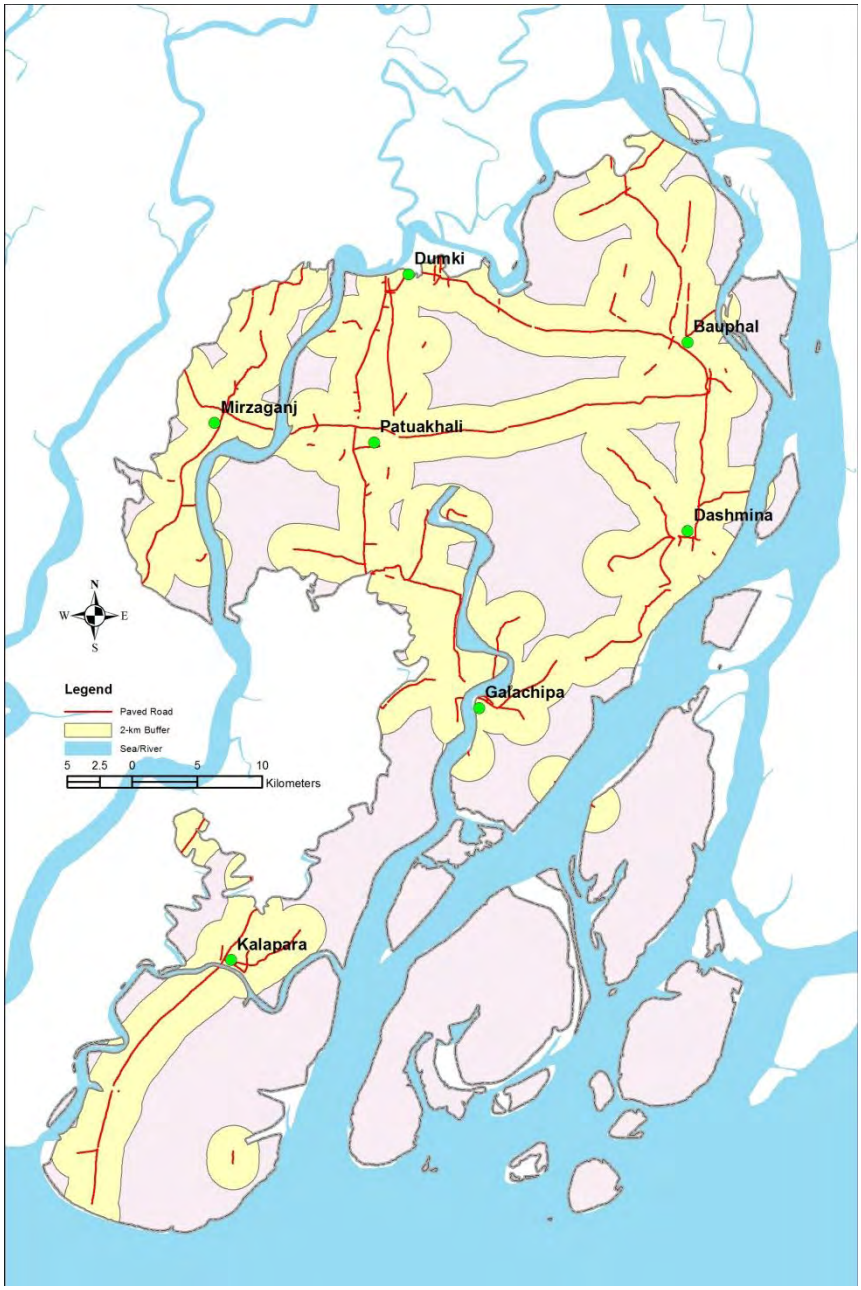


Figure 4-17: Patuakhali Road Transport Accessibility Area
Source: map prepared under this study

In Sunamganj District – there is insignificant road connectivity within the district administrative area and some isolated areas are not interconnected with the national connectivity road network as can be found in the following figure. As a result estimated road transport access index is very low.

From the topographical statistics, the districts total area is 3747.18 km2 out of which 178km2 is riverine area and 26.2km2 is reserve forest area. Besides that the district is full of haors and baors, in these big land depression water remains stands for around 8-months of the year and becomes dry at winter and a few of them water remains stand throughout the year. Renowned and big Tanguar Haor is in this district. Therefore people of this district are broadly accessed by waterway transport.

Being these geo-spatial characteristics, 53.39% holdings are engaged in agricultural farming activities, besides crops livestock and fishery are main sources of household income. A large variety of fresh water fish species are available in this district that plays an important role in the economy of the area in particular of the haor area. From this micro analysis, it is found that even if the area has low road transport accessibility but due other waterway blessings they are more accessed to socio-economic activities and as a result poverty incidence is low.

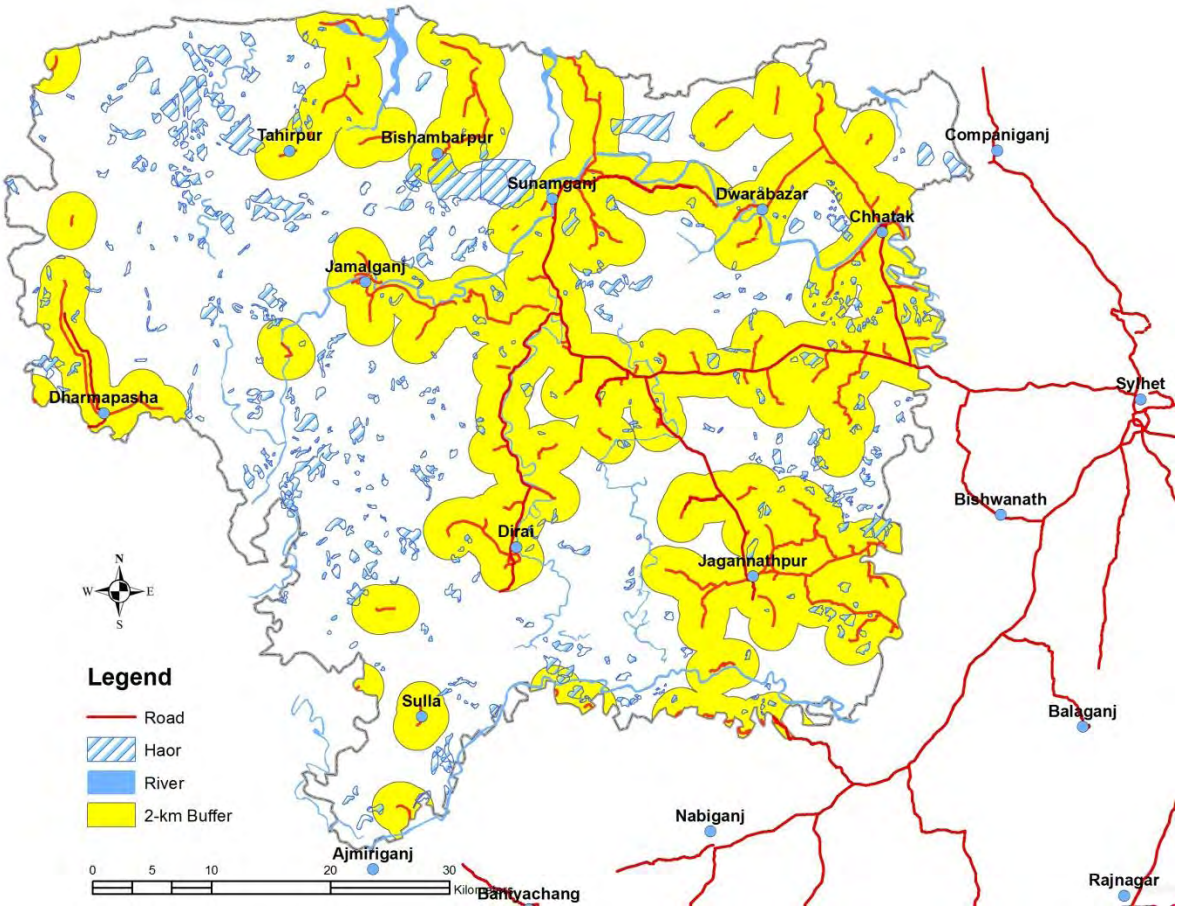


Figure 4-18: Sunamganj Road Transport Accessibility Area

Source: map prepared under this study

Rangamati, a district of different characteristics in terms of its geo-spatial location, land scape, demographics and socio-economies, exhibits a different phenomenon where poverty rate is lower than the national average value without having substantial transport accessibility, where about 12 percent people are said to be accessible to the formal road as estimated under this thesis study. The district has an administrative area of 6,116.19 sq. km., out of which reserve forest area is 2,234.06 sq. km., lake/water area is 294.61 sq. km. and the population is 5,95,979 out of which the rural population is 4,36,352 as per 2011-census. The majority of the population are tribal (ethnic minorities) population composed of 14 ethnic groups, like Chakma, Marma, Tanchanga, Tripura, Murong, Bowm, Khumi, Khiyang, Chak, Pankua, Lusai, Sujesaotal, Rakhain and Bangali. These indigenous people by nature are hardworking and both the male and female members are earning members of a family.

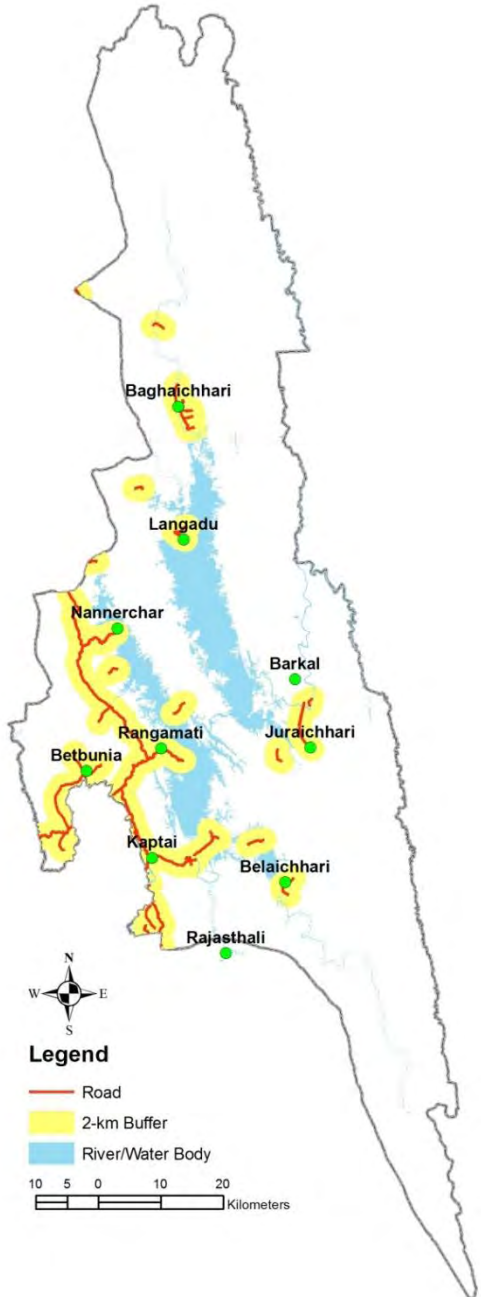


Figure 4-19: Rangamati Road Transport Accessibility Area
Source: this study

The economy of Rangamati is largely dependent on agriculture, hand loom cottage industries, fishery and forestry. Out of total 108,263 holdings of the district, 74.10% holdings are farms that produce varieties of crops. Besides crops, livestock, forestry and fishery are the main sources of household income. The district is very rich in forest resources also. This agricultural product, fisheries and forestry resources are transported by waterway to the District Headquarters or other parts of the country to sell and thereby earns a lot. This is the behind history of the District having lower poverty rate, even if the peoples in this area having lower level of road transport accessibility.

In this study, the rural transport accessibility has been estimated based on the proximity of the all-weather road; however, in case of Rangamati District where the coverage of all-weather road network is only 202.03 km. But it might be the reason that people have access by waterways and local informal roads which are accessible all the year round due to hilly area and the ground elevation of land is average 14 m from the mean sea level (MSL). The inhabitants in this hilly area by nature are hard worker and can have access to the social, commercial and financial activities either by the road, or by waterway or by informal roads (local walkways in or around the hill). As it can be seen from the map, some thanas/upazilas like Juraichhari, Barkal, Langadu and Baghaichhari are isolated from the mainland which is only accessible through waterway transport. Khagrachhari district resembles the same scenario of this district.

On the other hand, the road transport accessibility index in Noakhali district is lower than the national average level, with RAI value of 57.81%, means that around 58 percent people of the district have access to all-weather road and 42 percent people are out of reach to the all-weather road as per the definition of stated in Chapter-2. As a

consequence to this phenomenon, the district should have high poverty incidence, but in reality the poverty incidence is very low in Noakhali district. There are might be some other underlying reasons for which it is not complying the general phenomenon.

Figure 4-20:Noakhali District Road Transport Accessibility Area
Source: map prepared under this study

From micro analysis of the district‘s economic purview, it is found that agriculture plays a vital role where 30% of the regional GDP comes from agriculture with 45% of the population employed in this sector. As a coastal belt area, employment in fish sector is also dominant for the extreme poor and poor labour-intensive and about 15 to 20 percent labour has involved round the year in this sector (boat roaring, fishing, drying, net and boat making and repairing, transporting fish from one location to other etc.). **The important salient factor is that about 40% of population live in the abroad for their job**. And they play a vital role in the district economy and thereby poverty incidence is low.

4.8 Comparative Relation of Rural Transport Access Index (RAI) with the Socio-Economic Parameters

In this research study, comparative relational study was done to find out the association with Rural Access Index to the socio-economic parameters. In order to compute the socio-economic parameters, several demographic, social and economic dimensions and facilities were used. The demographic dimensions used are population, administrative unit area; the social dimensions used are poverty, literacy rate, educational facilities, health facilities; the economic dimensions used are growth centres, hat/bazars, industries, agro/live-stock farms, small and cottage industries.

4.8.1 RAI with Poverty and Literacy Rate

In this section it is tried to find out the relational association of rural transport accessibility index with poverty and literacy rate of each district of Bangladesh. In the table below, population data used from 2011 census statistics, poverty data used here as the percentage of population below the upper poverty line and the literacy data from districts statistics.

Comparative analyses were done for density of poor population under the upper poverty line per unit area (in this case per square kilometer) of each district expressed in percent and the literacy rate per thousand population of each district expressed in percent with the RAI.

Table 4-12: District Population, Poverty and Literacy Rate

		Population			Poverty			Literacy		RAI
District	Area	Land Area (sq. km)	Population-2011 ('000)	Population Density (Pop '000/sq.km)	Population below poverty line (%)	Population below poverty line ('000)	Density of Poor ('000/sq.km)	Literacy Rate-2011 (%)	Literacy Rate (%/'000)	
Barguna	1831	1334	893	0.67	19	170	0.1	58	6.5	66
Barisal	2785	2624	2324	0.89	55	1274	0.5	61	2.6	62
Bhola	3403	2105	1777	0.84	33	590	0.3	43	2.4	52
Jhalokati	707	674	683	1.01	41	276	0.4	67	9.8	88
Patuakhali	3221	2486	1536	0.62	26	396	0.2	54	3.5	44
Pirojpur	1278	1163	1113	0.96	44	491	0.4	65	5.8	87
Bandarban	4479	1745	388	0.22	40	156	0.1	32	8.2	65
Brahmanbaria	1881	1779	2840	1.60	30	852	0.5	45	1.6	74
Chandpur	1645	1438	2416	1.68	51	1232	0.9	**56**	2.3	97
Chittagong	5283	3621	7616	2.10	12	876	0.2	59	0.8	84
Comilla	3146	3058	5387	1.76	38	2042	0.7	53	1.0	92
Coxs Bazar	2492	1733	2290	1.32	33	749	0.4	39	1.7	89
Feni	990	931	1437	1.54	26	372	0.4	60	4.1	91
Khagrachhari	2749	2057	614	0.30	26	157	0.1	46	7.5	49
Lakshmipur	1440	1352	1729	1.28	31	540	0.4	49	2.9	63
Noakhali	3686	2856	3108	1.09	10	298	0.1	51	1.7	58
Rangamati	6116	3588	596	0.17	20	121	0.0	50	8.3	12
Dhaka	1464	1399	12044	8.61	16	1891	1.4	71	0.6	82
Faridpur	2053	1956	1913	0.98	36	694	0.4	49	2.6	87

District	Area	Population			Poverty			Literacy		RAI
		Land Area (sq. km)	Population-2011 ('000)	Population Density (Pop '000/sq.km)	Population below poverty line (%)	Population below poverty line ('000)	Density of Poor ('000/sq.km)	Literacy Rate-2011 (%)	Literacy Rate (%/'000)	
Gazipur	1806	1515	3404	2.25	19	660	0.4	63	1.8	98
Gopalganj	1469	1438	1172	0.82	43	501	0.3	58	5.0	92
Kishoreganj	2689	2568	2912	1.13	30	882	0.3	41	1.4	52
Madaripur	1126	1018	1166	1.15	35	407	0.4	48	4.1	88
Manikganj	1384	1151	1393	1.21	19	258	0.2	49	3.5	78
Munshiganj	1004	911	1446	1.59	29	415	0.5	56	3.9	78
Narayanganj	684	573	2948	5.15	26	769	1.3	57	1.9	85
Narsingdi	1141	1063	2225	2.09	24	527	0.5	50	2.2	92
Rajbari	1092	1019	1050	1.03	42	440	0.4	52	5.0	95
Shariatpur	1174	1041	1156	1.11	53	608	0.6	47	4.1	76
Tangail	3414	2811	3605	1.28	30	1071	0.4	47	1.3	81
Mymensingh	4395	4141	5110	1.23	51	2581	0.6	44	0.9	75
Sherpur	1365	1306	1358	1.04	48	657	0.5	38	2.8	88
Jamalpur	2115	1947	2293	1.18	51	1172	0.6	38	1.7	77
Netrakona	2794	2753	2230	0.81	35	787	0.3	39	1.8	55
Bagerhat	3959	3029	1476	0.49	43	632	0.2	59	4.0	59
Chuadanga	1184	1146	1129	0.99	28	313	0.3	46	4.1	89
Jessore	2607	2584	2765	1.07	39	1078	0.4	57	2.0	91
Jhenaidah	1965	1931	1771	0.92	25	438	0.2	48	2.7	95
Khulna	4389	2000	2319	1.16	39	900	0.4	60	2.6	94
Kushtia	1609	1442	1947	1.35	4	70	0.0	46	2.4	95
Magura	1039	1022	918	0.90	45	417	0.4	51	5.5	94
Meherpur	752	748	655	0.88	15	100	0.1	46	7.1	85
Narail	968	939	722	0.77	20	144	0.2	61	8.5	86
Satkhira	3817	2234	1986	0.89	46	919	0.4	52	2.6	81
Bogra	2899	2677	3401	1.27	17	565	0.2	49	1.5	88
Joypurhat	1012	1009	914	0.91	27	244	0.2	58	6.3	86
Naogaon	3436	3407	2600	0.76	17	439	0.1	48	1.9	73
Natore	1900	1861	1707	0.92	35	599	0.3	50	2.9	80
Nawabganj	1703	1552	1648	1.06	25	417	0.3	43	2.6	69
Pabna	2376	2216	2523	1.14	32	795	0.4	47	1.9	86
Rajshahi	2425	2314	2595	1.12	31	815	0.4	53	2.0	89
Sirajganj	2402	2111	3097	1.47	39	1199	0.6	42	1.4	69
Dinajpur	3444	3346	2990	0.89	38	1133	0.3	52	1.8	80
Gaibandha	2115	1928	2379	1.23	48	1142	0.6	43	1.8	69
Kurigram	2245	2000	2069	1.03	64	1318	0.7	43	2.1	59
Lalmonirhat	1247	1215	1256	1.03	35	433	0.4	46	3.7	76
Nilphamari	1547	1506	1834	1.22	35	638	0.4	44	2.4	82
Panchagarh	1405	1330	988	0.74	27	264	0.2	52	5.2	75
Rangpur	2401	2287	2881	1.26	46	1331	0.6	49	1.7	87
Thakurgaon	1782	1716	1390	0.81	27	375	0.2	49	3.5	70
Habiganj	2637	2457	2089	0.85	25	529	0.2	41	1.9	63
Moulvibazar	2799	2473	1919	0.78	26	493	0.2	51	2.7	75
Sunamganj	3747	3543	2468	0.70	26	642	0.2	35	1.4	43
Sylhet	3452	3248	3434	1.06	24	828	0.3	51	1.5	66

Source: this study and BBS

In Figure 4-21, the line diagram was drawn for rural transport access index and poverty rate against district, where it reveals the general association that where the RAI value is higher the poverty rate is lower with the exception in Dhaka and Narayaganj districts. As it has been observed in the earlier sections that people of the area having higher accessibility to all-weather road having privileges of access to social and financial activities, job location, agriculture inputs/outputs, growth centres, etc. resulting people are to be less poor. On the contrary, the people of the area having lower accessibility to all-weather road having less privileges of access to social and financial activities, job location, agriculture inputs/outputs, growth centres, etc. resulting people are to be more poor. The exception in Dhaka and Narayanganj districts, the reason might be the in-migration of rural poor to these areas for jobs in garment industry and informal sectors living in squatters and slams with a high density.

In Figure 4-22, illustrates the relation of RAI and Literacy rate of each district, where the general phenomenon is that the people of the area having higher accessibility level have higher literacy rate and the people of the area having lower accessibility level have lower literacy rate with the exception in Rangamati district. This exception might be the cause that described in the previous section, as this area is hilly area and unlike other districts the people might be able to access by informal road having less chance to inundate in the monsoon. Moreover, it is noted that in Rangamati as majority of the inhabitants are tribal, therefore a lot of NGOs schools are there. As a result the literacy rate is higher in this area.

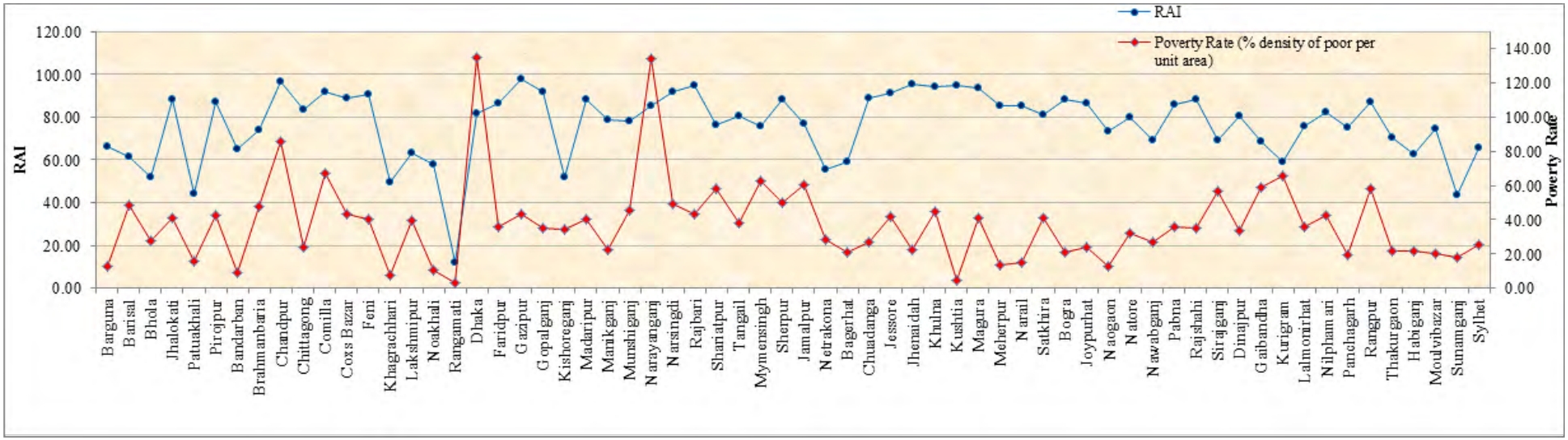


Figure 4-21: RAI with Poverty Rate

Source: this study

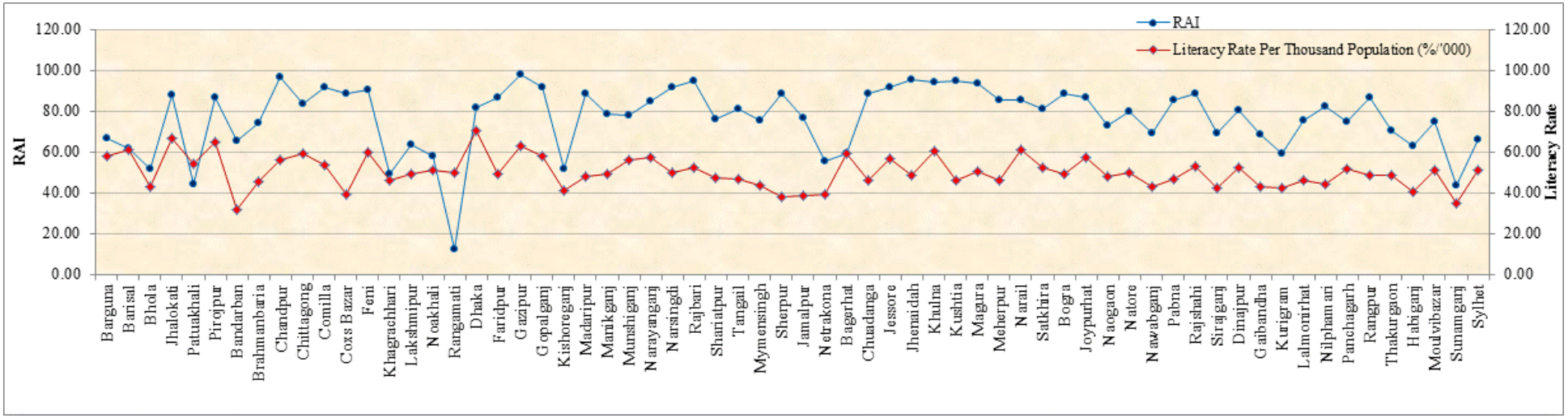


Figure 4-22: RAI with Literacy Rate

Source: this study

4.8.2 RAI with Education and Health Facilities

In this section it is tried to find out the relational association of rural transport accessibility index with Education and Health Care facilities of each district of Bangladesh, because without having access to these facilities, it is worthless to construct a school or a health complex. In the table below, population data used from 2011 census statistics, poverty data used here as the percentage of population below the upper poverty line and the literacy data from districts statistics.

Comparative analyses were done for density of educational facilities and health facilities per thousand population under each district expressed in percent with the RAI. The argument behind to investigate the association among education facilities, health facilities and RAI is that presumably it could be said where RAI value is higher there education and health facilities also higher. Because of without having access to these facilities, it is worthless to construct a school or a health complex.

In the Table 4-13 below all kinds of educational facilities and health care facilities are entered from districts statistics and using these data, line diagram has been drawn to apprehend the association with the estimated RAI value.

In Figure 4-23 and Figure 4-24 it can be observed the usual trend is that where RAI value is higher the educational facilities and health care facilities are higher and where RAI value is lower educational facilities and health care facilities are lower with some exception, like in Rangamati, Dhaka and Narayanganj districts. As it was seen in the earlier section in this chapter that due to its geo-spatial array the road transport accessibility is lower, however, in practical people are enjoying the accessibility by informal road (local walkway which is almost walk-able round the year due to hilly region) and by waterway as some thana/upazila like Juraichhari, Barkal, Langadu and Baghaichhari are isolated from the mainland.

On the other hand, in case of Dhaka and Narayaganj district different scenario exist, where though accessibility value is relatively higher but the educational and health care facilities are lower in quantity. Because Dhaka is the capital and largest urban area in Bangladesh and Narayagnaj is the industrial area that is why huge number of people are living here. Therefore with respect to population the educational and health care facilities become lower in calculation (facilities per thousand of population).

Table 4-13: RAI with Social Facilities

District	Population-2011 ('000)	Social Facilities (Numbers)														RAI (%)
		Educational Facilities								Health Care Facilities						
		Primary School	Secondary Schools	Colleges	Madrashas	Polytechnic, vocational colleges	Universities or higher colleges	Total Education Facilities	Educational Facilities Per (in %) Thousand Population	Hospitals	Upazial Health Complex	Union Health and Family Welfare Centres	Community Clinics	Total Health Facilities	Health Facilities Per Thousand Population	
Barguna	893	713	179	25	404	10	0	1331	149	1	15	35	84	135	15	66
Barisal	2324	1514	426	79	323	16	1	2359	101	1	16	50	199	266	11	62
Bhola	1777	975	262	35	590	12	0	1874	105	1	16	68	187	272	15	52
Jhalokati	683	558	195	21	182	5	0	961	141	1	10	25	62	98	14	88
Patuakhali	1536	1152	287	65	506	6	1	2017	131	2	28	59	121	210	14	44
Pirojpur	1113	955	266	37	388	12	0	1658	149	2	31	42	116	191	17	87
Bandarban	388	342	30	4	36	2	0	414	107	1	7	27	27	62	16	65
Brahmanbaria	2840	1162	215	35	206	5	0	1623	57	2	68	95	216	381	13	74
Chandpur	2416	1148	263	32	410	8	0	1861	77	1	74	88	114	277	11	97
Chittagong	7616	2385	710	145	953	39	12	4244	56	7	167	205	326	705	9	84
Comilla	5387	2021	509	93	1098	31	2	3754	70	1	128	140	451	720	13	92
Coxs Bazar	2290	652	157	21	396	7	0	1233	54	2	103	60	153	318	14	89
Feni	1437	530	168	172	272	6	0	1148	80	0	38	36	115	189	13	91
Khagrachhari	614	578	109	10	64	2	0	763	124	1	9	26	74	110	18	49
Lakshmipur	1729	732	167	22	223	5	0	1149	66	2	28	96	112	238	14	63
Noakhali	3108	1218	300	34	417	8	1	1978	64	3	72	68	222	365	12	58
Rangamati	596	626	83	12	37	2	0	760	128	2	28	33	34	97	16	12
Dhaka	12044	1144	399	172	680	26	44	2465	20	0	701	61	114	876	7	82
Faridpur	1913	838	260	35	348	15	0	1496	78	6	46	64	172	288	15	87
Gazipur	3404	742	308	42	389	15	6	1502	44	15	124	37	196	372	11	98
Gopalganj	1172	823	188	45	338	13	0	1407	120	8	47	63	116	234	20	92
Kishoreganj	2912	1279	237	37	475	20	2	2050	70	3	56	79	360	498	17	52
Madaripur	1166	663	155	23	164	9	0	1014	87	1	21	50	98	170	15	88
Manikganj	1393	612	154	31	85	2	0	884	63	6	53	55	117	231	17	78

		Social Facilities (Numbers)														RAI (%)
		Educational Facilities								Health Care Facilities						
District	Population-2011 ('000)	Primary School	Secondary Schools	Colleges	Madrashas	Polytechnic, vocational colleges	Universities or higher colleges	Total Education Facilities	Educational Facilities Per (in %) Thousand Population	Hospitals	Upazial Health Complex	Union Health and Family Welfare Centres	Community Clinics	Total Health Facilities	Health Facilities Per Thousand Population	
Munshiganj	1446	588	123	49	176	7	0	943	65	1	26	55	52	134	9	78
Narayanganj	2948	527	165	38	217	5	0	952	32	1	126	45	96	268	9	85
Narsingdi	2225	816	216	44	175	11	0	1262	57	1	135	53	190	379	17	92
Rajbari	1050	462	145	26	117	8	0	758	72	1	19	41	81	142	14	95
Shariatpur	1156	632	112	18	106	8	0	876	76	1	34	50	83	168	15	76
Tangail	3605	1550	483	74	407	13	1	2528	70	1	77	113	383	574	16	81
Mymensingh	5110	2051	617	91	1263	30	2	4054	79	1	141	138	432	712	14	75
Sherpur	1358	711	149	19	292	15	0	1186	87	1	16	39	122	178	13	88
Jamalpur	2293	1043	333	62	384	13	1	1836	80	1	34	68	261	364	16	77
Netrakona	2230	1217	245	35	371	20	0	1888	85	1	17	69	200	287	13	55
Bagerhat	1476	1114	292	40	343	21	0	1810	123	1	48	69	171	289	20	59
Chuadanga	1129	415	121	20	146	3	1	706	63	4	44	40	60	148	13	89
Jessore	2765	1237	513	104	432	9	1	2296	83	5	81	88	249	423	15	91
Jhenaidah	1771	893	279	67	179	2	0	1420	80	5	106	64	167	342	19	95
Khulna	2319	1188	370	88	284	24	3	1957	84	2	125	191	151	469	20	94
Kushtia	1947	790	299	81	182	9	1	1362	70	3	108	49	158	318	16	95
Magura	918	494	26	30	256	1	0	807	88	1	31	48	85	165	18	94
Meherpur	655	303	116	20	60	7	0	506	77	5	33	19	73	130	20	85
Narail	722	478	124	26	168	3	0	799	111	1	35	38	49	123	17	86
Satkhira	1986	1064	299	69	398	9	0	1839	93	6	84	67	174	331	17	81
Bogra	3401	1578	427	94	755	51	2	2907	85	12	92	110	329	543	16	88
Joypurhat	914	385	146	42	260	9	0	842	92	4	30	30	95	159	17	86
Naogaon	2600	1377	454	66	573	28	0	2498	96	5	95	86	252	438	17	73
Natore	1707	716	277	57	196	18	1	1265	74	3	29	44	124	200	12	80
Nawabganj	1648	704	236	63	224	15	1	1243	75	3	38	36	128	205	12	69

		Social Facilities (Numbers)														RAI (%)
		Educational Facilities								Health Care Facilities						
District	Population-2011 ('000)	Primary School	Secondary Schools	Colleges	Madrashas	Polytechnic, vocational colleges	Universities or higher colleges	Total Education Facilities	Educational Facilities Per (in %) Thousand Population	Hospitals	Upazial Health Complex	Union Health and Family Welfare Centres	Community Clinics	Total Health Facilities	Health Facilities Per Thousand Population	
Pabna	2523	1111	254	96	267	40	3	1771	70	1	75	100	320	496	20	86
Rajshahi	2595	1045	551	178	344	43	10	2171	84	2	76	70	273	421	16	89
Sirajganj	3097	1669	374	87	617	44	0	2791	90	16	48	99	311	474	15	69
Dinajpur	2990	1752	642	117	501	24	2	3038	102	5	53	97	270	425	14	80
Gaibandha	2379	1381	375	72	549	22	0	2399	101	12	26	63	123	224	9	69
Kurigram	2069	1213	302	74	506	28	0	2123	103	6	61	50	206	323	16	59
Lalmonirhat	1256	742	168	41	249	16	0	1216	97	3	19	44	122	188	15	76
Nilphamari	1834	1010	306	65	426	22	1	1830	100	4	34	51	162	251	14	82
Panchagarh	988	646	272	29	143	13	0	1103	112	2	14	40	90	146	15	75
Rangpur	2881	1378	514	102	579	32	7	2612	91	3	66	72	301	442	15	87
Thakurgaon	1390	933	383	49	320	5	0	1690	122	2	22	47	100	171	12	70
Habiganj	2089	1032	133	55	255	2	0	1477	71	1	59	51	149	260	12	63
Moulvibazar	1919	1135	187	62	198	26	0	1608	84	13	42	50	147	252	13	75
Sunamganj	2468	1437	204	26	357	4	0	2028	82	1	0	59	120	180	7	43
Sylhet	3434	1391	303	90	631	11	12	2438	71	6	84	70	172	332	10	66

Source: District Statistics, Bangladesh Bureau of Statistics (BBS)

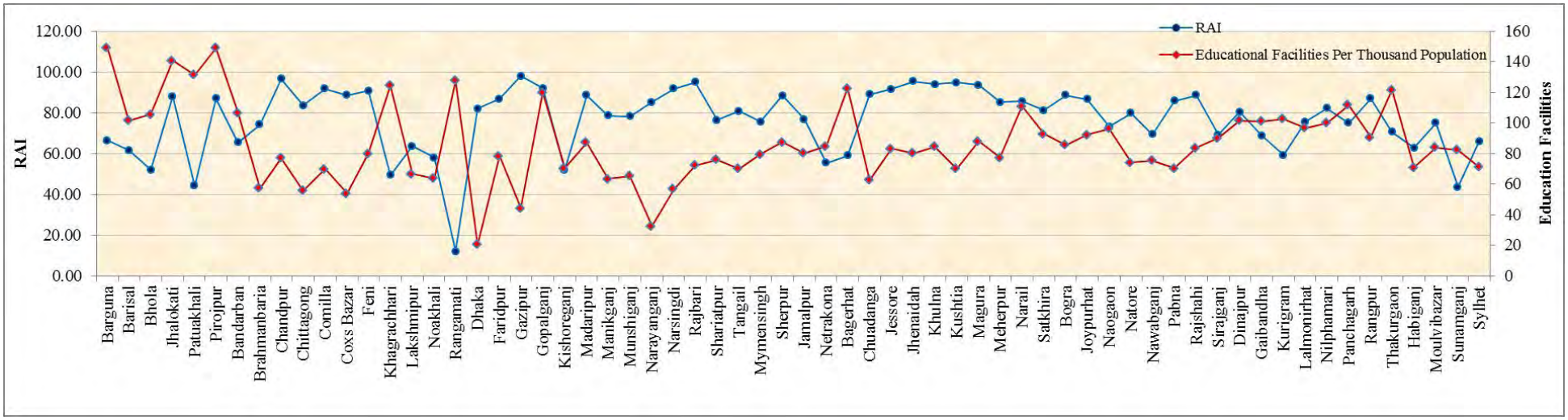


Figure 4-23: RAI with Educational Facilities

Source: this study

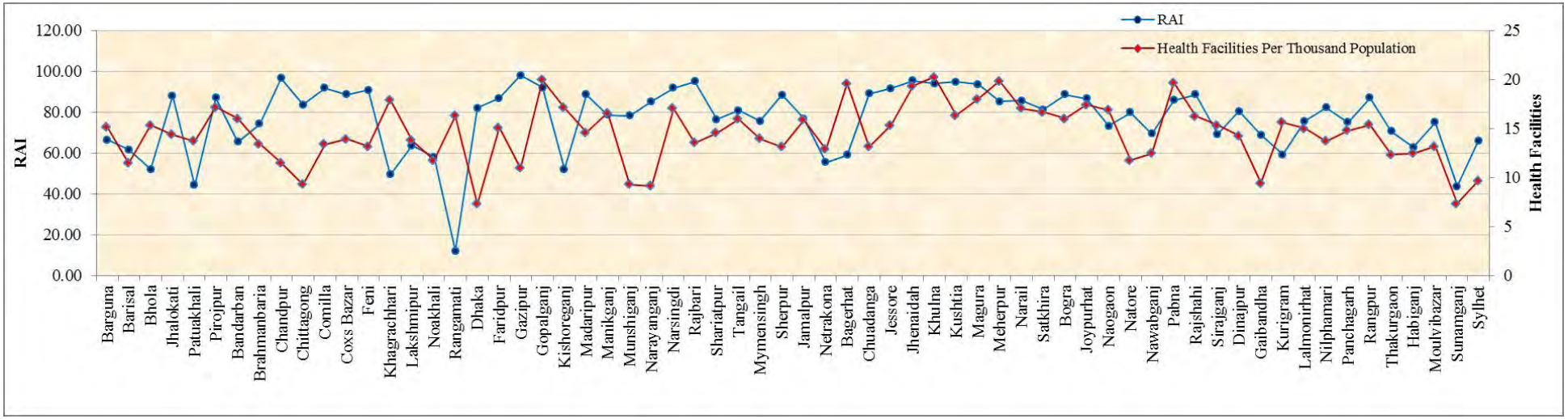


Figure 4-24: RAI with Health Care Facilities

Source: this study

4.8.3 RAI with Rural Economic and Industrial Facilities

In this section it is tried to find out the relational association of rural transport accessibility index with Economic and Industrial facilities of each district of Bangladesh, because without having access to these facilities, people can‘t have access to the job location and the farm/industries would not get the input and/or output feedback. In the table below, population data used from 2011 census statistics, economic and industrial facilities data from districts statistics. Here it is noted this economic and industrial facilities are particularly focused on rural context.

Comparative analyses were done for density of economic and industrial facilities per thousand populations under each district with the RAI. The argument behind to investigate the association between economic and industrial facilities and RAI is that presumably it could be said where RAI value is higher there economic facilities also higher. Because of without having access to these facilities, it is worthless to construct such facilities.

In the Table 4-14 below all kinds of economic and economic facilities are entered from districts statistics and using these data, line diagram has been drawn to apprehend the association with the estimated RAI value.

In Figure 4-25, it can be observed the usual trend is that where RAI value is higher the economic and economic facilities are higher and where RAI value is lower economic facilities are lower with some exception, like in Sirajganj and Jessore districts.
In Sirajganj district the economic and industrial facilities .are significantly higher, as it is found from statistics that in this districts dairy and poultry farm and small scale and cottage industry like weaving and handloom industries are predominantly higher than other districts.
On the other hand, in Jessore district, the economic and industrial facilities also higher, as it is found from the statistics that small scale and cottage industries are relative higher, in particular Husking Craft Mill and Gur (sweet from date tree juice) processing industries are very popular in this district.
It is worthwhile to mention that in Sirajganj and Jessore district where the rural economic and industrial facilities are higher, the rural transport accessibility is also higher

Table 4-14: RAI with Rural Economic and Industrial Facilities

District	Population-2011 ('000)	Economic and Industrial Facilities (Number)							RAI
		Growth Centers		Industries, Factories & Other Activities			Total Economic Facilities	Economic and Industrial Facilities Per Thousand Population	
		Growth Centers	Hat/Bazars	Industries & Factories	Small Scale and Cottage Industries	Dairy, Poultry & hatchery			
Barguna	893	27	119	465	2371	404	3386	3.8	66
Barisal	2324	37	381	1092	12920	2107	16537	7.1	62
Bhola	1777	37	241	535	1882	371	3066	1.7	52
Jhalokati	683	15	132	88	709	351	1295	1.9	88
Patuakhali	1536	34	280	478	3698	1626	6116	4.0	44
Pirojpur	1113	33	179	493	3069	1365	5139	4.6	87
Bandarban	388	8	38	40	4897	164	5147	13.3	65
Brahmanbaria	2840	32	230	655	30834	1467	33218	11.7	74
Chandpur	2416	38	244	580	8394	1729	10985	4.5	97
Chittagong	7616	112	513	1513	19209	22376	43723	5.7	84
Comilla	5387	68	490	2663	48229	3140	54590	10.1	92
Coxs Bazar	2290	74	147	144	21996	813	23174	10.1	89
Feni	1437	28	139	57	7726	900	8850	6.2	91
Khagrachhari	614	15	45	338	976	304	1678	2.7	49
Lakshmipur	1729	28	156	110	4769	718	5781	3.3	63
Noakhali	3108	74	271	291	7054	1784	9474	3.0	58
Rangamati	596	38	76	450	180	341	1085	1.8	12
Dhaka	12044	42	652	2604	4392	5114	12804	1.1	82
Faridpur	1913	34	228	457	6104	2210	9033	4.7	87
Gazipur	3404	23	211	1773	1227	9819	13053	3.8	98
Gopalganj	1172	27	187	622	3777	907	5520	4.7	92
Kishoreganj	2912	581	282	1612	11180	3023	16678	5.7	52
Madaripur	1166	29	179	312	1791	1241	3552	3.0	88
Manikganj	1393	26	199	276	4459	1537	6497	4.7	78
Munshiganj	1446	31	128	258	1408	2219	4044	2.8	78
Narayanganj	2948	15	217	10085	8994	4387	23698	8.0	85
Narsingdi	2225	26	212	2218	11629	3289	17374	7.8	92
Rajbari	1050	24	103	130	11080	3215	14552	13.9	95
Shariatpur	1156	18	157	162	1571	375	2283	2.0	76
Tangail	3605	77	457	1184	7050	5122	13890	3.9	81
Mymensingh	5110	71	565	1295	20016	2646	24593	4.8	75
Sherpur	1358	26	148	426	2734	1087	4421	3.3	88

District	Population-2011 ('000)	Economic and Industrial Facilities (Number)							RAI
		Growth Centers		Industries, Factories & Other Activities			Total Economic Facilities	Economic and Industrial Facilities Per Thousand Population	
		Growth Centers	Hat/Bazars	Industries & Factories	Small Scale and Cottage Industries	Dairy, Poultry & hatchery			
Jamalpur	2293	43	210	385	7123	1146	8907	3.9	77
Netrakona	2230	46	269	1129	6436	34421	42301	19.0	55
Bagerhat	1476	46	195	287	5954	2232	8714	5.9	59
Chuadanga	1129	25	96	307	3067	985	4480	4.0	89
Jessore	2765	41	306	1617	96413	3501	101878	36.9	91
Jhenaidah	1771	31	203	1200	7251	1333	10018	5.7	95
Khulna	2319	45	261	599	14999	3127	19031	8.2	94
Kushtia	1947	26	209	1494	33711	1816	37256	19.1	95
Magura	918	17	126	182	24125	546	24996	27.2	94
Meherpur	655	11	76	274	2691	461	3513	5.4	85
Narail	722	26	104	401	10984	411	11926	16.5	86
Satkhira	1986	39	274	566	22521	3809	27209	13.7	81
Bogra	3401	77	260	1380	26925	3407	32049	9.4	88
Joypurhat	914	39	91	873	9711	1695	12409	13.6	86
Naogaon	2600	62	248	1507	14111	1636	17564	6.8	73
Natore	1707	28	158	644	25735	2056	28621	16.8	80
Nawabganj	1648	21	196	627	12855	644	14343	8.7	69
Pabna	2523	59	242	666	29546	7903	38416	15.2	86
Rajshahi	2595	52	255	1188	22846	2350	26691	10.3	89
Sirajganj	3097	72	306	637	136910	14404	152329	49.2	69
Dinajpur	2990	68	423	1709	11552	1941	15693	5.2	80
Gaibandha	2379	41	252	2065	13855	3884	20097	8.4	69
Kurigram	2069	76	211	482	3671	813	5253	2.5	59
Lalmonirhat	1256	33	131	153	1530	432	2279	1.8	76
Nilphamari	1834	25	144	403	2206	552	3330	1.8	82
Panchagarh	988	18	153	250	860	299	1580	1.6	75
Rangpur	2881	57	231	1323	2628	5163	9402	3.3	87
Thakurgaon	1390	28	197	137	4754	6401	11517	8.3	70
Habiganj	2089	34	191	861	4094	1045	6225	3.0	63
Moulvibazar	1919	27	189	152	811	1251	2430	1.3	75
Sunamganj	2468	41	227	660	2302	748	3978	1.6	43
Sylhet	3434	64	315	781	3325	1752	6237	1.8	66

Source: BBS and this study

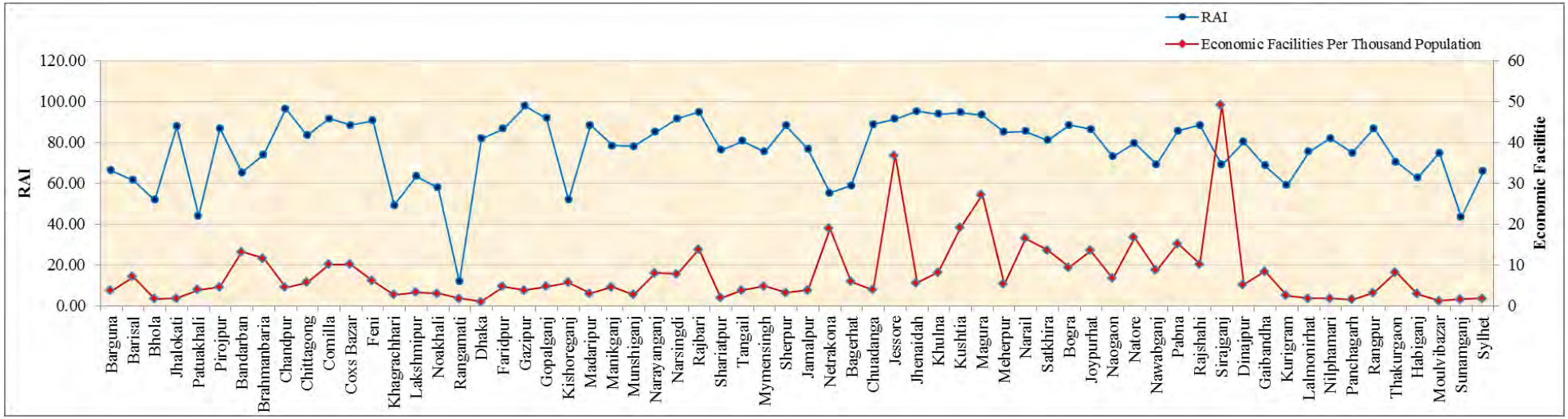


Figure 4-25: RAI with Rural Economic and Industrial Facilities

Source: this study

4.8.4 Rural Socio-Economic Score and Road Transport Accessibility

Taking into account all the demographic, social, economic and industrial facilities in each district as described earlier sections, a combined score was estimated, where it is called as ―Rural Socio-Economic Score" and then compared with the Rural Transport Accessibility to unearth the association if any.

In order to estimate the combined score, before that an individual score for each dimension of demographic, social, economic and industrial facilities is estimated as presented in the following table in a scale of 1 to 5, where score value near to 1 indicating the worse and value near to 5 indicates the good in terms of these facilities within the territory of each district. The individual dimension/facilities score was assigned on the basis of equal distribution range method. Then the combined score has been estimated applying the weightage factor as given in the following table:

Table 4-15: Weight Factor

Weightage Factor	Weight
Poverty	0.1
Literacy	0.2
Educational Facilities	0.2
Health Facilities	0.2
Economic and Industrial Facilities	0.3
Total =	**1.0**

Source: this study

Argument behind the weight, assigned for each factor, is that the area or place where accessibility is better there inhabitants can have the privilege or better opportunity to ease access to economic and industrial facilities, can have access to job location, rural people can sell their agricultural and farm products to the markets, can get the high yield seeds and other modern agricultural and farm inputs to enrich their household wellbeing as a result to get rid of poverty curse. After meeting the households' threshold limits, they can have leverage to spend on health and education. Following this notion, the more weightage assigned in the order of household's priority and to reduce poverty.

From Figure 4-26, it can be observed that the general phenomenon is that where the RAI is higher there combined score is also higher with some exception, like in South-East region districts of Bangladesh. In the South-East region district e.g. Brahmanbaria, Chandpur, Chittagong, Comilla, Cox's Bazar, Feni, Rangamati, the literacy, educational facilities, health facilities are less with respect to population.

Table 4-16: Combined Scoring of Demographic, Social and Economic Factors

District	Demographic Factor							Social Factor						Economic and Industries Factor			Total Score (within a scale of 5, where 1=bad, 5=good)	RAI
	Poverty				Literacy			Educational Institute			Health Centres							
	Population below poverty line (%)	Population below poverty line ('000)	Density of Poor ('000/km^2)	Poverty Score (1=bad, 5=good)	Literacy Rate-2011 (%)	Literacy Rate Per Thousand Population (%/'000)	Literacy Score (1=bad, 5=good)	Total Education Facilities	Educational Facilities Per Thousand Population	Education Facilities Score (1=bad, 5=good)	Total Health Facilities	Health Facilities Per Thousand Population	Health Facilities Score (1=bad, 5=good)	Total Economic Facilities	Economic Facilities Per Thousand Population	Economic Facilities Score (1=bad, 5=good)		
Barguna	19	170	0.2	5	57.6	0.1	5	1331	1.5	5	135	0.2	3	3386	3.8	2	3.7	66
Barisal	54.8	1274	0.5	1	61.2	2.6	5	2359	1.0	5	266	0.1	1	16537	7.1	4	3.1	62
Bhola	33.2	590	0.3	3	43.2	2.4	5	1874	1.1	5	272	0.2	3	3066	1.7	1	2.8	52
Jhalokati	40.5	276	0.4	2	66.7	9.8	5	961	1.4	5	98	0.1	3	1295	1.9	1	3.1	88
Patuakhali	25.8	396	0.3	4	54.1	3.5	5	2017	1.3	5	210	0.1	2	6116	4.0	2	3.2	44
Pirojpur	44.1	491	0.4	1	64.9	5.8	5	1658	1.5	5	191	0.2	4	5139	4.6	3	3.8	87
Bandarban	40.1	156	0.4	2	31.7	8.2	5	414	1.1	5	62	0.2	3	5147	13.3	5	4.3	65
Brahmanbaria	30	852	0.3	3	45.3	1.6	5	1623	0.6	1	381	0.1	2	33218	11.7	5	2.6	74
Chandpur	51	1232	0.5	1	56.3	2.3	5	1861	0.8	2	277	0.1	1	10985	4.5	3	2	97
Chittagong	11.5	876	0.1	5	58.9	0.8	5	4244	0.6	1	705	0.1	1	43723	5.7	3	2	84
Comilla	37.9	2042	0.4	2	53.3	1.0	5	3754	0.7	1	720	0.1	2	54590	10.1	4	2.2	92
Coxs Bazar	32.7	749	0.3	3	39.3	1.7	5	1233	0.5	1	318	0.1	2	23174	10.1	4	2.5	89
Feni	25.9	372	0.3	4	59.6	4.1	5	1148	0.8	2	189	0.1	2	8850	6.2	3	2.9	91
Khagrachhari	25.5	157	0.3	4	46.1	7.5	5	763	1.2	5	110	0.2	4	1678	2.7	2	3.8	49
Lakshmipur	31.2	540	0.3	3	49.4	2.9	5	1149	0.7	1	238	0.1	2	5781	3.3	2	2.1	63
Noakhali	9.6	298	0.1	5	51.3	1.7	5	1978	0.6	1	365	0.1	1	9474	3.0	2	1.7	58
Rangamati	20.3	121	0.2	5	49.7	8.3	5	760	1.3	5	97	0.2	4	1085	1.8	1	3.6	12
Dhaka	15.7	1891	0.2	5	70.5	0.6	5	2465	0.2	1	876	0.1	1	12804	1.1	1	1.4	82
Faridpur	36.3	694	0.4	2	49.0	2.6	5	1496	0.8	2	288	0.2	3	9033	4.7	3	2.7	87
Gazipur	19.4	660	0.2	5	62.6	1.8	5	1502	0.4	1	372	0.1	1	13053	3.8	2	1.9	98
Gopalganj	42.7	501	0.4	1	58.1	5.0	5	1407	1.2	5	234	0.2	5	5520	4.7	3	4	92
Kishoreganj	30.3	882	0.3	3	40.9	1.4	5	2050	0.7	2	498	0.2	4	16678	5.7	3	2.6	52
Madaripur	34.9	407	0.3	3	48.0	4.1	5	1014	0.9	3	170	0.1	3	3552	3.0	2	2.9	88
Manikganj	18.5	258	0.2	5	49.2	3.5	5	884	0.6	1	231	0.2	4	6497	4.7	3	3.2	78
Munshiganj	28.7	415	0.3	4	56.1	3.9	5	943	0.7	1	134	0.1	1	4044	2.8	2	2.2	78
Narayanganj	26.1	769	0.3	4	57.1	1.9	5	952	0.3	1	268	0.1	1	23698	8.0	4	2.4	85
Narsingdi	23.7	527	0.2	5	49.6	2.2	5	1262	0.6	1	379	0.2	4	17374	7.8	4	3.1	92
Rajbari	41.9	440	0.4	2	52.3	5.0	5	758	0.7	2	142	0.1	2	14552	13.9	5	3.5	95
Shariatpur	52.6	608	0.5	1	47.3	4.1	5	876	0.8	2	168	0.1	3	2283	2.0	1	2.2	76
Tangail	29.7	1071	0.3	4	46.8	1.3	5	2528	0.7	2	574	0.2	3	13890	3.9	2	2.2	81

	Demographic Factor							Social Factor						Economic and Industries Factor			Total Score (within a scale of 5, where 1=bad, 5=good)	RAI
	Poverty				Literacy			Educational Institute			Health Centres							
District	Population below poverty line (%)	Population below poverty line ('000)	Density of Poor ('000/km^2)	Poverty Score (1=bad, 5=good)	Literacy Rate-2011 (%)	Literacy Rate Per Thousand Population (%/'000)	Literacy Score (1=bad, 5=good)	Total Education Facilities	Educational Facilities Per Thousand Population	Education Facilities Score (1=bad, 5=good)	Total Health Facilities	Health Facilities Per Thousand Population	Health Facilities Score (1=bad, 5=good)	Total Economic Facilities	Economic Facilities Per Thousand Population	Economic Facilities Score (1=bad, 5=good)		
Mymensingh	50.5	2581	0.5	1	43.5	0.9	5	4054	0.8	2	712	0.1	2	24593	4.8	3	2	75
Sherpur	48.4	657	0.5	1	37.9	2.8	5	1186	0.9	3	178	0.1	2	4421	3.3	2	2.3	88
Jamalpur	51.1	1172	0.5	1	38.4	1.7	5	1836	0.8	3	364	0.2	3	8907	3.9	2	2.1	77
Netrakona	35.3	787	0.4	3	39.4	1.8	5	1888	0.8	3	287	0.1	2	42301	19.0	5	3.2	55
Bagerhat	42.8	632	0.4	1	59.0	4.0	5	1810	1.2	5	289	0.2	5	8714	5.9	3	3.8	59
Chuadanga	27.7	313	0.3	4	45.9	4.1	5	706	0.6	1	148	0.1	2	4480	4.0	2	2.4	89
Jessore	39	1078	0.4	2	56.5	2.0	5	2296	0.8	3	423	0.2	3	101878	36.9	5	3.3	91
Jhenaidah	24.7	438	0.2	4	48.4	2.7	5	1420	0.8	3	342	0.2	5	10018	5.7	3	3.5	95
Khulna	38.8	900	0.4	2	60.1	2.6	5	1957	0.8	3	469	0.2	5	19031	8.2	4	3.6	94
Kushtia	3.6	70	0.0	5	46.3	2.4	5	1362	0.7	1	318	0.2	4	37256	19.1	5	3.4	95
Magura	45.4	417	0.5	1	50.6	5.5	5	807	0.9	3	165	0.2	4	24996	27.2	5	4	94
Meherpur	15.2	100	0.2	5	46.3	7.1	5	506	0.8	2	130	0.2	5	3513	5.4	3	3.8	85
Narail	20	144	0.2	5	61.3	8.5	5	799	1.1	5	123	0.2	4	11926	16.5	5	4.8	86
Satkhira	46.3	919	0.5	1	52.1	2.6	5	1839	0.9	4	331	0.2	4	27209	13.7	5	3.8	81
Bogra	16.6	565	0.2	5	49.4	1.5	5	2907	0.9	3	543	0.2	3	32049	9.4	4	3.1	88
Joypurhat	26.7	244	0.3	4	57.5	6.3	5	842	0.9	4	159	0.2	4	12409	13.6	5	4.5	86
Naogaon	16.9	439	0.2	5	48.2	1.9	5	2498	1.0	4	438	0.2	4	17564	6.8	3	3.4	73
Natore	35.1	599	0.4	3	49.6	2.9	5	1265	0.7	2	200	0.1	1	28621	16.8	5	3	80
Nawabganj	25.3	417	0.3	4	42.9	2.6	5	1243	0.8	2	205	0.1	2	14343	8.7	4	3	69
Pabna	31.5	795	0.3	3	46.7	1.9	5	1771	0.7	2	496	0.2	5	38416	15.2	5	3.6	86
Rajshahi	31.4	815	0.3	3	53.0	2.0	5	2171	0.8	3	421	0.2	4	26691	10.3	4	3.3	89
Sirajganj	38.7	1199	0.4	2	42.1	1.4	5	2791	0.9	4	474	0.2	3	152329	49.2	5	3.3	69
Dinajpur	37.9	1133	0.4	2	52.4	1.8	5	3038	1.0	5	425	0.1	3	15693	5.2	3	3.1	80
Gaibandha	48	1142	0.5	1	42.8	1.8	5	2399	1.0	5	224	0.1	1	20097	8.4	4	2.9	69
Kurigram	63.7	1318	0.6	1	42.5	2.1	5	2123	1.0	5	323	0.2	3	5253	2.5	2	2.7	59
Lalmonirhat	34.5	433	0.3	3	46.1	3.7	5	1216	1.0	4	188	0.1	3	2279	1.8	1	2.8	76
Nilphamari	34.8	638	0.3	3	44.4	2.4	5	1830	1.0	4	251	0.1	2	3330	1.8	1	2.4	82
Panchagarh	26.7	264	0.3	4	51.8	5.2	5	1103	1.1	5	146	0.1	3	1580	1.6	1	3.3	75
Rangpur	46.2	1331	0.5	1	48.5	1.7	5	2612	0.9	4	442	0.2	3	9402	3.3	2	2.3	87
Thakurgaon	27	375	0.3	4	48.7	3.5	5	1690	1.2	5	171	0.1	2	11517	8.3	4	3.8	70
Habiganj	25.3	529	0.3	4	40.5	1.9	5	1477	0.7	2	260	0.1	2	6225	3.0	2	2.2	63

District	Demographic Factor							Social Factor						Economic and Industries Factor			Total Score (within a scale of 5, where 1=bad, 5=good)	RAI
	Poverty				Literacy			Educational Institute			Health Centres							
	Population below poverty line (%)	Population below poverty line ('000)	Density of Poor ('000/km^2)	Poverty Score (1=bad, 5=good)	Literacy Rate-2011 (%)	Literacy Rate Per Thousand Population (%/'000)	Literacy Score (1=bad, 5=good)	Total Education Facilities	Educational Facilities Per Thousand Population	Education Facilities Score (1=bad, 5=good)	Total Health Facilities	Health Facilities Per Thousand Population	Health Facilities Score (1=bad, 5=good)	Total Economic Facilities	Economic Facilities Per Thousand Population	Economic Facilities Score (1=bad, 5=good)		
Moulvibazar	25.7	493	0.26	4	51.1	2.7	5	1608	0.8	3	252	0.1	2	2430	1.3	1	2.3	75
Sunamganj	26	642	0.26	4	35.0	1.4	5	2028	0.8	3	180	0.1	1	3978	1.6	1	1.7	43
Sylhet	24.1	828	0.24	4	51.2	1.5	5	2438	0.7	2	332	0.1	1	6237	1.8	1	1.5	66

Source: BBS Zila Series Statistics, 2011

Estimation of scoring on basis of even distribution as per following table:

		poverty factor			*literacy factor*			*education factor*			*health factor*			*economic factor*		
Target per score for even distribution = 12.8		*min=*	*0.04*		*min=*	*0.01*		*min=*	*0.2047*		*min=*	*0.073*		*min=*	*1.063*	
		max=	*0.64*		*max=*	*0.10*		*max=*	*1.4908*		*max=*	*0.202*		*max=*	*49.18*	
		average	*0.32*		*average*	*0.03*		*average*	*0.8622*		*average*	*0.145*		*average*	*7.904*	
		Score	*value range*	*no. of events*	*Score*	*value range*	*no. of events*	*Score*	*value range*	*no. of events*	*Score*	*value range*	*no. of events*	*Score*	*value range*	*no. of events*
		5	*0.24*	*13*	*1*	*0.01*	*14*	*1*	*0.70*	*14*	*1*	*0.12*	*12*	*1*	*2.00*	*11*
		4	*0.30*	*16*	*2*	*0.02*	*15*	*2*	*0.80*	*14*	*2*	*0.14*	*16*	*2*	*4.00*	*15*
		3	*0.36*	*12*	*3*	*0.03*	*12*	*3*	*0.90*	*12*	*3*	*0.16*	*17*	*3*	*7.00*	*14*
		3	*0.42*	*12*	*4*	*0.04*	*10*	*4*	*1.00*	*7*	*4*	*0.18*	*13*	*4*	*11.00*	*11*
		1	+	*14*	*5*	+	*13*	*5*	+	*17*	*5*	+	*6*	*5*	+	*13*

Source: this study

Weitage Factor	weight
Poverty	0.1
Literacy	0.2
Educational Fac	0.2
Health Factor	0.2
Economic Facto	0.3
Total =	**1.0**

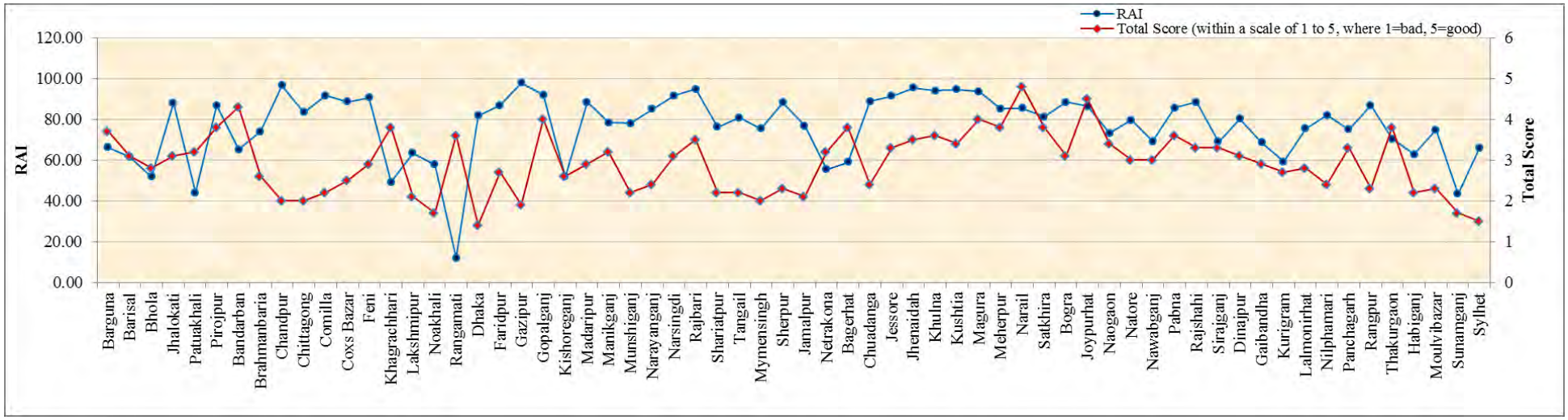


Figure 4-26: RAI with Combined Score

Source: this study

4.9 Correlation Analysis

Correlation analysis is the study to measure the relationship between variables. The basic idea of correlation is to report the association between two variables. In fact, through correlation analysis, it will be measured the strength and direction of this relationship between two variables by determining the coefficient of correlation.

The Coefficient of Correlation, developed by Karl Pearson in 1900, describes the strength of the relationship between ratio-scaled variables. It is designated by "r" (small r) often referred to as Pearson's "r" and as the Pearson product moment correlation coefficient. It can assume value from -1.00 to +1.00 inclusive. If there is absolutely no relationship between the two sets of variables, then r is zero. If r = -1.0, then it represents perfectly correlated in an inverse linear sense, i.e. when the independent variables increases the dependent variables decreases and vice-versa. If r = +1.0, then it represents also perfectly correlated in a positive linear sense, i.e. when the independent variables increases the dependent variables also increases and vice-versa.

4.9.1 Data Table to Perform the Correlation Analysis

In the previous section, it was presented the comparative relational analysis between Rural Transport Accessibility to Socio-Economic parameters of 64-Districts of Bangladesh. It is used the following socio-economic parameters score with RAI to measure the strength and direction of association with the socio-economic parameters. Here, the independent variable is Accessibility and dependent variables are socio-economic parameters used in the analyses.

Independent Variable (x) = Accessibility (RAI) values in column-2 of the table below.
Dependent Variables (y) = Socio-economic parameters in column-3, 4, 5, 6, 7, 8 of the table below.

Table 4-17: Rural Transport Accessibility and Socio-Economic Parameters

District	RAI	Poverty Rate (score)	Literacy Rate (score)	Educational Facilities (score)	Health Facilities (score)	Economic Facilities (score)	Total Score
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Barguna	66	5	1	4	1	2	2
Barisal	62	2	3	3	1	3	3
Bhola	52	4	1	3	2	1	2
Jhalokati	88	2	4	5	2	1	3
Patuakhali	44	5	1	3	1	1	2
Pirojpur	87	2	4	5	3	2	3
Bandarban	65	5	1	1	1	2	2
Brahmanbaria	74	2	5	4	5	5	5
Chandpur	97	1	5	5	4	4	4
Chittagong	84	4	5	5	4	4	4
Comilla	92	1	5	5	5	5	5
Coxs Bazar	89	2	3	2	4	5	4
Feni	91	2	5	5	4	4	4

District	RAI	Poverty Rate (score)	Literacy Rate (score)	Educational Facilities (score)	Health Facilities (score)	Economic Facilities (score)	Total Score
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Khagrachhari	49	5	1	1	1	1	1
Lakshmipur	63	3	4	3	3	2	3
Noakhali	58	5	3	1	2	2	2
Rangamati	12	5	1	1	1	1	1
Dhaka	82	1	5	5	5	4	4
Faridpur	87	3	2	2	2	3	2
Gazipur	98	2	5	4	5	4	4
Gopalganj	92	3	2	4	3	2	3
Kishoreganj	52	3	2	2	4	3	3
Madaripur	88	3	3	4	3	2	3
Manikganj	78	4	3	2	4	3	3
Munshiganj	78	2	5	5	2	2	3
Narayanganj	85	1	5	5	5	5	5
Narsingdi	92	2	5	5	5	5	5
Rajbari	95	2	3	2	2	5	3
Shariatpur	76	1	3	3	3	1	2
Tangail	81	3	4	3	4	3	3
Mymensingh	75	1	3	4	3	3	3
Sherpur	88	1	1	4	2	2	2
Jamalpur	77	1	2	4	4	3	3
Netrakona	55	4	1	1	1	5	3
Bagerhat	59	4	1	1	1	2	2
Chuadanga	89	4	2	1	2	2	2
Jessore	91	2	4	3	3	5	4
Jhenaidah	95	4	2	2	3	3	3
Khulna	94	2	4	4	5	4	4
Kushtia	95	5	4	4	5	5	5
Magura	94	2	2	2	3	5	3
Meherpur	85	5	2	1	3	3	3
Narail	86	5	2	3	2	5	3
Satkhira	81	2	2	3	2	4	3
Bogra	88	4	4	5	4	4	4
Joypurhat	86	4	3	3	3	4	3
Naogaon	73	5	1	2	2	3	2
Natore	80	3	2	1	1	5	3
Nawabganj	69	4	2	3	2	4	3
Pabna	86	3	3	2	5	5	4
Rajshahi	89	3	3	4	4	4	4
Sirajganj	69	1	4	5	5	5	4
Dinajpur	80	3	2	4	2	3	3
Gaibandha	69	1	3	5	1	4	3
Kurigram	59	1	2	5	3	2	3
Lalmonirhat	76	3	2	5	3	1	3
Nilphamari	82	2	3	5	3	1	3

District	RAI	Poverty Rate (score)	Literacy Rate (score)	Educational Facilities (score)	Health Facilities (score)	Economic Facilities (score)	Total Score
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
Panchagarh	75	5	1	3	1	1	2
Rangpur	87	1	4	5	4	2	3
Thakurgaon	70	4	1	4	1	4	3
Habiganj	63	4	1	1	1	2	2
Moulvibazar	75	5	1	1	1	1	1
Sunamganj	43	5	1	1	1	1	1
Sylhet	66	4	3	2	1	1	2

Source: BBS and this study

It has been used Microsoft Excel Data Analysis Tool to perform the Correlation Analysis. Through the correlation analysis, it was trying to find out the correlation coefficient (small ~~"r"~~), which indicates the direction and strength between the transport accessibility and other socio-economic parameters. The following output results have been derived from the data analysis tool.

Table 4-18: Correlation Coefficient

	RAI	Poverty Rate	Literacy Rate	Educational Facilities	Health Facilities	Economic Facilities	Total Score
RAI	1						
Poverty Rate	-0.41274	1					
Literacy Rate	0.534136	-0.57739	1				
Educational Facilities	0.413639	-0.62068	0.637469	1			
Health Facilities	0.563869	-0.50722	0.759223	0.517254	1		
Economic Facilities	0.491677	-0.30656	0.481177	0.230568	0.496297	1	
Total Score	0.619758	-0.49943	0.847106	0.657098	0.818578	0.804656	1

Source: this study

4.9.2 Interpretation of the Results – of Correlation Coefficient (small "r") Accessibility (RAI) Vs Poverty

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = poverty) is:

r = -0.41274; which indicates, *Firstly*, it is negative, representing correlated in an inverse sense between accessibility and poverty. This reveals that an increase in accessibility will likely slash to decrease the poverty and vice-versa. *Secondly*, the value of 0.41274 concludes that the association is moderate.

Accessibility (RAI) Vs Literacy Rate

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = literacy rate) is:

r = +0.534136; which indicates, *Firstly*, it is positive, representing correlated in a direct sense between accessibility and literacy rate. This reveals that an increase in accessibility will likely lead to increase the literacy rate and vice-versa. *Secondly*, the value of 0.534136 concludes that the association is fairly moderate.

Accessibility (RAI) Vs Educational Facilities

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = Education Facilities) is:

r = +0.413693; which indicates, *Firstly*, it is positive, representing correlated in a direct sense between accessibility and education facilities. This reveals that an increase in accessibility will likely lead to increase the literacy rate and vice-versa. *Secondly*, the value of 0.413693 concludes that the association is fairly moderate.

Accessibility Vs Health Facilities

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = Health Facilities) is:

r = +0.563869; which indicates, *Firstly*, it is positive, representing correlated in a direct sense between accessibility and health facilities. This reveals that an increase in accessibility will likely lead to increase the literacy rate and vice-versa. *Secondly*, the value of 0.563869 concludes that the association is fairly moderate.

Accessibility Vs Economic Facilities

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = Economic Facilities) is:

r = +0.491677; which indicates, *Firstly*, it is positive, representing correlated in a direct sense between accessibility and economic facilities. This reveals that an increase in accessibility will likely lead to increase the literacy rate and vice-versa. *Secondly*, the value of 0.491677 concludes that the association is fairly moderate.

Accessibility Vs Economic Facilities

The correlation coefficient between the independent variable (x = accessibility) and dependable variable (y = Socio-Economic Facilities) is:

r = +0.619758; which indicates, *Firstly*, it is positive, representing correlated in a direct sense between accessibility and socio-economic facilities. This reveals that an increase in accessibility will likely lead to increase the literacy rate and vice-versa. *Secondly*, the value of 0.619758 concludes that the association is fairly strong.

4.9.3 Testing the Significance of the Correlation Coefficient (t-Test)

This test is done to examine that the relationship is by chance or in reality there exists a relationship. It will imply the hypothesis testing steps, like the null hypothesis and the alternate hypothesis, which are:

H_0: $\rho = 0$ (the correlation is zero)

H_a: $\rho \neq 0$ or H_a : $\rho < 0$ or H_a : $\rho > 0$ (the correlation is different from zero)

Taking into consideration that in 95% confidence level i.e. in 5% significance level, with a degree of freedom for unequal variance n = 64.

So, Confidence Level, C = 95%;

Significance level, α = (100-95) = 5%

Using excel data analysis tool of t-Test, it has been got the following results between Accessibility and Poverty:

Table 4-19: Significance Test Results

t-Test: Two-Sample Assuming Unequal Variances			
(RAI and Poverty)			
		Variable 1	*Variable 2*
Mean		76.645	3
Variance		259.2453	2.031746
Observations		64	64
Hypothesized Difference	Mean	0	
df		64	
t Stat		36.44875	
P(T<=t) one-tail		7.98E-45	
t Critical one-tail		1.669013	
P(T<=t) two-tail		1.6E-44	
t Critical two-tail		1.99773	

Source: this study

4.9.4 Interpretation of Results of Significance Test Results

(a) Here, it is found that t Stat = 36.44875; and t Critical two-tail = 1.99773, therefore t Stat = 36.44875 > t Critical = 1,99773

so it can be reject the null hypothesis.

(b) Here P value is = 1.6 X 10^{-44} ; P << α – **indicates the relationship is statistically significant.**

(c) Here P value is very very low, so it can be reject the null hypothesis.

In bottom line, the alternative hypothesis can be accepted, means that there exists a true relationship between the variables.

4.10 Data Envelopment Analysis (DEA)

Data Envelopment Analysis (DEA) has been carried out to identify the optimal and equitable budget/resource allocation for the rural transport infrastructure. DEA utilizes linear programming method to produce measures of the relative efficiency of comparable units that employ multiple inputs and outputs [16]. It requires only that the selected inputs and outputs be quantifiable. The technique can analyze these multiple inputs and outputs in their natural physical units without reducing or transforming them into some common measurement. DEA takes into account these multiple inputs and outputs to produce a single aggregate measure of the relative efficiency of each comparable unit. The detail DEA background and process has been described in **Appendix-2**.

The basic principle uses in DEA analysis, which defines efficiency as the ratio of weighted outputs to weighted inputs:

$$Efficiency, \eta = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs} \quad \text{.....(i)}$$

Weighted output function is $\sum w_1 \times P_n$ .....(ii)

Weighted input function is $\sum w_2 \times RAI_n + w_3 \times L_n + w_4 \times E_n + w_5 \times H_n + w_6 \times EC_n$ .....(iii)

Where,

w_1 = weight of objective function
P = Poverty
n = 1 to 64
w_2 = weight of input function of RAI
RAI = Rural Access Index
w_3 = weight of input function of Literacy Rate
L = Literacy Rate
w_4 = weight of input function of Education Facilities
E = Education Facilities
w_5 = weight of input function of Health Facilities
H = Health Facilities
w_6 = weight of input function of Economic Facilities
EC = Economic Facilities

4.10.1 Objective Function for DEA

The objective function in the DEA analysis is Poverty. Data Envelopment Analysis (DEA) is done by Data Solver tools in the Microsoft Excel workbook. As the study area concern is the 64-Districts administrative area, therefore the poverty level of these 64-Districts is the objective function. In order to set the target, it can be done by two ways:

- A preemptive threshold level (set by the Govt.); or
- Maximum poverty level (existed according to HIES-2010 report) of a District across the country

In both cases, the target is to minimize the value. The underlying argument is that through budget/resource allocation to a particular area in an equitable and optimal fashion, where the allocation decision will be dictated by the priority ranking through DEA analysis.

4.10.2 Input Functions for DEA

The multivariate inputs functions used in DEA analysis are RAI, Literacy Rate, Education Facilities, Health Facilities and Economic Facilities of each individual District. Where the RAI i.e. the rural transport access index are expressed in percent of population having access (as defined in chapter 2) to an all-weather road, Literacy Rate expressed in percent of population of literal people (as per state definition), Education Facilities expressed in percent per thousand population, Health Facilities expressed in percent per thousand population, and economic facilities expressed in percent per thousand population.

Of all the cases, the target is to maximize the facilities in order to minimize the objective function. The underlying argument is that by investing in transport infrastructure and thereby enhancing the accessibility (enabling mobility to the rural people) will reduce the poverty, as we have seen in section 3 in this report. Pondering over the other facilities, e.g. literacy rate, education facilities, health facilities, economic facilities, will act as an aiding agent to reduce the objective function. In addition, presumably it can be said that accessibility augmentation will necessarily underpinning to enhance the other input facilities value and as well as utility.

4.10.3 Setting Target Value

From the objective function value range, find the maximum value of poverty among the 64 Districts area using the excel workbook function.

Maximum Poverty value = 63.7 (within 64 Districts)

Corresponding District Name (possessing the maximum poverty) in **Kurigram**

Maximum Value Index Number = 55 (from data table)

From the input function value range, find the minimum value of RAI among the 64-Districts area using the excel workbook function.

Minimum RAI value = 11.96

Corresponding District Name (possessing the minimum accessibility) in **Rangamati**

Minimum Value Index Number = 17 (from data table)

Target is to minimize the maximum Poverty Value by maximizing the minimum RAI value and to get higher efficiency using the input facilities under the following constraints.

4.10.4 Setting Constraints

(i) Weightage factor, w_1 less than or equal to 1 ($w_1 \leq 1.0$);
(ii) Sum of weightage factors, $w_2+w_3+w_4+w_5+w_6$, should be less than or equal to 1 ($w_2+w_3+w_4+w_5+w_6 \leq$;1.0) and
(iii) efficiency should be less than or equal to 1 ($\eta \leq 1.0$)

4.10.5 Base Data Table for DEA Analysis

The following is the Base Data Table, for which the Data Envelopment Analysis (DEA) has to be done. The **blue color** heading column (column no. 2) is the objective function data and the **orange color** heading columns (column nos. 4, 5, 6, 7, 8) are input functions.

Table 4-20: Base Data Table for Data Envelopment Analysis

SL. No.	District	Poverty (%)	RAI (%)	Literacy Rate (%)	Education Facilities per thousand Population	Health Facilities per thousand Population	Economic Facilities per thousand Population
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*
1	Barguna	19	66	58	1.5	0.2	3.8
2	Barisal	54.8	62	61	1.0	0.1	7.1
3	Bhola	33.2	52	43	1.1	0.2	1.7
4	Jhalokati	40.5	88	67	1.4	0.1	1.9
5	Patuakhali	25.8	44	54	1.3	0.1	4.0
6	Pirojpur	44.1	87	65	1.5	0.2	4.6
7	Bandarban	40.1	65	32	1.1	0.2	13.3
8	Brahmanbaria	30	74	45	0.6	0.1	11.7
9	Chandpur	51	97	56	0.8	0.1	4.5
10	Chittagong	11.5	84	59	0.6	0.1	5.7
11	Comilla	37.9	92	53	0.7	0.1	10.1
12	Coxs Bazar	32.7	89	39	0.5	0.1	10.1
13	Feni	25.9	91	60	0.8	0.1	6.2
14	Khagrachhari	25.5	49	46	1.2	0.2	2.7
15	Lakshmipur	31.2	63	49	0.7	0.1	3.3
16	Noakhali	9.6	58	51	0.6	0.1	3.0
17	Rangamati	20.3	12	50	1.3	0.2	1.8
18	Dhaka	15.7	82	71	0.2	0.1	1.1
19	Faridpur	36.3	87	49	0.8	0.2	4.7
20	Gazipur	19.4	98	63	0.4	0.1	3.8
21	Gopalganj	42.7	92	58	1.2	0.2	4.7
22	Kishoreganj	30.3	52	41	0.7	0.2	5.7
23	Madaripur	34.9	88	48	0.9	0.1	3.0
24	Manikganj	18.5	78	49	0.6	0.2	4.7
25	Munshiganj	28.7	78	56	0.7	0.1	2.8
26	Narayanganj	26.1	85	57	0.3	0.1	8.0
27	Narsingdi	23.7	92	50	0.6	0.2	7.8
28	Rajbari	41.9	95	52	0.7	0.1	13.9
29	Shariatpur	52.6	76	47	0.8	0.1	2.0
30	Tangail	29.7	81	47	0.7	0.2	3.9
31	Mymensingh	50.5	75	44	0.8	0.1	4.8

SL. No.	District	Poverty (%)	RAI (%)	Literacy Rate (%)	Education Facilities per thousand Population	Health Facilities per thousand Population	Economic Facilities per thousand Population
32	Sherpur	48.4	88	38	0.9	0.1	3.3
33	Jamalpur	51.1	77	38	0.8	0.2	3.9
34	Netrakona	35.3	55	39	0.8	0.1	19.0
35	Bagerhat	42.8	59	59	1.2	0.2	5.9
36	Chuadanga	27.7	89	46	0.6	0.1	4.0
37	Jessore	39	91	57	0.8	0.2	36.9
38	Jhenaidah	24.7	95	48	0.8	0.2	5.7
39	Khulna	38.8	94	60	0.8	0.2	8.2
40	Kushtia	3.6	95	46	0.7	0.2	19.1
41	Magura	45.4	94	51	0.9	0.2	27.2
42	Meherpur	15.2	85	46	0.8	0.2	5.4
43	Narail	20	86	61	1.1	0.2	16.5
44	Satkhira	46.3	81	52	0.9	0.2	13.7
45	Bogra	16.6	88	49	0.9	0.2	9.4
46	Joypurhat	26.7	86	58	0.9	0.2	13.6
47	Naogaon	16.9	73	48	1.0	0.2	6.8
48	Natore	35.1	80	50	0.7	0.1	16.8
49	Nawabganj	25.3	69	43	0.8	0.1	8.7
50	Pabna	31.5	86	47	0.7	0.2	15.2
51	Rajshahi	31.4	89	53	0.8	0.2	10.3
52	Sirajganj	38.7	69	42	0.9	0.2	49.2
53	Dinajpur	37.9	80	52	1.0	0.1	5.2
54	Gaibandha	48	69	43	1.0	0.1	8.4
55	Kurigram	63.7	59	43	1.0	0.2	2.5
56	Lalmonirhat	34.5	76	46	1.0	0.1	1.8
57	Nilphamari	34.8	82	44	1.0	0.1	1.8
58	Panchagarh	26.7	75	52	1.1	0.1	1.6
59	Rangpur	46.2	87	49	0.9	0.2	3.3
60	Thakurgaon	27	70	49	1.2	0.1	8.3
61	Habiganj	25.3	63	41	0.7	0.1	3.0
62	Moulvibazar	25.7	75	51	0.8	0.1	1.3
63	Sunamganj	26	43	35	0.8	0.1	1.6
64	Sylhet	24.1	66	51	0.7	0.1	1.8

Source: this study and BBS

The above base data table needs to prepare to feed into data solver analysis tools in excel workbook. It has to be defined the objective function, input functions, target value and constraints.

Setting Objective Function:

In this case of analysis, the objective function is taken as –Poverty" data, as the data range presented in the column-3 of the following table. Maximum poverty value among 64-Districts has been found as 63.7 of Kurigram District, the data index Sl. No. is 55 of the table. Target value of this objective function can set up by two ways:

i. Finding the maximum data value among the objective function and thereby target is to minimize the value to a level as to get maximum efficiency.
ii. Setting a threshold value (target set by Govt.)

In this study, the target set up following the first rule.

Setting Input Function:

The input functions are in the data range presented in column-4, 5, 6, 7 and 8 of the following table. Target of the input functions is to maximize the sum of the weighted input functions to get the maximum efficiency. Within these input functions a sub-target has been set-up. The minimum RAI value existed within 64-Districts is 11.96 of Rangamati District, the data index Sl. No. is 17 of the table. The sub-target is to maximize this minimum value to get the objective function target.

Weightage Functions:

Before undergone data solver tool application, the weightage used in equation (ii) and (iii) above, assumed are as follows:

$w1 = 1$

$\sum w2+w3+w4+w5+w6 = 1.0$

Weighted output values, in column-9 are calculated using formula (ii) and the weighted input values in column-10 are calculated using formula (iii), and efficiency values in column-11 are calculated using formula (i) in the following table.

Constraints:

Objective function weightage, $w1 \geq 1.0$

Sum of input function weightage, $\sum w_2+w_3+w_4+w_5+w_6 \geq 1.0$

Calculated efficiency value in column-11, $\eta \leq 1.0$

The following table has been prepared to run the data solver module in Microsoft excel spreadsheet for Data Envelopment Analysis. Before undergo the data solver tool, for the calculation of the weighted output and input, arbitrarily weights are assumed as presented at the bottom of the Table 4.22.

Table 4-21: Database Table to Solve the DEA Solver Tool

SL. No.	District	Poverty (%)	Literacy Rate (%)	Educational Facilities	Health Facilities	Economic Facilities	RAI (%)	weighted output	weighted input	efficiency		constraint
1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*		
1	Barguna	19	57.6	1.5	0.2	3.8	66	0.94	3.64	0.26	<=	1
2	Barisal	54.8	61.2	1.0	0.1	7.1	62	2.70	3.25	0.83	<=	1
3	Bhola	33.2	43.2	1.1	0.2	1.7	52	1.64	2.80	0.58	<=	1
4	Jhalokati	40.5	66.7	1.4	0.1	1.9	88	2.00	4.62	0.43	<=	1
5	Patuakhali	25.8	54.1	1.3	0.1	4.0	44	1.27	2.53	0.50	<=	1
6	Pirojpur	44.1	64.9	1.5	0.2	4.6	87	2.17	4.60	0.47	<=	1
7	Bandarban	40.1	31.7	1.1	0.2	13.3	65	1.98	3.44	0.57	<=	1
8	Brahmanbaria	30	45.3	0.6	0.1	11.7	74	1.48	3.69	0.40	<=	1
9	Chandpur	51	56.3	0.8	0.1	4.5	97	2.51	4.81	0.52	<=	1
10	Chittagong	11.5	58.9	0.6	0.1	5.7	84	0.57	4.13	0.14	<=	1
11	Comilla	37.9	53.3	0.7	0.1	10.1	92	1.87	4.55	0.41	<=	1
12	Coxs Bazar	32.7	39.3	0.5	0.1	10.1	89	1.61	4.36	0.37	<=	1
13	Feni	25.9	59.6	0.8	0.1	6.2	91	1.28	4.54	0.28	<=	1
14	Khagrachhari	25.5	46.1	1.2	0.2	2.7	49	1.26	2.75	0.46	<=	1
15	Lakshmipur	31.2	49.4	0.7	0.1	3.3	63	1.54	3.21	0.48	<=	1
16	Noakhali	9.6	51.3	0.6	0.1	3.0	58	0.47	2.94	0.16	<=	1
17	Rangamati	20.3	49.7	1.3	0.2	1.8	12	1.00	1.00	1.00	<=	1
18	Dhaka	15.7	70.5	0.2	0.1	1.1	82	0.77	3.92	0.20	<=	1
19	Faridpur	36.3	49.0	0.8	0.2	4.7	87	1.79	4.35	0.41	<=	1
20	Gazipur	19.4	62.6	0.4	0.1	3.8	98	0.96	4.76	0.20	<=	1
21	Gopalganj	42.7	58.1	1.2	0.2	4.7	92	2.10	4.74	0.44	<=	1
22	Kishoreganj	30.3	40.9	0.7	0.2	5.7	52	1.49	2.69	0.56	<=	1
23	Madaripur	34.9	48.0	0.9	0.1	3.0	88	1.72	4.46	0.39	<=	1
24	Manikganj	18.5	49.2	0.6	0.2	4.7	78	0.91	3.91	0.23	<=	1
25	Munshiganj	28.7	56.1	0.7	0.1	2.8	78	1.41	3.90	0.36	<=	1
26	Narayanganj	26.1	57.1	0.3	0.1	8.0	85	1.29	4.12	0.31	<=	1
27	Narsingdi	23.7	49.6	0.6	0.2	7.8	92	1.17	4.51	0.26	<=	1
28	Rajbari	41.9	52.3	0.7	0.1	13.9	95	2.06	4.71	0.44	<=	1

SL. No.	District	Poverty (%)	Literacy Rate (%)	Educational Facilities	Health Facilities	Economic Facilities	RAI (%)	weighted output	weighted input	efficiency		constraint
29	Shariatpur	52.6	47.3	0.8	0.1	2.0	76	2.59	3.85	0.67	<=	1
30	Tangail	29.7	46.8	0.7	0.2	3.9	81	1.46	4.05	0.36	<=	1
31	Mymensingh	50.5	43.5	0.8	0.1	4.8	75	2.49	3.83	0.65	<=	1
32	Sherpur	48.4	37.9	0.9	0.1	3.3	88	2.38	4.45	0.54	<=	1
33	Jamalpur	51.1	38.4	0.8	0.2	3.9	77	2.52	3.89	0.65	<=	1
34	Netrakona	35.3	39.4	0.8	0.1	19.0	55	1.74	2.90	0.60	<=	1
35	Bagerhat	42.8	59.0	1.2	0.2	5.9	59	2.11	3.20	0.66	<=	1
36	Chuadanga	27.7	45.9	0.6	0.1	4.0	89	1.36	4.40	0.31	<=	1
37	Jessore	39	56.5	0.8	0.2	36.9	91	1.92	4.59	0.42	<=	1
38	Jhenaidah	24.7	48.4	0.8	0.2	5.7	95	1.22	4.77	0.26	<=	1
39	Khulna	38.8	60.1	0.8	0.2	8.2	94	1.91	4.71	0.41	<=	1
40	Kushtia	3.6	46.3	0.7	0.2	19.1	95	0.18	4.70	0.04	<=	1
41	Magura	45.4	50.6	0.9	0.2	27.2	94	2.24	4.71	0.48	<=	1
42	Meherpur	15.2	46.3	0.8	0.2	5.4	85	0.75	4.28	0.18	<=	1
43	Narail	20	61.3	1.1	0.2	16.5	86	0.99	4.41	0.22	<=	1
44	Satkhira	46.3	52.1	0.9	0.2	13.7	81	2.28	4.14	0.55	<=	1
45	Bogra	16.6	49.4	0.9	0.2	9.4	88	0.82	4.46	0.18	<=	1
46	Joypurhat	26.7	57.5	0.9	0.2	13.6	86	1.32	4.39	0.30	<=	1
47	Naogaon	16.9	48.2	1.0	0.2	6.8	73	0.83	3.78	0.22	<=	1
48	Natore	35.1	49.6	0.7	0.1	16.8	80	1.73	4.00	0.43	<=	1
49	Nawabganj	25.3	42.9	0.8	0.1	8.7	69	1.25	3.52	0.35	<=	1
50	Pabna	31.5	46.7	0.7	0.2	15.2	86	1.55	4.28	0.36	<=	1
51	Rajshahi	31.4	53.0	0.8	0.2	10.3	89	1.55	4.46	0.35	<=	1
52	Sirajganj	38.7	42.1	0.9	0.2	49.2	69	1.91	3.56	0.54	<=	1
53	Dinajpur	37.9	52.4	1.0	0.1	5.2	80	1.87	4.13	0.45	<=	1
54	Gaibandha	48	42.8	1.0	0.1	8.4	69	2.36	3.58	0.66	<=	1
55	Kurigram	63.7	42.5	1.0	0.2	2.5	59	3.14	3.14	1.00	<=	1
56	Lalmonirhat	34.5	46.1	1.0	0.1	1.8	76	1.70	3.89	0.44	<=	1
57	Nilphamari	34.8	44.4	1.0	0.1	1.8	82	1.71	4.21	0.41	<=	1
58	Panchagarh	26.7	51.8	1.1	0.1	1.6	75	1.32	3.92	0.34	<=	1
59	Rangpur	46.2	48.5	0.9	0.2	3.3	87	2.28	4.40	0.52	<=	1

SL. No.	District	Poverty (%)	Literacy Rate (%)	Educational Facilities	Health Facilities	Economic Facilities	RAI (%)	weighted output	weighted input	efficiency		constraint
60	Thakurgaon	27	48.7	1.2	0.1	8.3	70	1.33	3.74	0.36	<=	1
61	Habiganj	25.3	40.5	0.7	0.1	3.0	63	1.25	3.20	0.39	<=	1
62	Moulvibazar	25.7	51.1	0.8	0.1	1.3	75	1.27	3.81	0.33	<=	1
63	Sunamganj	26	35.0	0.8	0.1	1.6	43	1.28	2.33	0.55	<=	1
64	Sylhet	24.1	51.2	0.7	0.1	1.8	66	1.19	3.34	0.35	<=	1

weights	0.05	0.00	0.34	0.00	0.00	0.05
Min/Max	63.7	70.50	1.49	0.20	49.18	11.96

Constraints	Reference set	Target Value (max/min)			
Literacy	≤	70.5			
Education	≤	1.49			
Health care	≤	0.2		Poverty	RAI
Economic	≤	49.18	District Data Index Sl. No.	55	17
RAI	≤	11.96	wt. output=	63.70	
			wt. input=	15.23	
Poverty Threshold	≥	30	input wt. sum=	1	

Source: this study

In data solver tool menu, the parameters have been set up by following way:

(i) Objective function cell reference of maximum value of poverty, target is to minimize it, therefore check the Min radio button.
(ii) Changing variable cells are the weightage values, setting the cell range of weightage.
(iii) Setting the constraints as stated earlier

Solving method: it can be chose any of the three algorithms or solving methods in the solver parameter dialog box, namely, (a) Generalized Reduced Gradient (GRG) Nonlinear used for problems that are smooth nonlinear; (b) LP Simplex used for linear; and (c) Evolutionary used for problems that are non-smooth. In this analysis, LP Simplex method has been used. The complete process of the data solver method has been described in Appendix-2.

4.10.6 Results of Data Envelopment Analysis (DEA)

Solving the database table by data solver tool, the following results have been found. The output results are ranked based on efficiency result, higher the efficiency means higher the priority to resource allocation. In the analysis, as the objective function target was poverty and input function target was RAI within the other input function, therefore Poverty and RAI values are tabulated below to find the ranking and interpreting the results of data envelopment analyses.

Table 4-22: Investment Priority Ranking

District	Poverty (%)	RAI (%)	Rank
Kurigram	64	59	1
Jamalpur	20	12	2
Shariatpur	55	62	3
Mymensingh	53	76	4
Sherpur	48	69	5
Gaibandha	43	59	6
Barisal	51	75	7
Bandarban	51	77	8
Rangpur	35	55	9
Chandpur	33	52	10
Bhola	40	65	11
Bagerhat	30	52	12
Satkhira	46	81	13
Sunamganj	26	43	14
Netrakona	39	69	15
Kishoreganj	48	88	16
Lalmonirhat	51	97	17
Nilphamari	46	87	18
Gopalganj	26	44	19
Pirojpur	31	63	20
Dinajpur	45	94	21

District	Poverty (%)	RAI (%)	Rank
Magura	44	87	22
Rajbari	26	49	23
Faridpur	38	80	24
Lakshmipur	43	92	25
Madaripur	42	95	26
Coxs Bazar	35	76	27
Jhalokati	35	80	28
Comilla	41	88	29
Rangamati	39	91	30
Khagrachhari	36	87	31
Natore	38	92	32
Sirajganj	35	82	33
Khulna	39	94	34
Habiganj	30	74	35
Brahmanbaria	25	63	36
Tangail	35	88	37
Patuakhali	33	89	38
Pabna	32	86	39
Jessore	29	78	40
Nawabganj	30	81	41
Rajshahi	27	70	42
Thakurgaon	24	66	43
Chuadanga	25	69	44
Munshiganj	31	89	45
Panchagarh	27	75	46
Moulvibazar	26	75	47
Sylhet	26	85	48
Narayanganj	28	89	49
Jhenaidah	27	86	50
Joypurhat	26	91	51
Feni	24	92	52
Narsingdi	19	66	53
Barguna	25	95	54
Manikganj	19	78	55
Naogaon	20	86	56
Narail	17	73	57
Gazipur	19	98	58
Bogra	16	82	59
Meherpur	17	88	60
Dhaka	15	85	61
Noakhali	10	58	62
Chittagong	12	84	63
Kushtia	4	95	64

Source: this study

A graph was drawn to better understand and to interpret the results of data envelopment analyses. Poverty and RAI in the vertical axis and District in the horizontal axis, as per ranking of priority of resource allocation, are presented in the graph. The left side of the

horizontal axis represents the higher priority of resource allocation and the right side represents the lesser priority.

In the graph, the districts are in the left side of the horizontal axis represents the **higher Poverty** value and **lower Accessibility** value which indicates that it needs to give higher priority for budget allocation to build physical infrastructure to increase the accessibility and thereby reduce the poverty.

The graph actually conveys the message to the policy makers regarding investment priority where the left side indicates high priority and right side indicates low priority.

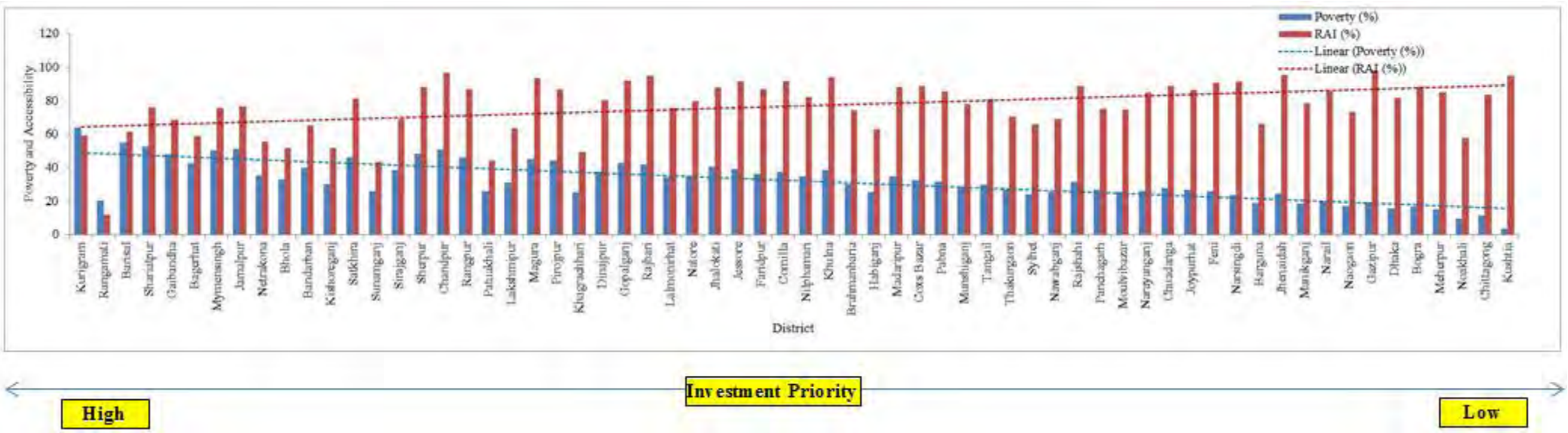


Figure 4-27: DEA Based Priority Ranking of Districts.

Source: this study

4.11 Overview

In this chapter data collection and analysis has been done for carrying out the thesis study. However, in this study, there was no primary data collection; rather it was all the secondary data that has been collected from different sources, particularly from different government organizations to do the analyses.

Secondary data encompasses mainly nationwide road network, demographic, socio-economic and poverty data of all sixty four districts of Bangladesh. Road network data was collected from Roads and Highways Department (RHD) and Local Government Engineering Department (LGED). Demographic, Socio-economic and Poverty data were collected from Bangladesh Bureau of Statistics (BBS). Using these data, a robust analysis was done in GIS environment to explore the objective oriented outcome set-forth in Chapter-1.

So in this study, it is found and explored road transport accessibility mapping; the relational association with accessibility to poverty and socio-economic parameters. Data envelopment analysis was carried out to prioritize the resource allocation in physical infrastructure.

In the next chapter, to address the issue of budget allocation on physical and social infrastructure on priority basis, considering the overarching objective of Bangladesh Government to reduce the Poverty, the outcome and results of this chapter will be presented elaborately to help better understanding for the policy maker to take decision.

CHAPTER -5

Conclusions and Recommendations

Chapter-5
CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The overall objective of this research project is to estimate the rural transport accessibility index of 64-Districts of Bangladesh and to develop the relationships between rural transport accessibility improvement and socio-economic parameters of Bangladesh. Based on the relationship an investment priority ranking has been prepared to help decision makers to allocate budget on transport interventions into poverty reduction programs. To this end, vigorous analyses were done in the previous chapter of this report.

In addition to that it was trying to find out the relational association between rural transport accessibility and socio-economic parameters to establish an argument that people, having better accessibility, (i.e. availing easy access to education, health, jobs, economic facilities, agricultural inputs, etc.) are less chance to get into poverty incidence than people not having accessibility, where in the later scenario, people are entangle into poverty incidence due to lack of access to education, health, jobs, economic facilities, agricultural inputs/output, etc.

This argument provides a strong basis to seek help decision makers to integrate transport interventions into poverty reduction programs because transport has a pervasive influence across a country‘s economy and its social fabric.

5.2 Summary

- **Estimate Rural Transport Accessibility Index**

In Chapter-4 detail analyses were done to estimate the rural transport accessibility index of 64-Districts of Bangladesh. The national average of RAI is 68%. Based on the estimated RAI value the Districts are ranked with ascending order, where ranking 1 reflecting the best case of RAI and ranking 64 reflecting the worst case of RAI. According to RAI estimation result, Gazipur district possess the highest RAI value of 97.64% and ranked first, on the other hand, Rangamati district possess the lowest RAI value of 11.96% and ranked last.

- **Prepared Accessibility Mapping**

The accessibility mapping has been prepared using the estimated Rural Transport Accessibility Index (RAI) value, with the objective to make easy and better understanding the extent of rural transport accessibility level that may arise a feeling to the policy maker, decision maker or even general people through a visual impression. As it is a proverb that seeing is believing, therefor the visual impression creating a feeling in the mind as a result this accessibility mapping could be more persuasive to the policy maker to allocate budget in rural transport on priority basis to the low accessibility areas.

- **Evaluate Relational Association between Accessibility and Poverty**

It has been found from the analyses that there exists an association between Transport Accessibility and Poverty. In a District administrative area, the general association is that where the Transport Accessibility value is higher, the Poverty value is lower and vice versa. The fact is that in the area where accessibility value is higher means that people of that area have the more opportunity to access to education facilities, healthcare facilities, job /employment, agricultural input/out, economic facilities (e.g. growth centers, hat/bazars, etc.) and social activities. Improved accessibility enables the rural sick people, pregnant women to use rickshaw/van to avail health care services. Access to markets significantly improved and thereby increasing household income and improving the household assets. Road transport accessibility reduces travel time, easy access to find the jobs and ultimately allowing increased income to rural households. The relational association has been shown in the following figures. In the analyses, Upper Poverty and Lower Poverty Line of Head Count Ratio (HCR) have been used to understand the ―Poverty" incidence of the areas.

- Road Transport Accessibility with Upper Poverty Line

  Estimated road transport accessibility value has been compared with the upper poverty line and presented in map and charts. The incidence of income poverty in terms of upper poverty line corresponds to the moderately poor households whose food expenditure is at the level of food poverty line. It is found that Gazipur district ranked first in RAI having UPL is 19.4, which is lower than the national average value of 35.2 (source: HIES, 2010). On the other hand, Rangamati district ranked last in RAI having UPL 20.3, however which is not the highest poverty incidence. The highest poverty incidence is in Kurigram district of 63.7, possessing RAI value of 59.17% with a ranking 55 out of 64.

- Road Transport Accessibility with Lower Poverty Line

  Estimated rural transport accessibility value was compared with the lower poverty line as presented in the following figures (map and charts). The incidence of income poverty in terms of lower poverty line corresponds to the extreme poor households whose total expenditures are equal to the food poverty line. It is found that Gazipur district ranked first in RAI having LPL is 8.2, which is lower than the national average value of 17.6. On the other hand, Rangamati district ranked last in RAI having LPL is 6.8 though which is not highest in Bangladesh. The micro analysis of Rangamati district is presented in Chapter-4 (section-4.7.3).

- **Evaluate Relational Association among the Rural Transport Accessibility and Socio-Economic Parameters**

Estimated rural transport accessibility index value of each district has been compared with the respective districts' socio-economic parameters to find out the association if any

exist. In chapter-4, it was analyzed the relational analyses and the findings of the analyses are presented here with graphs and charts.

It is found that poverty incidence is lower where the transport accessibility value is higher and vice-versa. In case of other socio-economic parameters namely, literacy rate, education facilities, health facilities and economic-industrial facilities are in higher value where transport accessibility value is higher and vice-versa. In addition to that, an individual and overall holistic score of socio-economic parameters has been developed as shown in chapter-4. It is also depicted the association with the total score to the rural transport accessibility.

- **Examine Correlation Analysis among Accessibility and Socio-Economic Parameters**

Correlation analysis was performed to substantiate the association among transport accessibility and socio-economic parameters as presented in the above section. From the results of the analysis, as presented below, it was found the correlation coefficient which indicates direction and strength of correlation among the accessibility and socio-economic parameters. After that, statistical significance test was also done to see the derived correlation happened by chance or the association exist in reality. The interpretation of the analysis results were demonstrated in Chapter-4.

From the analysis, it was found that there is a moderate correlation between Accessibility and Poverty Incidence in an inverse linear sense, i.e. with the increase in accessibility value the poverty incidence will decrease. The correlation between accessibility and other socio-economic parameters are moderate correlation in positive linear sense, i.e. with the increase of accessibility value the socio-economic facilities will crease. However, from the correlation coefficient it is evident that there is moderate strong relation in a positive linear sense between the rural transport accessibility and overall score of socio-economic parameters.

At the bottom line, it can be said that with the increase in rural transport accessibility the overall socio-economic status of the rural people will also increase that will eventually reduce the poverty incidence in rural areas.

- **Prepared Investment Priority Ranking on Rural Infrastructure**

An invest priority ranking has been developed taking into consideration the transport accessibility, poverty, and other socio-economic parameters using Data Envelopment Analysis (DEA) tool. The detail analysis of DEA was described in Chapter-4. This priority ranking will help the policy maker to take decision to allocate budget in physical infrastructure in an equitable manner with an objective to reduce poverty incidence. From DEA findings Kurigram district ranked first and Kushtia district ranked last. In fact by providing more accessibility to the rural people will eventually make the rural people to access to education, healthcare, jobs, socio-economic facilities, modern agricultural input and thereafter sell the households agro-farm production to the markets.

5.3 Conclusions

Based on the forgoing discussions the following conclusions can be drawn-

Where **Transport Accessibility** is higher there **Poverty** incidence is low, or in other words if Transport Accessibility can be increased then Poverty incidence can be decreased.

Taking into consideration the Transport Accessibility and Poverty incidence, the district priority listing has been developed to allocate budget equitably in physical infrastructure to stimulate the economic growth of Bangladesh.

Accessibility mapping will help decision maker to have visual understanding and thereupon allocating budget based on accessibility priority ranking.

There exist a correlation with transport Accessibility and Socio-economic parameters. Where the Transport Accessibility is higher the social condition is better of that area.

Eventually, improved accessibility will aide to increase the households earnings, which will give the household owner a leverage to spend for his/her family members in education, health and social linkages, which actually leads to development.

Nevertheless, the transport sector has a direct contribution to GDP at 11.53%, but its indirect contribution to GDP is enormous, since transport sector is underpinning all other sectors as a foundation. Because, say for instance if it is imagine a situation without transport accessibility then other sectors will come into a halt.

Therefore, it is indispensible to allocate budget on transport infrastructure and the priority ranking (evaluated in Chapter-4) could be a yardstick to allocate budget rationally and equitably.

5.4 Limitation of the Study

In this study, to estimate the rural transport accessibility index, only road transport network data across the country is used. Other transport modes like railway, waterway is not considered due to data source limitation, time constraints and volume of data analyses. In the calculation process to estimate the rural transport accessibility, 2-km buffer area on either side of all-weather road is considered, however within these 2-km buffer area there might be canal or other water bodies envelop within the buffer area which could not be considered and in fact is not possible to take into account due to data source limitation and for simplicity of calculation.

In data analyses, it is estimated the rural transport accessibility index for a particular year (2011) only, though, in the thesis proposal it had set-forth to analyze the time-series data. Due to data source shortcomings, it was not possible to estimate the accessibility index

for multiple years. Data Envelopment Analysis (DEA) was used for evaluating the relative efficiency of decision making unit (DMU's) to do a priority ranking for rural transport infrastructure financing. DEA is very promising technique to performance measurement. In this study DEA is used only to make priority ranking in a limited scale. However, it needs to explore further more about the DEA technique in future study.

Henceforth, even within the aforesaid limitations, the estimated rural transport accessibility index value is a good proxy to make help in decision making and planning process. It let help and make understands the decision makers to allocate the budget to physical and social infrastructure in rural areas on priority basis to reduce the poverty.

5.5 Recommendation for Future Study

Under this study, the Rural Transport Accessibility in Bangladesh was estimated considering only the road transport system. However, other modes like Railway and Waterway could not be considered due to data source limitation. In this backdrop there is promising opportunity to estimate the transport accessibility considering all these transport modes in a holistic manner.

In future, to estimate the "Rural Transport Accessibility" in Bangladesh following aspects are to be considered:

- Railway Transport System would be considered to estimate the further Rural Transport Accessibility.
- Waterway Transport System and Facilities would be considered to estimate the further Rural Transport Accessibility.
- Upazila Administrative area would be considered as the lowest unit of interest to estimate the rural transport accessibility.

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Calculate the Buffer Area within 2-km of Road in GIS

1. Introduction

In order to estimate the rural transport accessibility index, it is needed to calculate the buffer area within 2-km distance from the either side of the roads. This exercise has been done is GIS environment. Here the step by step procedure of calculating the buffer area has been presented in detail.

2. Step 1: Clip the Combine Road Layer under the Administrative Area of a District

The objective set out in Chapter-1 in this study to estimate the rural transport accessibility index of District level, therefore the all-weather accessible road as identified in section 4.2 in this chapter are clipped using the administrative District polygon of 64 Districts in GIS environment. One of the example e.g. Magura District road clipped is shown in the

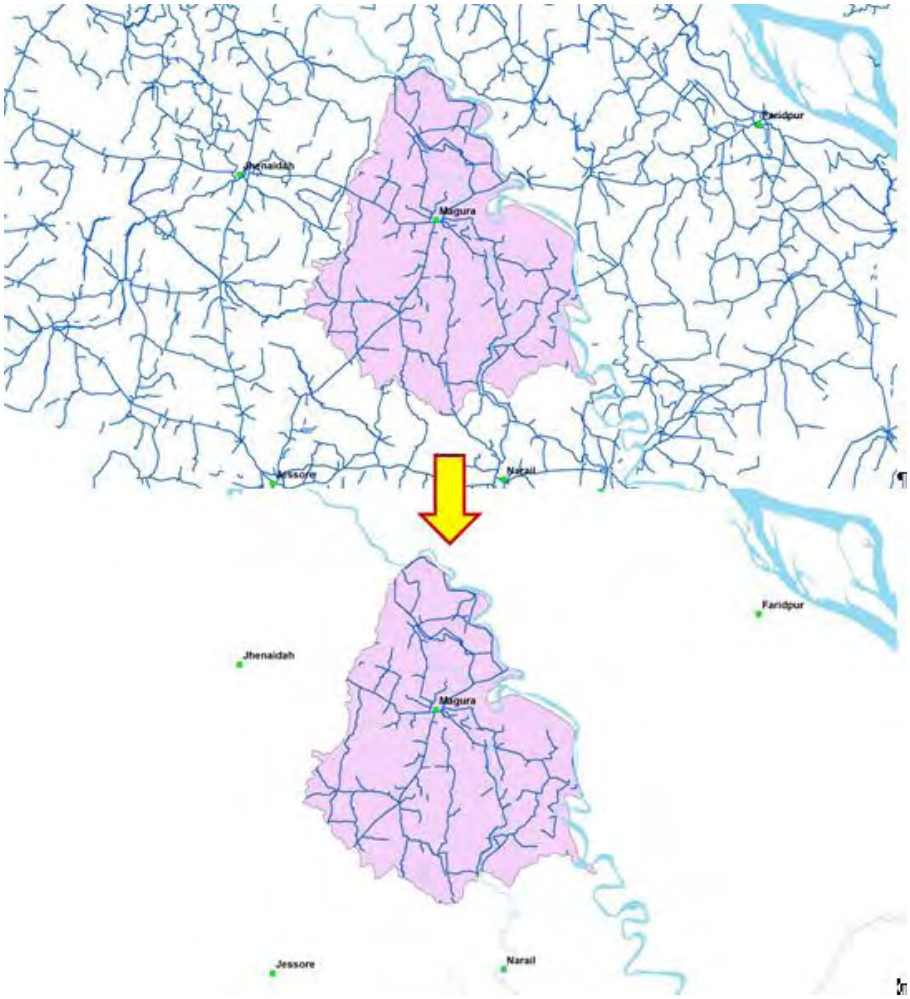


Figure-1: Extract All-Weather Road by District Administrative Area

The GIS tool used to clip the feature is shown in the figure below:

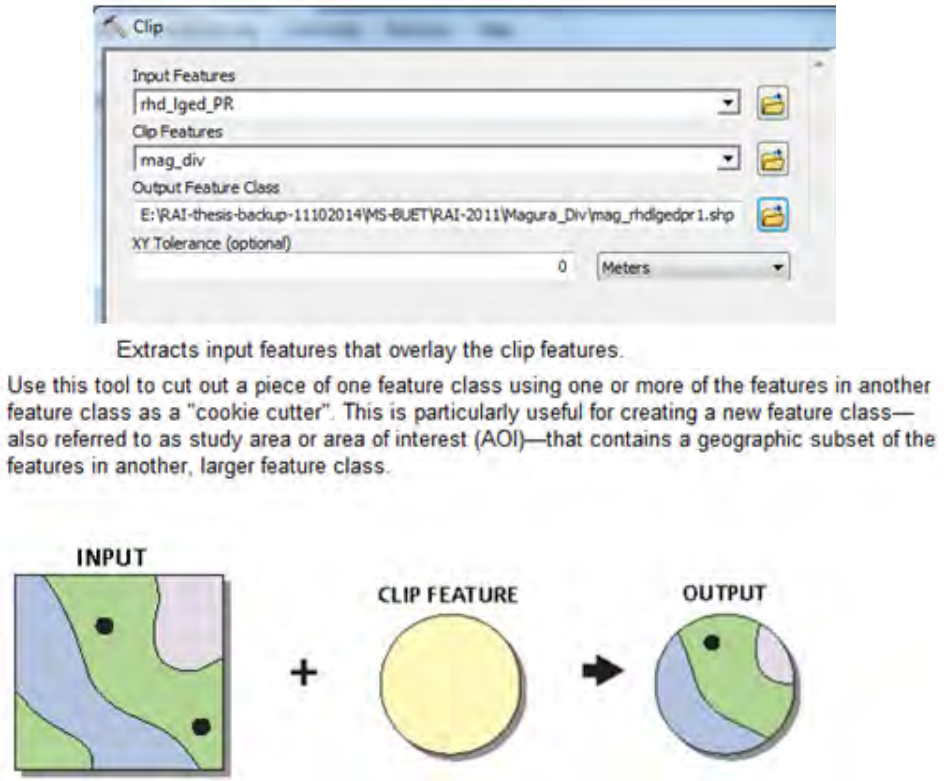


Figure-2: GIS Clipping Tool to Extract the Paved-Road by District Administrative Area

3. Step 2: Identify the 2 km buffer area on both side of an all-weather road in GIS

To find the accessible coverage area (service area) around the proximity of all-weather accessible road. The proximity distance from the centre line of the road is 2km (2000m). To find the 2km proximity area in GIS, it is done by proximity analysis tool, called ―Buffer" tool. The buffer area is shown in figure below then using this buffer area the district geo-statistical area.

Figure-3: 2km Proximity (buffer) Area Surrounding the Paved Road

The GIS buffer tool used to find the proximity area surrounding the all-weather accessible road by district wise.

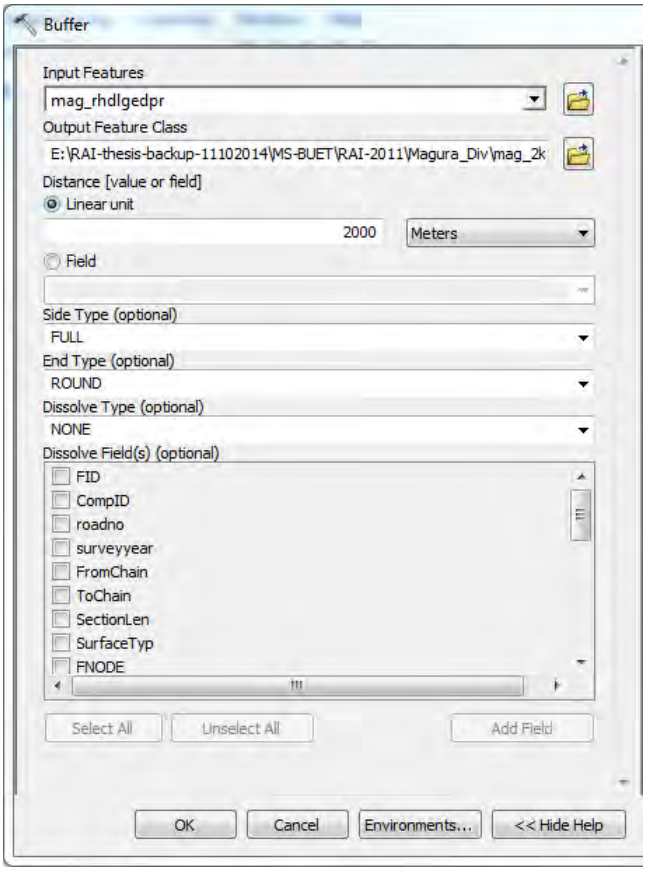


Figure-4: GIS Buffer Tool to Find the Proximity Area

4. Step 3: Using the Buffer Area Clipping the District Demographic Coverage

Using the buffer area, the District demographic coverage is extracted. The District demographic characteristics such as population, poor population, poverty, etc. to estimate the rural transport accessibility index and to establish the relationship the transport accessibility index to the poverty and socio-economic characteristics of districts.

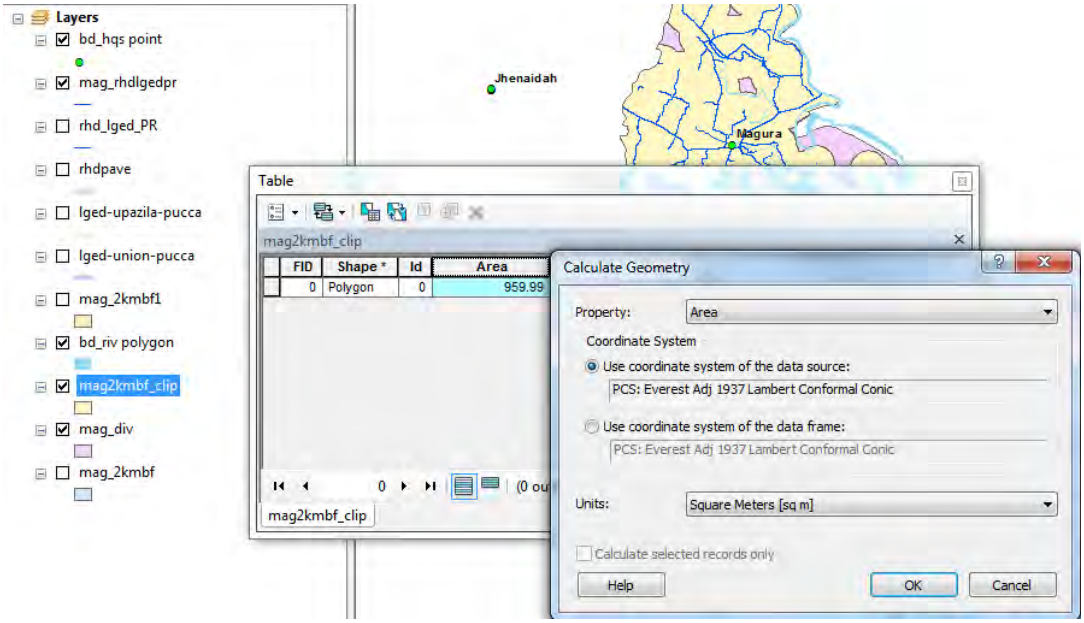


Figure-5: Calculating Proximity (buffer) Area in GIS

5. Step 4: From clipping coverage, calculate the accessible area under each "District"

From the clipping coverage as described in the section 4.3.3 in this chapter, the accessible area under each "District" are calculated in GIS is to estimate the rural transport accessibility index. This population settlement in this area is believed to have privilege in the sense of accessibility than other population who are far from 2km away off the all-weather road. Population being avail more accessible, can exploit socio-economic opportunity for their development. The following map shows the accessible area out of the total land area of each District.

DATA ENVELOPMENT ANALYSIS

1. INTRODUCTION

Many types of facility location/allocation models have been developed to find optimal patterns with respect to different location objectives such as: costs, time, coverage, and access among others. Some of these models have been formulated in a multi-objective programming framework to elicit trade-offs among different and conflicting objectives. In this study it has been used the concept of efficiency as defined by data envelopment analysis (DEA) as another objective for location modeling. DEA determines the relative efficiencies of comparable decision making units (DMUs) measured by the ratio of the sum of weighted outputs to the sum of weighted inputs, in which inputs and outputs can be measured in their natural units. Two types of efficiencies can be optimized in this way; spatial efficiency - measured the least cost location and allocation patterns for facilities, and the facility efficiencies in serving demands - measured by the DEA efficiency score for –opened" facilities (those that are chosen to operate in the optimal solution). In the next section, we provide a brief introduction to facility location/allocation and DEA models. Next, we develop and present formulations combining the uncapacitated and capacitated facility location models with the DEA model. Subsequently, we apply these models to a small hypothetical data set and present the results. Finally, the conclusions and future extensions are discussed.

2. BACKGROUND: FACILITY LOCATION MODELS

The initial focus of mathematical analysis for facility location was based upon the spatial availability of transport access to fulfill demand, targeted to enhance the rural people mobility to enable them to have access to education, healthcare, jobs, agricultural input/outputs, markets (growth centres), and other socio-economic activities to upgrade their socio-economic status. In this study, one of the indicators to measure the socio-economic status is to reduce the Poverty level that required coverage of all demand points within some time standard. A derivative of this is the proximity/closeness to all-weather road, which minimized the distance separating any facility point from its nearest location/settlement. Non-uniform distribution of these facilities was incorporated into these analyses to develop optimal and equitable deployment of resource allocation model.
In this study, 64 locational areas/units (i.e. 64-adminstrative District area) have been considered to minimize objective function –Poverty". The poverty minimization objective is overarching objective of the global agenda as well as the Government of Bangladesh.
Demand-oriented objectives focus on measuring the –accessibility" and the –closeness" of the facilities to the people –demonstrates how easily, conveniently and cheaply they can access to the facilities, where accessibility gives people the mobility and measured in terms of rural transport accessibility index and –closeness" may be measured in terms of

distance or travel time. A good location facility is one that not only optimizes the spatial interaction among facilities, and the demands they serve, but additionally, optimizes the performance (efficiency) of those facilities at the chosen locations. To evaluate the efficiency of the facilities we use a linear programming approach called Data Envelopment Analysis (DEA).

DEA, which has been used for about thirty years, was developed to address the common problem of measuring organizational efficiency when many measures of inputs and outputs are available; DEA utilizes linear programming to produce measures of the relative efficiency of comparable units that employ multiple inputs and outputs. It requires only that the selected inputs and outputs be quantifiable. The technique can analyze these multiple inputs and outputs in their natural physical units without reducing or transforming them into some common measurement. DEA takes into account these multiple inputs and outputs to produce a single aggregate measure of the relative efficiency of each comparable unit. DEA defines efficiency as the ratio of weighted outputs to weighted inputs:

$$Efficiency, \eta = \frac{weighted\ sum\ of\ outputs}{weighted\ sum\ of\ inputs} \quad \text{.....(i)}$$

The weighted output function is $\sum w_1 \times P_n$ .....(ii)

The weighted input function is $\sum w_2 \times RAI_n + w_3 \times L_n + w_4 \times E_n + w_5 \times H_n + w_6 \times EC_n$ .....(iii)

Where,

w_1 = weight of objective function
P = Poverty
n = 1 to 64
w_2 = weight of input function of RAI
RAI = Rural Access Index
w_3 = weight of input function of Literacy Rate
L = Literacy Rate
w_4 = weight of input function of Education Facilities
E = Education Facilities
w_5 = weight of input function of Health Facilities
H = Health Facilities
w_6 = weight of input function of Economic Facilities
EC = Economic Facilities

3. OBJECTIVE FUNCTION

The objective function in the DEA analysis is Poverty. Data Envelopment Analysis (DEA) is done by Data Solver tools in the Microsoft Excel workbook. As the study area concern is the 64-Districts administrative area, therefore the poverty level of these 64-Districts is the objective function. In order to set the target, it can be done by two ways:

- A preemptive threshold level (set by the Govt.); or
- Maximum poverty level (existed according to HIES-2010 report) of a District across the country

In both cases, the target is to minimize the value. The underlying argument is that through resource allocation to a particular area in an equitable and optimal fashion, where the allocation decision will be dictated by the priority ranking through DEA analysis.

4. INPUT FUNCTIONS

The multivariate inputs functions used in DEA analysis are RAI, Literacy Rate, Education Facilities, Health Facilities and Economic Facilities of each individual District. Where the RAI i.e. the rural transport access index are expressed in percent of population having access (as defined in chapter 2) to an all-weather road, Literacy Rate expressed in percent of population of literal people (as per state definition), Education Facilities expressed in percent per thousand population, Health Facilities expressed in percent per thousand population, and economic facilities expressed in percent per thousand population.

Of all the cases, the target is to maximize the facilities in order to minimize the objective function. The underlying argument is that by investing in transport infrastructure and thereby enhancing the accessibility (enabling mobility to the rural people) will reduce the poverty, as we have seen in section 3 in this report. Pondering over the other facilities, e.g. literacy rate, education facilities, health facilities, economic facilities, will act as an aiding agent to reduce the objective function. In addition, presumably it can be said that accessibility augmentation will necessarily underpinning to enhance the other input facilities value and as well as utility.

4.1 SETTING CONSTRAINT

In order to get the solution of the objective function, there are some bounded limits called the constraints. Data solver will solve the problem following these constraints set-out. In the Figure below, it has been shown how to set these constraints.

4.2 SETTING TARGET VALUE

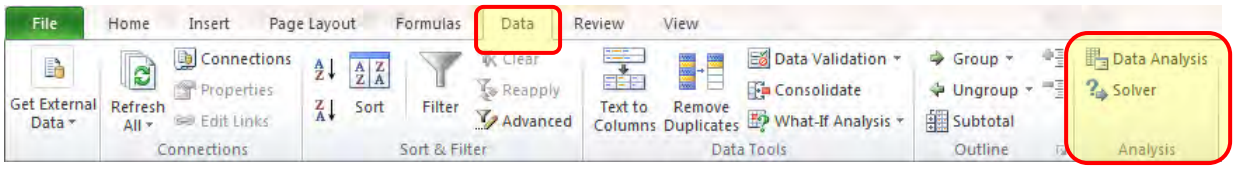
It is also needed to set the target values for which the data solver will solve the desired outcome. This target should be some sorts of threshold values for which we want the solution for the input functions.

4.3 USING SOLVER

After the DEA model is set up in the spreadsheet, we can use Solver to find the optimal solutions.

Step-1:

First, we need to invoke **Solver** tool in Excel by using the Tools/Solver menu item. In Microsoft Windows 2000 0r higher version, Click on the **Data tab**, in the **Analysis group**, then click **Solver**.



If the Solver command or the Analysis group is not available, one need to load the Solver Add-in (add-in: A supplemental program that adds custom commands or custom features to Microsoft Office.) Program.

How to load the Solver Add-in program

1. Click the **File** tab, click **Options**, and then click the **Add-Ins** category.
2. In the **Manage** box, click **Excel Add-ins**, and then click **Go**.
3. In the **Add-ins available** box, select the **Solver Add-in** check box, and then click **OK**.

Step-2: (Setting Solver Parameters) – Setting Objective

In the Set Objective box, enter a cell reference (cell reference: the set of coordinates that a cell occupies on a worksheet. For example, the reference of the cell that appears at the intersection of column C and row 67 is C67.) or name (name: A word or string of characters that represents a cell, range of cells, formula, or constant value. Use easy-to-understand names, such as Products, to refer to hard to understand ranges, such as Poverty!C2:C65.) for the objective cell. The objective cell must contain a formula.

In case of this thesis study, objective function is "Poverty" value in cell C67 of the (shown in figure below)

Step-3: Do one of the following to do the objective value

- If you want the value of the objective cell to be as large as possible, click **Max**.
- If you want the value of the objective cell to be as small as possible, click **Min**.
- If you want the objective cell to be a certain value, click **Value of**, and then type the value in the box.

In case of this thesis study, the aim is to maximize the objective function, i.e. to maximize the output function (shown in figure-1 below).

Step-4: In the By Changing Variable Cells box

Enter a name or reference for each decision variable cell range. Separate the nonadjacent references with commas. The variable cells must be related directly or indirectly to the objective cell. You can specify up to 200 variable cells.

In case of this thesis study, the changing variables are Poverty, Literacy Rate, Educational Facilities, Health Facilities, Economic Facilities and RAI (shown in figure-1 below).

Syep-5: Setting Constraints

In the Subject to the Constraints box, enter any constraints that you want to apply by doing the following:

1. In the **Solver Parameters** dialog box, click **Add**.
2. In the **Cell Reference** box, enter the cell reference or name of the cell range for which you want to constrain the value.
3. Click the relationship (**<=**, **=**, **>=**, **int**, **bin**, or **dif**) that you want between the referenced cell and the constraint.

   If it is clicked int, integer appears in the Constraint box. If you click bin, binary appears in the Constraint box. If you click dif, all different appears in the Constraint box.
4. If you choose <=, =, or >= for the relationship in the Constraint box, type a number, a cell reference or name, or a formula.
5. Do one of the following:
   - To accept the constraint and add another, click **Add**.
   - To accept the constraint and return to the **Solver Parameters** dialog box, click **OK**.

Note: You can apply the **int**, **bin**, and **dif** relationships only in constraints on decision variable cells.

You can change or delete an existing constraint by doing the following:

1. In the **Solver Parameters** dialog box, click the constraint that you want to change or delete.
2. Click **Change** and then make your changes, or click **Delete**.

Step-6: Click Solve and do one of the following:

- To keep the solution values on the worksheet, in the **Solver Results** dialog box, click **Keep Solver Solution**.

- To restore the original values before you clicked **Solve**, click **Restore Original Values**.

Notes:

- You can interrupt the solution process by pressing ESC. Microsoft Excel recalculates the worksheet with the last values that are found for the decision variable cells.
- To create a report that is based on your solution after Solver finds a solution, you can click a report type in the **Reports** box and then click **OK**. The report is created on a new worksheet in your workbook. If Solver doesn't find a solution, only certain reports or no reports are available.
- To save your decision variable cell values as a scenario that you can display later, click **Save Scenario** in the **Solver Results** dialog box, and then type a name for the scenario in the **Scenario Name** box.

4.4 DEA SOLVING METHOD

There are three algorithms or solving methods in the **Solver Parameters** dialog box:

- **Generalized Reduced Gradient (GRG) Nonlinear:** Use for problems that are smooth nonlinear.
- **LP Simplex**: Use for problems that are linear.
- **Evolutionary**: Use for problems that are non-smooth.

GRG Nonlinear model in which the objective function and all of the constraints (other than integer constraints) are smooth nonlinear functions of the decision variables is called a nonlinear programming (NLP) or nonlinear optimization problem. Such problems are intrinsically more difficult to solve than linear programming (LP) problems. NLP Solver must compute or approximate derivatives of the problem functions many times during the course of the optimization.

The GRG Nonlinear Solving method uses the Generalized Reduced Gradient method as implemented in Lasdon and Waren‘s GRG2 code. The GRG method can be viewed as a nonlinear extension of the Simplex method, which selects a basis, determines a search direction, and performs a line search on each major iteration – solving systems of nonlinear equations at each step to maintain feasibility.

In case of this thesis study, Linear Programming (LP) solving method has been used, since the objective and inputs functions and constraints are non-linear function of the decision variables.

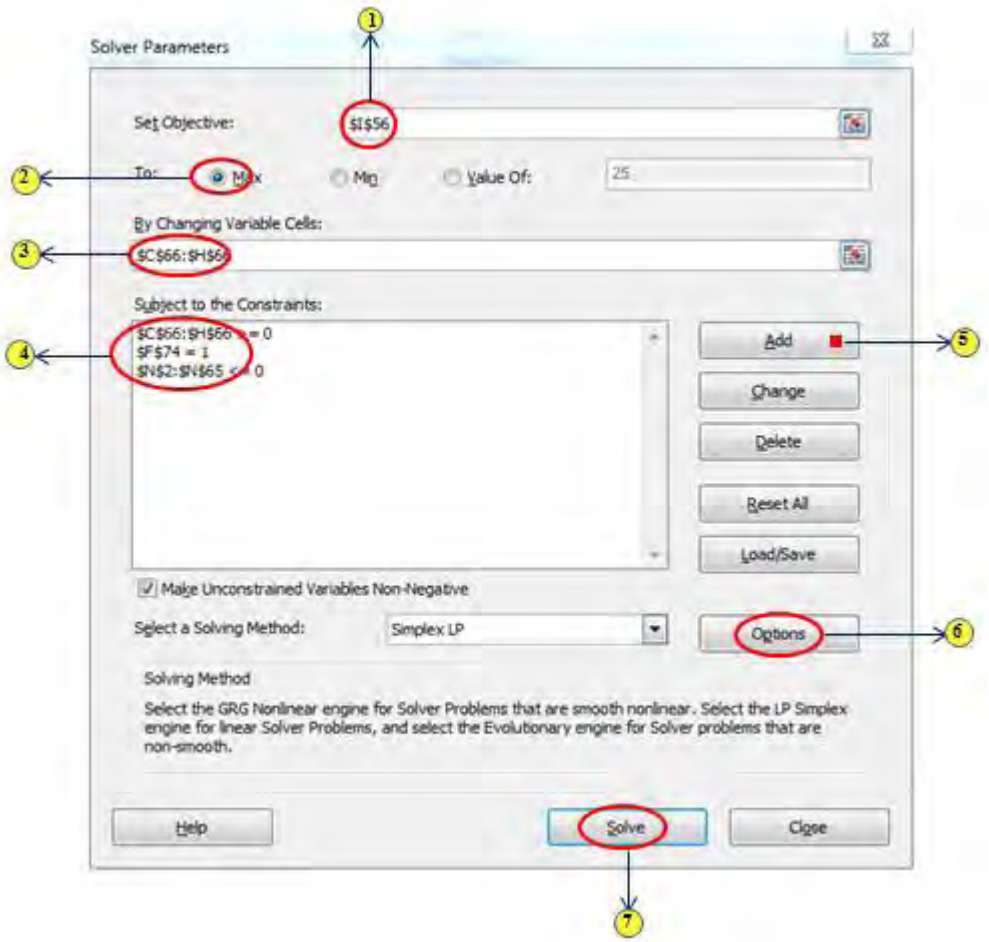


Figure-1: Solver Parameter Dialog Box in DEA

4.5 Options

1. In the "Solver Parameters" dialog box, click "Options".
2. In the "Solver Options" dialog box, on the Simplex LP tab, choose one or more of the following options:

Convergence

- In the "Convergence" box, type the amount of relative change that you want to allow in the last five iterations before Solver stops with the message "Solver converged to the current solution." Smaller values here usually mean that Solver will take more time, but will stop at a point closer to the optimal solution.

Derivatives

- In the Derivatives group box, select "Forward" to estimate derivatives through forward differencing, or select "Central" to estimate derivatives through central differencing. Forward is the default choice. Central differencing yields more accurate

derivatives, but requires twice as many calculations of the worksheet at each new trial solution.

MultiStart Options for Global Optimization

- Select the "Use Multistart" check box to use the multistart method for global optimization. If this box is selected when you click Solve, the GRG Nonlinear method will be run repeatedly, starting from different (automatically chosen) starting values for the decision variables. This process may find a better solution, but it will take more computing time than a single run of the GRG Nonlinear method.
- In the "Population Size" box, type the number of different starting points (values for the decision variables) you want the multistart method to consider. The minimum population size is 10; if you supply a value less than 10 in this box, or leave it blank, the multistart method uses a population size of 10 times the number of decision variables, but no more than 200.
- In the "Random Seed" box, type a positive integer number to be used as the (fixed) seed for the random number generator used to generate candidate starting points for the GRG Nonlinear method. If you enter a number here, the multistart method will use the same starting points each time you click Solve. If you leave this box blank, the random number generator will use a different seed each time you click Solve, which may yield a different (better or worse) final solution.
- Select the "Require Bounds on Variables" check box to specify that the multistart method should run only if you have defined lower and upper bounds on all decision variables in the Constraints list box. The multistart method is far more effective if you define bounds on all variables; the tighter the bounds on the variables that you can specify, the better the multistart method is likely to perform.

NOTE: You can click the Help button in the dialog box to get more information about other options.

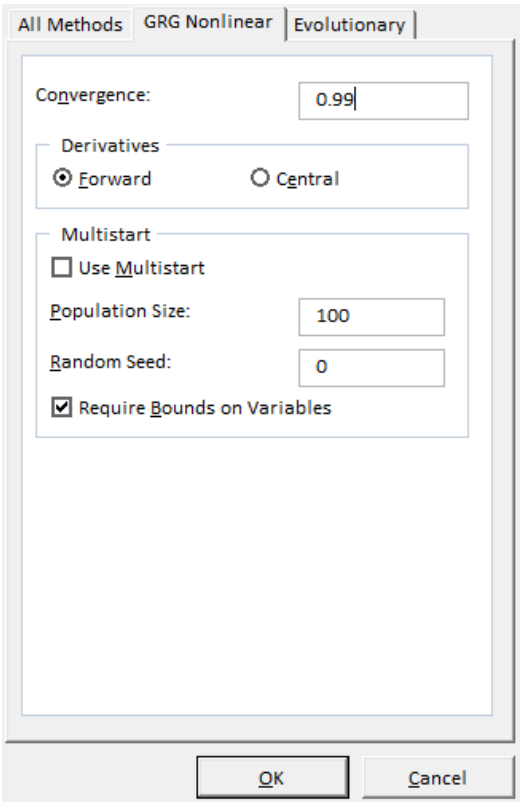


Figure-2: Solver Option Dialog Box

4.6 SOLVER RESULTS

After setting all the parameters and options as stated earlier, click on –Solve" button as shown in Figure 1.1. On clicking, it will popup the following where check the radio button of –Keep Solver Solution".

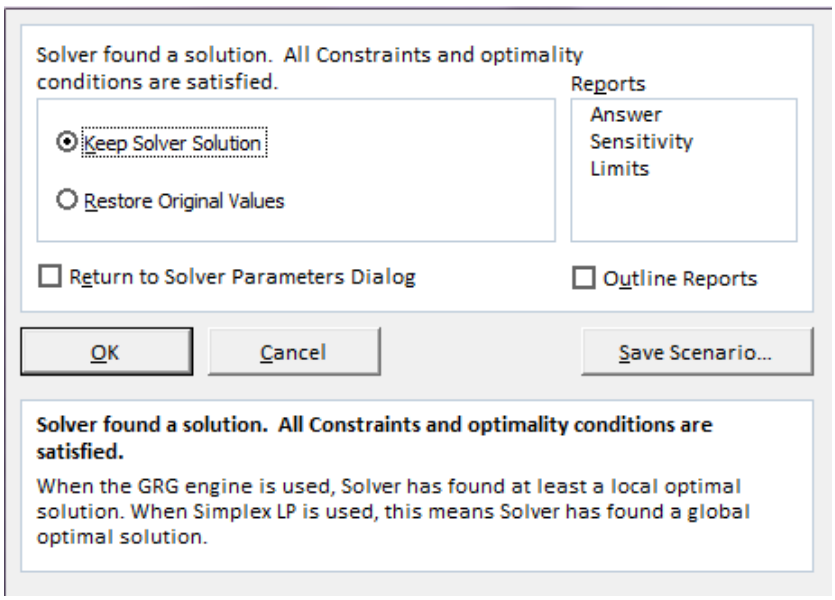


Figure-3: Solver Results Dialog Box and Settings