PLANNING OF RURAL ROADS IN BANGLADESH: A CASE STUDY AT UPAZILA LEVEL

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two concepts. For the purpose of the present study upazila has been considered as the planning unit. As a case study rural road network planning for Kahaloo upazila in Bogra district has been considered. The findings of the study suggest that the developed methodology is operational at the upazila level.

Title of the Thesis

Planning of Rural Roads in Bangladesh:
A Case Study at Upazila Level

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CHAPTER - 1

RURAL ROAD PLANNING

1.1 Introduction

Bangladesh, with a predominantly agrarian economy has nearly 84 percent of its population living in about 86,650 villages (BBS,1986). There is a pressing need of all weather transportation facilities all over the country. Unfortunately, most of these areas remain isolated for prolonged periods due to lack of properly laid out road network. A properly planned rural road network have several benefits. It may reduce transportation cost of agricultural inputs and farm produce,and help in providing better delivery systemsof health, education and other social services. It may be also more helpful to administration, enlargement of market facilities and better prospect of commercialisation of the rural economy resulting in better living conditions (Somasekhar, 1980).

The importance of the development of rural roads towards integrated rural development has been fully recognised and hardly calls for any emphasis. (The development of agriculture, the distribution of farm products, the provision of health services and access to educational centres,the provision of other services and enlargement of market facilities depend on transport facilities.) (For land locked rural areas, rural road is an important means of transportation and can play a dominant role to provide an assured means for the movement of goods and people)

For another, rural road development plays a major part in not only tackling rural employment but also integrating the remote villages with one another and with the rest of the country. It is not only required to meet the demands of development in different sectors, but is in itself a powerful force generating economic development. Thus, the development of rural road as an integral part of rural development deserves attention from considerations of social justice, national integration and economic upliftment of the vast majority of the rural people.

In the Second Five Year Plan (1980-85) Government gave more emphasis on the development of transportation for integrated development in the rural areas. In this connection, Government selected upazila as the focal point of local level planning (Ministry of Law and Land Reforms, 1982). The Government has given the upazila parishad a wide range of activities and responsibilities with special emphasis on planning of development activities including rural roads.

After the introduction of the upazila system national government is allocating a huge sum of money every year to upazila parishads in the form of block grant. A major share (about 30 percent) of the grant is spent for rural road development (Planning Commission, 1985). In the Third Five Year Plan (1985-90), a sum of Tk. 7930 millions has been allocated for providing rural road development grant to upazila parishads (Planning Commission,1985). Besides these, Government is conducting rural road development programme through upazila parishads by utilizing more than three

lac metric ton of wheat equivalent to Tk. 2000 millions every year under the Food for Works Programme (World Food Programme, 1987).

These scarce resources should be spent for their proper and most optimal utilization. The first step in this direction would apparently be to effectively plan all road development activities in a comprehensive and co-ordinated manner. The long range aspect of planning should be taken into consideration. It has to be recognized that any development of a rural road without any proper planning will eventually result in a colossal wastage of funds.

The present practices towards planning of rural roads, leave plenty of scope for further improvement. In the absence of any widely acceptable rational approach, the planning of rural road network as practiced in Bangladesh is mainly based on experience and subjective judgement. The need and priorities for rural roads are sometimes identified by the local leaders primarily on the basis of their subjective judgement (Siddique and Rafiquddin, 1987).

However, rural road is an essential requirement for integrated development of the rural areas. The provision of a systematized road network may stimulate the development in the rural areas. Thus it is important to plan the road network in the rural areas. But there is no well developed methodology for rural road planning. In the present study an attempt has been made to

develop a scientific methodology for planning of rural road network by applying the concepts of graph theory as applied in planning of urban road network, and hierarchy of settlement as applied in planning of service centres.

1.2 Strategy for Planning of Rural Road

Rural roads should be developed on the basis of a systematic planning approach. For the development of roads in rural areas some planning strategies are followed in many countries including Bangladesh. These planning strategies may help to give some idea to develop a scientific methodology for planning of rural road network in this country. These planning strategies are discussed below.

1.2.1 Integrated Road Development

An adequate and efficient system of rural road network is one of the prerequisites for the success of any integrated rural development. It is not only required to meet the demands of development in different sectors but is in itself a powerful force generating economic development. It is one of the most important infrastructure of any agriculture based economy. Thus, the development of rural roads and economy deserves the same priority as accorded to integrated rural development. Therefore the planning of a rural road network should be conceived integrally with the planning of rural development as a whole.

1.2.2 Area Planning and Growth Centres

For an integrated rural development programme to be successful there should be spatial integration between different sectors of rnral economy, with rural roads providing the linkages. So rural road projects should be planned on the basis of 'area planning' and 'development of growth centres'. This concept of area planning should encompass all aspects of rural life including road development (Rahman, 1975).

For rural development, when new facilities or development activities are proposed, they must bc concentrated in suitable locations all over the country in hierarchial order, maintaining linkage and interrelationship (Mahtab, 1975).

1.2.3 Hierarchical Planning

Rnral road should be developed in such a way that the needs of the people are served most economically and an efficient road network develops gradually. While planning rural roads, it should be ensured that some hierarchical patterns emerge in liue with the actual movement pattern in the areas concerned. After the growth centres of different types have been identified in a hierarchical pattern, rural road linkage must be provided to these centres in a phased manner.

1.2.4 Local Level Planniug

Local level planning has found favour as a more rational approach

to local development. While formulating local level rural roads planning, due regard should be given to the national guide lines, priorities and resources for the area concerned. It is essential to ensure that local level rural road plans are properly integrated, coordinated and duly reflected as the integral part of the national plan.

1.3 Rural Road Planning in Bangladesh and Some Neighbouring Countries

In the South and South East Asian countries, the interest in rural road planning is growing gradually aiming at improving the rural infrastructure and thus improving the rural economy. In this regard the countries like India, Nepal, Thailand, Indonesia have some contributions in planning rural roads. They have adopted some uew policies and techniques in this connection. The above mentioned countries having experience in rural road planning, are close neighbours of Bangladesh. Moreover, their socio-economic conditions arc similar to those of Bangladesh. For these, a discussion is made on the approach of their rural road planning.

1.3.1 Bangladesh

The development of rural road system during the initial years of Pakistan was very limited. The First and Second Five Year Plan of Pakistan which were initiated in 1956 and 1961 respectively played a vital role in development of road infrastructure in the country. Rural road first began to be constructed

on a substantial scale during the early sixties through the 'Rural Works Programme'. But the emphasis was more on connecting local places without adequate consideration for having links with nearest growth centre or with the arterial road system. Besides these, planning of rural road laid too much importance on the short run benefit without giving much importance to the long run.

Recognizing the shortcomings of rural road planning during the period of Pakistan, a master plan 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 rural roads in future will fit into the framework indicated in the master plan. The big village markets (hats and bazars) and the lowest level administrative unit (known as Upazila) was considered as growth centre in this context.

Initially, the growth centerswhich do not have any all weather communication facilities are to be connected with the country's arterial transportation system. Subsequently, medium sized markets and locations are to be linked. In this way, all the growth centres of a region will be linked with each other as also with the arterial road network of Bangladesh. Later on, roads of lower hierarchy e.g. primary to secondary markets will be considered. Such a rural road grid is expected to accelerate the process of rural development (Ahsan, 1979).

There are a number of road developing agencies like Roads and Highways Department, Local Government Engineering Bureau, Upazila Parishad who are engaged in developing the road system in rural areas of Bangladesh. They are planning and building the rural roads in their own way. The Roads and Highways Department has planned the upazila connecting road in order to connect all the upazila headquarters with the district headquaters. In this respect, they identified those roads which can connect the upazila headquarters with the nearest paved road. The Local Government Engineering Bureau mainly deals with feeder roads and plans a rural road network system between growth centres identified by Planning Commission. The upazila parishad deals with local roads and plans the roads to connect farm to market, village to union centre and villages with each other.

1.3.2 India

India has followed the 'Selective Approach' for rural road development from the beginning. In this approach only such roads were taken up under development where there was a felt need. As a result, rural road development in India has been very modest. Later on, India initiated 'Minimal Need Programme' for rural development. Under this programme all villages of population 1500 and above are sought to be connected with all weather roads (Deshpande, 1980). Keeping in view the guidelines of national government the State of Karnataka has evolved a planning procedure for connecting of villages with rural road in a phased

manner. They have tried to take up works according to the urgency and importance without any bias incorporating economic as well as social factors. They have selected some factors like population of the village, schooling facilities, medical facilities, communication facilities, market centres and administration. These factors are then assigned marks based on their judgement. By applying the above indicators, the priority list of villages are prepared separately in each Taluk according to the number of marks. Maximum number of marks a village can get is only 100 and as such a priority list of villages is prepared in the order of marks it gets in each Taluk (Reddy,1980).

1.3.3 Nepal

In Nepal, government gives more importance on local bodies in developing rural roads. The local bodies are stressed and encouraged to implementing their own local roads through their own resource collection and direct participation of the local people. Technological helps in planning rural roads are given from national level. The priority of road projects are determined on the basis of 'Benefit Cost Ratio' or 'Internal Rate of Return' criteria. Once the road is opened to the traffic in local level, the government accomodates it in the national programme so that people are encouraged to take up new projects and open up further areas (Singh, 1979).

1.3.4 Thailand

In Thailand, the Department of Highway (1979) introduced a ranking

procedure for planning of rural roads. In this procedure, they incorporate the social and political aspects as well as economic aspects. They have identified some important factors like population,normal agricultrual activities, foresty, mining and industry, tourism, administration, military and strategic and traffic. These factors are assigned weightages based on their judgement. A priority list of roads in order of points based on the assigned weightages of the indicators is prepared. A high score indicates a high requirement and gets top priority. This planning approach is widely practiced in Thailand.

1.3.5 Indonesia

In Indonesia, a ranking method using a 'Transport Priority Index' (TPI) as noted by Matulessy (1979) has been used in the Jogjakarta rural road study. TPI has been defined as the ratio of 'requirement factor score' to 'provision factor score' expressed as a percentage.

The requirement factors comprised of (a) average daily traffic, (b) traffic growth, (c) population density, (d) development and social benefits, (e) area of influence and (f) network significance. The highest value of each factor was awarded a maximum of 5 points excepting development and social benefits, which were awarded 15. So, the maximum possible total requirement factor score was 40.

The provision factors comprised of length of link (b) surface type (c) surface conditions (d) alignment in relation to terrain

(e) width of surface and formation (f) stability/drainage and culverts and (g) bridges/major crossings. The worst condition of each was awarded a maximum of 5 points excepting surface condition, which was awarded a maximum of 10, so that maximum total score was also 40. Transport Priority Index gave an indication of the order of merit when considering the minimum level of improvements to each road link.

The index developed for rural roads, appeared to give priority to roads with a high need for transport and with good existing facilities, and therefore seemed more appropriate to the planning needs of major roads rather than rural roads.

1.3.6 Conclusion

It is found that in the above mentioned countries, rural road has been treated as an important aspect for integrated rural development. In this connection, some guide lines, directives and programmes are made for planning road in rural areas. Some planning procedures of rural roads have been developed and are practiced in some of these countries. However, basically these procedures such as Thai and Indonesian ranking methods for ranking of rural roads are used for economic appraisal of rural road projects. These are simple yet useful methods for ranking and priority determination of rural feeder roads. But these procedures do not cover the network planning aspect of road in rural areas. In case of Bangladesh, some policies are directed from the national level and some procedures for planning rural road are

also followed by different rural road developing organizations. But there is a great need of a systematic methodology for developing an overall optimized road network in rural areas considering the area as a whole. Especially this is very important for road development at the upazila level considering the fact that this has become a very significant tier of development administration.

CHAPTER - 2

THEORETICAL FRAMEWORK : GRAPH THEORY AND HIERARCHY OF SETTLEMENTS

2.1 Introduction

Network planning is an important phase in transportation planning. In planning urban road network the application of graph theory has been widespread. Although planning of rural road network is equally important but no well developed methodology for the purpose exists. The graph theory although found its extensive application in the case of planning urban network, however, it can not be readily applied in the case of planning rural network. Because the 'nodes' of the graph are not well defined in the rural areas.

However, if a separate methodology is established for determining such 'nodes', the graph theory may be equally applied for planning rural network. The methodology for determining such 'nodes' however already exists. The concept of hierarchy of settlements may be applied to identify the nodes in rural areas. The concept of hierarchy of settlements may be applied to identify the nodes in rural areas. The concept of hierarchy of settlements has already been used at home and abroad for research as well as for planning the delivery of services and input distribution at the microlevel (for example, Bhat, 1976; Sen and Misra, 1974; Sen, Bose, Misra and Ramesh, 1971; Jahan, 1978; Parveen, 1984).

In the present study an attempt has been made to develop a methodology for the planning of rural road network in Bangladesh. At first by applying the concept of hierarchy of settlements, attempt is made to identifying the 'nodes'. Then the graph theory is applied in its conventional form to develop a rural road network.

2.2 Graph Theory with Application to Road Network Planning

Graph theory is an abstract mathematical concept. The description of the theory is widely available in the literature (for example, Black, 1981; Daellanbach and George, 1978; Wagner, 1974). The graph theory is helpful to understand the nature of problems which can be viewed as a graph. It deals with abstract configuration consisting of lines and points and is suitable to represent the topological properties of transport system.

An example is the problem of a rural mail carrier who must deliver mail to a number of locations (nodes). The mail carrier would like to know how to schedule a route, so as to minimize the distance to be travelled. Starting at a given node, the objective is to visit all other nodes and return to the starting point in minimum distance. Figure 2.1 below is a map of the area with each location representing a node. The nodes are labelled with integer numbers. Ordering is unimportant. The shortest route from one location to another is represented by a link. Each link has a distance associated with it. A diagram like this is called a graph.

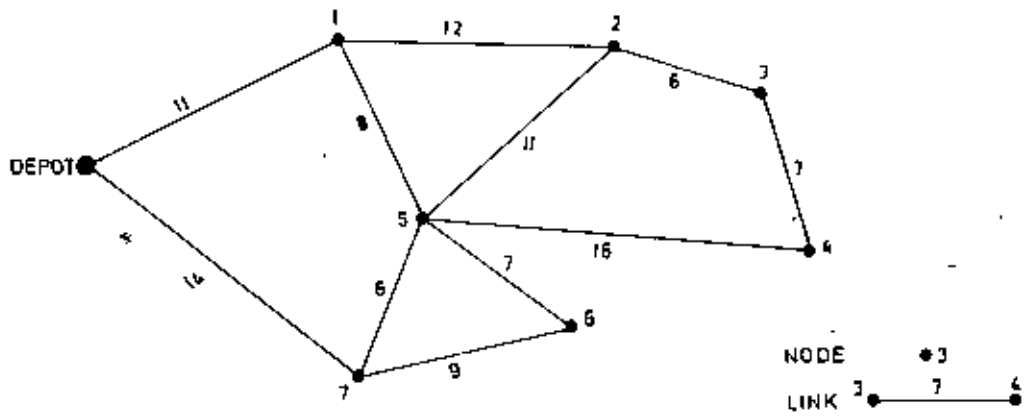


Figure 2.1 Graph of Rural Mail Dolivery
Source: Based on Daellanbach and George, 1978; p.149

2.2.1 Operational Definitions Relevant to Graph Theory

Few basic definitions relevant to graph theory are given below. A 'graph' consists of a set of nodes and links. A 'link' is an imaginary straight line that represents a finite length of road, railway or bus route. A 'node' is an imaginary point where links intersect. Nodes represent road intersections and railway junctions. On public transport networks nodes also indicate the location of stations or bus stops.

'Link impedence' specifies the average construction cost or average link travel time or cost as the measure of difficulty of getting along each link. A 'connected graph' is having at least one path between each pair of nodes. A 'tree' is a loop free connected graph. A tree in which one node (called the root)

is distinguished from all others is called a 'rooted tree'. A tree is said to be a 'spanning tree' of a connected graph if the tree is a subgraph of the connected graph and the tree contains all nodes of the connected graph.

If there is a real number representing link impedence associated with each link of a graph, then it is a 'weighted graph'. A spanning tree with the smallest weight in a weighted graph is known as the 'Minimal Spanning Tree'. Figure 2.2 shows how a minimal spanning tree can be constructed. Nodes of the graph are labelled with a different letter and the smallest distance from one node to another is represented by a link. Each link has a distance associated with it.

The minimal spanning tree is started from node A and connect it to its nearest node, say B. Now consider A and B as one snb-graph and connect this to its nearest node C. Now consider A, B and C as one sub-graph and continue connecting the nearest neighbouring nodes until all the nodes are connected. Thus the minimal spanning tree ABCDEF or G can be constructed from the weighted graph.

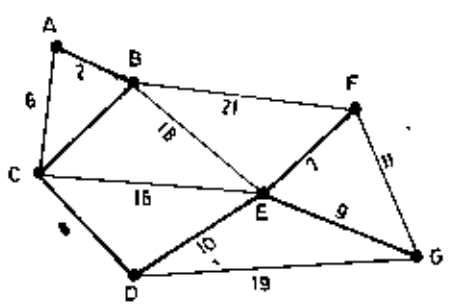


Figure 2.2 Minimal Spanning Tree in a Weighted Graph
Source: Swaminathan, Lal and Kumar, 1982; p. 893

2.2.2 Selection of Secondary Links of the Network

Various secondary link options to connect the secondary nodes are identified from the available maps and informations. The selection of one link from several link options is determined by using the 'link option weightage process' developed by Swaminathan, Lal and Kumar (1982). In their study they have shown that the weight of several secondary link options for any node may be computed as below:

$$W = \frac{P_o + \sum_{i=1}^{n} \frac{P_i}{L_i a}}{L_o} \qquad (2.1)$$

where

W = weightage of link options;

L_o = impedence (length) of link option;

P_o = self attracting force of the attracting node;

P_i = attracting force of the node;

L_i = impedence (length) of the node from the attracting node;

n = number of attracting forces on the path from the attracting node to its tree root;

a = parameter (0.5).

Various terms of the above equation (2.1) are explained in Figure (2.3).

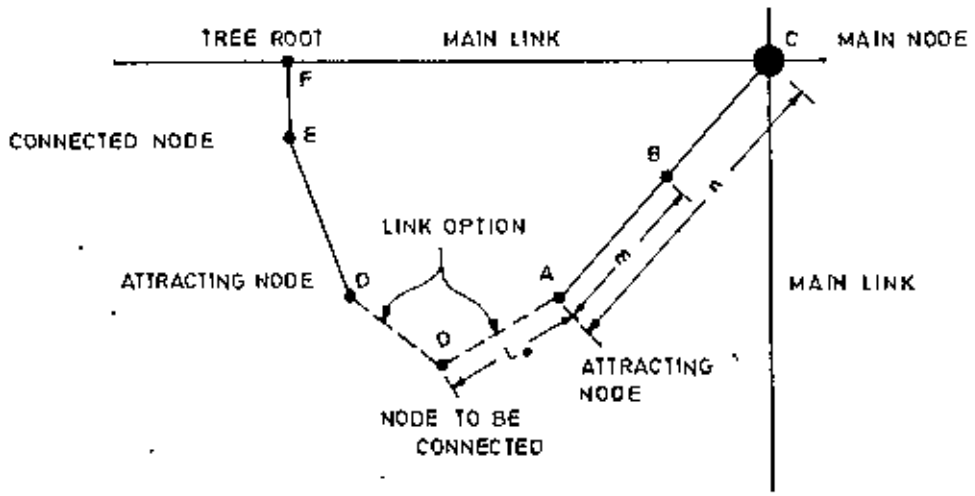


Figure 2.3 Illustration of Terms used in Equation 2.1

The above figure illustrates a hypothetical situation. There are two possible options OA and OD to link the node O either with node A or with node D. Node B of attracting force q and node C of attracting force r are already connected with node A. The distances of the nodes B and C from the node A are m and n respectively.

Now, due to the presence of node B and C at the back of the node A, the attracting force P of node A may increase by $\frac{q}{\sqrt{m}}$ and $\frac{r}{\sqrt{n}}$ respectively. Thus the total attracting force of node A becomes $P + \frac{q}{\sqrt{m}} + \frac{r}{\sqrt{n}}$. Now, the weight of the link option OA can be easily calculated by dividing total attracting force by the link option length L_o.

Similarly, the weight of link option OD can be calculated. If weight of option OA is greater than that of OD, then node O is connected with node A. Otherwise, the node O is connected with the node D. Thus, secondary links for nodes are selected from various available options.

2.3 Hierarchy of Settlements and Centrality

The concept of hierarchy of functions and settlements provides a valuable tool for planning. The identification of a settlement hierarchy and hinterlands of various centres at different levels of the hierarchy are the basic prerequisites for preparing a frame for area development. In identifying nodes of graph theory for planning rural road network emphasis is given on the measurement of centrality and identification of the hierarchical pattern of the settlements. The central place theory (Christaller, 1966; Losch, 1954) helps in identifying the hierarchy of settlements.

The hierarchy of settlementsis the product of the centrality of settlements in a region. The centrality in its turn can be explained in terms of quality and quantity of central functions performed by the settlement. The central functions are those which by their nature are available in a few settlements but are availed of by a number of settlements. Thus the central functions are essentially non-ubiquitous in nature. In fact the

degree of importance of a function is supposed to vary inversely with the frequency of its occurance.

The quality of a central function is normally affected by (i) number of different types of functions offered and (ii) by the level at which they are offered. A central function is composed of many sub functions and thus within a particular function, it is possible to identify different levels at which it is being performed. For example, functionally speaking, the educational service is being performed in the study area at primary school level, secondary school level and college level.

Clustering of central functions at a place reinforcesthe centrality of that place. The hierarchy of settlements is closely associated with the hierarchy of central functions. The latter could be determined by considering individual central functions such as health, education and others and by distinguishing their componeuts parts. Thus the choice and evaluation of the central functions and the measurement of association provides a basis for measure the centrality of any settlement.

CHAPTER - 3

RESEARCH DESIGN

3.1 Objective of the Study

The objective of the present study is oriented towards developing a systematic planning approach for the planning of rural road network in Bangladesh. In doing so the study specifies a set of objectives. The objectives are:

1. To study the existing planning process of rural roads in Bangladesh.
2. To develop a systematic methodology for the planning of rural road network at upazila level.
3. To formulate guidelines to establish priorities and implementing the network plan.

3.2 Methodology

Figure (3.1) illustrates the flow of work carried out in this study. The following briefly describes each of the work items indicated in Figure (3.1).

3.2.1 Literature Survey

Survey of available literatures on rural road planning studies carried out in Bangladesh and other countries in the region has been made to have a better understanding about the subject and to assess the existing rural road planning process.

3.2.2 Theoretical Framework

The graph theory and the concept of hierarchy of settlements serve as the basic framework for the purpose of planning a rural road network. These concepts and their applicability are critically searched in the study towards developing an operational methodology for the purpose.

3.2.3 Selection of the Study Area

For the present study, one upazila was chosen as a test case for the methodology. Kahaloo upazila of Bogra district was chosen. It was chosen by deliberate considerations to collect data easily within shortest period of time. However, it is also a rural upazila of Bangladesh, and therefore, the methodology may be applied for any similar upazila of the country also.

3.2.4 Data Collection

In the present study, two types of data were collected. One for determining the hierarchy of settlements and other about the existing road and traffic inventory. First type of data included ten categories of functions: distributive services; markets; finance; extension services; food processing industries; education; health; transportation; communications and specialised services. Information on these functions were collected from field survey, village questionnaire survey, and interviews. The village questionnaire survey covered all the villages of the study area.

Enquiries were made with different categories of people in each village such as union parishad member, primary school teacher regarding the facilities that are available in the village and also regarding other villages which the villagers normally visit for the satisfaction of their higher order social needs.

Second type of data were collected about the main roads, existing communication facilities in the form of railways lines, roads, cart truck, rivers, streams,and other topographical features. In this connection, information and maps were collected from the upazila office and from the office of the Surveyer General of Bangladesh. Population of all settlements were obtained from the census records of 1981. Other needed information were collected from secondary sources. Information obtained from different sources were checked against each other for accuracy and consistency.

3.2.5 Data Analysis

Data were analyzed in terms of the socio-economic characteristics of the settlements. Two methods were tested for the measurement of centrality of settlements and their hierarchy. The first method is based on cumulative summation of scores of individual function of the settlement and the second method concerns the application of Principal Component Analysis.

3.2.6 Ranking of Main Links

The main links of the study area were identified from available maps and the ranking of these roads was done based on scoring system as developed in Thailand and Indonesia. In the study, the factors used in ranking the roads were traffic volume, population density, network significance, area of influence, surface type, surface condition, surface width, type of vehicles, adminstrative usefulness and other benefits.

3.2.7 Identification of Main Nodes

The settlements of the study area were categorized into three levels of hierarchy based on the centrality score of the settlements. First and second level central places emerged as main nodes in the study area.

3.2.8 Generation of Minimal Spanning Trees

The final rural road network was generated in the form of minimal spanning trees by applying the concept of graph theory. These minimal spanning trees were developed by selecting the optimum link option of maximum weight for every secondary nodes. The node closest to the main link or main node was connected first. Now, spanning trees were started to generate by adding links of maximum weights and connecting node by node. And then proceeded towards the interior until all the secondary nodes were connected.

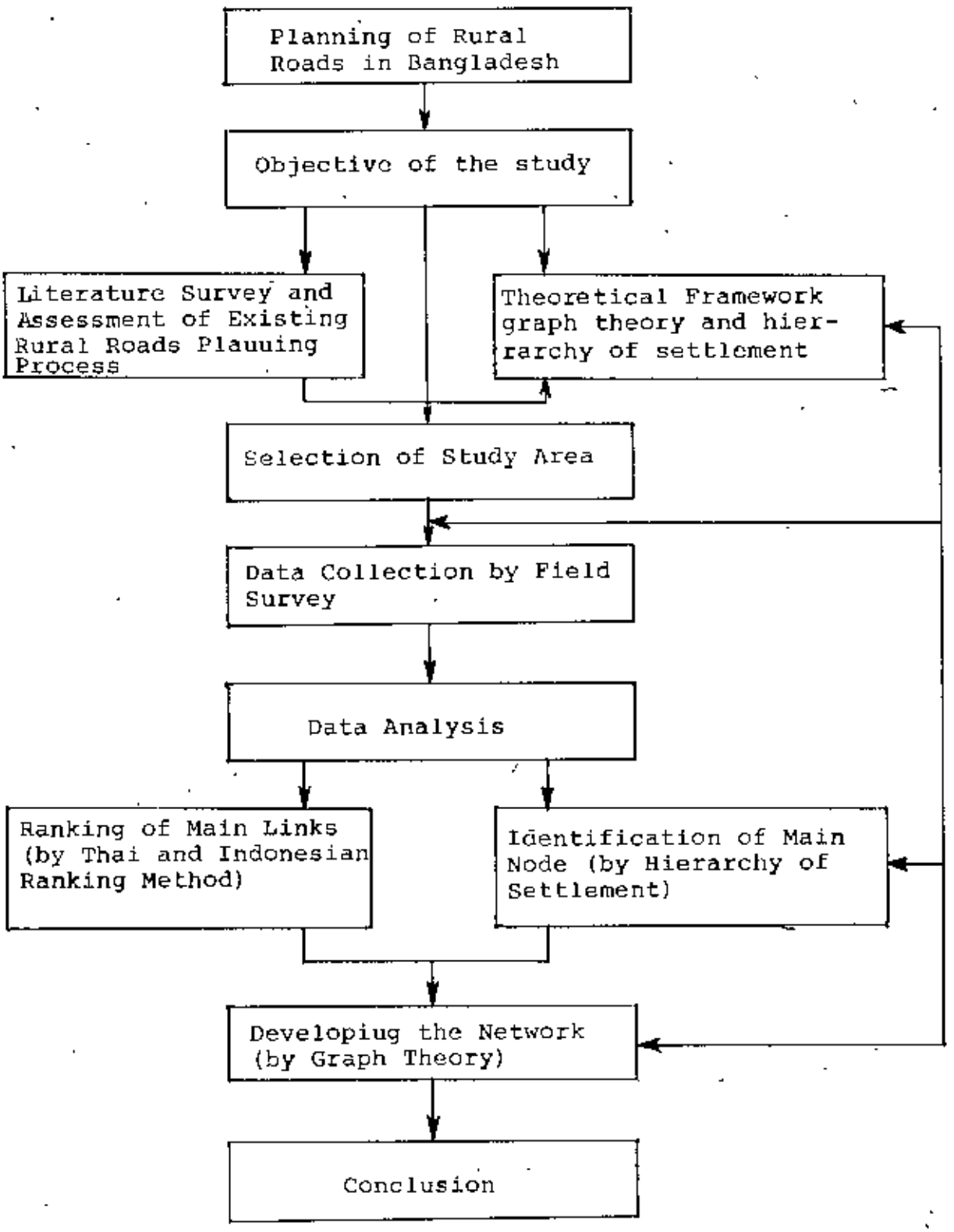


Figure 3.1: Study Flow Chart

3.3 Limitations of the Study

It is clear from the objectives that the study is mainly concerned with the network planning aspect of rural road development. The other aspects of developing rural road such as design, construction, maintenance are not incorporated in the study. The present study of planning rural road is confined to developing a planning process of road network in rural areas. The other issues of road planning like road geometrics, alignment, type, specifications etc. were not incorporated in the study.

The study is aimed to have only one outlet, leading to only one growth or service centre for every settlement. It does not deal with the link between neighbouring settlements and more than one outlet towards different growth and service centres.

The planning process of rural road network has not incorporated the presence of natural barriers. So, the network generated by the process in the present study, however, may not be directly implemented in all the cases without necessary modification depending upon the field conditions where such natural barrier exists.

3.4 Assumptions in the Study

While generating the rural road network by the concept of graph theory, the following assumptions were made:

1. Each mouza has only one settlement. In case of more than one settlements in a mouza, the location of main settlement is considered for the network planning.

2. Each and every settlement is to be connected by a rural road.

3. Only one road connection is sufficient for a settlement.

4. Every junction will be situated at a settlement only.

5. The traffic demands among the various settlements are insignificant as compared to the traffic demands between the various settlements and growth/service centres.

6. The construction costs are proportional to the length of the road.

3.5 The Study Area: Kahaloo Upazila

Kahaloo Upazila has got an area of 241 sqnare km. It consists of 164 mouzas and 9 unions. Total population of the upazila is 141298 and habitation per square km is 586 as was counted in the 1981 census. The distance of the upazila headquarters from district headquarters at Bogra is 12 km to the West and is linked with pucca road and railway line. The regional location of the study area is shown in Figure 3.2.

The number of different categories of educational institutions is 98. Literacy rate of the upazila is 23.6 percent. The upazila has got 15 km of railway line, 25 km of pucca roads and 420 km

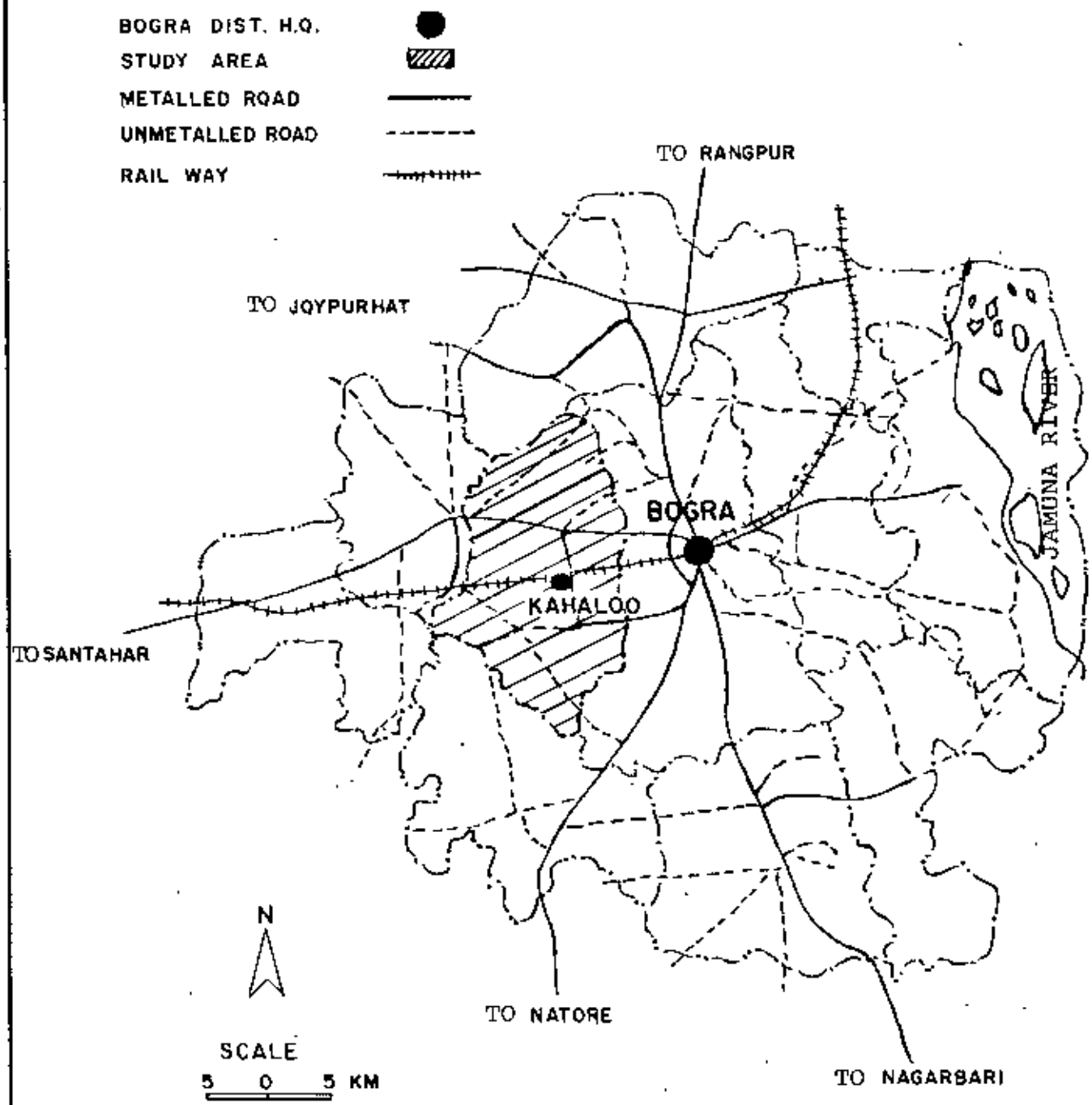
of kutcha raods. The upazila has got a hospital and 13 rural health and family planning welfare centres.There are 51 rice mills and 20 weekly markets in the upazila.

Total land area of the upazila is 24130 hectares and land pattern of the upazila is mostly plain. It has got 19076 hectares of land under cultivation, of which 4040 hectares are double cropped and 492 hectares are tripple cropped. Main agricultural production of the upazila is paddy. Total annual surplus food production is 27,000 metric tons (Upazila Parishad, 1986).

FIG. 3.2

KAHALOO UPAZILA

BOGRA DISTRICT



CHAPTER - 4

IDENTIFICATION OF CENTRAL PLACES

4.1 Introduction

To plan the rural road network for an area central places in the area are to be determined first. This chapter mainly deals with the determination of the centrality score of settlements and identification of the central places in the study area. Two methods were tested for the measurement of centrality of settlements and their hierarchy. The first method is based on cumulative summation of scores of individual function of the settlement, and the second method concerns the application of Principal Component Analysis. Two methods were used in order to observe the variation in the results and to examine the applicability of different methods to the unique conditions of the study area.

4.2 Selection of the Function of Centrality

To determine the centrality of a place it is necessary to take an account of all the central functions of that central place. In the present study functions taken into account are distributive services, markets, finance, extension services, food processing industries, education, health, transportation, communications, specialized services and component parts of these functions. It is possible to measure the centrality of

any settlement by determining the variety of functions performed and the level at which they are performed or by determining the scarcity of functions.

4.3 Operational Definitions of Functions Under Study

To measure the centrality and hierarchy of settlements after screening the available functions twenty two functions have been selected for the study area in order to avoid incongruous functions in analysis, to make the process more rational and to suit the functions with the methods applied in the study. A complete listing of the central functions appear in Table 4.1.

Table 4.1 List of Central Function

Sl.No.	Central Function
1.	Rice mill
2.	Wheat Milling mill
3.	Food godown
4.	Primary school
5.	Secondary school
6.	Madrasha
7.	Charitable dispensary
8.	Family planning centre
9.	Bank
10.	Post office
11.	Bus stoppage
12.	Food dealer
13.	Weekly market
14.	Fertilizer distribution centre
15.	Tailor
16.	Medicine shop
17.	Private medical practitioner
18.	Cycle reparing
19.	Grocery
20.	Stationary
21.	Retail cloth store
22.	Tea stall

Functions like grocery shop, tea stall, barber, carpenter, tailor, retail cloth store, post office, medicine shop etc. are self explanatory in their operational sense. Besides the above mentioned functions there are some functions which need explanation for their operational sense. These are as follows:

Market: In the rural areas, markets are of great importance. These are the weekly markets, held on two days of the week. Some of these markets do not have permanent structures but some have got permanent structures with provision for cloths, medicines, food grains, vegetables etc.

Education: (1) Primary School. An institution providing educational facilities upto 5th standard. (2) Secondary School. An institution providing educational facilities upto 10th standard.

Transport: Bus stop. Bus stops taken into consideration for the present study are the scheduled bus stops as well as the request bus stops.

4.4 Centrality of Settlements on the Basis of Cumulative Summation of Scores of Individual Function

Centrality of settlements on the basis of cumulative summation of scores of individual function was determined in the present study by two ways. The first follows that centrality of a function is based on the level of functional hierarchy and the second follows the principle that the importance or centrality of a function is based mainly on its scarcity. These are discussed below.

4.4.1 Centrality of Settlements on the Basis of Hierarchy of Functions

For the determination of the hierarchy and centrality of the settlements in the study, levels of functional hierarchy were identified on the basis of thresholds of functions under study. The thresholds of functions have been determined by the population size. It can be defined as the minimum number of population to support an economic activity. In the present study Reed Muench method (Haggett, P. and Gunecwardena, 1964) has been used to calculate the population threshold. The details of the technique and its application in the present case are provided in Appendix-A. Much elaboration is available in literature. So, in order to reduce the space, only the results are presented here. The lowest group of functions had the tendency to be found in population size between 400-850; the second group of functions tended to cluster between population size of 1600-2250; and the third group of functions tended to cluster at a population size of more than 2800 (Appendix-B, Table B.1). The levels of functional hierarchy have been given below.

First level (population size 400-800)

(1) Grocery shop (2) Tailor (3) Medicine shop (4) Private medical practitioner (5) Retail cloth store (6) Primary school (7) Stationary shop (8) Fertilizer distribution centre and (9) Cycle/Rickshaw repairing shop.

Second level (population size 1600-2250)

(1) Tea stall (2) Weekly market (3) Rice mill (4) Food dealer (5) Madrasha (6) Post office (7) Secondary school (8) Family planning centre and (9) Wheat milling mill.

Third level(population size 2800 and more)

(1) Bank (2) Charitable dispensary (3) Bus stoppage (4) Godown.

After determining the levels of functional hierarchy attempts were made to quantify them by giving appropriate weightages for each level. Three entry points emerged as the basis for different functional hierarchy. Population size 400 for the first level functions,1600 for the second level functions and 2800 for the third level functions were considered. Thus if the entry points in terms of population size were 'weighted', then the first level as a 'base' is awarded a value of one, the second level a value of four and the third level a value of seven. All the functions of a particular level are considered to be of equal importance. For example, in case of a grocery shop which is of eqnal importance as that of a primary school though the former has an entry point 400 and the latter 800 .

In order to arrive at the centrality of a settlement of a particular function, the weightage awarded to a particular level is multiplied by the quantity of that function at that particular level.

That is, if there are 2 primary schools in a particular settlement, it will be awarded the value of 2 (1x2). The names of the settlements and centrality scores associated with them determined by this method are shown in Appendix-E (Table E.1).

4.4.2 Centrality of Settlements on the Basis of Scarcity of Functions

The hierarchy and centrality of the settlements were also determined on the basis of scarcity of functions. The weightages of different functions were assigned in this method according to the principle that greater the importance interms of centrality and therefore, higher the weightage. The weightage of any function was determined by dividing total number of settlements by number of settlements having that function. For example, total number of settlements where primary school occur are 70 out of 164 settlements in the study area. Therefore, the weightage of primary school is 164/70 = 2.34. The weightages of the different functions are given in Appendix-C (Table C.1). On the basis of the weightages described above the centrality score for each settlement was calculated by adding the quantity of functions multiplied by their corresponding weightages. The names of the settlements and centrality scores associated with them determined by this method are shown in Appendix-E (Table E.2).

4.5 Principal Component Analysis

In the analysis of any given data set there exists underlying trends which may not be readily identifiable. These trends

may be the result of a number of variables interacting within the data set and a method of defining them should be sought. Principal Component Analysis seeks to do just this. The analysis groups variables into a new'synthetic' variable, or component. It has been recognised as a powerfnl tool in multivariate analysis and attacks problems at the point where standardisation fails or is not satisfactory. It recognises that all measurements within the data set are not of equal weight and that indeed may overlap. If several measurements show a similar pattern of variation, then it is suspected that a more 'basic pattern' lies beneath. The principal component is that 'basic pattern'.

The identification and interpretation of the components is based on the loadings which link the factors to the variables. Each component can be identified. The first principal component is that which accounts for the greatest part of the common variance of the orginal variables. The second component then accounts for the maximum share of the remaining variance and so on.

The centrality scores of the settlements of the study area were also calcnlated by the Principal Component Analysis method. The SPSS package available on the nniversity's computer system was nsed for the purpose of the present analysis.

The Principal Component Analysis was performed using the same set of twenty two central functions shown in Table 4.1 and village population. The weightage of any central function was determined by dividing total number

of settlements by number of settlements having that function. The weightages of different functions used in this analysis are shown in Appendix-C (Table C.1).

The first stage of the analysis was the derivation of the principal components. This is the transformation of the original variables into a new set of variables, the first of which will explain to a certain degree, the level of variance in the data. The following Table 4.2 shows the amount of variance explained by each component.

Table 4.2 The Principal Components and Their Percentage Contribution of Total Variance

Principal component	Eigen value	% variance explained	Cumulative % of variance explained
1	9.71098	42.2	42.2
2	2.90295	12.6	54.8
3	2.01610	8.8	63.6
4	1.40259	6.1	69.7
5	1.04898	4.6	74.3
6	0.94130	4.1	78.4
7	0.90217	3.9	82.3
8	0.77351	3.4	85.6
9	0.58316	2.5	88.2
10	0.54325	2.4	90.5

The component loadings for the first six components against each variable are listed in more detail in Table 4.3.

Table 4.3 Component Loading

	Components					
Variables	1	2	3	4	5	6
X1	0.2459	0.1224	0.3420	0.3939	0.5780	0.3311
X2	0.9306	0.1549	0.0979	0.1400	0.0039	0.0112
X3	0.9479	0.1234	0.1006	0.1214	0.0146	0.0160
X4	0.9578	0.0435	0.0721	0.0876	-0.0323	-0.0311
X5	0.0836	0.1027	0.0608	0.0747	0.0096	0.9025
X6	0.4519	0.4293	0.2341	-0.1674	0.0496	0.0557
X7	0.2986	-0.0589	0.2876	0.3766	0.4003	0.2269
X8	-0.0063	0.0483	0.8756	0.2258	-0.0363	0.0986
X9	0.3547	0.1519	0.7701	0.0604	0.2998	0.0225
X10	0.8477	0.3140	0.2644	0.0545	-0.0384	-0.0604
X11	0.3478	0.1402	0.6885	0.0623	0.0094	0.0777
X12	-0.1441	0.5163	0.4458	0.0931	0.2790	-0.0881
X13	0.7374	-0.0171	0.1441	0.2254	0.0555	0.3288
X14	0.0534	0.9206	0.0975	0.1418	-0.1110	0.0372
X15	0.4314	0.7625	0.0362	0.1470	0.2106	0.1247
X16	0.3899	0.2415	0.1665	0.6517	0.1772	0.0924
X17	0.5529	0.3254	0.1310	0.6695	0.0978	0.0065
X18	-0.0275	0.3578	0.1505	0.8363	0.0670	0.0494
X19	0.2017	0.8130	-0.0047	0.4041	0.0572	0.0211
X20	0.3456	0.7058	0.2273	0.3977	0.1314	0.1102
X21	0.5964	0.0276	0.1447	0.0496	0.1965	0.2840
X22	-0.0618	0.1011	0.0195	0.0614	0.9111	-0.0613
X23	0.7911	0.3488	0.0112	0.2668	0.0825	0.0454
Total variance explained	9.7109	2.9029	2.0161	1.4025	1.0489	0.9413
Percentage variance explained	42.2%	12.6%	8.8%	6.1%	4.6%	4.1%

78.4% of total variance was explained by the first 6 principal components.

The first principal component in this study explained about 42 percent of the total variation of the constituents. The aggregate scores of the settlements were obtained by adding the component loading based on first principal component (Appendix-D). The names of the settlements and centrality scores associated with them determined by the principal component analysis are shown in Appendix-E (Table E.3).

4.6 Hierarchy of Settlements

Hierarchy of settlements based on level of functions was determined by categorizing the scores of the settlements under three levels of hierarchy. These are shown in Table 4.4.

Table 4.4. Levels of Settlement Hierarchy Based on Level of Functions

Serial No.	Point scored	Number of settlements
1	0-50	150
2	51-400	13
3	400- above	1

Only one first level growth centre and thirteen second level service centres emerged in the study area by this method. These are Kahaloo, Durgapur, Kalai, Birkeder, Protappur, Murail, Deogaon, Shakahar, Zamgram, Narhatta, Aghore, Paiker, Pilkhunja and Bhadahar.

Hierarchy of settlements based on scarcity of functions was determined by categorizing the scores of the settlements under three levels of hierarchy. These are shown in Table 4.5.

Table 4.5. Levels of Settlement Hierarchy Based on Scarcity of Functions

Serial No.	Point Scored	Number of Settlements
1	0 - 100	150
2	101 - 500	13
3	500 - above	1

Only one first level growth centre and thirteen second level service centres emerged in the study area by this method. These are Kahaloo, Durgapur, Kalai, Birkeder, Protappur, Narhatta, Shakahar, Murail, Deogram, Zamgram, Agore, Paiker, Bhadahar and Pilkhunja.

Hierarchy of settlements was determined by categorizing the scores of the settlements determined by Principal Component Analysis under three levels of hierarchy. These are shown in Table 4.6.

Table 4.6 Levels of Settlement Hierarchy by Principal Component Analysis (Component 1 Score)

Serial No.	Point Scored	Number of settlements
1	-3.5 - + 3.5	150
2	3.5 - 50.0	13
3	50.0 - above	1

Only one first level growth centre and thirteen second level service centres emerged in the study area. These are Kahaloo, Durgapur, Kalai, Shakahar, Protappur, Birkeder, Narhatta, Paiker, Zamgram, Murail, Bhadahar, Deogram, Agore and Pilkhunja.

In the study above procedures were used to identify the hierarchy of settlements. These procedures were used in order to observe the variations in the results. Inspite of limitations of these methods, it is seen that the above methods identified the same growth and service centres in the study area. The principal component analysis methodis a relatively complex one. It requires computer and hence less accessible for operational purposes for all in determining the centrality and hierarchy of settlementsin developing the rural road network plan. On the other hand, the other methods are easily applicable in identifying the hierarchy of settlements. So, either the method based on level of function or method based on scarcity of function may be used for operational purposes in determining the centrality and hierarchy of settlements.

CHAPTER - 5

DEVELOPING THE NETWORK

5.1 Introduction

The rural road network plan may be developed by applying the concept of graph theory and the hierarchy of settlements.These two concepts and their applicability in the planning of rural road network are described in the prevlous chapters. Now the proceduresfor preparing the network plan for rural roads are stepwise described in this chapter. Here, main nodes and main links of the network are first identified and then the secondary links for other nodes are determined by selecting the optimum link options of maximum weightage.

5.2 Preparation of the Study Area Map

In the first step of rural road network planning, a topographical map of the study area is prepared. The present locatlon of the settlements, existing communication facilities in the form of railways lines, roads and cart trucks, river and other salient topographical features are identified on this map. The aerial distances between different settlements are got from the topographical map. The map of Kahaloo Upazila with the locations of its 164 settlements is shown in Figure (5.1).

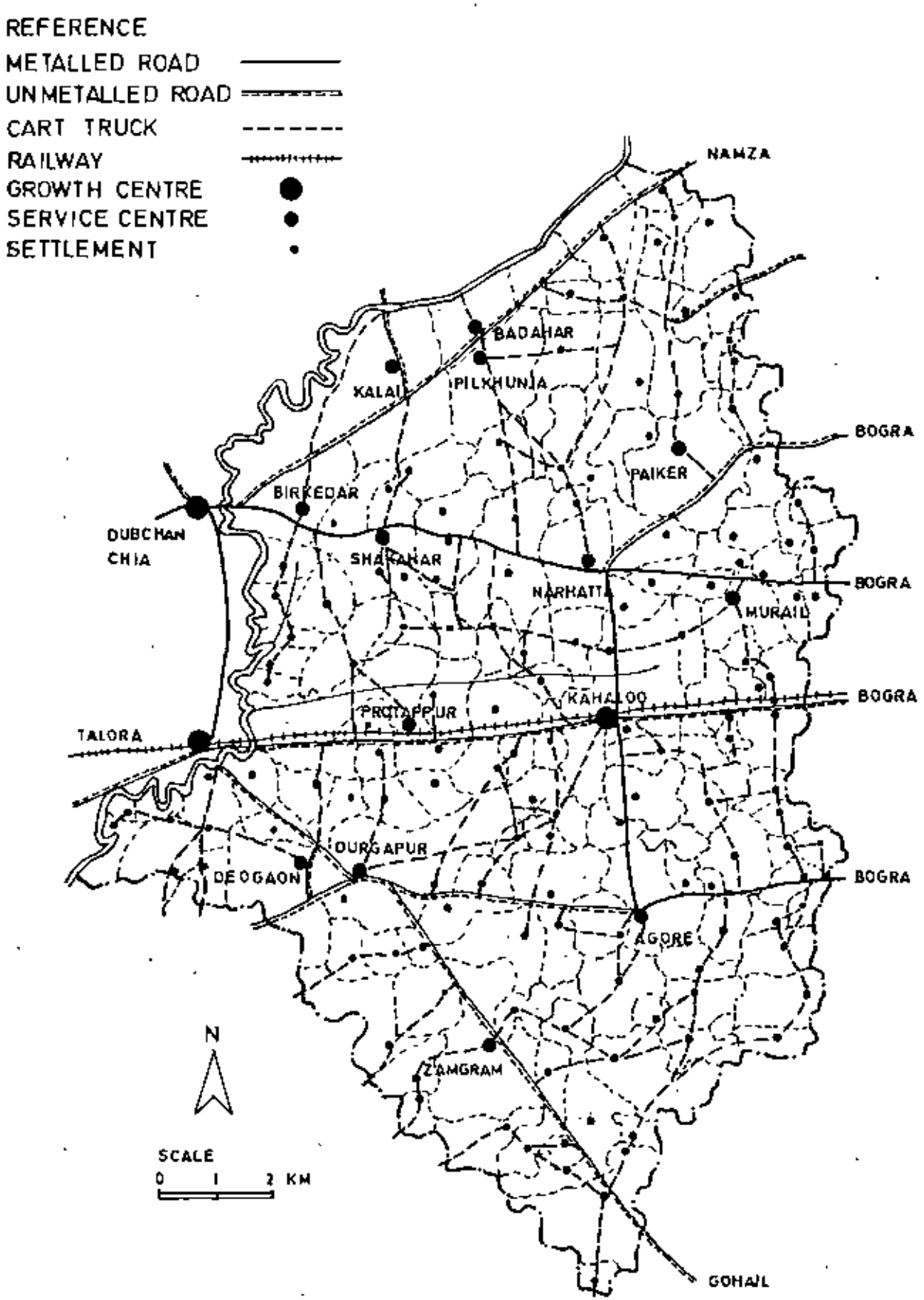
5.3 Identification of Main Nodes of the Network

The procedure of identification of growth and service centres

FIG. 5.1

KAHALOO UPAZILA

TRANSPORT AND SETTLEMENTS



in the study area is detailed described in the previous chapter. The score for each of the settlements is determined and the settlements are categorized into three levels of hierarchy based on the centrality score of the settlements. Only one first level and thirteen second level service centres emerged in the study area. These service centres are considered as the main nodes of the network and the remaining settlements are considered as the secondary nodes of the network. Their centrality scores are taken as the 'attracting force' of the nodes in case of network planning. The main nodes of the network with their attracting forces are shown in Figure (5.2).

5.4 Identification of Main Link System of the Network

The main link system of the network in the study area is identified from the available maps and informations from the secondary sources. The link between the main nodes and other major roads passing through the study area are considered as main link system of the network. These main links are scored according to their level of importance and serviceability (Appendix-F). In the present study the ranking of the main links has been done following the scoring systems developed in Thailand (The Highway Department, 1979) and Indonesia and as described in Section (1.3). These scores are considered as 'attracting force' of the main links in case of network planning. The main links with their attracting forces are shown in Figure (5.2).

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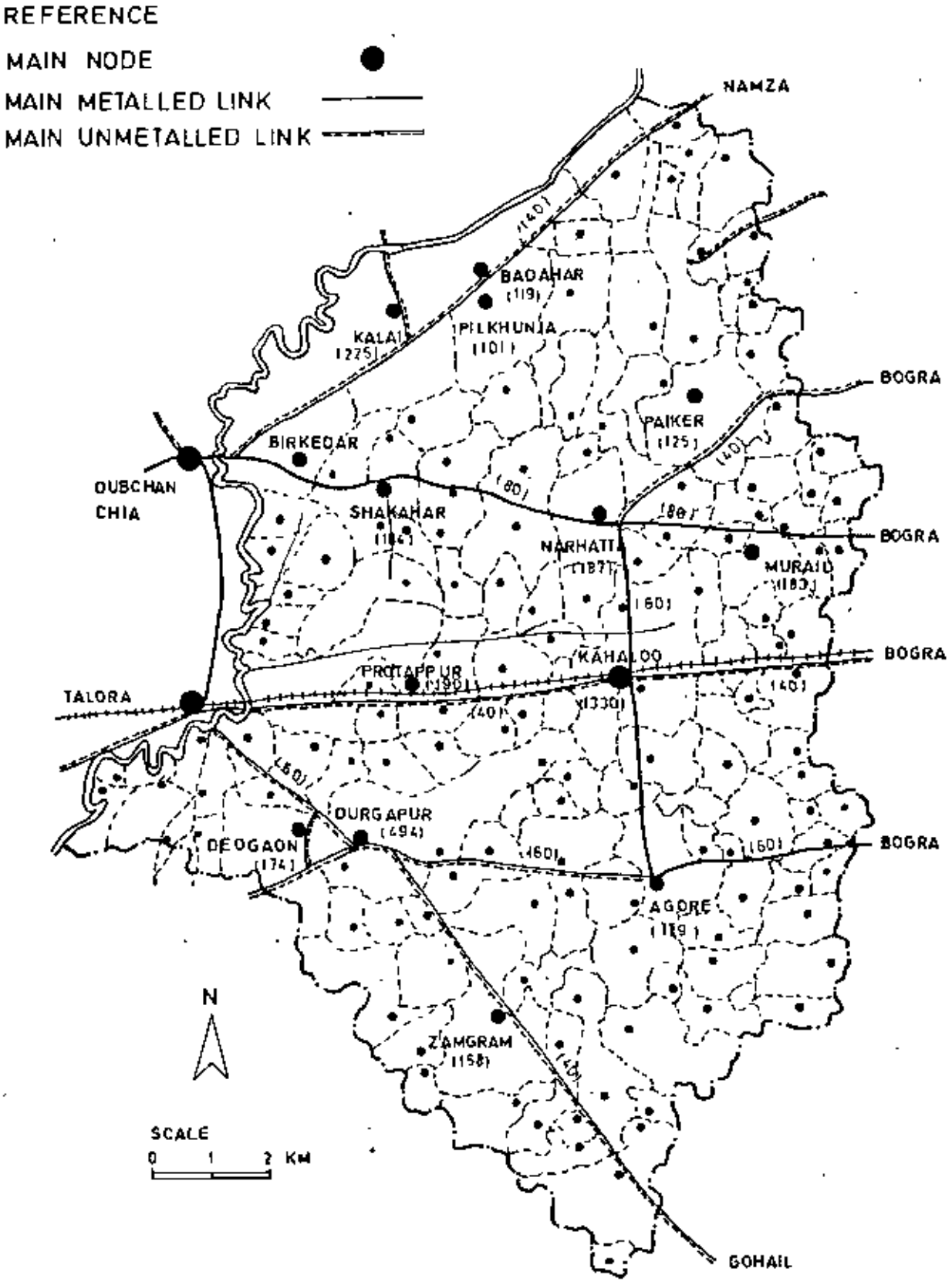
FIG. 5.2

MAIN NODES AND MAIN LINKS
WITH ASSOCIATED ATTRACTING FORCES



5.5 Generation of Final Rural Road Network

Final rural road networks are developed in the form of several minimal spanning trees. The generation of various rooted minimal spanning trees are explained by an example shown in Figure (5.3).

The Closest node 'Ulot(2)' is first connected with the main node 'Kahaloo(1)'. Then the node 'Joysara(3)' is connected with 'Ulot(2)' because the weightage of this link option is greater than that of the other two link options. Again, the weightage of the link option 'Joysara(3) to Agersal(4)' is greater than that of the other two link options. So, 'Agersal(4)' is connected with 'Joysara (3)'. Now, 'Domorgram(5)' is connected with 'Agersal(4)'; since the weightage of this link option is more than the others. The calculation for this minimal spanning tree is shown in Table 5.1.

Thus all the other minimal spanning trees are generated until all the secondary nodes are connected. An entire rural road network in the form of minimal spanning tree for the study area is shown in Figure (5.4). The selection of link option for these minimal spanning trees is shown in Appendix-G (Table G.1).

5.6 Superimposition of the Developed Network

The developed network of rural road by the above procedure is formed without any regard to the existing rural roads. Now, the

FIG. 5.3

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MINIMAL SPANNING TREE

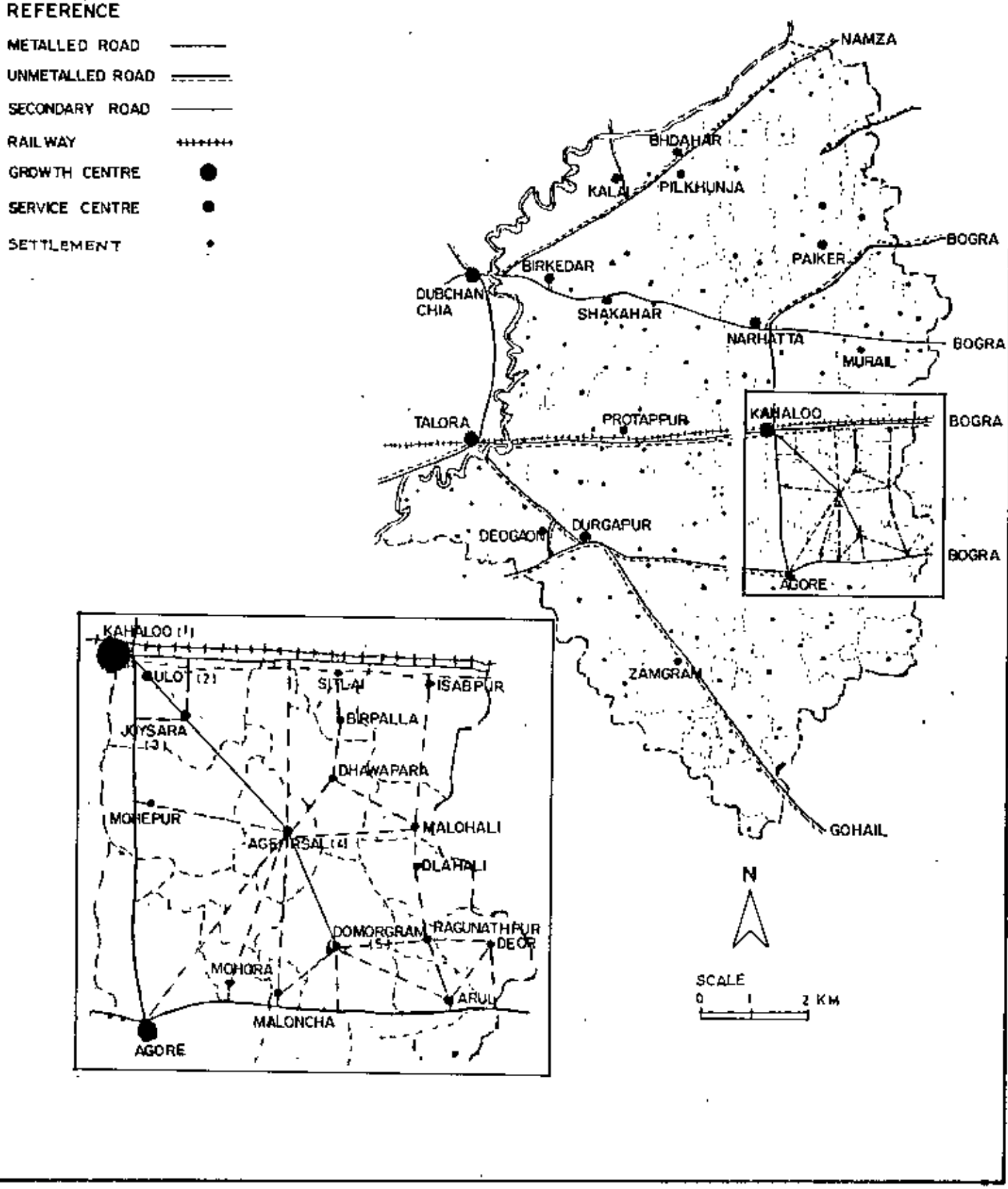

Table 5.1: Selection of Link Option

Sl. No.	Node to be connected	Link option	P_o	P_i	L_i (km)	$P_o + \Sigma \frac{P_i}{L_i}$	L_o (km)	$\frac{P_o + \Sigma \frac{P_i}{L_i}}{L_o}$	Remarks
1.	Ulot	-	-	-	-	-	-	-	Ulot is connected first with Kahaloo sine it is nearest to Kahaloo
2.	Joysara	Ulot	72	Kahaloo(1330)	0.5	1952	0.625	3123	Joysara is connected with Ulot
		Main Link	60	-	-	60	0.375	160	
		Main link	40	-	-	60	0.375	160	
3.	Agersal	Joysara	6.7	Kahaloo(1330) Ulot (72) Main Link(40)	0.625 0.375 1.25	1806	2.0	903	Agersal is connected with Joysara
		Dhawapara	12	Sitlai (22) Birpalla(2.4)	1.25 0.625	71	0.625	113	
		Mohespur	7.5	Main Link	0.25	127	1.625	78	
		Agore	129	-	-	129	2.5	52	
		Malancha	12	Main Link	0.25	146	1.875	77	
4.	Domorgram	Agersal	16	Kahaloo(1330) Ulot (72) Joysara (6.7)	2.87 2.37 1.8	850	1.25	680	Domorgram is connected with Agersal
		Main Link	60	-	-	60	0.625	96	
		Malancha	12	Main Link(60)	0.25	146	1.25	117	
		Raghunathpur	3.7	Main Link(60)	1.0	124	1.0	124	

FIG. 5-4

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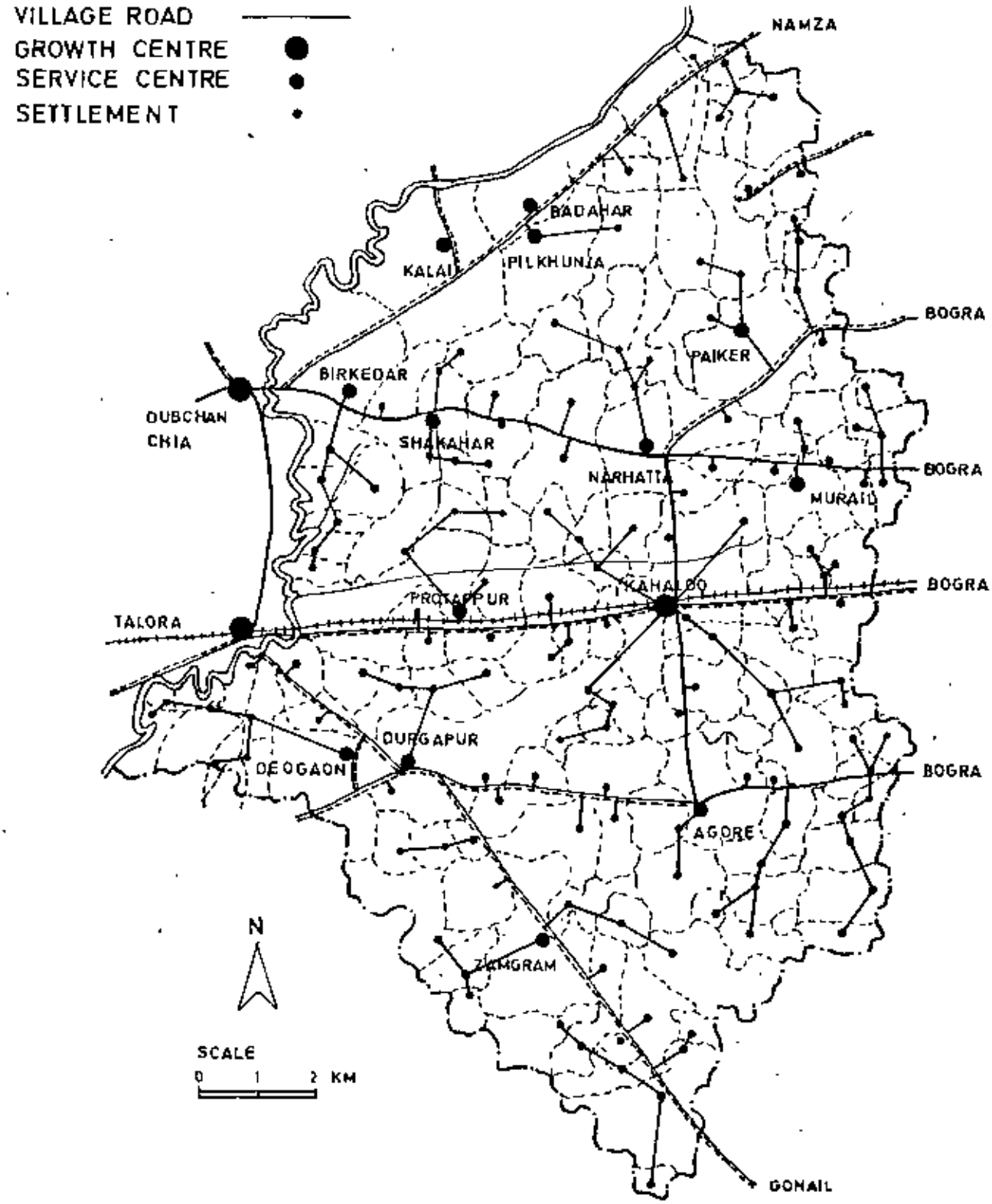
RURAL ROAD NETWORK



existing rural roads are superimposed over the developed network. The superimposing of existing roads on the developed rural road network is shown in Figure (5.5). It is done in order to test the applicability of the methodology developed in planning the rural road network in practice. From the figure (5.5) it is seen that the developed network almost represents the same with the existing road network except a few cases. A few links are slightly deviated from the developed links. From the topographical feature of these areas it is found that these deviations are due to the presence of some small natural barriers like canals (khal) and lowlands. These deviation in the developed network may be modified by analysing the field conditions in these areas.

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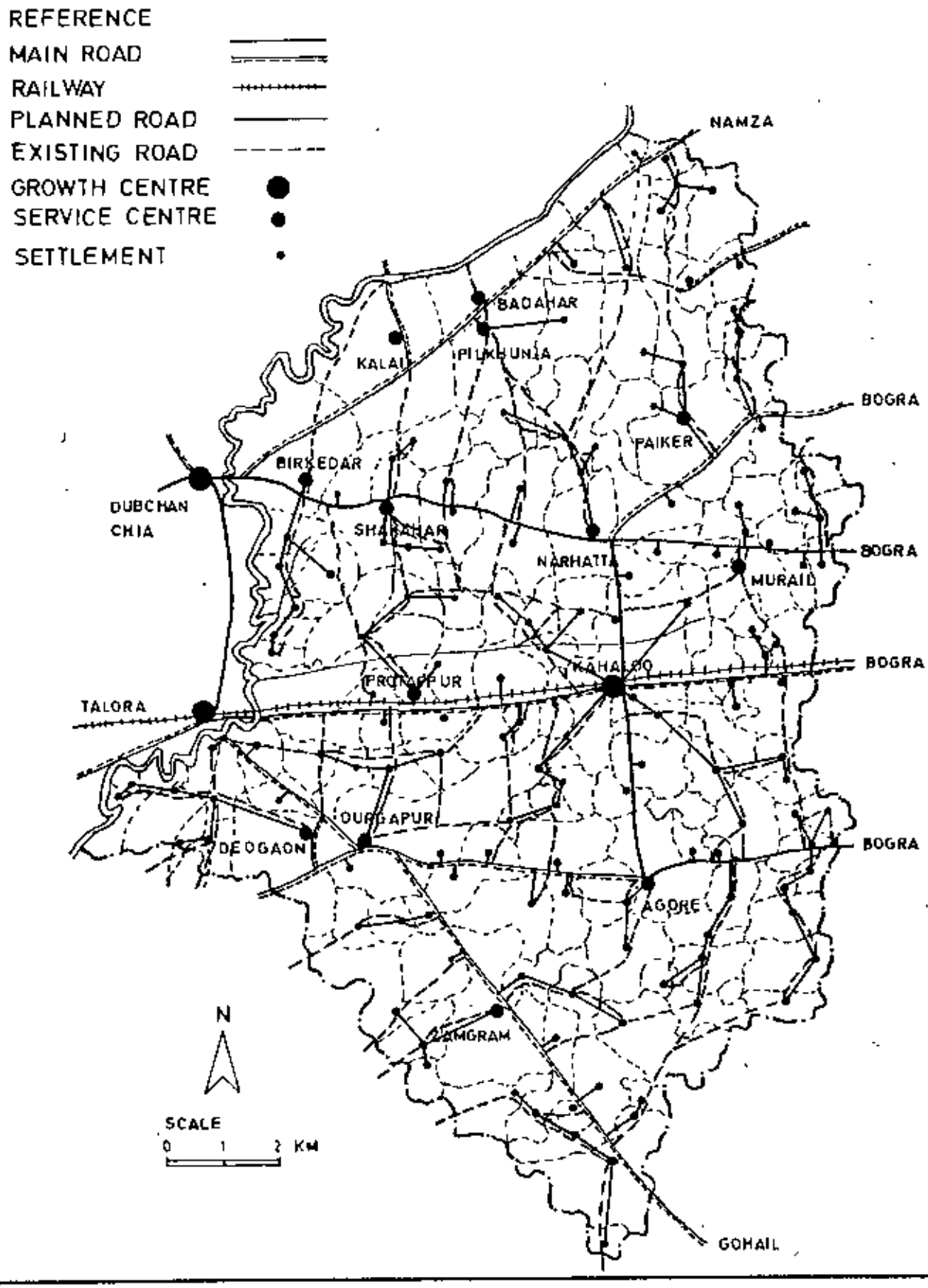
FIG. 5.5

SUPERIMPOSITION OF RURAL ROAD NETWORK



CHAPTER - 6

CONCLUSION

Rural road development includes planning, design, construction and maintenance as a total system. This study brings out a planning process which is required to be looked at as a part of the system. The study have tried to develop a planning methodology for rural road network and test its applicability in practice. The other issues of road planning like road geometrics, alignment, type, specifications etc were not incorporated in the study. However, network planning is completely a separate aspect than the other issues of road planning and it comes first and more important in rural road planning.

To develop a systematic rural road network, first centrality of the settlements in the study area based on the concept of hierarchy of settlements were determined. This was done by selecting several functions and weighting them on the basis of level of functional hierarchy and scarcity of functions. The settlements were then categorized into three groups according to the score of the settlements. The first and second level settlements came out as main nodes of the network in the study area.

The roads between the main nodes were identified as main links of the network from the available maps and information. They were ranked according to their importance and serviceability by selecting some parameters based on system developed in

Thailand and Indonesia. Then the links for secondary nodes were generated in the form of minimal spanning trees by applying the concept of graph theory. These spanning trees were developed by selecting the optimum link option of maximum weight for every secondary nodes. The node closest to the main link or main node is connected first. Then the tree was started to generate by adding link of maximum weight and connecting node by node. Thus proceeded towards the interior untill all the secondary nodes were connected. Thus the methodology developed for the planning of rural road may be outlined in the following figure (6.1).

The developed process is relatively a simple one. This was done with the objective in mind to make it operational at the upazila level considering the present constraints. Objective function of the process is simple and straight forward. Each of the settlements will have to be connected either to the nearest service centre or to the main road. This has to be done with minimum length of road to ensure economics in investment. The implicit assumption is that the cost is propotional to distance. However, this is not necessarily true in all cases.

The network was developed by this methodology with limited objectives. The network is mainly aimed to go to the growth or service centres. The network does not serve all the purposes of total accesibility. Say, people want to go to their agricultural field and other villages for their field work and social

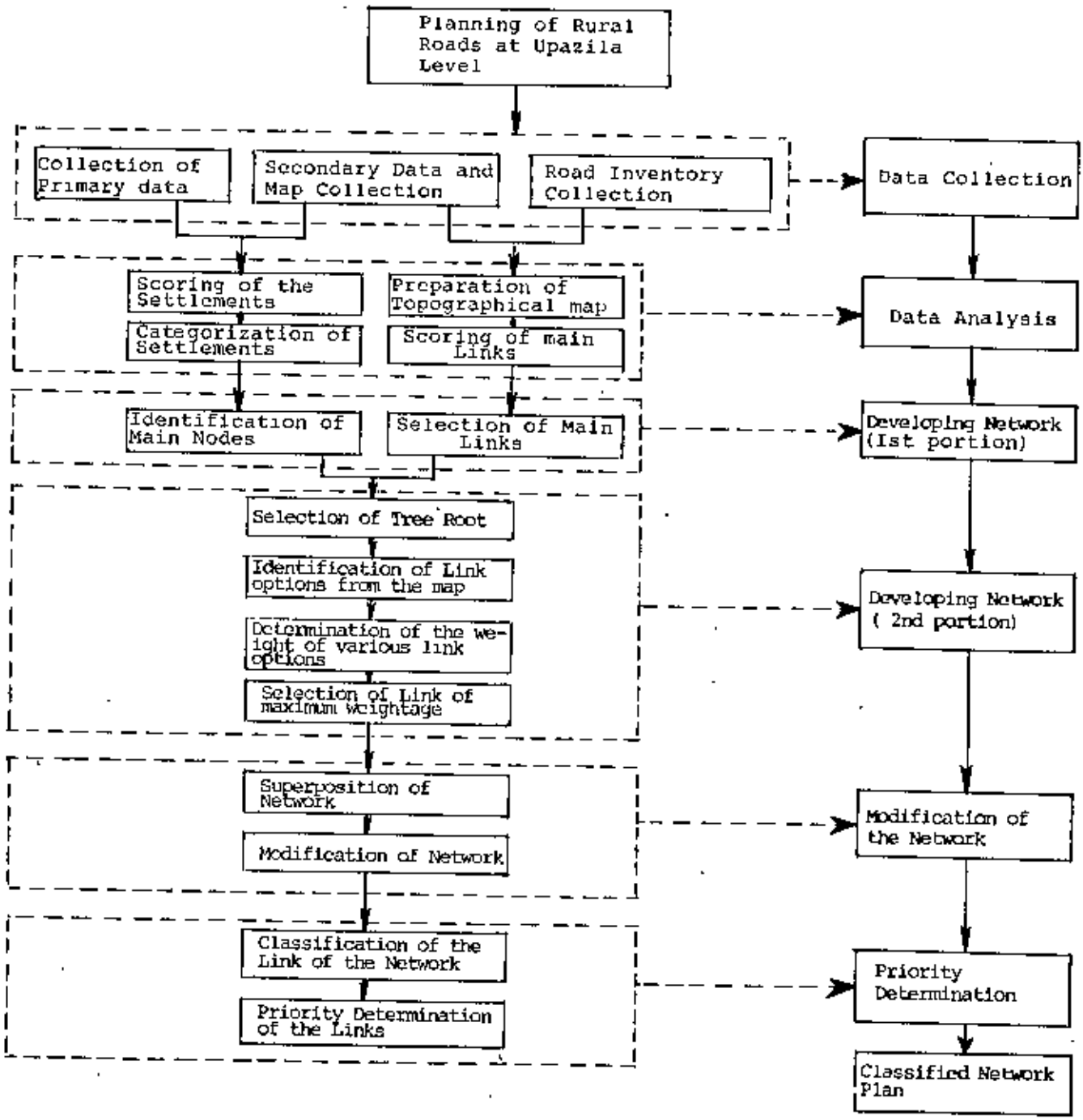


Figure 6.1 Methodology for Planning of Rural Road at Upazila Level

purposes. The existing roads to serve these purposes should remain the same as exists.

The developed network may, firstly, help in identifying the missing links,if any. The network may not require further new alignment since available alignments may serve the purpose well. Secondly, the network may help in priority determination from the existing road network for future investment and development. After priority determination by the network developed, the resource may not be available for developing all the links of the network selected. In such cases higher evaluation process may be practiced in order to identify the more feasible ones.

The network generated by the process developed in the present study to planning road in rural areas, however,may not be directly implemented in all the cases. Topographical features of the country vary from area to area. There may be streams, rivers, marshy lands in some areas and there may be hills, mountains etc.in some other areas. The network generated by the process may be directly implementable in areas where no such major natural barrier exists.

However, in the study, the planning process of rural road network has not considered incorporating the effects of such natural barriers. For example, if there exists a river or mountain between two settlements which are intended to be linked. Then the weightage if calculated by the equation (2.1), may have a higher

value in comparison to that of some alternative links. But due to river or mountain it will not be economical to adopt the link. This position is made clear in Figure (6.2).

Under these circumstances, a complex formula could have been developed by incorporating a parameter in the right side of the equation (2.1) to overcome the problem. The actual value of the parameter may be predecided depending upon the prevailing conditions. But it will be more complex in practicing and therefore, less operational at upazila level. There may be also disagreement to quantify the value of the parameter. Alternatively,rather than usiug complex formula, it is advantageous to modify the developed network by analyzing the field conditions where such natural barrier exists.

Where there is a marginal difference in the weightages of two link options for any settlement the developed road network may be modified. In such cases, the link of lower weight may be considered as the optimum link depending upon the field condition.

The study reveals that the developed network allows a considerable variation in the weightage value of the main link of the network. For example, the spanniug tree ABCDE shown in Figure (6.3) was formed when the weightage value of the main

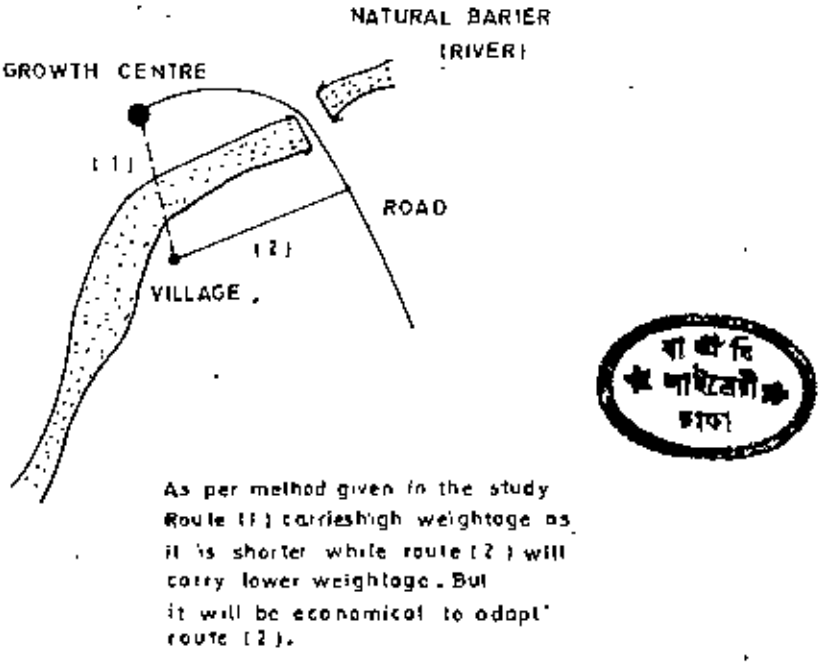


Figure 6.2 Modification of Rural Road Network due to Presence of Natural Barriers

link XY was calculated as 60. The same tree will be formed if the weighting value of the main link XY is changed either to 80 or 40. The calculation is shown in Appendix-H. For this, a comprehensive survey to collect the data for parameters to determine the weightage of different main roads is not essential. Prelimiuary survey in this respect is sufficient in practice at the field level.

Rural road network planning has been done in the study by linear method and not by star or grid method. In other words, every settlement is aimed to have only one outlet, leading to only one growth or service centre. When all the settlement of the

area get connected with surfaced roads, activities in the fields like agriculture, diary, animal husbandary, small and cottage industries etc may accelerate at a very fast rate. Hence, it will be necessary to have more than one outlet towards different growth and service centres. This can be achieved by connecting the link between different minimal spanning trees at suitable locations.

The study also does not consider about the link between the neighbouring settlements. This phase of connection may be considered in future when all the settlements are connected with minimum one surfaced road in order to increase the density of roads in the area.

The alignment should be decided at the initial stage itself to suit the future needs. The actual alignment will have to be fixed depending upon the field conditions. There may be depression, highly clayey soils, man made barriers and so on. These will have to be taken into account while fixing the alignment in the field.

Considering the serious constraints of very limited fnnds available for developing such a network in its entirely, a phased programme executed in a systematic manner is inevitable. Since different stretches of secondary nodes forming branches of minimal spanning tree will have different traffic volumes

and composition; it is necessary to classify the network in order to priority determination for purposes of implementing the network.

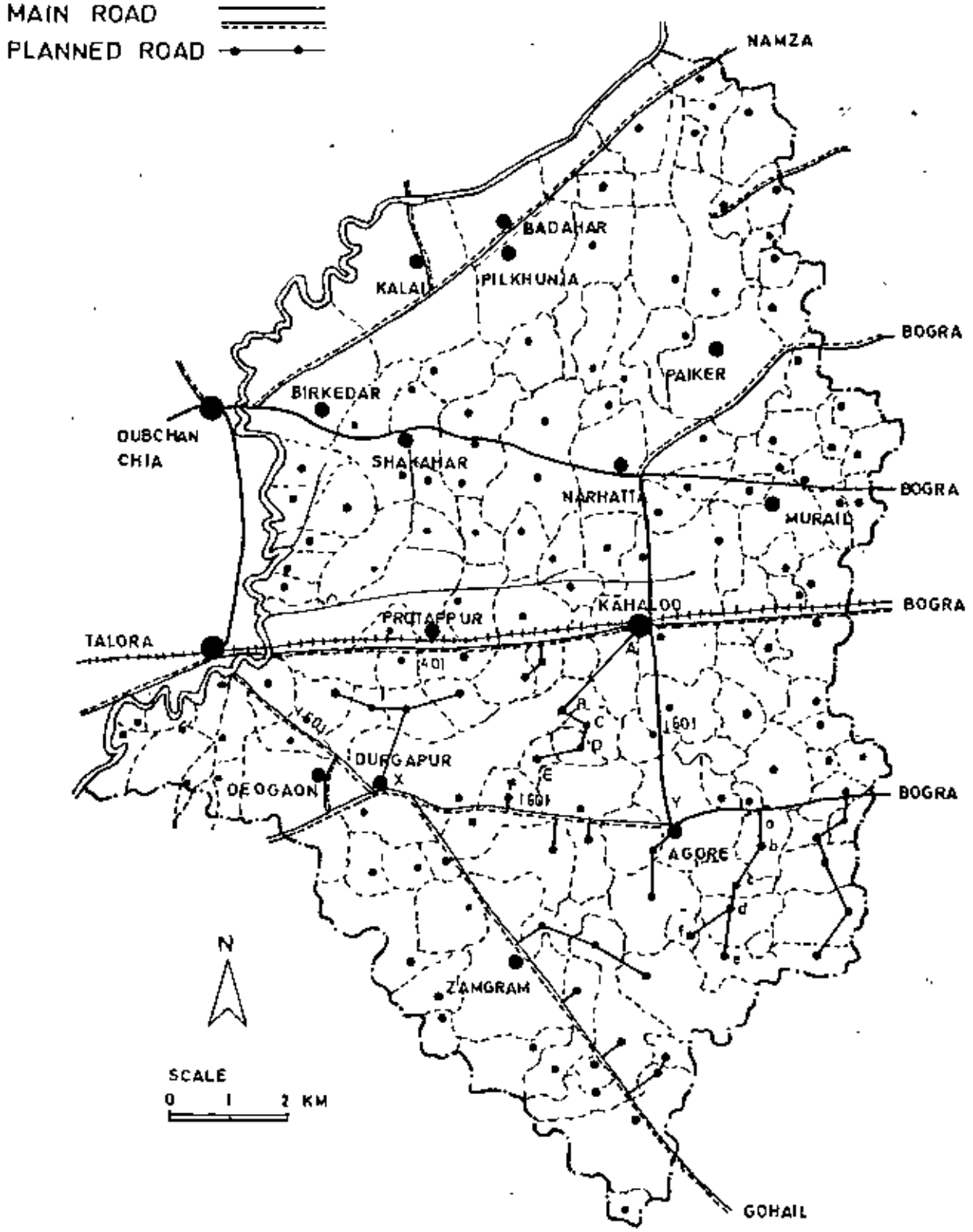
The various typesof roads are parts of the tree and this is shown in Figure (6.3). The traffic on the stem of the tree will be much more. It may be thought that the settlements close to the main road or service centre would naturally generated more traffic as the traffic will be coming from several settlements in the interior and this constitutes type 'A'. The various branches of the tree will constitute type 'B' and the traffic here will be much less and be of slow moving type in most cases. Type 'C' is the one which will be connecting only the isolated settlements in the very interior. If this is followed, it may be possible to work inwards from the main roads into the interior. For example; portion ab of the tree abcdef may be 'A' type; portion bcd may be 'B' type; and portion de or df of the tree may be 'C' type.

After making the necessary modifications and classifications of the rural road network, the total population served by each road link can be determined. Depending upon the requirement of construction/improvement, cost of developing each link can be determined. Thus the ratio of population served and investment needed for each link can be easily obtained. This ratio may be an important bearing on the priorities to be assigned for the development of various road linkages. But in case of roads

KAHALOO UPAZILA

FIG. 6-3

TYPES OF PLANNED ROAD



which require crossing by major bridges, this ratio will come out to be much less and will therefore have a very low priority, although actual requirement may be much higher. This point may, therefore, be also taken into consideration.

Upazila Parishad may prepare a master plan for rural roads at upazila level by following the planning methodology developed in the study. The existence of a master plan may help in achieving the integrated road system. This may bring to an end the present practice of the individual authority like Upazila Parishad, LGEB, Roads and Highways Department, building roads in their own way and reduce wastage of scarece resources and hapazard development of rural road. And thus an optimized rural road network can be generated at upazila level gradually.

APPENDIX - A

DETERMINATION OF POPULATION THRESHOLD FOR SETTLEMENT FUNCTION

Accordingly to Haggett and Gunecwardena(1964) functions are established in a given settlement for a variety of reasons of which its size is an important but not necessarily overriding factor. As a result of this complexity the simple concept of entry level must be replaced by one of an "entry zone". They suggest that we may view the threshold of any function as the middle point of its 'entry zone'. For a given function (F_i), there is a lower population level at which no settlements of this size have (F_i); conversely there is an upper population level at which all settlements of that size have F_i. By modifying a standard bioassy technique, the Reed-Muench Method, the middle point of this entry zone can be measured to give the median population threshold or PT_{50}.

For the purpose of illustration the problem of determining the population threshold for primary school in the study area is considered. In Table A.1 it is found that for the lowest level (population less than 500) the settlement does not have any primary school while for the highest level all settlements have primary school. Between these extremes the proportion 'without' declines as that with increase. Cumulative summing of the two columns gives values for an index Ag indicating absence of primary school at this and greater levels and for an index

TABLE A.1

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50})

Population level	0-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-above
Number of Settlement	61	63	17	12	6	1	1	3
With grocery	49	49	15	12	5	1	1	3
Without grocery	12	14	2	0	1	0	0	0
With grocery absent at this and greater levels (Ag)	29	17	3	1	1	0	0	0
With grocery present at this and smaller levels (Ps)	49	98	113	125	130	131	132	135
With Tailer	41	52	15	12	6	1	1	3
Without Tailer	20	11	2	0	0	0	0	0
Ag	33	13	2	0	0	0	0	0
Ps	41	93	108	120	126	127	128	131
With medicine shop	29	37	15	12	6	1	1	3
Without medicine shop	32	26	2	0	0	0	0	0
Ag	60	28	2	0	0	0	0	0
Ps	29	66	81	93	99	100	101	104

Continued.

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50}) (Continued)

With private medical practitioner	31	39	16	12	6	1	1	3
Without private medical practitioner	30	24	1	0	0	0	0	0
Ag	55	25	1	0	0	0	0	0
Ps	31	70	86	98	104	105	106	109
With retail cloth store	21	31	9	10	4	1	1	2
Without retail cloth store	40	32	8	2	2	0	0	1
Ag	85	45	13	5	3	1	1	1
Ps	21	52	61	71	75	76	77	79
With primary school	0	35	13	11	6	1	1	3
Without primary school	61	37	4	1	0	0	0	0
Ag	103	42	5	1	0	0	0	0
Ps	9	35	48	59	65	66	67	70
With stationary snop	22	25	6	10	6	1	1	3
Without stationary shop	90	38	11	2	0	0	0	0
Ag	90	51	13	2	0	0	0	0
Ps	22	47	53	63	69	70	71	74

(Continued)

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50}) (Continued)

With fertilizer dist. centre	18	25	11	10	4	1	1	3
Without fertilizer dist.centre	43	38	6	2	2	0	0	0
Ag	91	48	10	4	2	0	0	0
Ps	18	43	54	64	68	69	70	73
With Cycle/ Rickshaw repairing shop	24	20	8	7	5	1	1	3
Without Cycle/ Rickshaw repairing shop	37	43	9	5	1	0	0	0
Ag	95	58	15	6	1	0	0	0
Ps	24	44	52	59	64	65	66	69
With Tea stall	6	8	2	3	2	1	1	3
Without Tea stall	55	55	15	9	4	0	0	0
Ag	138	83	28	13	4	0	0	0
Ps	6	14	16	19	21	22	23	26
With weekly market	1	4	2	5	6	0	1	1
Without weekly market	60	59	15	7	0	1	0	2
Ag	144	84	25	10	3	3	2	2
Ps	1	5	7	12	18	18	19	20

(Continued)

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50}) (Continued)

With rice mill	4	4	3	0	3	1	1	2
Without rice mill	57	59	14	12	3	0	0	1
Ag	146	89	30	16	4	1	1	1
Ps	4	8	11	11	14	15	16	18
With food dealer	1	3	1	3	3	0	1	2
Without food dealer	60	60	16	9	3	1	0	1
Ag	150	90	30	14	5	2	1	1
Ps	1	4	5	8	11	11	12	14
With Madrasha	0	4	0	3	2	1	1	3
Without Madrasha	61	59	17	9	4	0	0	0
Ag	150	89	30	13	4	0	0	0
Ps	0	4	4	7	9	10	11	14
With post office	1	0	1	3	5	0	1	1
Without post office	60	63	16	9	1	1	0	2
Ag	152	92	29	13	4	3	2	2
Ps	1	1	2	5	10	10	11	12

(Continued)

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50}) (Continued)

With Secondary school	1	2	3	2	3	0	1	1
Without Secondary school	60	61	14	10	3	1	0	2
Ag	151	91	30	16	6	3	2	2
Ps	1	3	6	8	11	11	12	13
With Family Planning Centre	0	0	0	3	3	0	1	1
Without Family Planning Centre	61	63	17	9	3	1	0	2
Ag	156	97	32	15	6	3	2	2
Ps	0	0	0	3	6	6	7	8
With Wheat milling mill	0	2	1	0	2	1	1	2
Without Wheat milling mill	61	61	16	12	4	0	0	1
Ag	155	94	33	17	5	1	1	1
Ps	0	2	3	3	5	6	7	9
With Bank	0	0	1	1	2	0	1	0
Without Bank	61	63	16	11	4	1	0	3
Ag	159	95	35	19	8	4	3	3
Ps	0	0	1	2	4	4	5	5

(Continued)

DETERMINATION OF MEDIAN POPULATION THRESHOLD (PT_{50}) (Continued)

With charitable dispensary	0	0	0	2	2	0	0	1
Without charitable dispensary	61	63	17	10	4	1	1	2
Ag	159	98	35	19	8	4	3	3
Ps	0	0	1	2	4	4	5	5
With Bus stoppage	0	1	1	1	1	0	0	1
Without Bus stoppage	61	62	16	11	5	1	1	2
Ag	159	98	36	20	9	4	3	2
Ps	0	1	2	3	4	4	4	5
With godown	0	0	0	1	1	0	1	0
Without godown	61	63	17	11	5	1	0	3
Ag	161	100	37	20	9	4	3	3
Ps	0	0	0	1	2	2	3	3

Ps indicating presence of primary school at this and smaller levels.

The value for PT_{50} has been obtained graphically by ploting the values of Ag and Ps from Table A.1 on the same set of axes. Tho curves for the two parameters cross at a population value at which the number of settlements without primary school at this and smaller sizes is equal to the number of settlements with that function at this and greater sizes. This is 50 percent population threshold.

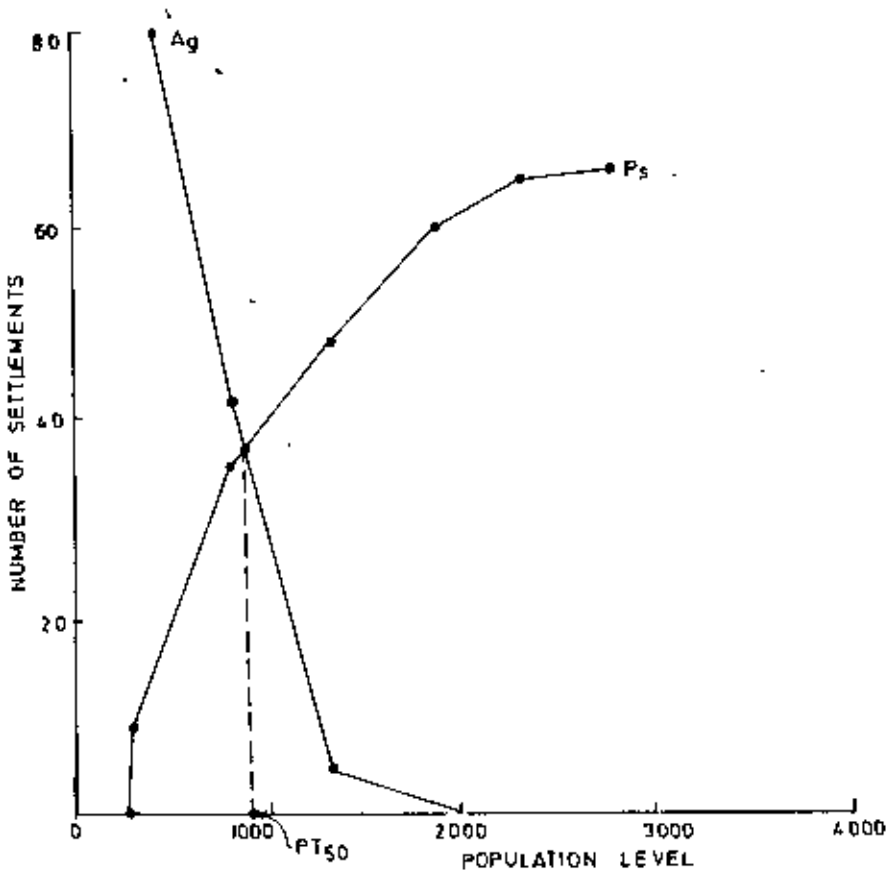


Figure A.1 Determination of Median Population Threshold PT_{50} for Primary School.

APPENDIX-B

Table B.1 Entry Points of Functions in Kahaloo Upazila

Function	Entry point
I LEVEL	
1. Grocery	400
2. Tailor	500
3. Medicine shop	600
4. Private Medical Practitioner	600
5. Retail Cloth Store	700
6. Primary School	800
7. Stationary shop	800
8. Fertilizer Distribution Centre	800
9. Cycle Rickshaw Repairing shop	850
II LEVEL	
10. Tea Stall	1600
11. Weekly/Biweekly Market	1700
12. Rice Mill	1900
13. Food Dealer	2000
14. Madrasha	2000
15. Post Office	2040
16. Secondary School	2050
17. Family Planning Centre	2250
18. Wheat Milling Mill	2250
III LEVEL	
19. Bank	2750
20. Charitable Dispensary	2750
21. Bus Stoppage	2750
22. Godown	3250

APPENDIX - C

Table C.1 Weighted Scores for the Functions

(Total No.of settlement in Kahaloo Upazila-164)

Functions	No.of settlements where they occur	Weightage
1. Primary school	70	2.34
2. Secondary school	13	12.61
3. Madrasha	14	11.71
4. Medicine shop	104	1.57
5. Private medical practitioner	109	1.50
6. Charitable dispensary	5	32.80
7. Family planning centre	8	20.50
8. Weekly market	20	8.20
9. Rice mill	18	9.11
10. Wheat milling mill	9	18.22
11. Food dealers	14	11.71
12. Godown	3	54.66
13. Fertilizer distribution centre	73	2.24
14. Post office	12	13.66
15. Bus stoppage	5	32.80
16. Bank	5	32.80
17. Grocery shop	135	1.21
18. Stationary shop	74	2.21
19. Retail cloth store	79	2.07
20. Tailor	131	1.25
21. Tea stall	26	6.30
22. Cycle Rickshaw repairing shop	69	2.37

APPENDIX - D

SCORING BY FIRST PRINCIPAL COMPONENT

```
1  COMMENT
2  RUN NAME              CENTRAL PLACE
3  FILE NAME             SENDER
4  VARIABLE LIST         X1 TO X23
5  INPUT MEDIUM          CARD
6  NO OF CASES           164
7  INPUT FORMAT          FIXED (4X,F4.0, 3F4.1, 19F3.1)
8  VAR LABELS            X1,VILLAGE POPULATION/
9                        X2,RICE MILL/X3,WHEAT MILLING MILL/
10                       X4,FOOD GODOWN/X5,PRIMARY SCHOOL/
11                       X6,HIGH SCHOOL/X7,MADRASHA/
12                       X8,CHARITABLE DISPENSARY/
13                       X9,FAM PLNG CENTRE/
14                       X10,BANK/X11,POST OFFICE/
15                       X12,,BUS STOPPAGE/
16                       X13,FOOD DEALER/
17                       X14,WKLY MARKET/
18                       X15,FERTILIZER DISTRIBUTION CENTRE/
19                       X16,TAILOR/
20                       X17,MEDICINE SHOP/
21                       X18,PRT MED PRACTITIONER/
22                       X19,CYCLE REPAIRING SHOP/
23                       X20,GROCERY/
24                       X21,STATIONARY SHOP/
25                       X22,RETAIL CLOTH STORE/
26                       X23,TEA STALL
27 COMMENT
28 COMMENT
29 CONDESCRIPTIVE
30 STATISTICS            ALL
```

Continued

Continued

```
31  COMMENT
32  READ INPUT DATA
33  COMMENT
34  FACTOR          VARIABLES = X1 TO X3/
35                  TYPE = PA1/
36                  N FACTORS =6/
37                  5,6,7,8,11
38                  1,2,4,6,7
39  COMPUTE         SCORE 1 = .93063 * (X2-2.886)/15.253
40                  +.24599 * (X1 - 861.098)/824.464
41                  +.94793 * (X3-4.440)/30.067
42                  +.95786 * (X4-2.334)/22.121
43                  +.45190 * (X6-1.259)/4.417
44                  +.29863 * (X7-.999)/3.279
45                  +.34786 * (X11-.915)/3.417
46                  +.73420 * (X13-1.284)/5.021
47                  +.43141 * (X15-1.479)/2.625
48                  +.38997 * (X16-3.094)/4.753
49                  +.55291 * (X17-2.358)/4.718
50                  +.34566 * (X20-4.430)/6.732
51                  +.59640 * (X21-2.5091)/4.4032
52                  +.79112 * (X23-1.9256)/6.7245
53  COMMENT
54  PRINT FORMAT    SCORE 1(2)
55  LIST CASES      CASES = 164/VARIABLES = X1, SCORE 1
56  CONDESCRIPTIVE  SCORE 1
57  FINISH
```

APPENDIX - E

Table E.1 Céntrality Score Based on Level of Functions

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
1. Kahaloo	430	41. Loharpara	18
2. Durgapur	162	42. Parisesh	18
3. Kalai	116	43. Joghirbhaban	17
4. Birkeder	101	44. Punchgram	17
5. Protappur	79	45. Sikor	17
6. Murail	76	46. Matihas	17
7. Deogaon	72	47. Burail	16
8. Shakahar	63	48. Modnai	16
9. Zamgram	63	49. Akhunja	16
10. Narhatta	60	50. Aloksattra	16
11. Aghore	58	51. Sitlai	15
12. Paiker	55	52. Katnahar	15
13. Pilkhunja	54	53. Chawk Nazib	15
14. Badahar	51	54. Kasimala	15
15. Santa	44	55. Bonbonai	14
16. Valson	44	56. Sabanpur	14
17. Ulot	40	57. Bhag jore	14
18. Boromohor	39	58. Mohismura	13
19. Arola	37	59. Siala Bhabanipur	13
20. Domorgram	35	60. Depoil	13
21. Bandaikhara	32	61. Atashi	13
22. Borongasanai	31	62. Borochapar	13
23. Arul	31	63. Panisara	13
24. Magura	30	64. Telian	12
25. Bhugoil	29	65. Basudebbati	12
26. Kollanpur	28	66. Panai	12
27. Joytul	25	67. Korai Gokul	12
28. Loknathpara	25	68. Isabpur	12
29. Kazipara	24	69. Lakshmipur	12
30. Kalma Bisha	24	70. Vetisonai	12
31. Kollya para	23	71. Utra	11
32. Jatrasol	22	72. Bholta	11
33. Silkomar	22	73. Samantahar	11
34. Karamza para	22	74. Bhag Dubra	11
35. Lohajal	20	75. Bakra	11
36. Nischintapur	20	76. Dekra	11
37. Belghoria	20	77. Papra	11
38. Khazlal	19	78. Baghohali	10
39. Uttar Akhrail	19	79. Gouripur	10
40. Maligacha	18		

Continued

Continued

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
80. Sakohali	10	123. Dakhin Akrail	6
81. Harlata	10	124. Nasir para	6
82. Mollikpur	9	125. Mohespur	5
83. Malibari	9	126. Khaliskura	5
84. Kuslihar	9	127. Uttardebkhanda	5
85. Dhawapara	9	128. Ayra	5
86. Aghore	9	129. Madhobbaka	5
87. Karna	9	130. Boropukuria	5
88. Bisha	9	131. Deor	5
89. Satruka	9	132. Naihati	5
90. Bakra	9	133. Joysara	4
91. Nimarpara	9	134. Dogachi	4
92. Anchilihar	9	135. Dhakanta	4
93. Gurbisha	8	136. Niamatpur	4
94. Krishnapur	8	137. Gokarna	4
95. Olahali	8	138. Pirapat	4
96. Kurson	8	139. Baniadighi	4
97. Khurasatti	8	140. Rampur	4
98. Kowrash	8	141. Borta	4
99. Titia	8	142. GouriLakshmiMondap	4
100. Bhatali	8	143. Haripur	4
101. Punchkhur	8	144. Moharazai	4
102. Damai	8	145. Dakhin Debkhanda	4
103. Borogacha	8	146. Kait	3
104. Larna	8	147. Damgara	3
105. Bhatra	7	148. Benode	3
106. Kharia Nishindara	7	149. Chakdaha	3
107. Shek Kalma	7	150. Dhalahar	3
108. Routhgari	7	151. Chirota	3
109. Narkeli	7	152. Kesabpur	3
110. Abilamba	7	153. Aolakhayer	3
111. Pandighi	7	154. Ragunathpur	3
112. Antahar	7	155. Chaipara	3
113. Darai	7	156. Dhanpuza	2
114. Kazipara	7	157. Pipra	2
115. Simulia	7	158. Birpalla	2
116. Bathai	6	159. Malohali	2
117. Mohisbatan	6	160. Mohismura	2
118. Girail	6	161. Lakshmichapur	1
119. Bishnapur	6	162. Dodai	1
120. Malancha	6	163. Ramzipur	1
121. Gundisar	6	164. Bhagair	1
122. Nalgharia	6		

Table E.2 Centrality Score Based on Scarcity of Functions

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
1. Kahaloo	1330.0	41. Jatrasol	32.0
2. Durgapur	494.9	42. Belgharia	31.8
3. Kalia	225.2	43. Loharpara	31.5
4. Birkeder	223.6	44. Modnai	30.2
5. Protappur	190.9	45. Matihas	29.0
6. Narhatta	187.6	46. Uttar Akrail	28.1
7. Shakahar	184.8	47. Shialabhabanipur	27.1
8. Murail	183.4	48. Burail	26.7
9. Deogram	174.6	49. Jogirbhaban	26.5
10. Zamgram	158.0	50. Bonbonai	26.3
11. Aghore	129.1	51. Katnahar	26.1
12. Paiker	125.1	52. Khazlal	25.9
13. Bhadahar	119.2	53. Sabanpur	25.7
14. Pilkhunja	101.9	54. Kasimala	25.5
15. Borongasanai	83.4	55. Maligacha	25.4
16. Arola	80.7	56. Panisara	24.8
17. Valson	79.7	57. Bhagjore	23.4
18. Santa	74.3	58. Isabpur	23.3
19. Ulot	72.2	59. Depoil	23.2
20. Bhugoil	62.6	60. Sitlai	22.1
21. Boromohor	61.9	61. Papra	21.7
22. Bandaikhara	60.2	62. Harlata	21.1
23. Nischintapur	55.6	63. Borochapar	20.8
24. Domorgram	53.9	64. Mohismura	20.6
25. Magura	53.7	65. Telian	20.5
26. Lokuathpara	52.7	66. Akhunja	20.4
27. Arul	52.5	67. Utra	20.3
28. Kazipara	50.6	68. Uttar Debkhanda	19.9
29. Kollya para	49.5	69. Atashi	19.8
30. Kollyanpara	48.8	70. Panai	19.3
31. Kalmabisha	46.2	71. Vetisonai	19.2
32. Silkomar	42.9	72. Bholta	18.8
33. Aloksattra	41.8	73. Bhagdubra	18.4
34. Jaitul	40.3	74. Basudebbati	18.0
35. Karamja para	35.7	75. Samantahar	18.0
36. Lohajal	35.3	76. Bhakra	17.7
37. Punchgram	34.9	77. Khurasatti	17.7
38. Sikor	34.6	78. Koraigokul	17.6
39. Chawknajib	32.5	79. Shakohali	17.3
40. Parishesh	32.2	80. Lakshmipur	17.1

Continued

Continued

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
81. Titia	16.4	123. Nalgaria	9.7
82. Agersai	15.8	124. Sekalma	9.2
83. Mollikpur	15.5	125. Moharazai	9.1
84. Malibari	15.3	126. Nishnapur	9.0
85. Satrokha	15.1	127. Ayra	8.7
86. Kuslihar	14.9	128. Nasirpara	8.6
87. Gouripur	14.8	129. Deor	8.5
88. Damai	14.8	130. Girail	8.3
89. Borogacha	14.8	131. Rampur	7.8
90. Kourash	14.6	132. Pirapat	7.7
91. Nimarpara	14.2	133. Madhobbaka	7.7
92. Kazipara(Durgapur)	13.9	134. Mohespur	7.5
93. Anchilihar	13.8	135. Boropukuria	7.3
94. Bhatali	13.8	136. Naihati	7.1
95. Dhekra	13.5	137. Borta	6.9
96. Bisha	13.3	138. Joysara	6.6
97. Bagohali	13.1	139. Baniadighi	6.6
98. Bakra	13.0	140. Dogachi	6.5
99. Narkeli	12.9	141. Gouri Laximondap	6.3
100. Panchkhur	12.8	142. Haripur	6.1
101. Larna	12.8	143. Niamatpur	6.0
102. Kurson	12.7	144. Gokorna	5.8
103. Karna	12.6	145. Dakhin Debknonda	5.5
104. Darai	12.5	146. Chaipara	4.8
105. Gurbisha	12.4	147. Damgara	4.8
106. Dhawapara	12.2	148. Aolakayer	4.7
107. Bhulta	12.1	149. Benode	4.6
108. Routhgari	11.7	150. Kesobpur	4.6
109. Malagacha	11.5	151. Pipra	4.4
110. Krisnapur	11.3	152. Chirota	4.3
111. Dhakhin Akrail	11.1	153. Kait	4.3
112. Karia Nisindara	10.9	154. Chakdaha	4.3
113. Abilamba	10.4	155. Dalahar	4.2
114. Khaliskura	10.4	156. Dhanpuza	3.8
115. Antahar	10.3	157. Ragunathpur	3.6
116. Olahali	10.2	158. Mohismura	2.7
117. Gundisan	10.1	159. Malohali	2.4
118. Bathoi	10.1	160. Birpalla	2.4
119. Simulia	10.1	161. Dodai	2.2
120. Dhakanta	9.9	162. Ranzipur	1.2
121. Mohisbatan	9.9	163. Baghair	1.2
122. Pandighi	9.8	164. Lakshmipur	1.2

Table E.3 Centrality Score by Principal Component Analysis Method

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
1. Kahaloo	67.30	41. Isabpur	-0.07
2. Durgapur	20.28	42. Bonbonai	-0.09
3. Kalai	13.07	43. Belgaria	-0.13
4. Shakahar	14.51	44. Aloksattra	-0.16
5. Protappur	11.23	45. Lohajal	-0.31
6. Birkeder	7.79	46. Chirota	-0.50
7. Narhatta	7.25	47. Uttar Akhrail	-0.52
8. Paiker	5.62	48. Jatrasol	-0.52
9. Zamgram	5.43	49. Joytul	-0.60
10. Murail	4.94	50. Siala Bhabanipur	-0.67
11. Bhadahar	4.67	51. Khajlal	-0.69
12. Deogram	4.63	52. Malagacha	-0.74
13. Agore	3.93	53. Bhag Dubra	-0.76
14. Pilkhunja	3.42	54. Katnahar	-0.84
15. Ulot	3.37	55. Parishesh	-0.84
16. Kurson	3.28	56. Sitlai	-0.97
17. Valson	3.26	57. Bholta	-0.99
18. Bhugoil	3.20	58. Jogir Bhaban	-1.03
19. Bhandaikhara	3.19	59. Agersal	-1.06
20. Santa	2.99	60. Sakohali	-1.08
21. Arola	2.39	61. Matihas	-1.10
22. Kallyapara	2.28	62. Kasimala	-1.11
23. Magura	1.95	63. Uttar Debkhanda	-1.13
24. Kazipara	1.78	64. Panai	-1.15
25. Boronga sanai	1.78	65. Depoil	-1.20
26. Boromohar	1.44	66. Atasi	-1.21
27. Krishnapur	1.30	67. Telian	-1.23
28. Domorgram	1.29	68. Satrukha	-1.23
29. Kalma Bisha	1.11	69. Khura satty	-1.29
30. Loknath para	0.74	70. Borogacha	-1.30
31. Kallanpur	0.71	71. Vetisonai	-1.33
32. Arul	0.70	72. Borochapar	-1.34
33. Chawk Nazib	0.69	73. Malancha	-1.36
34. Modnai	0.62	74. Lakshmipur	-1.37
35. Punchgram	0.35	75. Damai	-1.38
36. Silkomar	0.28	76. Basudeb bati	-1.39
37. Karamjapara	0.22	77. Panisara	-1.40
38. Sikor	0.15	78. Dhokra	-1.42
39. Sabanpur	0.14	79. Bagohali	-1.43
40. Harlata	0.09	80. Samantahar	-1.47

Continued

Continued

Name of Settlement	Centrality Score	Name of Settlement	Centrality Score
81. Bhag Jore	-1.53	123. Moharajai	-2.14
82. Papra	-1.53	124. Antahar	-2.15
83. Nalgoria	-1.53	125. Nasirpara	-2.16
84. Bhakra	-1.55	126. Benode	-2.18
85. Bhakra	-1.55	127. Simulia	-2.19
86. Loharpara	-1.58	128. Mohespur	-2.19
87. Karna	-1.59	129. Mohisbatan	-2.21
88. Bhatali	-1.60	130. Dakhin Akrail	-2.22
89. Routhgari	-1.65	131. Deor	-2.23
90. Utra	-1.66	132. Mollikpur	-2.26
91. Burail	-1.68	133. Lakshmichapar	-2.26
92. Norkeli	-1.68	134. Haripur	-2.28
93. Mohismura	-1.69	135. Chakdaha	-2.31
94. Rampur	-1.69	136. Joysara	-2.31
95. Dhakanta	-1.69	137. Bishnapur	-2.32
96. Kuslihar	-1.71	138. Kourash	-2.32
97. Korai Gokul	-1.72	139. Damgara	-2.33
98. Anchihar	-1.73	140. Khaliskura	-2.34
99. Bathoi	-1.76	141. Kesobpur	-2.34
100. Punchkhur	-1.76	142. Gokorna	-2.36
101. Nischintapur	-1.76	143. Baniadighi	-2.37
102. Bisha	-1.84	144. Dodai	-2.37
103. Gouripur	-1.84	145. Dakhin Debkhanda	-2.39
104. Dhawapara	-1.84	146. Niamatpur	-2.40
105. Abilamba	-1.89	147. Ayra	-2.41
106. Gurbisha	-1.91	148. Boropukuria	-2.41
107. Kharia Nisindara	-1.91	149. Kait	-2.42
108. Pirapat	-1.91	150. Dhalahar	-2.44
109. Girail	-1.91	151. Gundishwar	-2.44
110. Madhobbaka	-1.96	152. Titia	-2.45
111. Kazipara	-1.97	153. Mohismara	-2.47
112. Gouri Lakshmimondop	-1.97	154. Chaipara	-2.51
113. Darai	-1.97	155. Dogachi	-2.51
114. Larua	-1.97	156. Birpalla	-2.55
115. Pipra	-1.99	157. Borta	-2.55
116. Shekkalma	-2.02	158. Dhanpuza	-2.55
117. Nimarpara	-2.05	159. Molohali	-2.56
118. Olahali	-2.06	160. Ragunathpur	-2.57
119. Pandighi	-2.08	161. Aolakhayer	-2.65
120. Malibari	-2.11	162. Ranzipur	-2.65
121. Bhalta	-2.12	163. Baghair	-2.71
122. Naihati	-2.13	164. Lakshmipur	-2.71

APPENDIX - F

FACTORS USED IN RANKING OF RURAL ROADS

Source : Based on Highways Department, Thailand, 1979 and Yogyakarta Rural Road Study, Indonesia, 1979.

Factor	Level	Score
1. Average daily traffic	300- above Veh./day	40
	200- 300 " "	30
	100- 200 " "	20
	50- 100 " "	15
	30- 50 " "	10
	15- 30 " "	5
	0- 15 " "	0
2. Population(population density)		
	High density area	15
	Medium high density area	10
	Medium density area	8
	Small density	5
3. Network significance		
	National Highways	5
	Regional Highways	4
	Inter Districts Roads	3
	Feeder Roads	2
	Rural Roads	1
4. Direct Area of influence		
	>1.5 km^2 per km	5
	1-1.5 km^2 per km	3
	<1 km^2 per km	1
5. Surface type	Pucca	
	Pucca	5
	Semi pucca	3
	Earthen	1

Continued

Continued

Factor	Level	Score
6. Surface condition		
	Goog/Very Good	10
	Fair	8
	Poor	6
	Bad	4
	Impassible	2
7. Surface width		
	Above 6 metre	5
	5 - 6 metre	4
	4 - 5 metre	3
	3 - 4 metre	2
	2 - 3 metre	1
	Less than 2 metre	0
8. Types of vehicles		
	Truck/Bus	5
	Rickshaw/scuter	3
	Cart	1
9. Administrative	For all roads	5
10. Other benits	For all roads	5

APPENDIX - F.1

ATTRACTING FORCES OF MAIN LINKS
(KAHALOO UPAZILA)

KAHALOO NARHATTA ROAD:

Factor	Level	Score
1. Average daily traffic	100-200 Veh./day	20
2. Population density	Medium high density	10
3. Netowrk significance	Feeder road	2
4. Direct area of influence	<1 km^2 per km	1
5. Surface type	Pucca	5
6. Surface condition	Fair	8
7. Surface width	3-4 metre	2
8. Type of vehicles	Rickshaw	3
9. Administrative	-	5
10. Other benefits	-	4
	Total:	60

KAHALOO MALANCHA ROAD :

1. Average daily traffic	100-200 Veh./day	20
2. Population density	Medium high density	10
3. Network significance	Feeder road	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Pucca	5
6. Surface condition	Poor	6
7. Surface width	3-4 metre	2
8. Type of vehicles	Rickshaw	3
9. Administrative	-	5
10. Other benefits	-	4
	Total:	60

Continued

BOGRA-SANTAHAR ROAD :

Continued

Factor	Level	Score
1. Average daily traffic	200-300 Veh./day	30
2. Population density	Medium high density	10
3. Network significance	Regional highway	4
4. Direct area of influence	>1.5 km^2/km	5
5. Surface type	Pucca	5
6. Surface condition	Fair	8
7. Surface width	>6 metre	5
8. Type of vehicles	Truck/Bus	5
9. Administrative	-	5
10. Other benefits	-	3
	Total:	80

KAHALOO-BOGRA ROAD:

1. Average daily traffic	30-40 Veh./day	10
2. Population density	Medium high density	10
3. Network significance	Rural road	1
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Bad	4
7. Surface width	3-4 metre	2
8. Type of vehicles	Cart	1
9. Administrative	-	4
10. Other benefits	-	4
	Total:	40

Continued

MALANCHA-RANIRHAT ROAD:

Continued

Factor	Level	Score
1. Average daily traffic	100-200 Veh./day	20
2. Population density	Medium high density	10
3. Network significance	Feeder road	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Pucca	5
6. Surface condition	Poor	6
7. Surface width	4-5 metre	3
8. Type of vehicle	Rickshaw	3
9. Administrative	-	4
10. Other benefits	-	4
		Total:60

KAHALOO-PROTAPPUR ROAD:

1. Average daily traffic	30-50 Veh./day	10
2. Population density	Medium density	8
3. Network significance	Rural road	1
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Bad	4
7. Surface width	3-4 metre	2
8. Type of vehicle	Cart	1
9. Administrative	-	5
10. Other benefits	-	5
		Total : 40

Continued

MALANCHA-DURGAPUR ROAD:

Continued

Factor	Level	Score
1. Average daily traffic	100-200 Veh./day	20
2. Population density	High density	15
3. Network significance	Feeder road	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Poor	6
7. Surface width	4-5 metre	3
8. Type of vehicle	Cart	1
9. Administrative	-	5
10. Other benefits	-	4
		Total: 60

DURGAPUR-ZAMGRAM ROAD:

1. Average daily traffic	30-50 Veh./day	10
2. Population density	Medium density	8
3. Network significance	Feeder road	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Bad	4
7. Surface width	4-5 metre	3
8. Type of vehicle	Cart	1
9. Administrative	-	4
10. Other benefits	-	4
		Total : 40

Continued

BIRKEDAR-NAMZA ROAD:

Continued

Factor	Level	Score
1. Average daily traffic	30-40 Veh./day	10
2. Population density	Medium density	8
3. Network significance	Feeder roads	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Bad	4
7. Surface width	3-4 metre	2
8. Type of vehicle	Cart	1
9. Administrative	-	5
10. Other benefits	-	4
		Total : 40

DURGAPUR-TALORA ROAD:

1. Average daily traffic	100-200 Veh./day	20
2. Population density	High density	15
3. Network significance	Feeder roads	2
4. Direct area of influence	1-1.5 km^2/km	3
5. Surface type	Earthen	1
6. Surface condition	Poor	6
7. Surface width	4-5 metre	3
8. Type of vehicle	Cart	1
9. Administrative	-	5
10. Other benefits	-	4
		Total : 60

APPENDIX – G

Table G.1 Selection of Link Option

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
1.	Birkeder	-	-	Birkeder is a service centre.
2.	Kazipara	Abilamba	404	Kazipara is to be connected with Abilamba.
		Bathoi	75	
3.	Abilamba	-	-	Abilamba is to be connected with Shakahar since it is nearest to the service centre (Shakahar).
4.	Depoil	-	-	Depoil is to be connected with the main link since it is nearest to the main link.
5.	Shakahar	-	-	Shakahar is a service centre.
6.	Baniadighi	Borta	592	Baniadighi is to be connected with Borta.
		Shakahar	191	
7.	Bhalta	-	-	Bhalta is to be connected with the main link since it is nearest to the main link.
8.	Kasimala	-	-	Kasimala is to be connected with Birkeder since it is nearest to service centre (Birkeder).
9.	Modnai	Kasimala	541	Modnai is to be connected with Kasimala.Kasimala
		Mohisbatan		
10.	Mollikpur	Modnai	159	Mollikpur is to be connected with Modnai. Modnai.
		Mohisbatan	67	

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
11.	Titia	Mohisbatan	55	Titia is to be connected with Mollikpur.
		Mollikpur	266	
12.	Gundishwar	Titia	482	Gundishwar is to be connected with Titia.
		Mohisbatan	51	
13.	Mohisbatan	Protappur	126	Mohisbatan is to be connected with Protappur.
		Loknathpara	90	
14.	Kourash	Kasimala	216	Kourash is to be connected with Kasimala.
		Borta	207	
15.	Malibari	Mohisbatan	183	Malibari is to be connected with Mohisbatan.
		Borta	166	
		Protappur	96	
		Pandighi	170	
		Kourash	125	
16.	Kalai	-	-	Kalai is a service centre.
17.	Pilkhunja	-	-	Pilkhunja is service centre.
18.	Chawk Nazib	-	-	Chawk Nazib is to be connected with the main link since it is nearest to the main link.
19.	Punchgram	Pilkhunja	112	Punchgram is to be connected with Pilkhunja.
		Main link	44	
		Utra	66	
		Bhadahar	99	

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
20.	Bhadahar	-	-	Bhadahar is a service centre.
21.	Damgara	-	-	Damgara is to be connected with the main link.
22.	Utra	-	-	Utra is to be connected with the main link.
23.	Bhugoil	-	-	Bhugoil is to be connected with the main link.
24.	Mohismura	Kuslihar Punchkhur	173 68	Mohismura is to be connected with the main link.
25.	Bonbonai	-	-	Bonbonai is to be connected with the main link.
26.	Kuslihar	Bonbonai Jogirbhaban	110 37	Kuslihar is to be connected with Bonbonai.
27.	Baghohali	Kuslihar Bonbonai	108 87	Babhohali is to be connected with Kuslihar.
28.	Punchkhur	Bhugoil Utra	83 55	Punchkhur is to be connected with Bhugoil.
29.	Pirapat	-	-	Pirapat is to be connected with the main link.
30.	Jogirbhaban	-	-	Jogirbhaban is to be connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
31.	Bhatali	Arola	141	Bhatali is to be connected with Rampur.
		Rampur	363	
32.	Rampur	Borongasonai	138	Rampur is to be connected with Borongasonai.
		Arola	132	
33.	Arola	Paiker	104	Arola is to be connected with Paiker.
		Barongasonai	81	
34.	Uttar Akrail	Arola	250	Uttar Akrail is to be connected with Jogirbhaban.
		Jogirbhaban	44	
35.	Paiker	-	-	Paiker is a service centre.
36.	Borongasonai	-	-	Borongasonai is to be connected with the main link.
37.	Maligachi	-	-	Maligachi is to be connected with the main link.
38.	Kollyanpur	Madhopbaka	296	Kollyanpur is to be connected with Madhopbaka.
		Arola	105	
39.	Benode	Madhobaka	491	Binode is to be connected with Madhopbaka.
		Paiker	104	
40.	Ayra	Pilkhunja	73	Ayra is to be connected with Kollyanpur.
		Kollyanpur	163	

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
41.	Loharpara	Kollyanpur Paiker	134 91	Loharpara is to be connected with Kollyanpur.
42.	Dodai	Paiker Binode	208 96	Dodai is to be connected with Paiker.
43.	Bathoi	-	-	Bathoi is to be connected with the main link.
44.	Silkomar	-	-	Silkomar is a service centre.
45.	Lohajal	-	-	Lohajal is to be connected with the main link.
46.	Basudebbati	Baniadighi Lohajal	203 109	Basudebbati is to be connected with Baniadighi.
47.	Nischintipur	-	-	Nischintipnr is to be connected with the main link.
48.	Korai	Malibari Pandighi Protappur	228 212 105	Korai is to be connected with Malibari.
49.	Narhatta	-	-	Narhatta is a service centre.
50.	Sikor	-	-	Sikor is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
51.	Routhgari	-	-	Routhgari is to be directly connected with the main link.
52.	Madhobbaka	Norhatta Silkomar	155	Madhobbaka is to be connected with Narhatta.
53.	Larua	-	-	Larua is to be directly connected with the main link.
54.	Bholta	Naihati Simulia	394 206	Bholta is to be connected with Naihati.
55.	Naihati	Jatrasol Simulia	186 52	Naihati is to be connected with Jatrasol.
56.	Simulia	Boromohor Mainlink	235 111	Simulia is to be connected with Boromohor.
57.	Dogachi	Maligachi Boromohor	54 342	Dogachi is to be connected with Boromohor.
58.	Boromohor	-	-	Boromohor is to be directly connected with the main link.
59.	Samantahar	-	-	Samantahar is to be directly connected with the main link.
60.	Jatrasol	-	-	Jatrasol is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
61.	Bhagdubra	-	-	Bhagdubra is to be directly connected with the main link.
62.	Murail	-	-	Murail is a service centre.
63.	Bishnopur	Belgaria Murail	192 133	Bishnopur is to be connected with Belgaria.
64.	Bakra	Belgaria Main link	295 44	Bakra is to be connected with Belgaria.
65.	Katnahar	Murail Mainlink Kahaloo	153 50 554	Katnahar is to be connected with Kahaloo.
66.	Belgaria	-	-	Belgaria is to be directly connected with the main link.
67.	Birpalla	Dhawapara Sitlai	180 232	Birpalla is to be connected with Sitlai.
68.	Sitlai	-	-	Sitlai is to be directly connected with the main link.
69.	Isabpur	-	-	Isabpur is to be directly connected with the main link.
70.	Dhawapara	Agersal Birpalla	1089 133	Dhawapara is to be connected with Agersal.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
		Joysara	903	
		Dhawapara	113	
71.	Agersal	Mohespur	78	Agersal is to be connected with Joysara.
		Agore	52	
		Malancha	77	
		Agersal	680	
		Mainlink	96	
72.	Domorgram	Maloncha	117	Domorgram is to be connected with Agersal.
		Ragunathpur	124	
73.	Moharaja	-	-	Moharaja is to be directly connected with the main link.
		Malohali	1172	Olahali is to be conn-
74.	Olahali	Arul	237	ected with Malohali.
		Agersal	566	Malohali is to be
75.	Malohali	Isabpur	63	connected with Agersal.
		Olahali	165	Ragunathpur is to be
76.	Ragunathpur	Arul	181	connected with Arul.
		Mainlink	100	Deor is to be conn-
77.	Deor	Arul	156	ected with Arul.
		Nasirpara	1019	Joytul is to be conn-
78.	Joytul	Lohajal	106	ected with Nasirpara.
79.	Pandighi	-	-	Pandighi is to be connected with the service centre Protappur since it is nearest to the service centre.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
80.	Nasirapara	Girail Burail	1462 85	Nasirpara is to be connected with Girail.
81.	Karna	-	-	Karna is to be directly connected with the main link.
82.	Girail	-	-	Girail is to be connected with the growth centre Kahaloo since it is nearest to the growth centre.
83.	Burail	Kait Girail	152 1829	Bhunail is to be connected with Girail.
84.	Lakshmipur	-	-	Lakshimipur is to be directly connected with the main link.
85.	Damai	-	-	Damai is to be directly connected with the main link.
86.	Kait	-	-	Kait is to be directly connected with the main link.
87.	Kahaloo	-	-	Kahaloo is a growth centre.
88.	Ulot	-	-	Ulot is to be connected with the growth centre Kahaloo since it is nearest to the growth centre.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
		Ulot	3123	
89.	Joysara	Mainlink	160	Joysara is to be connected with Ulot.
		Mainlink	160	
90.	Mohespur	-	-	Mohespur is to be directly connected with the main link.
91.	Gouripur	-	-	Gouripur is to be directly connected with the main link.
92.	Khaliskura	-	-	Khaliskura is to be connected with the main link.
93.	Akhunja	Telian	222	Akhunja is to be connected with Telian.
		Narkeli	87	
		Kahaloo	738	
94.	Khazial	Telian	88	Khazial is to be connected with Kahaloo.
		Main link	40	
		Narkeli	173	Aolakhayer is to be connected with Shakohali.
95.	Aolakhayer	Shakohali	688	
		Khazlal	1787	Borta is to be connected with Khazlal.
96.	Borta	Papra	53	
		Papra	53	Shakohali is to be connected with Borta.
97.	Shakohali	Borta	2404	
98.	Telian	-	-	Telian is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
99.	Protappur	-	-	Protappur is a service centre.
100.	Loknathpara	-	-	Loknathpara is to be directly connected with the main link.
101.	Nalgaria	-	-	Nalgaria is to be directly connected with the main link.
102.	Chaipara	-	-	Chaipara is to be directly connected with the main link.
103.	Atashi	Nalgaria Durgapur	46 274	Atashi to be connected with Durgapur.
104.	Durgapur	-	-	Durgapur is a service centre.
105.	Lakshmi Chapar	-	-	Lakshimi Chapar is to be directly connected with the main link.
106.	Kharia	-	-	Kharia Nisindara is to be directly connected with the main link.
107.	Kazipara	Atashi Durgapur Mainlink	1078 274 26	Kazipara is to be connected with Atashi.
108.	Harlata	-	-	Harlata is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
109.	Chawkdaha	-	-	Chawkdaha is to be directly connected with the main link.
110.	Ranzipur	Niyamatpnr Chawdaha	200 16	Ranzipur is to be connected with Niyamatpur.
111.	Dekra	Haripur Main link	350 66	Dekra is to be connected with Haripur.
112.	Niyamatpur	Pipra Chawdaha	94 30	Niyamatpur is to be connected with Pipra.
113.	Pipra	Dalaha Dhanpuza	270 42	Pipra is to be connected with Dalaha.
114.	Dalahar	Deogaon Dalaha	82 21	Dalahar is to be connected with Deogaon.
115.	Dhanpuza	-	-	Dhanpuza is to be directly connected with Dhanpuza.
116.	Haripur	Dalaha Main link	225 89	Haripur is to be connected with Dalaha.
117.	Deogaon	-	-	Deogaon is a service centre.
118.	Narkeli	-	-	Narkeli is to be directly connected with the main link.
119.	Sabanpnr	-	-	Sabanpur is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
120.	Baghair	-	-	Baghair is to be directly connected with the main link.
121.	Magura	-	-	Magura is to be directly connected with the main link.
122.	Dhakanta	-	-	Dhakanta is to be directly connected with the service centre Agore since it is nearest to the service centre.
123.	Gurbisha	-	-	Gurbisha is to be directly connected with the main link.
124.	Boropukuria	Agore Mainlink	86 205	Boropukuria is to be connected with mainlink.
125.	Papra	-	-	Papra is to be directly connected with the main link.
126.	Aghore	-	-	Aghore is a service centre.
127.	Maloncha	-	-	Maloncha is to be directly connected with the main link.
128.	Matihas	-	-	Matihas is to be directly connected with the main link.
129.	Borogacha	Borochapor Main link	133 100	Borogacha is to be connected with Noro Chapar.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
130.	Arul	-	-	Arul is to be directly connected with the main link.
131.	Borochapar	-	-	Borochapar is to be directly connected with the main link.
132.	Bisha	Borogacha Borochapar	175 88	Bisha is to be connected with Borogacha.
133.	Satruka	Matihas Agore	123 79	Satruka is to be connected with Matihas.
134.	Panisara	Satruka Agore	313 71	Panisara is to be connected with Satruka.
135.	Kalma Bisha	Bisha Borochapar	82 53	Kalma Bisha is to be connected with Bisha.
136.	Shek Kalma	Kalma Bisha Panisara	128 72	Shek Kalma is to be connected with Kalma Bisha.
137.	Alok Satra	Sek Kalma Panisara	61 112	Aloksatra is to be connected with Panisara.
138.	Kallyapara	Valson Vetisonai Parisesh	157 103 227	Kallyapara is to be connected with Parisesh.
139.	Veti Sonai	Dhakanta Parisora	154 124	Veti Sonai is to be connected with Dhakanta.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
140.	Valson	Parisara	110	Valson is to be connected with Panisara.
		Darai	34	
		Krishnopur	33	
		Anchihar	42	
		Bhitisonai	84	
		Kollapara	98	
141.	Bandai Khara	Kesobpur	81	Bandaikhara is to be connected with Kesobpur.
		Harlata	50	
142.	Panai	-	-	Panai is to be directly connected with the main link.
143.	Bakra	-	-	Bakra is to be directly connected with the main link.
144.	Nimarpara	-	-	Nimarpara is to be directly connected with the main link.
145.	Bhagjore	-	-	Bhagjore is to be directly connected with the main link.
146.	Karamjapara	-	-	Karamjapara is to be connected with the service centre Zamgram since it is nearest to the service ceutre.
147.	Krishnapur	-	-	Krishnapur is to be directly connected with the main link.

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
148.	Antahar	-	-	Antahar is to be directly connected with the main link.
149.	Anchilihar	Main link	51	Anchilihar is to be connected with Mondop.
		Mondop	191	
		Krishnapur	56	
150.	Mondop	-	-	Mondop is to be directly connected with the main link.
151.	Santa	-	-	Santa is to be directly connected with the main link.
152.	Mohismura	Main link	26	Mohismura is to be connected with Santa.
		Santa	49	
153.	Uttar Debkhanda	Dakhin Debkhanda	92	Uttar Debkhanda is to be connected with Dakhin Debkhanda.
		Mainlink	39	
154	Chirata	-	-	Chirota is to be directly connected with the main link.
155.	Dakhin Debkhanda	Santa	82	Dakhin Debkhanda is to be connected with Santa.
		Chirata	45	
156.	Gokorna	-	-	Gokorna is to be directly connected with the main link.
157.	Parisesh	Vetisonai	96	Parisesh is to be connected with Dakhin Akrail.
		Dakhin Arail	187	
		Darai	85	

Continued

Selection of Link Option (Continued)

Sl. No.	Node to be connected	Link option	Weightage of link option	Remarks
158.	Darai	-	-	Darai is to be directly connected with the main link.
159.	Dakhin Akrail	-	-	Dakhin Akrail is to be connected with the service centre Zamgram since it is nearest to the service centre.
160.	Zamgram	-	-	Zamgram is a service centre.
161.	Kurson	Karamja Mainlink	143 86	Kurson is to be connected with Karamja.
162.	Siala Bhabanipur	Khurasatti Karamja	71 359	Siala is to be connected with Karamja.
163.	Khurasatty	Uttar Debkhanda Mainlink	68 30	Khursatty is to be connected with Uttar Debkhanda.
164.	Larua	-	-	Larua is to be connected with the main link.

APPENDIX - H

Effect of the Variation of Attracting Forces of Main Link

According to the equation (2.1)

$$\text{Weightage of link option DE} = \frac{17 + \frac{7}{\sqrt{0.5}} + \frac{25}{\sqrt{1}} + \frac{17}{\sqrt{1.5}} + \frac{1330}{\sqrt{3}}}{1.5}$$

$$= 555.76$$

Weightage of link option FE

(1) When the attracting force of the main link XY is 80.

$$= \frac{13 + \frac{80}{\sqrt{0.5}}}{0.5} = 252.2$$

(2) When the attracting force of the main link XY is 60.

$$= \frac{13 + \frac{60}{\sqrt{0.5}}}{0.5} = 195.7$$

(3) When the attracting force of the main link XY is 40.

$$= \frac{13 + \frac{40}{\sqrt{0.5}}}{0.5} = 139.1$$

From the above, the link option DE is to be connected. In this case, the variation of the attracting force of the main link XY does not effect on the result.

BIBLIOGRAPHY

Ahsan, Nazmul.1979. Case Study for Development of Rural Transport in Bangladesh. Proceedings of the Seminar-cum-Workshop on Rural Road and Transport Development with Special Emphasis on Man Power-Oriented Construction and Improvement of Indigenons Equipment.Dhaka.

Bangladesh Bureau of Statistics, Government of the People's Republic of Bangladesh. 1986. Zilla Statistics, Bogra Region. Dhaka.

Bhat, L.S. 1976. Micro Level Planning. New Delhi: K.B Publications.

Black, John. 1981. Urban Transport Planning. London: Groom Helm Limited.

Christaller, W. 1966. The Central Places in Southern Germany, Translation by C.W. Baskin. New Jersey: Prentice Hall Englewood Cliffs.

Daellenbach, Hans G. and George, John A. 1978. Introduction to Operation Research Technique. Boston: Allyn and Bacon, Inc.

Deshpande. 1980. Development of Rural Roads in India. Journal of Indian Road Congress, Volume 8, No.1, New Delhi.

Highways Department. 1979. Methods for Ranking of Rural Roads. Bangkok, Thailand.

Jahan, Sarwar. 1978. Strategy for Integrated Rural Development in Bangladesh. An Unpublished Thesis. Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology. Dhaka.

Hagett, P. and Gunecwardena. 1964. Determination of Population Threshold for Settlement Function by Reed-Muench Method. Newyork.

Losch, A. 1954. The Economics of Location, Translation by W.H. Woglom. Boston: Yale University Press.

Mahtab, F.U. 1975. Proceedings of the Seminar on Integrated Rural Development. Institute of Engineers, Dhaka.

Matulessy, Hendraka. 1979. Rural Road and Transport Development in Indonesia. Proceedings of the Seminar-cum-Workshop on Rural Road and Transport Development with Special Emphasis on Man-Power-Oriented Construction and Improvement of Indigeous Equipment. Dhaka.

Ministry of Law and Land Reforms, Government of the People's Republic of Bangladesh. 1982. The Local Government (Amendment) Act, 1982. Dhaka.

Parveen, Roksana. 1984. Location Analysis and Model for Union Welfare Centre in Rural Areas of Bangladesh. An Unpublished Thesis. Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology, Dhaka.

Planning Commission, Government of the People's Republic of Bangladesh. 1985. The Third Five Year Plan (1985-90).

Planning Commission, Government of the People's Republic of Bangladesh. 1985. Guide lines for Upazila Parishads for Utilization of the Development Assistance Provided by the National Government through ADP. Dhaka.

Rahman, Mujibur. 1975. Proceedings of the Seminar on Integrated Rnral Development. Institute of Engineers, Dhaka.

Reddy, K.C. 1980. Master Plan for Rural Roads in Karnataka. Indian Highways, Journal of Indian Road Congress, Vol.8, No.2, New Delhi.

Sen,Lalit K. and Misra, Girish K. 1974. Regional Planning for Rural Electrification. National Institute of Community Development, Hyderabad, India.

Sen, Lalit K., Bose, Sudhir Wanmali Saradindu, Misra Girish K. and Ramesh K.S. 1971. Planning Rnral Growth Centres for Integrated Area Development. National Institute of Community Development, Hyderabad, India.

Siddique, Q.I. and Rafiquddin, A.K.M. 1987. Rural Roads Programme in Bangladesh. Local Government Engineering Bureau, Dhaka.

Singh, S.R. 1979. Rural Roads in Nepal. Proceedings of the Seminar-cum-Workshop on Rural Road and Transport Development with Special Emphasis on Man Power-Oriented Construction and Improvement of Indigenous Equipment. Dhaka.

Somasekhar, P.V. 1980. Planning and Design of Rural Roads in Karnataka. Indian Highways, Journal of Indian Road Congress, Volume 8, No.12, New Delhi.

Swaminathan, C.G., Lal, N . B., and Kumar Ashok. 1982. A System Approach to Rural Road Development. Journal of Indian Road Congress, Vol. 42, No.4, New Delhi.

Upazila Parishad, Kahaloo. 1986. Podapkhep. A Description of Development Programmes, Kahaloo, Bogra.

Wagner, Harvey M. 1969. Principles of Operations Research. New Jersey, U.K.: Prentice Hall Inc.

World Food Programme. 1987. Project Bangladesh 2197 Expansion-5-National Work Programme for Water Development and Rural Roads. A Report of the Interim Evaluation of Food-for-Work Project in Bangladesh. Rome.