Thesis By

Adekunle Jimoh Aderamo

Department of Geography

University of Ilorin, Ilorin, Nigeria

ROAD DEVELOPMENT AND URBAN EXPANSION: THE CASE OF ILORIN, NIGERIA

JANUARY, 1990

ROAD DEVELOPMENT AND URBAN EXPANSION: THE CASE OF ILORIN, NIGERIA

By

Adekunle Jimoh Aderamo

Thesis
Doctor of Philosophy
Department of Geography
University of Ilorin,
Ilorin, Nigeria

JANUARY, 1990

SUPERVISOR'S CERTIFICATION

I certify that this thesis is the result of research carried out by Mr. Adekunle Jimoh Aderamo under my supervision during the course of his Post-graduate Studies in the Department of Geography of this University.

Supervisor
Albert Adeyomola Ogunsanya
B.Sc; Ph.D (Ife); MCIT
Reader in the Department of Geography
University of Ilorin
Ilorin, Nigeria.

CANDIDATE'S CERTIFICATION

I certify that the materials in this thesis have not been presented for any other degree or professional qualification in this or any other University.

Candidate

Adekunle Jimoh Aderamo. B.Sc (Hons). Mathematics; M.Sc. (Urban and Regional Planning) ABU.

ROAD DEVELOPMENT AND URBAN EXPANSION: THE CASE OF ILORIN, NIGERIA

PH.D THESIS

By

A. J. ADERAMO

ABSTRACT

This study is concerned with road development and urban expansion in Ilorin. The main objectives include the examination of the pattern and structure of road network evolution in Ilorin and how they have affected the changing nature of the morphology of the city; the identification of factors that help to explain the changing morphology of the city; the use of such factors to build a model that can be used to determine the nature and direction of urban morphology given specific transport network structure.

To achieve these objectives, the study depended on a comprehensive data set. The data collected include data from aerial photographs, socio-economic data, traffic surveys and data from records of ministries, parastatals

and local governments. These were collected through mapping from aerial photographs and fieldwork carried out between June and November 1988 within thirteen identified zones in the city. These zones are: Adewole, Baboko - Stadium, Central Area, Gaa Akanbi - Ero Omo, Gaa Imam, Reservation Area, Kulende - Tanke, Oke Oyi, Odokun - Odota, Oloje, Sabo-Oke - Amilegbe, Sobi, University - Polytechnic.

An examination of the state of the arts of the transportation system in the city revealed that intracity trips were dominated by motor cars accounting for 63% of total trips while mini buses accounted for 18.4%. Trips by foot accounted for 12.5% while trips by motorcycles and pedaled cycles accounted for 6.1%. Further, worktrips accounted for 24.4% while social and recreational trips accounted for a total of 33.0%. Business trips accounted for 15.6%, trips to religious centres accounted for 12.8% and trips to markets constituted 9.2%.

Using factor analysis procedure, the following regions of dominant flows in terms of importance of intra-city trips were identified:

1. Adewole, Baboko-Stadium, Odokun - Odota, Sabo-Oke - Amilegbe.
2. Kulende - Tanke, Reservation Area, Sabo-Oke - Amilegbe, University - Polytechnic.
3. Central Area, Oloje, Sobi.
4. Gaa-Akanbi - Ero Omo, Gaa Imam, Reservation Area.

The graph-theoretic approach identified an intra-city hierarchy of zones with Baboko - Stadium as the first order; Central Area, Reservation Area and Gaa Akanbi - Ero Omo as the second order; while Gaa Imam, Kulende - Tanke, Adewole, Odokun - Odota, Oloje, Sabo-Oke - Amilegbe and Sobi are in the third order.

A study of the changing morphology of the city reveals that in 1897, the pattern of the city was one of concentric pattern while by 1963 the pattern of growth has changed to that of radial growth along the road arteries. By 1973, the sectoral growth of the city had intensified along the axial roads of Jebba, Ajassepo, Kaima and Ibrahim Taiwo roads.

As a result of various developments in different directions of the city such as Army Barracks at Sobi, Adewole

Housing Estate and Ilorin Airport, Niger River Basin Authority, Kulende Housing Estates, University of Ilorin Main Campus and Federal Low-cost Housing Estate, Oloje, the 1982 pattern of the city depicts a lot of physical expansion in all directions of the city. By 1988, the sprawl of the city could be prominently noticed along the inter-city roads such as Ilorin - Jebba, Ilorin - Ajassepo road, Lagos road, Kaima road and Shao road.

The spatial pattern of road development in the city reveals that the number of road segments in the city increased from 17 in 1963 to 30 in 1973. The number of road segments increased to 68 by 1982 while by 1988 the number had risen to 72. Analysis of length of road network reveals that in 1963, the length was only 12km while by 1973, the length has risen to 22.7km. By 1982, the total length of road network was 67km while the figure rose to 86km by 1988.

In order to examine the expansion of the city, some basic factors were identified. Of the eight variables identified and used to explain the spatial expansion of Ilorin, it was found that only two variables contribute significantly to the explanation and the model derived is:

$$Y = 2.3067 + 0.13899 X_3 + 0.03003 X_4$$

where Y = Built-up Area;

X_3 = Retail Trade;

X_4 = Provision of Amenities

Using this model, the future land area of the city was obtained and used in the simulation of urban expansion.

The urban expansion itself is based on the Monte Carlo technique which was used to simulate the growth of the city for 1973 and 1982. This was done by determining the road networks of the city for 1973 and 1982 and simulating urban form to these periods in order to obtain the growth patterns. The simulation exercise was carried out using data on the city's population and land area. A comparison of the simulated and observed patterns of the city for 1973 and 1982 gives a good fit.

On the basis of the satisfactory fit obtained between the simulated and observed patterns for 1973 and 1982, the Monte Carlo technique was further used to simulate the future pattern of the city for 2000 A.D. This was done by determining the city's network for 2000 A.D. and simulating urban form to this period.

The study ended with the implications of the research for planning. Specifically it shows that the city of Ilorin has grown naturally over the years. In order to achieve a more purposeful growth for the city there is need for a conscious development policy. To the extent that transport is the dominating component of urban planning, the study recommends that government should control further development of the city by building roads along areas where urban expansion is desired.

ACKNOWLEDGEMENTS

I am greatly indebted to my supervisor, Dr. A. A. Ogunsanya for his constant guidance throughout the period spent on this work. He painstakingly led me through the proposal, data collection and analysis and went through the many drafts of this work offering criticisms and useful suggestions until this standard was achieved. Apart from guiding me on this work and giving me all forms of support, he allowed me access to his library and gave me off-prints of his numerous publications. I am sincerely grateful to him.

I am also very grateful to Professors J. O. Oyebanji and S. O. Onakomaiya for their contributions. My appreciation goes to Dr. A. A. Adedibu for allowing me access to his library and for his useful suggestions. I am grateful to Dr. O. J. Olaniran, Dr. J. F. Olorunfemi, Dr. R. Oyegun, Dr. J. O. Ameyan and Dr. A. F. Adedayo, all of the Geography Department, University of Ilorin for their inputs at various stages of this work. I also want to thank Professor M. A. Ibiejugba of Mathematics Department, Dr. O. S. Adegboye of Statistics Department, Dr. Odedokun and Dr. A. Jimoh of Economics Department and Dr. T. O. Adewoye of Business

Administration Department, University of Ilorin for their suggestions.

My thanks also go to Mr. Amos Ogundele, Alhaji W. J. Abomide, Mr. H. T. Kolawole, Timothy Ogunsola and Michael Abolarin all of the Survey Division, Ministry of Lands and Surveys for assisting me with the Ilorin Aerial Photographs and mapping work; Mr. A. A. Jimoh, Statistics Division, Ministry of Finance and Economic Planning; Engineer J. A. Oyeyipo, Utility Board and Engineers M. B. Aransiola and M. O. Oyeleke of Ministry of Works, Ilorin. I also appreciate the assistance rendered by Mr. O. J. Borokinni, Mrs. J. O. Olorunfemi and Mrs. M. O. Akinwumi, all of the Computer Centre, University of Ilorin for helping me with the computer work; Mr. Bajeh Abdulrahman for the cartographic work; and Mr. N. Jimoh and Mrs. R. O. Balogun for typing the thesis.

I acknowledge the financial and material support given by the Council for the Development of Economic and Social Research in Africa (CODESRIA) in carrying out this research. The council provided grant for the fieldwork, reference materials and the completion of the thesis. I shall ever remain grateful to the Council.

I also appreciate the financial and moral support given by Alhaji Raimi Oladimeji, the Jagunmolu of Igbaja and my Uncle Alhaji Adebayo Adisa, Managing Director, Nigerian Wire Industries Ltd, Lagos, and the patience exercised by my mother, brothers and sisters throughout the period of this work.

I acknowledge the support given by many friends and well-wishers including Dr. A. A. Saadu, Dr. D. B. Omotosho, Dr. R. O. Olarewaju, Dr. Y. Abdulkareem, Dr. C. O. Adegoke; Messrs J. J. Salami, S. O. Saleeman, A. L. Bobadoye, Y. O. Bello, P. D. Oyinloye, Jide Badmus, P. S. Ajayi, A. Alhassan, Kazeem Alabi and many others.

My profound gratitude goes to the Kwara State Polytechnic, Ilorin for granting me study leave for the period 1986 - 1989 to pursue postgraduate work and to the Rector, Deputy Rector and Dr. Ismaila Isa, Director, Institute of Technology for his support.

The cooperation, support and understanding given by my wife, Mrs. Kuburat Mopelola Aderamo, made this work relatively easy. She gave me the love and domestic peace necessary for the completion of this work. I also appreciate the forebearance of my children, Adeoye, Adebukola, Adeola, Adenike, Adefunke and Adebamke for my long hours of absence from home during the three exciting years spent on this work.

Finally, I am grateful to God Almighty for sparing my life and giving me the energy to complete this work.

TABLE OF CONTENTS

PAGE

PAGE

PAGE

CHAPTER SEVEN: MODELLING URBAN EXPANSION

LIST OF TABLES

PAGE

PAGE

LIST OF FIGURES

PAGE

PAGE

APPENDICES

CHAPTER ONE

INTRODUCTION

1.1 Background To The Problem

Urban transport problems the world over do not make news. Existing literature have shown that the major cities of the world today experience very serious transport problems which have greatly reduced mobility in these city centres.

In ancient Rome for example, Julius Caesar once prohibited the movement of carts during day-light to relieve traffic congestion on the roads (Bruton, 1970). Congestion was also common place in Seventeeth Century London and Nineteeth Century New York. In the United States, various studies have been carried out in cities with such traffic problems. Such studies include the Detroit Area Traffic Study (1953); the Chicago Area Transportation Study (1956); the San Diego Metropolitan Area Study (1959), the Penn-Jersey Transportation Study (1960) and the Tri-State New York Metropolitan Transportation Study (1968) all aimed at reducing the urban traffic congestion problems. Also in 1959, the Michigan State Government U.S.A. experimented with pedestrianisation in Kalamazoo (Roberts and Longe, 1976). In 1973, the Organisation for Economic Cooperation and Development Report discussed the widespread use of Restraint of Road Traffic techniques in the developed countries as a means of reducing heavy urban traffic flow problems (OECD, 1973). But the question can be asked, what are these urban transport problems?

Briefly, the urban transport problems can be seen from two major perspectives: The first is the lack of transport facilities which creates a situation of immobility, and the second is the clogging of the roads by too many vehicles thereby creating the common traffic congestion problems. This latter one is the more common in cities of the world today and it manifests itself in traffic hold-ups, delays, parking problems, accidents and environmental pollution problems.

The severity of these problems is a function of a combination of factors. As observed by Adedimila (1977); Adenle (1977) and Ogunsanya (1983), these factors include the road factor, the vehicle factor and the human factor. The road factor is concerned with the nature and surface condition of the road while the vehicle factor relates to the characteristics and performance capabilities of motor vehicles. The human factor refers to those aspects of transport problems that are man-induced and especially with individual behaviour of people in the traffic stream.

Existing studies have shown that previous attempts at finding solutions to the urban transport problem have failed to recognise the multifaceted nature of these transport problems. For example, in some studies, a particular urban transport problem is studied and tackled, (SELNEC Study 1962) while in some others a particular facet of a wider range of problems is looked at to the neglect of its relationship to other transport problems, (London Traffic Survey, 1960).

The recognition of the interdependence between urban transport system and the location of residences and work places has had a great impact on the analysis of the urban transport problem. For example, Mitchell and Rapkin (1954) have shown that intimate and inseparable interrelationships exist between transportation and geographic locations. Wingo and Perloff (1961) have also shown that transport influences land use patterns. They both contend that the development of the city over time will depend upon the sequence in which changes in land use and transportation occur. Also, the critical role of transportation in the form and evolution of the contemporary metropolitan areas and the relationship between traffic volumes and land use are vital interrelated variables worth serious consideration (Blumenfeld, 1967). Further, an understanding of what prompts, encourages and allows people to move is important in the understanding of the functions and limitations of a transport system. It is only through this that any meaningful prediction of the future scale and pattern of movement can be made (Daniels and Warnes, 1983).

Understanding the role of transport in spatial development is also important in solving the urban transport problem. There is no doubt that one of the greatest forces in the spatial development of any area is transport (Rostow, 1964, Wilson, 1966, Storey, 1969). The emergence of a new and efficient form of transportation, for example, has ever proved to be a powerful weapon of economic and spatial development of any environment. So complex are the activities in the cities that cities are incapable of existence except when adequate transport facilities exist.

The effect of transport on the development of cities becomes apparent in the spatial expansion of the city because cities are themselves creatures of transportation (Harvey and Clark, 1965; Pederson, 1980). A recurrent controversy in the discussion of transport and urban spatial expansion however is whether transport availability necessitates the spatial expansion of the city or the spatial expansion of the city calls up the need for transport. This study tries to address the relationship between transport availability and urban spatial expansion. The study examines the transport factor in the morphology of a developing environment like Nigeria and is based on the hypothesis that the understanding of the structure - transport relationship of the city, can help to ease its physical planning.

1.2 Statement Of The Problem

From the foregoing discussion, it is clear that existing works on urban transport studies adopt a topical approach. But the geographer's interest is in geographical patterns and inter-relationships with land use and other geographical elements of urban environment.

A significant feature in the evolution of transport is the ability to travel increased distances without consuming more time. This is crucial in the context of urban development because it allows the residences and workplaces of urban dwellers to be separated and has the ability to change the traditional 'compact' city to a more dispersed form. In addition, new methods of movement have conferred different accessibility advantages on intra-urban locations and encouraged functional segregation of land uses. This would not have been possible without the liberalizing influence of urban transport technology in the sense that it promotes outward expansion of cities while at the same time sustaining the accessibility advantages of the centre.

A major cause of traffic problems in the developing environment is that the city structure predates the advent of the automobile. In Nigeria for example, the problem of haphazard development, which is prevalent in all our growing urban centres can be attributed to unplanned growth resulting in scattered agglomeration of settlement patterns and the spatial expansion of the cities along the main transport routes (Bolade, 1986). This is worsened by the apparent lack of understanding of the relationship between the form of the city and its transport needs which in part is responsible for the uncontrolled sprawl of these cities along the transportation routes.

But as observed by Douglas and Carrol (1962), the problem is not best solved through a repression of the system of the technology, but rather through the understanding of the urban form and how to adapt to it. There is no doubt that transport provision promotes the outward expansion of cities because as explained by Pederson (1980), transportation remains the key to the understanding of land use change. Thus an understanding of the present and future morphology of the city is of prime importance in the repression of the transport problem.

Sargent (1972) recognised that the forces which influence urban morphology have been given little attention compared to studies of the nature of land occupance or social groups. Yet the spatial development of the urban area can best be understood by investigating the underlying forces behind the outward expansion of urban growth. According to Sargent, it is increasingly being accepted that the geographic analysis of an urban area is best carried out within a framework that is capable of providing insight into the pattern, timing and processes of urban growth. If such a pattern can be explained, modelled and future patterns predicted, a major gap would have been filled in urban transport studies.

1.3 Study Objectives And Scope Of Study

The main purpose of the study is to examine the transport factor in the spatial expansion of Ilorin. The study has the following specific objectives:

(i) To examine on a spatio-temporal basis the pattern and structure of road network evolution in Ilorin.

(ii) To examine the extent to which (i) above has affected the changing nature of the morphology of Ilorin.

(iii) To examine the other factors that help to explain the changing morphology of the city.

(iv) On the basis of (iii) above, to build and test a model that can be used to determine the nature and direction of urban morphology given specific transport network structure.

(v) To outline the implication of the study for urban planning and redevelopment.

1.4 Conceptual Framework

The basic concepts of urban form or urban morphology and those of network structure can be used to formulate a relationship between road development and urban expansion. This subsection examines these conceptual issues on which the thrust of the study rests.

(a) Urban Morphology

If closely observed, cities display a degree of internal organization. In terms of urban space, this order is most frequently described by regularities in land use patterns. These summarise the distribution of urban activities and population.

Some of the basic concepts used to describe urban form include the concentric zonation hypothesis of the urban ecologist Burgess (1923); the residential sector model of Hoyt (1939) and the multiple nuclei proposal of Harris and Ullman (1945).

The earliest and best known of the classical models of urban growth is Burgess concentric zonation hypothesis. Fig (1.1a). Burgess contends that as a city grows, it expands radially around the Central Business District (CBD) to form a series of concentric circles. Burgess identified five zones with each zone characterised by different land use and people of different status. The first zone is the centre of the city or the Central Business District; the second zone is the zone in transition comprising an area of residential deteriroration as a result of encroachments from the CBD. The third zone is the independent working man's homes. Next to the third zone is the zone of better residences. The fifth zone is the commuter's zone consisting of dormitory surburbs with the men commuting to jobs in the CBD. The operating mechanism of the concentric circle model was the growth and radial

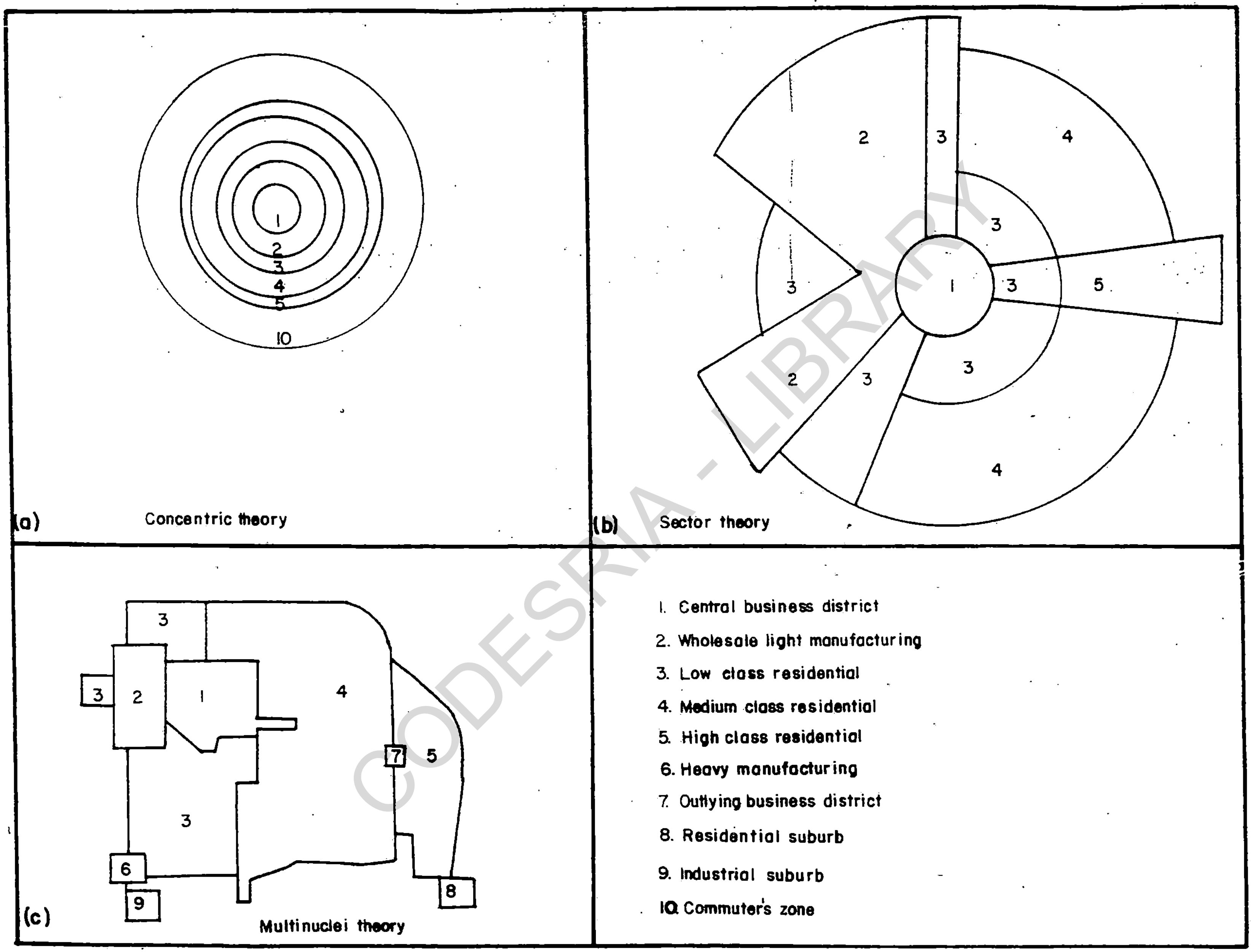


Fig. 1.1: Models of the internal structure of cities. Source: Hudson, F. S. Geography of settlements (1980).

expansion of the city with each zone having a tendency to expand outward into the next or what the urban ecologists describe as 'invasion' and 'succession'.

Hoyt's (1939) model of the growth and spatial structure of American cities is also known by the wedge or sector theory (Fig 1.1b). Hoyt analysed the distribution of residential neighbourhoods of various qualities as defined by rent levels, and found that they were neither distributed randomly nor in the form of concentric circles. According to Hoyt, different types of residential areas usually grew outward along distinct radii and new growth on the area of a given sector tended to take on the character of the initial growth in that sector. Hoyt's model had its origin in the works of Hurd (1903) who described urban expansion as 'axial growth, pushing out from the centre along transportation lines'. It is felt by some scholars that because Hoyt's model takes into account both distance and direction from the centre of the city, it is an improvement on the earlier Burgess effort (Richardson 1971, Johnson, 1972 p.173).

The multiple nuclei model formulated by Harris and Ullman (1945) is a modification of both Burgess's and Hoyt's models (Fig 1.1c). Harris and Ullman argue that the land use pattern of a city does not grow from a single centre but around several distinct nuclei. In some cases, these nuclei, elements around which growth takes place, have existed from the origin of the city but others may develop during the growth of the city. Their numbers vary from city to city but the larger the city, the more numerous and specialised are the nuclei.

These classical models which emerge from the process of analysis and generalisation do not rigidly conform to the reality of any city though many elements of each model are recognisable in the vast majority of urban centres. The models, however, remain as valuable conceptual tools for analysing the modern city and provide a basis for cross-cultural urban comparisons.

One of the most well known and probably most well tested model of urban structure derives from Lowry's (1964) model of the metropolis which has been subsequently developed and modified in recent years (Garin, 1969; Wilson, 1970).

The Lowry model organises the urban space economy into activities on the one hand, and land uses on the other. The activities which the model defines are population and service employment and basic (manufacturing and primary) employment, and these activities correspond to residential, service and industrial land uses. The mathematical structure of the Lowry-type of land use and transport interaction model is based on accessibility concepts and economic base concepts.

Basically, the urban economy is conceptualised to comprise basic activities and service activities. Basic employment is defined as that employment which is associated with industries whose products are exported outside the region while service employment are consumed within the region. Besides deriving population and service employment the model also allocates these activities to zones of the urban region. Population is allocated in proportion to the population potential of each zone and service employment in proportion to the employment or market potential of each zone. Constraints on the amount of land use accommodated in each zone are also built into the model.

Having located the various activities in accordance with the predetermined constraints, the model also tests the predicted distribution of population against the distribution used to compute potentials to find out whether the two distributions are coincident. Lowry's framework can be enlarged and embellished through the entropy-maximising methodology introduced by Wilson (1970). Some of the embellishments include:

(i) the disaggregation of population into wage classes, and the introduction of behavioural assumptions into spatial interaction and locational behaviour (Wilson, 1973).

(ii) the use of more consistent equations than Lowry's (1964) and Batty's (1970).

(iii) interpretation of the economic base concept in terms of both export generation and locational attributes of urban activities (Goldner, 1968; Ayeni, 1975b).

The Lowry-model can be used to estimate population of an area from total employment and retail employment generated in the different sectors from the population and retail land use. The major use of the model is to provide some means by which trajectory of urban spatial and locational behaviour might be traced.

Also Boyce (1966) broadened the analogical framework of the similarities between wave theory and metropolitan expansion. In his wave theory analog approach to explain urban morphology and change, Boyce conceptualises a metropolis to grow in two major respects. A metropolis might change in its distribution of internal density of land use, and it might increase in its area by growing about its edges. Boyce contends that most of the descriptive and analytical theories that describe the surface and extent of the metropolis such as rent theory, central place theory, density gradient studies and various descriptive studies such as those by Burgess (1923), Hoyt (1939) and Harris and Ullman (1945) are primarily static models. Very few of them take into account the dynamic nature of metropolitan change and almost nothing is available on the spread and outward movement or urban fringe of the metropolis.

Through the wave analog approach, Boyce recognises the existence of three major waves within metropolitan areas viz: a recession wave which occurs in the outer frame area of the central city and characterised by a decreasing change in population over time which moves outward from the central area; the precession wave which moves ahead of the main advance of the actual urban settlement and characterised by speculative land holdings, farm falling largely into disuse and by a plethora of real estate agents; the tidal wave or cutting edge of the metropolis which is recognised to be the actual front of urban settlement and referred to in many ways as the rural-urban fringe; the outer suburbia; or the cutting edge of the metropolis.

In an earlier work, Blumenfeld (1954) in his concept of tidal waves, argues that in any given time period, there is a particular "zone of maximum growth" which can be defined as the crest of the tidal wave of metropolitan expansion. It is also recognised that the form or shape of a metropolis is one of its most striking characteristics. This is because cities differ widely in shape and are rarely circular. They also grow outward in different directions at different times. If one subtitutes the terms city surface for ocean surface, and thinks of wave height as analogous to urban land intensity or density, then great similarities between the urban surface and the ocean surface can be noted.

Boyce's conceptual approach has been implemented by Newling (1969) in the context of urban population density analysis and by Morrill (1968, 1970) in the context of the study of diffusion. Krakover (1982) applied the concept to the study of spread of growth in urban field of large metropolitan centres. In the context of the study of urban expansion proposed in this work, the wave analog concept appears to hold great promise in providing a sound conceptual framework. This is because it indirectly incorporates earlier theories and concepts to evolve a more realistic frame for understanding the pattern of city growth.

(b) <u>Network Structure</u>

The term structure denotes the layout, geometry or pattern of transportation facilities or systems (Garrison and Marble, 1961). This expression implies a set of spatial relations between distinguishable elements of transportation networks in respect to each other and to the organised whole. According to Kansky (1963), it is possible to describe the structure of transportation networks in mathematical terms through a measure of relations between these distinguishable elements of transportation networks. By taking advantage of the abstract concept of mathematics available in graph theory, Kansky developed techniques for measuring and analysing the structure of transportation networks.

Kansky asserts that the strucutre of transportation network of any area cannot be divorced from the geographic characteristics of that area. He recognises that a temporally and spatially stable functional relationship exists between network structure and areal characteristics. According to him, the developmental changes in the network structure is characterised by a process of addition of transportation routes. He was thus able to construct a quantitative predictive model of the network structure such that the set of areal characteristics is a function of definite values of available graph-theoretic measures which define the network structure.

Two aspects of the areal characteristics, magnitude and location were recognised as necessary elements in the construction of the predictive model. Thus a network structure is a function of the quantity of areal characteristics and their locational distribution. A predictive model can thus be constructed as statistical regularity capable of predicting the most probable stages of the network structure.

Further, Kansky claims that the model may be used for the prediction of transporation networks of areas of study such as a city. The procedure of its application involves the following:

(i) determining the observational units of research.

(ii) derivation of an index of economic activities in an area and the size of the area.

(iii) location of the centre of economic activities.

(iv) calculation of the numerical values of the graph-theoretic measures.

(v) construction of the most probable map of the network structure by using the graph-theoretic ~~measures and~~ locating the network in the area by simulation techniques.

Graph-theoretic measures are useful in evaluating not only the accessibility of nodes but also the connectivity of networks. Kansky introduced a large number of graph-theoretic measures many of which are index numbers. Some of the measures that seem to have a greater degree of utility in the analysis of transportation networks are:

(a) Beta index;

(b) Gamma index;

(c) Alpha index;

(d) Cyclomatic number;

(e) Network disperson;

(f) Eta index;

(g) Iota index.

These selected indices were used by Kansky to express relationship between the structure of transportation networks and the economic characteristics of a number ~~of selected~~ regions. In particular, Kansky asserts that a significant correlation between measures of the level of economic development and the set of numerical values indicating degree of transportation development would indicate the utility of all or some of the proposed network measures as indices of degree of transportation development.

In the present context of identifying the structure and development of intra-urban road network in Ilorin, measures of Beta, gamma, alpha, cyclomatic number, eta and iota indices will be computed for the road network of the city for the years 1963, 1973, 1982, and 1988. Such indices can then be used to determine the pattern of network growth in Ilorin.

(c) Relationship Between Network And Morphology

Each system just discussed is directly concerned with the development of a framework which identifies and describes regularities in in patterns of human interaction in space and explains their origins and transformations in time whenever population aggregates in urban areas. Along with these rather fundamental

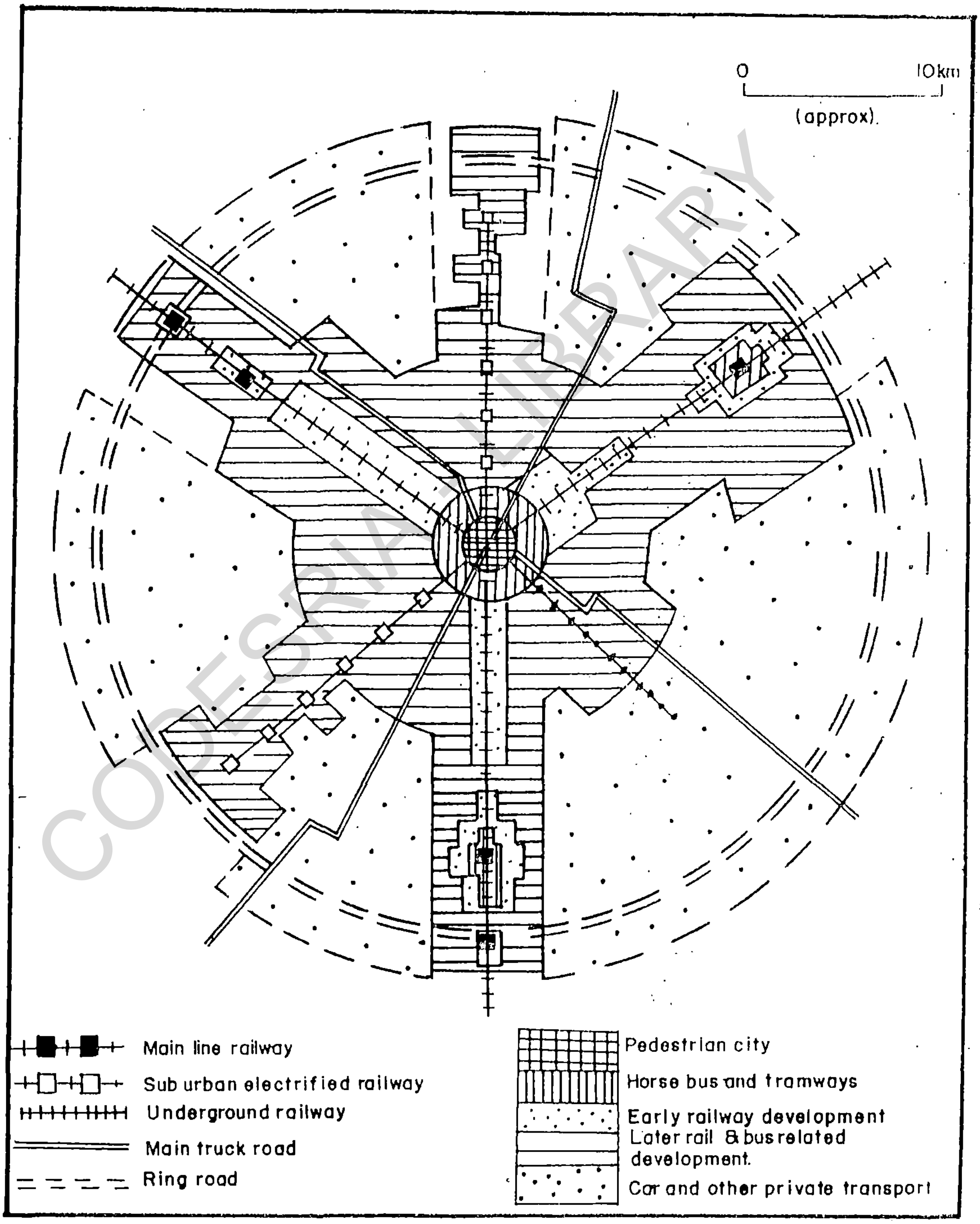


Fig.1.2: Schematic relationship between urban form and transport.

Source: Daniels P.W. and Warnes A.M. Movement in cities (1983) relationships in space and time is a common concern for accessibility. In describing interaction patterns, most of these conceptual systems make a distinction between patterns of intra-place and interplace interaction, the former having importance for the adaptation of space and the latter involving communications between spaces. Urban networks give meaning to the idea of the city as a system and transportation system holds the key to the way in which growth proceeds. It is therefore important to examine transportation systems and urban form together in order to facilitate purposeful growth.

The three models of Burgess (1923); Hoyt (1939); Harris and Ullman (1945) are combinable into a single model that shows a spatio-temporal dimension of the relationship between transport and urban form. Fig.1.2 shows five distinct phases of this relationship.

The first is the pedestrian city which represents the situation where the only means of transport was by foot. Cities in this category have been aptly described as "foot-cities" (Schaefer and Sclar, 1975). Distinctly, the pattern or structure is concentric. A dominant feature of the city at this time is a form of functional integration where jobs and residences are located in the same place. This pattern is not significantly different with the advent of the horse bus and tramways since these forms of transport do not adequately solve mobility requirement of the urban commuter. Thus city functions tend to agglomerate and the city still remains largely compact and concentric.

The development of the railway brought some changes in the size and structure of the city. The most significant feature in the evolution of this form of transport is that it allows longer distances to be covered without necessarily consuming more time. This is an important development in the context of spatial expansion, as it allows a greater separation of residences and workplace. This to a very large extent changed the compact traditional city to a dispersed one. The result is the sectoral growth of the city, following the lines of railway development.

The later development of fast railway and bus further increased the expansion of the city along the sectoral pattern. A notable development at this time is that of special nuclei along the wedges. These nuclei have led to the decentralisation of functions at the CBD and the creation of minor Central Business Districts along the wedges - a feature made possible by accessibility.

The arrival of the car and other forms of personal transport as new modes of transport conferred different accessibility advantages on intra-urban locations and encouraged further functional segregation and appearance of new land use. Up to the early 19th century the structure of the cities was determined solely by the distances residents were prepared to cover. With the time space convergence created by transport availability, the structure changed.

The resultant effect of transport provision is the outward expansion of cities. Better transport facilities result in greater alternatives in locating housing, jobs and services and therefore the expansion of the city over time (Ogunsanya, 1989). Thus the interdependence of transportation systems and urban form implies that they must be analysed and planned together for efficiency.

1.5 Study Area And Justification For Choice

The study area is Ilorin, the Kwara State Capital. It is located on latitude 8°30' North and longitude 4°35' East.

The city is divided into two parts, the West and East, by the Asa River which flows through the town in a roughly north-south direction. (See Fig. 1.3).
The West encompasses the traditional section of the town with the Emir's Palace as its hub. The 'Emir's Market' is also the centre of retailing, recreational,

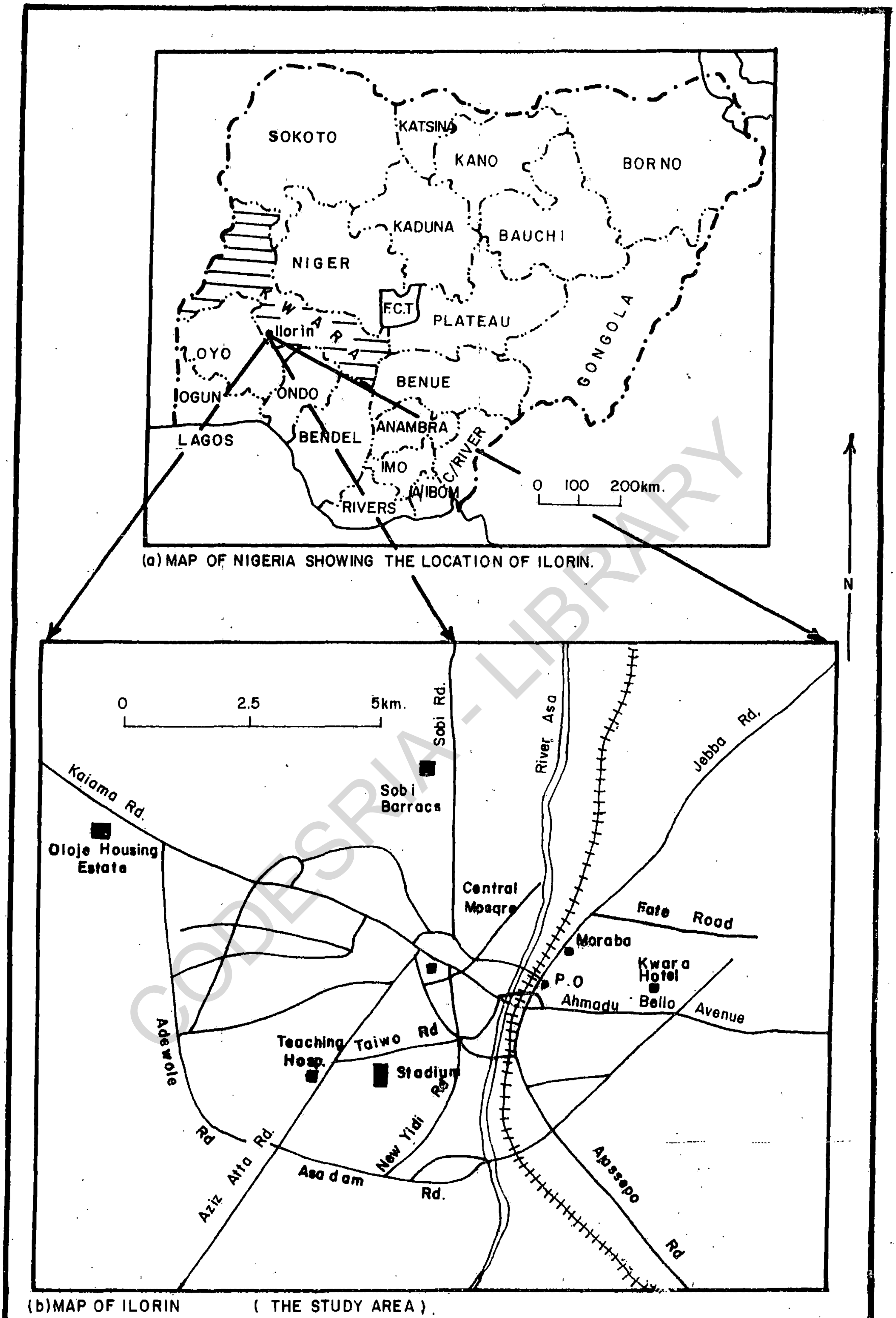


Fig.1.3: Map showing the study area.

religious and commercial activities to which urban residents commute daily.

The creation of Kwara State in 1967 and the choice of Ilorin as the State Capital has resulted in its rapid population increases and areal expansion. Over the years, the city has grown from what can be described as a "Foot-City" with residential houses located around the Emir's Palace to an automobile city.

Ilorin is undisputably the largest urban centre in Kwara State. Within about two decades of its becoming a state capital, the population of the city has more than doubled. By 1963, the population of Ilorin was put at 208,546. The city's 1973 population was estimated to be about 320,000 while the population in 1980 was put at approximately, 400,000. The estimated population of Ilorin for 1987 is approximately 474,000. This trend in population growth is very likely to continue because of the centrality of the city to very important places in the country. In fact, the location of Ilorin between the dry north and the wet south of Nigeria gave Ilorin the description as the "gateway between the northwest and the southwest of the country" (Adedibu, 1980).

The development of intra-city roads to cope with the demand of the city, when it became a state capital in 1967, has affected the spatial expansion of the city. The extension of the old roads opened up new sections of the town leading to the expansion of the city. Thus developments have concentrated along the routes. The development of the city has been concentrated in recent times along the intercity roads such as Ilorin - Jebba Road where the expansion has extended almost as far as Oke-Oyi, the Ilorin - Ajassepo Road which has merged Ganmo and Amayo with Ilorin, the Lagos road which now brings Eiyenkorin completely under the urban influence of Ilorin, the Kaima road, which now has enveloped Ogidi, and the Shao road which now puts Shao as part of the outskirt of Ilorin.

The growth of the city since it became a state capital has been in terms of physical expansion and growth of traffic. The western section of the city which is predominantly residential, generates a lot of traffic daily which have to go through the three bridges linking the West and East. This creates a condition which makes traffic to concentrate on and overstretch such routes as Emir's road, Taiwo/Unity road and Amilegbe road.

The location of markets and other centres of commercial activities in the city also act as traffic generation points and has significant effect on the city's traffic pattern. The distribution of various other land uses such as institutional, public and semi public buildings, industrial and recreational all sum up to dictate the pattern of city traffic and urban expansion. As observed by Ogunsanya (1986), although traffic congestion does not pose serious problems yet in Ilorin, signs of potential bottlenecks are already noticeable.

As a result of her numerical size, Ilorin interacts intensely with high-order urban centres as Lagos, Ibadan, Kano as well as others in the lower hierarchical levels. It also has strong links with other urban centres in the performance of its traditional roles as a centre of social and economic activities. Culturally, Ilorin possesses customs typical of many southern states of Nigeria. Administratively, it belongs to one of the Northern States of Nigeria.

Ilorin has been chosen for this study because it is a medium-size urban centre that grows mainly along intercity roads. Such urban centres eventually develop to have traffic problems like the bigger urban centres in Nigeria. An understanding of the transport system of such centres can be used to check the problem of traffic congestion before growing into uncontrollable level.

Thus the study of road development and urban expansion in Ilorin can serve as a guide to similar studies in other urban centres in Nigeria.

1.6 Organisation Of The Study

This research work is organised into eight chapters: Chapter I of the thesis is the introductory chapter and deals with the statement of the problem of study, the background of the problem, conceptual framework, the study objectives, the study area and justification for its choice.

Chapter II is a review of relevant literature related to the study. This deals mainly with previous publications on the theories of urban structure and network studies.

Chapter III deals with the research methodology employed in the study. These are mainly the types of data collected and strategy for their collection. It also gives a summary of the analytical techniques employed in the study.

Chapter IV discusses aspects of transportation situation in Ilorin as at the time of this study. The basic aspects discussed are the pattern of vehicular traffic, pattern of intra-urban trips, road quality and characteristics of trip makers. The chapter serves as a prelude to the understanding of the state of the transport system in the town.

Chapter V describes the morphology of Ilorin. This relates mainly to the spatio-temporal perspective of the evolution of Ilorin and the composite growth pattern in the last two decades. The chapter also attempts to account for any observable pattern.

Chapter VI deals mainly with the spatial pattern of road development in Ilorin. Areas of focus are the network factor in urban development; intra-urban network analysis by periods; evolution of intra-urban network and the composite growth pattern of the city's network.

Chapter VII discusses the modelling procedure in urban expansion. The chapter identifies the variables for the modelling procedure and applies the model to the development and growth of Ilorin for the periods 1973, 1982 and 2000 A.D.

Chapter VIII is the concluding chapter and deals with the summary of the work and discusses the planning implications of the results derived making appropriate recommendations and conclusions. The chapter also discusses areas for further research.

CHAPTER TWO

LITERATURE REVIEW

In Chapter One, an attempt was made in section 1.3 to explain the basic conceptual issues around which the objectives of this research work are woven. In this chapter, a review of related literature is made with the view to acquiring the background knowledge required for an understanding of the problem of study and an evaluation of related theories. To do this however, no attempt has been made to repeat the relevant theories which have been adequately dealt with in chapter one. Rather, attempts are focused in this chapter on those aspects not covered by the conceptual review and the existing empirical studies in the area. The chapter is organised in 2 parts:

(1) Recent theories of urban growth and structure,

(2) Network studies,

2.1 Recent Theories Of Urban Growth And Structure

The concentric zone theory of Burgess (1923), the sectoral hypotheses of Hoyt (1939) and the multiple nuclei model formulated by Harris and Ullman (1945) have been examined earlier. These models are however not mutually exclusive for both the Hoyt and the multiple nuclei models are modifications of the concentric circle theory. Even in Hoyt's concept, residential areas expand out concentrically. It is obvious too that the American city of the twenties and thirties which provided data upon which these models were built is undergoing important structural changes. Further, the traumatic effect of the automobile was not really apparent in the city studies that furnished the inspiration for these classic models.

Consequently, there has been declining relevance of the traditional models of urban structure and a corresponding increased need for new analytical formulations. The new formulations seek to evaluate current research into the criteria for theories of urban spatial structure. Some of the criteria are that a theory must have a dynamic aspect if it is to have utility in representing the processes by which cities are structured and by which they grow. Secondly, a theory must be susceptible of empirical verification such that it is capable of being tested. Thirdly, the theory must have an internal logic and consistency. Finally, the theory must not be so abstract as to have no relation to reality.

Thus, recent theories of urban growth and structure have been discussed in the light of these stated criteria. Other theories discussed here include Meier's (1962) communications theory of urban growth and structure; Webber's (1963) theory of the urban place and the non-place urban realm; and Lynch and Rodwin's (1958) theory of urban form:

(a) A Communications Theory Approach To Urban Growth

Meier (1962) conceptualizes the city in terms of systems of interaction prompted by man's urge to maintain communications with his fellow man. According to Meier, at any stage in man's state of development, transportation and communications technology supply the principal media of interaction. While noting that cities have always exerted a strong attraction for growth because of the opportunities for face-to-face transactions they offer, Meier holds that technological developments are reducing the necessity for face-to-face interaction and transportation overloads are imposing limiting conditions on opportunities for interaction through transportation systems. With the use of communications to represent transportation, communications becomes important as a focus for studying the city. The communications system offers what Meier considers to be the basis for understanding human interactions and the activity systems that arise out of human relations involved.

Meier develops a set of eight requirements for the communications process. These are: a sender, a message, a channel, a receiver, an intention span on the part of the receiver, a common language, time for process to take place and one or more purposes to be served. According to Meier, by obtaining a sample of communications flows in a metropolitan area, information theory can be used to construct a set of social accounts which can then become the basis for explaining activity systems.

Meier does not indicate fully the manner in which the framework would be used in a predictive application. However, he suggests that his concept of the "urban time budget", which estimates the proportions of a day's time a person would spend in various forms of public communication, would provide a means of making projections.

Meier's work possesses a distinct behavioural emphasis on the study of the city and tends more towards the explanatory than the normative emphasis. His work surely reflects a very strong feeling for the dynamic, not only in the usual time sense but also in his concern for constructing the evolutionary sequence in human behaviour patterns.

(b) A Theory Emphasising Human Interaction

Webber (1963) utilises interaction as the basic organizing concept of his theoretical systems of urban growth and structure. Webber views the urban communities in two related perspectives - one in which human interaction occurs in a particular metropolitan community, and another in which it extends to widely scattered places over the face of the earth. He calls the first a "place community" and the second a "non place community". With modern transportation and communications development having the effect of stretching distances, he notes that individuals, firms, organizations, and institutions more and more have contacts, conduct transactions, and maintain communications on a global basis. Thus their ties may extend to a variety of non place communities as well as exist within a particular urban place. To distinguish them from the urban place, Webber calls these non place communities "urban realms".

According to Webber's concept, what goes on within the spatial confines of an urban place must be interpreted in the framework of all the ties that the community may have with the world at large. In both the place and non place view of the urban community, Webber emphasizes the importance of viewing the city as a "dynamic system in action". This dynamic feature is traced through "linkages" which he defines as "dependency ties" relating individuals, groups, firms, and other entities to one another. He terms these "the invisible relations that bring various interdependent business establishments, households, voluntary groups, and personal friends into working associations with each other into operating systems". His spatial counterpart of this aspatial view of linkages involves three related perspectives. These are human interactions, physical form, and activity locations.

Using these three perspectives of the city, Webber develops a cross-classification system for describing urban spatial structure. The interaction, physical and activity components are classified according to: size of phenomenon, degree to which phenomenon piles up in major concentric forms around a point; propensity for phenomenon to pile up at points of lesser concentration; degree of pile-up per unity; relative "togetherness" of like phenomena and finally, relative degree of mixture. On using this framework in the investigation of the directions that future growth and development must take, he indicates it would involve an analysis of interaction in terms of the locational behaviour of various types of establishments.

(c) A System Focusing On Urban Form

Rodwin and Lynch (1958) view the city as being made up of what they call "adapted space" for the accommodation of human activities and "flow systems" for handling flows of people and goods.

In their framework, they are concerned first with a system for analysing urban form which they equate with adapted space and flow systems. Rodwin and Lynch propose evaluating urban form by six analytical categories: element types, quantity, density, grain, focal organization, and generalized spatial distribution. This six-part classification system is the basic analytical tool they propose for classifying urban form.

The second major conceptual problem with which the Rodwin-Lynch framework seeks to deal with is the formulation of goals utilizing this analytical tool. The identification of goals is one aspect of the problem, and the specification of content is a second aspect. Rodwin and Lynch point out that goals, must to some extent, be determined in the normal democratic processes. They suggest that the choice of goals have first a human and then an economic basis. Thus goals relating to urban form are fundamentally concerned on the one hand with relationships between man and man, and on the other hand, with the efficiency of these relationships - maximising the return and minimising the cost in both a social and an economic sense. The specification of goal content derive from the analytical framework they devised in the first instance. Thus the goals would be specified in terms of type of adapted space and flow system, quantity, density, grain, focal organisation and the spatial distribution pattern. Some would have quantitative emphasis, some would be subject to continuing checks as to relevance and reasonableness.

The final aspect of the Rodwin - Lynch framework is concerned with the application of the goal-form statements= in the study of the city. Through the use of simple cross-classification of the six components of their system of analysis applied to both adapted spaces and flow systems, they demonstrate how these two elements of urban form interact under different goal emphases.

In this respect, their framework has special significance for plan making. In sum, Rodwin and Lynch view the framework as a means for analysing urban form in a systematic and logical manner. The importance of a theory being a dynamic one is recognised by Rodwin and Lynch and in the sense that the sequence from goal formulation to form analysis in their conceptual system is seen as a continuous and dynamic interrelationship it is dynamic in conception.

2.2 Network Studies

The underlying and organising framework in the city consists of the media of interaction and the principal means of facilitating interaction of all types are the complex networks of transportation. These networks give meaning to the idea of the city as a system.

(a) Graph Theory In Network Studies

Over the past two decades, graph theory has been a useful tool for analysing transport networks. The basic aim of the technique is to provide measures of the structural properties of real world transportation networks by abstracting the system as a set of points (nodes or vertices) and routes (line segments or edges). The computation of aggregate measures of connectivity and structure provides a consistent basis for the analysis of network development through time, comparison of networks at various levels of spatial aggregation and association of network structure with measures of economic or regional development.

Although the study of transportation networks in terms of their topological properties dates back to Euler's classical problem of the seven bridges of Konigsberg in 1736, it was not until 1960 that Garrison, a pioneer in theoretical geography, introduced graph theory to the study of transportation networks in the literature of geography and of regional science.

According to Garrison and Marble (1965), networks possess many different structural properties. At the most simple level of conceptualization, a network may be thought of as composed of points and lines. At higher levels of complexity the notions of distance, capacity, angles between lines and so on may be introduced. Networks can be considered at different levels of aggregation either by (1) using measures of the characteristics of entire networks or (2) using measures of relationships among links (or nodes) on the network. The graph-theoretic concept has received wide application in geography because of its quantifiable characteristics. According to Garrison (1960), graph theory because of its relative simplicity has the ability to look at the network system as a whole or to look at individual parts of it in terms of the whole. Graph-theoretic concept has proved to be an important descriptive device in the analysis of the structure of systems and it is a ready-made mathematical structure of considerable utility.

Graph-theoretic concept was applied by Garrison and Marble (1960) to regional highway networks. Nystuen and

Dacey (1961) analysed functional connections between central places based on graph-theoretic concepts. Kansky (1963) applied graph-theoretic technique to the study of transportation networks. Inspite of their usefulness in analysing transportation networks, graph-theoretic concepts are in no way normative (Garrison, 1960), since the user of the method must make rather arbitrary decisions regarding the content of the graph.

However, graph-theoretic concept deserves a thorough development in geography because it is probably the best example of an abstract theoretical system that we have. It is easily adapted to spatial or aspatial concerns or mixtures of them, and despite an historical emphasis on transportation applications, it is not too heavily imbued with any particular geographical hue.

(b) Network Growth And Generation

Apart from the work of Kansky (1963) on the development of transportation networks, other analytical and descriptive studies of network growth include those of Garrison and Marble (1965) and Gauthier (1968). Although their studies were on a regional scale, they have implications for local studies of route development.

Gauthier (1968) in a study of Transportation and the Growth of the Sao Paulo Economy, investigated the problem of transportation development and economic change. Specifically, he examined the development of highway transportation and urban growth in the region of Sao Paulo, Brazil. The objective was to investigate for the period 1940 to 1960, the interrelationships between changes in accessibility to the highway network and the growth of urban centres. Gauthier determined the structural dimensions of the accessibility surfaces of the Sao Paulo highway network. This provided a basis for determining the extent to which changes in network accessibility are related to the economic growth of urban centres. Operationally, the structural dimensions of the accessibility surfaces provided measures of network accessibility at a regional scale. Measures of urban growth were provided by the surrogates of urban population, manufacturing and retail trade activity.

In his conclusion, Gauthier noted that with respect to the interrelationships between accessibility and urban growth, the strongest association exists between the construction of highway facilities in the Sao Paulo Maior Region and the development of manufacturing activities in urban centres which have been the beneficiaries of the resulting improvements in network accessibility.

Kolars and Malin (1970) developed a postdictive simulation model of the Turkish railway system based upon population and topographic features. In order to consider the impact of population near a route, the authors constructed a population map that summed population within twenty miles of selected points. The utility of such a map identifies "ridge lines" between major centres on the population surface, as well as population "pits". Kolars and Malin suggested that such ridge lines between peaks should help to identify optimum routes which give the greatest benefit to rural farmers.

The foregoing review indicates related literature to the study of urban growth and transportation development. The empirical examples cited are from both developed and underdeveloped environments. The facts that have emerged from this review are that urban land use is dynamic. The growth of urban population and the consequent need for greater amounts of land is a major source of land use change. Secondly, the amount of change and the direction of change can be attributed solely to the provision of transport infrastructure. In the words of Pederson (1980), "transportation remains the key to the understanding of land use change".

CHAPTER THREE

RESEARCH METHODOLOGY

The main objective of this study as identified in section 1.3 is to examine the transport factor in the spatial expansion of Ilorin. To do this, the study requires a comprehensive data set. The details of the methodology adopted are the object of this chapter. The research design is divided into three stages (see figure 3.1). These are

(i) Preliminary Stage;

(ii) Data Collection Stage;

(iii) Analysis Stage.

3.1 The Preliminary Stage

The preliminary stage for convenience can be examined in four parts. These are:

(a) Delimitation of study area;

(b) Mapping from aerial photographs;

(c) Field checks and updating of maps;

(d) Division of study area into traffic zones for data collection. Each stage is explained below:

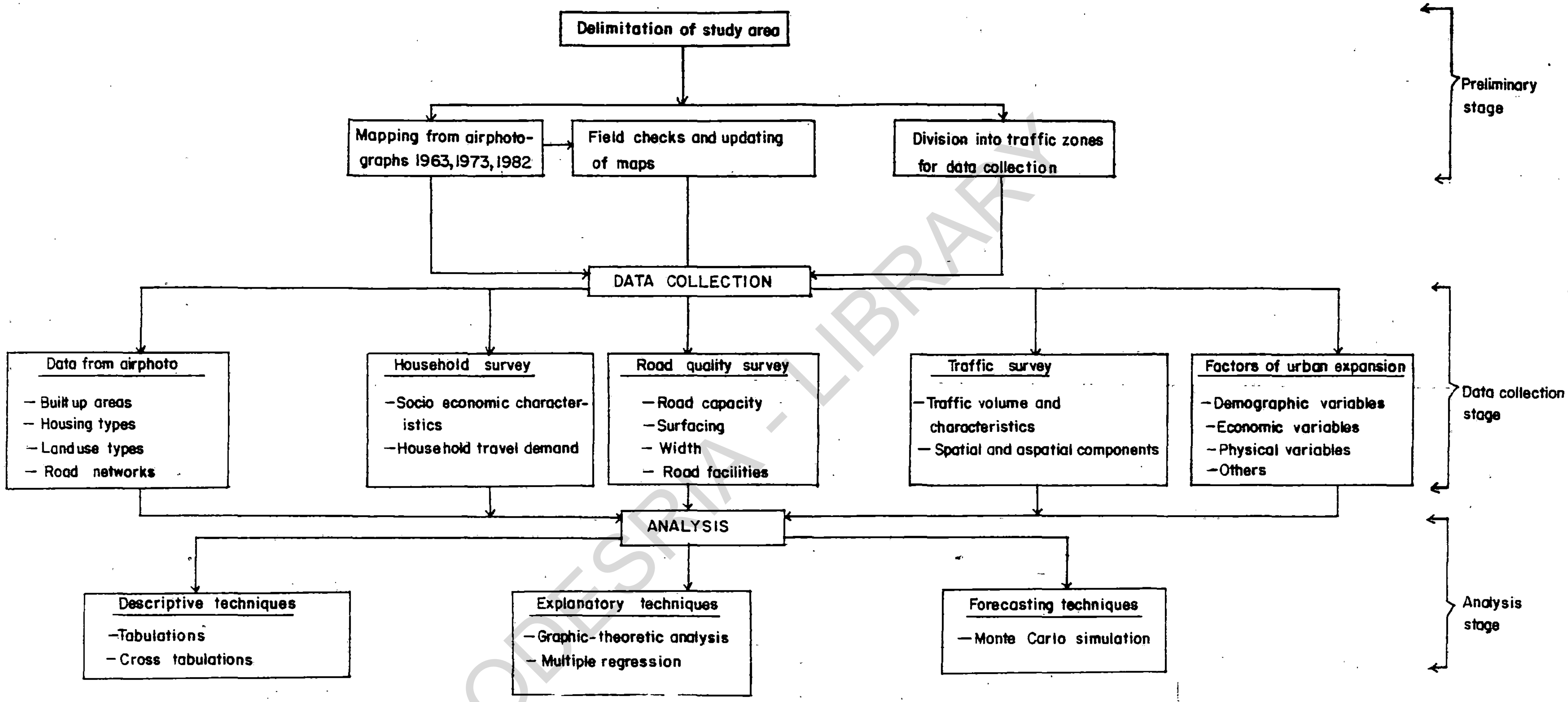


FIG. 3.1: RESEARCH DESIGN

(a) Delimitation Of Study Area

For a rapidly developing settlement, the determination of its areal extent is usually a problem. This is more so in the case of Ilorin which has almost engulfed other settlements such as Amayo, Gamo, Ogidi and Oke-Oyi in the course of its area expansion. To exclude these settlements will be cutting away areas of systematic movement oriented towards the town. To include them might be considered a "political offence". It was therefore decided to define the areal extent of Ilorin before proceeding to collect the required data. Various terms have been used to describe the areal extent or influence of the metropolis. Such terms include umland (Wise, 1966); Urban field (Smailes, 1947); City region (Dickson, 1930) and Community of interest area (Green, 1955).

In terms of criteria to be used Smailes (1947) has warned that one must be aware of those economic and social functions which a city performs for its neighbouring areas and in so doing pay attention to criteria with concrete measurable data. Such data include education, economic indicators, health sector, entertainment and movement of people among others, depending on the problem under investigation. The fields of each criterion or function involve plotting on a map, the distribution of the patronage for that function. Once the distribution has been plotted, a boundary line can be drawn to show the maximum extent of the field (see Yeates, 1963; Toyne, 1971).

A similar approach has been used by Green (1955) to determine the boundary between New York and Boston Metropolitan areas. Also Carruthers (1957) explained that the field of a city can be defined by the analysis of flow lines on the basis of overall transportation flows between the centre and its surrounding area. As a result of using frequency of taxi flows to define the boundaries of towns in England and Wales, Green (1955) concluded that motor transport diffuse metropolitan influence into every hamlet (see also Godlund, 1956). Cox (1973) also found that there is a symbiotic relationship between the city and the surrounding area with which it has strong movement ties. Thus it is possible to obtain the "sphere of influence" of a city on the basis of daily commuting.

Based on Green and Cox's suggestions, it was considered reasonable to use the extent of areas served by intra-city bus transport as an appropriate surrogate for determining the areal extent of Ilorin. The choice of this surrogate is particularly relevant because the problem of this research relates to road development and urban expansion. It was therefore decided that areas surrounding Ilorin and served by intra-city bus services could be determined by conducting surveys at various bus loading locations within the city.

Intra-city bus loading locations were determined by first conducting a pilot survey whereby the various bus loading locations for intra-city bus services in Ilorin were visited. The loading locations identified are shown on figure 3.2. These are:

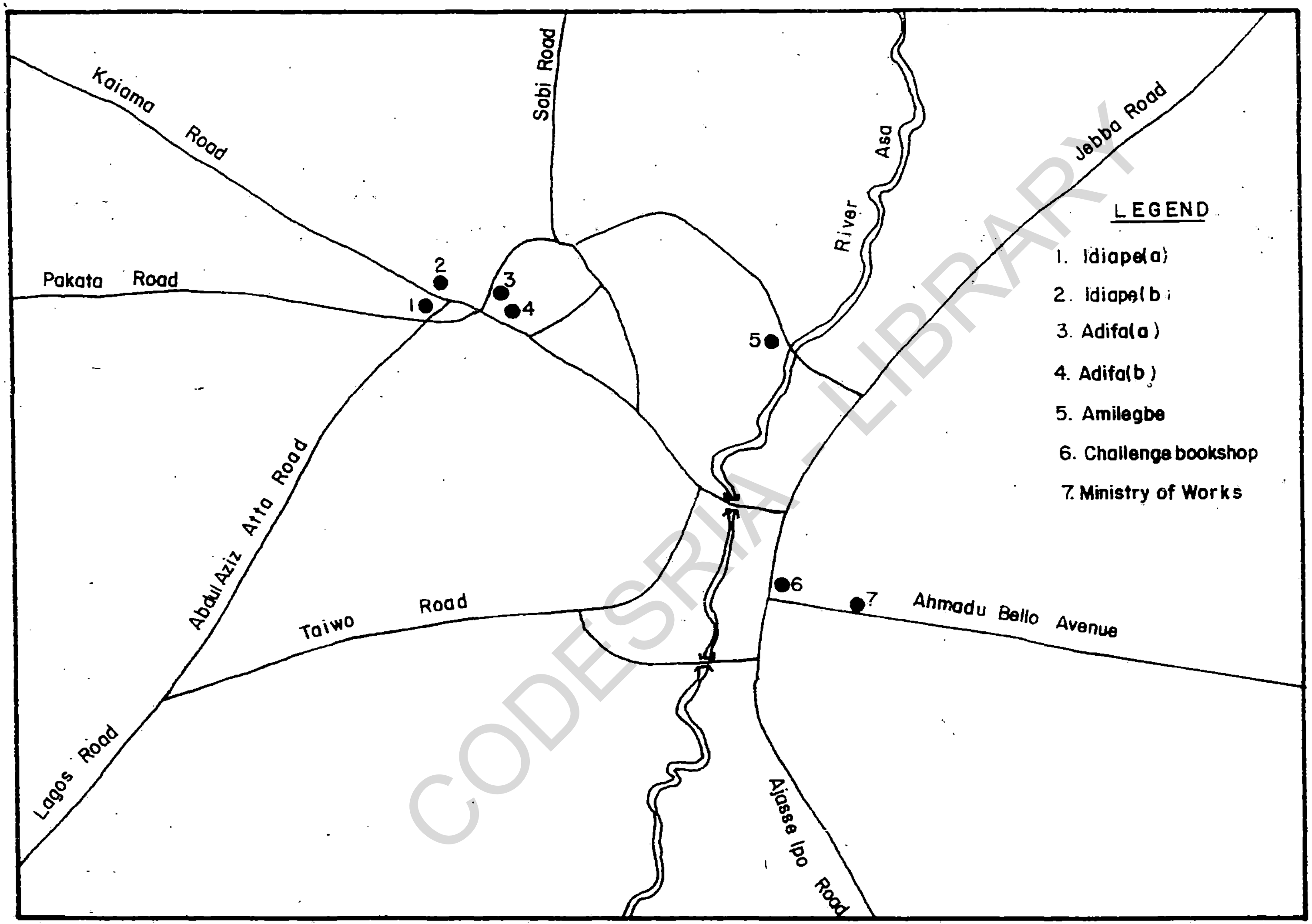


Fig. 3.2: Map showing Intra city bus stops in Ilorin

1. Idiape(a) - This location is for trips originating at 'Oja-Oba' and along Abdul Aziz Attah - Umoru Saro - Lagos route for passengers having their destinations at Sawmill; Garin Alimi Hospital area; Odota area and Airport.

2. Idiape (b) - for trips originating at 'Oja- Oba' and along Kaima route, for passengers having their destinations as Pakata, Alore, Omoda, Oloje, Adangba, Abayawo, Bonni, Abeemi and Ogidi.

3. Adifa Junction (a) - for trips originating at 'Oja-Oba' and along Gambari - Sobi route for passengers having their destinations as Akalambi, Akerebiata, Alagbado and Sobi.

4. Adifa Junction (b) - for trips originating at 'Oja-Oba' and along Emir - Murtala Way - Offa route for passengers having their destinations as Station, Post Office area, Tate and Lyle, Offa Garage, Ganmo and Amoyo.

5. Amilegbe Bridge Station - for trips originating at Amilegbe area and along Amilegbe - Jebba route for

passengers having their destinations as Kulende, Apata Yakuba, NNPC Depot, Oke-Oyi and Lajiki.

6. Challenge Bookshop;/(7) - Ministry of Works Junction for trips originating around Challenge Bookshop area and along Ahmadu Bello Avenue - Fate - Tanke - University of Ilorin route for passengers having their destinations at Tanke and Permanent site of the University of Ilorin.

Interviews were conducted at these locations on both drivers and passengers as to the origin and destinations of their trips, purposes of trips, routes usually taken by drivers, frequency of trips and approximate time usually taken per trip. (see questionnaire in Appendix I). The data collected were analysed by volume of traffic destined for different locations along the route of terminal. Using Dutt's (1971) technique of locating the cut-off point for passengers' destinations on a route, the termini were identified and represent the extent of the city along that route. These various locations were then joined using the author's knowledge of intermediate areas not linked directly by route. Fig.3.3 shows the result.

(b) Mapping From Aerial Photographs

Air photographs are important in the analysis of urban growth and change. The importance of air photographs in the study of urban growth has been demonstrated in such studies by Lo and Welch (1977) who monitored urban growth of thirteen Chinese cities through the use of LANDSAT photographs of these cities and by Adeniyi (1980) who used sequential aerial photographs and computer techniques to study the growth of Lagos. Hsu (1971); Lindgren (1971); Christensem and Lachowski (1976), Watkins (1984) and Olorunfemi (1985) have also studied urban growth through the use of aerial photographs. In order to monitor the growth of Ilorin, the methodology used by Adeniyi (1980) has been adopted in this study. Aerial photographs of Ilorin for 1963, 1973 and 1982 were obtained from the Survey Division of the State Ministry of Lands and Surveys.

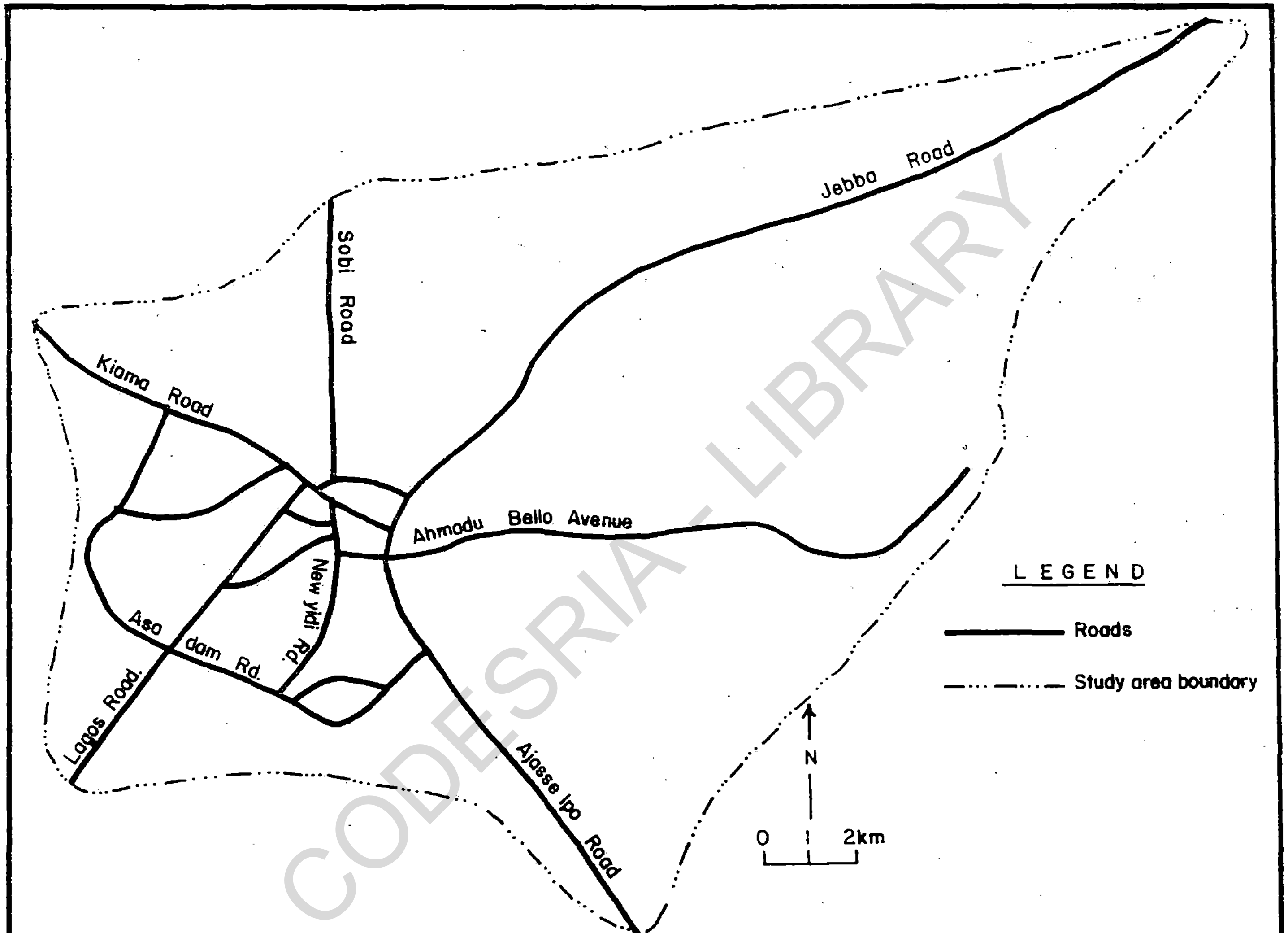


Fig. 3.3: Delimitation of the study area.

The aerial photographs available are those of 1963 on a scale of 1:12,000; 1973 on a scale of 1:10,000; 1982 on a scale of 1:6,000; semi-controlled photomosaics for 1982 photograph on a scale of 1:25,000. The following information were then mapped from the aerial photographs: (1) Built-up Areas (2) Major Land Uses (3) Housing Types (4) Main Road Networks.

Urban built-up areas encompass land that is used for housing, commerce, industry, institutions, recreational facilities and open spaces, transportation facilities and utilities (Adeniyi, 1980). The built-up areas were identified on the basis of use which can be essentially and directly observed on aerial photographs.

To obtain the built-up areas, each photograph was overlaid with transparent paper and each land use type transferred on to the transparent overlays.

The interpretation was carried out with the aid of a mirror stereoscope. The different land uses were transferred to transparent overlay and marked with each land use code (see Adeniyi, 1980). The area of each land use was then calculated using the dot grid method (Olorunfemi, 1981).[1] The total area for each land use category was obtained by summing up the areas of this use over the entire analysed area. The area of each land use type was then expressed as a percentage of the total land area in the city. These were done for the periods 1963, 1973 and 1982.

Different housing types were also mapped from the 1963, 1973 and 1982 aerial photographs using mirror stereoscope. This was to find out the growth of the different

1. The author is aware of Olorunfemi's (1985) work on this but still had to do his because this work was done for a different purpose. The author is grateful to the Survey Division for the materials and equipment made available.

house types in the city over the study period. Three housing types were identified for this study. These are:

(i) Indigenous houses;

(ii) Barrack/flatlets/bungalow;

(iii) Uncompleted houses.

This classification was to aid identification as the three house types were identifiable by their different characteristics (see Olorunfemi, 1984).

The technique of measurement employed was the house counting technique (Lindgren, 1971). The house types were transferred onto transparent overlay using different colour dots for each house type. The summation of the different dots gave the number of houses in each category.

Road networks for the city were similarly mapped for the years 1963, 1973 and 1982 from the aerial photographs. Three different categories of roads were mapped. These are:

(i) Major arterials;

(ii) Minor arterials;

(iii) Collectors.

This classification was to aid identification as it was possible to differentiate these categories from the aerial photographs through differences in their widths. The different road categories were also transferred on to transparency overlays using different colours for different road category. This exercise formed the basis for further analysis of road networks for the city.

(c) Fieldchecks And Updating Of Maps

Field checks were carried out to update information obtained from aerial photographs. This is to ensure the inclusion of more recent information on the study area that were not available on the air photographs and also to obtain 'ground - truth' on some of the information on the aerial photographs.

In order to update the map, the 1982 aerial photograph for Ilorin was used. For logistics, the built up area of the city was extracted from the aerial photograph and the map divided into four zones. These zones were visited by field assistants and new development areas were mapped. With this method, it was possible to produce an updated land use map of Ilorin for 1988.

(d) Division Into Traffic Zones For Data Collection

Information required in large details in the city include socio-economic information, trip information and traffic data. For the purpose of grouping origins and destinations of movements, the study area was divided into traffic zones. This was to allow for meaningful comparisons between various areas within the city and to permit easy aggregation of data.

In conventional urban transportation studies, internal traffic zones are defined using topographical barriers in conjuction with natural traffic catchment areas to delineate boundaries. These zones are then further subdivided on the basis of similarities in land use, population, employment and environmental characteristics (Bruton, 1970).

In the case of Ilorin, there has not been any major transportation study for the city in recent times. The land use map of Ilorin obtained from the

Town Planning Authority Office shows pockets of small land uses within dominant areas. This made classification on the basis of land use alone difficult and inappropriate for dividing Ilorin into traffic zones. Trips in Ilorin are governed more by major use areas and main routes. Thus traffic zones for the city were obtained by considering factors of predominant land uses and functional zones and also transportation networks. The predominant land uses were identified and the main routes providing access to them were used to delineate their boundaries. The major land uses in the city are residential, industrial, commercial, institutional transportational and mixed land uses. Based on these, the following traffic zones were obtained:

1. Adewole: This zone comprises Adewole, Agunbelewo, Olorunshogo, College of Education, Polytechnic Mini Campus, University of Ilorin Mini Campus and Agbo Oba. This zone is characterised by new private layouts of residential, commercial, industrial and institutional uses.

2. Baboko - Stadium: This zone comprises of Baboko area, Oko-Erin and Stadium areas. The zone stretches

along Abdul Aziz Attah road and eastwards towards and beyond Taiwo road to Stadium areas. It is partly inhabited by both the indigenes and also the non-indigenes.

3. Central Area: This zone includes the central core and the Emir's Palace; the Central Jumaat Mosque and the indigenous high density residential quarters of Alanamu, Gambari, Idiape, Oju-Ekun, Asunnara, and Okesuna areas. This zone contains the core of commerce, recreation and local administration of the city and the spatial pattern of urban growth in Ilorin began with this core.

4. Gaa Akanbi: This zone is an extension of new areas of private layouts and comprises of Gaa Akanbi, Atikekere - Oil Pipe Line; Ero-Omo, Olunlade, Ita Alamu and stretching to Ganmo and Amayo.

5. Gaa Imam: This zone contains the major industries in the city such as United Match Company, International

Tobacco Company, Kwara Furniture Manufacturing Company, Afro Works and the Kwara Transport Corporation. It has a few residential buildings with Gaa Imam being the nucleus of this residential development.

6. Reservation Area: This zone is the Government Reservation Area and consists mainly of Low Density Residential developments. Its western boundary is Murtala Mohammed road along which major commercial establishments can be found. These are C.F.A.O., G.B.O., P.Z. and also the Banks, Post Office, NEPA Office. Grafted to this low density area is the main administrative centre for the State Ministries, Parastatals and other offices located therein.

7. Kulende - Tanke: This comprises of Kulende and Tanke areas. The Kulende portion contains a medium density government residential layout and other private layouts. It also includes Oke-Andi, Apata

Yakuba. The Tanke portion is an extension of both government and private layouts with developments stretching from Niger River Basin Quarters, Fate Village and Tanke Villages and along the new University of Ilorin road including new government residential layouts to the south-eastern boundary of the zone.

8. Oke-Oyi: This zone comprises of settlements around the NNPC Depot, Oke-Ose and Oke-Oyi. It forms the north-eastern boundary of the study area.

9. Odokun-Odota: This zone comprises of Odo-Okun, Osere, Joro, Aiyetoro and Odota areas. It is an extension of private layouts and contains residential, commercial and industrial uses. It forms the southern boundary of the study area.

10. Oloje: This zone consists mainly of Pakata, Adeta, Okelele, Oloje, Akalambi, and Ojagboro areas. This zone is an extension of the central area

and is inhabited in the main by the indigenous population. Areas such as Abe-Emi and Ogidi, which have been engulfed by the spatial expansion of the city are included in this zone.

11. Sabo-Oke - Amilegbe: This zone encompasses Amilegbe area and Sabo-Oke. Sabo-Oke is the earliest settlement of "strangers" or non-indigenes in the town and it contains residential, institutional and commercial developments. The Amilegbe portion is an extension of new areas beyond the central core containing also residential, commercial and institutional uses.

12. Sobi: This zone comprises of areas towards Sobi Barracks including Akerebiata and is an extension of new private layouts to the north-east of the indigenous portion of Oloje zone.

13. University-Polytechnic: This zone comprises of the permanent site of the University of Ilorin and the permanent site of the Kwara State Polytechnic.

It contains institutional developments with residential quarters for staff of these institutions. These enumerated subdivisions form broadly the traffic zones for the study area. (Fig 3.4). The data collected from these zones were required for the understanding of the state the art of the transport system in Ilorin.

3.2 Data Collection Stage

Although five parts have been identified in the research design under the data collection stage, in terms of procedure of data collection, this can be aggregated into the following: (i) Data from aerial photographs (ii) Field work.

(a) Data From Aerial Photographs

Following the methods identified earlier for mapping from aerial photographs information on built-up areas; land use types; housing types and main road networks were extracted from the aerial photographs.

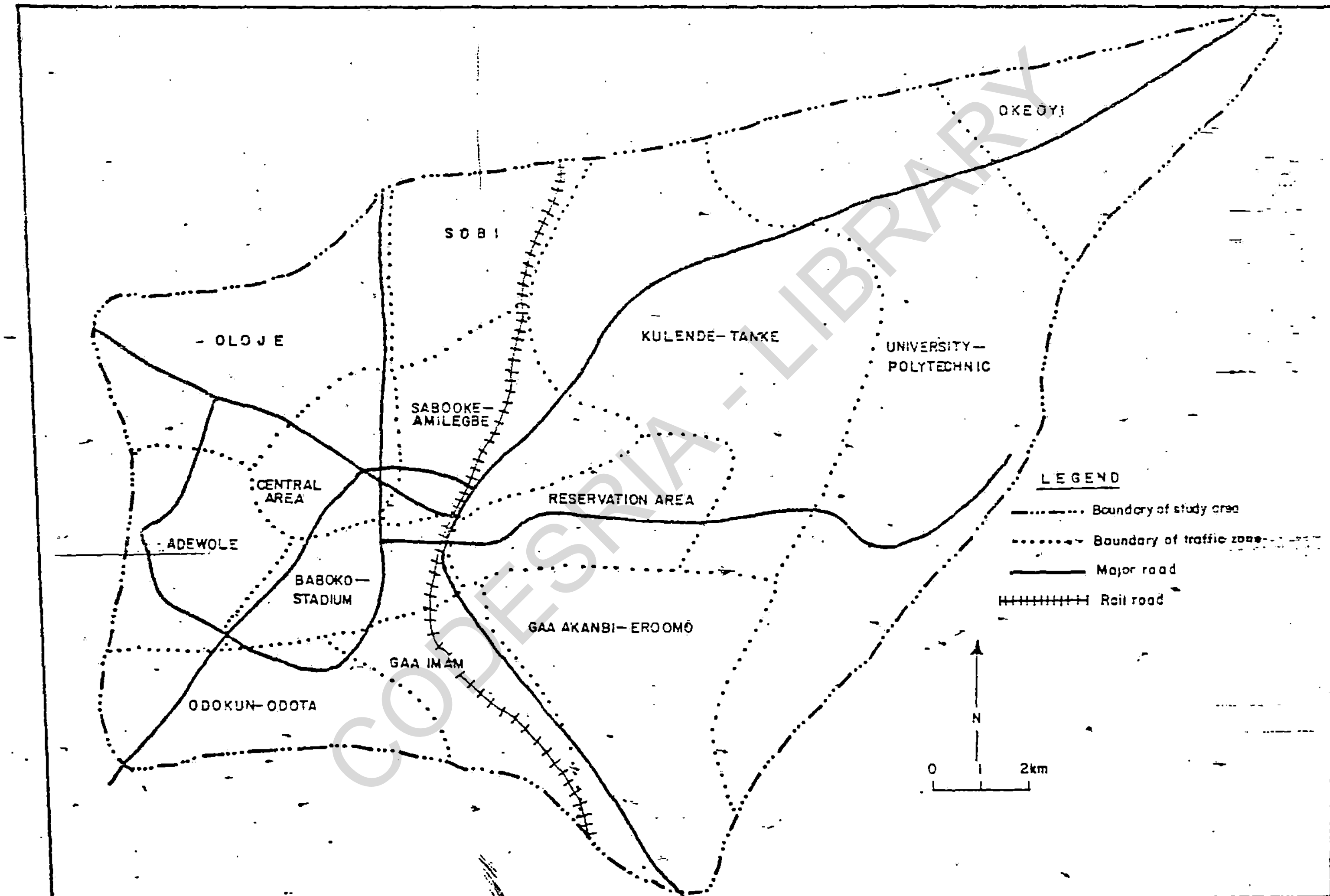


Fig. 3.4 Traffic zones in Ilorin.

(b) Field Work

Household survey, road quality survey and traffic surveys were carried out within the 13 traffic zones in the city. Data were also collected on factors of urban expansion.

The household survey was carried out to collect data on the socio-economic characteristics of the inhabitants of the city. As it was not possible to interview all the households in the city, a sampling technique had to be employed. To ensure that the sample is representative of the entire population and for adequate coverage, households included were distributed uniformly throughout the study area.

In conventional transportation study, Bruton (1970) recommends a sample of 1in 15 dwellings for a city of similar size as Ilorin. To adopt this sample size is to amass a very large amount of data which the author may not be able to cope with conveniently. Since the objective of this part of the work is just to obtain the generalized movement pattern for the understanding of the transport system of the city, a sample of 1in 20 was selected. To do this the first dwelling unit sampled in the systematic procedure was selected by field assistants at random and the next dwelling unit selected using the systematic sampling procedure of one in twenty dwellings. The sampling was done on dwellings along main streets. Two field assistants manned each of the traffic zones identified and with prepared questionnaires (see Appendix I), information were collected from households. The information collected include the address of the dwelling unit, and the demographic, social and economic characteristics of members of the households.

Because of time contraints, the household head and two other members of the household above fifteen years of age were interviewed.

In addition, information about all the travels of members of the households within the last forty-eight hours were obtained. The origin and destination of each trip, together with its purpose, the travel mode used and time taken were noted.

Road quality survey was also carried out for sampled roads in the city. The objective in the road quality survey was to obtain information for describing and categorising the roads in Ilorin. Various indices can be used to determine road quality. Ogundana (1972) has however suggested some indices which can be used in a developing country like Nigeria. These are width of road, capacity of road expressed in terms of number of lanes; surface condition of road; type of surface, period of motorability and road facilities.

Thus the information sought and collected through the use of questionnaires (see Appendix I) include road width, capacity of road, surface condition, type of surface, period of motorability, road facilities available and period of construction.

Due to time and cost constraints, it was not possible to survey all the roads in the city. Thus a sampling technique was adopted. The sampling involves first stratifying the road networks in the city into four categories by drawing North-South and West-East lines accross the middle of the road network map. The roads in each quarter of the subdivision were then allocated numbers. Ten percent of the total number of roads in each quarter was then selected through simple random sampling. A few major roads considered important but not selected in the random sample were added to the sample. The roads selected are: (1) Jebba road, (2) Kaima road, (3) Oko-Erin road, (4) New University road, (5) New Yidi road, (6) Reservation road, (7) Opo-Malu road, (8) Adewole road. These roads were then identified on the road network map and used for the survey. Information regarding ownership, maintenance and year of construction of the roads were also obtained from the State Ministry of Works.

Traffic surveys were also carried out along selected roads so as to determine the traffic pattern in the city. As it was not possible to conduct traffic surveys on all the roads in the city the roads selected for the road quality survey were also used for the traffic surveys. The traffic census involved a volumetric count with traffic classification along the sampled roads. Surveys were carried out at predetermined locations along the roads during the peak periods of 7.00 - 8.00 a.m. (morning peak) and 3.00 p.m. - 4.00 p.m. (afternoon peak). Counts were done by volume of flow and vehicle types (see Appendix I). The choice of peak periods for the surveys is due to the fact that peak period studies provide important information concerning the practical capacities of urban roads as they are the periods when the roads are carrying the highest volume of traffic (Salter, 1974).

In order to explain the morphology of Ilorin, factors of urban expansion were identified. Such identified factors can be used for the prediction of future morphology of the city. Some of the factors considered to be responsible for urban expansion are: housing demand, improved accessibility, improved standard of living, improved social and infrastructural facilities, industrialisation and land use type. As some of these factors cannot be measured directly, surrogate measures were used for them. Population was used as a surrogate measure for housing demand. Length of roads in the city for different periods was used as a measure of improved accessibility. Per capita income was used as a measure of improved standard of living. Enrolment in schools was used to measure improved social and infrastructural facilities. Employment in manufacturing was used to measure industralisation. Employment size was used as a measure of land use type.

Data on factors of urban expansion were collected from various secondary sources. Data on population, per capita income, employment in manufacturing, retail trade, total employment and vehicles registered were collected from records of the State Ministry of Economic Development while data on road lengths were collected from the Ministry of Works. Data on schools Enrolment were collected from the State Schools Board, Ministry of Economic Development and Ministry of Education, while data on water consumption was collected from the State Utility Board. Data on land cost were collected from records of Ilorin Local Government Estate Department.

3.3 Analysis Stage

The techniques of analysis used in this study include descriptive techniques, tabulations and cross tabulations, explanatory techniques such as graph-theoretic technique, factor analysis, multiple regression, correlation analysis and forecasting techniques such as Monte Carlo Simulation. These various techniques have been discussed and applied appropriately in the relevant portions of subsequent chapters.

CHAPTER FOUR

ROAD SYSTEMS AND INTERACTION PATTERNS IN ILORIN

From chapters one and three, it has become very important to understand the existing transport situation in Ilorin before examining the effect of the transport system on the spatial expansion of the city. It is to this aspect the chapter now turns.

This chapter which therefore examines the state of the art in the transportation system of Ilorin is discussed under the following sub-headings:

(i) Pattern of vehicular traffic,

(ii) Characteristics of intra-urban trips,

(iii) Spatial pattern of intra-urban trips.

This subdivision makes it possile to identify the traffic pattern in the city and the spatial pattern of intra-urban trips which are considered important in the growth of any city.

4.1 Pattern Of Vehicular Traffic

Traffic surveys were carried out on campled roads so as to determine the traffic pattern in the city. The procedure for selecting roads for the survey has been discussed in chapter III. For the roads selected, the following surveys were carried out.

(i) Road quality survey;

(ii) Traffic volumes and characteristics.

The roads surveyed are as shown on Fig.4.1.

(a) General Description Of Sampled Roads

The roads selected for the surveys are: (1) Adewole road (2) Jebba road (3) Kaima road (4) New University road (5) New Yidi road (6) Oko-Erin road (7) Opo-Malu road (8) Reservation road. Table 4.1 shows details of the selected roads.

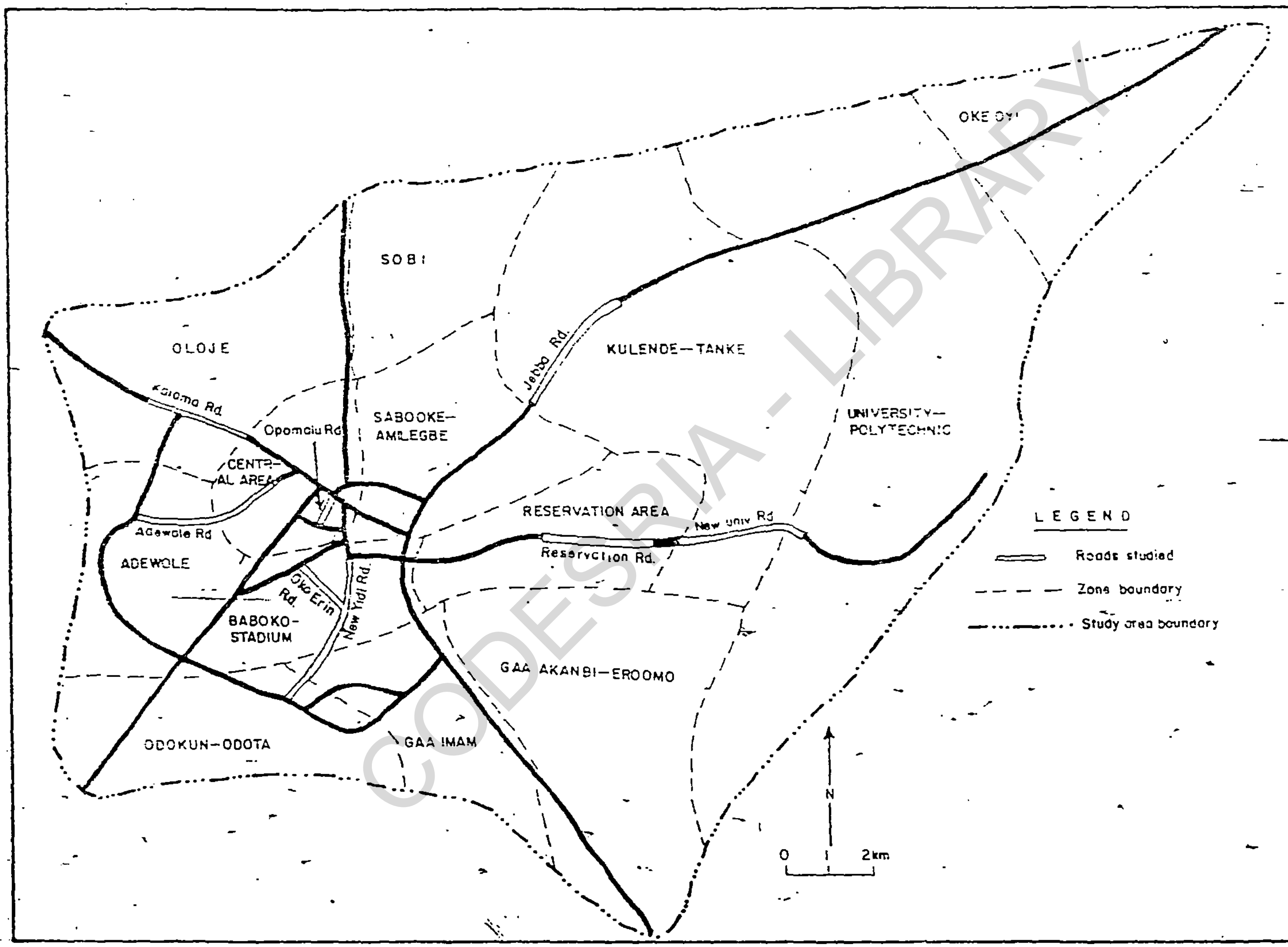


Fig. 4.1: Traffic zones showing roads studied.

Table 4.1 Selected Roads For Traffic Surveys

Name of Road	Traffic Zone	Body Which Owns The Road
Adewole	Adewole	Kwara State Govt.
Jebba	Kulende-Tanke	Federal Government
Kaima	Oloje	Federal Government
New University	University - Polytechnic	Kwara State Government
New Yidi	Baboko-Stadium	Kwara State Govt.
Oko-Erin	Baboko-Stadium	Kwara State Govt.
Opo-Malu	Central Area	Kwara State Govt.
Reservation	Reservation Area	Kwara State Govt.

Source: Author's Field Survey, 1988

The roads selected for the surveys differ in terms of standard and maintenance. For instance, Adewole road functions as a link between the commercial belt of Abdul Aziz Attah road and the indigenous residential quarters of Kuntu, Adeta and Pakata. It also connects the city with Adewole Housing Estate and Government High School. This road carries predominantly intra-city traffic and is owned and maintained by the Kwara State Government.

The other surveyed roads owned by the State Government are New Yidi road, Oko-Erin road, Opo-Malu road and Reservation road. The New Yidi road serves as a by-pass for traffic between the northern and southern parts of the country and in terms of local importance, the road collects traffic from Stadium road, Unity road and Osere road to feed Asa Dam road and the commercial and industrial land use zones along it.

On the other hand, Oko-Erin road is a single carriage-way and serves the residential areas of Oko-Erin, Odokun and Osere village. The road also serves Atoto Press Ltd; Government Girls' Day Secondary School and is an alternative route to Odokun motor park.

Opo-Malu road is also a single carriageway and is one of the busy roads within the Central Area of the city and serves as both a residential and commercial street. The road carries essentially local traffic and links the heavily commercial Emir's road with Saboline and Michael Ibru road (formerly Amilegbe road). To the northern end of the road is the Ipata market which is one of the busiest commercial centres in the town.

Reservation road is also one of the busiest roads within the Government Reservation Area. The road links the Kwara State Secretariat with Fate road. It is also a feeder to Saadu Alanamu road, Fate road and the New University of Ilorin road.

Jebba road and Kaima road are both owned and maintained by the Federal Government. They are both amongst the earliest Trunk A roads built by the Federal Government to link different regions of the country. Jebba road carries both intra city and through traffic as it links the city with the Northern parts of the country and to Kulende Housing Estate, Sango, Kulende village, Oke-Andi and the Kwara State Polytechnic. Kaima road on the other hand serves to link the city with Kaima, Shaki, Kishi, Igbeti and other settlements to the western boundary of the country. At the intra-urban level, Kaima road serves to link the indigenous quarters of Omoda, Oju-Ekun, Babata and Oloje. It also links the city with Ogidi quarters, the Federal Government College and various other institutional land uses to the western part of the city.

New University road is a single carriageway linking the permanent site of the University of Ilorin with the rest of the city. The road which carries only intra-city traffic serves also to link Tanke village, Government Reservation Area and Fate road.

(b) Road Quality Survey

The quality of these roads were determined using some indices of road quality. Indices used include

(1) Type of road surface;

(2) Condition of road surface;

(3) Width of road;

(4) Road vehicular capacity;

(5) Period of motorability;

(6) Seasonal condition of surface.

These various measures of road quality are of varying significance. The allocation of weighting scores to each of the measures can be effectively employed to take care of these differences.

In assessing road quality in Ife division, Aloba (1975) alloted weighting scores in order of importance to each road's subattributes.

For instance, in the assessment of type of surface, Bituminous surface was considered best and awarded a score of 10, gravel surface was awarded 5 while earth surface was awarded 1. In terms of condition of road surface, smooth surface was considered best and awarded 10 while rough surface was awarded 1 point. In this study, Aloba's (1975) methodology has also been adopted for assessing road quality. Table 4.2 shows the weighting employed for the analysis while Table 4.3 shows the assessment of the sampled roads using the weighting scores in Table 4.2.

Table 4.2 Weighting For Road Quality Assessment

Index	Weighting 10	Weighting 5	Weighting 1
Type of Surface	Bituminous	Gravel	Earth
Condition of Road Surface	Smooth	Fairly Smooth	Rough
Width of Road In Metres	14m or more	7 - 11 Metres	3-4 Metres
Road Vehicular Capacity	Four Lane	Two Lane	One Lane
Period of Motorability	All year Round	Partially Seasonal	Strictly Seasonal
Liable to Flooding	Not Applicable	Not liable to flooding	Liable to flooding

Source: Author's Data Analysis, 1988

From Table 4.3 it can be observed that Jebba road ranks first in terms of overall road quality scoring 14.19%. New Yidi and Reservation roads rank second scoring 13.89% while Adewole and New University

Table 4.3 Sampled Roads And Their Attributes

Name of Road	Seasonal Condition	Surface Condition	Type of Surface	Period of Motorability	Width of Road	Capacity of Road	Score	Percentage of Total Score
Adewole	Not floodable	Fairly Smooth	Bituminous	All Season	11.00m	Two Lane	40	12.35
Jebba	Floodable	Fairly Smooth	Bituminous	All Season	26.0m	Four Lane	46	14.19
Kaima	Floodable	Fairly Smooth	Bituminous	All Season	8.6m	Two Lane	36	11.11
New University	Not Floodable	Fairly Smooth	Bituminous	All Season	9.0m	Two Lane	40	12.35
New Yidi	Not Floodable	Smooth	Bituminous	All Season	11.0m	Two Lane	45	13.89
Oko - Erin	Floodable	Rough	Bituminous	All Season	7.95m	Two Lane	36	11.11
Opo - Malu	Floodable	Fairly Smooth	Bituminous	All Season	10.8m	Two Lane	36	11.11
Reservation	Not Floodable	Smooth	Gravel	All Season	11.0m	Two-Lane	45	13.89

Source: Author's Data Analysis, 1988

roads rank fourth. Kaima road, Oko-Erin road and Opo-Malu road rank sixth.

The characteristics of the sampled roads as calculated from the weighted indices is as shown on Table 4.4. The Table shows that 93.33% of the sampled roads are bituminous surfaced while the percentage of those with gravel surface is 6.67%.

Majority of those roads with bituminous surface are not liable to flooding. A total of 97.29% of the roads have smooth or fairly smooth surface. Only 2.71% have rough surface. Further, most of the roads 77.78% are of two lane while the four lane roads constitute only 22.22% of the sample.

The results show that there are more roads of bituminous surface than either gravel or earth surfaces in the city. Also, most of the roads are fairly smooth with average width of between 7 - 11 metres. In addition, most of the roads are of two lane, with all of them motorable throughout the year and only a few of them are liable to floodings.

Table 4.4: Characterisitics Of Sampled Roads

	Attributes	% of Sample
1.	Bituminous Surface	93.33
	Gravel Surface	6.67
	Earth Surface	0
2.	Smooth Surface	43.24
	Fairly Smooth Surface	54.05
	Rough Surface	2.71
3.	Width of 14m	22.22
	7 - 11m	77.78
	3 - 4m	0
4.	Four-lane Road	22.22
	Two-lane Road	77.78
	One-lane Road	0
5.	All Year Round	100.00
	Partially Seasonal	0
6.	Roads Not Liable To Flooding	92.31
	Roads Liable To Flooding	7.69

Source: Author's Data Analysis, 1988

In terms of land use concentration and road quality, the best roads in the city link institutional, industrial and reservation areas of the city. This is exemplified by the scores of Jebba road, New Yidi, Reservation and the New University road. The other roads viz. Kaima, Oko - Erin, Opo - Malu serve predominantly residential land use. It is noteworthy that while the Federal Government owns and maintains 25.0% of the roads; the Kwara State Government owns 75.0%.

(c) Road Facilities

The road facilities studied are drainage facilities, parking facilities, road signs, street lights, traffic lights, pedestrian crossings and the provision of traffic wardens within the segments of roads studied. Table 4.5 shows the analysis of facilities on these roads.

Table 4.5 Road Facilities On Studied Roads

Name of Road	Pedestrian Crossing	Traffic Lights	Street Lights	Parking Facilities	Road Signs	Traffic Wardens	Drainage Facilities
Adewole	-	-	-	-	-	-	x
Jebba	-	-	x	-	x	x	x
Kaima	-	-	x	-	-	x	-
New University	-	-	-	-	-	-	-
New Yidi	-	-	-	x	-	-	-
Oko-Erin	-	-	-	-	-	-	-
Opo-Malu	-	-	x	-	-	x	x
Reservation	-	-	-	-	-	-	-

Source: Author's Data Analysis, 1988

x Available

\- Not Available

The analysis of road facilities shows that none of the studied roads has pedestrian crossings, traffic lights and parking facilities. Further, 3 of the roads representing 37.5% have street lights while 2 roads representing 25.0% have road signs. Also, 3 roads each representing 37.5% have both traffic wardens and drainage facility.

The analysis shows a generally low level of provision of facilities on all the studied roads in the city. While the low provision of pedestrian crossing facilities contribute to pedestrian - vehicular conflicts at intersections and other major traffic generating points, inadequate provision of traffic lights and wardens, affects circulation at junctions. Inadequate provision of street lights increase accident rates at night on these roads while lack of parking facilities encourage on-street parking leading to reduction in effective road widths. Non-provision of road signs mislead motorists while lack of drainage facility on these roads leads to occasional flooding during the rainy season. The assessment of road facilities on the studied roads thus suggest that many of these roads need improved provision of facilities so as to increase their performance.

(d) Traffic Volumes And Characteristics

Traffic census was carried out on all the selected roads to determine the flow patterns. The method used for the surveys is as explained in chapter III.

Table 4.6, and figures 4.2 and 4.3 show the average volume of traffic along the sampled roads. The table shows that for both morning and afternoon peaks, Jebba road recorded the highest volume of traffic amongst the sampled roads these are 20.76% and 25.61% of total volume respectively. This is followed by the New University road with 16.98% and 14.90% for morning and afternoon peaks respectively.

New Yidi road ranks third recording 13.32% (morning peak) and 15.96% (afternoon peak) while Upo-Malu road recorded 12.61% (morning peak) and 14.37% (afternoon peak).

The flow along Jebba road exemplifies the gateway function of Ilorin. This is the only route by road through Ilorin connecting the northwestern and southwestern parts of the country. Besides, it serves Kulende residential estate, the commercial and residential areas of Kulende at the outskirt of the city, Oyun Police Barracks, School for the Handicapped and the Kwara State Polytechnic. Thus it carries a significant proportion of both through and local traffic.

Table 4.6 Average Volume Of Traffic Along Selected Roads

Census Point	Morning Peak			Afternoon Peak		
	VPH	PCU	% of PCU Total	VPH	PCU	% of PCU Total
1. Adewole at Post Office	490	475.3	7.92	460	454.0	7.05
2. Jebba Road at Kulende Estate Junction	1,134	1,245.5	20.76	1,488	1,649	25.61
3. Kaima Road at Akodudu	514	503.5	8.39	548	537.8	8.35
4. New University Road at Sofadin Departmental Store	1,043	1,019	16.98	950	959.5	14.90
5. New Yidi Road at Circular Hotel	769	799.3	13.32	974	1,027.3	15.96
6. Oko-Erin Road at Exodus Club	422	400.0	6.67	395	375.5	5.85
7. Opo-Malu Road at Alafia Hospital	792	756.8	12.61	972	925.3	14.37
8. Reservation Road at Agba Ornamental Park	816	801.0	13.35	514	509.5	7.91
Total	5,980	6,000.4	100.00	6,301	6,437.9	100.00

VPH represents Vehicles Per Hour, PCU represents Passenger Car Units.

Source: Author's Data Analysis, 1988

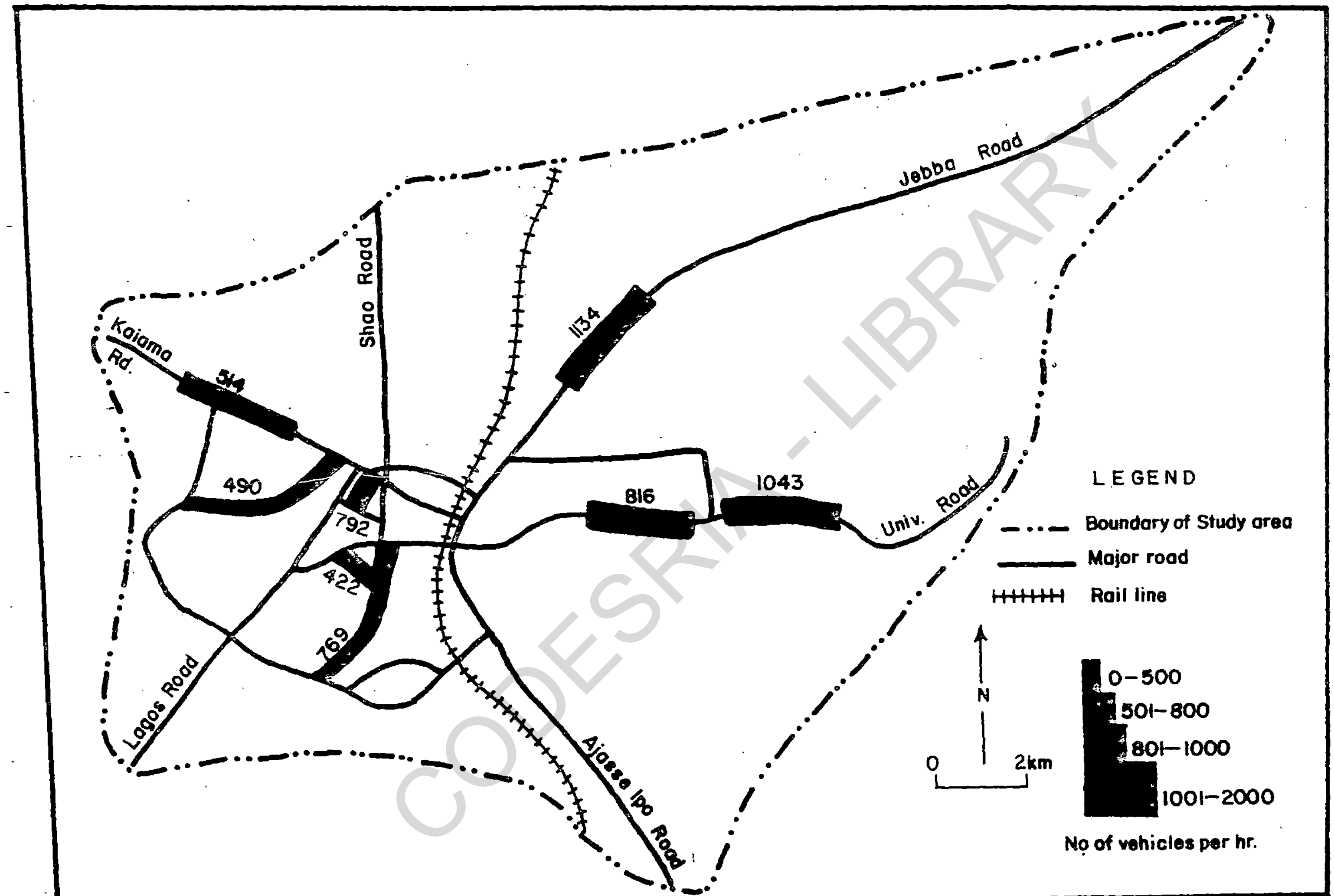


Fig. 4.2: Average volumes of traffic along selected routes in Ilorin (Morning peak).

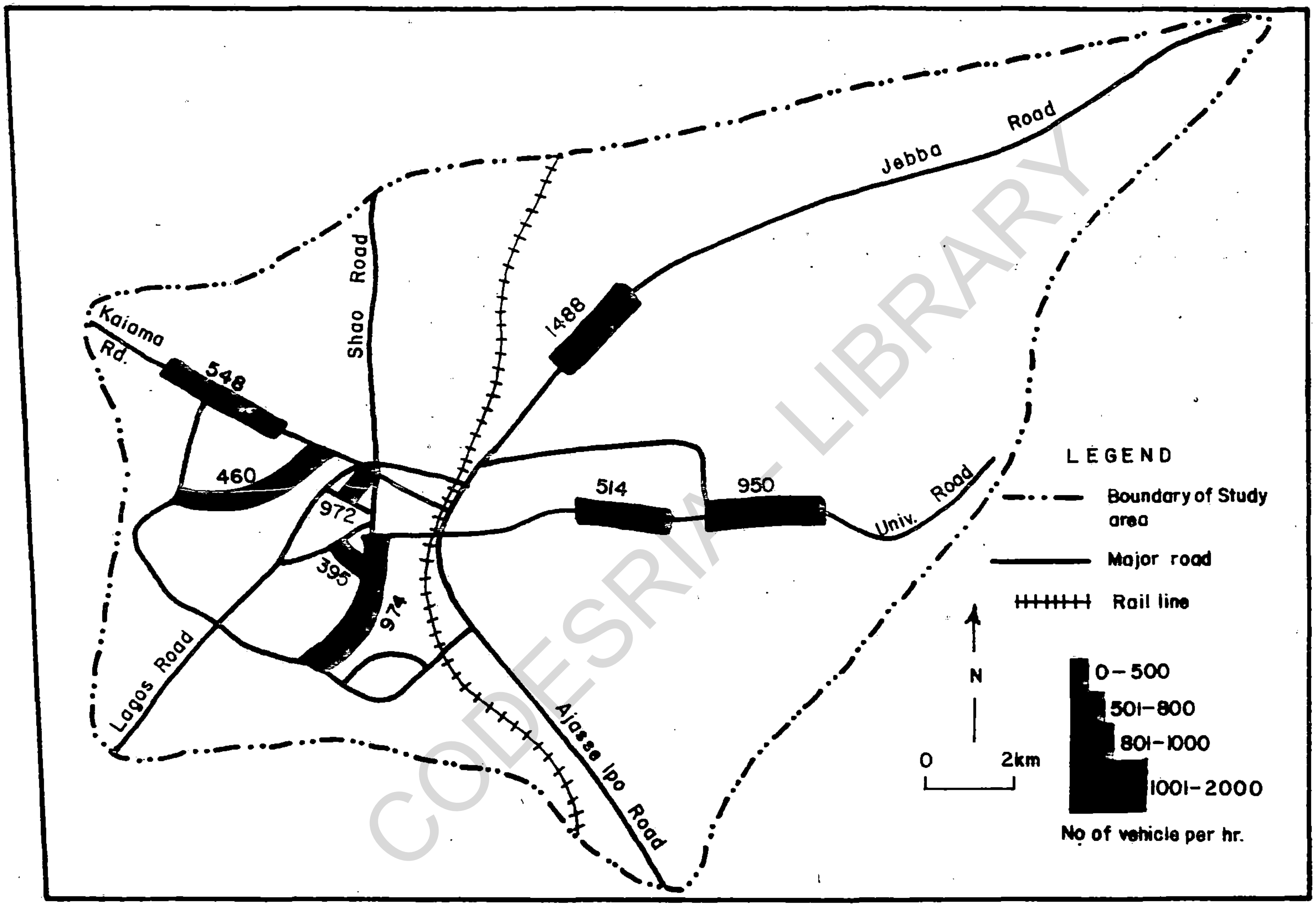


Fig. 4.3: Average volumes of traffic along selected routes in Ilorin (Afternoon peak).

The New University road, because of its role as the link to the main campus of the University of Ilorin carries a significant volume of daily traffic. Apart from the staff and students of the University who make daily trips to this site, the University Secondary School is located here. The Educational Resource Centre of the Kwara State Ministry of Education is another institutional land use attracting traffic along this road. Further, the New University road is the only major link between the city and Tanke village which is becoming one ofthe fastest growing residential areas in the city.

The proportion of traffic recorded by the new Yidi road goes to confirm its role as an important carrier of both through and local traffic. Also, the importance of Opo-Malu road as one of the busiest intra-city traffic arteries in the city is reflected in the percentage of total traffic volume recorded by it.

Reservation road is another important road amongst the studied roads as it recorded 13.35% (morning peak) and 7.91% (afternoon peak) during the survey. This is an important service road connecting the Government Reservation Area with other parts of the city.

Adewole Street, Kaima Road and Oko-Erin Road account for a total of 22.98% (morning peak) and 21.25% (afternoon peak) of total traffic volume. With the exception of Kaima road which carries low volume of inter-city traffic, these three roads carry mainly intra-city traffic to predominantly residential quarters in the city.

In terms of road capacity , most of the roads studied have not exceeded their design capacities. Although Jebba and New University roads carry high volumes of traffic during peak periods there are no restrictions on the roads.

However, with the spatial expansion of the city, more roads will be needed and the demand on the existing roads will increase. Thus traffic flows along major roads in Ilorin need to be monitored regularly so that the design capacities of these roads are not unduly exceeded. The consequence of 'over loading' any stretch of road beyond its design capacity is traffic congestion. As explained earlier, although traffic congestion is not yet a common feature on most streets in Ilorin, signs of potential bottlenecks are imminent (Ogunsanya, 1986).

In terms of traffic characteristics, the following vehicle categories were recognised. These are motorcycles, motor cars, including taxis, Mini Buses, Pick-ups, Lorries and Tippers, Big Buses, Trailers and Tractors. Appendix II shows the percentage distribution of vehicle types along the sampled roads in Ilorin.

The analysis shows that an average of 54.91% of all vehicles counted consisted of motor cars. This trend goes to show that in Ilorin, motor cars dominate the traffic.

Motorcycles recorded an average of 24.54% while Mini-buses and Pick-ups accounted for a total average of 17.21%. Lorries and tippers, Big buses, trailers and tractors constituted a total average of 4.61%.

The highest percentages of trailers and tractors were recorded along Jebba road (3.56%) and also on New Yidi road (3.12%). These two roads are the main carriers of trailers passing through Ilorin to the Northern and Southern parts of the country.

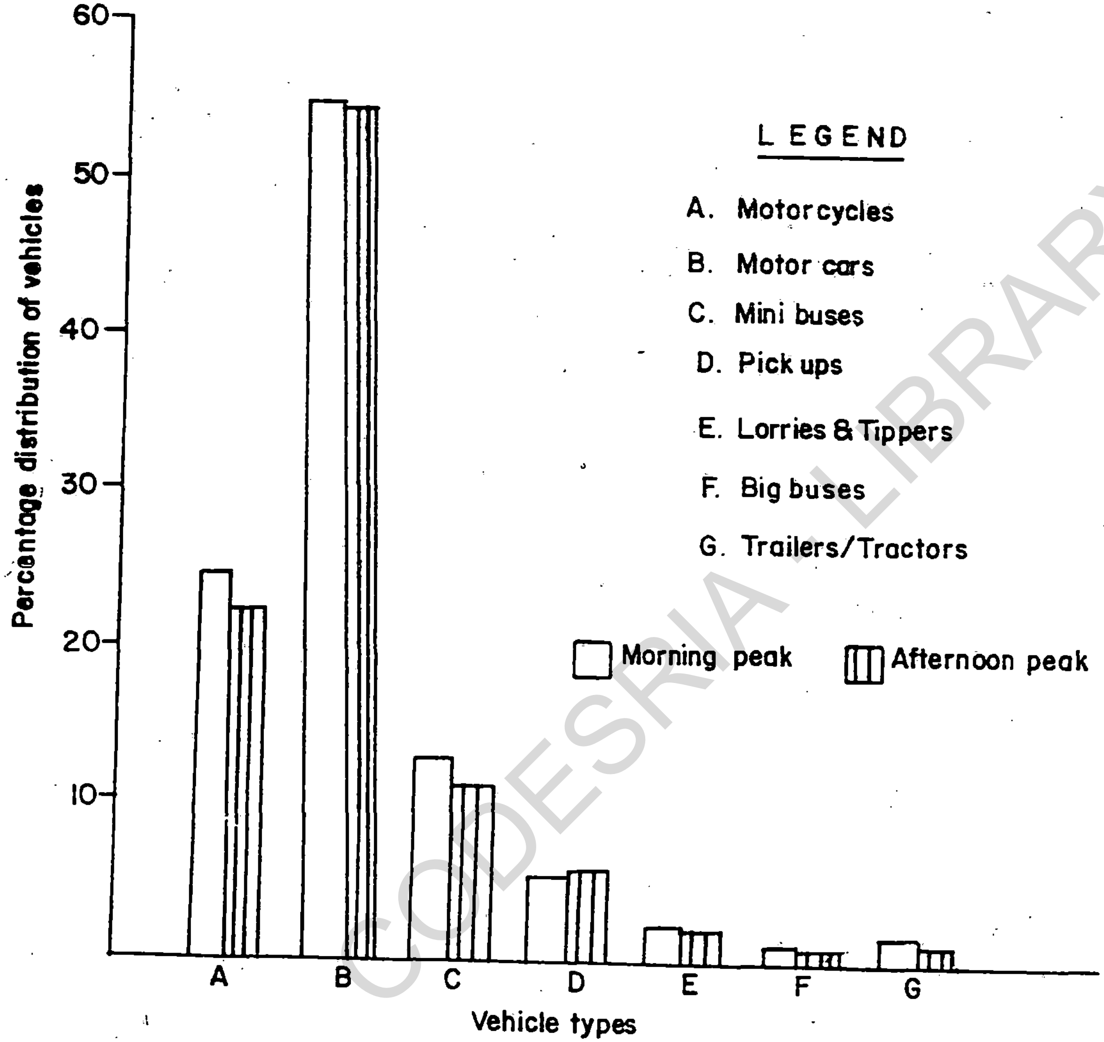


Fig.4.4: Graph of average distribution of vehicle types along selected routes in Ilorin.

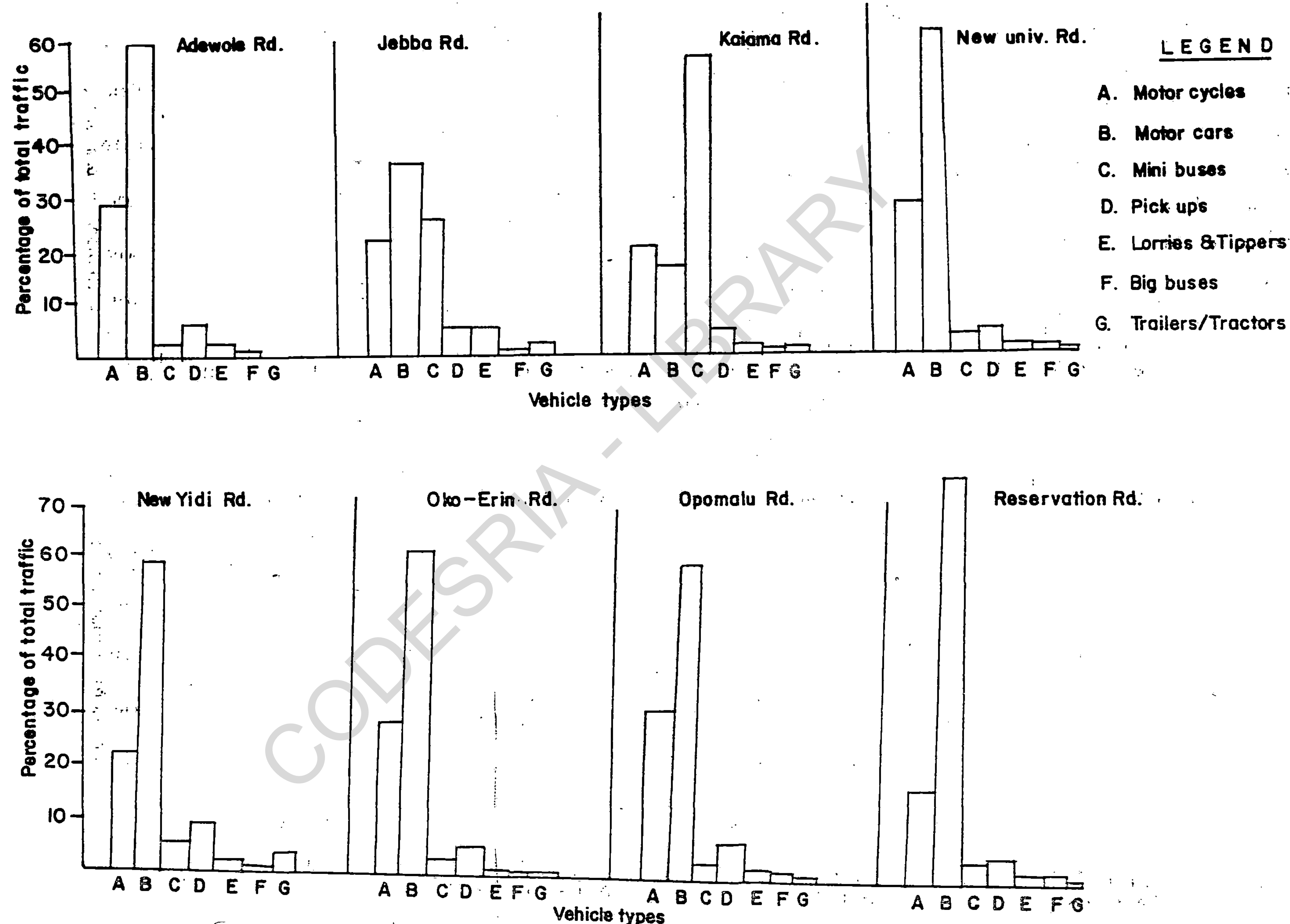


Fig.4.5: Distribution of vehicles by types along selected routes in Ilorin (Morning peak).

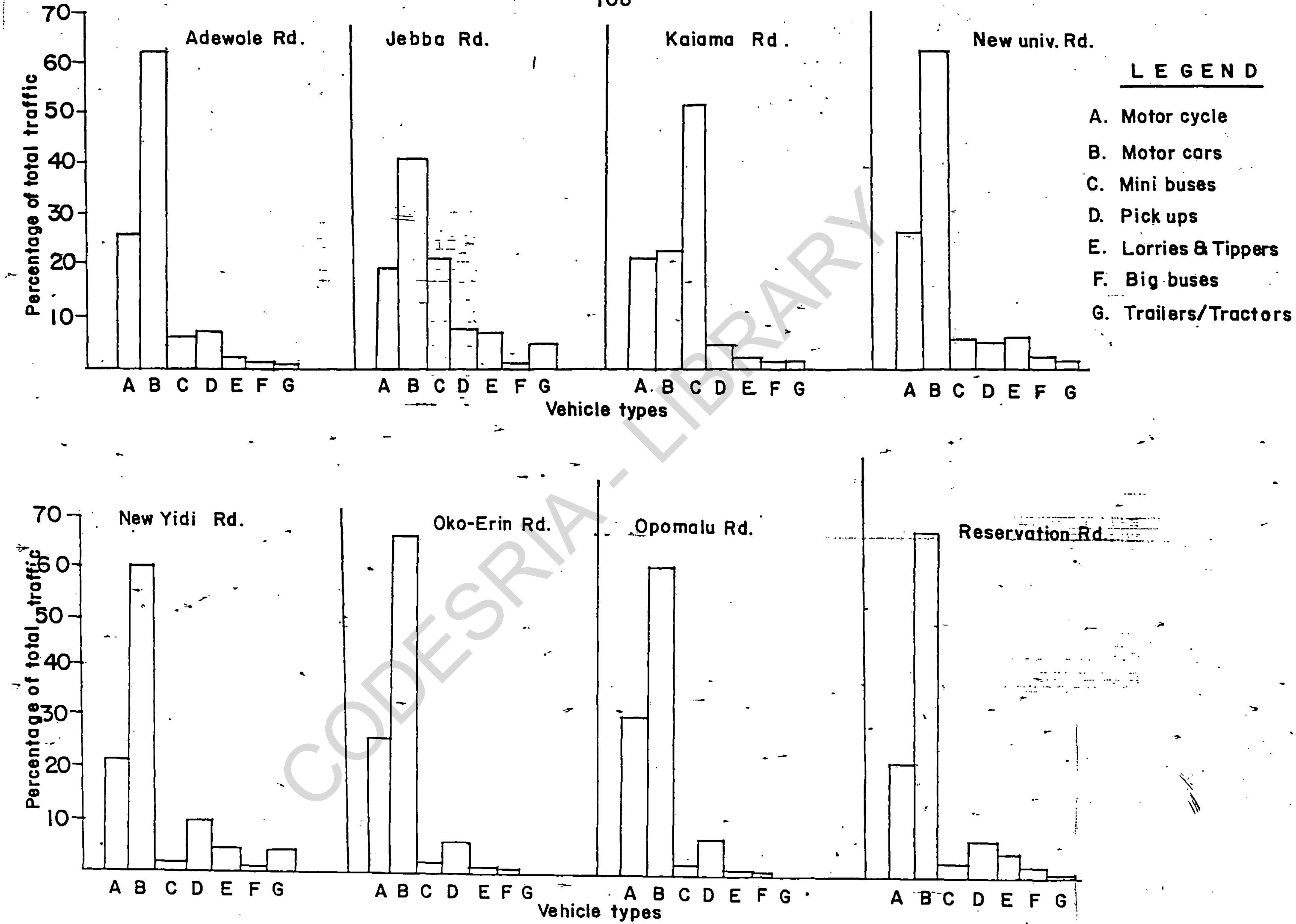


Fig. 4.6 :Distribution of vehicles by types along selected routes in Ilorin (Afternoon peak).

The highest percentages of Minibuses during the survey period were recorded on Kaima road(56.42%) and also on Jebba road(24.07%). These two roads are amongst the designated routes for intra-city bus service in Ilorin.

Overall the distribution of traffic volumes along selected routes in Ilorin depict the trend of growth of the city. Whereas the only major north - south route carrying the highest amount of traffic in the early sixties was the Emir's road, the expansion of the city including its road networks has resulted in the sharing of traffic volumes between other roads in the city. For instance, the New Yidi road has been serving as an effective by-pass for carrying through traffic that would otherwise have attempted to pass through the heart of the town thereby causing traffic congestion. Also the land use distribution has had significant effect on the distribution of traffic volumes. For example, the location of the main campus of the University of Ilorin to the north-east of the city serves to share traffic that would otherwise have concentrated on Abdul Aziz Attah, Taiwo and Lagos roads as a result of the former location of the University on the Mini Campus. So also is

4.2 Characteristics Of Intra-Urban Trips

Trip making is essentially concerned with movement between origins and destinations. Because patterns of movement of people appear to be similar for work, markets, recreation and shopping, trips made by urban dwellers result in various spatial patterns which come about as a result of passenger traffic interchange between the various origins and destinations. Interzonal trips make it possible to measure the functional link between zones and the spatial differentiation of activities. Thus functional regions of an urban centre can be identified through a study of the pattern of passenger movements.

The pertinent characteristics of intra-urban trips investigated here are the socio-economic characteristics of trips makers, the modes and purposes of trips and the spatial pattern of such trips. Such an approach makes it possible to discern the trip - generating and attracting capacity of various land use types or zones of the urban system.

(a) Socio-Economic Characteristics Of Trip Makers

A total of 1,870 people from all the 13 zones of the city were interviewed during the socio-economic survey.

The socio-economic information obtained from the respondents include age, sex, marital status, educational background, occupation and income.

Table 4.7 shows the age structure of the respondents. It can be observed that 34% falls in the 21 - 30 years age group. Respondents in the 31 - 40 years age group account for 24.1%, those in the 41 - 50 years constitute 20.0% while respondents above 50 years account for only 8.0%

Table 4.7 Age Structure Of Respondents

Age Group	No of Respondents	% of Total
15 - 20	375	20.0
21 - 30	637	34.0
31 - 40	450	24.1
41 - 50	259	13.9
Above 50	149	8.0
Total	1,870	100.0

Source: Author's Data Analysis, 1988

The analysis reveals that respondents in the more active age groups of 21 - 50 years constitute a total of 72.0%. The teenage group of 15 - 20 years and the older age group above 50 years constitute a total of 28.0%. These age groups are less active than the 21 - 50 years age groups and will therefore have less impact on the transport system of the town.

With respect to the sex composition of respondents 1,155 representing 61.8% are males while 715 representing 38.2% are females (Table 4.8). To the extent that men are the heads of households, there is more demand on transportation by men than women to meet the daily needs of their households.

Table 4.8 Sex Of Respondents

Sex	No of Respondents	% of Total
Male	1,155	61.8
Female	715	38.2
Total	1,870	100.0

Source: Author's Data Analysis, 1988

In terms of marital status, 1,346 respondents representing 72.0% are married while 498 representing 26.6% are single. Only 26 respondents or 1.4% are widowed. In Ilorin, early marriage, especially amongst the indigenous population is a popular practice. Such a pattern of marital status has implication for demand for more housing by couples and consequent physical growth of the city and transport development to meet the increased demand.

Table 4.9 shows the pattern of the educational level of the respondents. From the table, it can be observed that 29.5% of the respondents have secondary education while those with primary education constitute 18.2%.

Table 4.9 Educational Level Of Respondents

Qualification	Nof Of Respondents	% of Total
No formal Education	313	16.7
Primary Education	340	18.2
Secondary Education	551	29.5
University Education	332	17.8
Koranic Education	131	7.0
Diploma Holders	203	10.9
Total	1,870	100.0

Source: Author's Data Analysis, 1988

Respondents with University education account for 17.8% while those without any formal education constitute 16.7%. Diploma certificate holders and those with Koranic education account for 10.9% and 7.0% respectively. The pattern of educational level of respondents shows the people's acceptance of western education. In Ilorin, Koranic education had wider acceptance amongst the indigenous population until the early part of the 20th century when western education diffused the trend. Besides, Ilorin is a civil service town and contains a Federal Government University, a State Polytechnic, College of Education and many secondary and primary schools that provide the educational needs of the children of workers. Thus many primary, secondary and tertiary institutions have been built over the years. This has led to physical expansion and consequent improvement in the transport facilities.

With respect to the religion of respondents, 1,004, representing 53.7% are muslims while 827 representing 44.2% are christians. Respondents who are neither muslims nor christians account for 2.1%. Majority of the indigenous population of Ilorin are muslims living predominantly within the traditional area while christianity has wider acceptance in the new area of the city. More churches than mosques are also being built in the new area - contributing to the spatial expansion of the city and the demand on transport facilities.

The occupational pattern of respondents reveals that 32.3% engage in trade and commerce (Table 4.10). This is followed by those in government employment constituting 28.3%. Those engaged in Agriculture account for 7.3% while the percentage of those who are unemployed stands at 8.0%.

Table 4.10 Occupational Pattern Of Respondents

Occupation	No of Respondents	% of Total
Applicants	150	8.0
Agriculture	136	7.3
Construction	90	4.8
Trade and Commerce	604	32.3
Transport and Communication	65	3.5
Government Employment	530	28.3
Army/Force	61	3.3
Others	234	12.5
Total	1,870	100.0

Source: Author's Data Analysis, 1988

A few of the respondents, 4.8%, engage in construction, transport and communication account for 3.5%, while 3.3% are in the Army. As high as 12.5% are in other types of occupation such as artisans, craftsmen, portery makers and weavers. The analysis shows that those engaged in trade and commerce and those in government employment account for a total of 60.6%. The city has been growing along this occupational pattern as revealed by the land use pattern. Thus government employment centres and residential quarters for civil servants can be found to the East and North-East of the city while the western portion contains most of the commercial centres and markets in the city. The city is a growing centre of trading and commercial activities and a gateway city between the North and Southern States of the country.

Table 4.11 shows the pattern of the monthly income of respondents. 658 respondents representing 35.2% earn between ₦100 - ₦300.00 monthly. This is followed by those who earn between ₦301 - ₦500.00 constituting 24%. Those earning ₦100.00 or less account for 21.9% while those earning above

Table 4.11 Income Of Respondents

Income Per Month	No of Respondents	% of Total
0 - ₦100.00	409	21.87
₦101 - ₦300.00	658	35.19
₦301 - ₦500.00	449	24.01
₦501 - ₦700.00	250	13.37
₦701 - ₦900.00	86	4.60
Above ₦900.00	18	0.96
Total	1,870	100.00

Source: Author's Data Analysis, 1988

₦500.00 per month constitute a total of 18.9%. The income pattern of respondents indicates a generally low earning power of many people in the city. This trend is due to the initial status of the city as a civil service town with the majority of the working force as salary earners. Trade, commerce and industrial development are just beginning to make their impact in the city. It is therefore expected that the earning power of the inhabitants will continue to improve correspondingly with commercial and industrial development. This will definitely lead to faster physical development of the city, and greater transportation requirements.

The foregoing discussion gives the socio-economic background of people interviewed during the survey. The factors age, sex, education, occupation, and income just discussed affect trip making of a city's inhabitants and significantly affect trip patterns. In more developed countries for instance, the teenage population 15 - 20 years have been found to produce more journeys of a social and recreational nature than older age groups (Bruton, 1970). Further, the ability to pay for a journey affects the number of trips generated by a household. According to Maunder (1982), the higher the income, the higher the number of trips made. Schuldiner (1962) in his study of trip generation and the home, has shown that trip generation analysis based on socio-economic characteristics could lead to better understanding of trip length and trip interchange for the work and social trips.

(b) Modes And Purposes Of Trips

The modes used are foot, private cars, mini buses, taxi cabs, motorcycles and pedaled cycles while the trip purposes consist of work, business, social, recreation and shopping.

An examination of the modes of intra city trips in Ilorin reveals the dominant position of trips by private cars and taxi cabs. These modes account for a total of 63.0%. Trips by mini buses account for 18.4% while trips by foot constitute 12.5%. Trips by motorcycles and pedaled cycles account for a total of 6.1%. (Table 4.12).

The analysis of data shows that intra-urban trips in Ilorin are dominated by motor cars. Further, public transport modes such as taxi cabs, and mini buses account for a total of 53.1%. This trend is typical of most urban centres in Nigeria where there are no efficient mass transit systems. In these urban centres, taxi cabs and mini buses - which are para-transit modes of transport dominate the mode of urban travels (see Adeniji, 1983, 1985). This contrasts with the trend in more advanced countries of the world where urban travels are by well organised public transport system (Adeniji, 1983). In Ilorin, there has not been any well-organised public transport system for quite sometime now.

Table 4.12 Trips By Modes In Ilorin

Mode	No Of Trips	% of Total
Foot	497	12.5
Private Cars	1,128	28.3
Mini Buses	733	18.4
Taxi Cabs	1,380	34.7
Motorcycles	211	5.3
Cycles	32	0.8
Total	3,981	100.00

Source: Author's Data Analysis, 1988

The impact of the recently introduced public transport system provided by the Kwara State Transport Corporation is not being felt by the inhabitants of the city since it provides more of inter-city than intra-city services.

Analysis of trip purposes in Ilorin reveals the predominance of work trips over the other trip purposes. Work trips account for 24.4% of total trips and this is followed by recreational and social trips accounting for a total of 33.0%. Business trips constitute 15.6% while trips to religious centres such as mosques and churches account for 12.8%. The contribution of trips to markets and shopping centres is 9.2% while other trips constitute 5.0% (Table 4.13).

Table 4.13 Intra-City Trips By Purpose

Trip Purpose	No of Trips	% of Total
Work	972	24.4
Business	619	15.6
Social	646	16.2
Recreation	670	16.8
Market	368	9.2
Religious	508	12.8
Others	198	5.0
Total	3,981	100.0

Source: Author's Data Analysis, 1988

The analysis shows that work trips dominate intra-urban trip purposes in Ilorin. These are trips to the main government administrative centre in Ilorin (Secretariat), others are to the Federal Secretariat at Fate, the Local Government Secretariat and the various educational institutions in the town and other private establishments in various parts of the city.

The recreational trips are to major recreational areas such as the Amusement Park, Hotels, Stadium and Sports Grounds and social trips to friends and relations in various parts of the city.

With regards to trips to religious centres, these are trips to mosques and churches which are located within residential areas in various parts of the city. Such trips are made on a daily basis and especially on Fridays and Sundays which are special days observed by the muslims and christians respectively.

Trips to markets and shopping centres are to four main locations in the city. The main markets are the Emir's market or 'Oja Oba', Ago market, Ipata market and Baboko market. Emir's market has continued to attract a large number of trip makers daily in spite of government's efforts to stop market activities in this area. The reason for the persistent patronage of 'Oja Oba' appears to be due more to the traditional attachment the indigenous population have to this centre and the Emir's palace which still is the commercial, traditional and administrative nerve centre of the city. Ago, Ipata and Baboko markets also attract a significant number of trip makers daily. The other components of shopping trips are trips to various commercial establishments along Murtala Mohammed way, Ibrahim Taiwo road, Abdul Aziz Attah road, Wahab Folawiyo road (formerly Unity road) and various Supermarkets in the city.

The pattern of trips by age groups is as shown on Table 4.14. The table shows that respondents in the 21 - 40 age groups account for a total of 60.3% of total trips. This is followed by respondents in the teenage group of 15 - 20 years who constitute 17.2% of total trips. Respondents in the 41 - 50 years age group and those above 50 years constitute 15.8% and 6.7% respectively. This trend

Table 4.14 Trips By Age Groups

Age Groups	No of Trips	% of Total
15 - 20	685	17.2
21 - 30	1,244	31.3
31 - 40	1,154	29.0
41 - 50	632	15.8
Above 50 Years	207	6.7
Total	3,981	100.00

Source: Author's Data Analysis, 1988

shows that respondents in the age groups 15 - 20, 21 - 30 and 31 - 40 years are more active in trip making than respondents in the age groups 41 - 50 and above 50 years.

Further, the pattern of trips by income groups is as shown on Table 4.15. The table reveals that respondents who earn between ₦100 - ₦301.00 per month make the highest number of trips. Trips made by this group accounts for 32.50% of total Respondents earning between ₦301 - ₦500.00 make a total of 1,043 trips constituting 26.19% while respondents earning ₦100.00 and below make a total of 775 trips constituting 19.47%. Respondents earning above ₦500.00 make a total of 869 trips constituting 21.84% of total trips. Table 4.9 also reveals that an average of 2.72 trips are made by respondents earning above ₦700.00 while the lowest average number of trips of trips of 1.89 are made by respondents earning ₦100.00 and below. The analysis reveals that average number of trips increases as income increases. This trend goes to confirm findings revealed by studies in more advanced countries that increasing family income leads to greater trip production (Bruton, 1970 p.83).

Table 4.15 Pattern Of Trips By Income Groups

Income Per Month	No of Trips	% of Total	No of Respondents	Average No Of Trips
0 - ₦100.00	775	19.47	409	1.89
₦101 - ₦300.00	1,294	32.50	658	1.97
₦301 - ₦500.00	1,043	26.19	449	2.32
₦501 - ₦700.00	607	15.25	250	2.43
₦701 - ₦900.00	213	5.35	86	2.48
Above ₦900.00	49	1.24	18	2.72
Total	3,981	100	1,870	2.13

Source: Author's Data Analysis, 1988

The foregoing discussions reveal the characteristics of intra-urban trips in Ilorin. However, these characteristics only tell us the modal split and the purposes of trips. They tell us nothing about the spatial pattern of such trips. Spatial patterns are also important in the analysis of intra-urban trips because such patterns make it possible to link origins with destinations of such trips. This therefore is the object of the next section which describes the spatial pattern of intra-urban trips in Ilorin.

4.3 Spatial Pattern Of Intra-Urban Trips

The spatial pattern of intra-urban trips implies some recognizable order formed as a result of traffic interchange between various origins and destinations.

Table 4.16 shows the origin, destination matrix of trips between various traffic zones in Ilorin. It can be observed from the matrix that no recognisable order can be easily discerned. Some pattern discerning techniques can be used in the identification of spatial pattern of flows between regions. Such techniques include cartographic techniques (Ullman, 1957), graph theoretic approach (Nystuen and Dacey 1961), and factor analysis (Goddard, 1970).

In this study, factor analysis has been selected because of its inherent attribute of clarity with which inter-relationships can be identified. Besides, it can be

Table 4.16 ORIGIN DESTINATION MATRIX OF INTRACITY TRIPS IN ILORIN

	ADEWOLE	BABOKO-STADIUM	CENTRAL AREAS	GAA AKANBI-EROOMO	GAA IMAM	RESERVATION	KULENDE-TANKE	OKEOYI	ODOKUN-ODOTA	OLOJE	SABOOKE-AMILEGBE	SOBI	UNIVERSITY-POLYTECHNIC
1. ADEWOLE	34	84	18	5	0	20	11	0	12	1	7	1	1
2 BABOKO-STADIUM	13	109	89	12	0	40	8	0	21	1	35	0	2
3. CENTRA AREA	15	126	203	12	0	54	11	0	9	59	20	32	1
4. GAA AKANBI-EROOMO	26	156	99	33	14	129	19	0	15	35	29	2	1
5. GAA IMAM	4	12	16	23	5	17	3	0	3	7	6	1	0
6. RESERVATION AREA	3	36	12	8	8	63	38	0	1	3	14	2	21
7. KULENDE-TANKE	13	122	56	14	0	164	161	0	5	35	43	3	46
8. OKE OYI	0	0	7	0	0	0	4	92	0	0	2	0	0
9. ODOKUN-ODOTA	9	94	23	5	1	30	2	0	42	2	19	0	0
10. OLOJE	15	129	224	9	0	54	28	0	38	103	12	14	2
11. SABOOKE-AMILEGBE	6	16	18	1	0	25	10	0	0	9	23	0	0
12. SOBI	4	22	51	0	0	12	3	0	2	9	2	18	0
13. UNIVERSITY-POLYTECHNIC	4	23	11	3	0	35	28	0	0	26	5	0	63

Source: Author's Data Analysis 1988

used to determine from interrelationships of the large number of variables, the smallest number of factors whose association with the original variables will account for most of the observed interrelationships. According to Johnston (1978), Rees (1972), factor analysis can reduce any number of variables to new, hybrid variables that represent geographical associations of the original variables. Also Gould (1976) has pointed out that factor analysis is used to "attain scientific parsimony or economy of description".

Berry (1966) was the first to apply factor analysis to flow data. Thereafter, Britton (1971) used factor analytic technique to study commodity movements in England. Wheeler (1972) studied trip purposes in Lasing Michigan by using factor analysis. At the urban scale, Goddard (1970) analysed inter-zonal taxi flows within London with a view to regionalising the dominant flows. Kanno (1970) used factor analysis in showing the pattern of flows between U.S.A. metropolitan centres while Ogunsanya (1979) applied factor analytic technique to discern the spatial pattern of freight flows in metropolitan Lagos.

The application of factor analysis to matrices containing measures of flow or association between places enables us to delineate functional regions in a city, based upon the similarities in flow patterns. In such flow matrices the rows are origins and the columns are destinations. The matrix is initially subjected to correlation analysis. This yields correlation coefficients which indicate the strength and direction of the relationship between the variables. Factor analysis is then applied to the correlation matrix and the principal factor solution with verimax rotation extracts relevant factors.

The main outputs from the analysis which are useful in the interpretation of the flow pattern are the eigenvalues, the factor loadings; the factor scores and the percentage of total variance explained by the factors. The eigenvalues represent the total variance accounted for by the factor. The factor loadings are measures of the correlations between the original variables and the factors while the factor scores are measures of the contribution of each observational units on each factor. The percentage of total variance shows that part of the variation among the variables that is related to a factor pattern.

4.4 Application Of Factor Analysis To Trip Patterns In Ilorin

In order to identify the flow structures and functional regions in Ilorin, factor analytic method was applied to the origin destination matrix of intra-urban trips in the city. The 13 origin and destination zones were arranged in a 13 x 13 flow matrix with the cells containing volumes of intra-urban trips made. In this analysis, the destinations are treated as variables and the origins as observations. (See Goddard, 1970; Ogunsanya, 1982).

Using the R - mode factor analysis with varimax rotation, the flow matrix shown on Table 4.16 was subjected to the factoring process on the micro-computer AMSTRAD Model PC 1512 DD available at the University of Ilorin Computer Centre. This resulted in the extraction of four factors that accounted for 80.6% of total explained variance. Table 4.17 shows the factor loadings and the factor scores. These factors represent the four dimensions by which intra-urban trips may be classified in Ilorin. The factor loadings produce a regionalisation of the flow system in terms of the destination patterns while the factor scores identify the set of origins that interact significantly with these destinations. This results in a more precise indication of the functional nature and zonal composition of the factors as factor scores represent the relative importance of flows from particular origins (Wiseman, 1976). The resultant patterns are depicted by the series of flow maps shown in Fig. 4.7 to Fig. 4.10.

(a) <u>The First Dimension</u>

The first dimension accounts for 37.2% of the percentage of total variance with eigenvalue of 4.84112 and is

Table 4.17 The Factor Loadings and Factor Scores

Sector	Factor 1		Factor 2		Factor 3		Factor 4		
	Factor Loadings	Factor Scores	Factor Loadings	Factor Scores	Factor Loadings	Factor Scores	Factor Loadings	Factor Scores	
V1	0.69966	0.93927	-0.05174	-0.69921	0.08502	-0.84638	0.3007	-0.41360	V1=ADEWOLE
V2	0.80747	1.21284	0.208181	-0.15999	0.40157	-0.64331	0.32957	-0.33467	V2=BABOKO-STADIUM
V3	0.39992	-0.09209	-0.04344	-0.23935	0.89136	2.34463	0.07064	0.07960	V3=CENTRAL AREA
V4	0.41907	0.74143	0.18753	-0.15297	0.15503	0.00453	0.84949	2.88372	V4=GAA AKANBI-EROOMO
V5	0.00869	-0.76604	-0.06216	-0.62860	-0.13035	-0.42884	0.94854	0.63868	V5=GAA IMAM
V6	0.34402	-0.93606	0.74599	0.33630	0.15769	-0.46836	0.51900	0.83377	V6=RESERVATION AREA
V7	0.10290	0.42783	0.93936	2.91079	0.03589	-0.07154	0.02104	-0.14447	V7=KULENDE-TANKE
V8	-0.46146	-1.53583	-0.22391	-0.74523	-0.12881	-0.42872	-0.10138	-0.33741	V8=OKE OYI
V9	0.81099	1.39104	-0.24493	-0.64086	0.16075	-0.95598	-0.17050	-0.87208	V9=ODOKUN-ODOTA
V10	0.25513	0.96756	0.18632	-0.28201	0.85895	1.89955	0.02484	-0.67571	V10=OLOJE
V11	0.57770	-0.28739	0.57986	-0.10502	-0.04012	-0.62863	0.24704	-0.50205	V11=SABOOKE-AMILEGBE
V12	-0.05276	-0.99293	0.12418	-0.59842	0.89706	0.52874	-0.07050	-0.47818	V12=SOBI
V13	-0.24841	-1.06962	0.81818	1.00457	-0.08968	-0.20570	-0.12659	-0.67760	V13=UNIVERSITY-POLYTECHNIC
Eigenvalues	4.84112		2.66072		1.85407		1.11752		
PCT of Variance	37.2		20.5		14.3		8.6		
Cumulative PCT	37.2		57.7		72.0		80.6		

Source: Computer Output

characterised by high factor loadings on Adewole (VI), Baboko - Stadium (V2), Odokun - Odota (V9) and Sabo Oke-Amilegbe (V11) as destination zones (Table 4.11). The set of important origins as shown by the factor scores are Adewole (V1), Baboko - Stadium (V2), Gaa Akanbi - Ero Omo (V4), Kulende - Tanke (V7), Odokun - Odota (V9) and Oloje (V10). The region defined by the set of destination zones contains centres of Business Administrative, Educational and Recreational activities in the city. For instance, Baboko - Stadium zone contains some of the busiest business streets of Abdul Aziz Attah and Taiwo roads in the city. The Stadium Complex along Ibrahim Taiwo road attracts a lot of recreational trips while the Amusement Park along Wahab Folawiyo road (formerly Unity Street) also attracts significant traffic. Sabo Oke - Amilegbe zone contains the Government Ministries and Parastatals, primary and secondary schools while Adewole zone contains the University Teaching Hospital, University of Ilorin Mini Campus, Kwara State Polytechnic temporary site and the Kwara College of Education. Odokun - Odota zone contains Garin Alimi Hospitals, the Ilorin Airport and the Ilorin - Lagos road shopping belt. All these activities contribute to high traffic generation capacity of this region (Fig. 4.7).

(b) The Second Dimension

The second dimension accounts for 20.5% of the total variance with eigenvalue of 2.66072 and has high factor loadings on Reservation Area (V6) Kulende - Tanke (V7), Sabo Oke - Amilegbe (v11) and University - Polytechnic (V13). The set of important origins as shown by the factor scores are Reservation Area (V6), Kulende - Tanke (V7) and University - Polytechnic (V13). The set of destination zones contain most of the white - collar employment centres in the city. This region can therefore be labelled the 'white-collar employment' region of Ilorin. For example Reservation Area (V6) and Sabo Oke - Amilegbe (V11) contain the State Secretariat while Kulende - Tanke (V7) contains the Federal Secretariat. The University - Polytechnic (V13) contains a large number of white - collar workers in the city (Fig 4.8).

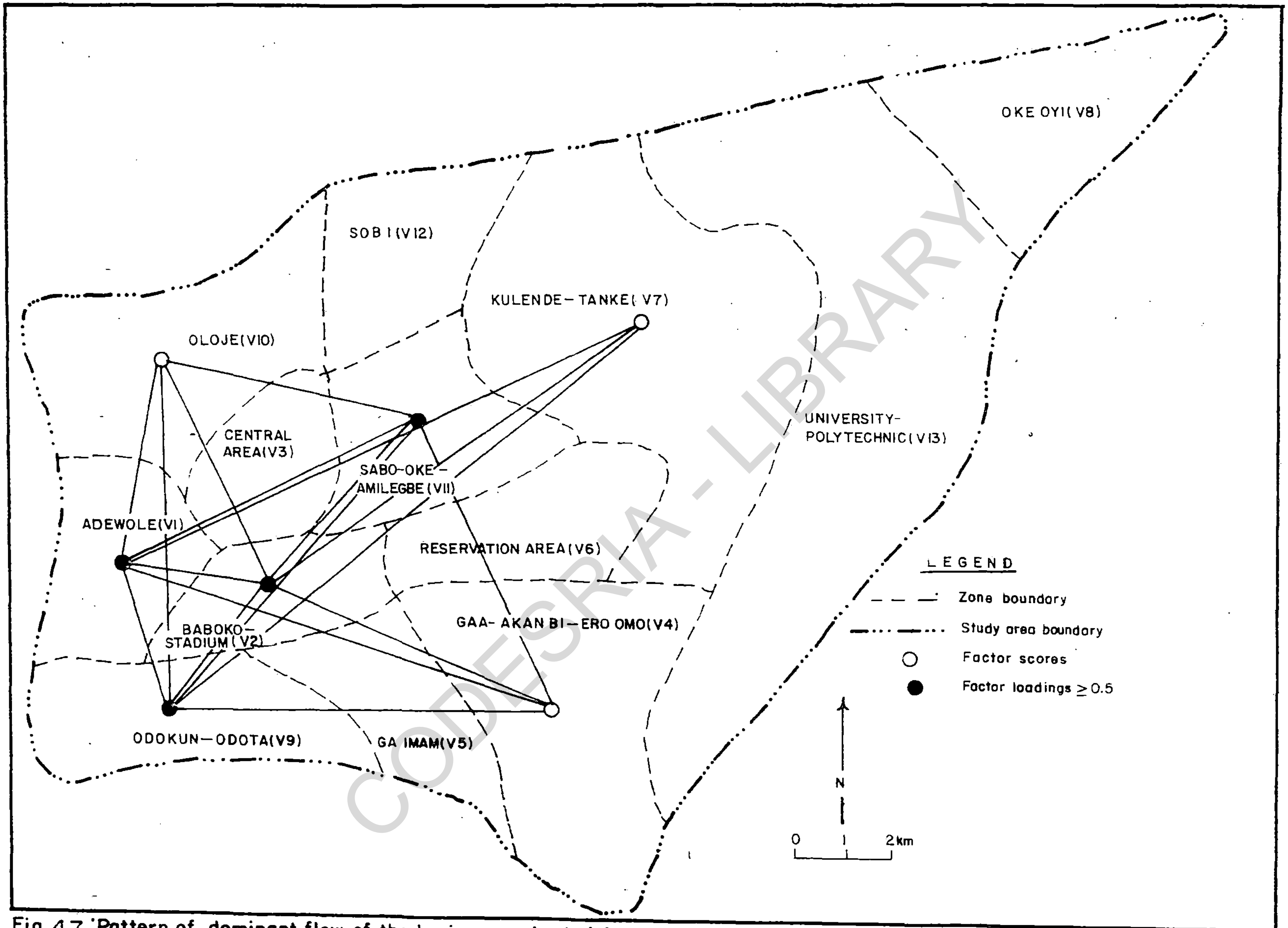


Fig.4.7 :Pattern of dominant flow of the business and administrative region.

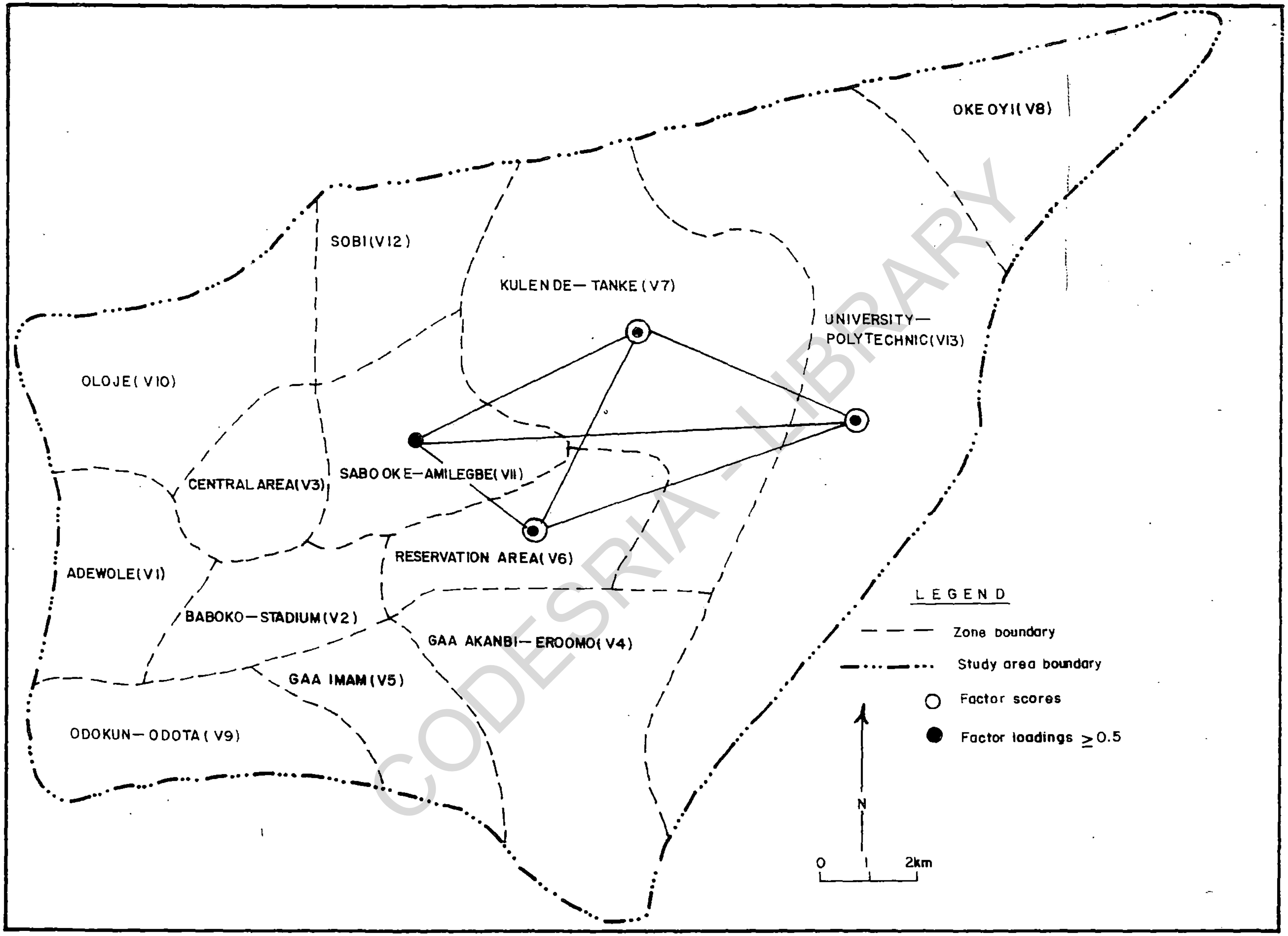


Fig.4.8: Pattern of dominant flow of the white-collar employment region.

(c) <u>The Third Dimension</u>

The third dimension accounts for 14.3% of the total variance with eigenvalue of 1.85407 and has high factor loadings on the central area (V3), Oloje (V10) and Sobi (V12). The set of important origins of traffic for this region are also central area (V 3), Oloje(V10) and Sobi (V12). The set of destination zones defines a region composing mainly of the indigenous population of the city. The zones are contiguous and can be labelled the 'indigenous' region. The Central Area (V3) contains the Oja Oba market, Ago market and the Local Government Secretariat. This zone is an important traffic generator as it contains the commercial, traditional and administrative nerve centre of the city. Oloje (V10) and Sobi (V12) attract more of social trips. (Fig. 4.9).

(d) <u>The Fourth Dimension</u>

The fourth dimension accounts for only 8.6% of the total variance with eigenvalue of 1.11752 and has high factor loadings on Gaa Akanbi - Eroomo (V4), Gaa Imam (V5) and Reservation Area (V6). These zones have correspondingly

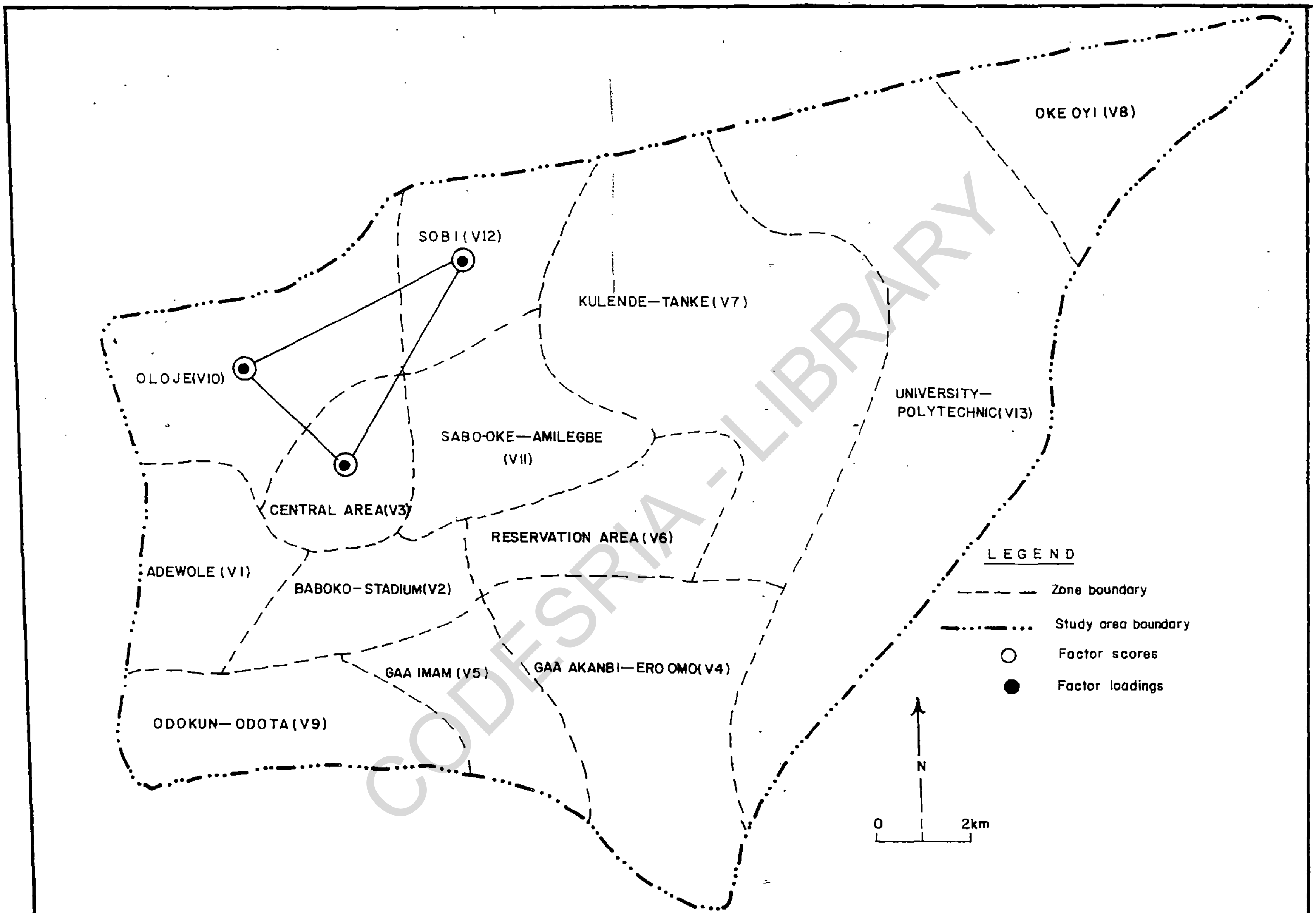


Fig.4.9: Pattern of dominant flow of the indigenous region.

high factor scores on Gaa Akanbi - Ero Omo (V4), Gaa Imam (V5) and Reservation Area (V6). The set of destination zones for this region are contiguous and contain most of the central facilities and services for the city. The region also contains the industrial centre. For example Gaa Akanbi - Ero Omo (V4) contains the State Utility Board Agba Water Works, the State Transport Corporation and the major industries in the city are found in Gaa Imam (V5) while the National Electric Power Authority Office, Commercial Banks, NITEL Office, Railway Station and commercial belts along Murtala Mohammed Way are found to the western end of the Reservation Area (V6). This region can therefore be labelled the 'central facilities and services' region. The importance of the functions of this region makes it a high traffic generator. The pattern of interaction for this region is shown on fig 4.10.

4.5 Zonal Hierarchies Within The City

The procedures just discussed enabled us to identify spatial pattern of trip flows between traffic zones. Through such an approach, it has been possible to analyze the extent

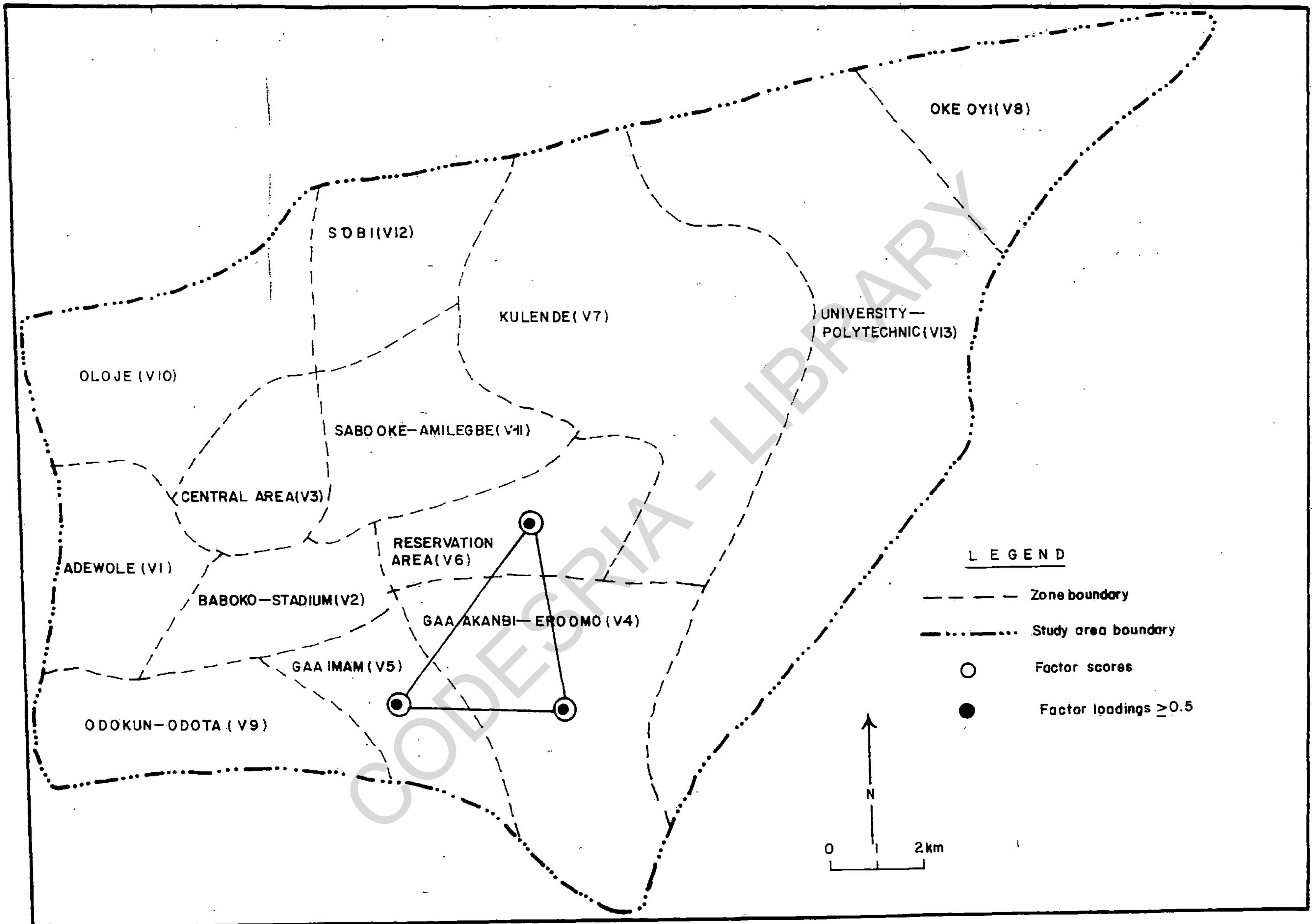


Fig. 4.10: Pattern of dominant flow of the central facilities and services region.

to which sets of nodes (either as origins or as destinations) have similar movement characteristics with a view to uncovering the significant regional connections. However, it is usually desirable to examine the nodality of each traffic zone in the interaction pattern so as to determine nodal hierarchies and particularly the "dominance order" of places and the channelling of flows up and down through such a hierarchy. In such analysis, places are grouped on the basis of the intensity of interaction between one zone and another, and specific traffic zones may be identified as dominating others. The assumption in this study is that intra-urban trip flows in Ilorin are structured through a zonal organisation which is hierarchical when trip interchange is used as a measure of functional linkage.

The hierarchical structure of traffic zones cannot be analysed by a mere examination of the flow matrix of intra-urban trips. Several methods have been proposed for determining the basic structure of such flows. However, the method used by Nystuen and Dacey (1961) and Soja (1968) is widely used in the literature on spatial interaction. Nystuen and Dacey used the graph theoretic approach to define nodal regions by reducing flow matrices to series of graphs and considering flows as links in a directed graph. Working with volumes of long - distance telephone calls between city pairs in the state of Washington, Nystuen and Dacey (1961) used interaction matrix to determine a flow structure which corresponded very closely with the nodal organization of the state. In the interaction matrix, the largest flow from each city that is, the maximum element in its row is determined. This notion of "largest flow" is then used to aggregate cities associated with a "central place" or "dominant centre". The functional size and rank of each city is measured by the number of messages it receives, that is, its column total.

A city is termed "independent" or "central" if its largest flow is to a smaller city whereas a "subordinate" or satellite city sends its largest flow of outgoing telephone messages to a larger city. The relationship between the central city or nodal point and the subordinates is transitive, for instance, if a city A is subordinate to city B which is satellite of city C, then city A is subordinate to city C. The graph showing this pattern of relationship contains a hierarachy of cities. Using this principle of "dominant association" Nystuen and Dacey went on to examine inter-urban linkages and dominance and established a nested hierarchy of urban centres and nodal regions.

These nodal regions comprise "central places" or "dominant centres" and surrounding cities which are subordinate to them. Each city dominates an area around it and, in turn, the small cities are assigned to those larger urban places with which they have the greatest number of linkages.

The largest flow from each satellite city is called the "nodal flow" and the aggregated flows from the nodal structure of the region contain a hierarchy of urban centres. Thus, order is established in terms of the aggregate values of incoming and outgoing flows and relations between nodes are determined by the maximum flow to a higher order node. The resulting network of flows defines the skeleton of the nodal organisation of the entire region and also displays the cities functional association.

4.6 Application Of The Zonal Hierarchy To Intra-Urban Trips In Ilorin

The 13 x 13 origin-destination matrix of intra-city trips in Ilorin was used to analyse the flow structure. The principle of "dominant association" was then used to order the city's traffic zones by the magnitude and direction of trips. The column total of the matrix are calculated to determine the zones functional sizes and ranks. The underlined values represent the largest flow from an origin to a particular destination. By simple examination, the maximum element in each row zone to the column zone is determined. This is the "nodal flow" and is underlined in the matrix. Using the property of "independent" and "subordinate" it is found that seven zones send their largest flows to larger zones while the largest flows in three zones are consumed within the zones (see Table 4.18). Thus ~~the~~ former ~~are~~ by definition "subordinate" while the latter are "independent". The resulting schema is shown in Fig. 4.11.

Table 4.18: ORIGIN-DESTINATION MATRIX OF INTRACITY TRIP FLOWS IN ILORIN

	ADEWOLE	BABOKO-STADIUM	CENTRAL AREA	GAA-AKANBI	GAA IMAM	RESERVATION AREA	KULENDE-TANKE	OKE-OYI	ODOKUN-ODOTA	OLOJE	SABOOKE-AMILEGBE	SOBI	UNIVERSITY-POLYTECHNIC
ADEWOLE	34	84	18	5	0	20	11	0	12	1	7	1	1
BABOKO-STADIUM	13	109	89	12	0	40	8	0	21	1	35	0	2
CENTRAL AREA	15	126	203	12	0	54	11	0	9	59	20	32	1
GAA AKANBI	26	156	99	33	14	129	19	0	15	35	29	2	1
GAA IMAM	4	12	16	23	5	17	3	0	3	7	6	1	0
RESERVATION AREA	3	36	12	8	8	63	38	0	1	3	14	2	21
KULENDE-TANKE	13	122	56	14	0	164	161	0	5	35	43	3	46
OKE-OYI	0	0	7	0	0	0	4	92	0	0	2	0	0
ODOKUN-ODOTA	9	94	23	5	1	30	2	0	42	2	19	0	0
OLOJE	15	129	244	9	0	54	28	0	38	103	12	14	2
SABOOKE-AMILEGBE	6	16	18	1	0	25	10	0	0	9	23	0	0
SOBI	4	22	51	0	0	12	3	0	2	9	2	18	0
UNIVERSITY-POLYTECHNIC	4	23	11	3	0	35	28	0	0	26	5	0	63
TOTAL	146	929	827	125	28	643	326	92	148	290	217	73	137
RANK	8	1	2	10	13	3	4	11	7	5	6	12	9

Source: Author's Data Analysis 1988

- Largest flow underlined.

Largest flow determined by the volume of outgoing trips.

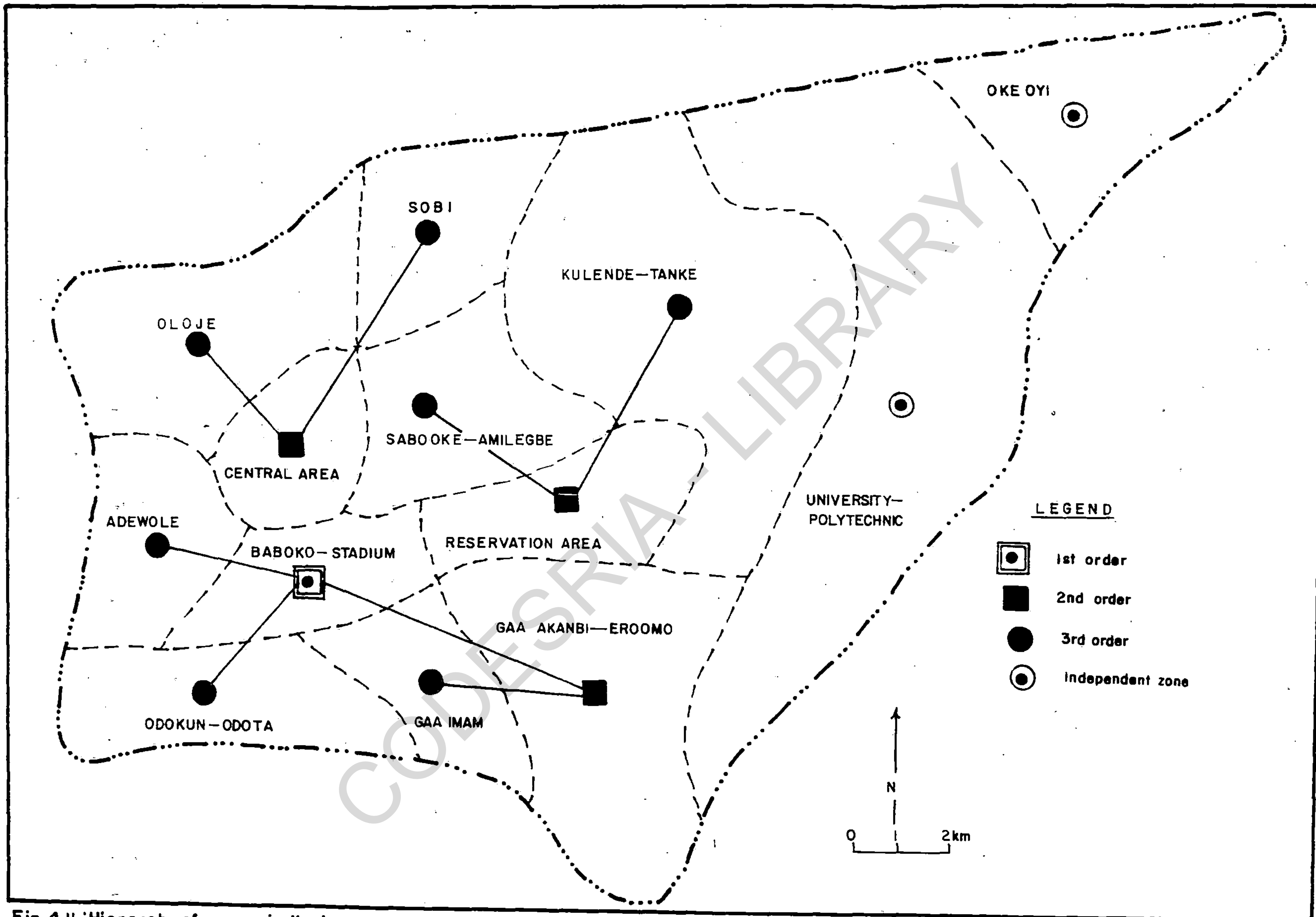


Fig. 4.11 :Hierarchy of zones in Ilorin.

From the result, it can be seen that Baboko - Stadium zone emerges as the most dominant centre with other subordinate zones which include sub-centres such as central area, Reservation Area and Gaa Akanbi - Ero Omo. These are concentrated to the western and northern parts of this dominant zone. The central Area dominates Oloje and Sobi zones while the Reservation Area dominates Sabo-Oke - Amilegbe and Kulende - Tanke zones. The largest flows from Oke-Oyi and University - Polytechnic are consumed by the zones themselves. These zones can therefore be regarded as independent zones. Gaa Imam is subordinate to Gaa Akanbi and Gaa Akanbi is subordinate to Baboko - Stadium. By the transitivity and the acyclic properties of the principles of dominant association, this flow pattern contains hierarchies. In the flow pattern, it is convenient therefore to rank Baboko - Stadium as the most dominant zone in the pattern of functional association. Central Area, Reservation Area and Gaa Akanbi - Ero Omo as second order zones while Adewole, Gaa Imam, Odokun - Odota, Oloje, Sabo-Oke - Amilegbe, Kulende - Tanke and Sobi can be regarded as minor or satellite zones. These dominant zones are areas of diffusion of trips to other parts of the city. Thus Baboko - Stadium zone being of the highest order in the hierarchy constitutes a major traffic generation and attraction zone in the city. Such high order zones in the hierarchy also constitute major growth points in physical area and traffic. In addition, such areas have the potential of rapid land use change.

The major objective of this chapter has been to highlight the fundamentals of the transport system in Ilorin. This is considered necessary for an understanding of the morphology of the city and the spatial pattern of road development in the city. The next chapters are concerned with the route development and the morphology of the city which are important aspects of the study.

CHAPTER FIVE

THE MORPHOLOGY OF ILORIN

This chapter discusses the changing nature of the morphology of Ilorin. The components of urban morphology as used here draw largely from Wuster's (1963) definition of urban form. According to Wuster, urban form can be described as "the physical pattern of land use, population distribution and service networks". In order to understand the changing morphology of Ilorin, changes in the built-up areas, the land use patterns and the housing types have been studied over time.

The data used here were acquired through mapping and interpretation of sequential aerial photographs of 1963, 1973 and 1982. The technique of photo interpretation is as discussed in chapter three.

5.1 Spatio-Temporal Perspective In The Evolution Of Ilorin

The study of the evolution of Ilorin has been classified into 5 periods. These are:

(i) The pre- 1897 pattern

(ii) The 1963 pattern

(iii) The 1973 pattern

(iv) The 1982 pattern

(v) The 1988 pattern

This classification is based on the availability of base maps and aerial photographs for these periods which form essential basis for an objective spatio-temporal analysis of the evolution of the city.

(a) <u>The Pre-1897 Pattern</u>

The pre- 1897 pattern of Ilorin is strongly tied to the history of the city. History has it that the town was founded about 1600 A.D. The series of wars which occurred between the then Ilorin ruler, Afonja, from Oyo and Alimi led to mixed ethnic groups in the city. These are the Yorubas, Hausas and Fulanis. There eventually emerged different warlords with the Oba becoming the Emir. The Emir's Palace which was centrally located became the centre of religious, commercial, recreational, administrative and cultural activities. The four warlords became the chiefs of their quarters which were located in a quandrangle around the Emir's Palace. These are the residential quarters of Balogun Ajikobi, Balogun Gambari, Balogun Fulani and Balogun Alanamu. The central core exerted a lot of influence on the quarters. Thus the spatial pattern of urban growth in Ilorin began with this small compact core.

The plan of Ilorin as prepared in 1897 is shown in Fig. 5.1. The plan shows the Emir's Palace in the central core and all routes originating from the outskirts of the town converged at the city centre. Because it was a pedestrian city then, the residential houses were located around the Emir's Palace to facilitate easy movement. There were no clearly defined "functional" areas and land use density decreased away from the city centre.

During this period, the whole town was surrounded by a wall. The overall pattern of growth then was one of concentric expansion. This pattern remained until the advent of the automobile in the 20th century.

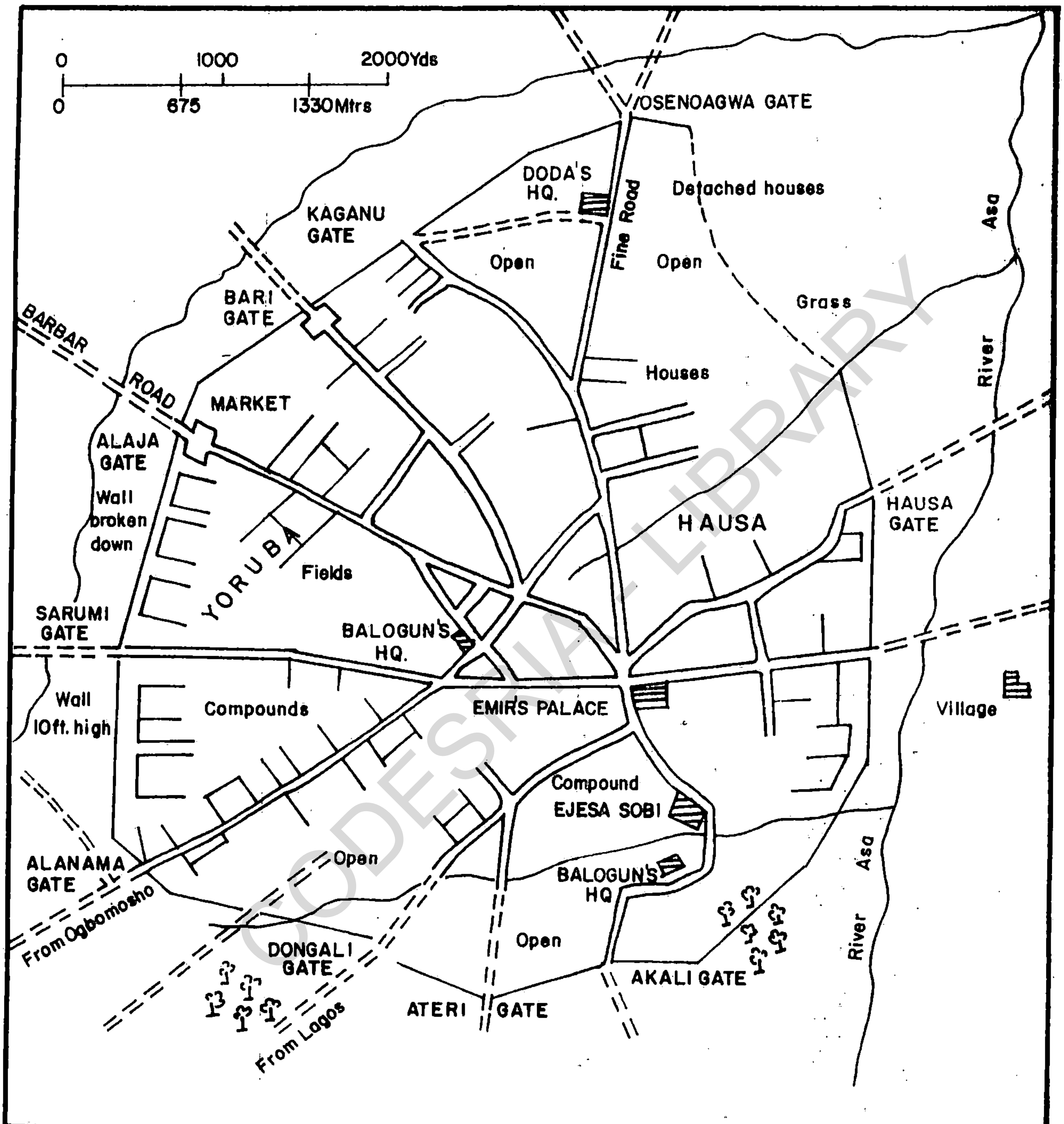


Fig.5.1. The plan of Ilorin (1897). Source: Olorunfemi, J.F. The growth of Ilorin: A documentation in aerial photography (1985)

(b) The 1963 Pattern

Fig. 5.2 shows the 1963 structure of Ilorin. This structure shows the land use pattern of the town which has emerged as a result of the growth of the city up to 1963. Compared with the structure in 1897, the core is still distinct with the Emir's Palace and the 'Oja Oba' serving as the centre of activities. However, a significant distortion has taken place in the pattern of Ilorin by this period. Unlike the concentric structure that obtained up till the late 19th century, modern technology and the introduction of the automobile in 20th century led to a sectoral form of development. Consequently, the hitherto concentric pattern of development around the centre and within the confines of the city walls has changed to radial growth along the road arteries in the city.

At this period too, the new section of the town had evolved. This new section resulted from a new

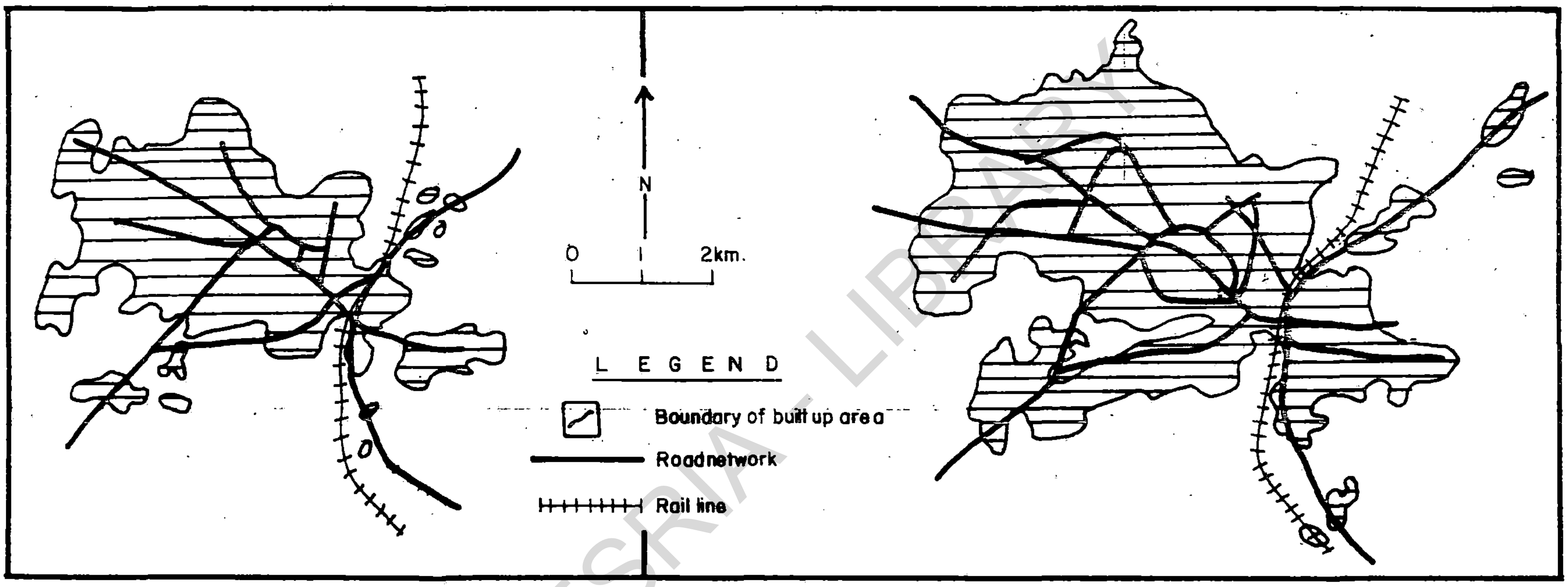


Fig.5.2: Map of built up area of Ilorin, 1963. Fig.5.3: Map of built up area of Ilorin, 1973.

area settled by 'strangers' or non-indigenes and the impetus of the colonial administration laid out a new area of the city in grid pattern in the early part of the 20th century. Thus the morphology of the city at this time consisted of the old and the new parts with the Asa River dividing the city almost into two. This brought about a combination of two different urban processes that are both indigenous and exogenous. The pattern then conforms with what McLee (1967) describes as a "dual city". According to McLee, the colonial administrators were responsible for this dualistic structure. In many such cities, both the traditional and the modern sectors display their own morphological patterns. Cities of this type have been referred to as orthogenetic cities (Redfield and Singer, 1954). Similar cities in Nigeria are Ibadan, Kano, Benin and Zaria. Examples of such cities in other countries are New Delhi-Delhi, Cairo, Tunis and Chinese Treaty Ports (Brush, 1962, Abu-Lughod, 1971, Brown, 1973, Ginsburg, 1965).

Table 5.1 depicts the land use pattern of Ilorin for 1963 while Table 5.2 shows the housing types. The total built-up area of the city was about 3,089.61 acres (1,235.84 ha) in 1963. This area consisted of 1,876 acres (750.4 ha) devoted to residential use and representing 60.72% of the total built-up area. The area devoted to transportation was 512.58 acres (205.03 ha) representing 16.56% while 295.25 acres (118.1 ha) representing 9.56% was devoted to commercial use. 217.0 acres (86.8 ha) representing 7.02% was devoted to institutional use while 178.58 acres (71.43 ha) representing 5.78% was devoted to recreation and open spaces. The area devoted to industrial use was only 10.5 acres (4.2 ha) representing 0.34%

<u>Table 5.1</u> <u>Land Use Analysis Of Ilorin 1963</u>

Land Use Category	Areas (Acres)	% of Total Area
Residential	1,876	60.72
Commercial	295.25	9.56
Industrial	10.5	0.34
Institutional	217.00	7.02
Transportation	512.28	16.58
Recreation and Open Spaces	178.58	5.78
Total Built-Up Area	3,089.61	100.00

Source: Author's Analysis of Data Extracted From 1963 Aerial Photograph of Ilorin.

The analysis shows the predominance of residential land use over other uses in the city during this period. Residential areas distributed all over the city included the residential quarters of the old part of the town and the new areas which included the Government Reservation Area carved out specifically by the colonial administrators for expartriates and senior civil servants.

Transportation land use ranked second to residential use and consisted of the main arteries for both internal circulation within the city and the main arterials linking Ilorin with the rest of the country. These are Jebba and Lagos roads serving as a North - South link while the Ajassepo and Kaima roads serve as links with the South - East and North - West respectively. The railway line runs acress the city in a North - South direction linking the city with the Northern and Southern parts of the country respectively.

The commercial land use covered the commercial areas and the Central Business Districts of the city. Commercial activities in the old part of the city concentrated at 'Oja Oba' and the local markets comprising the Alanamu, Pakata, Omoda, Ojagboro, Oloje, Gada and Alore markets. The most important of these is the emir's market which forms the traditional business district. Commercial activities could also be found along the main arteries of Emir's road, Balogun Fulani Street, Gambari Street, Pakata road, Abdul Aziz Attah road and Kaima road.

The institutional land use covered areas devoted to educational use, hospitals and health centres, public establishments and government administrative centres, police establishments and military premises. Notable institutional uses during this period were the Provincial Offices, the Local Government Offices, the Educational Institutions such as the Government Secondary School, Queen Elizabeth School, Bishop Smith Teachers' College, Ilorin Teachers' College, Ilorin Technical School and many Primary Schools located in different parts of the city.

With respect to industrial land use, the few industries existing at this time were the United Match Company, the

Tate and Lyle and the Tobacco Company.

The open spaces and recreational uses could be found within the built-up areas and at organised play grounds in schools and institutions.

Table 5.2 shows the housing types in Ilorin in 1963. Of the three house types - indigenous, barrack/flatlets, uncompleted buildings, the indigenous house type accounted for 76.23% of total while barrack/flatlets and bungalows constituted 16.81%. Buildings under construction accounted for only 6.90%. The indigenous house type could be found mainly within the old part of the city at this time while the barrack/flatlets and bungalows could be found within the new areas of the town and the Government Reservation Areas. Buildings under construction could be found in different parts of the city. The distribution of house types

Table 5.2 Housing Types In Ilorin, 1963

House Type	No	% of Total
Indigenous	6,412	76.29
Barrack/Flatlets and Bungalows	1,413	16.81
Uncompleted	580	6.90
Total	8,405	100.00

Source: Author's Analysis of Data Extracted From 1963 Aerial Photograph of Ilorin.

followed the broad division of the city into old and new areas. While the indigenous population adopted the traditional type of housing with enclosed courtyards, the Barrack/Flatlets and Bungalows were popular with the non-indigenes.

In terms of the directions of growth of the city at this time, development was confined mostly to the western side of the railway line. At this time too, development had just become noticeable within the Government Reservation Areas and at Sabo-Oke and along Jebba road. Except for a few institutions, development along Lagos road was scanty.

(c) <u>The 1973 Papptern</u>

By 1973, the sectoral growth of the city had intensified along the axial roads of Jebba, Ajassepo, Kaima and Oyo Bye-pass (now Ibrahim Taiwo Road). This trend came about as a result of the rapid development of the city when it became the state capital in 1967. The city attracted people who migrated in to take advantage of the various opportunities opened up by the new state capital. With its new administrative status, other complimentary services were attracted and the city expanded at a rapid rate. During this period too, new roads were built and old ones rehabilitated. While the old roads attracted development as a consequence of their improvements, the extension of the Okelele road opened up a new section of the town which led to the northward expansion of the city. By this time too, both Kulende and Oko-Erin Villages had been absorbed into the city.

Fig 5.3 shows the built-up area of Ilorin by 1973 while Table 5.3 shows the analysis of its land use pattern. The analysis shows that approximately 2,982.5 acres (1,193.0 ha) representing 63.53% of total built-up area was devoted to residential use. Transportation use accounted for 727.78 acres (291.1 ha) representing 15.50%. Commercial land use accounted for 388.15 acres (155.26 ha) representing 8.27% while institutional land use amounted to 355 acres (142.0 ha) representing 7.56%. The area devoted to recreational use and open spaces was 192.5 acres (77.0 ha) representing

4.1% while only 48.75 acres (19.5 ha) representing 1.04% was devoted to industrial use.

Table 5.3 Land Use Analysis Of Ilorin, 1973

Land Use Category	Area (Acres)	% Of Built-Up Area
Residential	2,982.5	63.53
Commercial	388.15	8.27
Industrial	48.75	1.04
Institutional	355	7.56
Transportation	727.78	15.50
Recreation and Open Spaces	192.5	4.10
Total	4,694.68	100.00

Source: Author's Analysis of Data Extracted From 1973 Aerial Photograph of Ilorin.

The land use analysis for 1973 shows the rapid growth of Ilorin since becoming a state capital in 1967. For instance residential land use had increased in both the old and the new parts of the city by a total of 58.98%. The newly settled areas to the east of Oyo Bye-pass, around Sabo-Oke and along Jebba and Ajassepo roads provided more residential buildings to accommodate civil servants who were deployed to the city from the former Northern Nigeria. The oil boom of the early 1970's also contributed significantly to increases in housing development.

The construction of new roads and the rehabilitation of existing ones were responsible for the increase in transportation land use. Commercial activities had by this time intensified along the main routes in the city. Intensive wholesaling and retailing activities could be noticed along Yakubu Gowon Way (now Murtala Mohammed Road) and the number of financial houses such as banks and insurance companies had increased. More supermarkets, bookshops and the NEPA Office had also taken off thus increasing commercial activities in this Central Business District. Commercial activities along Oyo Bye-pass, Emir's road and Abdul Aziz Attah road also got a boost while the 'Oja Oba' remained the dominant commercial centre in the old part of the city.

Institutional land use had also increased tremendously by this time. State Ministries and Parastatals had replaced the Provincial Offices and more institutions of higher learning were added to the existing ones. By now, the Ilorin Grammar School, Ansaril-Islam Secondary School, Federal Government College, Mount Camel, Ilorin College and the College of Technology had taken off. The General Hospital and the Maternity Centre were expanded while two military camps, the Army School of Education and the Infantry Brigade Camp had started to function. More mosques and churches were also built in different parts of the city.

The most important large scale industries in the city at this time were the Tate and Lyle, Philip Morris and the United Match Company. Small scale industries such as Sawmills, Afro Works, Concrete Making Industries, Workshops and Ware Housing were distributed along the main roads of the city contributing to axial growth while a large number of weaving industries were distributed within the old part of the city.

Recreational use and open spaces increased during this period too as social clubs and hotels grew along Oyo Bye-pass, Unity Hotel along Ajassepo road, Army Officers' Club, Recreation Club, Police Officers' Mess located in the Government Reservation Area. More sports grounds such as Polo Playing Ground, Tennis Courts and Playing Grounds belonging to institutions also added to recreational use.

Table 5.4 Ilorin Housing Types, 1973

House Type	No	% of Total	% increase over 1963
Indigenous	8,756	62.69	36.56
Barrack/Flatlets	4,143	29.66	193.20
Uncompleted	1,068	7.65	84.14
Total	13,967	100.00	66.17

Source: Author's Analysis of Data Extracted From 1973 Aerial Photograph of Ilorin.

Table 5.4 shows the analysis of the housing types in Ilorin in 1973. The analysis shows that indigenous house type accounted for 62.69% of total while Barracks/Flatlets and bungalows constituted 29.66%. Uncompleted buildings accounted for 7.65%. The increase in the indigenous house type could be attributed primarily to further construction of this house type in the traditional part of the city and those in Kulende and Oko-Erin Villages. The tremendous increase in the barrack/ flatlets and bungalows could be attributed to rapid housing construction in the new parts of the city to accommodate more of the new immigrants into the city. As the table shows, more houses were still under construction at this period. The trend in housing types could generally be attributable to the expanding status of the city.

(d) The 1982 Pattern

By 1982, a lot of physical expansion had taken place in all directions of the city. These centripetal forces were evidenced by such developments of the Army Barracks at Sobi which constitutes growth points along the north-west, the Adewole Housing Estate and the International Airport which constitute growth points along the south-west, the Niger River

Basin Authority headquarters and new Government Residential layout constituting growth points to the north-east, the Kulende Housing Estate constituting growth point to the north, the University of Ilorin Main Campus constituting growth point to the east, new industrial developments located to the south-east and the Federal Low-Cost Housing Oloje constituting another growth point to the west.

By this time too, a lot of land use reconversion had taken place. Such land use reconversion included residential houses along Taiwo road that had to give way for the construction of Ilorin Mini Stadium, the former 'Oja Oba' which had to give way to an ultra-modern Jumat Mosque. Residential buildings along Taiwo/Unity roads which had to give way for the construction of the State Fire Service and the Amusement Park. Within the indigenous part of the city, new roads reconstruction and the widening of old ones resulted in the demolition of many buildings. This change in land use calls for a change in travel demand, traffic generation and attraction.

Fig 5.4 shows the built-up area of Ilorin by 1982 while table 5.5 shows the analysis of land use pattern. The analysis shows that 4,700.5 acres (1,880.2 ha) representing 59.31% of total built-up area was devoted to residential use while 1,447.2 acres (578.88 ha) representing 18.25% was devoted to transportation use. Institutional land use amounted to 764.8 acres (305.92 ha) representing 9.65% while the commercial land use amounted to 548.9 acres (219.56 ha) representing 6.93%.

The amount of land devoted to industrial use was 247.2 acres (98.88 ha) representing 3.12% while 217.0 acres (86.8 ha) representing 2.74% was devoted to recreational use and open spaces.

Table 5.5 Land Use Analysis Of Ilorin, 1982

Land Use Category	Area (Acres)	% of Built-Area
Residential	4,700.5	59.3
Commercial	548.9	6.93
Industrial	247.2	3.12
Institutional	764.8	9.65
Transportation	1,447.2	18.25
Recreation and Open Spaces	217.00	2.74
Total	7,925.6	100.00

Source: Author's Analysis of Data Extracted From 1982 Aerial Photograph of Ilorin.

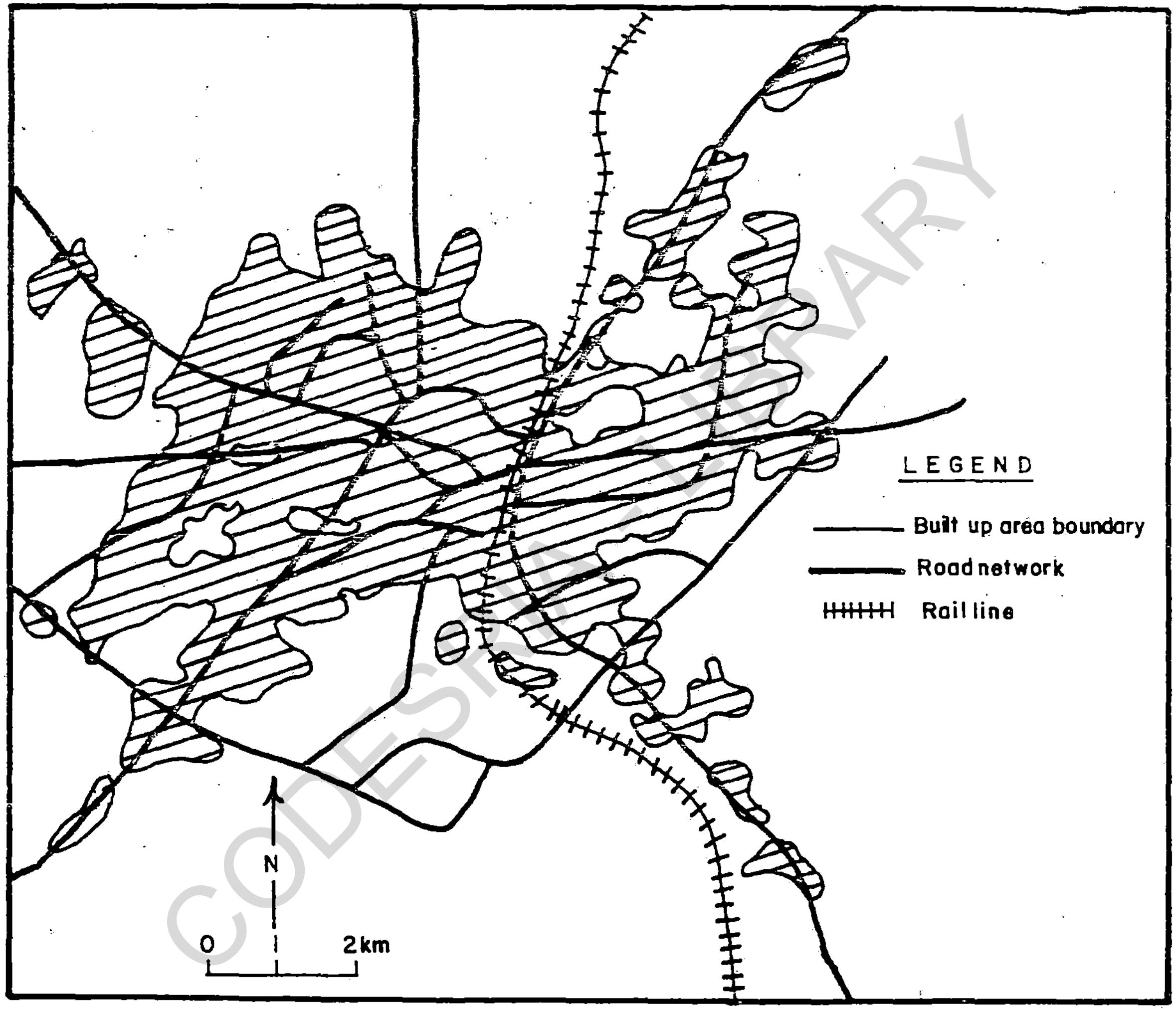


Fig. 5.4: Map of built up area of Ilorin(1982).

This analysis shows a reduction in the relative percentage of residential land use as against other uses when compared with the 1973 pattern. However, the trend in the land use pattern for 1982 where residential land use still accounts for the highest percentage could be as a result of further provision of residential housing by both public and private agencies although at a lower rate. While individuals provided housing for rental purpose, private organisations provided housing for their staff while government provided housing on owner-occupier basis for the public. The housing estates provided by government include the Adewole Housing Estate, Kulende Estate, Agba Estate and the Low-Cost Housing Estate at Oloje.

The main factor responsible for the increase in institutional land use could be attributed to the emergence of new institutions between 1973 and 1982. Such institutions include the University of Ilorin, Niger River Basin Authority and Sobi Barracks. These institutions occupy significant land areas.

The area devoted to transportation land use was as a result of improvement in the internal network of roads and the addition of a few new roads. For example Murtala Mohammed Way, Ahmadu Bello Way, Sulu Gambari Road, Umoru Audi Road and Fate Road were converted to dual carriage ways while Adewole Estate Road, Unity Road, Asa Dam Road and New Yidi Road were added to the network.

The commercial land use had increased with the expansion of the city. The new necleus of commercial activities around the Post Office area, the Murtala Road and Emir's Road had also expanded with the southern portion of Murtala Road housing most of the financial and commercial institutions such as banks and insurance offices while the major whole-sale and retail activities and warehouses were located at the Jebba end of Murtala Mohammed Road.

The industrial land use had increased due to the development of new industries. In addition to Tate and Lyle, Philip Morris and United Match Company, other industries such as Afro Works, Biomedical Services, Coca-Cola Bottling

Company, Metal Products Company and Kwara Furniture Manufacturing Company had taken off.

With respect to recreational land use and open spaces, play grounds provided by institutions, the Mini Stadium and the Amusement Park increased this land use category.

Table 5.6 shows the analysis of the housing types in the city by 1982.

Table 5.6 Ilorin Housing Types, 1982

Housing Type	No	% of Total	% Increase Over 1973
Indigenous	9,389	47.75	7.22
Barrack/Flatlets	8,143	41.41	96.55
Uncompleted	2,131	10.84	99.53
Total	19,663	100.00	40.78

Source: Author's Analysis of Data Extracted From 1982 Aerial Photograph of Ilorin.

From the Table, it can be seen that the indigenous house type accounted for 47.75% of total house in the city while the Barrack/Flatlets and bungalows accounted for 41.41%. Buildings under construction accounted for only 10.84%

The trend in the housing pattern as revealed by this analysis is that while the small increase in the number of indigenous house type could be attributed to absorption of small traditional settlements of Tanke, Adinimole and Osere Villages, the tremendous increase in the number of Barrack/Flatlets and bungalows could be attributed to the growth of modern housing in the new areas and the growth of housing by 'fission' (Mabogunje, 1968) in the old part of the city. The number of houses under construction had also increased significantly by this period too. This trend in the growth of housing provision is also a manifestation of the spatial expansion and sprawl of the city (Olorunfemi, 1985).

(d) The 1988 Pattern

By 1988, Ilorin had witnessed more physical expansion resulting in the city enveloping many of the small settlements surrounding it. At this time, the sprawl of the city could be prominently noticed along the intercity roads such as the Ilorin-Jebba road where the sprawl has enveloped Kulende, Elekoyangan, Polytechnic Permanent Site and extending almost as far as Oke-Oyi to the north-east, the Ilorin - Ajassepo road with development engulfing Gaa Akanbi, Ero-Omo, Olunlade, Ita Alamu and merging Gama and Amayo with Ilorin to the south-east. Along the Lagos road, the sprawl has absorbed Agunbelewo, Olorunshogo, Aiyetoro, Odota and has now brought Eiyenkorin completely under the urban influence of Ilorin while along the Kaima road, the sprawl has enveloped Ogidi. Along the Shao road, the Sobi barracks has been completely absorbed and Shao can now be described as part of the outskirt of Ilorin while along the new University road, Tanke Village and Mosudo have been completely absorbed into the city and physical development has stretched almost as far as the gate of the University.

A new industrial area has also developed along the Adewole Estate road and Asa Dam road. Notable amongst them are Steelfab Ltd., Sax (Nig.) Ltd., Global Detergents Ltd;, and Adal Industries Ltd. Also here, Joro and Osere Villages have merged with Odota bringing all under the city's sprawl. The sprawl can also be noticed along the new south link road linking Asa Dam road with Ajassepo road. This road now has both residential and industrial developments along it and can serve as catalyst for another 'leap - frog' form of urban sprawl.

Fig 5.5 shows the built-up area of the city by 1988 while Table 5.7 shows the analysis of the land use pattern.

Table 5.7 Land Use Analysis Of Ilorin 1988

Land Use Category	Area (Acres)	% of Built-Up Area
Residential	5,623.0	49.81
Commercial	736.9	6.53
Industrial	405.3	3.59
Institutional	1,865.4	16.52
Transportation	2,425.5	21.48
Recreation and Open Spaces	233.5	2.07
Total	11,289.6	100.00

Sources: 1. Author's Analysis of Data Extracted From 1982 Aerial Photograph Of Ilorin.

2. Author's Land Use Surveys, 1988.

The analysis shows that 5,623.0 acres (2,249.2 ha) representing 49.81% was devoted to residential use while 2,425.5 acres (970.20 ha) representing 21.48% was devoted

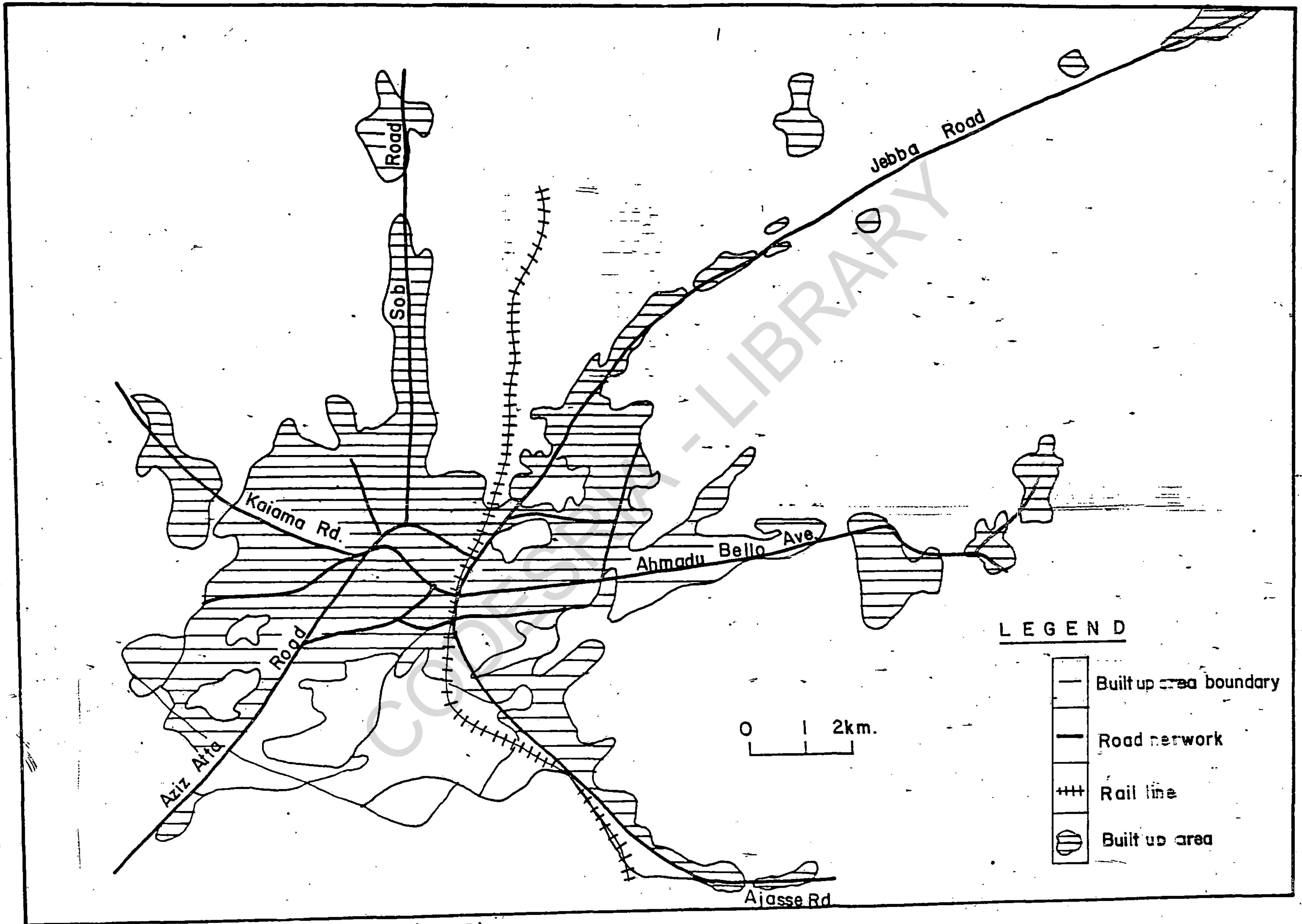


Fig. 5.5: Map of built up area of Ilorin (1988).

to transportation use. The area devoted to institutional use amounted to 1,865.4 acres (746.16 ha) representing 16.52% while that devoted to commercial use was 736.9 acres (294.76 ha) representing 6.53%. Industrial land use occupied 405.3 acres (162.12 ha) representing 3.59% while recreational use and open spaces occupied 233.5 acres (93.4 ha) representing only 2.07%.

The trend shows that residential land use still had the highest percentage of total built-up areas of the city while transportation land use ranked second. While the increase in the total area occupied by residential land use could be attributed to the absorption of small settlements surrounding the city, more residential developments had also taken place in all parts of the city to increase housing provision.

New roads provided in the city and the links with absorbed villages increased the area devoted to transporttational land use. The increase in institutional use could be attributed to further developments in this use category while more intensive commercial activities could be found all over the city and along major arteries. There was also significant growth in the industrial development while recreational use and open spaces also contributed significantly to the total built-up area.

5.2 Composite Growth Pattern (1963 - 1988)

The foregoing discussions show that Ilorin has a morphology which is often referred to as a two-in-one structure. This is due to the two historical sections of the city, the old and the new parts. The growth of the city could be primarily attributed to its graduation from a provincial headquarters to a state capital in 1967. Like many other urban centres in Nigeria with the same experience, the city began to receive an influx of people from all spheres of life. The job market then was also generally expanding and attractive for the skilled. Consequently, the centripetal forces of urban expansion came into play. The city began to experience growth in its areal extent due to residential development, road development and institutional buildings. Generally, the growth of Ilorin can be attributed to the changing economic base of the city (Olorunfemi, 1985).

Fig 5.6 shows the composite growth pattern of Ilorin between 1963 and 1988 while Tables 5.8, 5.9 and 5.10 show changes in land use pattern.

Table 5.8 shows that the rate of change of residential land use between 1963 and 1973 was 5.9 percent per annum while commercial land use changed at a rate of 3.2 percent per annum. The rate of change of industrial land use was 36 percent per annum while that of institutional land use changed at a rate of 6.4 percent per annum. Transportational land use changed at a rate of 4.2 percent per annum while recreational land use and open spaces changed at a rate of 0.8 percent per annum.

The overall rate of growth of urban land for the city between 1963 and 1973 was 5.2 percent per annum.

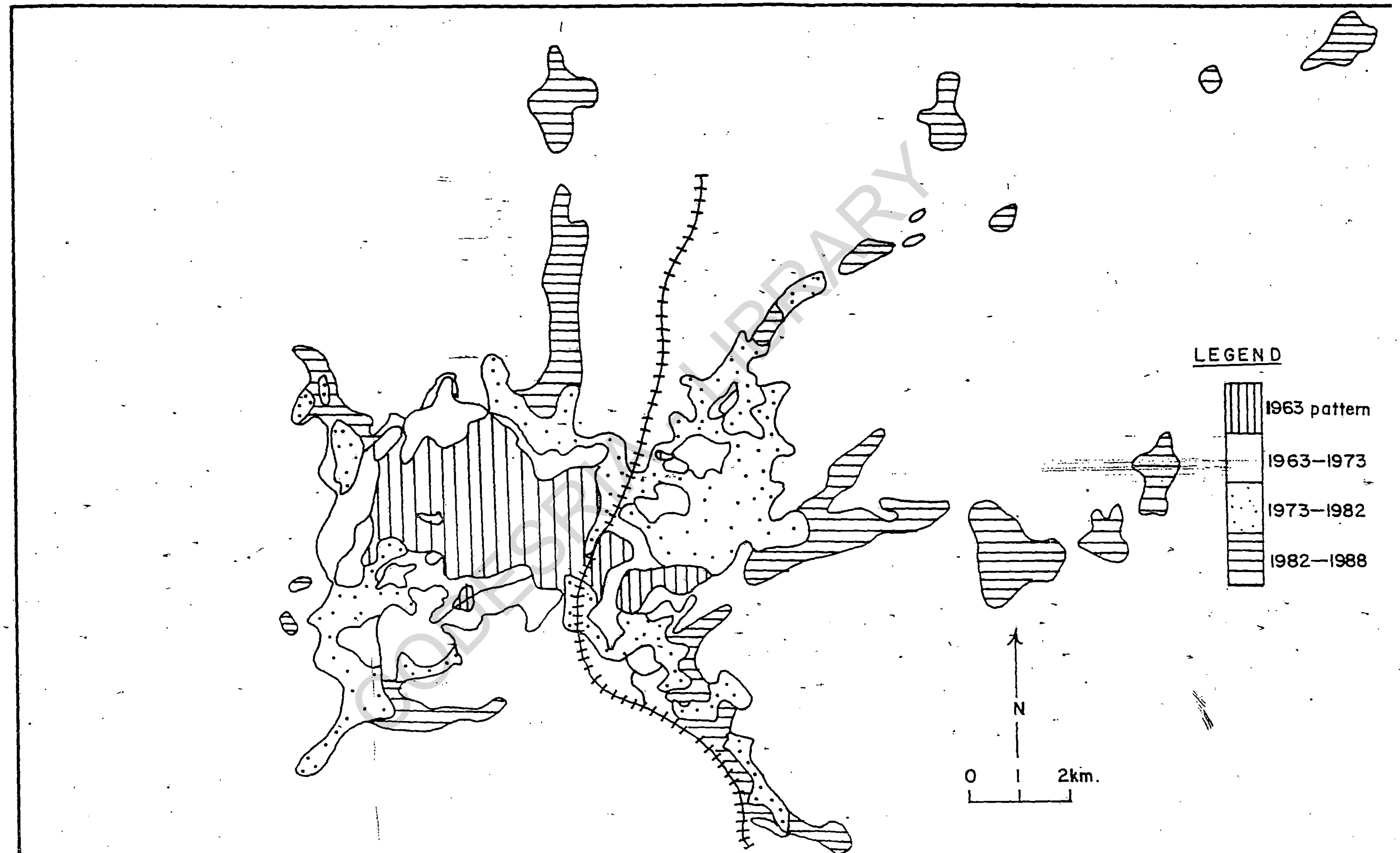


Fig.5.6: Map of composite growth pattern of Ilorin (1963—1988).

Table 5.8 Land Use Changes In Ilorin 1963 - 1973

Land Use Category	1963	1973	Absolute Change	Percentage Change	Rate Of Change
Residential	1,876	2,982.5	1,106.5	58.98	5.9
Commercial	295.25	388.15	92.9	31.46	3.2
Industrial	10.5	48.75	38.25	364.29	36.3
Institutional	217.00	355.00	138	63.59	6.4
Transportation	512.28	727.78	215.5	42.07	4.2
Recreational And Open Spaces	178.58	192.5	13.92	7.79	0.8
Total	3,089.61	4,694.68	1,605.07	51.95	5.2

Source: Author's Data Analysis, 1988.

Table 5.9 shows a summary of land use changes in Ilorin between 1973 and 1982. The table shows that the rate of change of residential land use between 1973 and 1982 was 6.4 percent per annum while that of commercial use was 4.6 percent per annum. The rate of change of industrial land use was 45.2 percent per annum while institutional land use changed at a rate of 12.8 percent per annum. Transportational land use recorded a rate of

Table 5.9 Land Use Changes In Ilorin 1973 - 1982

Land Use Category	1973	1982	Absolute Change	Percentage Change	Rate of Change
Residential	2,982.5	4,700.46	1,717.96	57.60	6.4
Commercial	388.15	548.91	160.76	41.42	4.6
Industrial	48.75	247.2	198.45	407.08	45.2
Institutional	355.00	764.78	409.78	115.43	12.8
Transportation	727.78	1,447.15	749.37	98.84	11.0
Recreation and Open Spaces	192.5	217.00	24.5	12.73	1.4
Total	4,694.68	7,925.5	3,230.82	68.82	7.7

Source: Author's Data Analysis, 1988.

change of 11.0 percent per annum while recreational land use and open spaces changed at a rate of 1.4 percent per annum. The overall rate of growth of urban land for the city between 1973 and 1982 was 7.7 percent per annum.

Table 5.10 shows the land use changes between 1982 and 1988. The analysis shows that the rate of change of residential land use was 3.3 percent per annum while that of commercial land use was 5.7 percent per annum. Industrial land use changed at a rate of 10.7 percent per annum while institutional land use changed at a rate of 24.0 percent per annum. Transportational land use changed at a rate of 11.3 percent per annum while recreational use and open spaces changed at a rate of 1.3 percent per annum. The overall rate of growth of urban land for the city between 1982 and 1988 was 7.1 percent per annum.

Table 5.10 Land Use Changes In Ilorin 1982 - 1988

Land Use Category	1982	1988	Absolute Change	Percentage Change	Rate of Change
Residential	4,700.46	5,622.98	922.52	19.63	3.3
Commercial	548.91	736.88	187.97	34.24	5.7
Industrial	247.2	405.33	158.13	63.97	10.7
Institutional	764.78	1,865.4	1,100.62	143.91	24.0
Transportation	1,447.15	2,425.53	978.38	67.61	11.3
Recreation and Open Spaces	217.0	233.5	16.5	7.6	1.3
Total	7, 925.5	1,289.12	3,363.62	42.44	7.1

Source: Author's Data Analysis, 1988.

Comparing tables 5.8, 5.9 and 5.10 it can be observed that whereas there were increases in the rates of change of the different land uses for 1963 - 1973 and 1973 - 1982; the trend for 1982 - 1988 has been a slowing down in the rate of change of the land uses in the city. Similarly, the change in the overall rate of growth for the city increased for between 1963 - 1973 and 1973 - 1982 while the city experienced a small reduction in the rate of growth between 1982 - 1988. This trend in the city's rate of growth could also be attributed to the changing economic base of the city.

The period before 1963 covered the pre-colonial and colonial periods when Ilorin was only a provincial headquarter and had low economic base. The creation of states in 1967 brought Ilorin to a state capital and during the early 1970's the city benefitted from the oil boom era and thus experienced a lot of physical expansion. This trend continued till early 1980 when the pace of expansion of the city started to slow down. Thus the low change in the overallrate of growth of the city between 1982 and 1988 could be attributed to the austerity measures introduced in the country.

Table 5.11 shows the land use changes between 1963 and 1988. The analysis shows that the rate of change of residential land use within this 25 years period was 8 percent per annum while that of commercial land use was 6.0 percent per annum. Industrial land use within this period changed at a rate of 150.4 percent per annum while institutional land use changed at a rate of 40.4 percent per annum. The rate of change of transportational land use was 14.9 percent per annum while the change in recreational use and open spaces within this period was at a rate of 1.2 percent per annum.

The overall rate of growth of urban land for the city between the span of 25 years from 1963 to 1988 was 10.6 percent per annum. The trend in the rate of growth of land use within this period shows that the rates are generally higher than those for 1962 - 1973; 1973 - 1982 and 1982 - 1988. Also there has been tremendous change in the growth of industrial land use compared with the position in 1963.

Table 5.11 Land Use Changes In Ilorin 1963 - 1988

Land Use Category	1963	1988	Absolute Change	Percentage Change	Rate Of Change
Residential	1,816	5.622.98	3,746.98	199.73	7.99
Commercial	295.25	736.88	441.63	149.58	5.98
Industrial	10.5	405.33	394.83	3,760.29	150.41
Institutional	217.00	1,865.4	1,648.4	759.63	30.39
Transporttation	512.28	2,425.53	1,913.25	373.48	14.94
Recreation And Open Spaces	178.58	233.5	54.92	30.75	1.23
Total	3,089.61	11,289.12	8,199.51	265.39	10.62

Source: Author's Data Analysis, 1988

However, the overall rate of growth of urban land shows that the city has been experiencing significant spatial expansion. Whereas the overall rates of change of urban land were 5.2 percent per annum for 1962 - 1973; 7.7 percent per annum, for 1973 - 1982; the rate experienced a slow down to 7.1 percent per annum for 1982 - 1988. Also the overall rate of change of urban land for 1963 - 1988 is 10.62 percent per annum. Thus overall, the city has been expanding for the period before 1982 but has started to slow down its pace of development since 1982.

The foregoing analyses explain the changing morphology of Ilorin. Although the trend just described gives a picture of the changing morphology of the city, it is desirable to explore whether the growth conforms with any existing model.

Figure 5.7 depicts the growth of built-up area of the city. The curve also shows that between 1963 - 1973 the city witnessed spatial expansion. Also the period 1973 - 1982 experienced further growth in the area of the city. However there was a decline in the growth

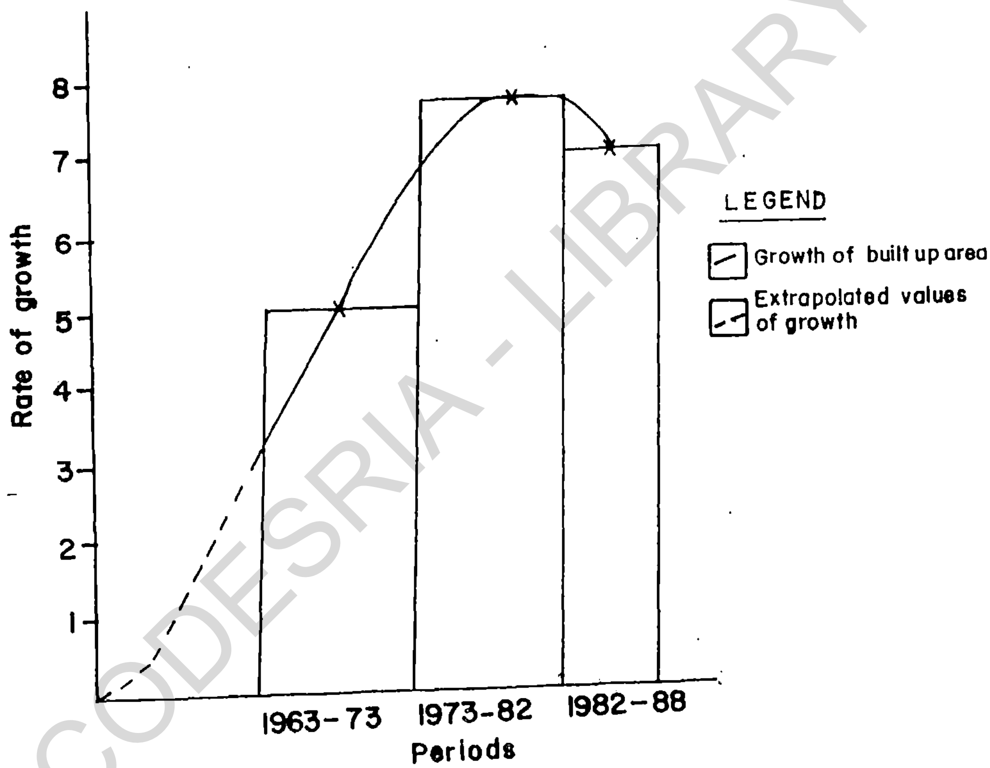


Fig. 5.7: Growth of built up area of Ilorin.

between 1982 - 1988. Such a pattern of growth can best be described by three components of a diffusion process namely, primary, expansion and condensation or declining phases. (Brown and Cox, 1971, Jones, 1966, Casetti, 1969).

This S - shaped curve describing the course of a diffusion process is known as a logistic curve. It is a very common one in diffusion problems, and there are good theoretical and empirical reasons why such a curve describes many processes of diffusion. The logistic curve is usually represented mathematically by the equation

$$P = \frac{U}{1 + e^{a - bt}}$$

in which U represents the upper limit of growth, The letter e is a mathematical constant with the approximate value of 2.7183. This constant is raised to the power or exponent $a - bt$, where a and b are particular values that will change from one diffusion problem to another. The value a controls the height above the t (time) - axis where the S - shaped curve starts, while b determines how quickly it rises.

Thus the period when the city originated represents the primary stage of the diffusion process, those between 1963 and 1973 and also between 1973 and 1982 represent an expansion period before an equilibrum stage was reached. The diffusion processes can be described in relation to the economic climate of the country and how it has affected physical development. The primary stage represents when the city started to develop both physically and economically.

The expansion stage can be described as falling within the period when the city started to witness rapid physical development more especially from 1967 when it became a state capital and also during the period of"oil boom" when the economy of the country was buoyant. This period was reflected in every sphere of the country's development. The declining stage of the logistic curve in which the rate of growth of urban land slows down falls within the period of "austerity" when the economy of the country began to experience a down turn. This stage is is still being experienced in the country now and has affected all spheres of the country's development.

Thus far, an attempt has been made to describe the changing morphology of Ilorin and its effect on the expansion of the city. In like manner, there is the need to understand the pattern and characteristics of network development in the city in order to provide the required background for the understanding of the relationships between road development and urban expansion. Thus the focus of the next chapter is on the evolution of routes in the city.

CHAPTER SIX

SPATIAL PATTERN OF ROAD DEVELOPMENT

In Chapter IV, various aspects of the routes in Ilorin were discussed. Eight routes were selected for specific attention and studied with reference to their quality and traffic carrying capacity. In this chapter, the important aspect of the evolution of the urban roads are discussed as they affect the morphology of the town.

6.1 The Network Factor In Urban Development

A network has been defined as a geometric structure designed to tie together two or more places located in space, (Abler, Adams and Gould, 1972). It may therefore be considered as a set of points and lines such that each point represents an origin, an intersection, or a terminal or a major settlement located on the road and each line corresponds to an existing route. Road network constitutes an important element in urban development as roads provide accessibility to the different land uses in an urban area. Thus the proper functioning of an urban area depends on an efficient transportation network. So important is the network factor in urban development that cities are incapable of existence except when adequate transport facilities exist.

Because of the importance of road network, a lot of attention has been given to it on a regional level using various approaches such as the morphological approach, functional approach and topological approach. In recent times, however, the topological approach using the Graph-theoretic method has turned out to be extensively used because of its quantifiable characteristics. Such works include Garrison and Marble (1960) who applied graph-theoretic measures to regional highway networks, Nystuen and Dacey (1961) who analysed functional connections between central places based upon communication flows in a network using graph-theoretic concepts. Essentially, these works had been on a regional level. Studies of intra-urban network using the graph-theoretic concepts are scanty. For example, Muraco (1972) used graph-theoretic technique in his study of intra-urban accessibility, Ugunsanya (1986) applied graph theory for the estimation of traffic flow in Barnsley, U.K. It is thus believed that the technique as used even on regional basis can be extended to the urban analysis. The main advantage of graph theory is that it provides an appropriate language suitable for measurement and analysis of the structure of transportation networks.

In graph theoretic applications to transport networks, locations or points are interpreted as nodes or vertices while the routes are links or edges. In the regional scale application of graph-theoretic technique, settlements are taken as nodes and the routes as links in a network. In the intra-urban application however, the nodes are considered as intersections or junctions and the roads as links in the network, (Ugunsanya, 1986). This allows for the abstraction of an urban road network as a graph for the determination of its structural pattern.

In using the graph theory various indices have been suggested (see Kansky, 1963). In this work however, the indices used include:

(a) Alpha index, defined as the ratio between the actual number of loops in a graph and the maximum possible number. The range of the alpha index is from 0 to 1.0 indicating absolute non connectivity to perfect connectivity.

(b) Beta index, defined as the number of linkages per place or node and measures the linkage intensity. The range of the beta index is from 0.5 for minimally connected graph and 3.0 for maximally connected graph.

(c) Gamma index, defined as the ratio between the number of edges in a network and the maximum possible number of edges in the graph. The limits of the gamma index are 0 and 1.0 indicating non-connectivity to maximal connectivity.

(d) Eta index, defined as the ratio between the total length of the network and the number of edges.

To facilitate the discussion on the intra-urban network studies, this chapter is divided into three sections viz:

(1) Intra-urban network analysis in Ilorin.

(2) Evolution of intra-urban networks.

(3) Composite growth pattern of network.

6.2 Intra-Urban Network Analysis In Ilorin

In order to study the intra-urban network by periods, the city's networks have been abstracted in form of graphs for 1963, 1973, 1982 and 1988. Only the main road networks were mapped from the aerial photographs and used for the analysis. Figs 6.1, 6.2, 6.5 and 6.7 show the city's road network patterns while Figs 6.3, 6.4, 6.6 and 6.8 show the graph representations of the networks for 1963, 1973, 1982 and 1988 respectively. The graph

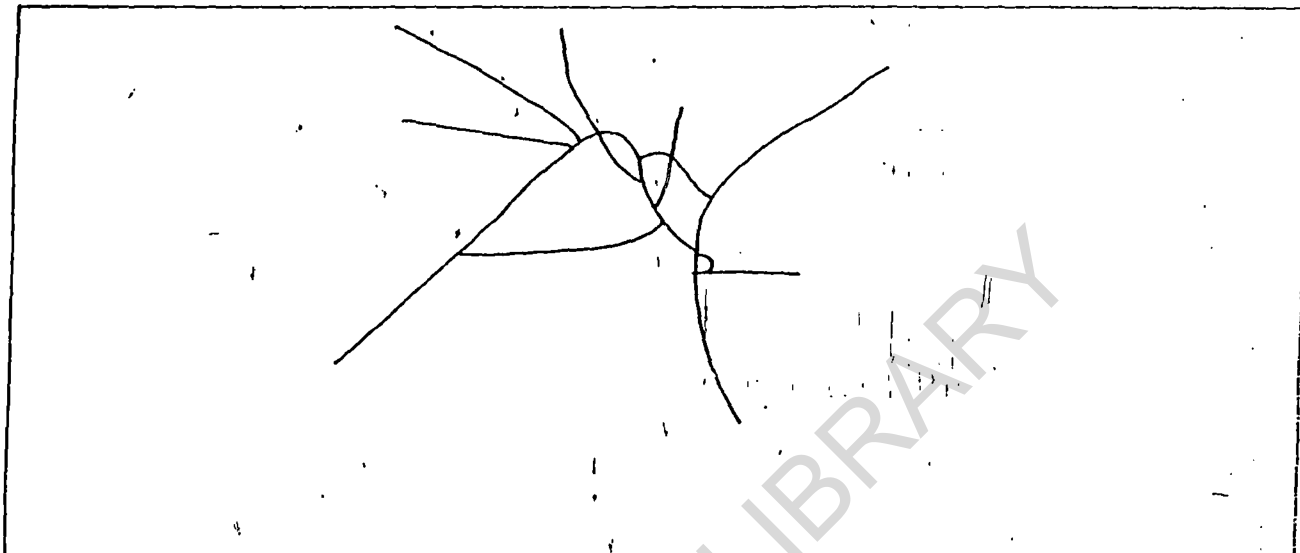


FIG. 6.1: ROAD NETWORK PATTERN OF ILORIN, 1963.

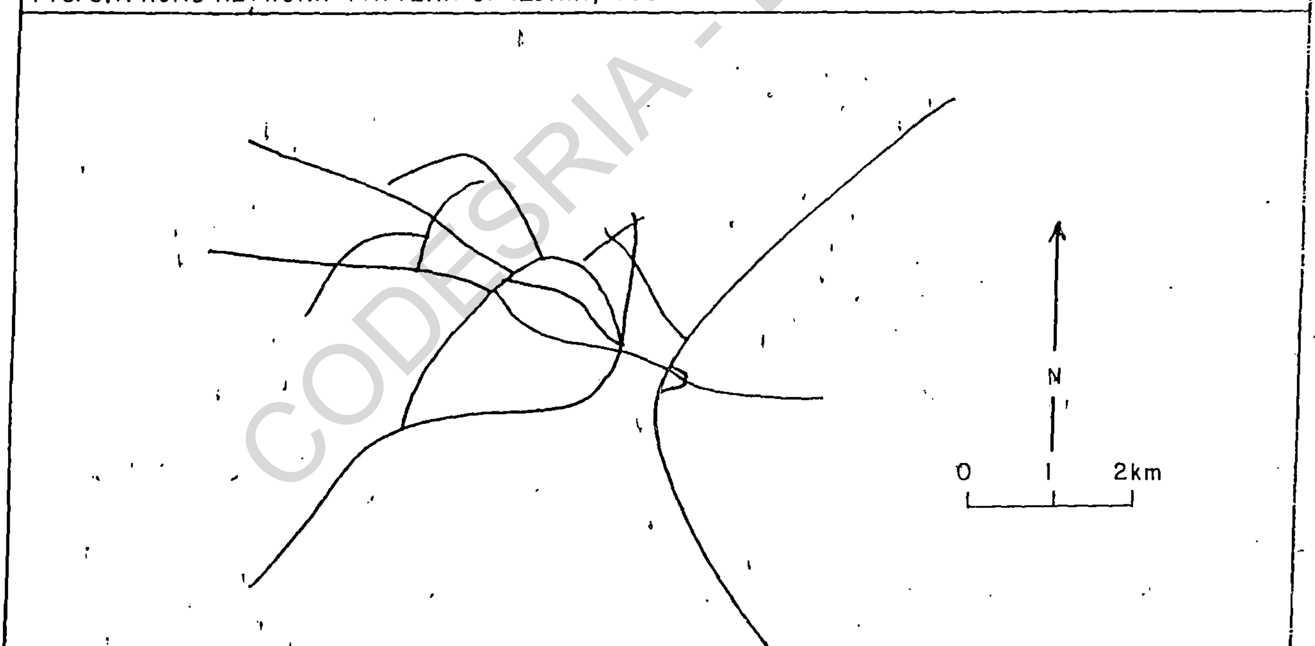


FIG. 6.2: ROAD NETWORK PATTERN, 1973.

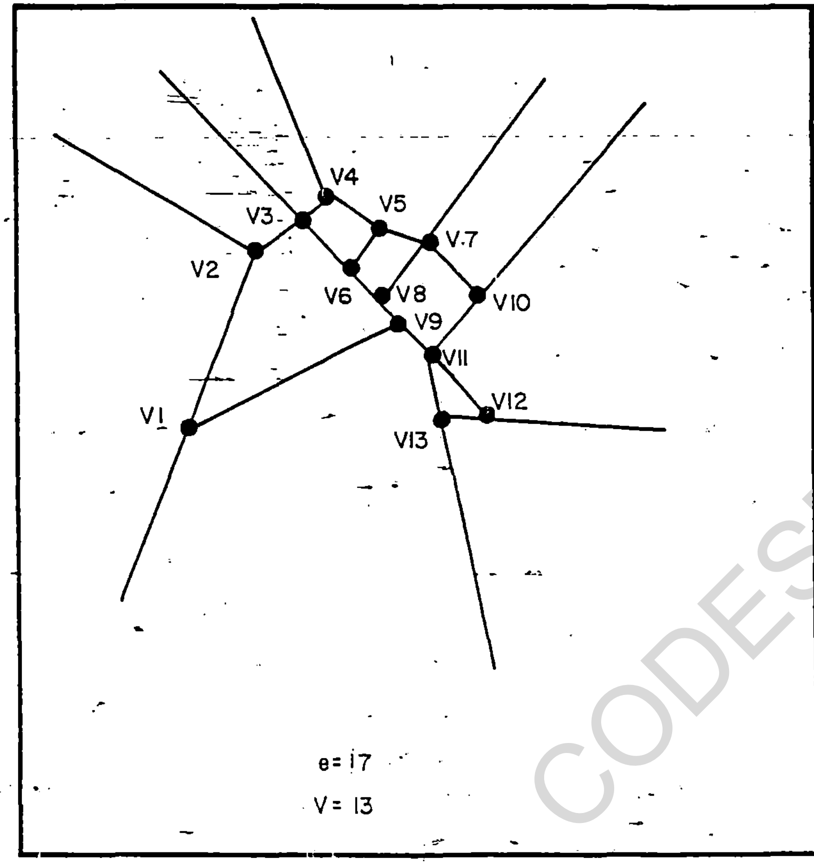


Fig. 6. 3 Graph representation of roadnet work, 1963.

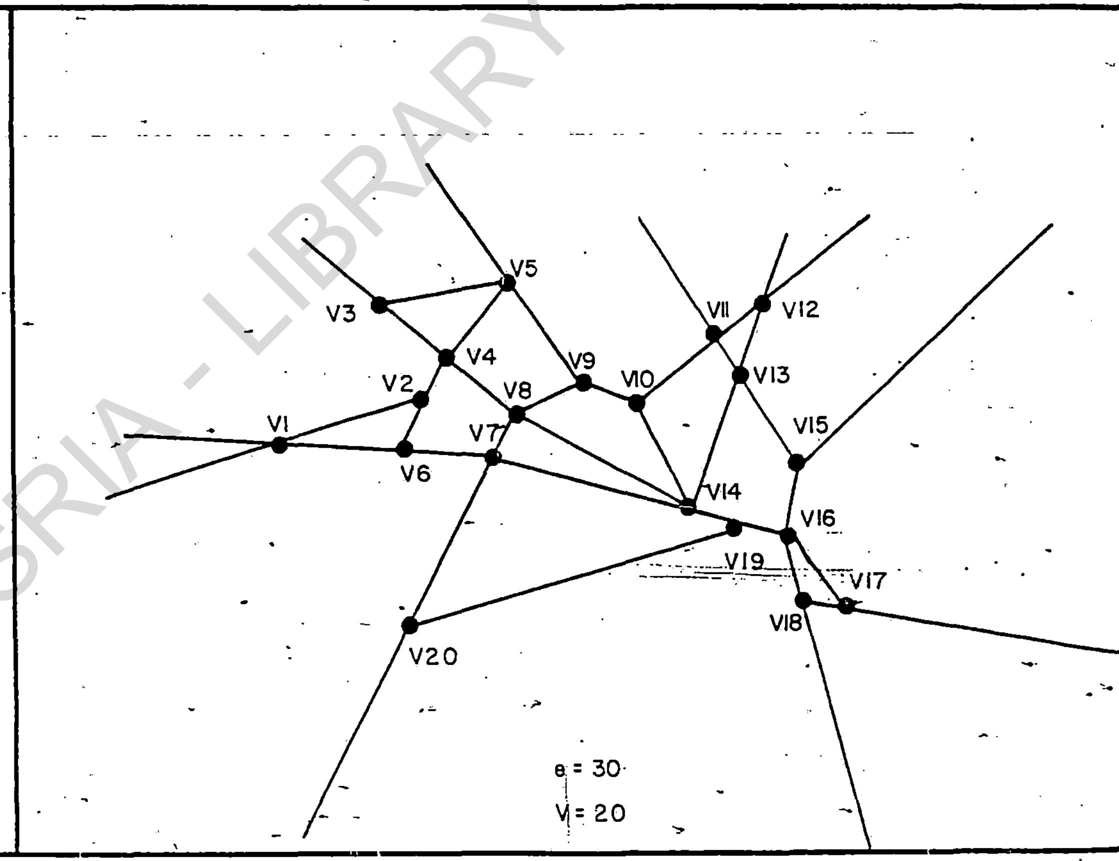


Fig. 6. 4 Graph representation of road net work, 1973.

representation of a network is essentially an idealised form of the network. In such graphs, only topological distances are shown.

Table 6.1 shows the structural indices of the city's networks by periods. From the graphs it can be observed that in 1963, the city's network had 13 vertices and 17 edges while in 1973 the network had 20 vertices and 30 edges. In 1982, there were 45 vertices and 68 edges while in 1988, the network had 49 vertices and 72 edges. This trend shows that the road network of the city has been growing over the years.

The values of other structural indices as shown on Table 6.1 show that in 1963, the value of the alpha index was 0.24 showing that the network was 24 percent connected while the value of the beta index was 1.31 indicating that the linkage intensity for the network was 1.31. The gamma index for the same period was 0.52 showing that the network had 52 percent level of connectivity while the Eta index or average edge was 0.71.

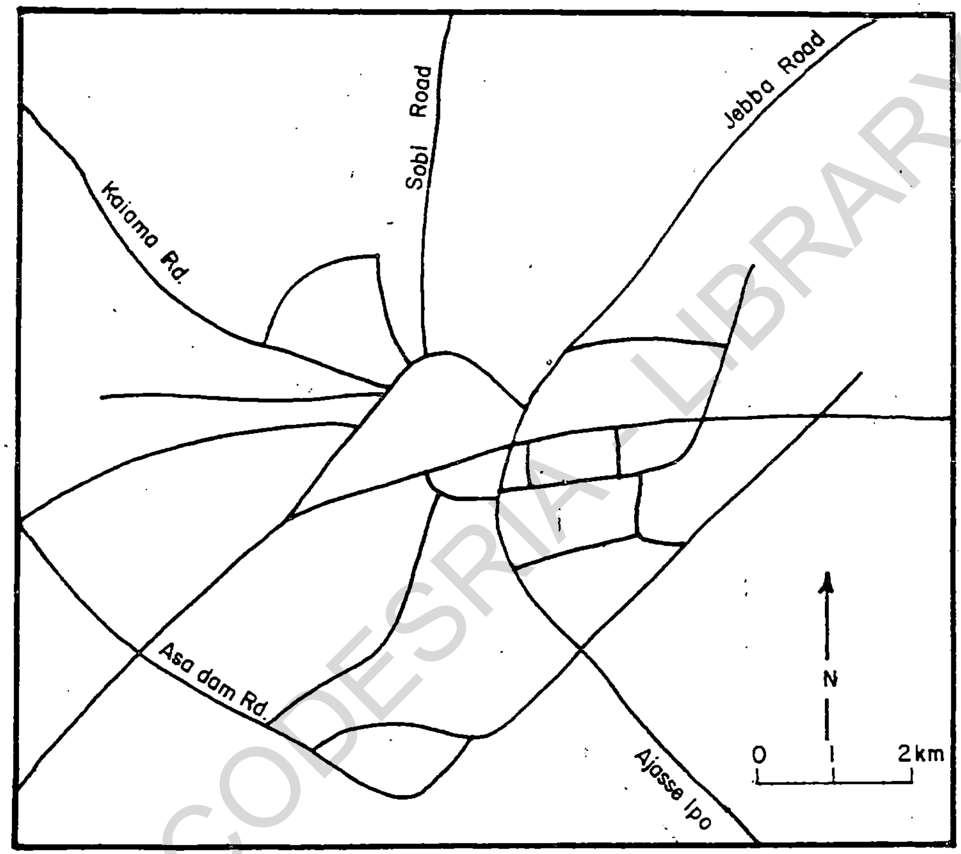


Fig.6.5 Road network pattern of Ilorin, 1982.

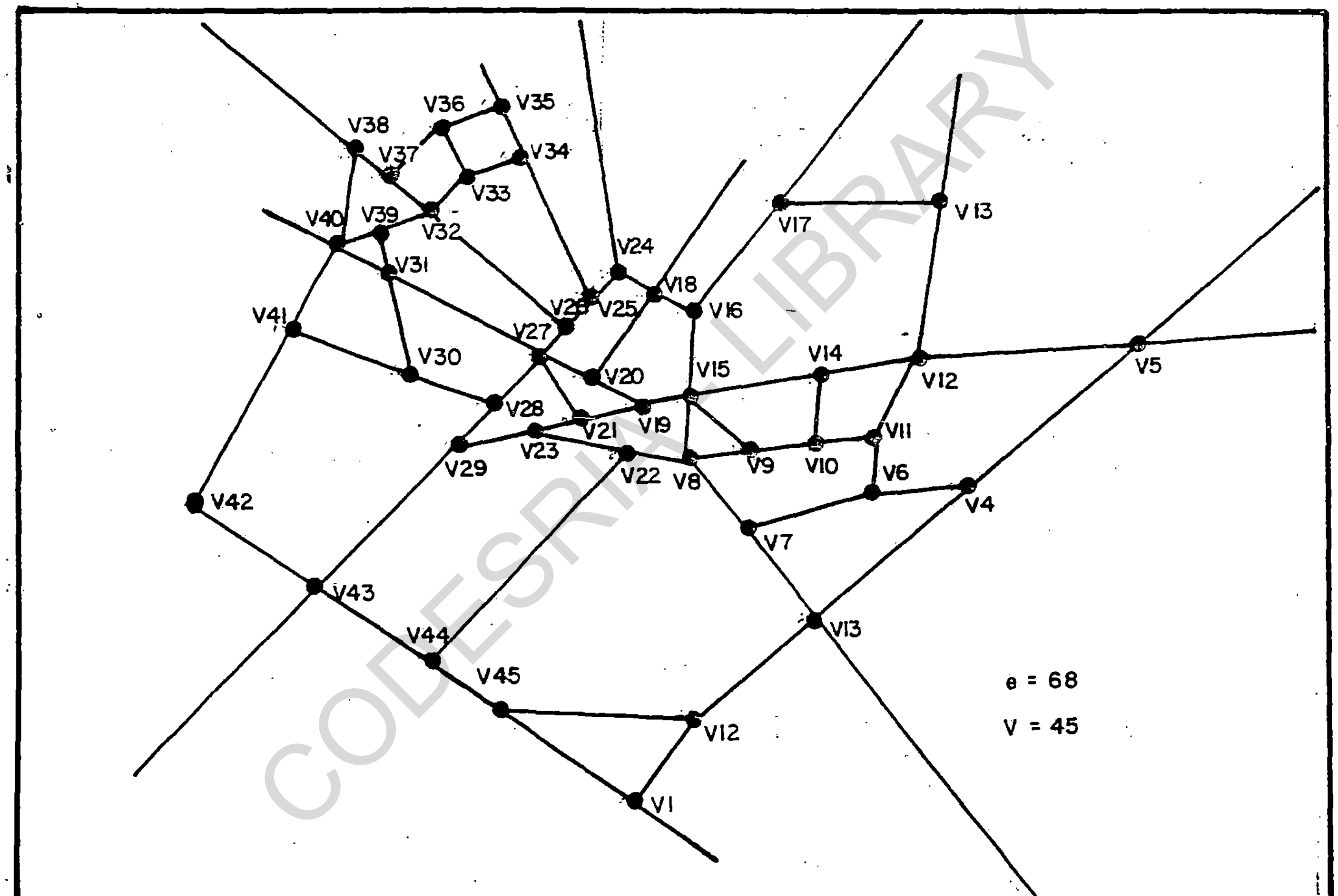


Fig. 6.6: Graph representation of road net work, 1982

The analysis also shows that in 1973, the alpha index was 0.31 indicating that the city's network was now 31 percent connected while the beta index was 1.5 showing that the linkage intensity had increased to 1.5. For the same period, the gamma index was 0.56 showing that the level of connectivity of the network had increased to 56 percent while the eta index or average edge had also increased to 0.92.

In 1982 however, the alpha index decreased to 0.28 indicating that the city's network was then 28 percent connected while the beta index was 1.51. The gamma index for this period was 0.53 indicating that the level of connectivity of the network had decreased to 53 percent while the eta index or average edge had however increased to 0.99. The decrease in the values of alpha and gamma indices for this period indicates that there were relatively few alternative routes added to the city's network.

In 1988, the alpha index still decreased to 0.26 showing that the city's network was only 26 percent connected while

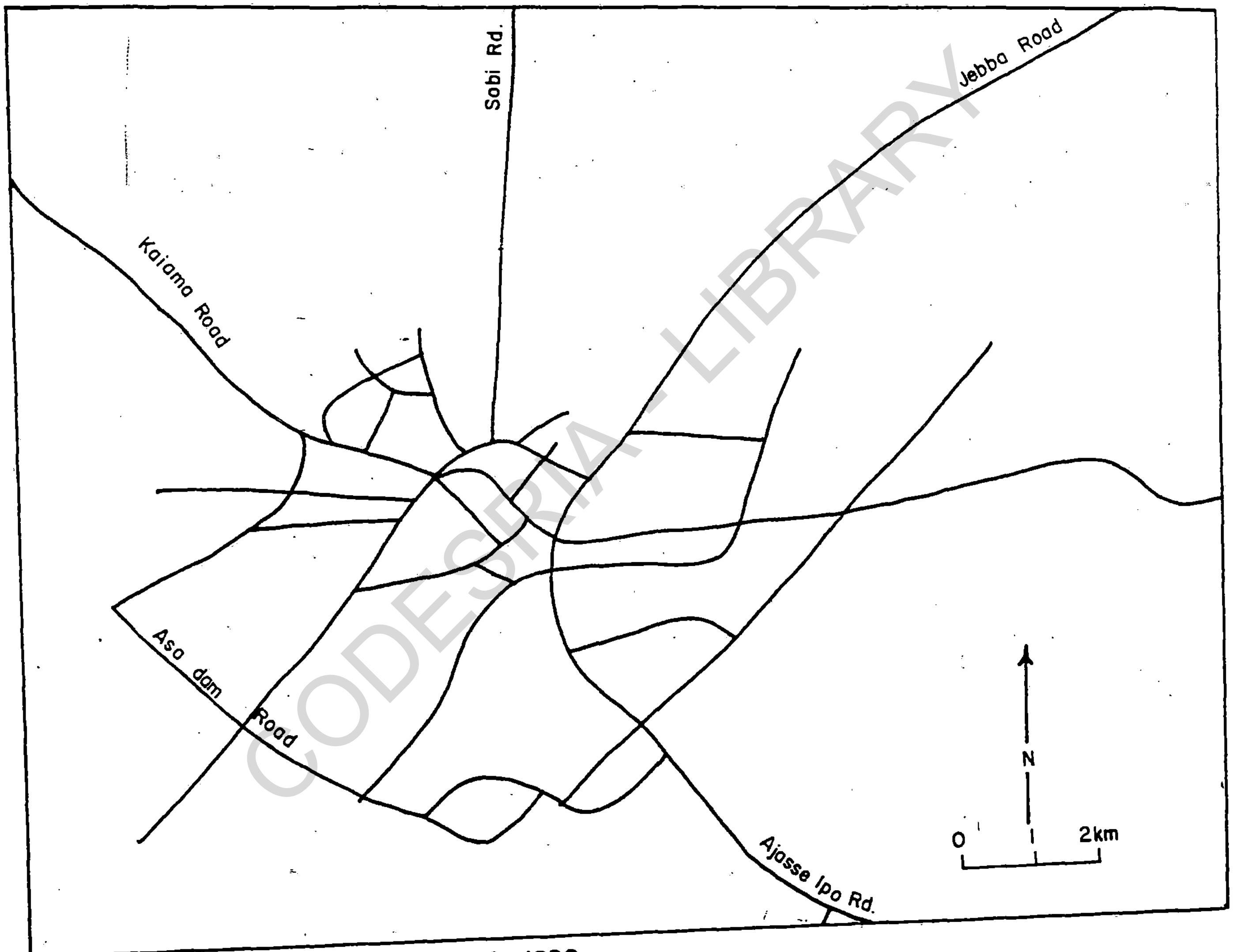


Fig. 6.7: Road network pattern of Ilorin, 1988.

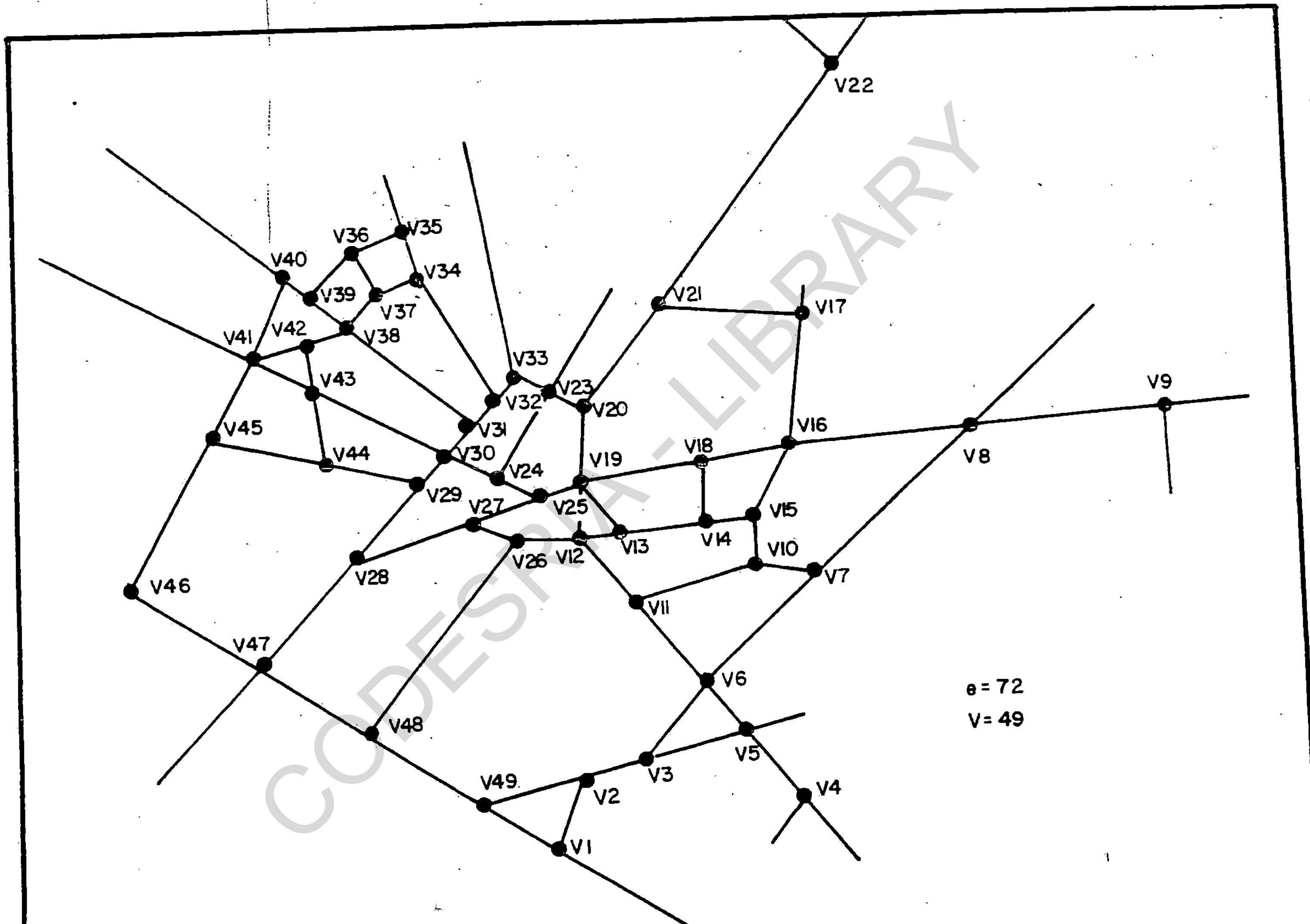


Fig. 6.8: Graph representation of roadnetwork of Ilorin, 1988.

Table 6.1 Structural Indices Of Intra-Urban Networks

Year	Alpha Index	Beta Index	Gamma Index	Eta Index	Number of Segments	Length of Paths (Km)
1963	0.24	1.31	0.52	0.71	17	12
1973	0.31	1.5	1.56	0.92	30	22.7
1982	0.28	1.51	0.53	0.99	68	67
1988	0.26	1.47	0.51	1.19	72	86

Source: Author's Data Analysis, 1988

the beta index decreased to 1.47 indicating that the linkage intensity of the network had also decreased. For the same period, the gamma index was 0.51 indicating that the level of connectivity of the network had also decreased to 51 percent while the eta index or average edge had however increased to 1.19.

The increases in the values of alpha, beta and gamma between 1963 and 1973 simply suggest improvement in the level of connectivity and the linkage intensity of the city's network during this period. The decreases in the values of beta and gamma between 1973 and 1988 suggest that during this period, few alternative links were constructed in the city's network. In general, the index values of beta and gamma in a network have direct correlation with levels of economic development. The increases in the values of the eta index between 1963 and 1988 suggest that the index was senstive to the economic significance of road development in the city during this period.

The other facts that emerge from this analysis are that the city's network are compact and highly irreducible.

Also, the fact that the value of the beta index is greater than unity for each period goes to confirm this compactness. The increases in the number of segments and length of paths as shown on Table 6.1 are clear indications of the progressive road development in the city.

6.3 Evolution Of Intra-Urban Network

The evolution of intra-urban road network in Ilorin can be described in two phases. The first phase is the pattern when the city was only a provincial headquarter until when it became a state capital in 1967. During this period, some of the intra-urban roads were maintained by the Native Authority while the Federal Government maintained Lagos, Abdul Aziz Attah, Emir's and Jebba roads. These roads were part of the stretch of the Lagos - Ilorin - Kaduna Trunk A road that links the Southern and Northern parts of the country. In the early sixties, the Government of Northern Nigeria was responsible for the maintenance of many of the intra-urban roads such as Balogun Alanamu, Kaima, Balogun Gambari, Balogun Fulani, Princess, Offa, Amilegbe and Pakata roads.

The second phase is the development of intra-urban roads since it became a state capital in 1967. At the inception of making Ilorin the Kwara State Capital, the city had to be given a face lift that befitted a state capital. Thus new roads were built and old ones rehabilitated especially during the 1973/74 financial year. During the state's second development plan (1975 - 1980), substantial financial allocation was made for the development of the city's intra-urban roads. During this period, the sum of ₦9.54 million was allocated for the construction of 14.11Km dual carriageways. These roads include Murtala Way, Ahmadu Bello Way/Sulu Gambari road, Umoru Audi road and Fate road. Further, the sum of ₦18.424 million was allocated for the rehabilitation of 22 roads in the city.

In subsequent plans, roads such as Taiwo, Emir, Lagos and Gambari - Amilegbe roads were upgraded to dual carriage ways. Unity road (now Wahab Folawiyo road) was constructed during this period. During the (1981 - 85) plan period, Adewole Estate road, Asa Dam and New Yidi roads were upgraded and linked with the intra-urban network to improve accessibility in the city. In 1987, the south link road was constructed to link Asa Dam road with Ajassepo road.

The growth of the city's road networks can be further explained by considering the composite growth pattern.

6.4 Composite Growth Pattern Of Road Network

The composite growth pattern of intra-urban road network in Ilorin can be described in terms of the progressive development of the network over the years. This takes the form of both spatial and temporal development of the network. Fig 6.9 shows the composite growth pattern of the network while Tables 6.2, 6.3 and 6.4 show the analyses of the growth pattern. From Table 6.2, it can be seen that between 1963 and 1973, the alpha index changed by 0.07 indicating a 29.17 percent change in the connectivity of the city's network while the beta index changed by 0.2 indicating a 15.38 percent change in the network's linkage intensity.

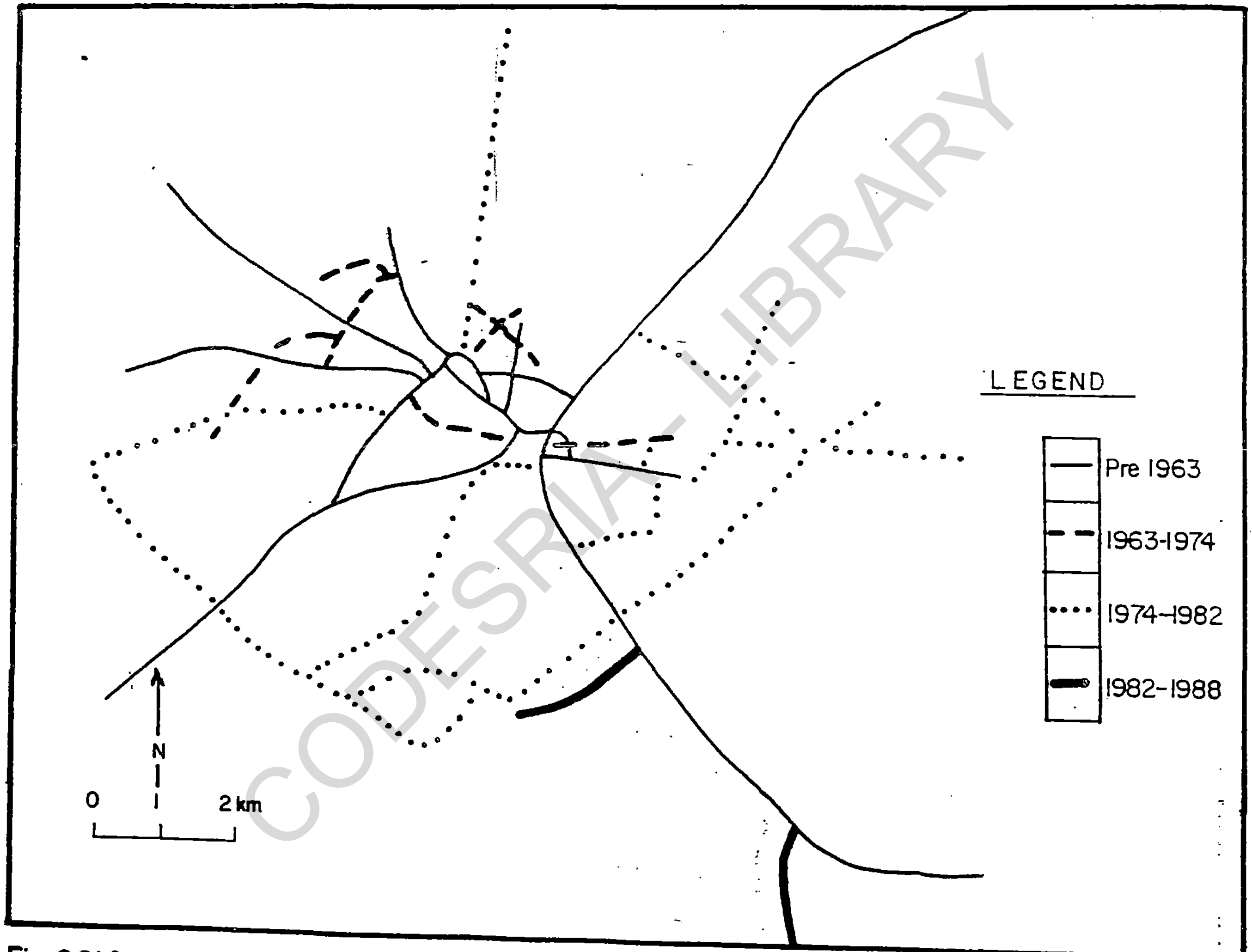


Fig. 6.9: Composite growth pattern of Ilorin roadnetwork, (1963-1988).

For the same period, the gamma index changed by 0.04 showing a 7.69 percent change in the level of connectivity of the network while the eta index changed by 0.21 indicating a 29.58 percent change in this structural index.

Between 1973 and 1982 the alpha index changed by -0.03 indicating a -9.68 percent change in the connectivity of the city's network while the beta index changed by 0.01 showing a 0.67 percent change in the network's linkage intensity. For this period, the gamma index changed by -0.03 indicating a -5.36 percent in the level of connectivity of the city's network while the eta index changed by 0.07 indicating a 7.61 percent change in this structural index.

Between 1982 and 1988, the alpha index changed by -0.02 indicating a -7.14 percent change in the connectivity of the network while the beta index changed by -0.04 indicating a -2.65 percent change in the network's linkage intensity. The gamma index for this period also changed by -0.02 indicating a -3.77 percent change in the level of connectivity of the network while the eta index changed by 0.2 indicating a 20.2 percent change in this structural index.

Table 6.2 Changes In The Strucurual Indices Of Network (1963 - 1973)

Structural Indices	1963	1973	Absolute Change	% Change
Alpha index	0.24	0.31	0.07	29.17
Beta index	1.31	1.5	0.2	15.38
Gamma index	0.52	0.56	0.04	7.69
Eta index	0.71	0.92	0.21	29.58
No of Segments	17	30	13	76.47
Length of road(km)	12	22.7	10.7	89.17

Source: Author's Data Analysis, 1988

Table 6.3: Changes In The Structural Indices Of Network (1973 - 1982)

Structural Index	1973	1982	Absolute Change	% Change
Alpha index	0.31	0.28	-0.03	-9.68
Beta index	1.5	1.51	0.01	0.67
Gamma index	0.56	0.53	-0.03	-5.36
Eta index	0.92	0.99	0.07	7.61
No of Segments	30	68	38	126.67
Length of road(km)	22.7	67	44.3	195.15

Source: Author's Data Analysis, 1988

Further, the total number of road segments between 1963 and 1973 changed by 13 representing 76.47 percent while the total length of roads changed by 10.7km representing 89.17 percent increase. Between 1973 and 1982, the total number of road segments changed by 38 indicating a 126.67 percent increase while the total length of roads changed by 44.3km representing a 195.15 percent increase. With respect to the period between 1982 and 1988, the total number of road segments changed by 4 representing a 5.88 percent increase while the length of roads changed by 19km representing a 28.36 percent increase.

Table 6.4 Changes In The Structural Indices Of Network (1982 - 1988)

Structural Indices	1982	1988	Absolute Change	% Change
Alpha index	0.28	0.26	-0.02	-7.14
Beta index	1.51	1.47	-0.04	-2.65
Gamma index	0.53	0.51	-0.02	-3.77
Eta index	0.99	1.19	0.2	20.2
No of Segments	68	72	4	5.88
Length of roads(km)	67	86	19	28.36

Source: Author's Data Analysis, 1988

The general pattern of changes in the development indices show that the network experienced significant growth between 1963 and 1973. This can be attributed to the fact that within this period, the city grew from being a provincial headquarters to a state headquarters and the consequent attention paid to the construction of new roads and the improvement of existing ones.

Between 1973 and 1982, there was still some attention paid to the development of intra-urban road network but the strigent measures being adopted by government in respect of funds being allocated to all sectors of the economy affected road construction. The pattern of changes in the network indices between 1982 and 1988 are clear indications of the general state of the country's economy. Besides, the initial rapid growth experienced by the city's network was commensurate with the city's rapid expansion. As the city's expansion slowed down, there was also a decline in road construction. Although some improvements were made on existing road networks, no significant construction of new roads took place during this period.

The growth of the city's network is further depicted by the curve in Fig 6.10. This is an attempt to see if the development of the road network in the city conforms to any existing model. As with the growth of urban land in chapter IV, the pattern of network growth in the city conforms to the logistic curve. The cumulative totals of road segments again conform to the primary, rapid and declining phases of a diffusion process. (see Casetti, 1969). From Fig 6.10, it can be seen that the period 1963 - 1973 represents the primary phase, while the expansion phase occurred between 1973 and 1982. After 1982, a deceleration of road development has started to set in. The reasons for this trend in road network growth can be attributed to the changing nature of the country's economy. Secondly, road networks cannot grow indefinitely. The city's expansion is also a significant factor in network growth.

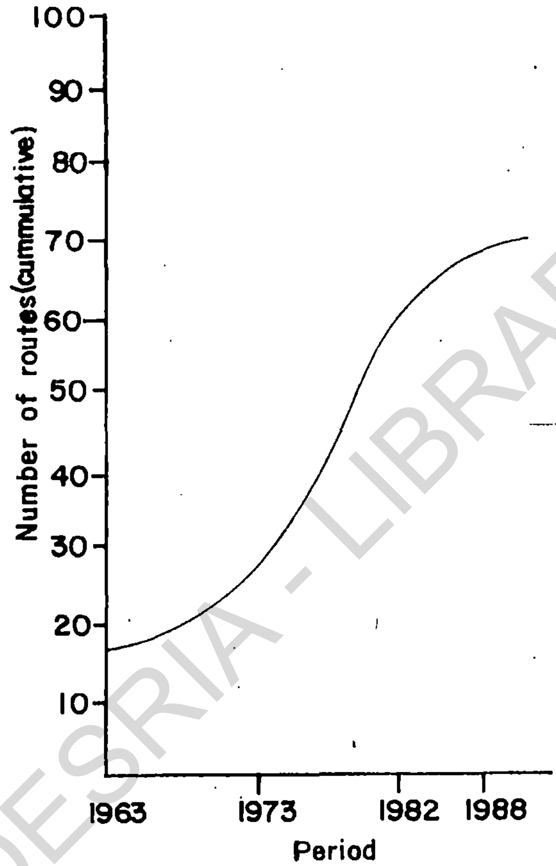


Fig. 6.10: Network growth in Ilorin 1963–1988.

The foregoing analyses of growth in road network have helped to establish a complimentary form of development between road development and urban expansion. These analyses are however not sufficient for predictive purposes. The next chapter is an attempt to model road development and urban expansion for such predictive uses.

CHAPTER SEVEN

MODELLING URBAN EXPANSION

The discussions in chapters V and VI have helped to elucidate the evolutionary changes in the built-up area of Ilorin and its transportation networks. The results of the mentioned chapters have also shown that a spatio-temporal relationship exists between the network development and the spatial expansion of the city. The evolutionary changes in the network structure of the city are controlled by the magnitude of changes in the built-up area.

However, planning for the growth of a city and its transportation networks becomes meaningful if predictive models of the growth of such a city and the structure of its transportation networks can be formulated.

In developing a spatio-temporal model of urban expansion, one must be able to determine the network structure and urban form of a city at any given time. Such a model can then be used to simulate the form of a city for a predetermined network pattern. This chapter is concerned with the identification of basic factors of urban expansion and the use of such factors for the modelling of urban expansion in Ilorin. The chapter is also concerned with the simulation of the growth of the city.

7.1 Factors Of Urban Expansion

In modelling urban expansion, it is important to identify those factors responsible for the morphology of a city. Such factors can then be used to establish a relationship between the form of a city at any given time and one or more of the identified independent variables. Thus a change in the values of the independent variables is accompanied by a change in the form of the city. An important requirement of the independent variables is that they must be both measurable and amenable to accurate forecasting. This is necessary in order to make reliable forecasts of the form of a city given a set of independent variables.

In this study the factors considered to be useful explanatory variables for determining the morphology of a city at a given time are:

(i) Population of the city (ii) city's level of industrialisation (iii) level of retail trade
(iv) provision of amenities (v) Urban services
(vi) Land speculation (vii) Transportation
(viii) Land use

(a) Measurement of Explanatory Variables

Table 7.1 indicates the selected explanatory variables and the methods for measuring them.

Population

The first explanatory variable is the population of the city. The choice of population as an explanatory variable is based on the fact that urban centres both in developed and developing world attract population in the form of rural-urban migration. Lampard (1955) attributed this drift in population to the advantages of access to metropolitan labour pool. In fact Czamanski(1964) emphasized that job-creating investments result in a city's population growth.

Table 7.1 Explanatory Variables and Their Measurements

	Variable	Surrogate Measure
1.	Population	Population for different periods
2.	Industrialisation	Industrial employment
3.	Retail trade	Employment in retail trade
4.	Amenities	Primary School enrollment
5.	Urban Services	Water consumption per capita
6.	Land Speculation	Land cost per plot
7.	Transportation	Per Capita Income
8.	Land use	Total employment

Preston (1971, 1972) attributed the attractive nature of the urban centre to the opportunity of attractive job markets in city centres while Johnson (1972) identified improvement in medical techniques, in sanitation and in the general standard of living as factors leading to natural increase of population in urban centres. The effect of continuous urban population growth is an increasing demand for more housing and consequently urban expansion (Clark, 1965).

In Nigeria, there is the concentration of employment opportunities and better standard of living in urban centres which continuously attract population. Thus rural-urban migration becomes a significant factor of rapid population and consequently urban growth in these urban centres. For example, average annual rates of growth of urban populations in Nigeria were found to be 3.8 percent for 1965 - 1970; 6.2 percent for 1970 - 1975 and 5.8 percent for 1975 - 1980 (E.C.A. 1980). This trend in population growth in urban centres of Nigeria is sure to continue and population has therefore been chosen in this study as a contributory factor to urban expansion.

As for the measurement procedure, population data in a time-series form are generally scarce for individual cities (Richardson, 1971). Most population figures used for planning purposes rely on census information and their projections. The population census figure for Ilorin for 1963 and its projections were used for this study.

Industrialisation

The second factor in explaining urban expansion is the city's level of industrialisation. Industrialisation is the degree of industrial development of an area. This factor is considered important because industrial development has been identified as the leading sector of economic growth due to its high linkages (Myrdal and Hirshman, 1957; Friedman, 1966). The rate of urban development is in direct proportion to the rate of economic growth.

Preston (1971) identified industrial dispersal as one of the forces shaping urban pattern. He contends that the nature of industrial developments especially large enterprises seeking such locations as the urban periphery, results in industrial dispersal and consequently urban growth. Similarly Green (1966) found a significant relationship between city growth and employment in local market-oriented industries while Blumenfeld (1965) contends that fast growth in cities depends on the local service industries. Industrialisation is therefore considered an important factor in urban growth.

In measuring industrialisation, Lipton (1977) used capital expenditures by manufacturers as well as the level of blue-collar workforce to measure the level of manufacturing activity in twenty United States cities. Green (1966) on the other hand suggested tertiary employment as a proxy for the measurement of the level of a city's industrialisation while Oyebanji (1981) used percentage of population engaged in manufacturing industry as a measure of industrial growth.

Data on capital expenditures by manufacturing industries are not available for Ilorin. Thus data on the number of workers engaged in manufacturing employment in the city were used.

Commercial Activities

The third factor is the commercial activities in the city. This factor is considered important because traditionally, business is associated very closely with the people and also urban growth. According to Trewartra (1943) there is a close relationship between people, settlement and commerce. Commercial development, especially retail trade, is usually considered to be consequent to developments in other sectors. Indeed, some scholars consider the spread in retail trade through the development of shopping centres as a catalytic factor attracting other economic and residential enterprises (Epstein, 1967; Muller, 1981; Morrill, 1982; Steiness, 1982). According to them, an increase in the number of major retail centres in an urban area could be associated with the area's development. Epstein (1967) identified two major types of commercial development in the urban expansion. These are consequent commercial expansion and catalytic commercial expansion. While consequent commercial expansion is a response to an observed established market-potential as is exemplified by commercial strips along business streets, catalytic commercial expansion is a reaction to already established residence and is seen as a major force that acts as a spur for further urban growth.

As for measurement of commercial activities, Krakover (1982) used the number of employees engaged in retail activity as a surrogate measure for commercial development. In this study data on employment in retail trade is also used as a proxy for commercial development in the city.

Social Amenities

The fourth factor is provision of amenities. The extension of amenities to different parts of an urban area brings land within such areas closer to the point of actual development. According to Preston (1971) one of the forces stimulating urban development is the immigration of numerous people to the urban areas because of opportunity to enjoy amenities such as schools, water, electricity etc. Such living needs are usually numerous at the fringe because of accessibilities resulting from urban expansion. Further, urban dwellers seek housing environments which offer accessibility to urban facilities (Clark, 1965). Thus the search by urban dwellers for housing environments which offer accessibility to urban facilities result in urban expansion.

The problem usually encountered with the measurement of amenities is the choice of appropriate surrogate measure due to the multifaceted nature of this factor. One approach is to regard provision of amenities as indicator of urban development. Using this notion, Berry (1961) suggested energy consumption per capita, value of imports and population density as possible measures of development of an area. Berry came up with 43 such measures and contended that any one of them might serve as an index of development in an appropriate fashion. On the other hand Nichols (1969), Moseley (1973), Pred (1976) contended that composite as well as single-dimensioned variables can be used to represent development indices. Using this notion, Krakover (1982) used growth in retail trade sector to analyse the spatial reorganisation of growth in urban fields in the eastern United States.

In this study, data on energy consumption and population density are not available for the city. Provision of educational facilities measured in terms of enrolment in primary education has thus been used as an index for provision of amenity. This is because primary education is free and universal in Nigeria while secondary and tertiary education are optional.

Urban Services

The fifth factor is closely related to the fourth. The point of divergence that has not led to grouping them together is that urban services are those essential services that make the city to function. Amongst the essential services usually cited in the literature are water and electricity, sewage disposal systems and convenient means of transportation. The need for the provision of urban services commensurate with urban population growth has been pointed out by Mabogunje (1973) and Adeniyi (1978). In many of these urban centres, the inability of urban governments to adequately provide urban services lead to overstretching of the services and the spread of slums. To the extent that expansion necessitates the extension of these services to newly developing areas, Harvey and Clark (1965) have suggested that the economies of utilities may induce sprawl in the uncontrolled periphery. Also Clawson (1962) has pointed out that the provision of new services in an urban area gives a fillip toward further development. Thus provision of urban services has been identified as a factor of urban expansion.

In measuring the level of provision of urban services, indices such as water consumption per capita and electricity consumption can be used (see Berry 1962). In this study, information on electricity consumption per capita were not readily available. Hence, water consumption per capita has been used.

Land Speculation

The sixth factor is land speculation. Land speculation entails the with-holding of land for development in anticipation of future high land prices. Such expectations of future land prices and dates of maximum net gains results in the premature subdivision of land and uncoordinated development. According to Harvey and Clark (1965), the consequences of independent increamental additions to urban land is a growth process permitting a sprawl pattern. Further, Clawson (1962) has argued that urban sprawl and speculation in raw suburban land are the natural consequences of the economic and social processes in an area. For example, the independence of placement and timing of speculative ventures permits a sprawl pattern. It is this lack of coordination of the decision to speculate which produces sprawl.

As for the measurement of land speculation, Clawson (1962) has suggested that when land comes within the zone of suburban influence, for possible later development, its prices and taxes often rise. It is therefore considered reasonable that a surrogate measure for land speculation is the changing cost of land. Thus the cost of a plot of land for different periods has been chosen as a measure of land speculation.

<u>Transportation</u>

The seventh factor is transportation. Transportation has been identified as a catalyst of urban expansion. According to Harvey and Clark (1965), it is the automobile which permits access to remote areas that provides the essential condition which allows expansion to occur.

Thus over time, transport provision has promoted the outward expansion of cities. According to Beesley and Kain (1964), the city evolves through time in ways which depend upon the sequences in which changes in land use and movement facilities are introduced.

Scholars have looked at the measurement of transportation facility from the point of view of urban travel demand and trips generated by the inhabitants of a city. Such a demand is a function of income level, car ownership and personal preference. According to Bruton (1970), rapid car ownership as well as improved local transport facilities accelerate the trend of trips from the city centres to the fringes of the cities. On the other hand, Maunder (1982) observed that trip making increases with income. Thus the higher the income, the higher the number of trips made. Per capita income has thus been used in this study as a measure of travel demand in the city.

Land Use Control

The eighth factor is land use control of the city. The importance of land use control as a factor of urban expansion is that inefficient land use control and failure of government to prevent heterogeneous land uses contribute to urban expansion (Harvey and Clark, 1965). According to Preston (1971) growth in certain areas of an urban centre can be stimulated in their early stages by the search for cheap land. This search, if not controlled, scatters urban development and contributes to sprawl.

In measuring land use, Starkie (1967) put forward gross or net income sales, employment size and floor space area as surrogates for estimating different types of land use in a city. Ogunsanya (1982) used employment size as a surrogate measure for land use in Lagos metropolis. Employment was considered useful because there is a relationship between a land use type and the number of people employed (Also see Oduola, 1973).

In this study, employment size has also been adopted as a surrogate measure for land use because data on net income sales and floor space area were not available for the city.

7.2 Regression Model Of Urban Expansion

The approach adopted here in modelling urban expansion is to identify the salient variables to use out of the independent variables hypothesised to be factors of urban expansion. The identified variables are then used to simulate urban growth.

From the foregoing discussion of factors of urban expansion, it can be conceptualised that the growth of the city is influenced by a set of independent variables X_1, X_2, X_3, ... X_8, and that a relationship exists such that

$$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8) \qquad (1)$$

where

X_1 represents population of the city

X_2 represents city's level of industrialisation

X_3 represents level of retail trade

X_4 represents provision of amenities

X_5 represents urban services

X_6 represents land speculation

X_7 represents transportation

X_8 represents land use

Y represents the built-up area of the city.

By this approach, we seek to derive an equation which weights the individual independent variables according to their effects upon the dependent variable. Thus equation (1) can be made operational in the form of a multiple regression equation.

$$Y = a + b_1x_1 + b_2x_2 + \ldots\ldots + b_8x_8 + e \text{ -----} \quad (2)$$

where b_1, b_2 ...... b_8 are the weights determined by empirical evidence, a is a constant (the intercept) and e is the error term which explains the effects of the unspecified variables. Using the values of the built-up area of the city at different periods as the dependent variable and the factors of urban expansion as the independent variables, it is possible using the least squares technique to establish the values of the a' and b's. Such use of the least squares techniques assumes that the relationship between the dependent and independent variables is linear. Even if the relationship between the dependent and independent variables is not linear, Chisholm and O'Sullivan (1973) have explained that such non-linearity could be neglected.

The regression procedure selected for the analysis is the stepwise regression. The stepwise regression has the quality of selecting those independent variables that statistically explain the greatest variance in the dependent variables. The independent variables that enter the regression equation each individually and independently explains part of the variance in the dependent variables.

The outline of the steps involved in the stepwise procedure according to Draper and Smith (1966) and reported in Ogunsanya (1984) are:

<u>Step 1</u>: Compute the simple correlation coefficients between the dependent and independent variables and select the variable with the highest coefficients, X_4 say for the regression equation.

<u>Step 2</u>: Compute the partial correlation coefficients and select the variables with the highest partial coefficient as the next variable X_1,

Step 3: Compute regression equation $Z = f(X_4, X_1)$ and using the criterion F_1 to exclude and F_2 to include, decision is made whether to retain X_4 in the light of including X_1. The partial correlation coefficient for the remaining variables are computed and the next variable X_2, say, is selected as in step 2.

Step 4: The regression equation $Z = f(X_4, X_1, X_2)$ is then computed and X_4 and X_2 are examined as to their significance. The decision is then made as to whether they should be retained before an additional variable to be included is determined as in step 3. This continues until all the variables are exhausted and the final best equation selected.

The computation for this analysis was done on the University of Ilorin Micro-Computer AMSTRAD Model PC 1512 DD.

7.3 Results Of The Regression Model

Before further discussion of the model output explaining the relationship between the dependent and the identified independent variables, it is pertinent to consider the coefficients of correlation obtained for the pairs of eight variables listed in Table 7.2. The coefficient of correlation quantifies the relationship between two observed geographic factors and shows the direction and strength of relationship between the variables.

A detailed analysis of the table reveals a number of interesting relationships. First is the fact that most of the coefficients of correlation are positive indicating the tendency for the variables to increase or fall together. Secondly, the dependent variable has high correlation coefficients of 0.97, 0.95, 0.98, 0.94, 0.77, 0.95 and 0.97 with X_1 (population), X_2 (industrialisation), X_3 (commercial employment), X_4 (Amenities provision),

Table 72 Correlation Matrix Of The Dependent And Independent Variables

	Y	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8
Y	1.0000								
X_1	0.9709	1.0000							
X_2	0.9548	0.9866	1.0000						
X_3	0.9751	0.9989	0.9891	1.0000					
X_4	0.9382	0.8483	0.8025	0.8576	1.0000				
X_5	0.7695	0.7886	0.6806	0.7758	0.8000	1.0000			
X_6	0.9505	0.9847	0.9937	0.9867	0.8118	0.7112	1.0000		
X_7	0.9704	0.9983	0.9760	0.9967	0.8604	0.8198	0.9751	1.0000	
X_8	-0.1107	-0.0281	-0.0743	-0.0410	-0.2085	-0.0416	-0.1553	-0.0050	1.0000

Source: Computer Output

X_5 (urban services), X_6 (land speculation), and X_7 (land use) respectively. Also many of the variables are inter-correlated. For instance, X_2 (industrialisation) has a high correlation coefficient of 0.99 with X_1 (population) while X_3 (commercial employment) has correlation coefficients of 0.99 and 0.98 with X_1 (population) and X_2 (industrialisation) respectively. X_4 (amenities provision) has correlation coefficients of 0.85, 0.80 and 0.86 with X_1 (population), X_2 (industrialisation) and X_3 (commercial employment) respectively, while X_5 (urban services) has correlation coefficients of 0.79, 0.68, 0.78 and 0.8 with X_1 (population), X_2 (industrialisation), X_3 (commercial employment) and X_4 (amenities provision) respectively. X_6 (land speculation) has correlation coefficients of 0.98, 0.99, 0.99, 0.81 and 0.7 with X_1 (population), X_2 (industrialisation), X_3 (commercial employment), X_4 (amenities provision) and X_5(urban services) respectively while X_7 (land use) has correlation coefficients of 0.99, 0.98, 0.99, 0.86, 0.82, and

0.98 with X_1 (population), X_2 (industrialisation), X_3 (commercial employment), X_4 (amenities provision), X_5 (urban services) and X_6 (land speculation) respectively. This results in the problem of multicollinearity being built into the model. However, the stepwise regression technique adopted has the inherent advantage of overcoming the multicollinearity problem such that only those variables that make the greatest contribution to the dependent variables are selected.

A further observation of the analysis reveals that X_8 which is land use in the city has consistently low and negative correlations with both the dependent and other variables. This may be due to the fact that this variable, which is represented by the total employment in the city, was estimated by considering mainly secondary and tertiary employment in the city. It was not possible to obtain an accurate figure for the number of people engaged in primary occupation.

However, the results of the correlation analysis must be interpreted with caution because deductions from such analysis are subject to limitations of statistical generalisation.

Thus the dependent variable was further regressed against the independent variables using the stepwise procedure. The stepwise regression selects only two of the independent variables. These variables, namely (X_3) representing commercial employment and (X_4) representing schools enrollment as a surrogate for amenities, both account for 99.01% of the total variation in the dependent variable. This indicates that the two factors combined explained reasonably the spatial variation in the built-up area of the city. Table 7.3 shows the summary for the stepwise regression analysis.

Table 7.3 Regression Summary For Dependent And Independent Variables

Dependent Variable	Independent Variable	Regression Coefficients	Standard Error	Computed F - Value
Y	X_3	0.13899*	0.02407	33.36
	X_4	0.03003*	0.00869	11.92

Source: Computer Output.

R^2 = 0.9901: Regression Constant = 2.30676

* Significant at 0.1500 level.

Multiple regression equation is

$$Y = 2.30676 + 0.13899\,X_3 + 0.03003\,X_4$$

where Y = Built-up Area; X_3 = Commercial employment; X_4 = Schools enrolment.

From the regression summary, the coefficient of determination (R^2) is 0.9901 implying that only 0.99% of the total variance is unexplained by the combined influence of the two independent variables. It is usual to seek for additional elements of the environment responsible for the remaining unexplained 0.99%. Other elements that may probably account for the unexplained variance are ethnic segregation whereby the traditional area of the city is inhabited mainly by the indigenes while the new areas are occupied by the non-indegenes.

Table 7.4 Summary Of Residuals

	Observed	Computed	Residual
1963	3.08961	3.09391	-0.00430
1968	3.98091	3.62368	0.35723
1973	4.69468	4.72010	-0.02542
1978	6.21173	6.83406	-0.62233
1982	10.00055	9.85529	0.14526
1988	11.28960	11.00557	0.28403

Source: Computer Output.

Table 7.4 shows the summary of residuals. This summary explains the deviation of the expected from the observed values. The distribution shows that the residuals are low ranging from -0.62 to 0.36. It can also be seen from the table that three of the observations record positive residuals while the rest three record negative residuals.

The model of urban expansion just obtained provides the essential ingredients for future simulation of the city. The next subsection is an attempt to simulate the city's growth.

7.4 Simulating Urban Growth

Most of the analytical models used for describing urban growth are of the deterministic linear regression type (Czamanski 1964; Lackschman and Hansen, 1965). But according to Lowry (1964), a model of the metropolis should ideally be a dynamic system. The model should incorporate time lags, inertia factors, sequences of decisions and dynamism that are apparent in any city system (Colenutt, 1970). Further, the non-incorporation of the time element into many of the linear urban models results in the production of models that Lowry (1964) has termed "an instant city". In such models, each new pattern of urban development is predicted independently which for predictive purposes could be unreliable.

Thus in our attempt to simulate urban growth, we are interested in building a set of models that will permit experimentation with urban form and structure and prediction of the future spatial pattern and operation of the city. Such experimentation or urban simulation modelling is not new. Infact simulation modelling is quite well documented in Batty (1972).; Brown et al (1972); Goldberg

(1973a); Goldner, (1972); Harris (1965 and 1968); Putman (1972); Sweet (1972); Wilson (1969) and Ayeni (1979). In spite of this, simulation still remains an important technique for identifying future situation where a stochastic process is required.

Our choice of a suitable model depends on the objective of study such that we can express relationships between variables and the rules for modelling our concept. Model builders have tried a variety of methods for the predictive modelling of various phenomena-multiple regression and simulataneous equation systems (Lowry, 1964; Hill, 1965; Kain 1962; Scott, 1968); linear programming (Herbert and Stevens, 1960; Schlager, 1964) and probabilistic models such as Markov Chains (Harris, 1965) and Monte Carlo simulation (Morrill 1965; Chapin and Weiss, 1964). While linear models are representative of the deterministic modelling approach, Markov Chain models and Monte Carlo simulation are probabilistic.

The Monte Carlo simulation approach has often been adopted in Geographic research because most researchers in Geography subscribe to the view that observable results of location decisions and actions appear to the observer as though they are governed by probabilistic laws (Dacey, 1975). In addition, urban system has a number of properties that do not make it amenable to simulation by deterministic equation systems. Processes seem to be probabilistic and subject to possible random fluctuations and disturbances that cannot be incorporated in a linear model. Thus Monte Carlo simulation has frequently been proposed as the natural framework for both investigating and experimenting with urban phenomena, (Garrison, 1962; 1966; Chapin, 1962, 1965; Harvey, 1960).

7.5 The Monte Carlo Approach To Simulation Of Urban Growth

The Monte Carlo simulation method involves "setting up a stochastic model of a real situation and then performing sampling experiments upon it" (Harling 1958; Ackoff, 1962). The objective of the Monte Carlo technique is to simulate patterns very comparable to real conditions in lieu of the unknown information which may dictate exact location in a deterministic model.

In the Monte Carlo simulation of a stochastic growth process a set of probabilities govern choice of behaviour. The new situations or states of the phenomenon of interest are outcomes of a selection process that is probabilistic in operation. Monte Carlo simulation has various uses one of which is for studying the transitional processes of a dynamic system.

Monte Carlo simulation has received wide applications in both the physical and engineering sciences. It has also been applied in urban geographical problems. Its earliest application to urban modelling was by Donnelly, Chapin et al (1964) who translated the Monte Carlo concept into a model in which the decisions to build on vacant land were conceived in probabilistic terms. Hagerstrand (1965) applied the concept in the study of diffusion processes while Morrill (1965a) utilised the technique in a study of the expansion of urban fringe in Seattle. Morrill (1965b) applied the Monte Carlo ideas to the growth and spread of settlements in Sweden while Colenutt (1969) simulated roadside land uses especially bill boards using the Monte Carlo concept. Ayeni (1969) used the Monte Carlo technique to simulate the pattern of development in Ikere-Ekiti, Nigeria.

Despite its wide application to geographical problems, the Monte Carlo technique suffers from some of the limitations of early urban simulation efforts. The first difficulty is the derivation of the probability surfaces as the surfaces should theoretically be constructed or derived from some appropriate empirical observations. Authors have however used the actual surface of development to calculate probability. Secondly, changes in the probability surface over time are difficult to define. For this reason, subjective rules are introduced which may help in revealing some of the hidden structures of the process. Thirdly, there is the problem of management of the time dimension in the model, thus the model merely simulates spatial patterns that result from processes implicitly assumed to operate over time (Colenutt, 1970).

Monte Carlo simulation technique must therefore be treated with caution. But if we are satisfied as to the theoretical interpretation of the random variables contained in the model and if we are treating aggregated events and certain that a simple theoretical model is inadequate to solve the problem, then the Monte Carlo technique is an invaluable tool for problem solving.

7.6 Procedures In The Monte Carlo Technique

The steps involved in using a Monte Carlo technique as outlined by Ayeni (1979) consist of the following:

(i) formulation of a set of possible hypotheses on factors governing the system of interest.

(ii) the construction of a matrix of probabilities from theoretical considerations about the system of interest.

(iii) the allocation procedure using both the probability matrix and a random number table.

The set of hypotheses generated must be related to the nature of our system of interest. The probability surface must also be constructed directly from the same set of theoretical considerations.

The urban area under study is usually divided into cells which are assigned attractive scores based on set factors. Probability values and range of random numbers are then derived from the probability scores.

7.7 Application Of The Monte Carlo Simulation Technique To Ilorin

The foregoing procedures suggest a useful methodology for the application of Monte Çarlo technique to simulate urban growth. Our conceptual premise for the simulation of urban growth is based on Boyce's (1966) wave theory analog concept of metropolitan expansion. Of particular relevance to our simulation experiment is the observation that cities grow outwards in different directions at different times, thus the edge of the metropolis is rarely equidistant from the central core. Further, the growth of the city might be channelled into particular areas and retarded in others at any given time. Barriers to growth could be physiographic, land use zoning or growth could be transportation network induced (see also Abler, Adams and Gould, 1972, p. 402). This analogy from a wave standpoint can be interpreted in terms of population movement, urban density movement or the movement of urban fringe.

In order to analyse the growth of Ilorin from a wave theory analog approach using the Monte Carlo simulation technique, the following procedures were followed:

1. A set of hypotheses was formulated on factors governing urban expansion.
2. A matrix of probabilities was then constructed from theoretical considerations about urban expansion.
3. The probability matrix was used in conjuction with a random number table to allocate the items whose growth are being considered.

The listed procedures led to the formulation of the following hypotheses:

(i) City's growth tends to follow directions of least resistance usually dictated by physiographic features such as hills, steep slopes and land liable to floodings.

(ii) Developers seek for land near major tarred roads to build houses because of the advantages of accessibility.

(iii) Commercial activities and provision of amenities stimulate urban growth.

The following specific procedures were used to simulate the growth of Ilorin:

1. The built-up areas of Ilorin mapped from the 1963, 1973 and 1982 aerial photographs of the city at scales of 1: 12,000; 1: 10,000 and 1: 6,000 respectively were reduced to a scale of 1: 50,000 to facilitate the simulation exercise. The technique used for the mapping is as described in chapter III. For each year of study, the study area was divided into grid cells of 0.25 square kilometres each. Although, in using the Monte Carlo technique, the city can be partioned into wards, enumeration areas, squares or hexagons, the choice of squares is because they are more convenient to handle and to facilitate easy interpretation.
2. The road network patterns of the city were separately mapped from the aerial photographs and reduced also to a scale of 1: 50,000. In the case of simulating the pattern for 1973, the 1973 road network pattern was superimposed on the 1963 urban form while in the case of simulating the pattern for 1982, the 1982 road network pattern was superimposed on the 1973 urban form before the simulation experiment. In the case of forecasting the pattern for

2000 A.D. the master plan routes as prepared by the Town Planning Division of the State Ministry of Lands and Surveys were adopted. These routes include existing and proposed routes up to 2000 A.D. The master plan routes were then superimposed on the 1982 urban form for the simulation experiment (see figures 7.1, 7.5 and 7.9).

Four factors were hypothesised to govern the growth of the city. These are physical factor, transport factor, land liable to floodings and land use factor. In assessing and rating these factors, the criterion of suitability of land for development was used for the physical factor including land liable to floodings. The transport and land use factors were assessed in terms of accessibility and land values.

Dorau and Hinman (1928) had classified physiographic features which interfere with the free central and axial growth of cities as land features including flat land, hills; and water features such as rivers, lakes and swamps. According to them, when the demand for land is not great the town conforms itself to the advantageous features such as flat land. As the town expands and the demand for land increases, the process of altering the land features to suit the city's needs begins. Further, business sections occupy level land and residential sections land of moderate elevation, transport utilizes low land, industries occupy poor lands often filled in and recreational uses are developed around points of natural beauty.

The transport and land use factors are symbiotic. This is because for land to be developed for any use, it must have access. According to the Chicago Area Transportation Study report (CATS, 1959), accessibility is the prime requirement of commercial activities as commercial land has always had an affinity for places which are closest and accessible to most people. Residential land uses on the other hand occupy large areas and they do not need to compete with business for central locations or for sites with particular transportation or other locational advantages.

In scoring the factors, the transport factor was considered most important and in our point score method it was rated as such. The physical factor was categorised as flat, steep or hilly. Flat and well drained sites were considered as best and awarded 5 points while areas of steep gradient had 3 points and hills scored zero (see also Ayeni, 1979, p.190).

With respect to transport factor, areas were weighted in terms of nearness of development to motorable roads. Areas within 100 metres from the tarred roads were awarded 10 points while areas within 500 metres scored 5 points. Areas about 1 kilometre away scored zero.

Land liable to floodings was assessed in terms of nearness to rivers. Such a consideration affects the development of land and the further away the land from the river, the higher its suitability for development. Thus areas within 20 metres from a river were awarded - 5 points while areas within 30 metres were awarded - 3 points. Areas within 50 metres scored - 2 points (see Everson and FitzGerald, 1972).

The land use factor was more subjectively rated. The land use categories considered were residential, commercial, industrial and institutional. To the extent that commercial use has higher land values near major roads than other uses, commercial land use was awarded 6 points residential land use was awarded 3 points while industrial land use scored 2 points.

The next stage of the experiment involved the calculation of factor weightings for each grid cell. For each grid cell, the points scored for each of the factors were added to obtain the factor weightings. This represents the point score matrix (see Appendix V).

In order to obtain the growth probability matrix all the elements of the points score matrix were added and then each element was divided by the total. The computation was done using the following expression.

$$S = \sum_{i=1}^{n} \sum_{j=1}^{m} Sij \quad \text{where}$$

Sij represents each element of the point score matrix.

S represents the sum of all the elements of the point score matrix.

Also

$$Pij = \frac{Sij}{S} \qquad i = 1, \dots. n; \quad j = 1, \dots. m.$$

where Pij represents each element of the growth probability matrix. It should be noted that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} Pij = 1.00$$

where n and m are the dimensions of the growth matrix. The growth probability matrices for 1973, 1982 and 2000 A.D. simulated patterns are shown in Appendix V.

The next stage was the conversion of the growth probability matrix into random number fields. This involves two steps. First, we neglect the decimal signs and then make successive cumulations for rows beginning with the first row and moving from left to right.

As observed by Ayeni (1979), each element of the random number matrix is given by

$$q_{ij} = \sum_{i=1}^{n} \sum_{j=1}^{m} r_{ij}$$

where

q_{ij} represents each element of the random number matrix.

r_{ij} represents the cell elements of the probability matrix after neglecting the decimal points.

In order to obtain the random number field for allocating factors of growth the lowest and highest values in each cell were obtained. The random number fields are shown in Appendix V.

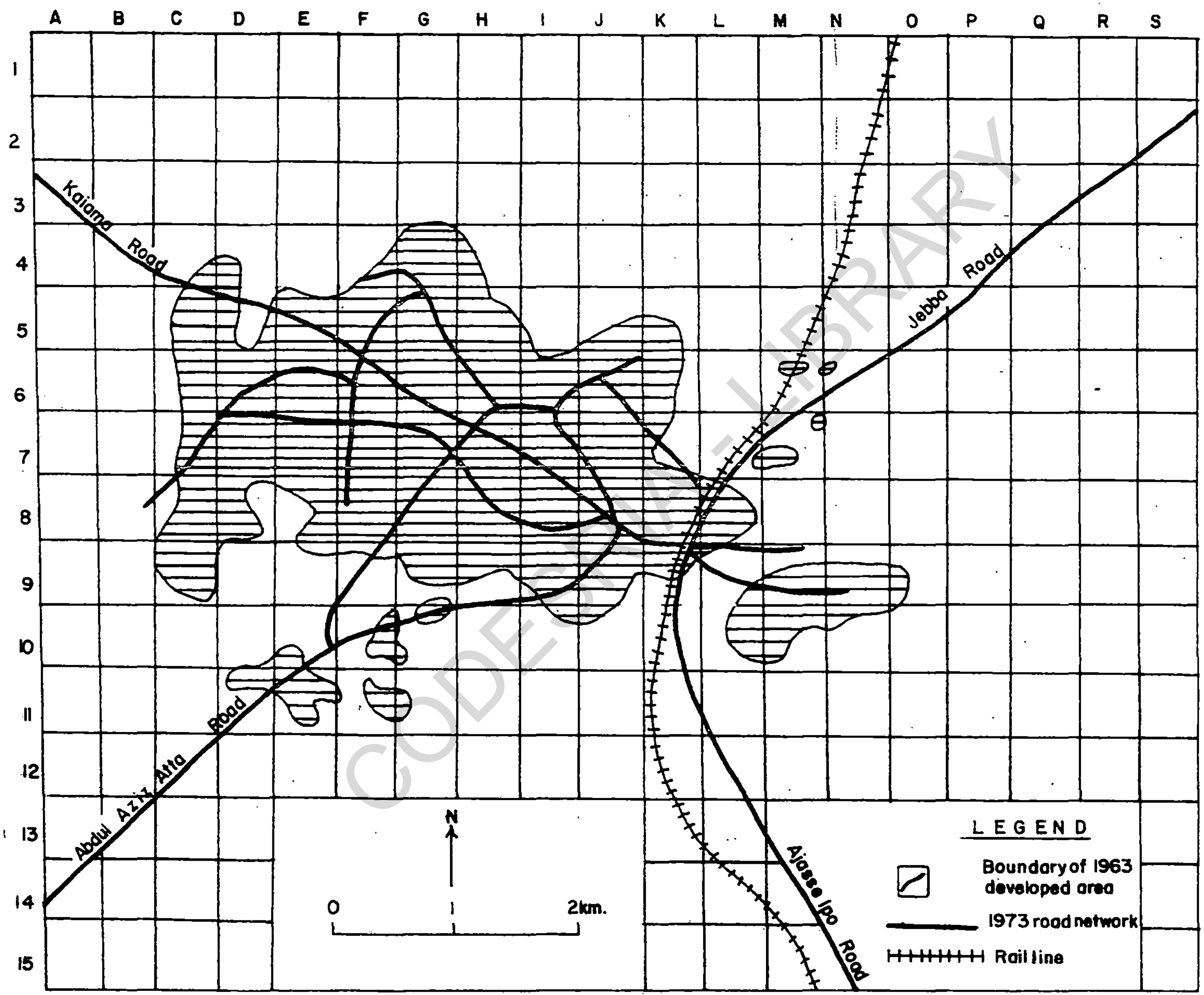


Fig. 7.1: Map of Ilorin showing 1963 built up area and 1973 road network.

The final stage of the exercise was the use of a random number table in conjuction with the random number field to obtain locations of city spread. To do this, two types of procedures and sets of data were used. These are (a) Population (b) Land Area.

The choice of population is based on previous urban simulation attempts. Everson and FitzGerald (1972) reported the use of population in simulating the growth of Dunstran bridge, East Anglia. In the case of Land Area, it is also possible to determine the built-up area of the city for any desired period using the deterministic model of urban expansion obtained earlier in this chapter.

7.8 Simulation of City Growth Using Population

The 1973 Pattern

In order to simulate the growth of the city between 1963 and 1973 the difference in population between these two time periods was obtained (see Appendix III for population figures). This gave a value of 76,000. A random number table (Neave, 1978) was then used in conjuction with the random number field to allocate the 76 000 population (see Everson and FitzGerald 1972).

The total number of grid cells allocated in the random number field is 73. This gives an average of 1041 people per grid cell. However since the allocation is random and the simulation manually done it was decided that each tally from the simultaneous use of the random number field and the table of random numbers meant that each cell concerned received 500 people (see Everson and FitzGerald, 1972 p. 204). Thus four-digit numbers each representing 500 people were drawn until the full 76,000 increase in population was accounted for. After the allocation of 76,000 people had been made, grid cells with hits were joined together to represent the spread of the city between 1963 and 1973 based on population. Figure 7.2 shows the simulated pattern for 1973 while figure 7.4 shows the observed pattern.

The 1982 Pattern

With respect to the growth of the city between 1973 and 1982, the difference in population between the two time periods gave 104,000. This increase in population was then allocated using the random number table in conjuction with the random number field to allocate the 104,000 population.

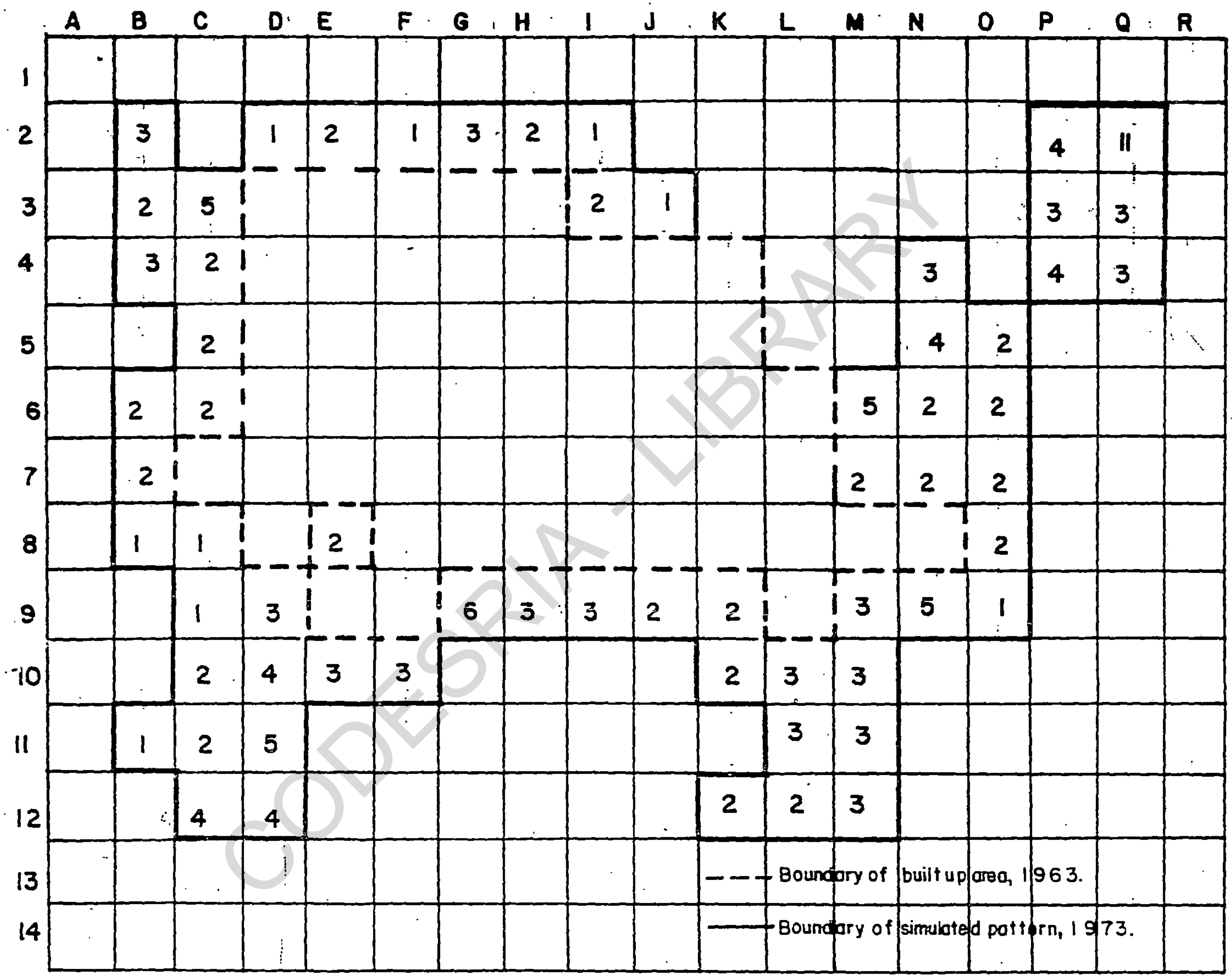


Fig. 7.2: Simulated pattern for 1973 using population.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		21		11	12	3	26	16	11	6						16	38	
3		24	26						11	7					16	22	25	
4		2	12											17		24	33	
5		10	22											23	17	12		
6		6	10										38	10	15			
7		8											10	9	15			
8		15	9		9										8			
9			11	20			24	18	18	5	15		16	26	9			
10			23	31	13	14					11	24	26					
11		9	26	4							18	16	14					
12			27								11	18	11	4				
13																		
14																		

- - - - Boundary of built up area, 1963. ——— Boundary of simulated pattern, 1973.

Fig. 7.3: Simulated pattern for 1973 using land area.

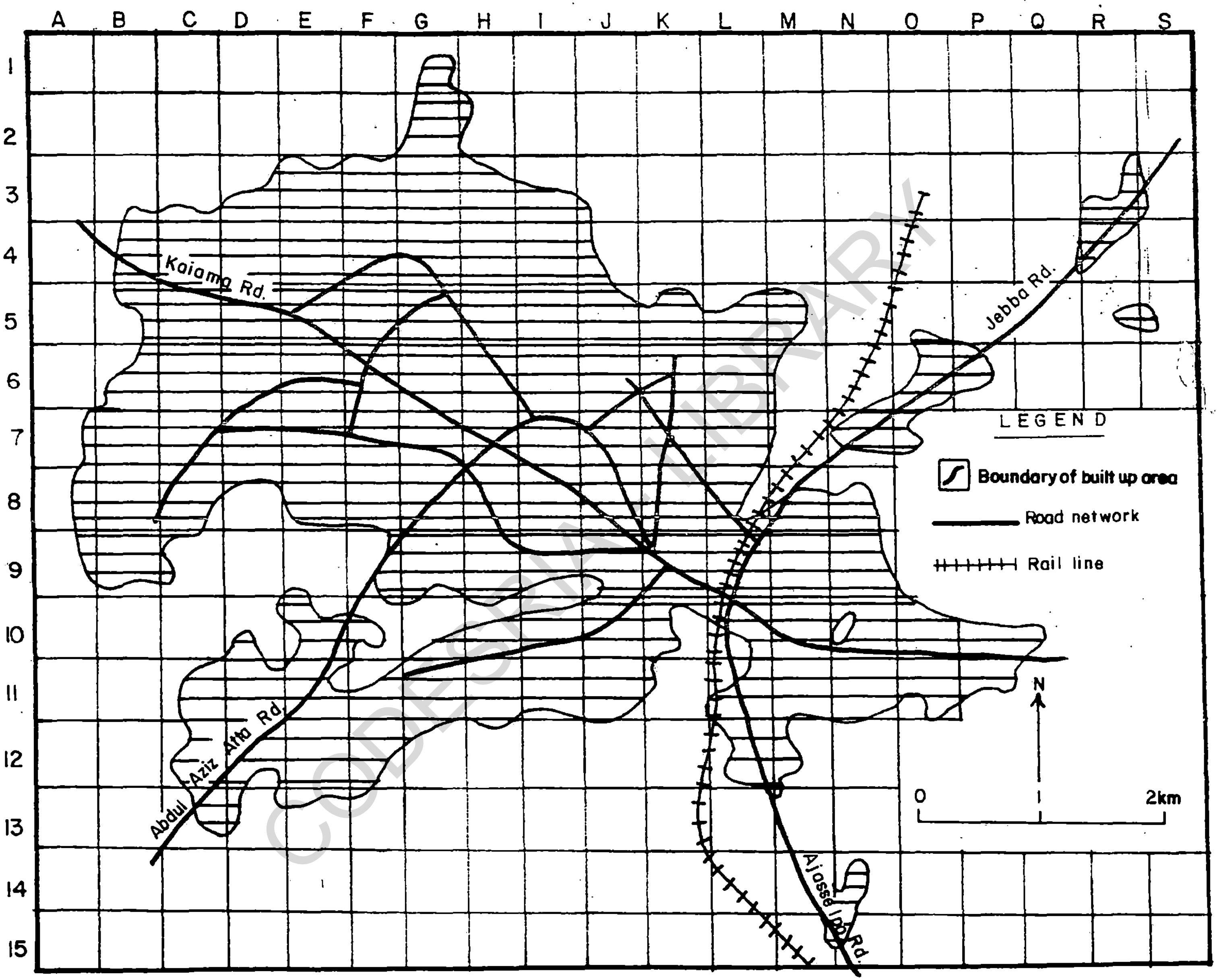


Fig. 7.4: Observed pattern of built up area of Ilorin, 1973.

The total number of grid cells allocated in the random number field is 216 (see Appendix V) using the same procedure as for the 1973 pattern each tally from the simultaneous use of the random number field and the table of random numbers meant that each cell concerned received 500 people. Four-digit numbers each representing 500 people were drawn until the full 104,000 increases in population was accounted for. After the allocation of the 104,000 had been made grid cells with hits were joined together to represent the spread of the city between 1973 and 1982 based on population. Fig. 7.6 shows the simulated pattern for 1982 while Fig. 7.8 shows the observed pattern.

7.9 Simulation Of City Growth Using Land Area

The deterministic model of city expansion earlier obtained in this chapter was used for this aspect of the simulation experiment. The model gives the land area of the city for any desired period for which values of the independent variables are given. The multiple regression equation obtained is:

$$Y = 2.30676 + 0.13899\, X_3 + 0.03003\, X_4$$ where

Y represents the built-up area of the city

X_3 represents commercial employment

X_4 represents schools enrolment as a measure of amenities provision.

The 1973 Pattern

The increase in land area of the city between 1963 and 1973 using the deterministic model gave a value of 1598 acres. The total number of houses in the city in 1963 as obtained from the aerial photograph was 8,405 while the figure for 1973 was 13969 (see Chapter V). Thus the increase in housing units of 5562 had to be allocated on 1598 acres. This gave approximately 4 houses per acre. However since the process is probabilistic and the simulation manually done, it was decided that each tally from the simulateneous use of the random number field and the table of random numbers meant that the cell concerned received 5 houses (see Ayeni, 1979 p.190). This resulted in an allocation of 1113 houses. Thus four-digit numbers each representing 5 houses were drawn until the full 1113 houses were accounted for. After the allocation of 1113 houses had been made grid cells with allocation were joined together to represent the growth of the city between 1963 and 1973 based on land area. Figure 7.3

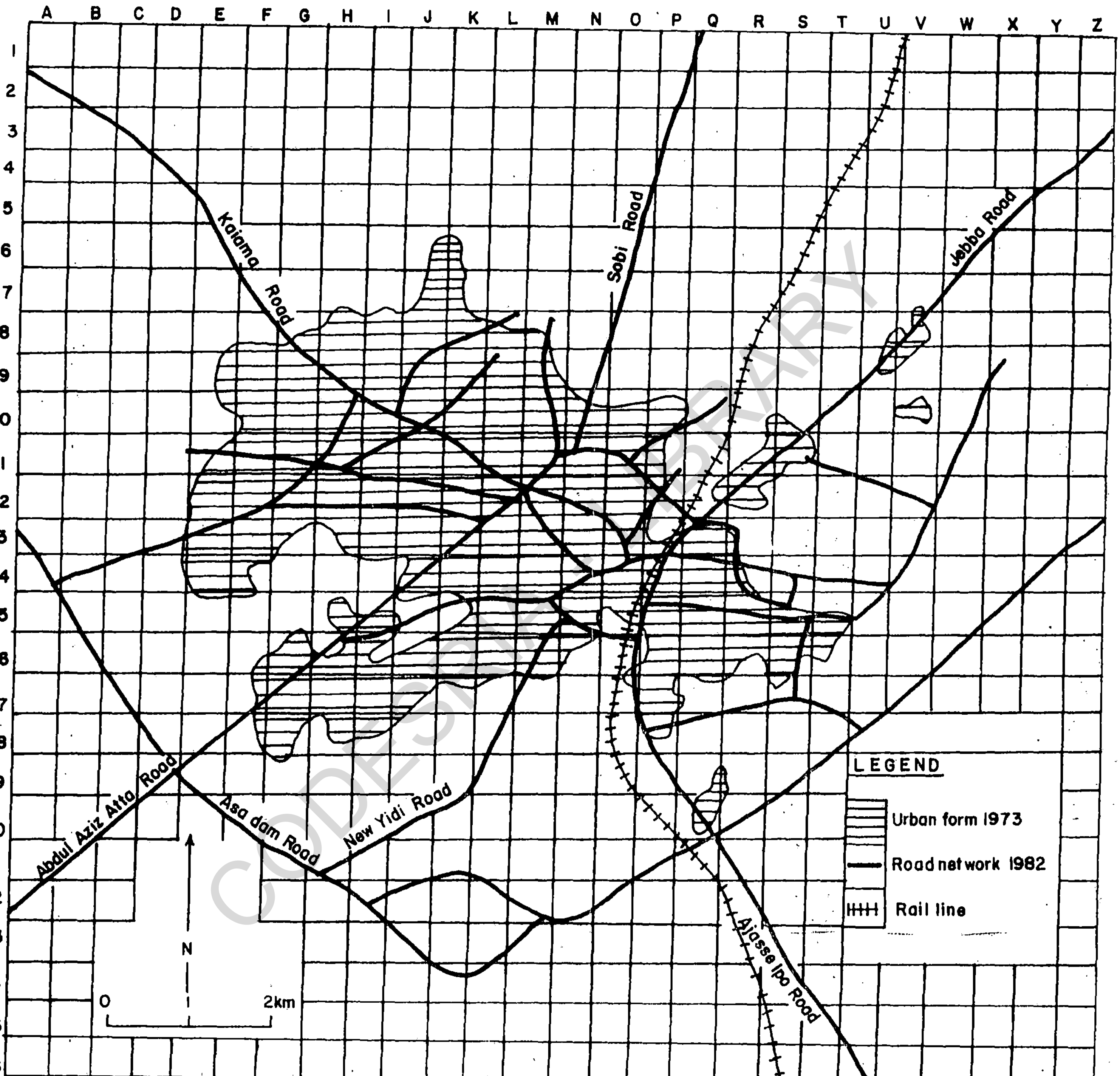


Fig. 7.5: Map of Ilorin showing 1973 built up area and 1982 road network.

shows the results of the simulation while figure 7.4 shows the observed pattern.

The 1982 Pattern

With respect to simulating urban growth for 1982 using land area, the increase in land area of the city between 1973 and 1982 using the deterministic model was 5134 acres. The total number of houses in the city in 1982 as obtained from the aerial photograph was 19,663. This gave an increase of 5,696 units between 1973 and 1982 (see Chapter V). Thus the increase in housing units of 5 696 was allocated on 5,134 acres. As in the case of the 1973 pattern, it was also decided that each tally from the simultaneous use of the random number field and a table of random numbers meant that the cell concerned received 5 houses. This resulted in an allocation of 1139 houses. Similarly, four-digit numbers each representing 5 houses were drawn until the full 1139 houses were accounted for. After the allocation of 1139 houses had been made, grid cells with allocation were joined together to represent the growth of the city between 1973 and 1982 based on land area. Figure 7.7 shows the results of the simulation experiment while Figure 7.8 shows the observed pattern.

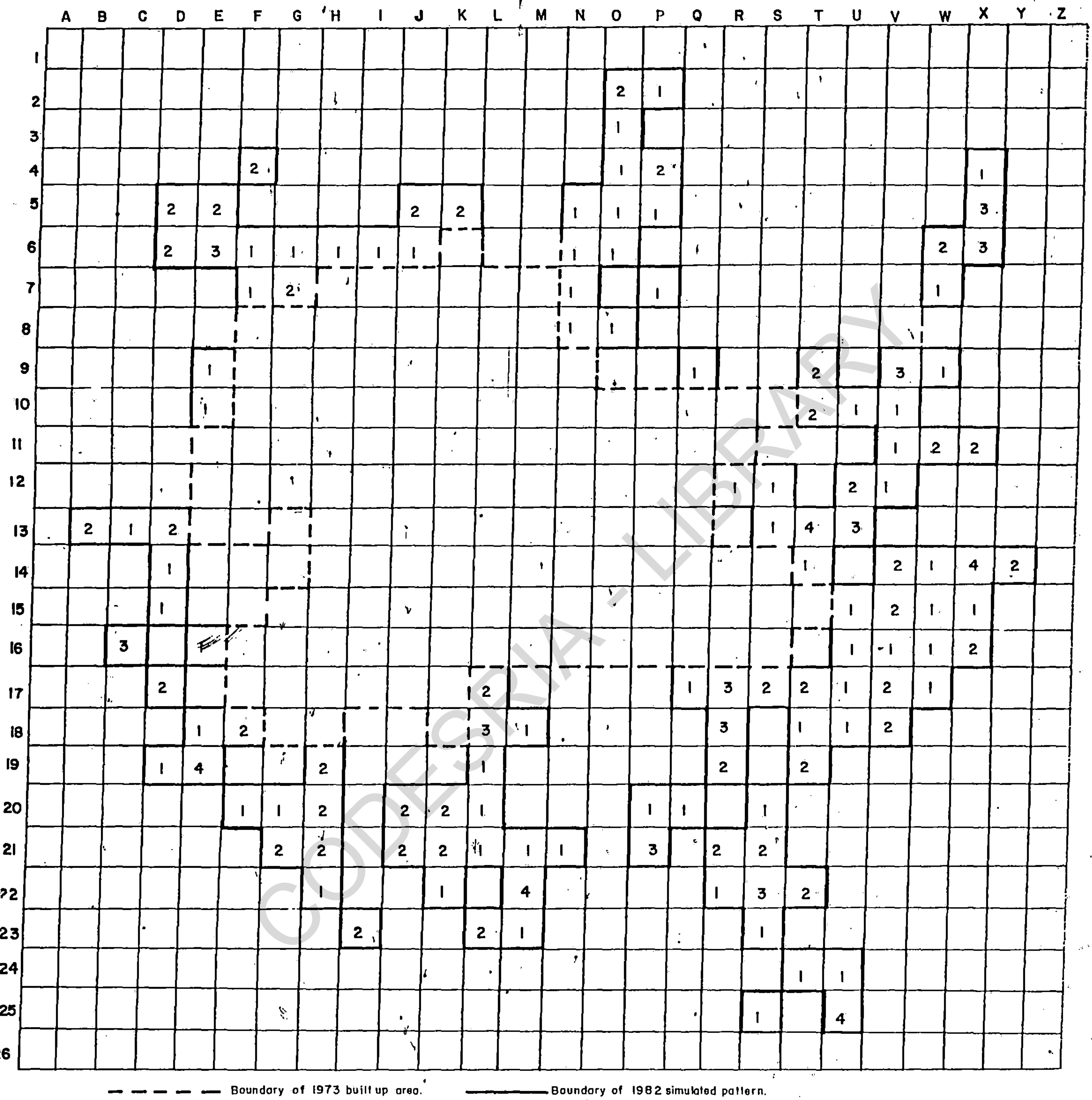


Fig. 7.6: Simulated pattern for 1982 using population.

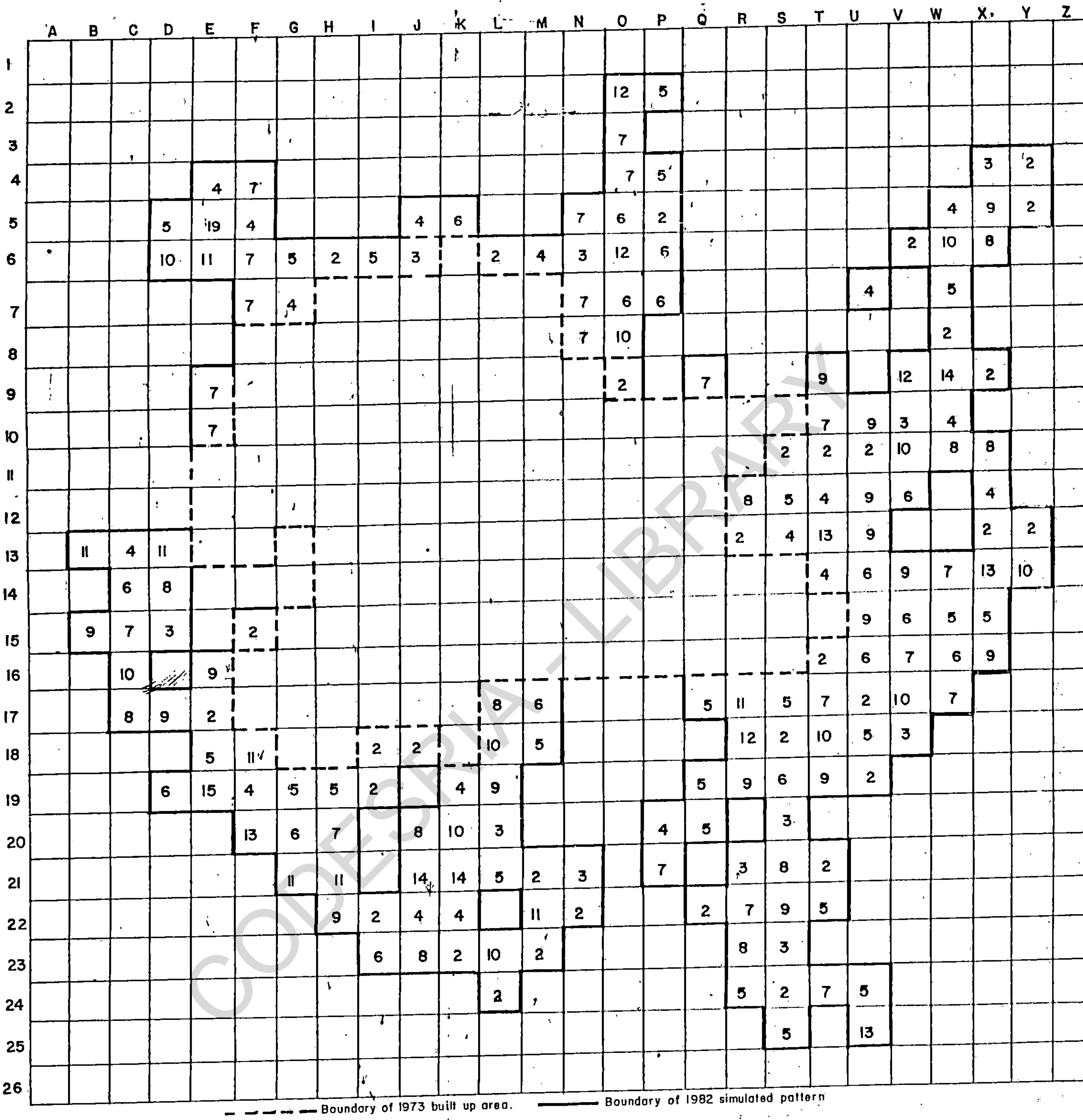


Fig. 7.7: Simulated pattern for 1982 using land area.

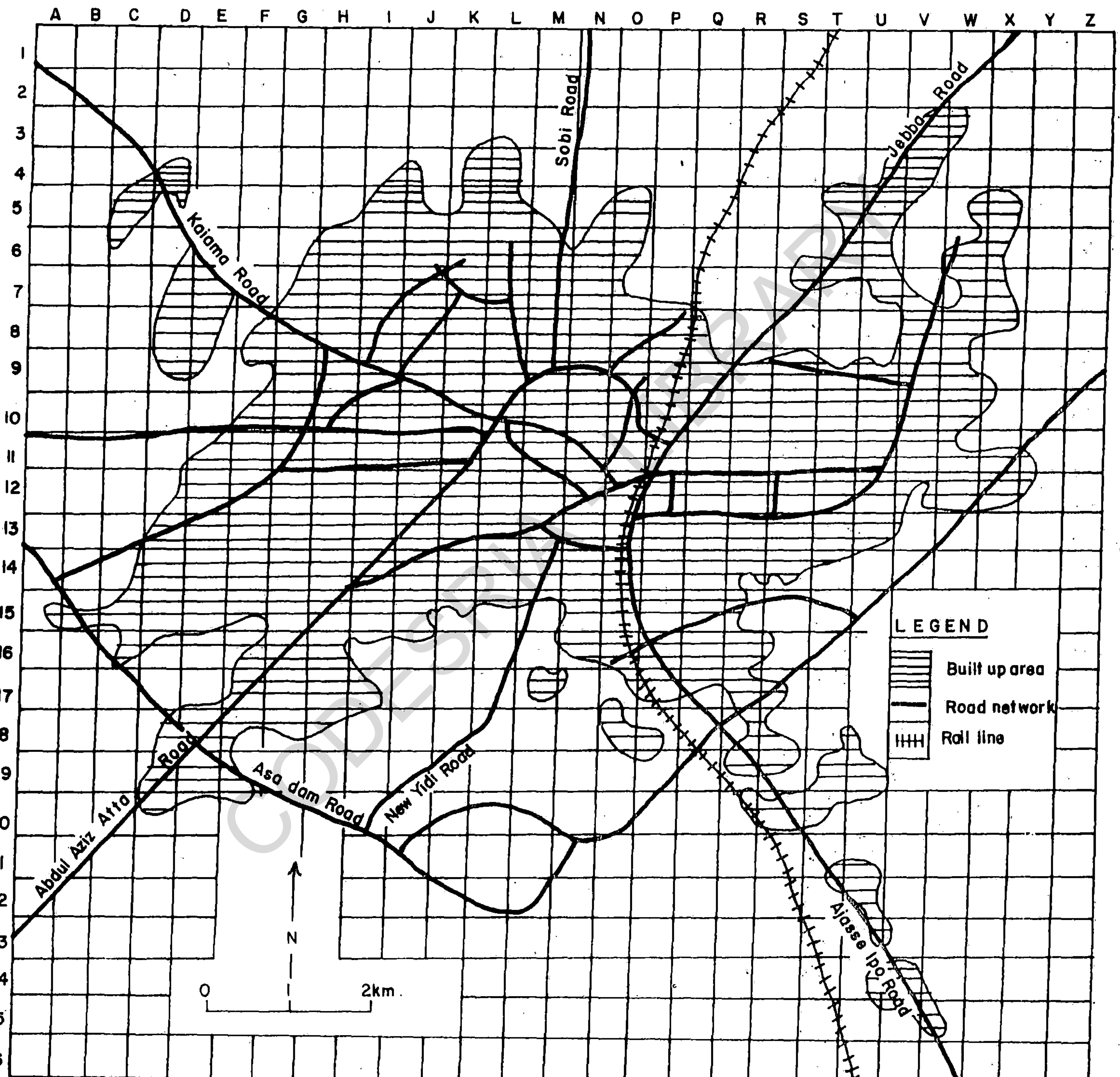


Fig. 7.8: Observed pattern of built up area of Ilorin, 1982.

7.10 Evaluation Of The Results Of The Simulation Model

The evaluation of a Monte Carlo Simulation experiment involves determination of the correlation between the observed and simulated patterns of city spread. In practice, the testing and evaluation are more difficult than testing a linear model.

However, a Monte Carlo model can be tested by firstly selecting a result or combination of results that are considered to be representative of the model and secondly of comparing these results with the actual pattern of city growth.

Although few statistical tests of goodness of fit are available for evaluating the Monte Carlo model objectively, attempts have been made at applying various methods. Chi-Square and Kolmogorov tests can be applied (Ayeni, 1979, p.187). It has also been shown that if various probability distributions are fitted to observed and expected patterns from simulation models it can be determined whether the distributions produced by the model are random (Harvey, 1966). Spectral analysis of residuals of the series can also be used to identify significant spatial frequencies that may have been omitted in the model formulation (Colenutt, 1966). The evaluation can also be based on the subjective comparison of results (Morril, 1965a). Thus the testing and evaluating of a Monte Carlo model are closely tied up with the purpose of the model.

Because the simulation experiments in this study were manually done and for different time periods, it was not possible to carry out many runs of the simulation. In order to determine the degree of fit between the simulated and observed patterns in this study a Kolmogorov-Smirnov test (Mathews, 1981) for the comparison of the distribution of the two patterns was adopted.

The procedure involved comparing the grided maps of the observed patterns of growth of the city for the years 1973 and 1982 with the simulated patterns (see Figures 7.2, 7.3, 7.4, 7.6, 7.7 and 7.8) and calculating the differences in the two patterns. Table 7.5 shows the distribution of the simulated and observed patterns for 1973 while Table 7.6 shows the accumulated proportions (see Ayeni, 1979, p.196).

Table 7.5 Distribution Patterns For 1973

Classes	Number of Cells Using Population		Number of Cells Using Land Area	
	Observed	Simulated	Observed	Simulated
A - C	12	17	12	18
D - F	22	29	22	28
G - I	28	24	28	24
J - L	21	23	21	24
M - O	13	18	13	22
P - S	2	6	2	7

From Table 7.6, the maximum observed difference in the distribution using population is 0.052 which is 5.2% while the D statistic using the 1% significance level is 0.223 (see Appendix IV). Similarly, the maximum observed difference in the distribution using land area is 0.083 which is 8.3% while the D statistic using 1% significance level is 0.221 showing that the differences that existed were not statistically significant.

Table 7.6 Accumulated Proportions For 1973 Distribution

Classes	Accumulated Proportion Using Population			Accumulated Proportion Using Land Area		
	Observed	Simulated	Diffe-rence	Observed	Simu-lated	Diffe-rence
A - C	0.122	0.145	0.123	0.122	0.146	0.024
D - F	0.347	0.393	0.046	0.347	0.374	0.027
G - I	0.633	0.598	0.035	0.633	0.569	0.064
J - L	0.847	0.795	0.052	0.847	0.764	0.083
M - O	0.980	0.949	0.031	0.980	0.943	0.037
P - S	1.000	1.000	1.000	1.000	1.000	1.000

Table 7.7 shows the distribution of the simulated and observed patterns for 1982 while Table 7.8 shows the accumulated proportions.

Table 7.7 Distribution Patterns For 1982

Classes	Number of Cells Using Population		Number of Cells Using Land Area	
	Observed	Simulated	Observed	Simulated
A - C	5	3	5	7
D - F	38	31	38	35
G - I	39	44	39	47
J - L	35	48	35	56
M - O	36	40	36	45
P - R	35	34	35	40
S - U	30	31	30	43
V - X	21	24	21	31
Y - Z	1	1	1	4

From Table 7.8 the maximum observed difference in the distribution using population is 0.046 which is 46% while the D statistic using 1% significance level is

0.147. (see Appendix IV). Similarly the maximum observed difference in the distributions using land area is 0.053 which is 5.3% while the D statistic using the 1% significance level is 0.140 (see Appendix IV) showing that the differences that existed between the observed and simulated patterns were not statistically significant.

Table 7.8 Accumulated Proportions For 1982 Distribution

Classes	Accumulated Proportion Using Population			Accumulated Proportion Using Land Area		
	Observed	Simulated	Difference	Observed	Simulated	Difference
A - C	0.021	0.012	0.009	0.021	0.023	0.002
D - F	0.179	0.133	0.046	0.179	0.136	0.043
G - I	0.342	0.305	0.037	0.342	0.289	0.053
J - L	0.488	0.492	0.004	0.488	0.471	0.017
M - O	0.638	0.648	0.001	0.638	0.617	0.021
P - R	0.783	0.781	0.002	0.783	0.647	0.036
S - U	0.908	0.902	0.006	0.908	0.886	0.022
V - X	0.996	0.996	0.000	0.996	0.987	0.009
Y - Z	1.000	1.000	1.000	1.000	1.000	0.000

To the extent that the differences between the observed and simulated patterns were not statistically significant it can be argued that both the simulated and observed patterns for 1973 and 1982 give good fits. The simulation model can thus be said to be good enough for use as a predictive device. In the next subsection an attempt is made to simulate the pattern of growth of Ilorin using this model for the year 2000 A.D.

7.11 Simulating Urban Pattern For 2000 A.D. Using Population

In order to simulate the pattern of city growth for the year 2000 A.D., the city's population was projected using a growth rate of 3.5 percent per annum. This gave a value of 708000 (see Doxiadis, 1976; Kwara State Statistical Digest 1987). The actual 1982 configuration was used as a new starting point to simulate the expected pattern in 2000 A.D. The difference in population between 1982 and 2000 A.D. gave a value of 320,000. This increase in population was allocated using the random number table in conjuction with the random number field to allocate the 320,000 population.

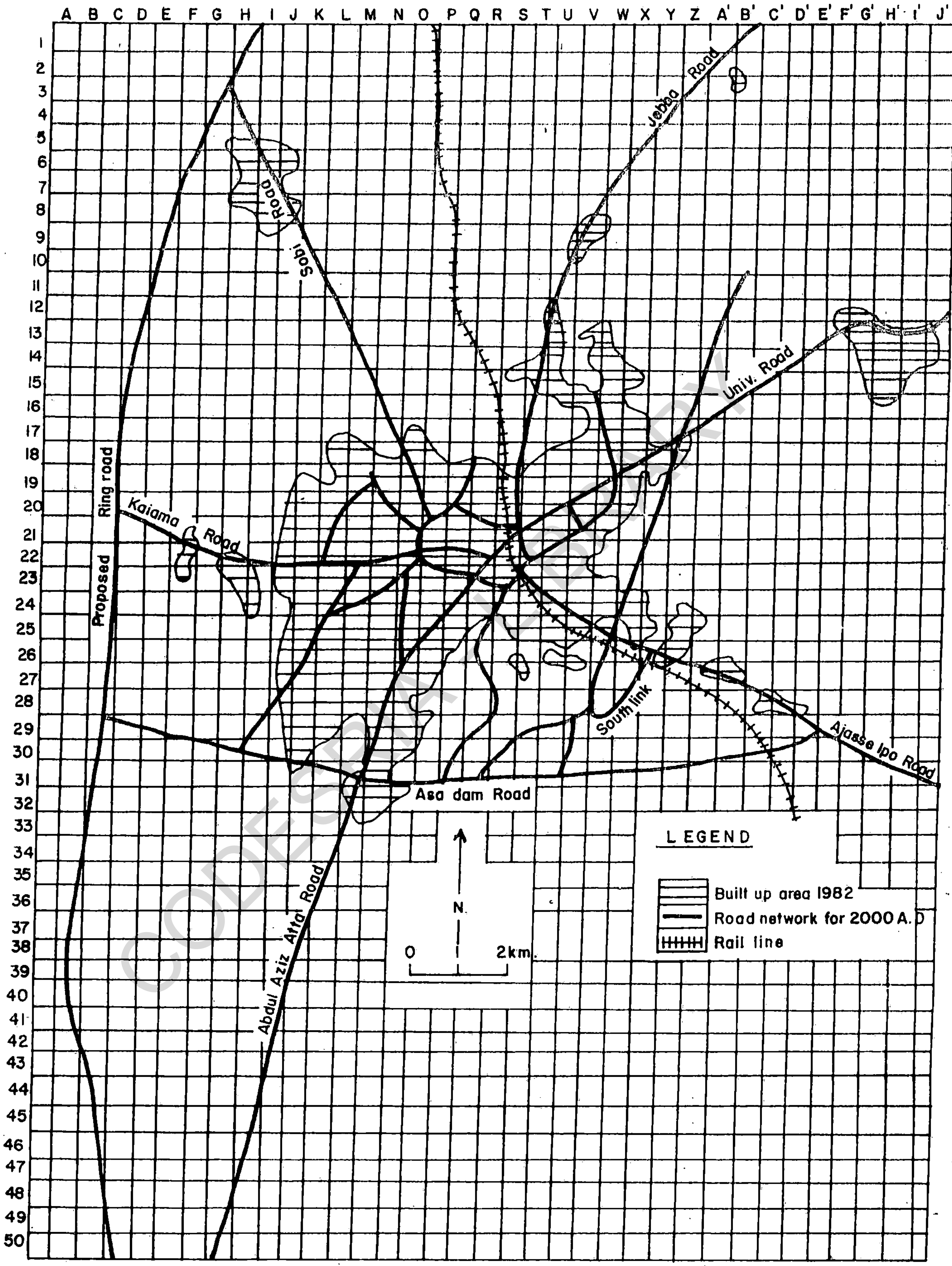


Fig. 7.9: Map of Ilorin showing 1982 built up area and 2000 A.D road network.

The total number of grid cells allocated in the random number field is 336 (see Appendix V). The same procedure whereby the simulateneous use of the random number table in conjuction with the random number field meant that each cell received 500 people was used. Thus four digit numbers each representing 500 people were drawn until the full 320,000 increase in population was exhausted. After the allocation of the 320 000 had been made, grid cells with hits were joined together to represent tee spread of the city between 1982 and 2000A.D. based on population. Figure 7.10 shows the simulated patterns for 2000A.D. The foregoing gives result of the simulation using population. It is believed area extent can also be used because of previous satisfactory results. The next subsection therefore utilises area extent.

7.12 Simulating Urban Pattern for 2000A.D. Using Land Area

Simulating the growth of the city for the year 2000A.D. using land area involved two steps. First the independent variables needed for the projection of land area for the year 2000A.D. had to be obtained. The value of the land area so obtained then had to be distributed

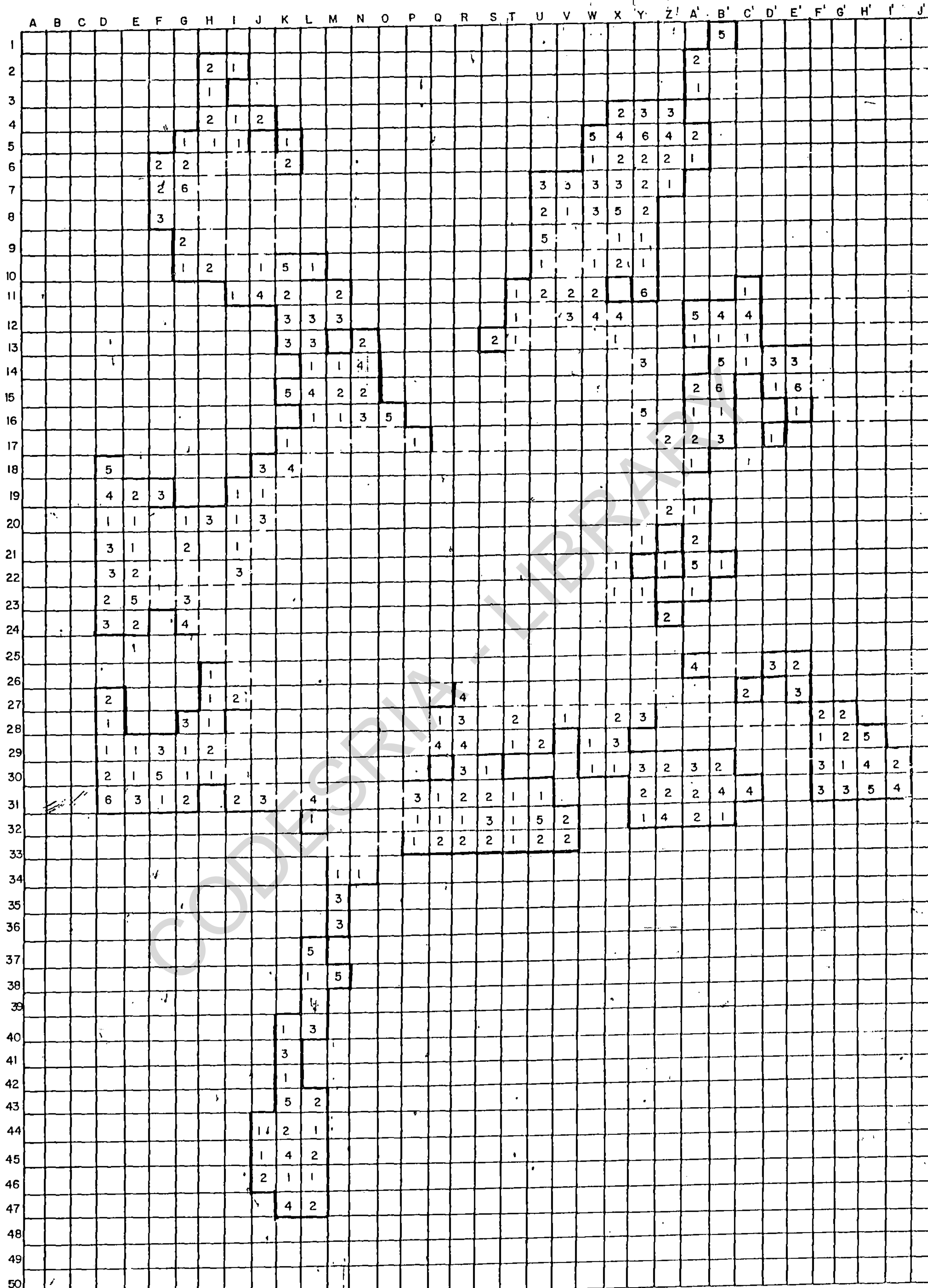


Fig. 7.10 Simulated pattern for 2000 A.D using population.

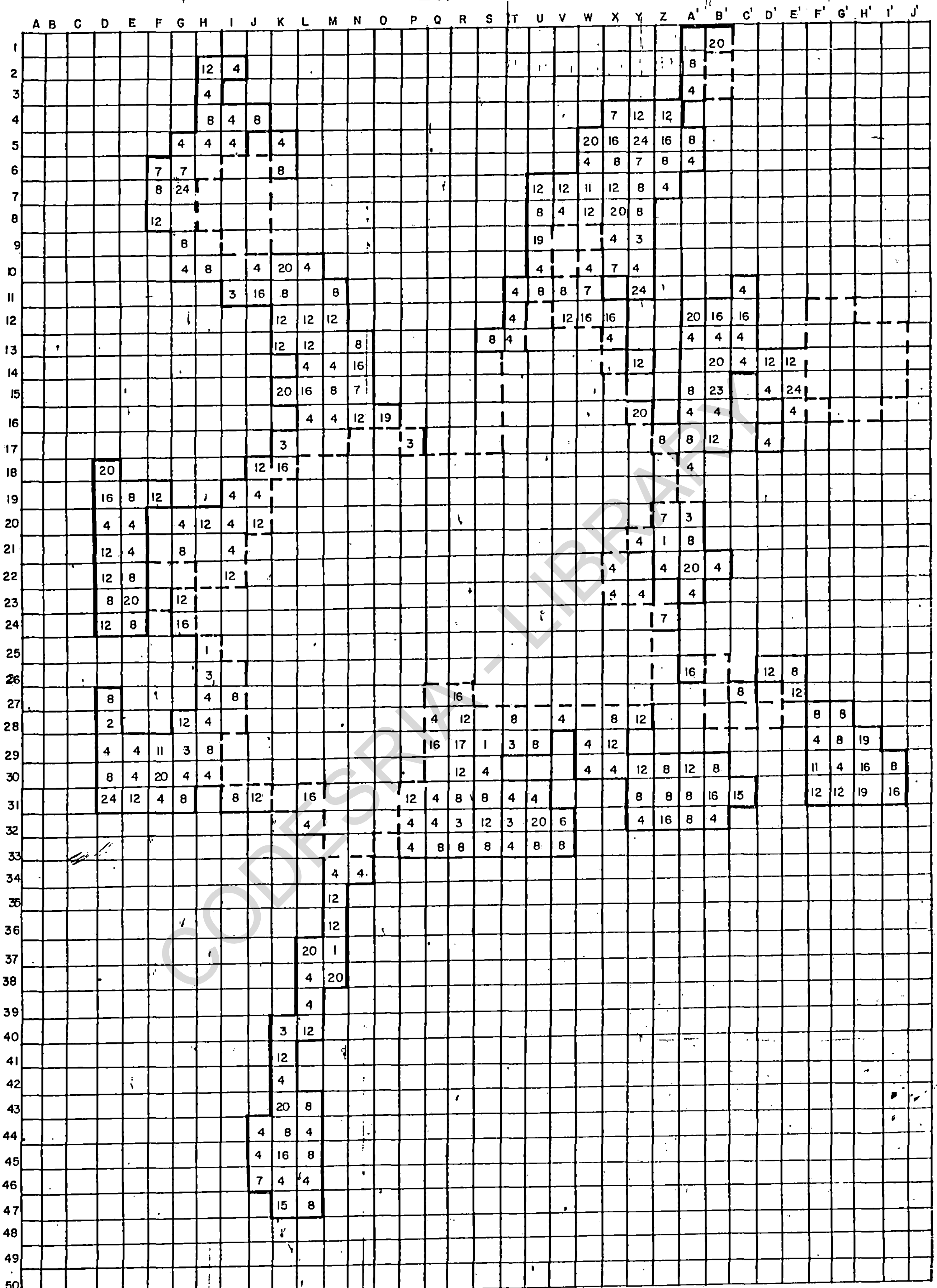


Fig. 7.11 ? Simulated pattern for 2000 A.D using land area.

among the grid cells. The independent variables needed are commercial employment and schools enrolment for the year 2000A.D. The projected figure for commercial employment in the city for the year 2000A.D. is 123 200 (see Doxiadis, 1976) while the projected figure for schools enrolment is 120,500 (kwara State Statistical Digest , 1987). Using these values the projected land area for 2000A.D. is 23,049 acres. Thus the expected increase in land area between 1982 and 2000A.D. is 13,195 acres. Using a growth rate of 4.3% per annum (Chap.V) the projected figure for the housing units in the city by 2000A.D. is 32,833 units. This gives an expected increase of 13 170 housing units between 1982 and 2000A.D. Thus the increase in housing units of 13,170 was allocated on 13,195 acres. As in the cases for 1973 and 1982, it was decided that each tally from the simultaneous use of the random number field and the table of random numbers meant that the cell concerned received 5 houses. This resulted in an allocation of 2,634 houses. Thus four-digit numbers each representing 5 houses were drawn until the full 2,634 houses were accounted for. After the allocation of 2 634 houses had been made, grid cells with hits were joined together to represent the expected growth of the city by the year 2000A.D. using land area. The result of the simulated pattern for 2000A.D. using land area is shown in Figure 7.11. As it is difficult to evaluate such a model for a forecast period the results of the evaluation of the model for 1973 and 1982 give promises that the simulated pattern for 2000A.D will also be real. However only time will tell whether the actual pattern of growth will proceed in the way predicted.

CHAPTER EIGHT

CONCLUSION

8.1 Summary

This study has examined the transport factor in the spatial expansion of Ilorin. The major aspects examined include: the state of the arts in the transport development of Ilorin, the examination of the morphology of Ilorin and the factors of its evolution; the examination of the network of Ilorin and the factors of its evolution; and the aspect of simulating urban morphology for future transport development.

The study indicates various interesting results. Firstly, the study shows that intra-urban trips in Ilorin are dominated by motor cars. This mode accounts for a total of 63.0%. Trips by minibuses rank second accounting for 18.4% while trips by foot ranks third accounting for 12.5%. Trips by motorcycles and pedaled cycles account for a total of 6.1%.

With respect to trip purposes in Ilorin, the study reveals the predominance of work trips over other trip purposes. Work trips account for 24.4% of total trips followed by recreational and social trips which account for a total of 33.0%. Business trips constitute 15.6% while trips to religious centres account for 12.8%. The contribution of trips to markets and shopping centres is 9.2%.

In examining the spatial pattern of intra-urban trips in Ilorin, four major patterns become evident. These are:

The Business and Administrative Region: Adewole, Baboko - Stadium, Odokun - Odota, Sabo-Oke - Amilegbe.

The White-Collar Employment Region: Kulende - Tanke, Sabo-Oke - Amilegbe, University - Polytechnic.

The Indigenous Region: Central Area, Oloje, Sobi.

The Central Facilities and Services Region: Gaa Akanbi - Ero Omo; Gaa Imam, Reservation Area.

These sets of origin and destination regions were found to be spatially interdependent.

An examination of the intra-city hierarchy of zones was made through the use of graph-theoretic concept. The analysis reveals that Baboko - Stadium zone emerges as the most dominant zone being in the first order while Central Area, Reservation Area and Gaa Akanbi - Eroomo area are in the second order. The other zones are in the third order.

A study of the pattern of vehicular traffic in the city also reveals a lot of information. This aspect was studied by considering the road quality, and the traffic volumes and characteristics on some sampled roads in the city. Empirical analysis of road quality reveals that Jebba road has the highest quality while New Yidi and Reservation roads rank second. New University road and Adewole roads rank third while Kaima, Oko-Erin and Opo-Malu roads rank fourth. The road quality was assessed in terms of the type of surface, condition of road surface, width of road, road capacity, period of motorability and seasonal condition of surface.

Analysis of road facilities also reveals that none of the roads studied has pedestrian crossings, none has traffic lights, none has parking facilities, only Jebba and New Yidi have road signs; Jebba, Kaima and Opo-Malu roads have street lights and traffic wardens while Adewole, Jebba and Opo-Malu roads have drainage facility.

With respect to traffic volumes on the studied roads, Jebba road records the highest volume of traffic with 25.61% of total volume. This is followed by New University road with 16.96% while New Yidi road ranks third with 15.96% of total volume. Opo-Malu road ranks fourth with 14.37% while Reservation road ranks fifth with 13.35%. Adewole Street, Kaima road and Oko-Erin road account for a total of 22.98% of total volume of traffic on the roads.

Analysis of vehicle types on the sampled roads reveals that an average of 54.91% of all vehicles counted consist of motor cars. Motorcycles record an average of 24.54% while minibuses and pick-ups account for a total average of 17.21%. Lorries and tippers, Big buses, trailers and tractors constitute a total average of 4.61%.

Secondly, the morphology of Ilorin has been studied by considering the spatio-temporal evolution of the city. The study reveals that the 1897 pattern of the city was one of concentric pattern with the Emir's Palace as the central core and all routes originating from the outskirts of the town and converging at the city centre. By 1963, the pattern of growth of the city has changed from the hitherto concentric pattern of development to that of radial growth along the road arteries in the city. The 1973 pattern of growth shows that the sectoral growth of the city had intensified along the axial roads of Jebba, Ajassepo, Kaima and Ibrahim Taiwo roads. This trend came about as a result of the rapid development of the city when it became a state capital in 1967.

The 1982 pattern of the city shows that a lot of physical expansion has taken place in all directions of the city. The forces responsible for this expansion are the various developments such as Army Barracks at Sobi, Adewole Housing Estate and Ilorin Airport, Niger River Basin Authority, Kulende Housing Estates, University of Ilorin Main Campus, New Industrial Layouts and Federal Low-Cost Housing Estate, Oloje. All these constitute growth points in different directions of the city. By 1988, the city has witnessed more physical expansion resulting in the city enveloping many of the small settlements surrounding it. At this time too, the sprawl of the city could be prominently noticed along the inter-city roads such as Ilorin-Jebba, Ilorin-Ajassepo road, Lagos road, Kaima road and Shao road.

Thirdly, the study has examined the spatial pattern of road development in Ilorin. The study reveals that in 1963, the number of road segments in Ilorin was 17 while by 1973, the number had risen to 30. By 1982, the number of road segments had increased to 68 while by 1988 the number had risen to 72. The total length of road network in the city was only 12km in 1963 while the length had risen to 22.7km by 1973. The total length of road network was 67km by 1982 while the figure had risen to 86km by 1988. This trend in network growth has been attributed to the changing nature of the country's economy.

Fourthly, the study has also explored ways of estimating the built-up area of the city for a desired period. Here factors responsible for the spatial expansion of the city were identified. Such factors as commercial employment and schools enrolment in the city both help to explain 99.01%

of total variance in the dependent variable. In order to explain the remaining variance in the dependent variable, certain other factors were suggested.

Finally, an attempt has been made to simulate the growth of Ilorin for the periods 1973, 1982 and make a forecast for 2000 A.D. It was found that the Monte Carlo simulation technique proved to be an appropriate model for simulating the growth of the city. By using two sets of data - population and land area, the city's growth was simulated separately for 1973 and 1982. This was done by determining the road networks of the city for 1973 and 1982 and simulating urban form to these periods in order to obtain the growth pattern.

Bucause the results of the Monte Carlo technique proved successful for simulating the growth of Ilorin for 1973 and 1982, the technique was further used to simulate the pattern of growth of the city for 2000 A.D.

The major contributions of this study therefore are: the identification of factors considered to be responsible for the spatial expansion of a city and the use of such factors to build a model for estimating the built-up area of Ilorin for any desired period; the use of population figures and land area to simulate the growth of the city for different periods given specific network structure; and the forecasting of the growth of Ilorin for the year 2000 A.D.

8.2 Planning Implications And Recommendations

The major objective in the work is the study of transport factor in the spatial expansion of Ilorin. The result as outlined in the summary above has great implications for future planning. For example, the identification of the state of the arts in the transport system of any urban centre helps to identify those transport factors that are considered important in the growth of the city.

The planning implications of these have been earlier identified by Ogunsanya (1989). Most important however is the issue of sprawl. The city of Ilorin has grown naturally over the years. In order to achieve a more purposeful growth for the city, there is need for a conscious development policy. The fact that has emerged from this study is that there is a clear relationship between road development and the sprawl of the city. In this respect, government can consciously develop areas by building roads along areas where urban expansion is desired. Transport is no doubt the dominating component of urban planning and can therefore be used successfully as a basis for planning.

Since the understanding of the structure-transport relationship helps to ease the planning procedure, the following observations and recommendations are made:

(i) There has not been any comprehensive transportation study in Ilorin to date. Thus no one knows the volume of traffic and the characteristics of the traffic along the urban routes in the city. A time-series data on the various components of urban traffic is of great importance to city planners interested in future transport planning. This calls for the establishment of a data bank for transport.

(ii) The city of Ilorin shows a sprawl that engulfs the nearby villages. Rather than allow such linear development of these villages, the concept of the Garden City of Howard (1946) should be examined with the view to developing such villages to be independent.

(iii) Since routes attract land use, and since there is the tendency for urban sprawl to develop along routes, there is the need to a look at the master plan of Ilorin to see how the current form of the city has deviated from the proposed plan. Roads should be constructed along areas where development has hitherto been neglected because of transport problems.

(iv) The idea of a ring road in Ilorin is worthwhile. This ring road could be in three layers - an inner ring, an intermediate ring and an outer ring. These will act as local distributor, district distributor and primary collector and distributor respectively.

(v) Some of the township roads need rehabilitation. Both the rehabilitated and yet to be rehabilitated roads require adequate parking provisions and pedestrian walkways.

(vi) The roads of the future in Ilorin should be designed in such a way that adequate provisions would be made for a mass transit system on its main routes.

8.3 Future Research Areas

This study has shown that a strong link and interdependence exists between urban transportation, land use and the spatial structure of cities. Urban change, both in the sense of expansion in city size and in terms of shifts in location has marked repercussions on the journey to work and on the tasks facing the transport system.

Although this study has concentrated on the understanding of the form of the city with respect to its transport needs in order to plan for city expansion, much more work remains to be done on the relationship between urban structure and transportation in Nigeria. Such areas include:

(i) Population distribution and forecast of urban form. The significance of population growth in urban development calls for further work in this area such that a clearer picture of the relationship between population and urban form can be obtained.

(ii) Urban facilities and their degree of accessibility. This is important because the location of urban facilities puts a lot of burden in terms of travel time and travel cost on the urban dwellers who demand them.

(iii) Simulation modelling of intra-urban network development. Although some work has been done on simulating regional road network, studies on the simulation of intra-urban road network are scanty. This therefore is a fertile area for further research.

Finally this study has shown the importance of transport in the development of a medium-size city of a developing environment. No doubt, transport facilitates development and promotes growth, and transport is one of the many sectors in which it is desirable to channel investment. The problems discussed in this study are also common features of many of the larger urban centres in Nigeria and other parts of the developing world. Consequently, the methodology used can be adopted as a guide for similar studies in other urban centres of the developing world.

APPENDIX I

QUESTIONNAIRES

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF ILORIN

TRANSPORT STUDIES PROJECT

SURVEY OF INTRA-CITY TRAFFIC MOVEMENT BY HIRED MODE OF TRANSPORTATION

Name of Interviewer:....................Date:............

Location:..............................Time:............

A. QUESTIONS TO BE ANSWERED BY DRIVERS:

1. Where is the Origin of your Trip:...............
2. What is your Destination:.......................
3. Which roads do you usually follow:...............
4. How many trips do you make in a day:.............
5. How long does the Journey take?..................

B. QUESTIONS TO BE ANSWERED BY PASSENGERS:

RESPONDENT	ORIGIN	DESTINATION	PURPOSE	FREQUENCY	COST
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF ILORIN
TRANSPORT STUDIES PROJECT

A. GENERAL INFORMATION

1. (i) House No..............(ii) Interviewer.........

   (iii) Date:...............

2. Age of house
   (i) Less than 5 years
   (ii) 6 - 10 years
   (iii) 11 - 20 years
   (iv) 21 - 50 years
   (v) above 50 years

3. Materials used
   (i) Mudwall and Tatch roof
   (ii) Mudwall and Mudroof
   (iii) Concrete Block and G.I. Sheets
   (iv) Others (Specify).

4. Original use of house if reconstructed
   (i) Residential
   (ii) Commercial
   (iii) Temporary Structure.

5. Current use of house
   (i) Residential
   (ii) Commercial
   (iii) Others (Specify)

6. Nearness of house to road (m) ....

7. Housing type
   (i) Compound
   (ii) Bungalow
   (iii) Storey Building

B. SOCIO-ECONOMIC INFORMATION

	Particulars	Responses	Members of the Household 1	2	3
1.	Age	15 - 20			
		21 - 30			
		31 - 40			
		41 - 50			
		above 50			
2.	Sex	Male			
		Female			
3.	Marital Status	Single			
		Married			
		Widowed			
4.	Highest Education level	Primary			
		Secondary			
		University			
		Koranic			
		Diploma			
		Others			

	Particulars	Responses	Members of the household 1	2	3
5.	Religion of respondents	Muslim			
		Christian			
		Others			
6.	Occupation	Agric			
		Construction			
		Trade & Commerce			
		Transport & Communication			
		Govt. Employ			
		Army/ Force			
		Others			
7.	Monthly income	Less than ₦100			
		₦100 - ₦300.00			
		₦301 - ₦500.00			
		₦501 - ₦700.00			
		₦701 - ₦900.00			
		Above ₦900.00			

C. TRIP INFORMATION

1. Do you own a private vehicle Yes
No

2. Type of vehicle ....

3. Trips made within the last 48 hours

Trip Purpose	Origin			Destination			Mode Of Transport			Distance From O - D			Cost Of Transport			Frequency Of Trip		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
A Work																		
B Business																		
C Social																		
D Recreation																		
E Market																		
F Religious																		
G Others (Specify)																		

For Mode

a = Foot
b = Private Car
c = Mini Bus
d = Taxi Cab
e = Motor Cycle
f = Bicycle
g = Others

For Frequency

1/24 = Once a day
1/7 = Once a week
$\frac{1}{4}$ = Once a month
1/12 = Once a year

DEPARTMENT OF GEOGRAPHY, UNIVERSITY OF ILORIN
TRANSPORT STUDIES PROJECT

TRAFFIC COUNTS ALONG SELECTED ROUTES IN ILORIN

NAME OF STREET DATE ______________

CENSUS POINT
DIRECTION

INCOMING ___________ OUTGOING ___________

Time (15 Mins. Interval	0.00 0.15	0.15 0.30	0.30 0.45	0.45 0.000
Motorcycles				
Passenger Cars				
Kombi Buses				
Pick-Ups				
Lorries/ Tippers				
Big Buses				
Vehicles With More Than Two Axles				
Others, Specify				

TRANSPORT STUDIES PROJECT

DEPARTMENT OF GEOGRAPHY
UNIVERSITY OF ILORIN

ILORIN ROAD QUALITY SURVEY:

1. Name of Survey Assistant:........................

2. (a) Name of Road:..............................

   (b) State of Road: (i) Under Construction
   (ii) Constructed

3. Who built the Road:

   (a) Federal Government
   (b) State Government
   (c) Local Government
   (d) Communal Effort

4. Who maintains the Road:

   (a) Federal Government
   (b) State Government
   (c) Local Government
   (d) Communal Effort

5. Width of Road:.................................

6. Road Vehicle Capacity

   (a) One lane Road
   (b) Two lane Road
   (c) Four lane Road

7. Frontage access (Measurement of five randomly selected houses)

   (a) ....
   (b) ....
   (c) ....
   (d) ....
   (e) ....

8. Surface Condition:

(a) Tarred

(i) Smooth
(ii) Fairly Smooth
(iii) Rough

(b) Untarred:

(i) Smooth
(ii) Fairly Smooth
(iii) Rough

9. Type of Surface:

(a) Bituminous surface
(b) Gravel Surface
(c) Earth Surface

10. Period of Motorability:

(a) Seasonal
(b) All Season

11. Seasonal Condition of Surface
(a) Flooded during rainy season
(i) Occasionally (after Rainfall)
(ii) Always
(b) Very dusty during dry season
(c) Neither "a" or "b"

12. Road Facilities available:

(a) Pedestrian crossing signs (No. per ½km.....)
(b) Road Traffic Light
(c) Street Light
(d) Parking Facilities (No. per ½km............)
(e) Road Signs for dividers
(f) Traffic Wardens
(g) Drainage facility.

APPENDIX II

PERCENTAGE DISTRIBUTION OF VEHICLE TYPES

ALONG SELECTED ROADS IN ILORIN

Appendix II Percentage Distribution Of Vehicle Types Along Selected Roads In Ilorin

Vehicle Type	Adewole Road		Jebba Road		Kaima Road		New University Road		New Yidi Road		Oko-Erin Road		Opo-Malu Road		Reservation Road		Average for the 8 Roads	
	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m	a.m	p.m
1. Motor cycles	29.18	25.22	22.40	19.62	20,62	20.62	27.23	24.63	22.78	21.66	28.44	24.81	30.43	29.53	15.20	21.40	24.54	23.44
2. Motor Cars	59.59	61.09	37.21	42.74	17.70	21.53	62.13	61.58	59.43	59.86	62.80	65.82	59.97	59.36	77.45	67.32	54.53	54.91
3. Mini Buses	2.86	4.35	24.07	20.77	56.42	51.82	3.45	4.32	3.88	2.87	2.61	2.28	1.89	2.88	2.33	2.92	12.10	11.53
4. Pick-Ups	5.10	5.43	5.73	6.32	3.11	3.65	4.03	3.89	8.19	8.21	4.74	5.82	5.56	6.38	3.67	4.47	5.02	5.52
5. Lorries & Tippers	2.24	2.83	5.73	5.38	1.17	1.46	1.82	3.90	0.95	1.27	1.52	1.13	1.52	1.13	0.74	3.31	1.98	22.90
6. Big Buses	10.3	0.87	1.41	1.61	0.39	0.73	0.86	0.95	0.78	0.42	0.24	-	0.76	0.72	0.61	0.58	0.76	0.74
7. Trailers/ Tractors	-	0.22	3.45	3.56	0.59	0.19	0.48	0.63	3.12	3.08	0.22	-	-	-	-	-	0.98	0.96
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	00.00	00.00	100.00	100.00

Source: Author's Data Analysis, 1988

APPENDIX III

VARIABLES FOR URBAN EXPANSION

VARIABLES USED AS FACTORS OF URBAN EXPANSION

VARIABLES	1963	1964	1965	1966	1967	1968	1969	1970
POPULATION (Thousand)	209	216	223	230	237	244	252	260
MANUFACTURING EMPLOYMENT	1593	1780	1967	2155	2342	2530	2717	2903
COMMERCIAL EMPLOYMENT	3759	4345	4955	5588	6244	6923	7700	8408
GOVERNMENT EMPLOYMENT	16302	16416	16948	17710	18480	18788	19152	19500
TOTAL EMPLOYMENT	99959	95040	98126	101200	104229	107360	110880	114399
SHOOLS ENROLMENT	8810	7989	10765	11968	11209	11805	12352	14425
WATER CONSUMPTION (L/CAPITAL)	77.0	82.18	87.22	96.74	107.34	112.91	114.29	117.69
ELECTRICITY CONSUMP. (KH/C)	1.2	1.2	1.2	1.5	1.3	1.3	1.8	2.1
PER CAPITAL INCOME (N)	122	127	132	137	143	149	155	161
LANDCOST (N/PLOT)	60	60	60	100	100	150	150	150

VARIABLES	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
POPULATION (Thousand)	268	276	285	293	303	314	325	336	348	360	374
MANUFACTURING EMPLOYMENT	3397	3919	4442	4964	5487	6009	6532	7054	7577	8100	9477
COMMERCIAL EMPLOYMENT	10050	11755	13572	15664	16172	17092	20536	21224	23923	25406	27949
GOVERNMENT EMPLOYMENT	19832	20148	20235	20400	20604	20724	20800	21168	21576	21960	22066
TOTAL EMPLOYMENT	114399	121457	125403	128920	133100	140672	145601	150528	155904	157800	167558
SHOOLS ENROLMENT	16498	17025	17547	24238	30930	38227	42464	52502	96743	110967	111220
WATER CONSUMPTION (L/CAPITAL)	28.34	134.42	135.09	140	142	140	133	185.6	180.6	176.4	178
ELECTRICITY CONSUMP. (KH/C)	2,1	3.2	2.3	1.8	1.8	2.6	1,9	2.6	2.9	3.2	2.0
PER CAPITAL INCOME (N)	167	180	188	196	203	213	220	229	233	248	257
LANDCOST (N/PLOT)	150	200	- 200	300	200	600	600	600	800	800	800

APPENDIX IV

CALCULATION OF THE 'D' STATISTIC FOR THE EVALUATION OF THE SIMULATION MODEL

APPENDIX IV

CALCULATION OF THE 'D' STATISTIC FOR THE EVALUATION OF THE SIMULATION MODEL

The Kolmogorov - Smirnov D statistic is calculated using the 1% significance level by the formula:

$$D = 1.63\sqrt{\frac{n_1 + n_2}{n_1 n_2}}$$

where n_1 = sample size of sample 1 and n_2 = sample size of sample 2.

For The 1973 Pattern

$n_1 = 117$; $n_2 = 98$, using population.

$$\text{Thus } D = 1.63\sqrt{\frac{n_1 + n_2}{n_1 n_2}} = 1.63\ \frac{215}{11466} = 0.2232$$

$n_1 = 123$; $n_2 = 98$ using land area.

$$\text{Thus } D = 1.63\sqrt{\frac{221}{12054}} = 0.221$$

For The 1982 Pattern

$n_1 = 256$; $n_2 = 240$ using population

$$\text{Thus } D = 1.63\sqrt{\frac{496}{61440}} = 0.147$$

$n_1 = 308$; $n_2 = 240$ using land area.

$$\text{Thus } D = 1.63\sqrt{\frac{548}{73920}} = 0.140.$$

APPENDIX V

POINT SCORE MATRICES, PROBABILITY MATRICES,

RANDOM NUMBER FIELDS.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		14	9	9	9	9	14	9	9	9						15	21	
3		21	21		14				9	9					15	20	20	
4		9	9											15	15	20	15	
5		15	15											18	20	13		
6		9	9										21	13	14			
7		9											14	9	14			
8		9	9	9	9										14			
9			11	15			20	20	15	9	15		14	14	14			
10			21	21	14	9					20	13	14					
11		14	21	10							18	15	9					
12		14	21	11							14	20	14	14				
13																		
14																		

Appendix V(a): Point score matrix for 1973 simulated pattern.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		·0136	·0088	·0088	·0088	·0088	·0136	·0088	·0088	·0088						·0146	·0204	
3		·0204	·0204		·0136				·0088	·0088					·0146	·0195	·0195	
4		·0088	·0088											·0146	·0146	·0195	·0146	
5		·0146	·0146											·0175	·0195	·0127		
6		·0088	·0088										·0204	·0127	·0136			
7		·0088											·0136	·0088	·0136			
8		·0088	·0088		·0088										·0136			
9			·0107	·0146			·0195	·0195	·0146	·0088	·0146		·0136	·0136	·0136			
10			·0204	·0204	·0136	·0088					·0195	·0127	·0136					
11		·0136	·0204	·0097							·0175	·0146	·0088					
12		·0136	·0204	·0107							·0136	·0195	·0136	·0136				
13																		
14																		

Appendix V(b): Probability matrix for 1973 simulated pattern.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1																		
2		0000 0135	0136 0223	0224 0311	0312 0399	0400 0487	0488 0623	0624 0711	0712 0799	0800 0887						0888 1033	1034 1237	
3		1238 1441	1442 1645		1646 1718				1782 1869	1870 1957					1958 2103	2104 2298	2299 2493	
4		2494 2581	2582 2669											2670 2815	2816 2961	2962 3156	3157 3302	
5		3303 3448	3449 3594											3595 3769	3770 3964	3965 4091		
6		4092 4179	4180 4267										4268 4471	4472 4598	4599 4734			
7		4735 4822											4823 4958	4959 5046	5047 5182			
8		5183 5270	5271 5358		5359 5446										5447 5582			
9			5583 5689	5690 5835			5836 6030	6031 6225	6226 6371	6372 6459	6460 6605		6606 6741	6742 6877	6878 7013			
10			7014 7217	7218 7421	7422 7557	7558 7645					7646 7840	7841 7967	7968 8103					
11		8104 8239	8240 8443	8444 8540							8541 8715	8716 8861	8862 8949					
12		8950 9085	9086 9289	9290 9396							9397 9532	9533 9727	9728 9865	9864 1.0000				
13																		
14																		

Appendix V(c): Random number field for 1973 simulated pattern.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
1																										
2															.0056	.0056										
3															.0056	.0056										
4					.0053	.0053									.0056	.0056								.0053	.0053	
5				.0038	.0053	.0053				.0027	.0027			.0056	.0056								.0053	.0053	.0032	
6				.0038	.0053	.0053	.0053	.0027	.0027	.0027		.0027	.0027	.0056	.0056	.0041						.0053	.0056	.0038		
7					.0027	.0053	.0053						.0027	.0056	.0056	.0041					.0053		.0053			
8					.0027									.0056	.0056	.0022							.0027			
9					.0027										.0027		.0056			.0053		.0027	.0053	.0053		
10					.0027															.0053	.0056	.0041	.0053	.0053	.0027	
11				.0027															.0027	.0027	.0027	.0053	.0053	.0041		
12				.0027														.0027	.0027	.0027	.0041	.0053	.0053	.0027		
13		.0053	.0053	.0056				.0027										.0027	.0056	.0056	.0053	.0053	.0041	.0056	.0056	
14			.0053	.0027			.0027	.0027												.0041	.0053	.0053	.0056	.0053	.0056	
15		.0050	.0050	.0027	.0027	.0027															.0038	.0056	.0056	.0056		
16		.0050	.0050	.0027	.0027	.0027														.0056	.0056	.0056	.0056	.0041		
17			.0050	.0062	.0056	.0062					.0027	.0056	.0062				.0056	.0056	.0056	.0056	.0056	.0056	.0041			
18				.0050	.0062	.0062		.0027	.0027	.0027	.0027	.0056	.0041			.0056	.0027	.0056	.0056	.0056	.0056	.0041				
19				.0062	.0062	.0050	.0041	.0041	.0035	.0053	.0056	.0056						.0056	.0056	.0041	.0041					
20						.0056	.0050	.0050	.0035	.0050	.0053	.0027				.0050	.0050	.0053	.0041	.0027						
21							.0056	.0056	.0050	.0053	.0053	.0056	.0050	.0043		.0050	.0050	.0062	.0053	.0041	.0027					
22								.0056	.0050	.0050	.0050		.0050	.0050			.0029	.0050	.0062	.0041						
23									.0041	.0050	.0050	.0050	.0050					.0050	.0062	.0053						
24										.0041	.0050	.0050							.0062	.0062	.0041					
25																			.0041	.0062	.0041					
26																										

Appendix V(d) Probability matrix for 1982 simulated pattern.

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
														0000 0055	0056 0111										
														0112 0167	0168 0223										
				0224 0276	0271 0329									0330 0385	0386 0441								0442 0474	0495 0547	
			0548 0585	0586 0638	0639 0691				0692 0718	0719 0745			0746 0801	0802 0857	0858 0898							0899 0950	0952 1004	1005 1037	
			1038 1075	1076 1128	1129 1181	1182 1234	1235 1261	1262 1288	1289 1315		1316 1342	1343 1369	1370 1425	1426 1481	1482 1522						1523 1575	1576 1621	1632 1669		
				1670 1696	1691 1749	1750 1802						1803 1829	1830 1885	1886 1941	1942 1982					1983 2035		2036 2088			
				2089 2115									2116 2171	2172 2227	2228 2254							2255 2281			
				2282 2308										2309 2335		2336 2391			2392 2444		2445 2471	2472 2524	2525 2577		
				2578 2604															2605 2657	2658 2696	2697 2737	2738 2790	2791 2843	2844 2870	
			2871 2897															2898 2924	2925 2951	2952 2978	2979 3031	3032 3084	3085 3125		
			3126 3152														3153 3179	3180 3206	3207 3233	3234 3274	3275 3327	3328 3380	3381 3407		
	3408 3460	3461 3513	3514 3569				3570 3596										3597 3623	3624 3679	3680 3735	3736 3791	3792 3844	3845 3885	3886 3941	3942 3997	
		3998 4050	4051 4077			4078 4104	4105 4131												4132 4172	4173 4225	4226 4278	4279 4334	4335 4390	4391 4446	
	4447 4496	4497 4546	4547 4573	4574 4600	4601 4627															4628 4666	4667 4722	4723 4778	4779 4834		
	4835 4884	4885 4934	4935 4961	4962 4988	4989 5015														5016 5071	5072 5127	5128 5783	5184 5239	5240 5280		
		5281 5330	5331 5392	5393 5448	5449 5510					5511	5538	5594				5656 5711	5712 5767	5768 5823	5824 5879	5880 5935	5936 5991	5992 6032			
			6033 6082	6083 6144	6145 6206		6207 6233	6234 6260	6261 6287	6288 6314	6315 6370	6371 6411			6412 6467	6468 6496	6495 6550	6551 6605	6606 6662	6603 6718	6719 6759				
			6760 6821	6822 6883	6884 6933	6934 6974	6975 7015	7016 7051	7052 7104	7105 7160	7161 7216						7217 7272	7273 7328	7329 7369	7370 7410					
					7411 7466	7467 7516	7517 7566	7561 7602	7603 7652	7653 7705	7706 7732				7733 7782	7783 7832	7833 7885	7886 7926	7927 7953						
						7954 8009	8010 8065	8066 8115	8116 8168	8169 8121	8222 8277	8278 8327	8328 8371		8372 8421	8422 8471	8472 8533	8534 8586	8587 8627	8628 8654					
							8655 8710	8711 8760	8761 8810	8811 8860		8861 8910	8911 8960			8961 8990	8991 9040	9041 9102	9103 9143						
								9144 9184	9185 9234	9235 9284	9285 9334	9335 9384					9385 9434	9435 9496	9497 9549						
									9560 9590	9591 9640	9641 9690							9691 9752	9753 9814	9815 9855					
																		9856 9896	9897 9958	9959 1,000					

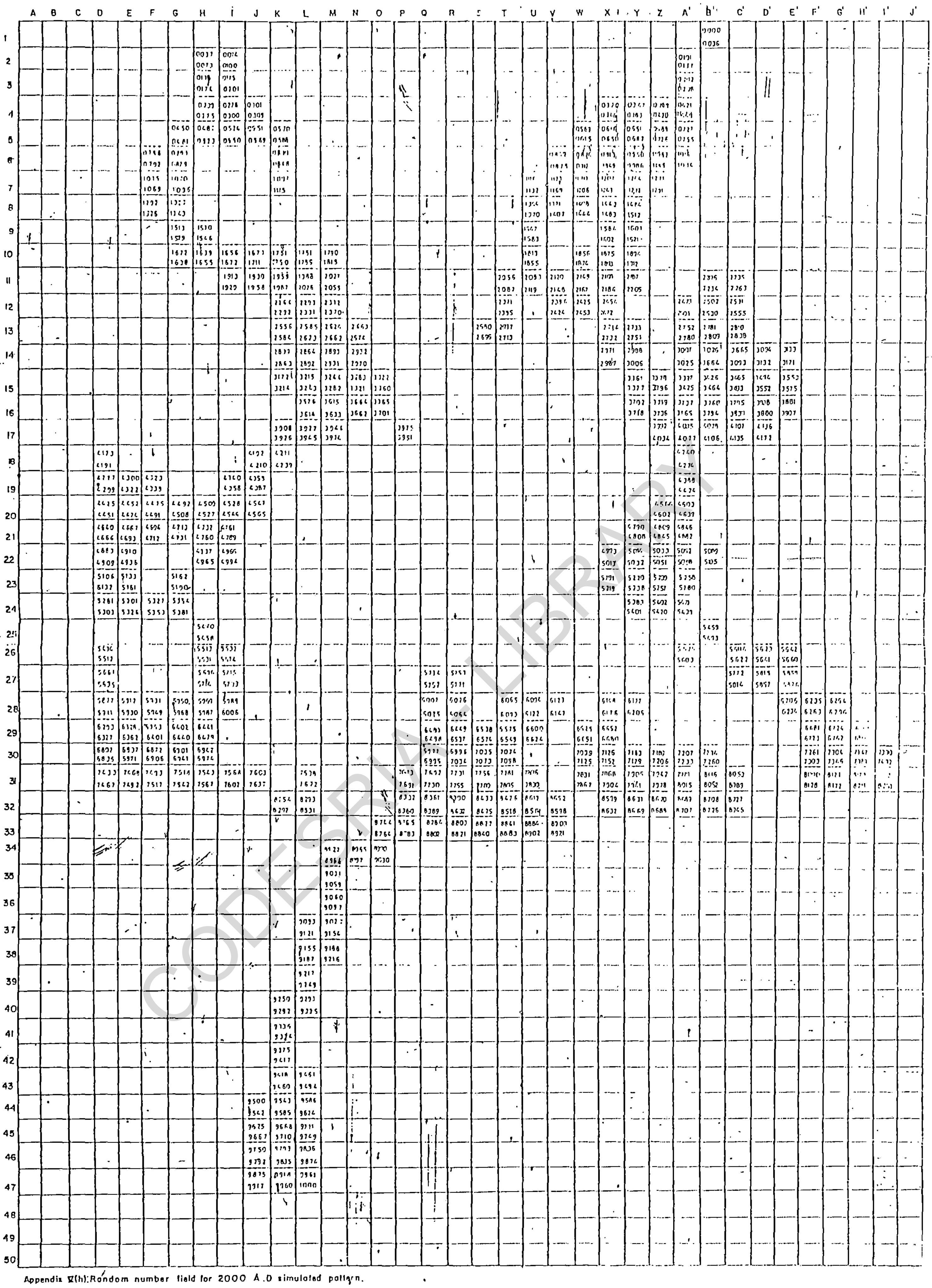
Appendix V(e): Random number field for 1982 simulated pattern.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'
1																													18								
2								18	13																		18										
3								18	13																		18										
4								18	12	9															13	18	18	14										
5							18	8	13	9	9													13	17	18	19	14										
6						18	18				9											13	18	18	18	14	9										
7						17	13															8	18	18	18	14	9											
8						17	8															13	18	18	19	14												
9							8	8														18			9	9												
10							8	8	8	19	19	19	14								18		9	9	9												
11									8	14	14	19	14							13	18	14	9	9	9			14	14							
12											14	19	19							12		14	14	9			14	14	12							
13											14	19	19	8					8	8				9	9		14	14	12							
14											14	19	19	8										9	9		19	14	19	19	21					
15											14	19	19	19	8										9	14	19	14	19	21	19					
16												9	14	19	8										9	14	14	21	21	14	13					
17											9	9	14			8										19	21	21	14	14						
18										9	9																	14										
19				18	11	11			8	9																	14										
20				18	13	11	8	8	9	9																19	9										
21				18	18	18	13	9	9															14	14	9										
22				18	18			13	13															14	14	9	9	9									
23				18	8		13																	14	14	9	9										
24				11	11	11	13																		14	9	9										
25								9																					9									
26				17				9	9																		21		14	9	9					
27				17				9	9								9	9													21	21	9					
28				17	9	9	9	9	9								9	19		14	14	12		14	14							14	14	14			
29				17	17	19	19	19									9	19	18	12	12		13	14								21	19	19		
30				17	17	17	17	17									9	19	19	12			12	12	12	12	12	12				21	21	21	21	
31				17	12	12	12	12	17	17		17				9	19	12	12	12	12		18	18	18	18	18	18	18			19	21	19	21	
32											14	14				21	21	21	21	18	18	18		9	9	9	9	9	9						
33															9	9	9	9	9	9	9	9													
34													21	9	9																					
35													21																						
36													16																						
37												16	14																						
38												16	14																						
39												16																							
40											16	14																								
41											16																								
42										21	14																								
43										21	19																								
44									21	21	19																								
45									21	21	19																								
46									21	21	19																								
47									21	21	19																								
48																																				
49																																				
50																																				

Appendix. VI(f) Point score matrix for 2000 A.D simulated pattern.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A'	B'	C'	D'	E'	F'	G'	H'	I'	J'
1																												0031								
2								0037	0033																		[illegible]									
3								0031	0031																		0037									
4								0037	0035	0031														0027	0031	0037	0021									
5							0031	0033	0017	0019	0019												0017	0035	0031	0029	0017									
6						0031	0031				0033											0027	0037	0037	0031	0029	0044									
7						0035	0033				[illegible]										0031	0031	0031	0011	0019	0035										
8						0015	0031														0021	0033	0037	0031	0019											
9							0017	0033													0037			0031	0031											
10							0047	0017	0017	0037	0019	0031	0029								0031		0019	0019	0049											
11									0017	0031	0029	0033	0019							0017	0027	0021	0019	0043	0033			0021	0029							
12											0029	0031	0031							0025		0021	0029	0019			0029	0029	0015							
13											0019	0031	0029	0017					0017	0017				0019	0019		0029	0029	0015							
14											0019	0034	0071	0017										0019	0041		0015	0023	0039	0039	0043					
15											0019	0031	0033	0019	0017										0019	0029	0039	0029	0019	0043	0029					
16												0019	0073	0035	0017										0015	0025	0029	0043	0043	0029	0029					
17											0019	0019	0029			0017										0037	0043	0043	0029	0035						
18				0037						0019	0019																0029									
19				0037	0073	0073			0017	0019																	0039									
20				0037	0033	0023	0017	0013	0033	0033																0039	0019									
21				0031	0031	0017	0027	0019	0019																0039	0129	0049									
22				0037	0037			0027	0027															0029	0027	0049	0049	0011								
23				0037	0017		0021																	0021	0029	0049	0033									
24				0033	0033	0023	0027																		0033	0019	0021									
25								0019																				0049								
26				0075				0049	0049																		0063		0029	0049	0049					
27				0035				0019	0019								0019	0147											0167	0043	0019					
28				0035	0019	0049	0019	0019	0031								0019	0039		0029	0029	0015		0029	0021						0019	0019	0027			
29				0035	0035	0039	0021	0019									0019	0019	0037	0025	0025		0033	0039								0041	0019	0019		
30				0035	0035	0035	0035	0035									0013	0021	0021	0025			0033	0027	0027	0027	0027	0027				0043	0043	0043		
31				0035	0025		0035	0035	0035	0015		0015				0019	0029	0025	0015	0025	0015		0017	0037	0037	0033	0031	0033	0037			0039	0043	0019		
32											0029	0033				0043	0043	0043	0043	0017	0031	0037		0019	0013	0019	0019	0041	0019							
33															0019	0019	0019	0049	0049	0049	0049	0019														
34													0015	0019	0019																					
35													0043																							
36													0043																							
37												0033	0023																							
38												0033	0029																							
39												0033																								
40											0031	0029																								
41											0033																									
42											0043																									
43											0043	0019																								
44										0043	0043	0039																								
45										0043	0043	0033																								
46										0043	0043	0011																								
47										0043	0033	0017																								
48																																				
49																																				
50																																				

Appendix V(g) Probability matrix for 2003 A.D. simulated pattern.



Appendix V(h): Random number field for 2000 A.D simulated pattern.

APPENDIX VI

REFERENCES

REFERENCES

Abler, R; Adams J. S. and Gould P. R. (1972) - Spatial Organisation: The Geographer's View of the World. Englewood Cliffs New Jersey: Prentice-Hall.

Abu-Lughod, J. (1971) - Cairo: 1001 years of the city Victorious, Princeton Princeton University Press.

Ackoff, R.L. (1962) - Scientific Method: Optimizing applied research decisions, New York. Wiley

Adedibu, A.A. (1980) - Spatial pattern of Housing Modernization in the traditional residential area of Ilorin. Nigerian Geographical Journal 23 pp. 147-161.

Adedimila A.J. (1977) - Towards Improving Traffic Flow in Lagos. In Transportation in Nigerian National Development. (eds.) S.O. Onakomaiya and N.F. Ekanem NISER, Ibadan.

Adenle J.A. (1977) - Factors Militating against Free Flow of Traffic in Metropolitan Lagos. In Transportation in Nigerian National Development (eds.) S,O, Onakomaiya and N.F. Nkanem NISER, Ibadan

Adeniji, K. (1983) - Nigerian Municipal Bus Operators. Transportation Quaterly Vol. 37

Adeniji, K. (1985) - Urban Transport System in Nigeria in ODU No. 28.

Adeniyi, E.O. (1978) - National Development Planning and Plan Administration in Nigeria. Journal of Administration Overseas Vol. xix I.

Adeniyi P.O. (1980) - Land-Use Change analysis using sequential aerial photograph and computer techniques. Photogrammetric Engineering and Remote Sensing 46(II) pp. 1447-1464.

Aloba A.O. (1975) - Some Geographical Aspects of Rural Transport Network in Ife Division, Western Nigeria. Unpublished M.Phil Thesis. University of Ife, Ile-Ife Nigeria.

Ayeni M.B. (1970) - The Built-up Area of Ikere-Ekiti. Past Present and the Future: A Simulation Study: B.Sc. Dissertation Department of Geography University of Ibadan, Nigeria.

Ayeni, M.B. (1975b) - A Model of the Metropolis. The Development of a Lowry Model for Jos, Benue-Plateau State Nigeria. Socio-Economic Planning Sciences 9 pp. 273-83

Ayeni, M.B. (1979) - Concepts and Techniques in Urban Analysis. Groom Helm. London

Batty, M. (1970) - An activity Allocation Model for the Nothinghamshire Derbyshire Subregions. Regional Studies 4 pp. 307-332.

Batty, M. (1972) - Recent Developments in Landuse Modelling: a review of British research. Urban Studies 9 pp. 151-177.

Beesley, M.E. and J.F. Kain (1964) - Urban Forms Car ownership and public policy an appraisal of Traffic in Towns. Urban Studies 1, pp. 174-263

Berry, B.J.L. (1961) - Basic Patterns of Economic Development. In Atlas of Economic Development (ed) N.S. Ginsburg Chicago: University of Chicago Press p. 119.

Berry, B.J.L. (1966) - Interdependency of Flows and Spatial Structure: A general field theory formulation. In Essays on Commodity Flows and the Spatial Structure of the Indian Economy. Chicago: University of Chicago, Department of Geography, Research paper No. 3.

Berry, B.J.L. and Horton, F.E. (1970) - Geographical Perspectives on Urban Systems. Prentice-Hall.

Blackock, H.M. (1963) - Correlated Independent Variables. The Problem of Multi Collinearity; Social Forces 42, pp. 237.

Blumenfeld, H. (1954) - The tidal wave of metropolitan Expansion. Journal of the American Institute of Planners. Vol. 20 pp. 3-24.

Blumenfeld, H. (1964) - The Urban Pattern. Annals of the American Academy of Political And Social Science

Bolade, A. (1986) - Transport In Metropolitan Lagos. Transport Review, Vol.6, No.1.

Boyce, R.R. (1966) - The Edge of the Metropolis: The Wave Theory Analsg Approach. British Columbia Geographical Series 7, pp. 31 - 40.

Britton, J.N.H. (1971) - Methodology in Flow analysis. East Lakes Geographer 7, pp. 22 - 36

Brown, L.C. (1933) - From Madina to Metropolis: heritage and change in the near Eastern City: Princeton: The Dorvin Press.

Brown, L.A. and Cox, K.R. (1971) - Empitical Regulatities in the Diffusion of Innovation. Annals of the Association of American Geographers. Vol. 61, pp. 551-559.

Brown, H.J., Ginn, J.R., James, F.J., Kain J.F. and Straszheim, M. (1972) - Empirical Models of Urban Landuse: Suggestion on research Objectives and orgnisation. Newyork National Bureau of Economic Research.

Brush, J.F. (1962) - The morphology of Indian Cities: In Turner, R. (ed.) Indian's Urban Feature. Berkeley University of California.

Bruton, M.J. (1970) - Introduction to Transportation Planning. Hutchinson.

Burgess, E. (1923) - The Growth of the City. An introduction to a Research Project. In R.E. Park et al (eds.) The City: Chicago: Chicago University Press.

Burghardt, A. (1969) - The Origin and Development of the roadnetwork of the Niagara Penninsula Ontario 1770-1851 - Annals of the Association of American Geographers, 59, pp. 417-440.

Burton, I. (1960) - Accessibility in Northern Ontario. An application of Graph Theory to Regional Highway Network: Unpublished report for the Ontario Department of Highways.

Carroll, J.D. (1955) - Spatial Interaction and the Urban Metropolitan regional description. Papers and Proceedings of the Regional Science Association. Vol. 1 pp. 1-14.

Carruthers, W.I. (1957) - A Classification of Service Centres in England and Wales. Geographical Journal 122, pp. 371-385.

Casetti E. (1969) - Why do diffusion Processes conform to Logistic trends? Geographical Analysis 1 101-105.

Chapin F.S. and Weiss, S.F. (1962) - Factors influencing land development. University of North Carolina, Institute for Research in Social Science Urban Studies Research Monograph.

Chischolm, M. and O'sullivan P. (1973) - Freight Flows and Spatial Aspects of British Economy. Cambridge University Press, Cambridge.

Christensen, J.W. and Lachowski (1976) - Urban area delineation and detection of change along the urban-rural boundary as derived from landsat digital data. Proceedings ASP/ASCM Fall Technical Meeting. Seattle W.A.

Clawson M. (1962) - Urban Sprawl and Speculation in Suburban land. Land Economics 32(2) pp. 99-111.

Colby C.C. (1933) - Centrifugal and centripetal forces in Urban Geography. Annals of the Association of American Geographers Vol. 23 pp. 1-20.

Colenutt R.J. (1966) - Linear Diffusion in an Urban Setting. Pennsylvania State University. Unpublished. M.Sc. Thesis.

Colenutt R.J. (1969) - Linear Diffusion in an Urban Setting an example. Geographical Analysis 1 pp. 106-14

Colenutt R.J. (1970) - Building models of Urban Growth and Spatial Structure in C. Board et al (eds.) Progress in Geography Vol. 2 London Arnold pp. 109-52.

Cox, K. R. (1973) - Man, Location and Behaviour. New York John Wiley and Sons Inc.

Czamanski, S. (1964) - A Model of Urban Growth. Papers and Proceedings of the Regional Science Association Vol. 13, pp. 177 - 200.

Czamanski, S. (1965) - A Method of forecasting urban growth by distributed Lag Analysis. Journal of Regional Science 4. pp. 15 - 20.

Dacey, M. F. (1975) - Comments on Papers by Isard and Smith. Papers Regional Science Association 35, pp. 15-56.

Daniels, P. W. and Warnes, A. M. (1983) - Movement in Cities. Methuen London.

Dickson, R. E. (1930) - The regional functions and zones of influence of Leeds and Bradford. Geography 15, pp. 548 - 557.

Donnelly, T. G., Chapin, F. S. and Weiss, S. F. (1964) - A probabilistic modelfor Residential Growth. An Urban Studies Research Monograph. Chapel Hill, University of North Carelina, Press.

Dorau, H. Pand Hinman, A. G. (1928) - Urban Land Economics. The Macmillan Company. New York.

Doxiadis (1976) - Masterplan and Programme for the Development of Ilorin. Final Master Plan.

Draper, W. R. and Smith, H. (1966) - Applied Regression Analysis Wiley, New York.

Dutt, A. K. (1971) - Delineation of the Hinter land of Calcutta Port. The Professional Geographer, Vol. 23.

Epstein B.J. (1967) - The Trading Function. In Metropolis on the Move: Geographer's Look at Urban Sprawl (eds.) J. Gottman; R.A. Harper. John Wiley New York. pp. 93-101.

Everson J.A. and FitzGerald, B.P. (1972) - Inside the City. Concepts in Geography. Longman.

Filani, M.O. (1970) - Highway Network Development and Urban growth in Pennsylvania 1920-1960. Unpublished M.Sc. Thesis Pennsylvania Transportation and Traffic Safety Centre. The Pennsylvania State University.

Friedmann J. (1966) - Regional Development Policy: A Case Study of Venezuala: Cambrdige M.I.I.

Garin, R.A. (1969) - A Matrix formulation of the Lowry Model. Journal of the American Institute of Planners. Vol. 32, pp. 361-364.

Garrison, W.L. (1960) - Connectivity of the Interstate Highway system. Papers of the Regional Science Association Vol. 6, pp 121-137.

Garrison W.L. (1962) - Towards simulation models of Urban growth and development. In Norborg K. (ed.) Proceedings of the I.G.J. Land Studies in Geography Series 24 pp. 910-1080.

Garrison, W.L. (1966) - Difficult decisions in Land Use Model Construction. Highway Research Record 126 pp. 17-24.

Garrison W.L. and Marble, D.F. (1961) - The Structure of Transportation Networks. Unpublished report for the U.S. Army Transportation Research Command by the Transportation Centre of North Western University.

Garrison W.L. and Marble D.F. (1965) - A Prolegomemon to the Forecasting of Transportation Centre. North Western University pp. 40-68 and 89-96.

Gauthier, A. L. (1968) - Transportation and the growth for Sao Paulo Economy. Journal of Regional Science. Vol. 8 pp. 88 - 94.

Ginsburg, N. S. (1965) - Urban Geography and Non-Western Areas. In Hauser, p. and Schrore L. F. (eds.).

Goddard, J. B. (1970) - Functional regions within the City Centre: a study by factor analysis of taxi flows in Central London. Institute of British Geographers. 49, pp. 161 - 182.

Godlund, S. (1956) - Bus Services in Sweden. Lund Series in Geography Series B, 17.

Goldberg, M. A. (1973) - Quantitative approaches to Land Management: a Survey Critique and Exposition of recent work. Monograph Series No. 4. Vancouver. Urban Land Economics Program, Faculty of Commerce, University of British Columbia.

Goldner, W. (1968) - Projective Land Use Model (PLUM). Berkley California Bay Area Transportation Studies. Technical Report 24a pp.

Goldner, W. (1971) - The Lowry Model Heritage. Journal of the American Institute of Planners, 37, pp. 100 - 111.

Gould, P. R. (1960) - The Development of the Transportation Pattern in Ghana. Northwestern University Studies in Geography. No.5, Evaston, Illinois.

Green, F. H. W. (1950) - Urban Hinterland in England and Wales: an analysis of Bus Services. Geographical Journal, 96, pp. 64 - 81.

Green, H. L. (1955) - Hinterland boundaries of New York City and Boston in Southern New England. Economic Geography. 31, pp. 283 - 300.

Green, G. (1966) - Community Size and Agglomeration of Trade, Service and other locally oriented industries, Washington University, St. Louis WP5.

Hagerstrand, T. (1952),-The Propagation of Innovation Waves. Lund Studies in Geography Series B. Human Geography 4. Lund, Gleerup.

Hagerstrand, T. (1953) - Innovations foplopper ur Korologisk Synpunkt. Lund, Gleerup, Sweden. G. A. Pred, 1967, Innovation Diffusion as a Spatial Process, Chicago: University of Chicago Press.

Hagerstrand, T. (1965) - Quantitative techniques for analysis of the spread of information and technology. In Anderson, C. A. and Bowman, M. J. (eds.) Education and Economic Development, Chicago pp. 244 - 280.

Harling, J. (1958) - Simulation techniques in operation Research. Operations Research 6, 307 - 19.

Harris, B. (1965) - Introduction: New tools for planning. Journal of the American Institute of Planners 31, pp. 90 - 95.

Harris, B. (1968) - Quantitative modesls of Urban Development: Their Role in Metropolitan Policy-making. In Issues in urban economics (eds.) Harvey, S. Perloff and Lowdon Wingo. Baltimore: John Hopkins University Press.

Harris, C. C. (1966) - Stochastic Process of Suburban Development. University of California, Berkeley: Centre for Real Estate and Urban Economics, Technical Report 1.

Harris, C. D. and Ullman, E. (1945) - The Nature of Cities. Annals of the American Academy of Political and Social Science. Vol. 242, pp.7 - 17.

Harman, H. (1960) - Factor Analysis: Chicago University of Chicago Press.

Harvey, D. (1967) - Models of the Evolution of Spatial Patterns. In Chorley, R. J. and Haggett, P. (eds.) Models in Geography, London: Metnuen, pp. 549 - 608.

Harvey, R. O. and W. A. Clark (1965) - The Nature and Economics of Urban Sprawl. Land Economics, 41(1) pp. 1 - 9.

Herbert, J. D. and Stevens, B. (1960) - A Model of the Distribution of Residential Activity in Urban Areas. Journals of Regional Science, 2, pp. 21 - 36.

Hill, D. M. (1965) - A Growth Allocation Model for the Boston Region. Journal of the American Institute of Planners. 31, pp. 111 - 120.

Hirschman, A. O. (1957) - Investment Policies and Dualism in Underdeveloped Countries. The American Economic Review, Vol. 47, pp. 550 - 570.

Hoyt, H. (1939) - The Structure and Growth of Residential Neighbourhoods in American Cities. Chicago University Press.

Howard, E. (1946) - Garden Cities of Tomorrow. Faber.

Hsu, S. Y. (1971) - Population Estimating. Photogrammetric Engineering and Remote Sensing Vol.37.

Hurd, R. M. (1903) - Principles of City Land Values. The Record and Guide, New York.

Johnson, J. H. (1972) - Urban Geography: An Introductory Analysis. Pergamon Press.

Johnston, R. J. (1978) - Multivariate Statistical Analysis in Geography. London: Longman.

Kain, J. F. (1962) - A Multiple Equation Model of Household Location and Trip Making Behaviour. Rand Memorandum RM-3086. ff.

Kanno, M. (1976) - Canonical Analysis of Commodity Flows and Socio-Economic Structure in major U.S. Metropolitan Areas, Geographical Review of Japan 49, pp. 197 - 216.

Kansky, K. J. (1963) - The Structure of Transportation Networks. Chicago Department of Geography, Research Paper No.84.

Kolars, J. F. and H. J. Malin (1970) - Population and Accessibility. An Analysis of Turkish Railroads. The Geographical Review, 60 pp. 229 - 246.

Krakover, S. (1982) - Spread of Growth in Urban Fields Eastern United States, 1972 - 1978. Ph.D. Dissertation, University of Maryland.

Lakshmanan, T. R. and Hansen, W. G. (1965) - A Retail Market-Potential Model. Journal of the American Institute of Planners. Vol. 31. pp. 134 - 143.

Lampard, E. E. (1955) - The history of cities in economically advanced areas. Economic Development and Cultural Change. Vol.3, pp. 81 - 136.

Leinbach, (1974) - Forecasting Transport Development and Testing the Utility of a simple Regression Approach. Transportation, 3, pp. 243 - 254.

Lindgren, D. T. (1971) - Dwelling Unit Estimation with Colour - IR photos. Photogrammetric Engineering and Remote Serving, Vol. 37, pp. 373 - 377.

Lipton, S. G. (1977) - Evidence of Central City Revival. Journal of the American Institute of Planners. 43(2) pp. 136 - 147.

LO, C. P. and Welch, R. C. (1977) - Chinese Urban Population Estimates - Annals of the American Association of Geographers, 47, 246 pp

London Traffic Survey (1964) - The London Traffic Survey Vol. 1 the London County Council, London.

Lowry, I. S. (1964) - A Model of Metropolis. Rand Memorandum. RM 4035 R.

Mabogunje, Akin (1968) - Urbanisation In Nigeria: London University Press.

Mathews, J. A. (1981) - Quantitative And Statistical Approaches To Geography. Pergamon Press.

Maunder, D. A. C. (1982) - TRRL Supplementary Report 767 Growthorne. Berkshire.

Meier, R. L. (1962) - A Communications Theory of Urban Growth Cambridge. The M.I.T. Press.

Mitchell, R. B. and Rapkin, C. (1954) - Urban Traffic: A Function of Land Use. Columbia University Press.

Mclee, T. G. (1967) - The Southeast Asian City. London Bell. 204pp.

Morrill, R. L. (1965a) - Expansion of the Urban Fringe: a simulation experiment. Regional Science Association Papers and Proceedings 15, 185 - 202.

Morrill, R. L. (1965b) - Migration and the Spread and Growth of Urban Settlement. Lund, Gleerup. Sweden.

Morrill, R. L. (1968) - Waves of Spatial Diffusion. Journal of Regional Science, 8, pp. 1 - 18.

Morrill, R. L. (1970) - The Shape of Diffusion in Space and Time. Economic Geography 46, pp. 259 - 268.

Morrill, R. L. (1982) - A note; Continuing Decentralization Trends in Trade: Growth and Change 13, pp. 46 - 48.

Moseley, M. J. (1973) - The Impact of Growth Centres in Rural Regions I. An Analysis of Spatial Patterns in Brittany. Regional Studies 7. pp. 57 - 75.

Muller, P. O. (1981) - Contemporary Suburban America Prentice-Hall, Englewood Cliffs, NJ.

Muraco, W. A. (1972) - Intra-urban Accessibility. A Quantitative Analysis Use of Graph Theoretic Method. Economic Geography, 48 pp.388 - 405.

Myrdal G. (1957) - Richlands and Poor. New York. Harper.

Neave, H. R. (1978) - Statistical Tables for Mathematicians Engineers, Economists and Behavioural and Management Sciences. George Allen and Urwin London.

Newling, B. E. (1969) - The Spatial Variation of Urban Population Densities. Geographical Review 59, pp. 242 - 252.

Nichols, V. (1969) - Growth Poles: on evaluation of their propulsive affect. Environment and Planning. 1, pp. 193 - 208.

Nystuen, J. D. (1967) - A Theory and Simulation of Intra-Urban Travel in Quantitative Geography (eds.) Garrison, W. L. and Marble D. F.

Nystuen, J. D. and Dacey, M. F. (1961) - A Graph Theory Interpretation of Nodal Regions. Papers and Proceedings Regional Science Vol. 7 pp. 29 - 42.

Oduola, S. O. (1973) - Commuter Transport for Lagos. Unpublished Master's Thesis. University of Nottingham.

OECD (1973) - Road Research. Proceedings of the Symposium on Techniques of Improving Urban Conditions by Restraint of Road Traffic held at Cologne, Germany, 25 - 27 Oct. 1971. Organisation for Economic Cooperation and Development, Paris.

Olorunfemi, J. F. (1981) - The Spatial Expansion of Housing Land Use in Ilorin 1950 - 1973. A Study in Aerial Photography in 24th Annual Conference Bayero University, Kano. Falola, Olofin, Nichols (eds.) pp. 152 - 156.

Olorunfemi, J. F. (1984) - Land Use and Population: A Linking Model. Photogrammetric Engineering and Remote Sensing, Vol. 50, No.2, pp. 221 - 227.

Olorunfemi, J. F. (1985) - The Growth of Ilorin: A Documentation in Aerial Photography. Environment International, Vol.II pp. 509 - 514.

Ogundana, B. (1972) - Road Quality. Unpublished.

Ogunsanya, A. A. (1979) - Spatial Aspects of Freight Transport in Lagos Metropolis. Unpublished Ph.D. Thesis, Department of Geography, University of Ife, Ile-Ife.

Ogunsanya, A. A. (1981) - Urban Freight Transport in a Developing Economy. The case of Lagos. Nigerian Geographical Journal, Vol. 24.

Ogunsanya, A. A. (1982) - Spatial Pattern of Urban Freight Transport In Lagos Metropolis. Transportation Research, Vol. 16A, No. 4.

Ogunsanya, A. A. (1983) - The Human Factor In Urban Traffic Congestion In A Developing Environment: The Case of Lagos, Nigeria, Papers Presented at the World Conference of Transport Research Federal Republic of Germany.

Ogunsanya, A. A. (1984) - Estimating Intra-Urban Freight Generation and Attraction In Transportation Research, Vol. 18A, No. 3.

Ogunsanya, A. A. (1985) - Generating Urban Traffic Flow Data For Urban Transport Studies in Developing Countries: An Approach; Geoforum, Vol.16, No.4, pp. 403 - 412.

Ogunsanya, A. A. (1986) - Graph Theory In Intra-Urban Traffic Flow Estimation. Geo. Journal, 12 pp.334 - 336.

Ogunsanya, A. A. (1989) - Road Development and Urban Sprawl: The Case of Ilorin. Journals of the Nigerian Institute of Town Planners, Vol.30/31.

Osili, I. (1977) - Federal Highway Programme In Nigeria. Third National Development Plan 1975 - 1980 In Transportation In Nigerian National Development NISER, Ibadan.

Oyebanji, J. O. (1981) - Regional Inequalities In Economic Growth and Development. A Case Study From Nigeria. Journals of the Nigerian Institute of Town Planners, Vol. 1 (1), pp.71 - 85.

Pederson, E. O. (1980) - Transportation In Cities. Pergamon Press.

Pred, A. (1976) - The Interurban Transmission of growth in advanced economies: empirical findings versus regional planning assumptions. Regional Studies 10, pp. 151 - 171.

Preston, R. E. (1971) - The changing form and structure of the Southern California Metropolis. The California Geographer, Vol.2.

Putman, S. H. (1972) - Intra-urban employment forecasting models: a review and a suggested new model construct. Journal of the American Institute of Planners, Vol. 38, pp. 216 - 230.

Redfield and Singer (1954) - The Cultural Role of Cities. Economic Development and Cultural Change, Vol.3.

Rees, P. H. (1972) - Problems of Classifying Subareas within cities. In city classification handbook: Methods and applications (ed.) B. J. Berry and K. B. Smith. New York. Wiley.

Richardson, H. W. (1971) - Urban Economics. Penguim.

Roberto, B. and Longe, G. (1976) - Banning the Car from Town

Rodwin, L. and Lynch, K. (1958) - A theory of Urban form. Journal of the American Institute of Planners XXIV pp. 201 - 214.

Rostow, W. W. (1964) - The Stages of Economic Growth: A Non-Communist Manifesto. Cambridge.

Rummell, R. J. (1967) - Understanding Factor Analysis. Journal of Conflict Resolution, 40, pp. 440 - 480.

Salter, R. J. (1974) - <u>Highway Traffic Analysis and Design</u> Macmillan.

Sargent, C. S. (1972) - Towards a Dynamic Model of Urban Morphology. <u>Economic Geography</u>. Vol. 48, No.4.

Schaeffer, K. H. and Sclar, E. (1975) - Access for all: <u>Transport and Urban Growth</u>. Penguin London.

Schlager, K. J. (1964) - Simulation Models in Urban and Regional Planning. <u>Regional Planning Commission. Wiscousin Technical Record</u>. 3.

Schuldiner, P. W. (1962) - Trip Generation and Home. <u>Highway Research Board</u>. Bulletin No. 347.

Scott, A. J. (1968) - <u>An Equation System for the Analysis of an Urban Complex</u>. University of Pennsylvania: Regional Science Research Institute. Mimeo.

SELNEC (1962) - <u>A Highway Plan</u>. Prepared by the South-East Lanchashire and North-East Cheshire Highway Engineering Committee.

Smailes, A. E. (1947) - The Analysis and Delimitation of Urban Fields, <u>Geography</u>, 32 pp. 151 - 161.

Soja, E. W. (1968) - Communications and Territorial Integration in East Africa: An Introduction to Transaction Flow Analysis. The <u>East Lakes Geographer</u>. 4, pp.39 - 57.

Starkie, D. N. M. (1967) - <u>Traffic and Industry</u>. Tinselay and Co. Ltd., Manur Form Road Alperton. Wembley Middx.

Steiness, D. N. (1982) - Suburbanization and the Mailing of America. Urban Affairs Quaterly, 17 pp. 401 - 418.

Sweet, D. C. (1972) - Models of Urban Structure, Lexington Mass. D. C. Heath.

Taaffe, E. J. Morrill, R. and Gould, P. R. (1963) - Transportation Expansion in Underdeveloped Countries. A Comparative Analysis. Geographical Review. 53 pp. 503 - 529.

Theil, H. (1966) - Applied Economics Forecasting. North-Holland Armsterdam.

Toyne, P. (1971) - Customer Trips To Retail Business in Exeter. In Ravenhill W.L.D. and Gregory K.K. (eds,) Exeter Essays In Geography. Exeter U.P.

Trewartra, (1943) - Unincorporated Hamlet - Annals of the Association of American Geographers, 33, 32 - 81.

Ullman, E. L. (1957) - American Commodity Flow. Seattle, University of Washington Press.

Watkins, J. F. (1984) - The effect of residential structure variation on dwelling unit enumeration from aerial photographs. Photogrammetric Engineering and Remote Sensing. Vol. 50, No.II, pp.1599-1607.

Webber, M. N. (1963) - The Urban Place and the Nonplace Urban Realm. Explorations Into Urban Structure. (eds.) Webber et al Philadeiphia: University of Pennsylvania Press.

Wheeler, J. O. (1972) Trip Purpose and Urban Activity Linkage. Annals of the Association of American Geographers. 62 pp. 641 - 654.

Wilson, A.G. (1968) - Development of Some elementary residential location models. Centre for Environmental Studies. WP. 22.

Wilson, A.G. (1969) - Development of some elementary residential location models. Journal of Regional Sciences, 9, pp. 377-385.

Wilson, A.G. 1970) - Entropy in Urban and Regional Planning London.

Wilson, A.G. (1973) - Urban and Regional Models in Geography.

Wingo, L.J. and Perloff, H.S. (1961) - The Washington transportation plan: technics or politics? Papers and Proceedings of the Regional Science Association Vol. 7 pp. 49-62.

Wise, M.J. (1966) - The City region; Advancement of Science 23, pp. 571-588.

Wisemann, R. (1976) - Interpretation of factorial flow Data. A comparison of two traffic systems. The Professional Geographer 28(2) pp. 172-177.

Wuster, C.B. (1963) - Form and Structure of the Future Urban complex in L. Wingo Jr. (ed.). Cities and Space. Baltimore. John Hopkins Press 75pp.

Yeates, M. (1963) - Hinterland delimitation: A distance minimization approach. Professional Geographer 15, pp. 7-10.