MEASURING ACCESSIBILITY INDEX FOR RURAL AREAS: AN ACTIVITY BASED APPROACH

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It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any degree or diploma.

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RAKTIM MITRA

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Abstract

In the context of rural areas, accessibility or the quality of access is determined by the extent to which it connects the locality to basic access, market opportunities for agricultural products and employment opportunities. Good access can increase productivity of a rural area, induce non- agricultural employment also improve socio economic condition by increased income and increased supply of various products and necessities.

This study has examined the applicability of three accessibility measurement methods- Isochrone model, Geographic model and Potential (Gravity) model to determine the accessibility indices for rural mouzas in respect to their access to service centres. Pourasava, Union Headquarters and growth Centres have been considered as service centres. Geographic Information System (GIS) has been used as a tool for measuring distance. Transportation system has been classified as *pucca* road and *katcha* road; while network distance has been measured on the basis of generalized travel time.

The study findings reveal that Potential accessibility model can best represent the Overall Accessibility Level (OAL) of the mouzas as measured by a questionnaire survey, and therefore, is regarded as the best option to measure the accessibility the rural localities. Isochrone model could explain only 43.8% of the changes in the accessibility index values of the mouzas, and was rejected as an option for accessibility measurement. Potential model was finally chosen on the basis of Rank Correlation analysis, as it could explain 86.2% of the variations of the accessibility levels compared to 69.4% explained by Geographic model.

The study outcomes suggest that the accessibility of the rural areas is affected by both the availability of service centres and also the availability of *pucca* roads. Another interesting finding of the study is that the areas with high accessibility remain distributed along the major transportation network, which might have significant implications in rural development and transportation planning strategies in respect of Bangladesh

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Supervisor: Professor Dr. Sarwar Jahan, Department of URP, BUET.

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Chapter 1

INTRODUCTION

1. Introduction

1.1 Background of the Study

Bangladesh's population is mostly rural with 76.6% (BBS, 2002) of the total population of the country living in rural areas. Therefore, the physical and socio economic development of rural areas are likely to be the key factor for the national economic development. However, this large population is principally dependent on agriculture for their livelihood. Agriculture sector employs 69 percent of the national labour force and produces of the country, directly and indirectly (The World Bank, 1996).

After the independence of Bangladesh, agricultural products have grown at a rate of 2.5% per annum, barely above the population growth rate of the country. Three factors are said to be the main reasons for the growth of agriculture- expansion of acreage, increase of yield and introduction of higher value crops (The World Bank, 1996).With limited resources and severe scarcity of land, improvement in agriculture is therefore increasingly being dependent on access to improved technology and proper supply of seed and fertilizer. Good access can induce non-agricultural employment to the rural areas and also improve socio economic condition by increased income and increased supply of various products and necessities.

Accessibility to the rural regions is provided by rural road network. Although the term accessibility is generally defined as "the ability to reach desired goods, services, activities and destinations" (Victoria Transport Policy Institute, 2003), in the context of rural areas the quality of access is determined by the extent to which it connects the locality to "basic access", market opportunities for agricultural products and employment opportunities. Therefore, the role of rural roads in the development of rural areas can hardly be over emphasized. Studies have proved that the development of transport facilities fosters economic development by causing a kind of "network effect" in the adjoining regions by improving their position in respect of the hierarchy of rural road network and thereby increasing accessibility of these places relative to other places and among themselves as well (Peeters *et al*, 2000).

Theories suggest that increased accessibility may replace "fertility as a determinant of land rent" in an agricultural economy and therefore cause redistribution of economic activities (O'Sullivan, 1996). Empirical studies also proved definite relationships between increased accessibility and consequential economic development of the regions.

Since 1979, the basic policy interventions for rural infrastructure development in Bangladesh have followed a Growth Centre Approach, which emphasize on the improvement of large rural markets to foster rural development (Khan, 1987). The basic approach of rural road network development in Bangladesh has also followed somewhat the same strategy, and it is expected that improved accessibility to the growth centres would accelerate socio economic development of the rural regions and their population. The recent policy interventions also explicitly states that transport projects should be designed to maximize the benefit to the poor (GOB, 2004).

The accessibility of various locations is best measured and compared by some forms of Accessibility Index. There have been substantial studies throughout the world to develop appropriate theories and explore empirical implications of various accessibility indices which followed three basic methodological approaches namely infrastructure based accessibility measures, activity based accessibility measures and utility based accessibility measures. In Bangladesh, although there have been some empirical studies on accessibility analysis in the urban context, no significant research have been conducted on the implications of accessibility index for rural areas.

Under these circumstances, the research is an attempt to develop an appropriate accessibility index for the rural areas in Bangladesh in respect of their access to growth centres, and therefore, focusing principally on activity based measurement methods. It is expected that the outcomes of the research would be a good indicator of the implications of road network development in rural development, and therefore, may help the transport sector appraisal process by maximizing the benefits to the rural localities.

1.2 Research Objectives

The objectives of the proposed research may be outlined as follows-

- To review and examine various methods of measuring accessibility index for the rural localities of case study area in respect of their proximity to service centres.
- To choose an appropriate methodology to measure accessibility index for rural areas in the context of Bangladesh.

1.3 Methodology of the Study

The study attempts to measure accessibility index for the rural areas in respect to their proximity to the service centres. Activity based accessibility measurement measures have been applied in the research, with the aid of Geographic Information System (GIS) and available spreadsheet softwares. The methodology of the study may be discussed in three major steps; initial stage, intermediate stage and final stage (Figure 1.1)

1.3.1 Initial Stage of Research

1.3.1.1 Literature Search and Review: At the very first stage of the study, extensive literature have been consulted in the form of books, journals, previous researches and internet sources. This review has helped to develop a clear concept of accessibility and also of the accessibility measurement measures. The transportation and rural development studies and strategies of the Government of Bangladesh have also been reviewed to understand the problem and potentials in Bangladesh perspective. Activity based accessibility measures have been selected as the basic approach of the study.

1.3.1.2 Setting of Research Objectives. Based on the understandings of the literature search, the objectives of the study was determined.

1.3.1.3 Selection of Study Area: Meherpur Sadar Upazila was initially selected as the study area for the research. Later after the field investigation, the study area was

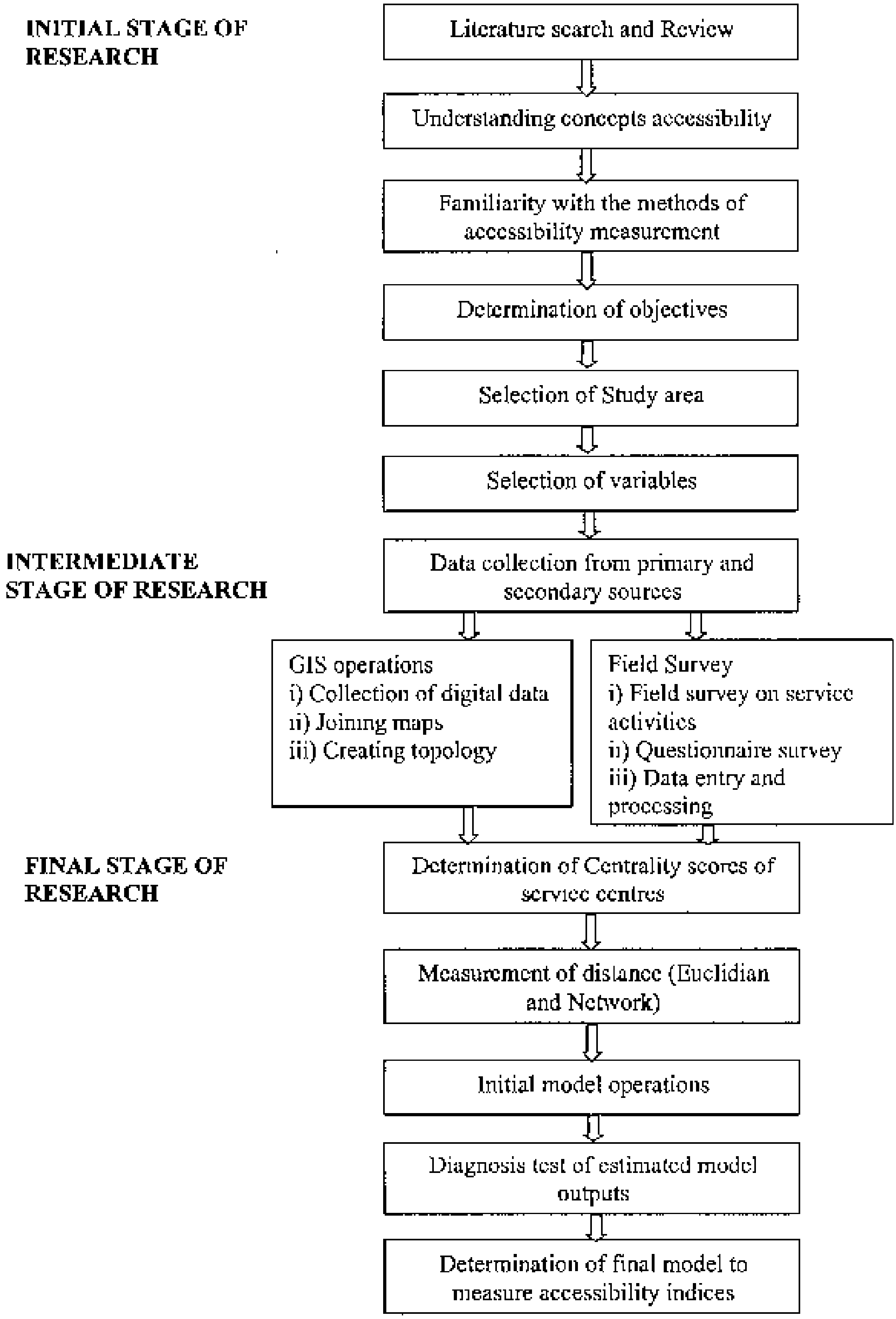


Figure 1.1: Methodology of the Study

increased to include two Upazilas; Meherpur Sadar and Mujibnagar, both in the Meherpur District. These two Upazilas are adjacent, and the retail activities and trips made to them are overlapped between the two Upazilas.

1.3.1.4 Selection of Variables: At this stage of investigation, specific criteria and variables were selected to be used in the study. Mouza was selected as the geographic unit for which accessibility indices would be measured, and transportation impedance (distance) was decided to be determined on the basis of generalized travel time

1.3.2 Intermediate Stage of Research

1.3.2.1 Collection of GIS Data and Preparation of Required GIS Database: The study was greatly supported by the digital Geographical Information System (GIS) database collected from Local Government Engineering Department (LGED) during June 2005. The database included data of natural features, administrative boundaries and headquarters, transport infrastructure and socio economic infrastructure including markets.

To use in this study, the digital data of Meherpur Sadar Upazila and Mujibnagar Upazila was used. The attributes of the two maps were adjusted and matched by using EDGEMATCH command of the ArcInfo Workstation of ArcGIS 9.0 software. Later each attribute were joined together using APPEND command. During this operation, the topologies of the coverages were rebuilt deleting the previous attributes. Therefore new attributes were added to these coverages as required. The study used three major output coverages for analysis; mouza boundary, road network and service centres. A list of coverages has been shown in Table 1.1.

1.3.2.2 Field Survey: Field surveys were conducted to aid the study at different levels. At the early stage of the study, a physical survey was conducted at the service centres which counted the total available activities at the selected service centre and also collected data on the average daily transaction of those activities. Another survey was conducted in eight sample mouzas to measure Overall Accessibility Level (OAL) of the mouzas. The survey was conducted following Key Informant Discussion method.

Table 1.1: GIS Coverages used in the Study

Name of the Coverage	Major Attributes	Description
MOUJA1	Polygon	Mouja boundaries
HQMH	Point	Administrative headquarters of Meherpur Sadar Thana
HQMJ	Point	Administrative headquarters of Mujibnagar Thana
ROADF	Arc	Road network and types of roads
RETAILF	Point	Selected service centres in the study area
RIVER	Polygon	Rivers in the study area

1.3.3 Final Stage of Research

1.3.3.1 Initial Modeling: At this stage of the study, accessibility indices for the mouzas were calculated applying three selected models; Isochrone model, Geographic model and Potential (Gravity) model. The models required two basic attributes; hierarchy of service centres was calculated on the basis of field survey, whereas distance was measured with the aid of GIS with NODEDISTANCE command of ArcGIS 9.0 Workstation module and some AVENUE scripts of ArcView 3.2.

1.3.3.2 Diagnosis of Estimated Models: The results of three models were then tested against another index of Overall Accessibility Level (OAL) estimated from a key informant survey at eight mouzas. The outputs of the three models were compared with the results of questionnaire survey using correlation analysis.

1.3.3.3 Determination of final Accessibility Measurement Model: Based on the findings of the correlation analysis, Gravity model was identified as the most effective model explaining the accessibility condition of the rural localities in respect to their access to the service centres.

1.4 Scope of the Study

This study has examined the applicability of three models, Isochrone model, Geographic model and Gravity model, to measure the accessibility indices for the rural areas in respect to their access to service centres. Mouza was taken as the geographic unit for which accessibility was measured, while major market centre at Union Parishad headquarter and the designated growth centres were considered as service centres. The model outputs have been compared with the results of a questionnaire survey to choose the best approach that can explain the accessibility level of the rural areas. However, the study has entirely focused on the methodology of measuring accessibility for the study area; and therefore the interpretation of the resultant accessibility levels (i.e., the cause effect relationship) was not included within the scope of the study.

1.5 Limitations of the Study

During the study, no empirical evidence was found of measuring levels of accessibility for rural areas in the context of Bangladesh. Therefore, the study had to rely on the basic accessibility measurement models. The applicability of these models in the rural areas is not tested, so three models had to be applied simultaneously. However, unavailability of secondary data restricted the use of variables in the models.

However, the major problem was to determine the best applicable one, as three models resulted in different patterns of accessibility index values. Socio-economic data of the rural localities (mouzas) could be a good indicator of the level of accessibility of the areas, as higher accessibility tends to improve socio-economic condition of the region. But this could not be done because of unavailability of secondary data. Under the circumstances, the study had to compare the outputs with the results of a key informant survey made on the rural elites. In the survey, the Overall Accessibility Level (OAL) of the rural areas was calculated based on selected activities. A measure based on all the activities available and taking sample respondents from all social class could make the result more comprehensive.

Finally, in this study, accessibility of the localities was measured on the basis of their proximity to the service centres. The affect of activities located otherwise on the level of accessibility could not be counted for. The affect of large service centres outside the study area also could not be considered.

1.6 Organization of the Study

The thesis comprises of nine chapters. The first chapter provides an introduction to the study with a brief discussion on the methodology followed. The second chapter discusses on the concepts of accessibility, its impacts on economic development and the accessibility measurement methods. The third chapter provides an outline of the transportation and development strategies of the Government of Bangladesh in respect of rural areas. The fourth chapter consists of an introduction of the study area.

The next chapters of the thesis discussed on the methodology of the accessibility measurement. The fifth chapter discusses on the basic model structures applied in this study with a discussion on the variables used. The sixth chapter discusses the method of determining hierarchy of service centres, while the seventh chapter discusses the methods used in measuring distance.

The eighth chapter discusses the outputs of the model operation and the diagnosis test. Finally the ninth chapter concludes the thesis report with some general comments based on the study finding.

Chapter 2

CONCEPT OF ACCESSIBILITY

2. Concept of Accessibility

Accessibility is a key element of transport geography as it is a direct expression of mobility either in terms of people, freight or information (Rodrigue, *nd*). Though accessibility is a widely used term in the arena of transport planning, it is an abstract concept. There have been multi disciplinary and multi dimensional perspectives in the study of accessibility; researchers have defined it in various ways depending on specific purpose and have developed numerous mathematical formulations to measure its value. Therefore, it is important to understand the concept and scope of accessibility and related analysis in relation to this particular study.

2.1 Definition of Accessibility

The word "Accessibility" or "Access" have many meanings and implications in the field of development and planning. Accessibility may be defined as the "measure of the capacity of a location to be reached by, or to reach different locations" (Rodrigue, *nd*). In a more simple term, accessibility, or simply access, may be defined as the ability to reach desired goods, services, activities and destinations (together called opportunities) (Victoria Transport Policy Institute, 2003). Thus accessibility is linked with an array of opportunities, either economic or social. Habib (2004, p6) writes the variability of implications of accessibility in the following way-"A step ladder provides access to the top shelf of our kitchen. A store provides access to goods. A library, telephone and the internet provide access to various types of information. A highway or transit improvement can increase the services and jobs accessible from a neighbourhood."

In the field of transport planning, the implications of accessibility may differ depending on the contest of planning. In an urban context, "access" refers to connections to the adjacent properties. A roadway with "limited access" has minimal connections to the adjacent properties, while a local or access road provides more direct access. But in the rural areas, quality of access is determined by the extent to which a locality is connected to "basic access", market opportunities for agricultural products and employment opportunities. A region with well developed transportation system is expected to offer high level of accessibility, while less developed transportation networks would result in lower level of accessibility.

Sometimes, the concept of accessibility is well understood with another related notion "Proximity". Proximity can be defined as the physical nearness in space or time of various actors and elements in a region, combined with multiple interdependencies between these elements (Crevoisier, 1996). A place's accessibility, from this perspective would be a function of its proximity (measured in time, distance or generalized cost for example) to alternative destinations of varying utility (Alam, 2001).

Therefore, access may be termed as the ultimate goal of most transportation, except the small portion of travel in which movement itself is an end in itself (e.g cruising, historic train rides, horseback riding or jogging). The capacity and structure of the transport infrastructure are key elements in the determination of accessibility.

2.2 Characteristics of Accessibility

Accessibility can be viewed from various perspectives, such as from the perspective of a particular location, a particular group, or a particular activity. It is therefore important to specify the perspective being considered when describing or evaluating accessibility. The need for accessibility generally rises from the need to reach resources, jobs, health, education, employment etc. (Janelle, 2002). Accessibility on the other hand reflects generalized costs (time, money, discomfort and risk) to reach these activities (Victoria Transport Policy Institute, 2003). Where the marginal financial cost of travel is relatively low, travel time tends to be the most dominant component of accessibility. Individuals often evaluate accessibility in terms of convenience, i.e. the ease with which they can reach what they want.

Given enough time and money, nearly every location on earth is accessible. But the degree of accessibility varies widely, depending on the location, time and person. "The relative degree of accessibility affects where one goes, what one does, ..., and one's opportunities for education, employment and recreation." (Victoria Transport Policy Institute, 2003). Accessibility can affect type of business, property values and economic development that occur in an area.

However, accessibility, or more precisely transport accessibility, can be evaluated at various geographic scales-

- Building or site: Pedestrian mobility
- Block, neighbourhood, or village: Pedestrian facility and connection between buildings, transit access, and local streets.
- Municipality or community: Arterials, bridges, transit services, routes
- Regional: Arterials, highways, bridges and ferries, and transit service.
- Interregional: Highways, interregional bus and rail service, and air service.

Sometimes accessibility is affected by the transport options (Figure 2.1). Transport options (may be called transportation density and transportation choice as well) refer to the quality and quantity of transportation services available to a particular type of user under particular condition (Victoria Transport Policy Institute, 2003). Improved transport options tend to improve access.

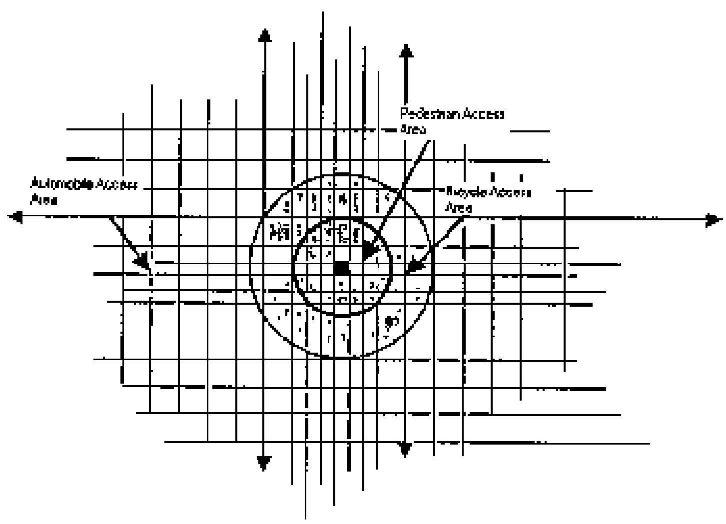


Figure 2.1: Effects of Transport Options on Accessibility
Source: Victoria Transport Policy Institute (2003)

The roadway network also affects the level of accessibility. Figure 2.2 represents a typical pattern of hierarchical road network, with many dead end streets connected to a major arterial or highway. In this type of network, there is no direct connection between the minor roads which connects the localities, and most of the trips are directed through the arterial. This pattern of layout reduces access as they require longer trips to reach destinations.

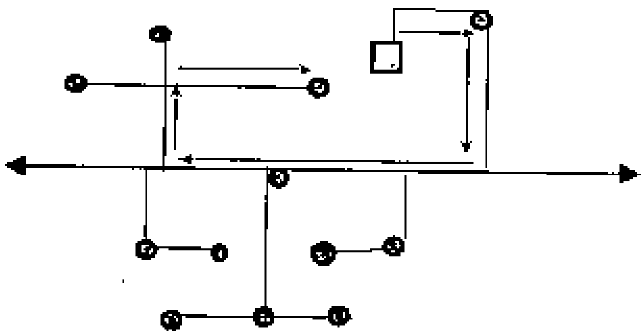


Figure 2.2: Accessibility in Hierarchical Road Network
Source: Victoria Transport Policy Institute (2003)

To sum up, the notion of accessibility consequently relies on, and can be expressed by two core concepts-

Firstly, **Location**, where the relativity of places is estimated in relation to the transportation infrastructures, since they offer the mean to support movements,

And secondly, **Distance**, which is derived from the connectivity between locations. Connectivity can only exist when there is a possibility to link two locations through transport (Rodrigue, *nd*). It expresses a friction of space (or deterrence) and the location which has the least friction relatively to others is likely to be the most accessible. Commonly, distance is expressed in units such as kilometers or time, but variables such as cost or energy spent may also be used.

There are, however, two spatial categories applicable to accessibility problems, which are also interdependent. The first type is known as **topological accessibility** and is related to measuring of accessibility in a system of nodes and paths (a transportation network). It is assumed that accessibility is a measurable attribute significant only to specific elements of a transportation system, such as terminals, or bus stops etc. Accessibility is measured only for nodes, while the intervening spaces are not considered outside the distance they represent.

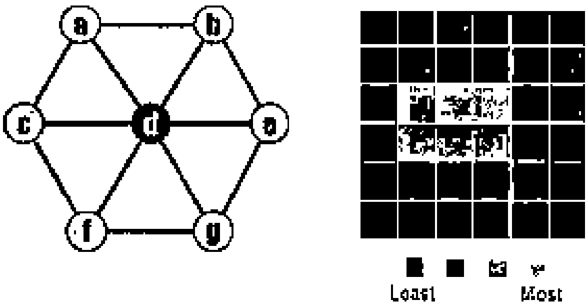


Figure 2.3: Topological (Left) and Contiguous Accessibility (Right)
Source: Rodrigue (*nd*)

The second type is known as **contiguous accessibility**, and involves measuring accessibility over a surface. Under such conditions, accessibility is a measurable attribute of every location, as space is considered in a contiguous manner. Spaces in this case are not considered as isometric, implying an unequal effect on the friction of space.

In this particular study, concentrations have been made basically on topological accessibility, the friction of space between localities have been overlooked.

2.3 Accessibility and Economic Development

It has been argued over the years that a reliable and efficient transportation infrastructure is one of the key factors that play pivotal role in the economic development of the regions (Ozbay *et al.*, 2003). This is principally due to the fact that a well- developed transportation network provides adequate access to the regions, which in turn is a necessary condition for the efficient operation of production, retail, labour and land markets.

Benister and Berechman (2000) provided a general framework that describes the relationship between the transportation system and economic growth (Figure 2.4). The figure show that improved accessibility changes the travel pattern of the regions, which in the long run changes land use pattern and also fosters economic development.

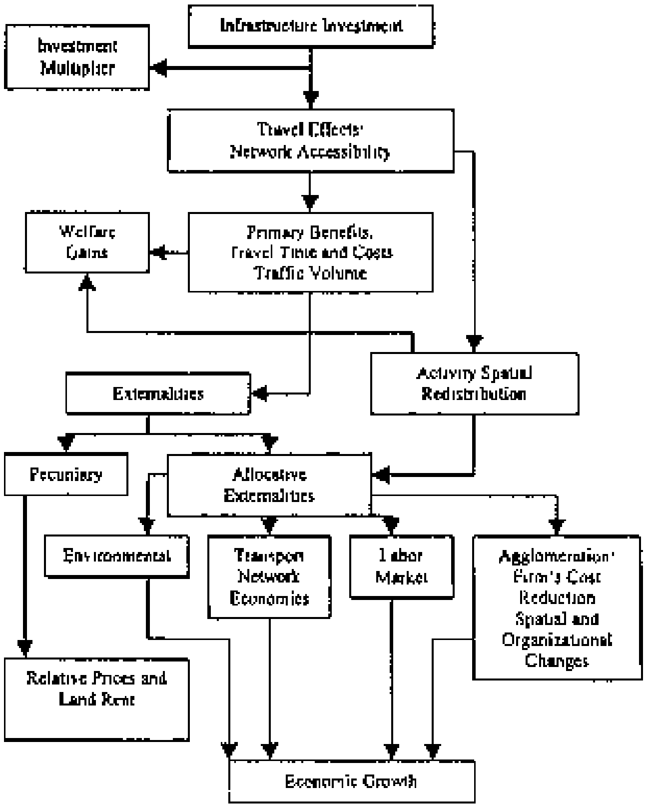


Figure 2.4: Relationship between Accessibility and Economic Development
Source: Benister and Berechman (2000)

A review of the literature on the relationship between transportation infrastructure (or accessibility as its resultant) show that researchers have reached to somewhat similar conclusion irrespective of their methodological approaches or types of data employed.

Forkenbrock and Foster (1990) have studied the economic benefits of corridor highway investment. An input- output model was applied to evaluate four alternative routes in a corridor connecting two large metropolitan areas in the United States The study concluded that highway investments promote local economic development by lowering transportation cost relative to other locations.

Aschauer (1991) has analyzed the relationship between transportation infrastructure spending and economic growth and labour productivity using a production function based growth model. The study used annual changes in the output per employee in the 48 continental US streets as the dependent variable. The study's principal finding was that that the effect of total transportation expenditure on the growth rate of the ratio of private capital to labour is high.

Boarnet (1996) has tested the way highway investments redistribute the economic activities by dividing the economic impacts of the transportation infrastructure into direct and indirect effects. The impacts on locations near highways were considered as direct effect, while impacts on locations distant from highways were taken to be indirect effect. The study used data like county employment, using capital stock in the county and other counties as independent variables and the county's output as the dependent variable. The conclusion of the study was that the direct and indirect effects of transportation development were of equal and opposing magnitude.

Clay *et al.* (1988) in their research have found that transportation development is central to economic development, based on the fact that large spending on highways has been accompanied by rapid employment growth in metropolitan areas.

A quasi- experimental analysis was made by Isserman *et al* (1988) to investigate the effect of highways on smaller communities and rural areas in the US. They examined income growth rates during a period of 25 years for 231 small rural cities, some with highway access, and some without It was found that the cities located near highways had faster economic growth.

2.4 Measures of Accessibility

Even though the concept of accessibility is widely accepted and practiced, there is no universal method for measuring accessibility, as the definition and scopes of accessibility varies significantly based on the specific research goals In some researches, concentrations are made on *physical* accessibility, which measures peoples' ability to reach transport facilities or other opportunities, while other researches focus on *social* accessibility which measures peoples' utility as a resultant from their access to various destinations or opportunities.

2.4.1 Types of Accessibility Measurements

In general, various methods of accessibility measurements can be divided in to the following three groups (Hilber and Arendt, 2004) -

Infrastructure Based Accessibility Measures: These methods are principally founded on the performance of the transport system (e.g. travel speed), and are principally in the urban context, where already developed road network exists.

Activity Based Accessibility Measures: These methods measures accessibility based on the distribution of activities in space and time. Activity based accessibility measures may further be subdivided into following major mythological approaches

- Contour/ Isochrone measures
- Geographical measures
- Potential accessibility measures
- Space time measures

Utility Based Accessibility Measures: These types of measures are founded on the benefits people derive from access to the spatially distributed activities. Utility based measures are based on random utility theory (RAM) which assumes that people select an alternative with the highest utility (Dong *et al.*, 2004).

The basic purpose of this research is to measure accessibility index for the rural localities. It is accepted that rural roads are the means to provide accessibility to the settlements and as the rural areas do not have developed road network and adequate alternatives to travel, infrastructure based accessibility measures are not applicable as the methodological approach for this particular research. Again, utility based accessibility measures work on two interconnected but opposing components consisting of observable attributes & characteristics of decision makers and unobservable disturbances, and therefore the notion of utility is not known with certainty to the analyst (Dong *et al.*, 2004). Under the circumstances, this research focus on activity based accessibility measures as the methodological approach to achieve its objectives.

2.4.2 Activity Based Accessibility Measurements

As stated earlier, the basic approach of activity based accessibility measures is the distribution of activities over space and the ability of people to reach those activities. Various activity based measures have been discussed below-

2.4.2.1 Contour/ Isochrone measures

This type of accessibility measures is also called "cumulative opportunity" measures (Dong *et al.*, 2004). They count the number of opportunities that can be reached within a given travel time, distance, or generalized cost. The basic equation of Isochrone measures can be shown as follows-

$$Acc_i = \sum_j W_j a_j \qquad (2.1)$$

Where a_j represents the opportunities in zone j

W_j equals 1 if $c_{ij} \leq c_{ij}^*$, and 0 otherwise

c_{ij} is a measure of impedance between zone i and j

c_{ij}^* is the pre determined range within which the activity opportunities are counted

An example of an Isochrone measure is the "total number of schools within 30 minutes of travel". In some researches, this measure has been named as "Container Index" (as in Alam, 2001). In this particular method count of facilities (measure of service provided) by any geographic unit- ward, *mouza*, planning district, Upazila etc. would be equally valid. The main strength of this measure is that it is easy to compute and understand. However, this measure of accessibility is highly se3nsitive to the size of the range (30 minutes in the above example) and the representation of opportunities (number of schools), both of which are quite difficult to determine.

2.4.2.2 Geographic Measures

Geographic measure is another rather simple but practical approach of accessibility measure which assumes that the accessibility of a location is the summation of all distances between another locations pondered by the number of locations (

Rodrigue, *nd*). The lower its value, the more the location is accessible. The basic formulation of Geographic measure of accessibility may be given by the equation-

$$Acc_i = \sum_j d_{ij} / N \qquad (2.2)$$

Where d_{ij} represents the distance or opportunity cost between origin i and destination j

N represents total number of opportunities available

Sometimes, this method is defined as a measure of *travel cost*, as they are adopted from locational optimization models. It is therefore a simple measure of the total or average distance between each origin (localities) and all destinations (opportunities or activities).

2.4.2.3 Potential accessibility measures

Potentially activity measures (commonly known as "Gravity measures" or simply "Potential measures") This concept is of fundamental importance to modern scientific geography because it makes explicit and operational the idea of relative as opposed to absolute location (Haynes and Fotheringham, 1988). Potential accessibility works on two major components: a transport component, essentially the distance, travel time or opportunity cost between zones, and a land use component determined by the activity opportunities per zone. In this method facilities are weighted by their size and adjusted for the "friction of distance" for each location, the computed accessibility score characterizes the potential supply of services by every facility in a region. The standard equation for the Gravity model, as modified from the Reilly's Law of Retail Gravitation (Haynes and Fotheringham,1988) may be represented as-

$$Acc_{ij} = k P_i^{\lambda} P_j^{\alpha} / d_{ij}^{\beta} \qquad (2.3)$$

Where P_i and P_j represents population of zones i and j

d_{ij} represents distance between locations

β represents distance decay parameter

k represents scale parameter based on empirical formulations

However, various researches have also used simpler forms of potential accessibility models. (See Froast and Spence, 1995; Suxia and Seong, 2000; Alam, 2001; Hilber and Arendt, 2004; Rodrigue, *nd.*) Hilber and Arendt (2004) used in their study the following accessibility model-

$$\text{Acc}_i = \sum_j D_j \times F(C_{ij}) \qquad (2.4)$$

Where D_j is the number of activity points in zone j

C_{ij} is the generalized travel cost between zone I and zone j, and

$F(C_{ij})$ is the impedance function where $F(C_{ij}) = e^{-\beta . C_{ij}}$

Here the parameter β determines the weighting of activity opportunities. The higher the values of β, the more heavily the nearby activity opportunities are weighted. However, the value of B has been approximated at 0.5 at regional level.

Other researchers (Suxia and Seong, 2000 and Alam, 2001) used a rather straight model in measuring accessibility. The models used in their studies may be represented as follows-

$$\text{Acc}_i = \sum_j M_j / d_{ij}^{\alpha} \qquad (2.5)$$

Where M represents the number of facilities or their size (weight)

d_{ij} represents the distance between two locations

α represents the distance decay factor.

There have long been debates and researches to determine an acceptable and universal value of the distance decay. However, the Newtonian analogy is the most accepted one where the square of distance is used as the impedance and the value of distance decay parameter is approximated as 2 (Haynes and Fotheringham,1988).

2.4.2.4 Space Time Measures

This approach represents the potential of activities in which individuals can participate given (predefined) time constraints. This measure takes into account time budget to determine the area that could be assessed from a starting point within a given duration of time and speed through a space time prism (Janelle, 2002). This method is originated from the concepts of Hägerstrand's Time Geography which models the movement of individuals over space and time (Hariharan and Hornsby, 2000). Geospatial lifelines (Mark *et al.*, 1999) also use this approach to model movements as a time-stamped record of the locations that an individual has occupied over a period of time, and set all possible locations that an object could feasibly pass through or visit while moving between two points or locations (For more detail see Miller, 1991; Forer, 1998). This approach requires analysis of individual cases of travel to determine the area of access, which make the approach more complex. Moreover, in the context of rural areas, where the level of accessibility is primarily defined by mere access to the basic facilities, this type of measurement methods proves to be impractical. Therefore, this method of accessibility measurement is not considered within the scope of this study.

2.5 Conclusion

The measure of accessibility may include various other considerations depending on particular situations such as automobile ownership (as demonstrated by Pacione, 1989), networks of interacting services and agglomeration economics (White, 1979) or the issue of multipurpose travel (Arentze *et al, 1994*). However, for the purpose of the analysis used in this study, these complicating factors have been ignored and a simple distance metric has been used. Even though this is not without its limitations, it is an acceptable and well established method of calculating accessibility of the localities.

Chapter 3

STRATEGIES FOR RURAL DEVELOPMENT IN BANGLADESH

3. Strategies for Rural Development in Bangladesh

An adequate and efficient system of rural road network is one of the prerequisites for the success of integrated rural development. It is not only required to meet the demands of sectoral development but it itself is a powerful force generating economic development (Khan, 1987). For land locked rural areas, rural roads are important means of transportation and can play dominant role to provide accessibility. Rural roads also play vital role in integrating the remote villages to each other and with the rest of the country. Therefore, the development of rural roads has always been in focus in various rural development strategies and policy papers carried out in Bangladesh.

3.1 Policies in the Early Years

Development of rural transport as a key component of integrated rural development has been emphasized at the policy level since the early years. The World Bank (1976) stated that " improvement in transport is expected to ease the problems of rural life, increase agricultural production and provide better social services to the rural areas", emphasizing the role of feeder roads in rural development. The first master plan on rural road network development was prepared by the Planning Commission in 1979. The master plan was prepared following the "Growth Centre Approach" for rural road development for the period 1980-2000. It was envisaged that construction of all the rural roads in future will fit into the framework indicated in the master plan. The big village markets and (hats and bazaars) and the lowest level administrative unit (Upazila) was considered as growth centre in this context.

3.2 Strategy for Rural Development Projects (1984)

In 1984, Bangladesh Planning Commission provided a framework for the development of rural infrastructure in the policy titled "Strategy for Rural Development Projects". In the paper they identified the major shortcomings of the former rural development projects, while the major conclusion was that the earlier projects had failed to achieve their targets in alleviating poverty among the rural poor in Bangladesh because of excessive emphasis on agricultural development. The policy paper identified that the strategic goal for rural development should be "....improving the quality of life for the rural people through sustained employment and higher incomes" (Bangladesh Planning Commission, 1984). It also emphasized on three recommended components of rural development projects: development of physical infrastructure including roads, storage and markets; expansion of irrigation and production and employment programs for the rural poor. However, the GOB's strategy for rural development was based on the decentralization policy of 1982 in which Upazilas were transferred the responsibilities to most rural roads and markets.

3.3 Growth Centre and Rural Development

In 1984 the GOB adopted a policy of identifying selected important markets as *Growth Centres* to be focal points for rural development where investments in rural economic and social infrastructure should be concentrated, as a part of the Strategy for Rural Development Projects. In fact this was the practical implementation of the master plan policy formulated in 1979. Initially 1408 growth centres were identified (consisting in rural local assembly and secondary markets) by the Planning Commission with participation by the local authorities based on a set of guidelines that included the revenue potential, trading volume, area/population served, and a minimum distance between neighboring growth centres (LGED, 1995). The basic characteristics that were considered to select markets as growth centres are shown in Table 3.1.

In 1994, an additional 700 markets were selected by the Planning Commission, which reflected population growth and regional growth, making the total number of growth centres about 2100. With the new interventions, each Upazila had at least three growth centres, and there was about one growth centre for every two Union Parishads.

3.4 Bangladesh Transport Sector Study (1994)

Bangladesh Transport Sector Study was undertaken by the Government of Bangladesh and was implemented by the World Bank with a primary goal to

Table 3.1: Selection Criteria for the Growth Centres

Selection criteria	Growth centre	
	Assembly market	**Secondary market**
Function/ activity	• Some wholesale with retail • Farmers sell their products to internal traders as well	• Whole sale and retail • Links smaller markets with internal markets • Farmer sellers, internal traders, whole sellers, brokers, commission agents and Govt. agents operate
Catchment radius	3 to 8 km	8 to 30 km
Visitors	2000 to 10000	10000 to 30000
Periodicity	1 To 2 days a week	1 To 2 days a week

Source: LGED (1995)

enhance the capability of the Government in the planning and policy making in the transportation sector. The objectives of the study were to analyze the transportation system of Bangladesh with emphasis on individual transport modes and key transportation issues (The World Bank, 1994).

In respect of rural transport, the study examined the situation of traditional transport modes of the rural economy, and links of rural areas to the markets and the rest of the economy. The study focuses on internal access issues, and reform measures to alleviate the rural transport burden. They defined the problem of rural transportation beyond "mobility" to encompass the broader concept of "accessibility" to reduce or obviate the need to travel, generally by location of facilities and delivery of services and goods closer to rural communities. Moreover, the study also emphasized that the transport planning should be "area based" rather than "project based". In doing so, the study recommended various transportation and also non- transport interventions for development of rural transport infrastructure and also accessibility of the rural localities.

3.5 Bangladesh Rural Infrastructure Strategy Study (1996)

This study was done by the World Bank in association with the Local Government Engineering Department and Rural Infrastructure Development Wing of the Planning Commission, GOB to evaluate the former projects of the physical infrastructure development and to develop a set of recommendations for the future rural infrastructure based on lesions from the past experience (The World Bank, 1996).

The main recommendation of the study was to continue the growth centre approach and no major changes were required. Only some readjustments were suggested which could be justified in the light of the experiences acquired by the different rural development projects.

The study identified the investments in promoting better roads as good investments which help agricultural production. Although Bangladesh in endowed with very large rural road network, it is the "condition" and not the "size" of the network that is the relevant variable in explaining productivity differentials. Thus, projects aimed at improving the road conditions of the existing poor feeder and rural roads are expected to increase substantially income and productivity of an area and should be the basis for further project development. Similarly, improving the growth centre network was also encouraged as it was found to be associated with increases in agricultural income and productivity, as well as generate non- agricultural employment opportunities.

However, the major strategic recommendations and concepts of the study may be summarized as follows-

Accessibility Planning- responding to such questions as who needs access to what, for what reason or purpose, by what means of transport, with what relative priority and with what prospective return or effect.

Infrastructure Development- based on the results of accessibility planning and taking into account such issues as appropriate design and technology.

Complementary Interventions- including a potentially wide range of transport and non- transport activities maximizing the response to infrastructure development and minimizing transport burdens among the target groups.

Rural Transport Monitoring- with sustained access, mobility and minimization of the travel and transport burden as the key issue in the new recommended approach

3.6 National Land Transport Policy (2004)

Recognizing good infrastructure as a precondition of development, the Government of Bangladesh has prepared a Land Transport Policy in 2004 to ensure proper physical and institutional infrastructure transport in order to achieve national development. The Land Transport Policy has been prepared for a long term vision of at least 30 years to make the role of transport in economic activities more significant and underpin continued economic and social development (Ministry of Communications, 2004).

The policy concluded with recommendations for paved connections between all the economic growth centres and the country's road network will be provided. Suggestions are also made for the extension of the program of small bridge and culvert construction on the rural road network.

The policy document states that concurrent with the development of the road network, it will be necessary to foster a higher level of rural mobility and access to basic transport facilities A high diversity of vehicles and technologies will be encouraged through removing inappropriate regulations. Transport and rural development policies has recommended to be more closely linked so as to improve economic conditions through improved local markets, labour based contracting on roads, transport hire facilities, and access to credit.

3.7 Poverty Reduction Strategy Paper (PRSP) - Draft

The recently undergoing Poverty Reduction Strategic Plan also recognizes that infrastructure facilities provide impetus to the "growth-poverty nexus" through three ways. First, it concludes that, physical infrastructure service directly affect the socio-economic condition of the people and enhance capabilities of the poor. Second, infrastructure services help the poor in availing themselves of economic opportunities of growth, e. g. through better access to markets and services; increased inter- sectoral and inter regional labour migration; and investment in more profitable economic activities. Third, infrastructure helps in the realizations of the benefits of policy reforms through providing the socio- economic and spatial integration of the economy required. However, the policy has recommended the exploration of various options for financing road maintenance and operations to ensure efficiency gains (Bangladesh Planning Commission, 2005).

The PRSP has concluded that the rural road network of Bangladesh has reached a level where it would be more appropriate to invest in quality improvement rather than network expansion. Therefore, the policy has emphasized on the quality construction and maintaining and upgrading of the existing network, and undertaking selective expansion to ensure balanced rural- urban linkages. Therefore, the policy paper has put added emphasis on the developing growth centres and developing rural roads which connect villages with growth centres and feeder roads to ensure balanced and sustained rural development.

3.8 Conclusion

It is evident from the previous studies that the major strategy for rural development in Bangladesh has been focused on the development of road network and providing connectivity to the growth centres so as to ensure economic development of the rural areas. Recent studies have emphasized the necessity of improvement of present road network of the rural areas with justified expansion to provide access to the rural people and at the same time increase mobility. Therefore, a proper investigation into the actual levels of accessibility of the rural localities is essential from the policy perspectives, as it would be helpful in identifying the priority regions for transportation development and development of economic conditions of the rural areas.

Chapter 4

STUDY AREA

4. Study Area

4.1 Introduction

The study area for the research includes Meherpur Sadar Upazila and Mujibnagar Upazila of Meherpur District. Meherpur Thana was one of the oldest thanas of former Kushtia District and was named as Meherpur Sadar Thana (Upazila) when Meherpur was upgraded as District. Later in 1999, a new Upazila named Mujibnagar was created dividing the Meherpur Sadar Thana into two parts. The administration of the Upazila started from 8 April 2000[1]. The two Upazilas constitute the majority of the total population of Meherpur District, and depend on one another for economic and market activities.

4.2 Location and Area

The study area is located between $23^0 36'$ and $23^0 59'$ north latitude and $88^0 39'$ and $88^0 53'$ East longitude (BBS, 1994). The two Upazilas are bounded to the North by Gangni Thana of Meherpur District and India, to the East by Alamdanga and Damurhuda Upazila of Chuadanga District, to the South by Damurhuda Upazila of Chuadanga District and India and to the West by India (Map 4.1).

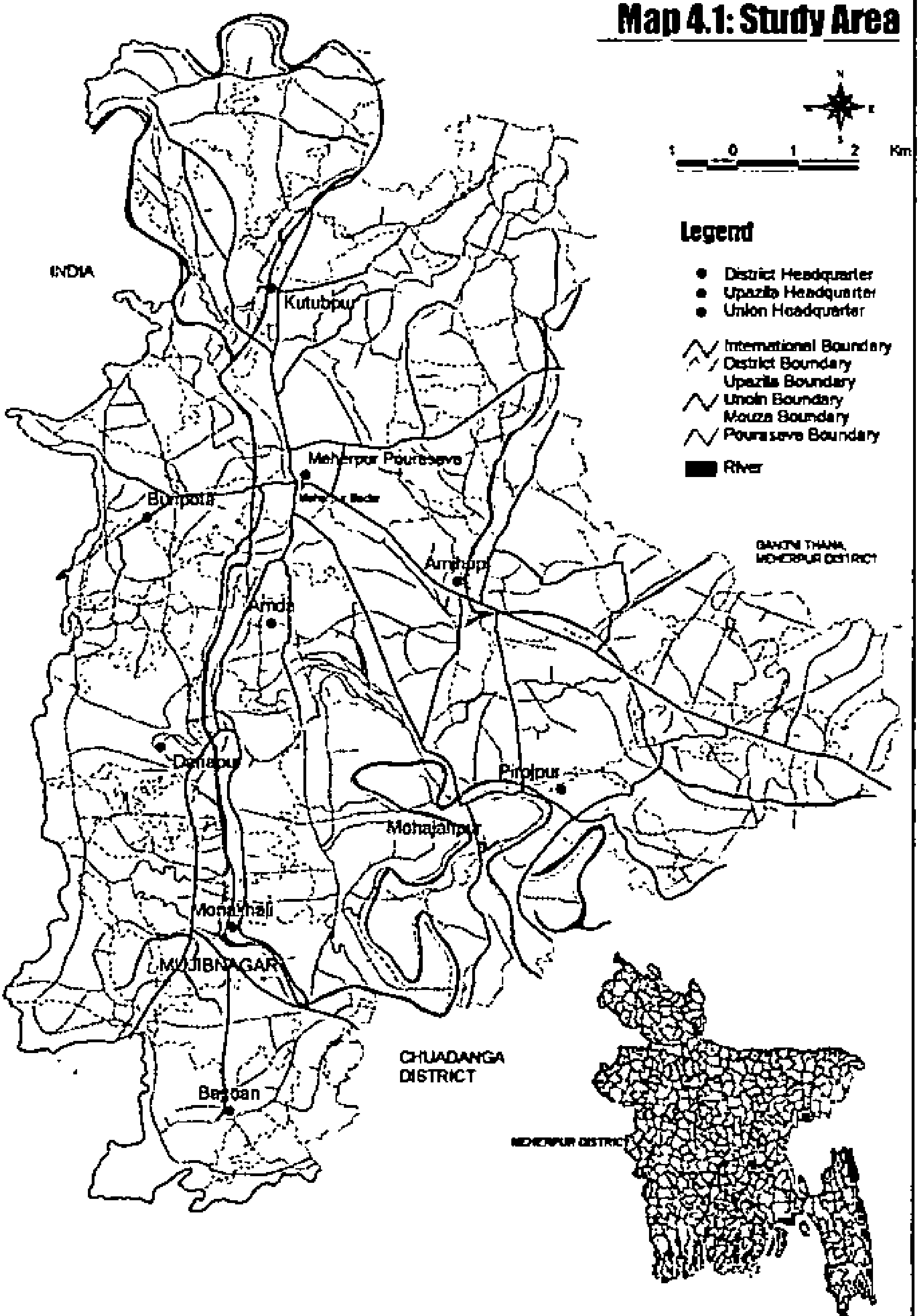
The study area has an area of 374.1 square km. including 5.31 square km. of river area. There are 1 Pourasava, 9 Unions (5 in Meherpur Sadar Upazila and 4 in Mujibnagar Upazila) and 166 Mouzas/ Mahallas (136 in Meherpur Sadar Upazila and 30 in Mujibnagar Upazila) in the study area (BBS, 2003).

4.3 Demographic Characteristics

According to the Bangladesh Population Census 2001, there are a total of 71420 households in the study area (Table 4.1) with average household size of 4.49. The total population of the study area was 320900 in 2001 compared to 262779 in 1991, which has grown at a rate of 2.02% over the last ten years (Figure 4.1). 98.83% of the population live in rural areas (BBS, 1994) with average density of 857.8 person

[1] Interview with TNO, Mujibnagar Upazila

Map 4.1: Study Area



Original Map Source: LGED(2005)

per square km. The male- female ratio of the study area is 105.6 and average literacy rate is 38.98%.

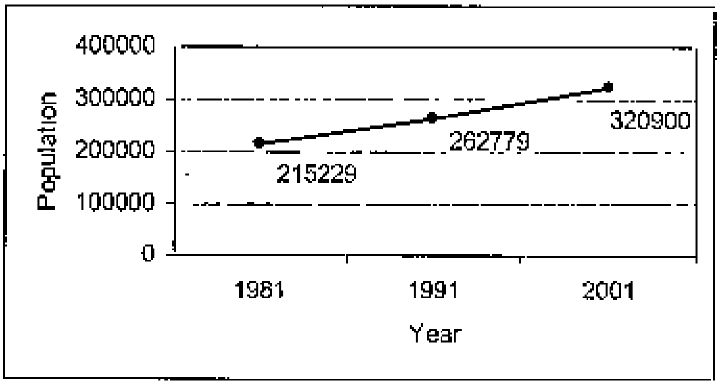


Figure 4.1: Population Growth of the Study Area

4.4 Employment and Economic Activities

Majority of the population of the study area depend on agriculture for their livelihood. According to Census data of 1991, as much as 71.71% of the dwelling households of the study area depend on agriculture as their main source of income, including 36.64% on cultivation/ share cropping, 0.91% on livestock, forestry and fishery, 0.15% on pisciculture and 34.01% on agricultural labour. However, other major sources of household income are business, employment and non- agricultural labour (Figure 4.2).

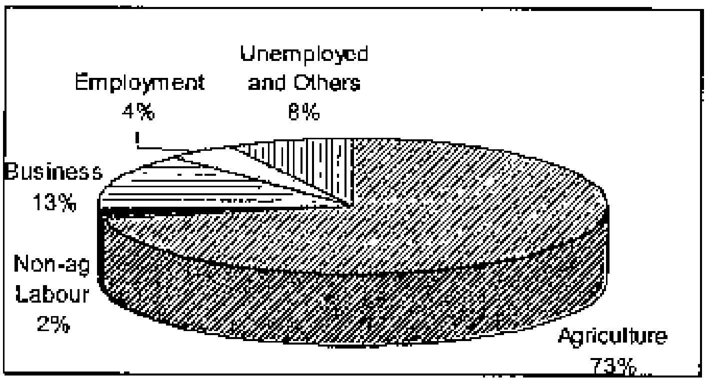


Figure 4.2: Major Sources of Household Income in the Study Area

4.5 Transportation

With the absence of any major river, the transportation system of the study area depends solely on road transport. Being the District Headquarter, Meherpur is well connected by the National Highway. Mujibnagar has also well connected by the regional highway. Even though all the Union Headquarters are accessible through metalled (*pucca*) road, the distant rural localities are still devoid of proper connectivity by road. The total length of the road network in the study area is 671.74 km. including 195.72 km of *pucca* road and 476.02 km of *katcha* road (Table 4.1).

Table 4.1: Meherpur Sadar and Mujibnagar Upazila at a Glance

	Meherpur Sadar Upazila	Mujibnagar Upazila
Area (km^2)	261.42	112.68
Population	230880	90020
Male	119140	45680
Female	119140	44340
Geographical Units		
Union	5	4
Pourasava	1	0
Mouza/ Ward/ Mahallah	136	30
Village	103	31
Education		
Literary Rate	38.50	39.45
College	Govt. 2, Non- Govt. 3	Govt. 0, Non- Govt. 2
Secondary School	Govt. 2, Non- Govt. 32	Govt. 0, Non- Govt. 10
Primary School/ Madrasa	Govt. 60, Non- Govt. 41	Govt. 23, Non- Govt. 9
Road		
Metalled	151	44.72
Non- Metalled	383	93.02
Economic Infrastructure		
Growth Centre	2	3
Hat/ Bazaar	31	Not available

Source: BBS (2003)
Office of the Upazila Engineer, Meherpur Sadar Upazila
Office of the TNO, Mujibnagar Upazila

4.6 Market and Retail Facilities

As the economy of the two Upazilas are principally based on agriculture, markets and retail centres play a crucial role. There is a total of 5 growth centres in the study area, along with other hat-bazaars. Besides, Meherpur Sadar Pourasava and Union Headquarters also have developed retail centres.

4.7 Conclusion

The study area is bounded almost on its three sides by India, which is expected to minimize the external effects on the retail centres created by the people coming from outside. Pourasava, Union Headquarters and Growth Centres make the total number of retail centres to be studied 9, which is a considerable and at the same time manageable number to be used in this study. The transportation system of the study area is based solely on road transport, which is expected to reduce deviations from the study results and make the findings more comprehensive. The economy of the study area is clearly dominated by agriculture, making it more appropriate as a case study for the particular research. Finally, the study area seems to represent a typical picture of the rural Bangladesh that could make the study findings more acceptable and comprehensive in its implications.

Chapter 5

STUDY DESIGN

5. Study Design

5.1 Selection of Variables

Measurement of accessibility level of rural localities requires three types of attributes to be considered as variables to be used in the measurement methods; firstly, the economic attributes or activities for which accessibility would be measured; secondly the geographic level at which accessibility would be determined; and finally the distance, either network or Euclidian, which would assess the proximity of localities to the selected activities.

5.1.1 Economic Attributes

The strategy for rural development in Bangladesh follows "Growth Centre" approach, which emphasizes that rural markets would be the focal point of economic development. Therefore, the basic principle in selecting economic attributes for the study lies in the "Growth Point" approach which has originated from the agglomeration tendencies of the early locational theories. However, the modern developments of the theory stems from Francois Perrox's concepts of "pole de development" and "pole de croissance"(Perrox, *nd*). The theory is derived inductively from observations of the actual process of economic development, which envisaged that "development does not appear everywhere and all at once it appears in points or development poles with variable intensities"(Perrox, *nd* as in Jahan, 1978, p17). Although it is difficult to give a precise definition of "growth point", theorists have provided guidelines within which the theoretical and empirical specifications of the concept may be determined. A basic notion behind the growth point concept is that economic activity tends to agglomerate around certain focal points. The polarization flow (commodities, factors, services, traffic, communications etc.) will gravitate within a sub-region towards the control centre (or dominant pole) (Richardson, 1969)

The "growth point" approach may be considered as the spatial dimension of the "growth pole" concept. While the growth point concept involves economic space defined in terms of forces of attraction and repulsion between one centre and various others, the growth point concept basically refers to centres of activities, functionally linked with other large and smaller centres (Jahan, 1978). Richardson (1969, as in Jahan, 1978, p16) says "the underlying idea behind growth points is simply that there is some kind of order and regularities in space shaped by human, particularly economic activities. We can conceive of the structure of human settlements as a system of modes and functional linkages. Those nodes are organized into a hierarchical framework where nodes in each rank of the hierarchy perform a particular set of functions."

Therefore, the growth point concept has been considered to have direct relevance to the geographical pattern of development (see more details in Hirchman, 1958, Christaller, 1966, Myrdal, 1967 and Firedman, 1972)

In Bangladesh Rural Assembly Markets and Rural Secondary Markets are considered as Growth Centres as potential and strategic centres of rural development. The basic characteristics and types of activities of these growth centres, as identified by LGED, are outlined in Table 5.1.

For the purpose of this study, two types of service centres have been identified as potential growth points and considered as economic attribute to be used in determining accessibility level of the rural localities; they are- i) Retail Centres at Pourasava and Upazila Headquarters, and ii) Designated growth centres by the LGED. Accessibility of various rural areas has been identified on the basis of their accessibility to various activities prevailing in these economic centres.

5.1.2 Geographic Unit of Accessibility Measurement

To obtain an effective measurement of accessibility index, it is of utmost importance important to determine a proper geographic extent for which accessibility would be measured. For the purpose of this study, the following considerations were made to identify the appropriate geographic and spatial level at which rural localities would be divided to measure their respective accessibility level-

i) The area should be clearly identifiable

ii) Should be sufficiently small so that continuous variables (population) might be considered as discrete variables

iii) Should be Small enough so that the variability of the level of transportation infrastructure could be easily identified

iv) Maximum of them do not include service centres (selected) within their geographic boundary.

In this context, the "smaller geographic areas", as identified by the census of Bangladesh (BBS, 1994) may be evaluated to select the appropriate geographic unit for the research.

Union: Unions are the smallest administrative unit (Local Government unit) of rural area which is comprised of mouzas and villages.

Mouza: Mouzas are revenue village with a jurisdiction list number and defined area. That may be populated or depopulated.

Village: Villages are the smallest geographic areas in rural area. A village may be the same as the mouza or rather there may be more than one village in a mouza. A village, unlike mouza, represents the settlements of rural area rather than its geographic extent (Asiatic Society of Bangladesh 2004). Therefore, villages are always populated.

Ward: Wards are the smallest local administrative and local Government unit in urban areas.

The total number of these geographic units as well as their population structure as in 1991 has been shown in Table 5.1.

Table 5.1: Smaller Geographic Areas in the Study Area

Geographic unit	Total no. in study area	Average Population in 1991
Union	9	26230
Ward	9	2968
Mouza	90	2623
Villages	134	2018

Source: BBS (1994)

With this characteristics in view, mouzas have been selected as the geographic unit for which accessibility index would be measured. Mouzas are the smallest identifiable geographic unit with considerably small population size, and as there are a total of 90 mouzas in the study area, most of them do not contain any service centres. Being small in geographic extent, the variability of transport infrastructure available can easily be differentiated. However, in the digital map, 88 mouzas could be identified (Meherpur Pourasava was considered as one mouza). Therefore, the measurements have been done accordingly.

5.1.3 Transportation Infrastructure

Bangladesh has a very large rural road network, which has increased at a considerable rate over the past twenty years. The total length of rural roads in Bangladesh was 13605 km. in 1993 (The World Bank, 1996), and has been increased now to 170109 Km (RHD, 2005). In 1993, the total length of rural roads in Bangladesh per 100km^2 of land area was found to be 70.2 km, which is very high compared to other developing countries, but the overall road condition was found to be poor. Only 5.3% of the total LGED maintained lower level rural roads were found to be in good condition, while the condition of 16.8% was poor (The World Bank, 1996). The various types of rural roads in Bangladesh have been listed in the following table.

Table 5.2: Types of Rural Roads in Bangladesh

Type of Road	**Surface Type**		**Maintenance Authority**
	Metalled (*Pucca*)	Not metalled (*Katcha*)	
National Road	√		Roads and Highways Dept.
Regional Road	√		Do
Zila Road	√		Do
Upazila Road	√	√	Local Govt. Eng. Dept.
Union Road	√	√	Do
Village Road Type A	√	√	Do
Village Road Type B	√	√	Do

Source: LGED (2005)

Different types or road, however, is expected to have different level of impacts on the travel pattern, and therefore, their impact on the rural economic development should be different. The classification of road infrastructure as used in this study is based on the findings of the Bangladesh Rural Infrastructure Strategy Study which states that "It is the condition and not the size of the network that is the relevant variable in explaining productivity" (The World Bank, 1996, p33). The statement has been made on the basis of the results of a macro- economic analysis on the relationship between agricultural productivity and rural infrastructure, where it was found that the total road length of various types (Major highways, feeder roads and rural roads) per square km. is not correlated with agricultural productivity. It is argued that although this classification of roadway system has significant impacts in longer distance movements and therefore long term regional development, in case of the accessibility of the rural localities to the service centres, this variability of roadway types can hardly make any significant difference, except the quality of their surface. A metalled (*pucca*) road should make people more accessible to the service facilities because of increased travel speed and less travel time than a *katcha* road. Therefore, although the study considers all types of rural roads for determining distance between rural localities and the service centres, the roads have been classified into only two types, i) *Pucca* road, and ii) *Katcha* road.

The second question that comes in this respect is that of their comparative impact on the network, i.e., how they should be weighted to be ranked. However, it is quite logical to assess their relative significance on the basis of "generalized travel time", which may be determined from the design speed of these two types of roads. This may result in a more comprehensive measure of network distance as the use of absolute travel time may often be proven unrealistic because of variability in convergence and divergence among places over time (Janelle, *nd*).

In this study, average speed on metalled (*pucca*) and Non- metalled (*katcha*) roads are assumed to be represented by the average speed of motorized and non-motorized vehicles. Kadiyali (2003) specifies the standard speed limits applicable for Indian roads; which says that the average speed of a car is 50 to 80 km. per hour, while that of a cycle/rickshaw is 8 to 15 km. per hour. If we consider the upper limits of the speed, a motorized vehicle can run (80/15 =) 5.33 times faster than a non- motorized one. Therefore, the "generalized travel time" for *katcha* road (where it is assumed that people would travel usually by non-motorized vehicles) should be 5 times greater than a *pucca* road. This proposition may also be supported by previous studies. Highways department, Thailand (1979) weighted network impact of highways and rural *katcha* roads as 5:1, which was later used by Khan (1987) in his research. Therefore, in this study, the generalized travel time on *pucca* roads are considered as 1, while that of *katcha* roads as 5.

5.2 Determination of Accessibility Measurement Models

This study follows activity based approach to measure accessibility of the rural areas which primarily focuses on the people's ability to take part in various retail activities. Among the methods of activity based accessibility measurement, Space Time Measures have not been considered because of its non- relevance to the particular problems of the study, and also because of its complexity and unavailability of required data. Therefore, the accessibility indices have been measured by three other recognized methods of activity based accessibility measurement; Isochrone (Contour) Approach, Geographic Approach and Potential (Gravity) Approach.

5.2.1 Isochrone Method

As discussed earlier in Chapter 2, Isochrone or Contour measures count the number of opportunities that can be reached within a given travel time, distance, or generalized cost. For the purpose of the study, the basic Isochrone model has been used, as shown in Equation 2.1. The basic equation contains two attributes; a pre determined distance that would be considered as the accessible range for the people to reach certain activity, and a measure of opportunities at any zone. To determine the range of accessible distance, this study has considered the catchment radius of the service centres of rural Bangladesh. As discussed in chapter 3, rural assembly markets and secondary markets have been selected as growth centres by the Government of Bangladesh. As this study principally deals with basic access of the rural localities, access to rural assembly markets (or the activities at that level) seem to be the most important to assess their level of accessibility. However, secondary markets also offer certain services that the rural localities may require to access off and on. Therefore, for the purpose of the study, the range of accessible distance has been taken to be 8 km, which is the maximum radius that a rural assembly market can serve, and also the minimum service radius for a secondary market. The level of opportunity offered by service centres have been determined by the respective centrality scores of the centres, calculated based on the hierarchical classification of activities available at those (See Chapter 6). Therefore, the specific model used can be explained as-

$$Acc_i = \sum_j W_j D_j \qquad (5.1)$$

Where W_j represents the opportunities in zone j

D_j equals 1 if $C_{ij} \leq 8$ km (8000 m), and 0 otherwise

C_{ij} is the measure of Euclidian distance between zone i and j

5.2.2 Geographic Method

Geographic method of accessibility measurement has also been widely used in measuring accessibility of regions for its simplicity. In this study the basic model (Equation 2.2) has been used to measure geographic accessibility of rural localities. Network distance based on generalized travel time has been used in the model.

5.2.3 Potential (Gravity) Method

The Potential measurement approach, most commonly known as Gravity measures, is probably the mostly practiced method of accessibility measurement throughout the world. Even though there have been considerable researches on the scopes and limitations, the acceptably of the method to measure basic level of accessibility can hardly be disregarded.

The basic Potential model for spatial interaction has been discussed in Chapter 2 (Equation 2.3). However, to determine the index for accessibility of the localities, the "scale factor" k seems to be the most appropriate.

$$K = T / \sum_i \sum_j V_i^{\lambda} W_j^{\alpha} d_{ij}^{\beta} \qquad (5.2)$$

Where V represents the original propulsiveness variable

W represents the destination attraction variable

And λ, α and β are the parameters to be estimated

However, in respect of the study, the concern over origin propulsiveness has not been considered, and therefore, the value of V may be taken as 1. The destination attractiveness has been calculated on the basis of hierarchy of activity centres, which has already been discussed above, while the network distance between locations based on generalized travel time has been considered as distance factor between points. The value of the parameters may vary from 0.5 to 2 in practice. However, for simplification, they might be assumed as 1 (Haynes and Fotheringham,1988). The distance decay parameter β is also a crucial aspect to be considered to apply gravity model, as this affect a lot the quality and acceptability of outcome. In this study, the parameter has been assumed to be 2, the Newtonian analogy of square of distance, to be the distance factor which is the common practice in potential accessibility measures (See Haynes and Fotheringham,1988; Froast and Spence, 1995; Suxia and Seong, 2000; Alam, 2001; Hilber and Arendt, 2004; Rodrigue, *nd*).

However, with these simplifications, the resultant Potential model should look somewhat like the one used by Suxia and Seong (2000) and Alam (2001), which has been shown in Equation 2.5. And therefore, the potential model used in this study to measure accessibility index is as follows-

$$Acc_i = \sum_j M_j / d_{ij}^2 \qquad (5.3)$$

Where M represents the centrality score (relative weigh based on the availability of activities) of the service centres

d_{ij} represents the network distance between two locations

5.3 Measurement of Variables

5.3.1 Determining Hierarchy of Service Centres

Hierarchy of selected service centres (economic attributes) are determined based principally on "central place" concept. Various activities at the service centres were ranked after their level of availability. Thereafter, the centrality score (relative importance) of the service centres were determined on the basis of all the activities they offer.

5.3.2 Measurement of Distance

The selected methods of accessibility measurement require two types of distance measurement; Euclidian distance and network distance. ArcView 3.2 software was used with necessary customization by AVENUE scripts to measure Euclidian distance between various pairs of rural localities and service centres; while for determining network distance, ArcGIS 9.0 software was used.

5.4 Diagnosis of the Estimated Model

One of the mostly used and accepted methods of testing accessibility or proximity measures is the use of spatial correlation. Spatial correlation measures the degree to which objects or activities are similar to other objects or activities located nearby (Ding and Fotheringham, 1992). Therefore, this measure has the advantage of dealing with two quite distinct types of information; location and their respective attributes. If objects which are similar in location also seem to be similar in attributes, then the pattern as a whole is said to show positive auto correlation. There have been considerable researches employing diagnosis tests based on spatial autocorrelation techniques to solve accessibility problems(see Anselin and Florax 1995, Haider and Miller 2000) The application of autocorrelation techniques depends on two basic assumptions; firstly the sample values should be drawn from a normally distributed population, and secondly the attribute values should have a random arrangement (Ding and Fotheringham 1992). In the context of rural areas, the proposition of "normal distribution of attributes" might not be justified as the availability of transportation network may affect substantially some of the mouzas in improving their level of accessibility, while some other nearby mouzas the things may be different because of absence of proper network connectivity, which is unlikely to the urban context for which autocorrelation techniques have been applied. Therefore, the use of spatial autocorrelation technique to diagnose the alternative findings may be misleading.

Under these circumstances, an alternative technique has been applied in this study to test the results of the three accessibility measurement methods; the theoretical results have been evaluated on the basis of peoples' responses.

5.4.1 Overall Accessibility Level (OAL)

The basic method applied in this study to test model outputs has been adopted from Sarkar and Mashiri (*nd*) who used a weighted index to measure the Overall Accessibility Level (OAL) of the rural area or the section of the population of the area. They developed a composite index of various activity requirements to quantify the ability of prevailing transport system to overcome the distance.

$$\text{OAL} = \sum_{i=1}^{N} W_i V_i \qquad (5.4)$$

Where N represents the number of basis activities

W represents importance (weight) associated with the accessibility to the i th activity

V represents the level of accessibility to the i th activity.

The methodology followed to measure OAL of the regions, however, was quite different from the original approach followed by Sarkar and Mashiri (*nd*). While their index was completely based on peoples' response, this study used the measured hierarchy of retail activities as the value of W.

5.4.2 Survey Methods

The OAL of the mouzas were collected for 8 sample mouzas at the northern part of the study area. The eight selected mouzas showed large differences in the index values as measured by various models, and therefore, they were selected as potential ones to be tested to compare and evaluate the three model estimations.

The survey was conducted on the basis of key informant discussion. Questions were asked to determine the level of accessibility to 6 selected activities of 6 different levels of hierarchy. One set of data was collected from each of the selected mouzas, while the discussion was carried out as far as possible at the centroid of the mouzas. Therefore, 8 sets of data were collected in total for the study purpose.

The group discussion was conducted preferably with the rural elites (key personnel) as they are expected to have proper understandings about the levels of accessibility at the respective mouzas. This methodological approach has possibilities of biased results to some extent as it does not include the perspectives of all social classes. To minimize the problem, the samples were selected to include a wide range of professionals to encompass their ideas about the level of accessibility for the mouzas. In each of the sample mouzas, 5 persons were discussed to identify their level of accessibility to the selected activities. The shares of various professionals among these 40 respondents of the survey have been shown in Figure 5.1.

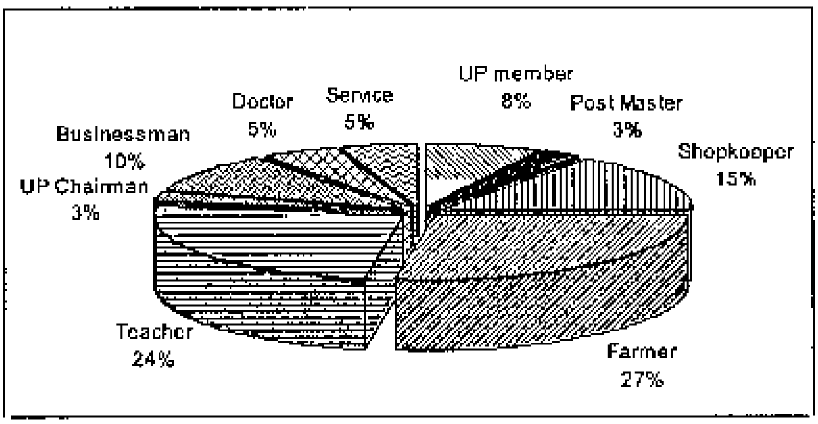


Figure 5.1: Professions of the Respondents of the Key Informant Survey

5.4.3 Analysis of Results

The survey results were compared with the outputs of the three models to select the best one that represent the overall accessibility level of the localities. The comparison was made by Correlation analysis. The coefficient of correlation (R) between the two sets of variables represent the extent or degree of relationship between them; while the Coefficient of determination (R^2) represent the portion of changes in one variable that can be explained by the change in other (For detail see Sufian, 1998; Gupta and Gupta, 2002). Two types of correlation analysis were made to taste the model results, Simple correlation and Rank correlation, which tested the accessibility index values and accessibility levels respectively.

Chapter 6

HIERARCHY OF SERVICE CENTRES

6. Hierarchy of Service Centres

In this study, Central Place concept has been emphasized in the determination of the hierarchy of service centres. A service centre in central place can be defined as a permanent settlement where exchange of goods and services takes place for population beyond its own, and therefore, which commands it commands its region as well as the immediately contiguous areas encircling it (Bhuiyan, 1997).

The Central Place theory articulates that the significance of a service centre is linked much to its centrality. The centrality of service centres is the product of the quality and quantity of central functions performed by any settlement, whereas the central functions may be defined as those functions which by their nature are available in few settlements (or service centres in this case) but are availed by a number of other settlements as well (Jahan, 1978; Khan, 1987 and Bhuiyan, 1997). The quality of a central function is normally affected by (i) the number of different types of function offered, and (ii) the level at which they are offered. Therefore, the relative importance of various functions at the service centres varies depending on the extent of availability. A service centre offering a number of functions at a particular level will be more significant than a centre offering less number of functions at the same level. But when the two service centres have identical number of functions, the level of functional hierarchy becomes more important, making it a decisive part of the whole question of hierarchy.

6.1 Identification of Service Centres

Service centres, according to its functional definition, may include a wide range from rural markets to large cities. However, for the purpose of this study, market centres at Union level have been considered as service centres. Meherpur Pourasava, major market places at Union Parishad headquarters of the two selected Upazilas, and market places at the designated Growth Centres have been recognized as places of potential attraction, and thereby, central places, to calculate accessibility of rural settlements. The list of selected service centres have been shown in Table 6.1 and in Map 6.1.

Table 6.1: Selected Service Centres in the Study Area

	Meherpur Sadar Upazila	Mujibnagar Upazila
Pourasava	Meherpur Pourasava	
Union Parishad Headquarters	Amjhupi, Pirojpur, Kutubpur, Buripota, Amdaha	Monakhali, Dariapur, Bagoan, Mohajonpur, Kedarganj (Mujibnagar)
Growth Centres	Baradi, Sholmari	Dariapur, Anandabash

6.2 Ranking of Service Centres on the Basis of Functional Hierarchy

Central Place studies in the western world have tended to use single indicators of functionality for the identification of hierarchy or for the formulation of regional development policies, such as telephone density, range of retail shopping or bus service frequencies (Jahan, 1978). But when applied to Bangladesh, such approach is likely to give misleading picture of centrality and therefore of the hierarchy of the service centres. It has, therefore, been considered necessary to determine the centrality of the service centres under concern by taking into account all the central functions that they perform.

During field survey, a total of 61 functions were identified (listed in Table 6.2), which have later been scaled and ranked to calculate the relative weighs of the service centres in the study area.

6.2.1 Determining Hierarchy of Functions

The first step to decide on the functional hierarchy of the service centres was to determine an appropriate hierarchy of the functions. In this study, the hierarchy of activities (or functions) has been determined on the basis of the availability of various functions at the selected service centres in the study area The basic approach followed has been adopted from Bahauddin (1989) with necessary modifications to fit the particular purpose of the study. The operational steps followed to determine the hierarchy of functions is described below, and the results have been shown in Appendix B.

Listing: All the selected 61 functional activities were listed against the service centres according to their availability to a particular service centre, and total available number was calculated for each function.

Scaling: Function that is the least available among all the service centres was given a value of 100 representing its least availability and therefore greatest significance; while the function that is the most available have been given a value of 1. The other functions were scaled at the inverse proportionate ratio of their availability.

For example, there is only one Pourasava in the study area, and therefore, it has been given a value of 100, while the mostly available function, tea stall (145 nos) was given a value of 1. Correspondingly rice mill (25 nos) has obtained a score of 83 5 while grocery shop (75 nos) has been scored as 49 15.

Ranking: At the next stage, the functional activities have been ranked by their corresponding Z-scores. The basic idea was to scale the availability of the functions on the basis of average number of various functions available among all the service centres. The Z- score represents the deviation of the total score of a certain function (on the basis of their scarcity) from the average. In the study area, the average number of functional activities available among all service centres is 86.52 with a standard deviation of 16.57 (Appendix B). Therefore, for example, the Z- Score of grocery shop was calculated as follows-

$$Z\ (Grocery\ Shop) = \left(X - \overline{X}\right)/\partial\ = (83.5 - 86.52)/16.57 = -0.18224$$

Likewise, the Z- scores for other functions have also been calculated. The Z- values scored by various functions range from 0.813 to – 5.16, with the more scarce functions having a tendency to score higher and vice versa.

Then the functional activities were grouped based on their resultant Z- scores and were given weights. Functions scoring lower were given lower weights because of their higher degree of availability and thereby relatively lower significance. The functional hierarchy of activities and their corresponding weights are listed in Table 6.2.

Table 6.2: Functional Hierarchy of Various Activities at the Service Centres

Hierarchy	Name of Functions	Z- Score	Weight
1	Grocery Shop, Hardware Store, Retail Cloth Store/ Readymade Garments, Stationary Shop, Tea Stall	-1.25 < Z	1
2	Barber, Medicine Store	-1.25 ≥Z< -0.75	2
3	Fertilizer Distribution Centre, Mobile Call Centre/ Phone Booth, Rickshaw Cycle Repairing, Shoe Store, Tailor, Wholesale	-0.75 ≥Z< -0.25	3
4	Administrative Office, Blacksmith, Cobbler, Electric Shop, Electronic Servicing Centre, Fruit Shop, Furniture, carpenter, Jewellary Store, Machinery Store, Primary School, Private Medical Practitioner, Restaurant, Rice Mill, Saw Mill, Seed Distribution Centre, Sweetmeat, Utensils Store, Welder	-0.25 ≥Z< 0.25	4
5	Bank, Book Shop, Brick Field, College, Courier Service, Cloth Ironing Shop, Decorator, Family Planning Centre/ Charitable Dispensary, Godown, Hat/ Bazaar, Health Complex/ Hospital, Library/ Club, Motor Cycle Repairing, Oil Shop, Photo Studio/Lab, Photostat, Post Office, Residential Hotel, Sanitary Store, Secondary School, Show Room/ Sales Centre, Union Parishad	0.25 ≥Z< 0.75	5
6	Animal Husbandry Centre, Cinema Hall, Flower Shop, Insurance, Police Camp, Pourasava, Sports Store	Z ≥0.75	6

6.2.2 Centrality Score of Service Centres

Based on the assigned weights of the functional activities, the centrality scores of various service centres have been determined. The centrality scores have been calculated by the summation of available functions multiplied by their corresponding weights, according to the following equation, and listed in Appendix C, and plotted on Map 6.2.

$$Centrality\ Score = \sum_{j} N_j \times W_j \qquad (6.1)$$

Where N represents total number of function j available

And W represents functional hierarchy of j

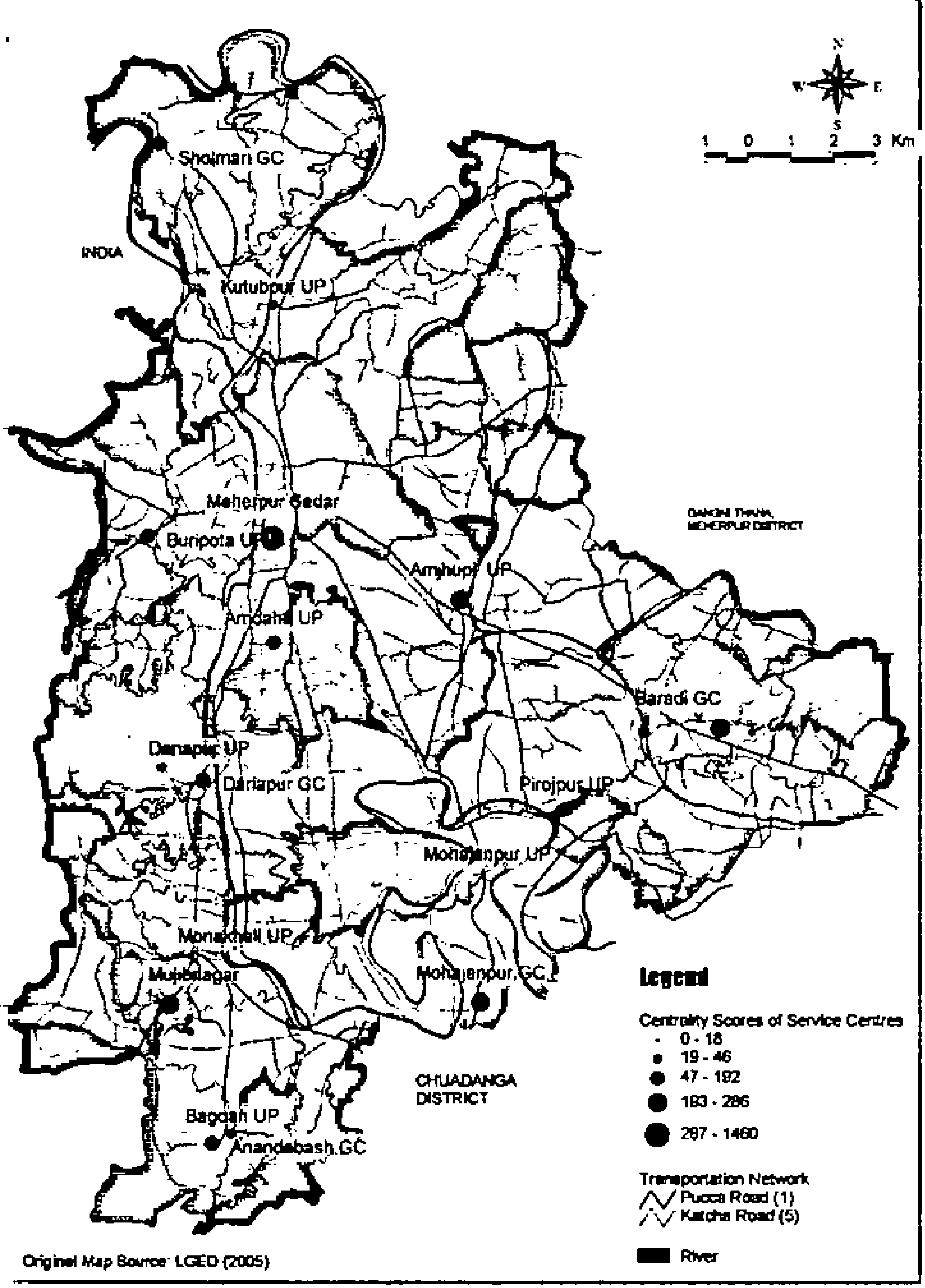
The scores of the service centres have been listed in Table 6.3, along with average daily transaction of the service centres. The data on daily transactions were collected by field survey. Data were collected on average daily sales on typical weekdays.

Table 6.3: Centrality Scores of Service Centres

Name of Service Centre	Centrality Score	Average Daily Transaction (Thousand Taka)
Meherpur Pourasava	1460	1470.58
Amjhupi	273	59.98
Pirojpur	136	19
Kutubpur	46	11.24
Buripota	98	12.35
Amdaha	188	22.1
Monakhali	18	1.1
Dariapur	27	0.98
Bagoan	31	1.1
Kedarganj (Mujibnagar)	286	104.2
Baradi Growth Centre	271	75.4
Sholmari Growth Centre	138	58.1
Dariapur Growth Centre	192	115.85
Anandabash Growth Centre	119	37.48
Mohajonpur Growth Centre	285	137.7

Source: Field Survey (2005)

Map 6.1: Selected Service Centres and Their Centrality Scores



It can be seen from analysis that that there is strong positive correlation exists between the calculated centrality scores of the Union Parishad Headquarters and their respective average daily transactions. The coefficient of correlation (R) between these two variables (for the Union Parishad headquarters) is 0.9004 and the coefficient of determination (R^2) is 0.8018, which represents that the centrality scores can well explain the relative significance of the Union headquarters in the local context.

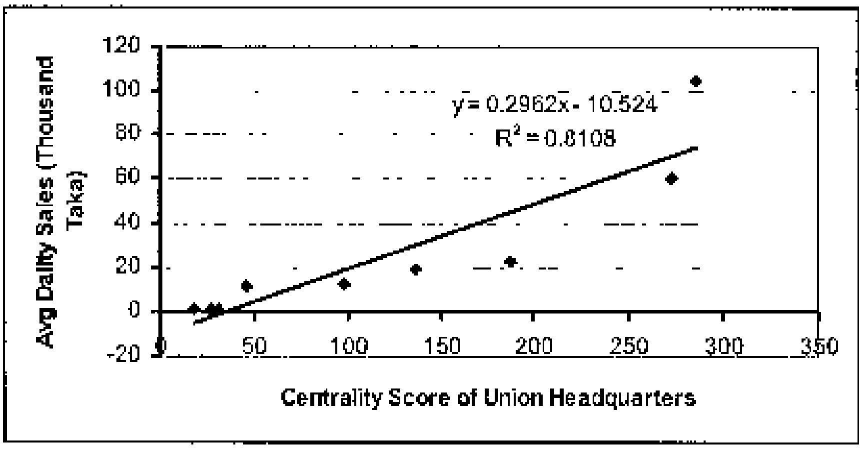


Figure 6.1: Correlation between Centrality Scores of the Union Headquarters and their Respective Average Daily Transactions

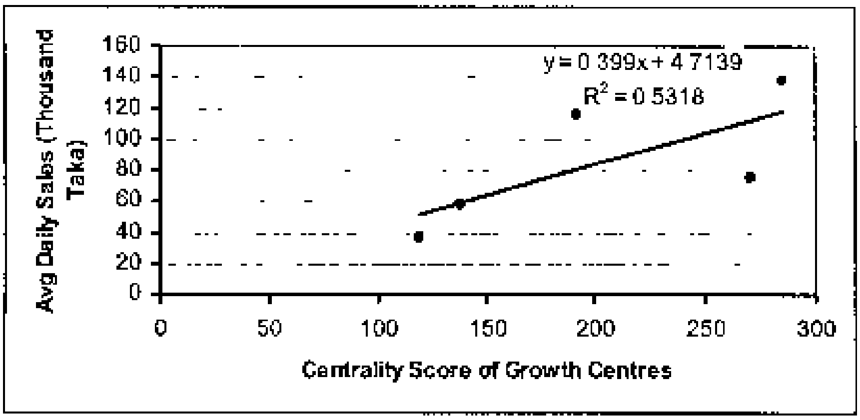


Figure 6.2: Correlation between Centrality Scores of the Growth Centres and their Respective Average Daily Transactions

However, the derived centrality score cannot explain the relative significance of Growth Centres in the study area with R^2 value of 0.5318. This may be because Hat/ Bazaar was considered as one unit of functional activity during the field survey, rather than considering their component activities. Still there are positive correlation (R = 0.7293) between Centrality Scores of Growth Centres and their average daily transaction, and therefore the use of the calculated centrality scores remains justified.

Chapter 7

MEASUREMENT OF DISTANCE

7. Measurement of Distance

Measurement of accessibility in the three adopted models involves two types of distance measurement; Euclidian distance and network distance. In this study the distance has been measured with the aid of AVENUE scripts of ArcView 3.2 and ArcInfo Workstation of ArcGIS 9.0. The service centres were considered as point features and the accessibility of mouzas were measured from their calculated centroids.

7.1 NODEDISTANCE Command

NODEDISTANCE is a command of ArcInfo Workstation of ArcGIS 9.0, which computes the distances between all pairs of specified network elements (nodes, stops or centers) in the network coverage. This command is useful to construct OD (origin-destination) matrices which are needed in many transportation-planning models and applications

NODEDISTANCE works with the currently selected set of NODES, STOPS or CENTERS. CENTERS specifies that distances will be computed from or to the centers specified by the CENTERS command. STOPS specifies that distances will be computed from or to the stops specified by the STOPS command. NODES specifies that distances will be computed from or to all nodes in the selected set.

The use of NODEDISTANCE command involves in specifying <CENTERS | STOPS | NODES> keywords to specify the origin or destination network elements from or to which distances will be computed. The output are stored in an INFO data file (Out Distance File) created by NODEDISTANCE which holds the distance measurements. The command also has an option of <CUTOFF_DISTANCE> keyword to specify the maximum distance which nodes can be apart for the distance between the nodes to be calculated and recorded in out info file. The maximum distance is given in coverage units.

NODEDISTANCE employs three computational methods used for calculating distance for all pairs of specified network elements. Any combination of these keywords may be specified.

NETWORK - keyword to specify that the shortest path distance will be computed for all pairs of specified network elements. This is the default, and measures the "minimum cost path" between any two points or a set of points.

EUCLIDEAN - keyword to specify that Euclidean distance will be computed for all pairs of specified network elements.

MANHATTAN - keyword to specify that Manhattan distance will be computed for all pairs of specified network elements.

However, a typical out distance file may have the following components-

Column	Item name	Width	Output	Type	N.DEC
1	<cover>-IDA	4	5	B	-
5	<cover>-IDB	4	5	B	-
9	<cover>#A	4	5	B	-
13	<cover>#B	4	5	B	-
17	NETWORK	4	12	F	3
21	EUCLIDEAN	4	12	F	3
25	MANHATTAN	4	12	F	3

The out_distance_file will have N x M records, where N is the number of selected nodes, stops or centers that distances will be calculated from and M is the number of selected nodes, stops or centers that distances will be calculated to.

7.2 Initial GIS Operations

7.2.1 Determining Centroids of Mouzas

The first task in determining the distances were to determine the origin points of the potential trips, from which distance would be measured. In this study all the attributes of the mouza have been considered to be concentrated at their centroids. The centroids of the mouzas were determined and calculated by a script (CENTRD AVE) written in Avenue, scripting language of ArcView GIS 3.2, and from that a shape file of point features was created and added to ArcView GIS 3.2

project file (CENMJ.SHP) [Appendix D]. A total of 88 centroids were added for the 88 mouzas as found on the map (Map 7.1).

7.2.2 Determining Location of Service Centres

The point coverage of service centres of the study area (RETAILF) has been used as the locations of service centres. No additional GIS operation has been done at this stage. The coverage contains the point attributes of fifteen service centres, which has been considered as destination points of the distance measurement methods.

7.2.3 Determining the Road Network

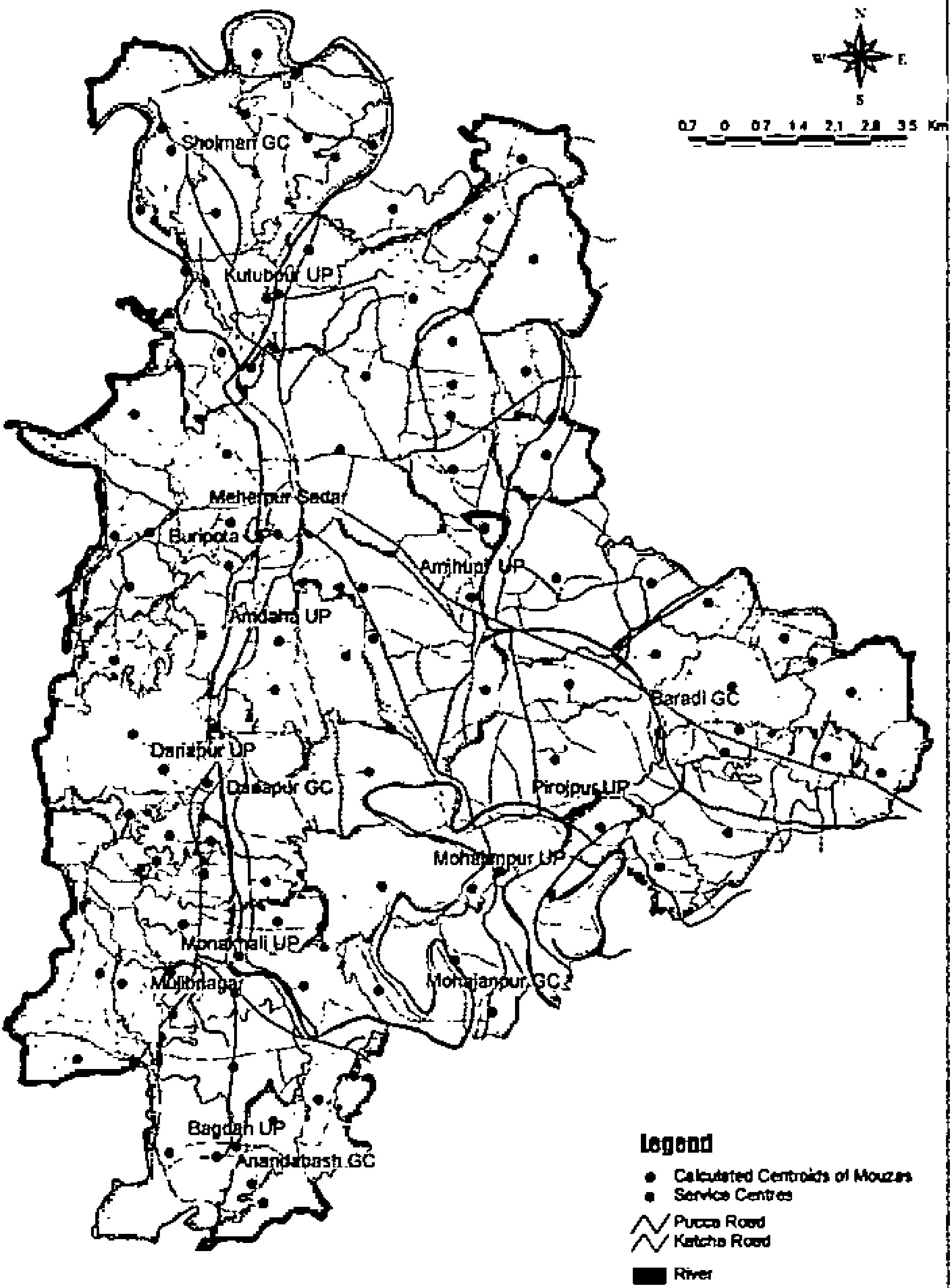
Before measuring the distance, the final step was to develop a linear network between the origin and destination points (i.e., the centroids of mouzas and the service centres). The road network of the study area was already available, even though the original topology was lost because of the APPEND operation (See section 1.3.2.1) done earlier. However, the task of preparing a complete network was done in the following consequential steps-

Firstly, the mouza centroids and service centres (point feature) were added to the original network manually in the ArcEdit environment of ArcGIS 9.0. The new network was saved in the workspace as ROADNET coverage.

The second step comprised of editing of the newly built network coverage (ROADNET). The activities included successive operation of CLEAN and BUILD command, with necessary edits in the Arcs of the network by means of ADD, DELETE, MOVE, UNSPLIT commands. After the final operation of CLEAN and BUILD, a new topology was created for the network coverage which was later used in determining distance.

The third and final step was to add impedance values of the road network to the attribute table of the ROADNET in ArcPlot environment of ArcGIS9.0. The *Pucca* roads were appointed a value of 1 and *katcha* roads were given 5, which represented their respective generalized travel time. The new elements of the network (manually added) were considered as *katcha* roads.

ap 7.1: Centroids of Mouzas



Original Map Source: LGED (2005)

7.3 Measuring Euclidian Distance

The NODEDISTANCE command could also be used to measure the Euclidian distance between the attributes. But due to lack of metadata of collected spatial data of the study area the NODEDISTANCE command could not be used successfully to determine Euclidian distance.

Euclidian distance was calculated through developing scripts in AVENUE in ArcView GIS 3.2 (EUCLDIST.AVE). The output of the process, distance between mouza centroids and service centres, was stored in the Point Attribute Table (PAT) of shape file of service centres (RETAILF). The measurement unit for Euclidian distance was meter [Appendix D].

7.4 Measuring Network Distance

The network distances between the mouza centroids and the service centres were measured using NODEDISTANCE command. The coverage of service centres (RETAILF) was specified as CENTRES, and that of mouza centroids (CENMJ.SHP) was specified as STOPS. Then NETCOVER command was used to specify the coverage ROADNET and the commands, 'CENTRES' and 'STOPS' were used to indicate centres and stops of the Coverage ROADNET. The resultant network distances was on the basis of generalized travel time. The calculated Euclidian distance and network distance has been shown in Appendix E and Appendix F.

Chapter 8

ACCESSIBILITY MODELING AND ANALYSIS OF FINDINGS

8. Accessibility Modeling an Analysis of Findings

Based on the selected criteria, centrality scores of the service centres and calculated distances between the mouzas and various service centres, accessibility indices for all the mouzas of the study area have been calculated. The estimated model outputs have been analyzed and tested for selecting the best option.

8.1 Measuring Accessibility Indices

8.1.1 Initial Model Application

The distance data (both Euclidian and network) were imported to spread sheet software (Microsoft Excel 2003) from its DBF format. The accessibility indices for 88 (eighty eight) mouzas were calculated in Microsoft Excel 2003 applying the three specified model equations [Equation 5.1 for Isochrone method, Equation 2.2 for Geographic method and Equation 5.3 for Potential (Gravity) method]. The index values for three models have been listed in Appendix G.

8.1.2 Standardizing Index Values

Because of the differences in measurement techniques, the index values as found from three alternative models were different. In the Isochrone model, the results represented cumulative value of central scores of all service centres with specified distance around every mouza, and therefore, the resultant index values were high, and higher values represented higher level of accessibility. On the other hand, the Geographic model calculates index values entirely on the basis of generalized travel time from each mouza to all the service centres; the values were therefore lower, and because of its methodological approach, lower values represented higher level of accessibility and vise versa. Finally in the Potential (Gravity) model, the index values were even lower than Geographic approach because of the distance decay factor, while the higher values represented higher accessibility for the mouzas.

To compare and hence test the index measures as obtained from different models, standardization was made to the index outputs. For each set of index values, the whole series was divided into a range of 0 to 100, considering the highest accessibility value to be 100, and the lowest as 0; while the other index values were standardized accordingly. The standardized index values for three measurement methods are listed in Appendix G.

8.1.3 Specifying Level of Accessibility

As the standardized output showed similar range of values (0 to 100) for each models, the next task was to classify these values into various levels of accessibility. For this, the range was equally divided into five classes to define five different levels of accessibility for the mouzas. The defined accessibility levels and their corresponding share for different model outputs have been shown in Table 8.1.

Table 8.1: Levels of Accessibility for Various Estimated Models

Values	Level of Accessibility	No of Mouzas		
		Isochrone Model	Geographic Model	Potential Model
80-100	Highly Accessible	9	19	2
60-79.99	Moderately High Accessible	28	40	2
40-59.99	Accessible	3	20	11
20-39.99	Less Accessible	29	8	31
0-19.99	Least Accessible	19	1	42

8.2 Analysis of Findings

8.2.1 Isochrone Model

The results of Isochrone model represent concentric distribution of accessibility index values in the study area (Map 8.1). The methodological approach for this model suggests that the mouzas with high concentration of service centres in or near them should show higher index values. In the study area, the central part shows the higher concentration of service centres, both in number and by size (See Map 8.1).

Therefore, the central part of the study area shows higher levels of accessibility according to this model. Index values follow a decreasing trend radially away from the centre; this may be because of the methodological approach of the model, as the mouzas at the periphery has limited option of service centres to be accessed. The pattern of distribution of mouzas with various accessibility levels does not show any significant relationship with the pattern of roadway network of the study area.

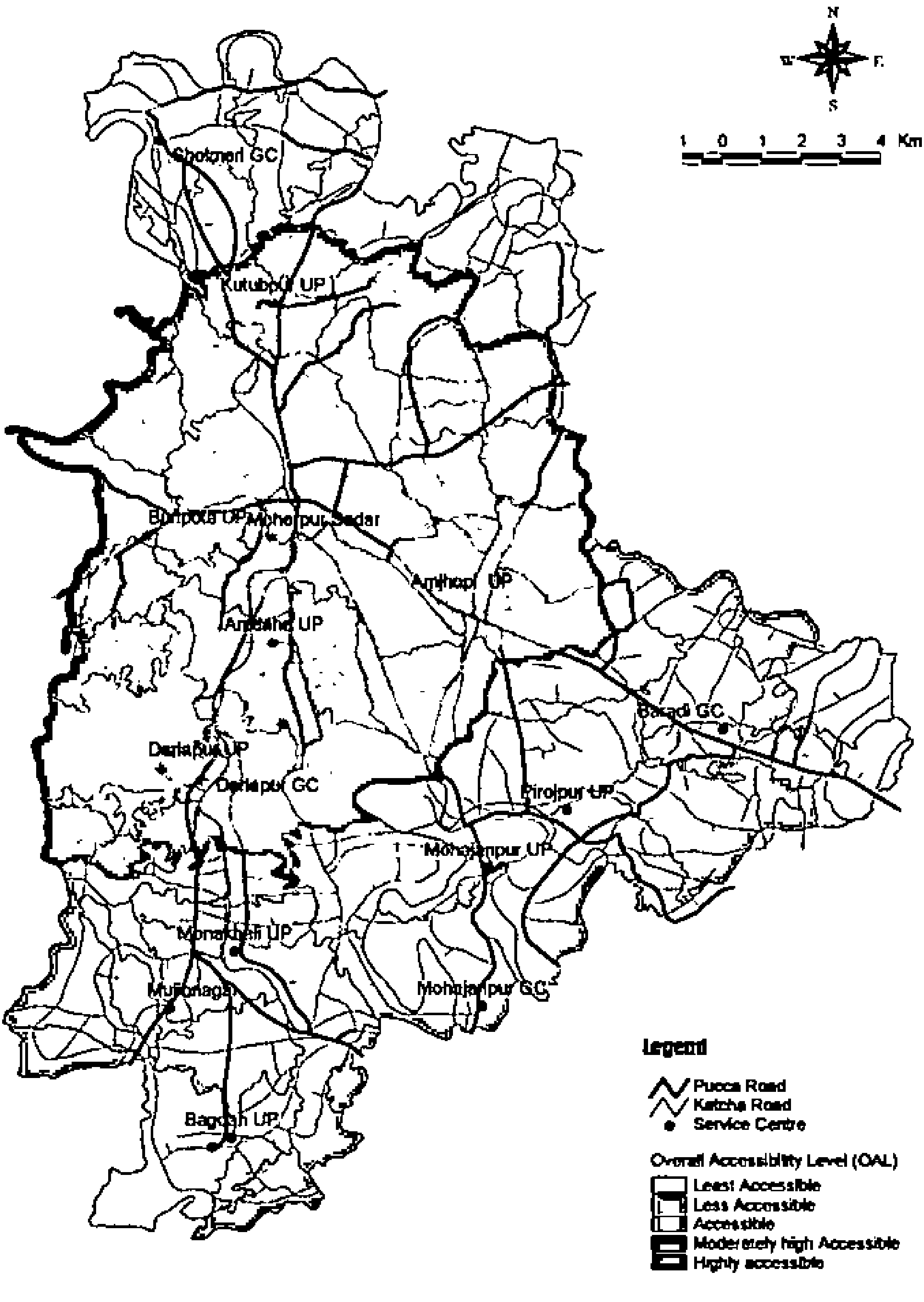
8.2.2 Geographic Model

The index values measured by Geographic model have been highly affected by the pattern of road network in the study area (Map 8.2). The highly accessible areas are concentrated at the centre of the study area and thereafter distributed along the major roads. The level of accessibility of the mouzas seems to have been directed by the concentration or availability of roads. The mouzas with more concentration of roads (especially *pucca* road) generally shows higher level of accessibility, while those with less density of roads have lower accessibility level The methodological approach does not suggest that the accessibility should be affected by the size of the service centres. But still, mouzas near to large service centres have higher index values. This may be because of the fact that the large service centres have improved connectivity and developed road network around them.

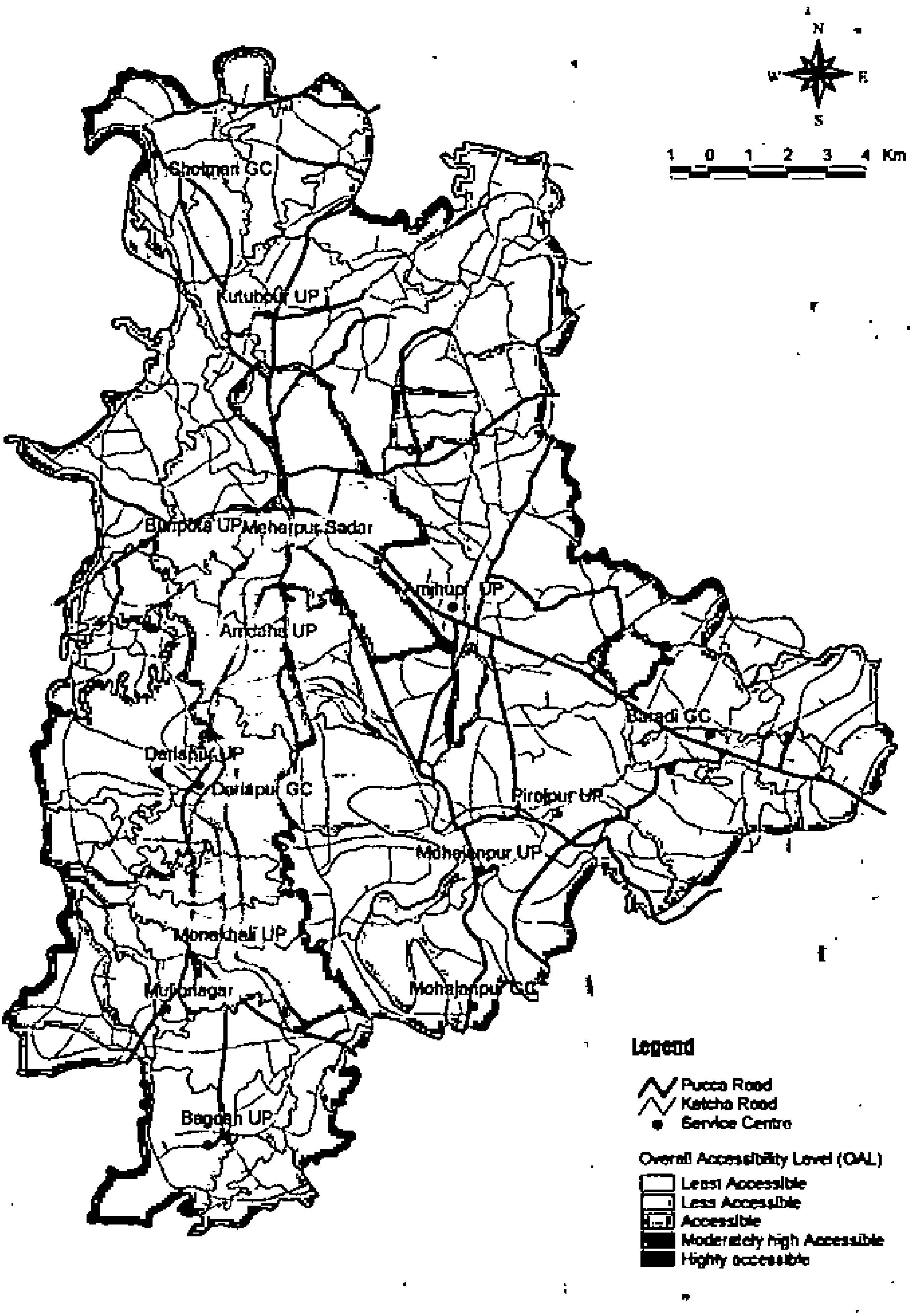
8.2.3 Potential Model

Results from Potential model also seem to represent similar pattern of distribution of accessibility index values, with the highest values concentrated at the centres of the study area which have the highest density of *pucca* road, and other mouzas with higher accessibility values are distributed along the major road network (Map 8.3). Methodologically, the index values depend both on the size of the service centres and distance. As all the selected service centres are located along the major transport links, the index values have also been distributed accordingly. The distribution also

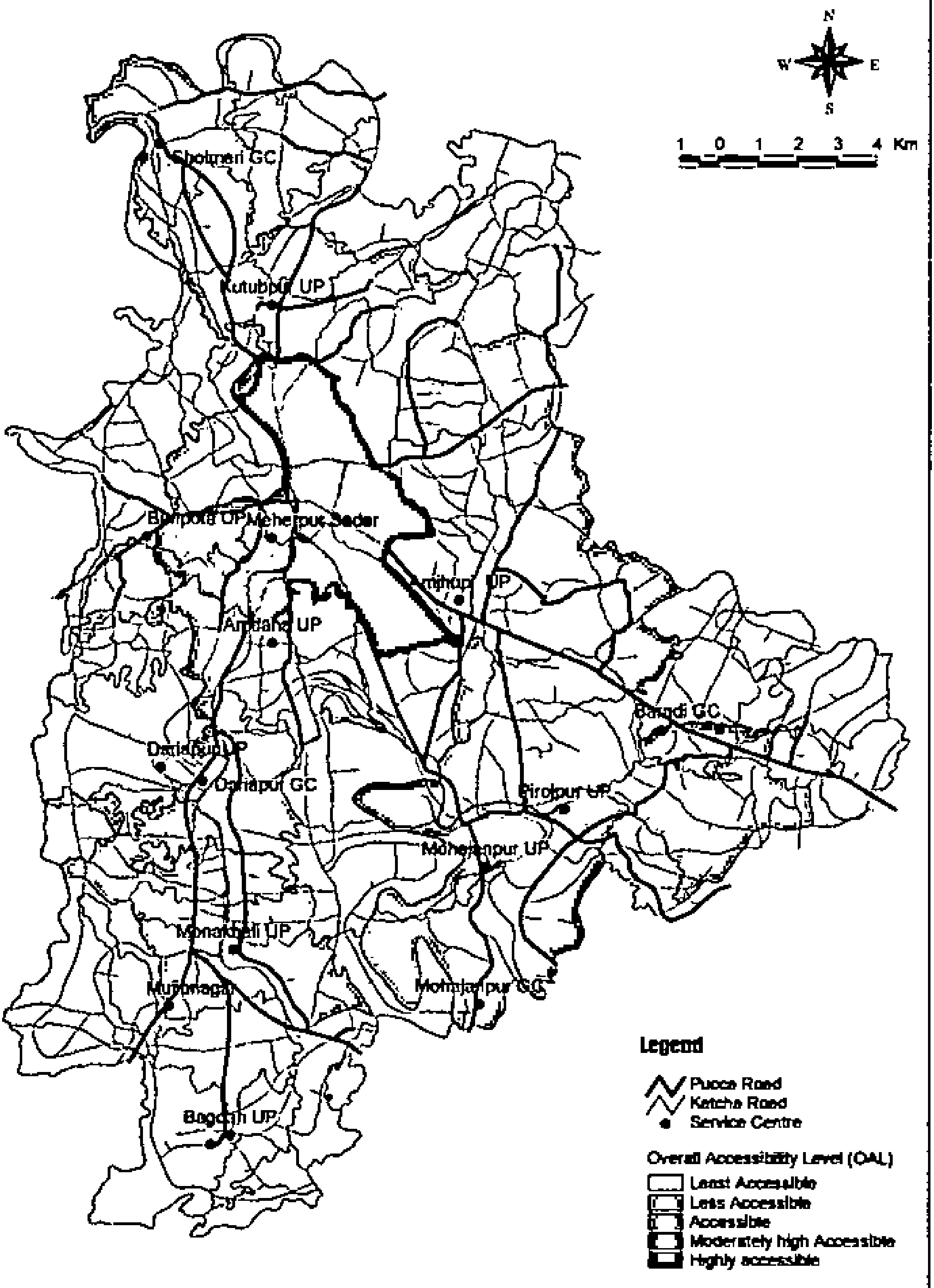
Map 8.1: Accessibility Index of Mouzas (Isochrone Model)



Map 8.2: Accessibility Index of Mouzas (Geographic Model)



Map 8.3: Accessibility Index of Mouzas (Potential Model)



seems to have been affected by the availability of *pucca* roads, as the mouzas with no or less density of *pucca* roads show lower level of accessibility However, the index values show a decreasing tendency with distance because of the distance decay factor, and therefore, the level of accessibility decreases significantly with small decrease in distance. This, however, makes the major difference in the output of this method with that of Geographic model.

8.3 Diagnosis of Estimated Model Outputs

As the outputs of three applied models showed different patterns of accessibility index values both in terms of distribution and level of accessibility, it was a crucial problem to determine which of the models produced the most appropriate measures of accessibility. In this study a composite weighted index has been used as the test model (Equation 5.4).

8.3.1 Measuring Overall Accessibility Level

Data on the levels of accessibility in respect of 6 selected activities at 8 sample mouzas were collected by a key informant discussion survey and were combined into a composite index to determine the Overall Accessibility Levels (OAL) of the mouzas. The results were standardized to determine the hierarchy of accessibility levels. The index values of the mouzas were classified into five equal class intervals showing different levels of accessibility over a range of 21 to 105 (minimum and maximum). The results have been shown in Table 8.2. The results show that all the surveyed mouzas have relatively lower levels of accessibility.

8.3.2 Comparison of Model Outputs

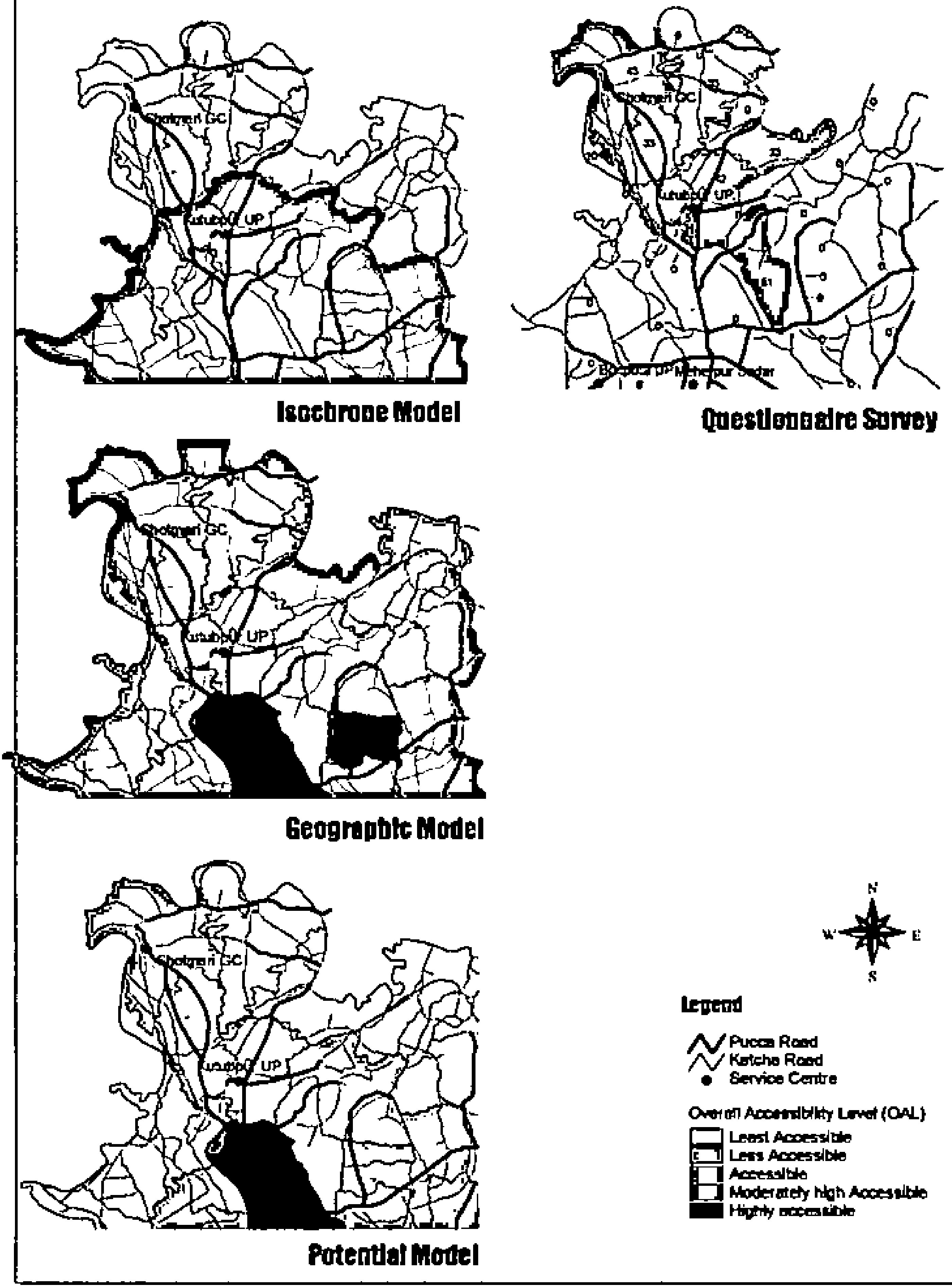
Finally, the result of the survey was compared with the three model outputs to assess their validity in the context of rural areas of Bangladesh. Coefficient of correlation was measured between each of the selected model outputs and the OAL as measured from the key informant discussion survey (field survey) for the selected mouzas. The results of correlation analysis have been shown in Table 8.3.

Table 8.2: Overall Accessibility Level (OAL) of the Mouzas

Name of Mouza	Accessibility Level								
	Grocery Shop(Hierarchy 1)	Medicine Shop (Hierarchy 2)	Fertilizer Dist. Centre (Hierarchy 3)	Rice Mill (Hierarchy 4)	Hat/ Bazaar (Hierarchy 5)	Cinema Hall (Hierarchy 6)	Accessibility Index Value $W_i \times V_i$	Standardized Value	OAL
Ujjalpur	4	4	3	4	3	2	64	51.19	3 (Accessible)
Sholmari	4	3	3	3	4	1	57	42.86	3 (Accessible)
Rudranagar	1	1	2	1	2	1	29	9 52	1 (Least Accessible)
Teroghariа	3	2	3	3	3	1	49	33.33	2 (Less Accessible)
Monoharpur	3	2	2	4	3	2	56	41.67	3 (Accessible)
Kutubpur	2	2	1	2	4	2	49	33.33	2 (Less Accessible)
Subidpur	3	3	2	4	3	3	64	51 19	3 (Accessible)
Fulbaria	2	2	1	3	2	3	49	33 33	2 (Less Accessible)

The table shows that all three model outputs represent positive correlation with the field survey results. While the Geographic model and Potential model showed to have high positive correlation with the survey results (0.871 and 0.806 respectively), the results of Isochrone model could not explain the variation in accessibility index values much efficiently. In case of Geographic model and Potential model, 75.9% and 64.9% of the changes in the accessibility level of the mouzas could be explained by the changes in the index values, while the Isochrone model could explain only

Map 8.4: Accessibility Index in Selected Mouzas by Alternative Methods



43.8% of the variations. Therefore, the validity of Isochrone model was discarded at this stage of diagnosis.

Although Geographic model and Potential model show similar values of R^2, the level of accessibility for the mouzas represented by the two models are quite different. While Geographic model shows higher levels of accessibility for the mouzas, for Potential model, the accessibility levels are quite low. Therefore, the two model outputs were further diagnosed against the field survey results using Rank Correlation analysis. The methodological approach of Rank Correlation suggests that the results which show much similarity in their values would show higher degree of correlation (Gupta and Gupta, 2000). The results of correlation analysis reveal that Potential model has very high degree of positive correlation with the OAL measured from the field survey, and can explain 86.2% of the variation in the level of accessibility of the mouzas. The Geographic model proved to be quite

Table 8.3: Correlation Analysis between Accessibility Index Values

Name of Mouza	**Isochrone Model**		**Geographic Model**		**Potential Model**		**OAL (From field survey)**	
	Std. Values	**Accessibility Level**	**Std. Values**	**Accessibility Level**	**Std. Values**	**Accessibility Level**	**Std. Values**	**Accessibility Level**
Ujjalpur	60.16	4	75.88	4	29.55	2	51.19	3
Sholmari	4.9	1	74.56	4	28.57	2	42.86	3
Rudranagar	8.37	1	25.66	2	3.68	1	9.52	1
Teragharia	4.9	1	78.29	4	32.14	2	33.33	2
Monoharpur	60.16	4	79.82	4	34.52	2	41.67	3
Kutubpur	4.9	1	54.61	3	12.45	1	33.33	2
Subidpur	76.52	4	76.32	4	29.44	2	51.19	3
Fulbaria	4.9	1	66.67	4	19.91	1	33.33	2
R (R)	0.662		0.871		0.806			
R^2	0.438		0.759		0.649			
Rank R		0.881		0.833		0.929		
Rank R^2		0.776		0.694		0.862		

less effective in this respect, which have an R^2 value of 0.694 The visual interpretation also suggests that the distribution of accessibility levels for the selected mouzas is more similar to the results of the Potential model rather than that of Geographic model. Therefore, we may conclude that Potential model is the best method to measure the accessibility indices for the rural areas in respect to their proximity to the service centres.

Chapter 9

CONCLUSION

9. Conclusion

This study has examined the applicability of three accessibility measurement methods- Isochrone model, Geographic model and Potential (Gravity) model, to determine the accessibility indices for rural mouzas in respect to their access to service centres. The study findings reveal that Potential accessibility model can best represent the Overall Accessibility Level (OAL) of the mouzas, and therefore, is regarded as the best option to measure the accessibility level of the rural localities.

The findings of the study suggest that the accessibility of the rural areas is affected by both the availability of service centres and also the availability of *pucca* roads; and moving away from any of these two variables reduces the level of accessibility significantly.

Another interesting finding of the study is that the areas with high accessibility are distributed along the major transportation network. This proposition is demonstrated by both Geographic model and Potential model. While the location and distribution of mouzas with high accessibility level has been guided by road network in the study area, this has principally been directed by the availability or proximity of *pucca* roads. The impacts of *katcha* roads on the level of accessibility seem to be negligent.

The study and its findings may have significant implications in rural development strategies in respect of Bangladesh. The model output represents a positive impact of transportation investment on accessibility of regions. The findings also suggest that the importance of surface quality of roadway network as the results show that *pucca* roads affect the level of accessibility much more than *katcha* roads. As it has been accepted that improvement in the level of accessibility have positive impacts on economic development (Chapter 2), the study findings also lead to the conclusion that improvement in transportation infrastructure may result in economic development of the rural areas (by means of improving their OAL).

Therefore the study might have strong potentials in respect of rural transport infrastructure development as a whole. Following the methodology, the least accessible rural areas may be identified, and this may help in determining priority regions for further development interventions. The methodology may also be used in evaluating future transportation infrastructure investments by assessing their possible impact on the level of accessibility in the rural areas, and also may be used in evaluating the alternative options for transport sector development.

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APPENDICES

Appendix A

Questionnaire Survey on Functional Activities at Service Centres

Thesis Title: Measuring Accessibility Index for Rural Areas: An Activity Based Approach

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This survey is being carried out as a part of the above mentioned research of Master of Urban and Regional Planning (MURP) programme of Bangladesh University of Engineering and Technology, Dhaka-1000, Bangladesh. The data would be used only for research purpose and would be kept secret.

Name of the Interviewer: Serial No

Date of Interview:

1. Name of the Growth Centre:
2. Location:
3. Information on Retail Activities:

Sl. No.	Type of Activity	Average Daily Transaction

Signature of the Interviewer

Appendix B

Table: Hierarchy of Functions at Service Centres

Sl No.	Type of Use	Monakhali	Dariapur	Dariapur GS	Bagoan	Anandabash	Mohajonpur	Kedarganj (Mujibnagar)	Amjhupi	Pirojpur	Kutubpur	Buripota	Amdaha	Baradi	Sholmari	Meherpur Sadar	Total	Scaled Score	Mean	SD	Z Value	Weightage
1	Administrative Office	0	2	2	1	0	1	3	1	0	1	1	0	5	0	5	22	85.5625	86.52	16.57	-0.06	4
2	Animal Husbandry Centre	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	100			0.81	6
3	Bank	0	0	1	0	0	0	1	2	0	0	0	1	2	0	3	10	93.8125			0.44	5
4	Barber	1	0	0	0	3	4	4	4	4	2	3	4	3	1	10	43	71.125			-0.93	2
5	Blacksmith	0	0	0	0	0	1	3	2	1	0	1	2	2	0	6	18	88.3125			0.11	4
6	Book Shop	0	0	2	0	0	1	3	1	0	0	0	0	0	0	5	12	92.4375			0.36	5
7	Brick Field	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	4	97.9375			0.69	5
8	CD/ Cassette/ Video	0	0	1	0	1	2	2	2	0	0	0	0	2	1	12	23	84.875			-0.10	4
9	Cinema Hall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	100			0.81	6
10	Cloth Ironing Shop	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5	6	96.5625			0.61	5
11	Cobbler	0	0	1	0	0	1	1	3	2	0	0	1	4	0	8	21	86.25			-0.02	4
12	College	0	0	1	0	0	0	0	0	0	0	0	0	1	0	2	4	97.9375			0.69	5
13	Courier Service	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	4	97.9375			0.69	5
14	Decorator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	98.625			0.73	5
15	Electric Shop	0	0	1	0	0	3	0	0	0	0	0	0	0	0	13	17	89			0.15	4
16	Electronic Servicing Centre	0	0	2	0	1	0	1	0	0	0	1	0	0	0	13	18	88.3125			0.11	4
17	Family Planning Centre/ Charitable Dispensary	0	0	0	1	0	0	0	2	1	2	0	2	2	0	3	13	91.75			0.32	5
18	Fertilizer Distribution Centre	0	0	2	0	2	5	0	2	3	0	1	3	3	3	6	32	78.6875			-0.47	3
19	Flower Shop	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	99.3125			0.77	6
20	Fruit Shop	0	0	3	0	0	0	11								8	22	85.5625			-0.06	4
21	Furniture Store/ Carpenter	0	0	1	0	0	4	1	1	2	0	1	3	2	0	6	21	86.25			-0.02	4

22	Godown	0	0	3	0	0	0	0	0	0	0	0	3	1	6	0	13	91.75			0.32	5
23	Grocery Shop	0	2	3	1	5	8	10	4	2	0	2	2	4	5	27	75	49.125			-2.26	1
24	Hardware Store	0	0	3	0	3	5	1	4	6	0	0	4	0	0	26	52	64.9375			-1.30	1
25	Hat/ Bazar	0	0	1	0	0	1	0	1	0	1	0	0	1	1	2	8	95.1875			0.52	5
26	Health Complex/ Hospital	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	5	97.25			0.65	5
27	Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	99.3125			0.77	6
28	Jewellary Store	0	0	1	0	0	1	0								18	20	86.9375			0.03	4
29	Library/ Club	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	4	97.9375			0.69	5
30	Machinery Store	0	0	1	0	1	2	0	4	1	0	1	0	0	0	6	16	89.6875			0.19	4
31	Medicine Store	0	0	2	0	4	7	3	6	1	0	4	2	1	1	11	42	71.8125			-0.89	2
32	Mobile Call Centre/ Phone Booth	0	0	1	0	0	0	3	3	2	0	0	2	3	2	12	28	81.4375			-0.31	3
33	Motor Cycle Repairing	0	0	1	0	0	3	0	1	0	0	0	0	0	0	4	9	94.5			0.48	5
34	Oil Shop	0	0	2	0	1	2	0	0	0	0	0	0	1	1	5	12	92.4375			0.36	5
35	Photo Studio/ Lab	0	0	2	0	0	1	2	0	0	0	1	0	0	0	6	12	92.4375			0.36	5
36	Photostat	0	0	0	0	0	0	0	1	0	0	0	0	1	0	5	7	95.875			0.56	5
37	Police Camp	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	2	99.3125			0.77	6
38	Post office	0	0	0	0	0	0	0	1	1	0	0	1	1	0	1	5	97.25			0.65	5
39	Pourasava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	100			0.81	6
40	Primary School	1	0	1	1	0	2	1	1	1	1	1	1	1	0	4	16	89.6875			0.19	4
41	Private Medical Practitioner	0	0	0	0	0	1	0	4	1	0	1	0	2	0	12	21	86.25			-0.02	4
42	Residential Hotel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	97.9375			0.69	5
43	Restaurant	0	0	0	0	3	2	6								10	21	86.25			-0.02	4
44	Retail Cloth Store/ Readymade Garments	0	0	3	0	11	9	4	15	2	0	0	3	4	3	22	76	48.4375			-2.30	1
45	Rice Mill	0	0	0	0	3	2	2	1	1	0	1	4	4	1	6	25	83.5			-0.18	4
46	Rickshaw Cycle Repairing	0	0	2	0	2	2	2	2	2	1	2	2	3	2	5	27	82.125			-0.27	3
47	Sanitary Store	0	0	0	0	0	1	0	0	0	0	0	0	0	0	5	6	96.5625			0.61	5
48	Saw Mill	0	0	4	0	1	0	1	2	0	0	0	1	2	0	6	17	89			0.15	4
49	Secondary School	0	0	1	1	0	1	0	1	1	1	0	2	1	0	2	11	93.125			0.40	5
50	Seed Distribution Centre	0	0	0	0	1	2	0	1	1	0	0	2	2	1	11	21	86.25			-0.02	4

51	Shoe Store	0	0	1	0	0	1	6							13	13	34	77.3125			-0.56	3
52	Show Room/ Sales Centre	0	0	0	0	0	1	0	0	0	0	0	0	0	0	8	9	94.5			0.48	5
53	Sports Store	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	100			0.81	6
54	Stationary Shop	0	0	2	1	1	4	6	13	13	2	2	8	9	0	25	86	41.5625			-2.71	1
55	Sweetmeat	0	0	2	0	0	2	6	0	0	0	3	0	0	0	10	23	84.875			-0.10	4
56	Tailor	0	0	0	0	1	2	1	3	1	0	2	3	4	3	12	32	78.6875			-0.47	3
57	Tea Stall	2	2	5	1	8	14	20	15	7	4	3	9	9	5	41	145	1			-5.16	1
58	Union Parisad	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	11	93.125			0.40	5
59	Utensils Store	0	0	0	0	1	1	2	2	1	0	0	1	2	0	6	16	89.6875			0.19	4
60	Welder	0	0	1	0	1	2	0	3	2	0	2	0	2	0	5	18	86.3125			0.11	4
61	Wholesale	0	0	0	0	0	0	0	3	0	0	0	0	1	0	23	27	82.125			-0.27	3

Appendix C

Table: Centrality Scores of Service Centres

Sl No.	Type of Use	Monakhali	Dariapur	Dariapur GS	Bagoan	Anandabash	Mohajonpur	Kedarganj (Mujibnagar)	Amjhupi	Pirojpur	Kutubpur	Burpota	Amdaha	Baradi	Sholmari	Meherpur Sadar
1	Administrative Office	0	8	8	4	0	4	12	4	0	4	4	0	20	0	20
2	Animal Husbendry Centre	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0
3	Bank	0	0	5	0	0	0	5	10	0	0	0	5	10	0	15
4	Barber	2	0	0	0	6	8	8	8	8	4	6	8	6	2	20
5	Blacksmith	0	0	0	0	0	4	12	8	4	0	4	8	8	0	24
6	Book Shop	0	0	10	0	0	5	15	5	0	0	0	0	0	0	25
7	Brick Field	0	0	0	0	0	0	0	0	0	0	0	10	10	0	0
8	CD/ Cassette/ Video	0	0	4	0	4	8	8	8	0	0	0	0	8	4	48
9	Cinema Hall	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
10	Cloth Ironing Shop	0	0	0	0	5	0	0	0	0	0	0	0	0	0	25
11	Cobbler	0	0	4	0	0	4	4	12	8	0	0	4	16	0	32
12	College	0	0	5	0	0	0	0	0	0	0	0	0	5	0	10
13	Courier Service	0	0	0	0	0	0	0	0	0	0	0	0	5	0	15
14	Decorator	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
15	Electric Shop	0	0	4	0	0	12	0	0	0	0	0	0	0	0	52

16	Electronic Servicing Centre	0	0	8	0	4	0	4	0	0	0	4	0	0	0	52
17	Family Planning Centre/ Charitable Dispensary	0	0	0	5	0	0	0	10	5	10	0	10	10	0	15
18	Fertilizer Distribution Centre	0	0	6	0	6	15	0	6	9	0	3	9	9	9	24
19	Flower Shop	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
20	Fruit Shop	0	0	12	0	0	0	44	0	0	0	0	0	0	0	32
21	Furniture Store/ Carpenter	0	0	4	0	0	16	4	4	8	0	4	12	8	0	24
22	Godown	0	0	15	0	0	0	0	0	0	0	0	15	5	30	0
23	Grocery Shop	0	2	3	1	5	8	10	4	2	0	2	2	4	5	27
24	Hardware Store	0	0	3	0	3	5	1	4	6	0	0	4	0	0	26
25	Hat/ Bazar	0	0	5	0	0	5	0	5	0	5	0	0	5	5	10
26	Health Complex/ Hospital	5	5	0	5	0	5	0	0	0	0	0	0	0	0	5
27	Insurance	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12
28	Jewellary Store	0	0	4	0	0	4	0	0	0	0	0	0	0	0	72
29	Library/ Club	0	5	0	0	0	0	0	0	0	0	0	0	0	0	15
30	Machinery Store	0	0	4	0	4	8	0	16	4	0	4	0	0	0	24
31	Medicine Store	0	0	4	0	8	14	6	12	2	0	8	4	2	2	22
32	Mobile Call Centre/ Phone Booth	0	0	3	0	0	0	9	9	6	0	0	6	9	6	36
33	Motor Cycle Repairing	0	0	5	0	0	15	0	5	0	0	0	0	0	0	20
34	Oil Shop	0	0	10	0	5	10	0	0	0	0	0	0	5	5	25
35	Photo Studio/ Lab	0	0	10	0	0	5	10	0	0	0	5	0	0	0	30
36	Photostat	0	0	0	0	0	0	0	5	0	0	0	0	5	0	25
37	Police Camp	0	0	0	0	0	6	0	0	0	0	0	0	0	0	6

38	Post office	0	0	0	0	0	0	0	5	5	0	0	5	5	0	5
39	Pourasava	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
40	Primary School	4	0	4	4	0	8	4	4	4	4	4	4	4	0	16
41	Private Medical Practitioner	0	0	0	0	0	4	0	16	4	0	4	0	8	0	48
42	Residential Hotel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
43	Restaurant	0	0	0	0	12	8	24	0	0	0	0	0	0	0	40
44	Retail Cloth Store/ Readymade Garments	0	0	3	0	11	9	4	15	2	0	0	3	4	3	22
45	Rice Mill	0	0	0	0	12	8	8	4	4	0	4	16	16	4	24
46	Rickshaw Cycle Repairing	0	0	6	0	6	6	6	6	6	3	6	6	9	6	15
47	Sanitary Store	0	0	0	0	0	5	0	0	0	0	0	0	0	0	25
48	Saw Mill	0	0	16	0	4	0	4	8	0	0	0	4	8	0	24
49	Secondary School	0	0	5	5	0	5	0	5	5	5	0	10	5	0	10
50	Seed Distribution Centre	0	0	0	0	4	8	0	4	4	0	0	8	8	4	44
51	Shoe Store	0	0	3	0	0	3	18	0	0	0	0	0	0	39	39
52	Show Room/ Sales Centre	0	0	0	0	0	5	0	0	0	0	0	0	0	0	40
53	Sports Store	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
54	Stationary Shop	0	0	2	1	1	4	6	13	13	2	2	8	9	0	25
55	Sweetmeat	0	0	8	0	0	8	24	0	0	0	12	0	0	0	40
56	Tailor	0	0	0	0	3	6	3	9	3	0	6	9	12	9	36
57	Tea Stall	2	2	5	1	8	14	20	15	7	4	3	9	9	5	41
58	Union Parisad	5	5	0	5	0	5	5	5	5	5	5	5	5	0	0
59	Utensils Store	0	0	0	0	4	4	8	8	4	0	0	4	8	0	24

60	Welder	0	0	4	0	4	8	0	12	8	0	8	0	8	0	20
61	Wholesale	0	0	0	0	0	0	0	9	0	0	0	0	3	0	69
	CENTRALITY SCORE	**18**	**27**	**192**	**31**	**119**	**285**	**286**	**273**	**136**	**46**	**98**	**188**	**271**	**138**	**1460**

Appendix D

AVENUE Scripts Used in the Study

Script no 1

Description: This script was used to determine the centroids of the mouzas. A shape file of point features was created and added to ArcView GIS 3.2 project file

File Name: CENTRD.AVE

Source Code:

```
theView = av.GetActiveDoc
'must be global to work in Calc exp below
_theProjection = theView.GetProjection
project_flag = _theProjection.IsNull.Not  'true if projected
theTheme = theView.GetActiveThemes.Get(0)

'Check if point or polygon theme
if (((theTheme.GetSrcName.GetSubName = "point") or
    (theTheme.GetSrcName.GetSubName = "polygon")).Not) then
 MsgBox.Info("Active theme must be polygon or point theme","")
  return nil
end

'get the theme table and current edit state

theFTab = theTheme.GetFTab
theFields = theFTab.GetFields
edit_state = theFTab.IsEditable

'make sure table is editable and that fields can be added
if (theFtab.CanEdit) then
theFTab.SetEditable(true)
if ((theFTab.CanAddFields).Not) then
MsgBox.Info("Can't add fields to the table."+NL+"Check write permission.",
"Can't add X,Y coordinates")
return nil
end
else
MsgBox.Info("Can't modify the feature table."+NL+
"Check write permission.","Can't add X,Y coordinates")

return nil
end

'Check if fields named "X-coord" and Y-coord" exist
x_exists = (theFTab.FindField("X-coord") = NIL).Not
y_exists = (theFtab.FindField("Y-coord") = NIL).Not

if (x_exists or y_exists) then
  if (MsgBox.YesNo("Overwrite existing fields?",
  "X-coord, Y-coord fields already exist", false)) then
```

```
    'if ok to overwrite, delete the fields as they may not be defined
    'as required by this script (eg., created from another script).
 if (x_exists) then

 theFTab.RemoveFields({theFTab.FindField("X-coord")})
 end
if (y_exists) then
theFTab.RemoveFields({theFTab.FindField("Y-coord")})
end
else
return nil
  end  'if (MsgBox...)
end  'if

x = Field.Make ("X-coord",#FIELD_DECIMAL,18,5)
y = Field.Make ("Y-coord",#FIELD_DECIMAL,18,5)
theFTab.AddFields({x,y})

'Get point coordinates or polygon centroid coordinates
if (theTheme.GetSrcName.GetSubName = "point") then
if (project_flag) then

    'Projection defined
theFTab.Calculate("[Shape].ReturnProjected(_theProjection).GetX", x)
theFTab.Calculate("[Shape].ReturnProjected(_theProjection).GetY", y)
else
'No projection defined
theFTab.Calculate("[Shape].GetX", x)
theFTab.Calculate("[Shape].GetY", y)
end  'if
else  'polygon case
 if (project_flag) then
theFTab.Calculate("[Shape].ReturnCenter.ReturnProjected(_theProjection).Get
X", x)

theFTab.Calculate("[Shape].ReturnCenter.ReturnProjected(_theProjection).Get
Y", y)

else
theFTab.Calculate("[Shape].ReturnCenter.GetX", x)
theFTab.Calculate("[Shape].ReturnCenter.GetY", y)
  end  ' if
end

'Return editing state to pre-script running state
theFTab.SetEditable(edit_state)


'-------------------------

newshpname = filedialog.put("distance.shp".asfilename,"*.shp"," Distance")

if (newshpname = nil) then
exit
end


 xv = theFTab.findfield("X-coord")
 yv = theFTab.findfield("Y-coord")
 idv = theFTab.findfield("id")
```

```
distftab = ftab.makenew(newshpname,point)
distftab.seteditable(true)
distftab.addfields({idv.clone})

shpfield = distftab.findfield("shape")
idf = distftab.findfield("id")


 for each i in theFTab
 x1 = theFTab.returnvalue(xv,i)
 y1 = theFTab.returnvalue(yv,i)
 id = theFTab.returnvalue(idv,i)

 distftab.seteditable(true)
 newrec = distftab.addrecord

 xw = distftab.setvalue(shpfield,newrec,x1@y1)

  distftab setvalue(idf,newrec,id)

 end
distftab.seteditable(false)
theview.addtheme(ftheme.make(distftab))
```

Script no 2

Description: This script was used to calculate Euclidian distance between service centres and the centroids of the mouzas. The output of the process, distance between mouza centroids and service centres, was stored in the Point Attribute Table (PAT) of shape file of service centers.

File Name: EUCLDIST.AVE

Source Code:

```
'Calculates distances from points in one theme to points in another


theThemeList = av.GetActiveDoc.GetThemes.Clone
thePrj = av.GetActiveDoc.GetProjection

'  Use these lines to hard-code the input parameters...
'theFromFtab =
av.GetProject.FindDoc("View1").FindTheme("FromTheme").GETFTab
'theFromIDField = theFromFtab.FindField("Bnmb")
'theToTheme = av.GetProject.FindDoc("View1").FindTheme("ToTheme")
'theToFtab = theToTheme.GetFTab

'  Use these lines to prompt the user for input parameters...
theFromTheme = (MsgBox.List(theThemeList,"to calculate the distance
FROM.","Please select a theme..."))

if (theFromTheme = nil) then exit end
theFromFtab = theFromTheme.GetFTab
theThemeList.RemoveObj(theFromTheme)
theToTheme = (MsgBox.List(theThemeList,"to calculate the distance
TO.","Please select a theme..."))
if (theToTheme = nil) then exit end
theToFtab = theToTheme.GetFTab
theFromIDField = MsgBox.ListAsString(theFromFtab.GetFields,"containing the
point identifier.","Please select a field...")
  if (theFromIDField = nil) then
    exit
  end

theFromShapeField = theFromFTab.FindField("Shape")

theToShapeField = theToFtab.FindField("Shape")

theToFtab.SetEditable(true)

for each f in theFromFtab.GetSelection

  theFromIDValue = theFromFtab.ReturnValueString(theFromIDField,f)
  theNewFieldName = "DistTo"+theFromIDValue

' If a distance field doesn't exist, add it...
  if (theToFtab.FindField(theNewFieldName) = nil) then

'   Choose the field size commensurate with the view's projection.
    if (thePrj.IsNull) then
```

```
      theDistanceField = field.make(theNewFieldName,#field_decimal,8,4)

    else
      theDistanceField = field.make(theNewFieldName,#field_decimal,8,2)
    end

    theToFtab.addfields({theDistanceField})
' If a distance field does exist, clear it...
  else
    theToFtab.Calculate("0",theToFtab.FindField(theNewFieldName))
    theDistanceField = theToFTab.FindField(theNewFieldName)
  end

' Get the point location you are measuring FROM.
' If the view is projected, get the the point location in projected units.
  theFromShape = theFromFTab.ReturnValue(theFromShapeField,f)

  if (thePrj.IsNull.Not) then
    theFromShape = theFromShape.ReturnProjected(thePrj)
  end

  for each t in theToFtab
    '  Get the point location you are measuring TO.
    '  Get it in projected units, if the view is projected.
    theToShape = theToFTab.ReturnValue(theToFtab.FindField("Shape"),t)
      if (thePrj.IsNull.Not) then
        theToShape = theToShape.ReturnProjected(thePrj)
      end

    ' Calculate the distance between the two points.

    ' Add the value to the output (TO) branch table.
    theDistance = theFromShape.Distance(theToShape)
    theToFtab.SetValue(theDistanceField,t,theDistance)
  end

end

theToFtab.SetEditable(false)

av.ShowMsg("Distance calculation complete")
```

Appendix E

Table: Euclidian Distance Between Service Centres and Mouza Centroids (Meter)

NAME	Pirojpur UP	Amjhupi UP	Meherpur Sadar	Buripota UP	Amdaha UP	Kutubpur UP	Sholmari GC	Baradi GC	Monakhali UP	Bagoan UP	Mujibnagar	Dariapur UP	Darlapur GC	Ananda bash GC	Mohajan pur GC
DISTTO1	20000.0	14000 0	12000.0	12000 0	14000 0	5929.6	2965.4	20000 0	22000 0	27000 0	24000.0	18000 0	18000 0	27000 0	24000.0
DISTTO2	19000.0	13000.0	9796 4	9401.1	12000.0	4414.5	613 1	20000.0	20000 0	25000 0	21000 0	15000.0	18000 0	25000 0	23000 0
DISTTO3	18000.0	12000 0	9762 6	10000.0	12000 0	3901 4	3631 5	18000.0	20000 0	25000 0	22000 0	16000 0	16000.0	25000.0	22000.0
DISTTO4	20000.0	14000 0	11000 0	12000 0	14000 0	5445 0	3600.4	20000 0	22000 0	27000.0	23000 0	17000.0	18000.0	27000 0	24000 0
DISTTO5	19000 0	13000.0	10000 0	11000 0	13000 0	4495 6	2087.7	19000 0	21000.0	26000 0	22000 0	18000.0	17000.0	26000 0	23000 0
DISTTO6	17000 0	11000.0	9386.7	10000 0	12000 0	3665.4	4382.3	17000 0	20000.0	25000 0	22000.0	16000 0	16000 0	25000 0	21000 0
DISTTO7	16000.0	11000.0	11000 0	13000.0	13000 0	6915 8	8989.1	15000.0	21000 0	26000 0	23000.0	17000 0	17000 0	26000 0	21000 0
DISTTO8	17000.0	11000 0	9854 2	11000 0	12000 0	4353.0	5249 7	17000 0	20000.0	25000 0	22000 0	16000.0	16000 0	25000 0	22000 0
DISTTO9	17000 0	11000 0	8052 0	8026 9	11000.0	2526.7	2488 2	18000 0	18000.0	23000 0	20000 0	14000 0	14000 0	23000 0	21000 0
DISTTO10	18000 0	13000 0	8663 2	7922 7	11000.0	3987.0	2101.4	20000.0	19000 0	23000.0	20000 0	14000.0	14000.0	23000 0	22000 0
DISTTO11	15000 0	9329 1	9363.9	11000 0	12000 0	5558.7	8429 6	14000 0	19000 0	24000 0	21000.0	16000.0	16000.0	24000 0	20000.0
DISTTO12	16000 0	9750.4	8494.0	9988 5	11000 0	3549.4	6094 0	15000.0	19000 0	24000 0	21000 0	15000 0	15000 0	24000.0	20000.0
DISTTO13	14000.0	8470 3	9292 4	12000 0	11000 0	6425.1	9802 0	13000.0	19000 0	23000 0	21000 0	16000.0	15000 0	24000 0	19000 0
DISTTO14	15000 0	9463.4	7028.3	7979 3	9660.4	1319 9	4723 1	16000 0	18000.0	22000.0	19000 0	13000.0	13000 0	23000.0	19000 0
DISTTO15	13000.0	7497.8	6695 1	8701 6	9069.0	3354 2	7523 6	13000.0	17000 0	21000 0	19000 0	13000 0	13000.0	22000.0	18000.0
DISTTO16	15000 0	8939.4	5789 7	6427 0	8434.7	309 6	4953 4	16000 0	16000.0	21000.0	18000.0	12000 0	12000.0	21000 0	18000 0
DISTTO17	14000 0	8662.7	4689 0	4775 0	7264 5	1999 9	5718.6	16000.0	15000 0	20000 0	16000 0	10000.0	11000 0	20000.0	18000.0
DISTTO18	17000 0	11000 0	6869.1	6490 0	9413.3	2368.1	3572 5	18000 0	17000 0	22000.0	18000.0	12000.0	13000 0	22000 0	20000 0
DISTTO19	12000 0	6058.5	4462 3	6595 6	6882 4	2961.6	7930.2	13000 0	15000 0	19000 0	16000 0	11000 0	11000.0	20000 0	16000 0
DISTTO20	16000.0	9912 8	5590 1	4864 5	8019.0	2901.0	5113 9	17000.0	15000.0	20000 0	17000 0	11000 0	11000 0	20000.0	19000 0
DISTTO21	12000 0	6323 2	6434 9	8871 0	8556 4	4495 4	8937 2	12000.0	16000 0	21000 0	18000 0	13000.0	12000 0	21000.0	17000.0
DISTTO22	11000 0	5717.7	7339 4	10000 0	9032.6	6440 4	11000 0	10000 0	16000 0	20000.0	18000.0	13000.0	13000 0	21000.0	16000 0
DISTTO23	11000 0	4883 2	2599 6	5155.4	4965 2	4128.8	9080.4	12000.0	13000 0	17000 0	15000 0	9017.8	8873.8	18000 0	14000 0
DISTTO24	14000 0	7886 0	4156 3	4766 7	6784.3	1924.9	6297.2	15000 0	15000 0	19000.0	16000.0	10000.0	10000 0	20000.0	17000.0
DISTTO25	15000 0	9513 5	4624 2	2931 0	6652.0	4626.4	7080 3	17000 0	14000 0	18000.0	15000.0	8788.1	9285 1	18000 0	17000 0
DISTTO26	11000 0	5268 4	5703.6	8363 0	7664 0	4880.5	9600.7	11000 0	15000 0	20000 0	17000 0	12000 0	12000.0	20000 0	16000 0
DISTTO27	10000.0	4499 8	5188 6	8003 2	7000 9	5234 4	10000.0	11000 0	14000 0	19000 0	16000.0	11000 0	11000 0	19000 0	15000 0
DISTTO28	12000 0	7033 7	2345 1	2715 8	4799.8	4128 7	8185 3	14000 0	12000 0	17000 0	14000.0	7933 1	8144.1	17000.0	15000 0
DISTTO29	8860 1	3978 5	6963 2	10000 0	8083 4	7762.5	13000 0	8278.7	15000 0	19000.0	17000 0	12000.0	12000.0	19000 0	14000 0

DISTTO30	13000.0	8978.6	4036.6	863.3	4828.7	7197.4	10000.0	18000.0	11000.0	15000.0	12000.0	5880.8	6517.7	18000.0	15000.0
DISTTO31	9033.8	3190.6	4648.0	7899.6	6062.4	6128.6	11000.0	9500.1	13000.0	18000.0	15000.0	10000.0	9871.9	18000.0	13000.0
DISTTO32	11000.0	6259.7	1200.9	2021.8	3162.0	5745.9	9870.2	14000.0	11000.0	15000.0	12000.0	8303.0	8459.6	18000.0	14000.0
DISTTO33	5621.8	2169.1	7013.1	10000.0	7070.8	9834.1	15000.0	5869.2	12000.0	18000.0	14000.0	11000.0	10000.0	17000.0	11000.0
DISTTO34	7381.1	1715.5	5149.1	8324.5	5813.5	7738.6	13000.0	8010.0	12000.0	17000.0	14000.0	9926.9	9323.6	17000.0	12000.0
DISTTO35	6700.1	2643.5	3498.6	6134.7	2338.3	8799.5	14000.0	9358.2	8550.1	13000.0	11000.0	6113.2	5459.5	13000.0	9730.0
DISTTO36	11000.0	6085.7	1448.4	2123.0	2248.9	8794.5	11000.0	13000.0	9878.3	14000.0	11000.0	5272.8	5401.1	15000.0	13000.0
DISTTO37	7730.1	2897.2	2506.0	5478.4	2478.4	7531.9	12000.0	9959.5	9833.3	14000.0	12000.0	6873.8	6194.3	15000.0	11000.0
DISTTO38	13000.0	8499.9	3902.5	1433.3	3953.1	8088.1	11000.0	18000.0	9560.5	14000.0	11000.0	4591.3	5229.8	14000.0	14000.0
DISTTO39	5934.1	4489.8	8369.5	13000.0	9366.7	12000.0	17000.0	4204.9	14000.0	17000.0	18000.0	13000.0	12000.0	18000.0	11000.0
DISTTO40	6077.1	5864.0	11000.0	14000.0	11000.0	13000.0	18000.0	3226.2	15000.0	18000.0	17000.0	14000.0	13000.0	18000.0	11000.0
DISTTO41	10000.0	6763.8	3119.8	2841.0	1927.1	8599.0	13000.0	14000.0	8025.6	13000.0	9440.8	3447.9	3672.5	13000.0	12000.0
DISTTO42	6964.9	3440.6	3450.0	5746.1	1696.2	9088.1	14000.0	9029.1	7899.5	12000.0	9872.4	5306.5	4663.0	13000.0	9555.7
DISTTO43	6650.7	7829.8	13000.0	16000.0	13000.0	15000.0	20000.0	2515.1	16000.0	19000.0	18000.0	18000.0	15000.0	19000.0	12000.0
DISTTO44	11000.0	9070.4	6111.6	4999.0	4299.9	11000.0	15000.0	15000.0	6130.2	11000.0	7036.8	1174.5	2222.7	11000.0	11000.0
DISTTO45	12000.0	9005.7	5118.2	3284.3	4117.3	9893.6	13000.0	18000.0	7970.5	12000.0	8900.6	2958.2	3813.8	13000.0	13000.0
DISTTO46	8157.0	5382.8	3840.1	4979.0	1197.7	9743.0	14000.0	12000.0	8873.3	11000.0	8448.4	3383.4	2883.7	12000.0	9653.1
DISTTO47	4352.8	4785.3	9646.8	13000.0	9365.0	13000.0	18000.0	2781.0	13000.0	18000.0	15000.0	13000.0	12000.0	17000.0	8768.4
DISTTO48	4858.8	6816.6	12000.0	15000.0	11000.0	15000.0	20000.0	1081.8	14000.0	17000.0	16000.0	14000.0	13000.0	17000.0	10000.0
DISTTO49	3834.7	2304.0	6434.1	9199.8	5265.2	11000.0	16000.0	6367.4	8999.6	13000.0	11000.0	8217.8	7287.7	13000.0	7999.6
DISTTO50	7352.4	9701.5	15000.0	18000.0	14000.0	17000.0	22000.0	2926.7	17000.0	19000.0	19000.0	17000.0	16000.0	20000.0	12000.0
DISTTO51	6835.1	8583.1	14000.0	17000.0	13000.0	16000.0	21000.0	2466.1	16000.0	19000.0	18000.0	16000.0	15000.0	19000.0	12000.0
DISTTO52	3182.5	3233.2	8130.5	11000.0	7281.5	12000.0	17000.0	4360.6	11000.0	14000.0	13000.0	10000.0	9315.8	15000.0	8354.1
DISTTO53	8065.7	7156.3	6336.4	6885.2	3711.9	12000.0	16000.0	12000.0	4161.0	8881.4	5953.1	2335.7	1221.1	9150.0	8067.2
DISTTO54	1450.9	4505.1	6858.5	12000.0	7458.3	13000.0	18000.0	4614.4	9243.7	12000.0	11000.0	9719.3	8687.8	13000.0	6471.5
DISTTO55	9306.6	7135.8	5021.8	5064.4	2657.8	11000.0	15000.0	13000.0	5714.4	10000.0	7200.3	1627.4	1394.0	11000.0	9874.2
DISTTO0	5324.7	4988.8	8289.0	8042.0	3922.2	12000.0	17000.0	9231.7	5611.3	9890.8	7762.8	5098.7	4040.2	10000.0	8715.1
DISTTO57	7514.1	11000.0	16000.0	19000.0	15000.0	19000.0	24000.0	3664.8	17000.0	18000.0	19000.0	18000.0	17000.0	19000.0	11000.0
DISTTO58	3893.9	7357.9	12000.0	15000.0	11000.0	16000.0	21000.0	660.7	13000.0	16000.0	15000.0	14000.0	13000.0	18000.0	8656.1
DISTTO59	6256.1	9531.3	15000.0	18000.0	14000.0	18000.0	23000.0	2257.8	15000.0	18000.0	17000.0	16000.0	15000.0	18000.0	10000.0
DISTTO60	3716.5	8641.6	13000.0	16000.0	12000.0	17000.0	22000.0	7593.5	13000.0	14000.0	15000.0	14000.0	13000.0	15000.0	7341.1
DISTTO61	2152.9	7606.2	11000.0	13000.0	9218.4	16000.0	21000.0	6194.7	7892.6	10000.0	9861.3	10000.0	6978.8	11000.0	3274.5
DISTTO62	11000.0	10000.0	7656.0	7004.7	5878.1	13000.0	17000.0	15000.0	4455.9	8656.6	5074.9	1428.3	2055.4	8739.4	10000.0
DISTTO63	645.6	8537.8	11000.0	13000.0	9228.4	15000.0	20000.0	4203.9	8522.4	12000.0	12000.0	11000.0	9838.7	13000.0	5311.9

DISTT064	10000.0	9547.0	7933.8	7525.1	5534.9	14000.0	17000.0	14000.0	3465.8	7894.7	4436.3	1663.4	1612.6	8031.7	9145.9
DISTT065	9211.7	8868.7	7788.1	7798.1	5248.0	14000.0	18000.0	13000.0	2941.8	7602.7	4391.1	2133.4	1453.0	7805.6	8192.7
DISTT066	2392.0	8138.8	13000.0	15000.0	11000.0	17000.0	22000.0	3947.9	11000.0	13000.0	13000.0	13000.0	11000.0	13000.0	5483.7
DISTT056	5261.1	7500.2	9098.3	10000.0	5590.9	15000.0	20000.0	9891.5	3926.5	7399.4	6076.8	6139.2	5036.4	7847.7	4159.6
DISTT067	9468.6	9558.5	8627.1	8582.5	8077.9	14000.0	18000.0	14000.0	2211.7	8798.4	3552.1	2804.7	2277.0	6986.4	7940.5
DISTT068	11000.0	10000.0	6640.6	8146.8	6245.7	14000.0	18000.0	15000.0	3135.8	7354.2	3822.0	2302.4	2316.0	7480.4	8150.3
DISTT069	3284.1	7222.1	10000.0	12000.0	7795.4	15000.0	20000.0	7713.3	8015.2	8870.5	8061.5	8215.1	7092.2	9185.8	3094.2
DISTT070	7975.7	8894.1	8815.8	9130.5	5973.5	15000.0	10000.0	12000.0	1959.9	6613.0	4025.0	3788.5	2884.2	8912.6	6477.4
DISTT071	13000.0	13000.0	12000.0	11000.0	9374.8	17000.0	21000.0	17000.0	3509.1	5488.1	2083.1	5335.7	5440.9	5386.1	9808.8
DISTT072	4815.3	6999.2	11000.0	13000.0	9033.1	17000.0	22000.0	9068.4	5343.7	7135.9	7128.2	8840.8	7561.0	7683.1	1591.8
DISTT073	10000.0	11000.0	8949.3	9749.8	7415.3	18000.0	20000.0	15000.0	1811.5	5588.3	2244.4	3892.1	3564.2	5800.3	7988.4
DISTT074	8000.6	9373.5	8597.1	10000.0	6951.3	16000.0	20000.0	12000.0	1262.7	5675.7	3460.2	4715.7	3854.2	6006.2	5805.2
DISTT075	12000.0	13000.0	12000.0	11000.0	9345.8	17000.0	21000.0	17000.0	3007.4	4942.0	1482.4	5435.3	6415.2	4873.9	8237.2
DISTT076	11000.0	12000.0	11000.0	11000.0	6684.3	17000.0	21000.0	15000.0	1770.5	4599.0	1019.7	5078.5	4812.9	4889.1	8057.2
DISTT077	8107.3	10000.0	11000.0	12000.0	6578.7	17000.0	21000.0	13000.0	1760.8	4320.2	3325.2	6417.1	5589.7	4738.4	4730.2
DISTT078	6879.7	10000.0	12000.0	13000.0	9003.4	17000.0	22000.0	11000.0	3551.7	5249.5	5140.8	7654.4	6679.8	5756.8	2682.7
DISTT079	9881.7	11000.0	11000.0	12000.0	6783.5	17000.0	21000.0	14000.0	913.9	3818.7	1641.0	5833.0	5254.7	4075.6	6405.5
DISTT080	11000.0	13000.0	13000.0	13000.0	11000.0	19000.0	23000.0	15000.0	2758.2	1973.3	1998.4	7802.7	7084.8	2243.3	6576.6
DISTT081	9849.5	13000.0	14000.0	15000.0	11000.0	20000.0	24000.0	14000.0	4055.8	2354.2	4182.1	9054.4	8325.5	2896.8	4642.2
DISTT082	8812.2	12000.0	14000.0	14000.0	11000.0	19000.0	24000.0	13000.0	4099.7	3423.6	4745.8	8949.9	8121.2	3067.0	3782.0
DISTT083	14000.0	15000.0	14000.0	13000.0	12000.0	20000.0	23000.0	16000.0	4778.7	4509.1	2826.1	7518.9	7574.6	4206.1	10000.0
DISTT084	13000.0	16000.0	16000.0	15000.0	13000.0	21000.0	25000.0	16000.0	5167.9	1666.1	3420.4	9513.9	9211.2	1168.3	8751.9
DISTT085	11000.0	14000.0	15000.0	15000.0	12000.0	20000.0	25000.0	15000.0	4169.9	1128.4	3834.1	9147.2	6544.7	1669.0	6075.4
DISTT086	12000.0	16000.0	16000.0	16000.0	13000.0	22000.0	26000.0	0.0	5834.5	978.6	4815.0	11000.0	9967.8	1106.3	7338.0
DISTT087	12000.0	16000.0	17000.0	17000.0	14000.0	22000.0	27000.0	17000.0	6118.6	1523.2	5181.1	11000.0	10000.0	1635.0	7360.1

Appendix F

Table: Network Distance Between Service Centres and Mouza Centroids (Generalized travel time)

		Sholmari GC	Kutubpur	Burfpola	Meherpur S	Amjhupi	Amdaha	Baradi GC	Darlapur UP	Darlapur GC	Pirojpur UP	Mohajanpur	Monakhali UP	Mujibnagar	Bagoan UP	Anandabash
MOUJA1_ID	Net_ID	23	86	209	212	258	303	386	434	446	467	520	569	595	643	647
1	8	31	36	58	46	55	57	62	68	58	60	58	69	71	82	88
4	18	26	34	51	39	48	50	55	61	51	53	51	62	64	75	81
5	26	30	29	49	37	46	48	53	59	49	51	49	60	62	73	79
3	31	32	27	51	39	48	50	55	61	51	53	51	62	64	75	81
8	35	17	23	40	28	37	39	44	50	40	42	40	51	53	64	70
2	37	31	28	50	38	47	49	54	60	50	52	50	61	63	74	80
6	39	49	33	56	44	53	55	60	66	56	58	56	67	69	80	86
7	51	36	18	43	31	40	42	47	53	43	45	43	54	56	67	73
12	52	30	46	62	51	60	62	67	73	63	65	63	74	76	87	93
10	56	19	21	38	26	35	37	42	48	38	40	38	49	51	62	68
9	62	49	38	54	42	50	53	57	64	54	55	54	65	67	78	84
11	72	30	12	37	25	34	36	41	47	37	39	37	48	50	61	67
14	75	49	39	45	33	40	44	46	55	45	44	45	56	58	69	75
13	82	30	46	54	51	60	62	67	73	63	65	63	74	76	87	93
18	92	34	24	39	27	35	38	42	49	39	40	39	50	52	63	69
15	93	31	12	39	27	36	38	43	49	39	41	39	50	52	63	69
16	108	35	51	49	48	59	61	66	72	62	64	62	73	75	86	92
20	111	43	33	39	27	34	38	41	49	39	39	39	50	52	63	69
21	116	35	33	50	38	47	49	54	60	50	52	50	61	63	74	80
17	121	24	16	33	21	30	32	37	43	33	35	33	44	46	57	63
24	125	46	36	42	30	37	41	41	52	42	39	42	53	55	66	72
22	127	33	23	38	26	34	37	41	48	38	39	38	49	51	62	68
19	132	38	28	34	22	29	33	38	44	34	34	34	45	47	58	64
26	141	60	51	29	38	49	51	56	62	52	54	52	63	65	76	82

35	142	55	46	24	33	44	46	51	57	47	49	47	58	60	71	77
25	146	37	27	33	21	28	32	35	43	33	33	33	44	46	57	63
27	156	33	23	26	14	23	25	30	36	26	28	26	37	39	50	56
23	164	45	37	36	26	37	39	44	50	40	42	40	51	53	64	70
28	166	48	38	39	27	24	38	27	49	39	25	29	50	52	63	69
29	177	45	35	41	29	36	40	43	51	41	41	41	52	54	65	71
31	204	40	30	26	17	28	30	35	41	31	33	31	42	44	55	61
32	207	50	40	41	29	26	40	29	51	41	27	31	52	54	65	71
34	214	57	47	21	34	45	47	52	58	48	50	48	59	61	72	78
30	225	42	32	31	17	30	32	37	41	31	35	33	42	44	55	61
36	236	51	41	42	30	27	41	26	52	42	28	32	53	55	66	72
33	242	51	41	42	30	27	41	24	52	42	26	31	53	55	66	72
39	246	49	39	12	26	37	39	44	50	40	42	40	51	53	64	70
38	247	37	27	28	16	25	23	32	38	28	25	20	37	39	50	56
37	261	56	46	47	35	32	46	25	57	47	31	36	58	60	71	77
40	295	43	33	32	18	31	32	38	40	30	36	34	41	43	54	60
41	297	39	29	30	18	25	25	30	38	28	23	18	39	41	52	58
43	298	85	75	76	64	61	75	46	86	76	57	64	87	89	100	106
47	319	45	35	36	24	21	35	18	46	36	20	25	47	49	60	66
42	322	48	38	39	27	33	31	38	47	37	31	26	48	50	61	67
45	327	72	62	35	48	60	58	67	50	47	65	63	56	58	71	75
51	329	69	59	60	48	45	59	28	70	60	38	45	71	73	84	90
52	343	55	45	46	34	31	45	22	56	46	20	27	57	59	70	76
48	350	65	55	56	44	41	55	26	66	56	38	45	67	69	80	86
46	351	52	42	43	31	40	25	47	35	25	45	41	34	36	47	53
49	352	43	33	34	22	19	31	24	44	34	22	18	45	47	58	64
50	356	70	60	61	49	46	60	29	71	61	39	46	72	74	85	91
55	383	43	33	34	22	31	22	36	24	14	36	32	25	27	38	44
44	393	59	49	43	38	47	38	54	35	28	52	48	39	41	52	58
58	414	53	43	44	32	29	43	13	54	44	19	26	55	57	68	74
59	421	63	53	54	42	39	53	22	64	54	32	39	65	67	78	84
54	426	51	41	42	30	27	41	28	52	42	18	23	53	55	66	72
0	437	59	49	50	38	39	37	44	40	30	32	27	35	37	48	54
57	438	66	56	57	45	42	56	25	67	57	35	42	68	70	81	87

53	448	52	42	43	31	40	31	47	29	19	42	37	26	28	39	45
62	469	62	52	53	41	50	41	57	34	25	55	51	31	31	46	50
63	484	52	42	43	31	28	41	19	53	43	13	20	50	52	63	69
60	489	56	46	47	35	32	46	22	57	47	20	27	57	59	70	76
64	491	57	47	48	36	45	38	52	29	20	50	46	26	26	41	45
65	496	57	47	48	36	45	36	52	29	20	50	46	26	26	41	45
68	514	62	52	53	41	50	41	57	34	25	55	51	21	21	36	40
66	518	62	52	53	41	38	51	31	63	53	23	30	60	62	73	79
67	525	55	45	46	34	43	34	50	27	18	48	44	18	18	33	37
70	531	49	39	40	28	37	28	44	26	16	38	33	19	21	32	38
56	534	68	58	59	47	48	54	48	52	42	38	31	43	45	56	62
69	537	53	43	44	32	33	39	33	52	42	23	16	48	50	61	67
61	544	52	42	43	31	28	41	23	53	43	13	18	50	52	63	69
74	557	56	46	47	35	44	35	51	33	23	45	40	22	24	35	41
73	559	60	50	51	39	48	39	55	32	23	50	45	13	13	28	32
72	572	55	45	46	34	35	41	35	54	44	25	18	50	52	63	69
76	576	64	54	55	43	52	43	59	39	30	53	48	16	16	31	35
71	577	69	59	60	48	57	48	64	44	35	58	53	21	21	36	40
75	580	74	64	65	53	62	53	69	49	40	63	58	26	26	41	45
77	582	53	43	44	32	41	32	48	30	20	42	37	15	17	28	34
78	586	61	51	52	40	41	47	41	60	50	31	24	53	55	66	72
79	589	56	46	47	35	44	35	51	33	23	45	40	12	14	25	31
83	621	79	69	69	58	67	58	74	50	45	68	63	31	29	46	40
80	626	64	54	55	43	52	43	59	41	31	53	48	18	20	17	23
82	632	63	53	54	42	51	42	58	40	30	52	47	21	23	31	35
81	634	68	58	59	47	56	47	63	45	35	57	52	26	28	26	30
85	636	67	57	58	46	55	46	62	44	34	56	51	25	27	26	30
84	644	74	64	65	53	62	53	69	49	40	63	58	26	24	21	15
86	652	82	72	73	61	70	61	77	59	49	71	66	36	34	21	25
87	656	79	69	70	58	67	58	74	54	45	68	63	31	29	26	30

Appendix G

Table: Accessibility Indices measured by Various Models

MOUJA1_ID	NET_ID	ISOCHRONE	GEOGRAPHIC	POTENTIAL	Standardized Values		
					ISOCH.	GEOG.	POTN
1	0	184	42.50	1.56	4.90	74.56	7.79
4	8	184	59.90	1.38	4.90	36.40	5.84
5	18	184	53.40	1.86	4.90	50.66	11.04
3	26	184	51.60	1.99	4.90	54.61	12.45
8	31	184	53.30	1.82	4.90	50.88	10.61
2	35	184	42.50	3.48	4.90	74.56	28.57
6	37	184	52.50	1.90	4.90	52.63	11.47
7	39	46	59.20	1.40	0.00	37.94	6.06
12	51	184	46.10	2.68	4.90	66.67	19.91
10	52	282	64.80	1.18	8.37	25.66	3.68
9	56	184	40.60	3.81	4.90	78.29	32.14
11	62	46	57.60	1.52	0.00	41.45	7.36
14	72	1742	40.10	4.03	60.16	79.82	34.52
13	75	46	49.50	2.31	0.00	59.21	15.91
18	82	1742	64.30	1.18	60.16	26.75	3.68
15	92	1917	42.70	3.33	66.37	74.12	26.95
16	93	1742	41.90	3.57	60.16	75.88	29.55
20	106	1742	63.70	1.23	60.16	28.07	4.22
21	111	1779	43.70	3.27	61.48	71.93	26.30
17	116	1930	53.10	1.85	66.83	51.32	10.93
24	121	2203	36.50	5.25	76.52	87.72	47.73
22	125	1779	46.30	2.75	61.48	66.23	20.67
19	127	2203	41.70	3.56	76.52	76.32	29.44
26	132	1967	38.70	4.68	68.14	82.89	41.56
35	141	2374	56.00	1.78	82.58	44.96	10.17
25	142	1930	51.00	2.30	66.83	55.92	15.80
27	146	1967	37.70	5.08	68.14	85.09	45.89
23	156	2065	31.50	10.08	71.62	98.68	100.00
28	164	2092	44.90	3.33	72.58	69.30	26.95
29	166	1779	41.10	3.97	61.48	77.63	33.87
31	177	2065	45.70	2.89	71.62	67.54	22.19
32	204	2264	36.30	6.95	79.39	88.16	66.13
34	207	2103	43.10	3.47	72.97	73.25	28.46
30	214	2011	51.80	2.25	69.71	54.17	15.26
36	225	2264	37.50	6.75	79.39	85.53	63.96
33	236	2328	43.90	3.35	80.95	71.49	27.16
39	242	680	43.50	3.46	22.49	72.37	28.35
38	246	1965	43.70	3.92	68.07	71.93	33.33
37	247	2420	31.80	8.54	84.21	98.03	83.33
40	261	680	48.30	2.66	22.49	61.84	19.70
41	295	2238	37.70	6.16	77.76	85.09	57.58
43	298	680	76.50	0.84	22.49	0.00	0.00
47	319	680	37.50	5.45	22.49	85.53	49.89
42	322	2392	41.40	3.67	83.22	76.97	30.63
45	327	1983	59.00	1.27	68.71	38.38	4.65
51	329	407	59.90	1.61	12.81	36.40	8.33
52	343	868	45.90	3.26	29.16	67.11	26.19
48	350	680	56.60	1.85	22.49	43.64	10.93

46	351	2256	39.70	3.10	78.40	80.70	24.46
49	352	2805	35.90	6.16	97.87	89.04	57.58
50	356	407	60.90	1.53	12.81	34.21	7.47
55	383	2542	30.90	5.99	88.54	100.00	55.74
44	393	2269	45.40	2.14	78.86	68.20	14.07
58	414	680	43.60	4.61	22.49	72.15	40.80
59	421	407	53.90	2.20	12.81	49.56	14.72
54	426	1153	42.70	3.80	39.27	74.12	32.03
0	437	2865	41.30	2.60	100.00	77.19	19.05
57	438	407	56.90	1.87	12.81	42.98	11.15
53	448	2542	36.70	3.46	88.54	87.28	28.35
62	469	2269	45.30	2.12	78.86	68.42	13.85
63	484	965	41.30	4.64	32.60	77.19	41.13
60	489	692	46.50	3.16	27.92	65.79	25.11
64	491	2300	40.30	2.84	79.96	79.39	21.65
65	496	2419	40.30	2.84	84.18	79.39	21.65
68	514	861	42.60	2.53	28.91	74.34	18.29
66	518	692	51.40	7.25	22.92	55.04	15.26
67	525	1146	36.70	3.69	39.02	87.28	30.84
70	531	1282	32.50	4.55	43.85	96.49	40.15
56	534	1555	50.10	1.73	53.53	57.89	9.03
69	537	1363	42.40	3.82	46.72	74.78	37.25
61	544	983	41.40	4.57	33.24	76.97	40.37
74	557	1146	38.50	2.96	39.02	83.33	22.94
73	559	1146	38.50	3.93	39.02	83.33	33.44
72	572	1067	44.40	3.28	36.22	70.39	26.41
76	576	673	42.50	2.87	22.24	74.56	21.97
71	577	673	47.50	2.04	22.24	63.00	12.99
75	580	673	52.50	1.55	22.24	52.63	7.68
77	582	958	34.40	4.02	32.35	92.32	34.42
78	586	1094	49.60	2.28	37.18	58.99	15.37
79	589	958	35.80	4.09	32.35	80.25	35.17
83	621	673	56.40	1.31	22.24	44.08	5.09
80	626	958	41.40	2.64	32.35	76.97	19.48
82	632	739	42.80	2.32	24.58	73.90	16.02
81	634	739	46.50	1.86	24.58	65.79	11.04
85	636	739	45.60	1.95	24.58	67.76	12.01
84	644	454	49.10	2.15	14.47	60.09	14.18
86	652	184	57.10	1.29	4.90	42.54	4.87
87	656	739	54.70	1.39	24.58	47.81	5.95

Appendix H

Questionnaire Survey of Local Key Personnel

Thesis Title: Measuring Accessibility Index for Rural Areas: An Activity Based Approach

By
Raktim Mitra
Department of Urban and Regional Planning, BUET

This survey is being carried out as a part of the above mentioned research of Master of Urban and Regional Planning (MURP), Bangladesh University of Engineering and Technology, Dhaka-1000. The data would be used only for research purpose and would be kept as secret.

Name of the interviewer: Serial No.:

Date of interview:

1. Location of interview:
   a. Mouza:
   b. Union.
2. Name of the interviewees:

Name	Profession

3. Please rank the following activities in respect to the selected criteria.

Name of the activity	Assess your position (as a general inhabitant of the Mouja) in respect of these activities**
Grocery Shop	
Medicine Store	
Fertilizer Distribution Centre	
Rice Mill	
Hat/ Bazar	
Cinema Hall	

** 5 = Highly satisfactory, 4 = Satisfactory, 3 = Undecided, 2 = Not much satisfactory, 1 = Not satisfactory at all.

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Signature of the Surveyor

Appendix I

Table: Overall Accessibility Level (OAL) from Questionnaire Survey

Name of activity		Grocery shop		Medicine store		Fertilizer dist		Rice mill		Hat/ Bazar		Cinema Hall		Index Value	Standardized Value	OAL
Mouza no	Name	W	V	W	V	W	V	W	V	W	V	W	V			
1	Ujjalpur	1	4	2	4	3	3	4	4	5	3	6	2	64	51.19	3
2	Sholmari	1	4	2	3	3	3	4	3	5	4	6	1	57	42 86	3
3	Rudranagar	1	1	2	1	3	2	4	1	5	2	6	1	29	9.52	1
4	Terogharia	1	3	2	2	3	3	4	3	5	3	6	1	49	33.33	2
5	Monoharpur	1	3	2	2	3	2	4	4	5	3	6	2	56	41.67	3
6	Kutubpur	1	2	2	2	3	1	4	2	5	4	6	2	49	33.33	2
7	Subidpur	1	3	2	3	3	2	4	4	5	3	6	3	64	51.19	3
8	Fulbaria	1	2	2	2	3	1	4	3	5	2	6	3	49	33.33	2