Dissertation

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The accessibility of major centres to the bus transport services in Enugu, Enugu State, Nigeria

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THE ACCESSIBILITY OF MAJOR CENTRES TO THE BUS TRANSPORT SERVICES IN ENUGU, ENUGU STATE, NIGERIA

BY

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CERTIFICATION

Mr. Alphonsus Nwachukwu Ali, a postgraduate student in the Department of Geography specializing in Transport Geography, has satisfactorily completed the requirements for course and research work for the degree of Master of Science in Geography. The work embodied in this project is original and has not been submitted in part or full for any other diploma or degree of this or any other University.

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(HEAD OF DEPARTMENT)

DEDICATION

This work is dedicated
to my late mother, Janet,
who died on 23rd August,
1992.

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I wish to use this opportunity to express my unalloyed and profound gratitude to the following persons and organizations for their various contributions towards the accomplishment of this research project.

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1997

A.N. Ali
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ABSTRACT

The central aim of this study is to find out the level of accessibility of different parts of Enugu to the mass transit bus network measured in terms of shortest bus route distance and bus travel-time and to relate the level of accessibility to the level of bus services. The level of bus services was defined in terms of bus passenger waiting time, bus frequency arrival and passenger walking distance to the nearest bus stop.

The data collected between 1994 and 1995, were based on field observations, government documents and personal interviews. In this thesis, a classification of 31 sampled settlements, called major centres, was first developed based on population and type of land-uses such as residential, employment, market and educational land-uses. By means of graph theory, the complex network of mass transit bus routes was abstracted into a set of nodes and edges which enabled us to construct indices of connectivity and relative accessibility of the major centres on the network.

The connectivity indices reveal that the mass transit bus routes in Enugu have very low connectivity. Similarly, the indices of nodal (major centre) accessibility based on shortest bus route distance show that there exists a central core of highly accessible centres to mass transit bus network which constrasts with peripheral centres of

very low level of accessibility. Inaccessible centres are found both within the inner and peripheral areas of the city of Enugu.

The results of correlation analysis between bus route distance accessibility and some bus service indices show a strong relationship between accessibility and bus passenger waiting time and also weak relationship between accessibility and bus service frequency. Similarly a strong relationship was found to exist between bus passenger waiting time and bus service frequency.

Bus services for the movement of persons within the city of Enugu are provided mainly by a multitude of individual operators and partly by few government agencies and companies. The capacities of urban buses are found to be in three categories - minibus (14 - 18 persons); medium bus (36 - 45 persons) and big bus (80 - 120 persons).

Based on the findings, recommendations that could enhance the improvement and equitable distribution of bus services in Enugu are: creating additional bus routes to link inaccessible and less accessible areas; construction of urban link roads and maintenance of the existing ones; privatization of government owned mass transit bus companies; provision of high capacities of urban buses; fixing and enforcement of bus fare and improvement of bus stop facilities.

CHAPTER ONE

INTRODUCTION

1.1 Background to the study:

A very significant factor in city growth is the ability or inability to move about freely within its limit. The city, like the human body, is a series of connected parts and organs and as such requires an efficient circulatory system in order to function as a living and vital organism. Just as the life and growth of the body depend upon the adequacy of the bloodstream, so do the life and growth of the city depend upon the adequacy of its internal transport system. A city is said to be as big as its transportation facilities which enable people to move about their business, move and distribute their goods (Smerk, 1974).

With the present rapid expansion of urban boundaries and corresponding increases in population in urban areas, the need to improve the existing internal transport system becomes imperative. This is because these increases in urban boundaries and populations have in turn resulted in massive increases in the demand for transport. Other factors adding significantly to the level of demand are increased commercial and industrial activities and a greater propensity to travel where incomes have risen. In most Nigerian cities, because of these factors, demand for public transport in particular, has grown even faster than the population.

Public transport systems provide the most efficient means of moving large number of people especially in densely populated urban centres. In addition to the well being of its users, public transport plays a vital role in the productivity of cities which in turn has a direct bearing on national economies. Public transport by definition connotes the act or the means of conveying large number of people "en masse" as opposed to conveyance in individual vehicles carrying very few people at a time. In other words, public transport or mass transit is a system in which a greater number of people are moved at a time along principal corridors (Ogbazi, 1992).

Broadly speaking, public transport comprises mainly of the rail system; light rail system; tramways and monorails; bus system, and where possible, water transport system.

Today, experiences show a need for greater variety of public transport modes, but buses are choice of a majority of the communities and are the only means of mobility that can be afforded by the poor in developing countries of the world. The choice of any or a combination of the public transportation systems enumerated above could be influenced by population and size of the city, their transportation demand and characteristics and landuse pattern. Given our level of technological development, we have in mind in this research, the bus system. The bus system is the transport

system that uses buses that may have a range of passenger capacities and performance characteristics, and may operate on fixed routes with fixed schedules, or may be flexibly routed.

Bus transport system in towns has the potential of being used as a policy tool to reduce the number of cars on urban roads and so reduce traffic chaos in the city. Bus transport system has also the potential of extending transportation services to a greater proportion of urban residents who do not have private cars, and cannot afford frequent taxi fares. These are captive bus riders. Bus also called Omnibus is any of a class of large self-propelled wheeled vehicles that are designed to carry passengers generally on a fixed route.

One of the critical issues in the provision of mass transit bus system in any urban area, is the issue of accessibility of service of the system to a greater majority of captive bus riders. The heart of transportation planning in any part of the worldis concerned with the design of circulation systems which maximize accessibility for essential movements between linked activities (Onokala, 1995). Accessibility is a loose term which is used to mean many things. Various definitions of accessibility are put forward to connote either social, economic or legal nearness to needed services (Daly, 1975; Mitchell and Town, 1976).

Accessibility is generally understood to mean approximately "ease of reading". Accessibility also implies the opportunity that an individual or type of person at a given location possesses to take part in a particular activity or set of activities (Jones, 1981); as a function of point's location in space to other points in any given system (Hack, 1976); and de Lamnoy and Qudhensden Van, (1978) and as inherent characteristics or advantage of a place with respect to over-coming some spatially operating source of friction, for example, time and/or distance (Igram, 1971). The term accessibility as used in this research project is the ability of bus users to get bus services and the ability of bus transport service to provide a low cost and/or quick method of over-coming the distances between different centres in Enugu.

1.2 Statement of the research problem:

In the past three decades, the population of many cities in developing countries of the world has doubled as a result of the influx of migrants from rural to urban areas. The growth was accompanied by a substantial expansion of city boundaries and much higher level of industrial and economic activities. The changes have placed new and heavy demands on an efficient and adequate mass transportation system in such cities. As a result, the existing transport facilities in

most of the urban areas in developing countries are grossly inadequate and overused (World Bank, 1985).

The high cost of car maintenance and purchasing in Nigeria now, due to economic downturn, has all the more increased the demand for mass transportation in the cities. In view of these problems, government agencies as well as corporate bodies and private individuals have been involved in the provision of public passenger transport services by bus to meet the evergrowing demand for intra-urban mobility in Nigerian cities. The Federal Military Government introduced the Federal Urban Mass Transit Programme in 1988 to improve and moderate the urban mass transit services in the country (First National Rolling Plan 1990-92).

Laudable as these efforts by the government agencies and private bodies and individuals were, not much successes have been recorded by them in terms of meeting the needs of urban riders in Nigerian cities. The existing mass transportation services by bus in Nigerian cities, generally characterized by inadequate bus route densities, poor frequency and low predictability of bus services, and few number of buses actually in circulation particularly at peak periods, are not sufficient to cope with the demand (Okpala, 1977; Adefolalu, 1981; Omatseye et al, 1989; Ogbazi, 1992).

Enugu, being one of the metropolitan centres in Nigeria, has also been experiencing population growth and expansion of urban environment over the years. The rapid rate of population growth and the expansion of Enugu urban environment, have led to the extension of low-income unplanned settlements on the peripheries and workers from these areas are exerting increasing pressure on already inadequate public transport facilities. The spreading of suburbs and transformation of villages into dormitory settlements have also created residential-to-work transportation problems in Enugu. Workers, school children and the whole populace are experiencing hardships in their journeys to and from work and other activity centres due to lack of efficient mass transport services by bus.

Most parts of Enugu are not adequately linked by bus routes and as a result, the supply of bus services in such areas does not match the ever growing demand for it. Motorcycle transport services popularly known as "Okada" are highly patronized by the urban dwellers living in the bus service-disadvantaged-areas of Enugu by those who can afford to pay the exorbitant fares charged by the operators. Those who cannot afford to pay for motorcycle transport services trek a lot because of inadequate intra-urban transport services by bus.

The interplay of the above enumerated factors in the services of intra-urban bus transport in Enugu is seriously hampering the accessibility of the bus users to the services of the buses in the study area. This lack of accessibility to bus transport services by the majority of urban dwellers craving for such services is adversely affecting their economic and social life in the study area.

1.3 Aims and Objectives of the research

This research investigates the accessibility of major centres to the network of mass transit bus services for the masses in Enugu with a view to pursuing the following specific objectives:

1. To describe the level of provision of buses for mass transit bus services in Enugu.
2. To describe the pattern of accessibility of major centres to the network of mass transit bus services in Enugu.
3. To explain the patterns of quality of bus service indicators in the major centres.
4. To relate the level of accessibility of a major centre to the observed quality of bus service indicators in the major centre.
5. To discuss the intra-urban mass transit by bus and the planning implications of the observed variations.

These objectives will enable us to establish the criteria for carrying out mass transit improvement, especially by bus, that will maximize accessibility of major centres and captive bus riders to the mass transit bus services in Enugu.

1.4 Theoretical framework:

The relevance of theoretical models to the understanding of transportation systems and their services in an urban environment cannot be over-emphasized. A model has been defined as a simplified structuring of reality which present supposedly significant features or relationship in a general form (Chorley and Hagget, 1967). Hence, with respect to this research project, it will be pertinent to introduce some basic concepts that would enable us generate our working hypotheses and as well as provide the framework for testing of our hypotheses.

1.4.1 Mass transit system:

Mass transit systems are the systems in which a greater number of people are moved at a time along principal corridors (Ogbazi, 1992). The main types of mass transit systems are:-

i) Bus system: This refers to a transport system that uses buses that may have a range of passenger capacities and

performance characteristics; and may operate on fixed routes with fixed schedules, or may be flexibly routed and demand scheduled.

ii) Light rail transit: Light rail transit refers to a wide range of electrically powered rail systems.

iii) Rapid rail transits: These are often referred to as metro, underground or subway. They are very fast and in fact, have the highest transit capacity and speed currently available.

iv) Suburban rail: It is also referred to as commuter rail system. It is operated on tracks shared with inter-city passenger trains and freight trains (World Bank, 1986).

The option of any of the systems mentioned above by an individual depends on factors such as availability, affordability, quickeness and reliability.

Bus services are the dominant mode of motorized transport in Third World cities. Because of low incomes of the majority of inhabitants, buses provide the only mode of transport that they can afford. Buses dominate because generally they are at a level of technology compatible with local experiences and facilities (Armstrong-Wright, 1993). The characteristics of bus transit system as regards capacity of buses are summarized in Table 1.

TABLE 1: Capacity of urban buses

Type of Bus	Designed Seated	Capacity Total	Typical Peak Period Crush Loading
Minibus	12	20	40
Small bus	20	30	50
Adapted truck	20	35	45
Medium bus (standard bus)	40	80	105
Large Single-deck bus	50	100	125
Double deck-bus	80	120	150
Large-double deck-bus	80	170	200
Articulated bus	55	120	150
Large Articulated bus	55	170	210

SOURCE: World Bank Technical Paper 1987, No. 68.

While bus designs vary considerably, most are typically single deck two-axle vehicles powered by front mounted direct injection of diesel engines. They generally have two doors and as much standing space as authorities or passengers will tolerate. Standing/sitting ratio of 3:1 is found in the Third World cities. Double-deck buses are less common - large fleets of buses are found mainly in India and Indonesia. The use of large articulated buses is rare, except in major Chinese cities where large fleet of

articulated buses and trolley are found (Armstrong-Wright, 1993).

1.4.2 Graph theoretic model:

Graph theory, a branch of topology, is concerned with abstract configurations of points and lines (Taaffe and Gauthier, 1973). It is a mathematics of relations (Nystuen and Dacey, 1961). Graph theoretic model provides a measure of accessibility. It provides a convenient method of evaluating and comparing the accessibility of the nodes or places in a network by measuring the degree to which they are connected with each other and to the network as a whole. The accessibility of the nodes or places in the network can be related to socio-economic variables and physical variables of such places or nodes (Taaffe and Gauthier, 1973). A transport network is a set of geographic locations interconnected in a system by a number of routes (Kansky, 1963). Transport network serves to link locations or places.

For transportation networks to be treated as graphs, it is necessary to abstract the complex structure of the networks as a series of vertices (representing nodes or places in the networks) and a set of edges (representing linkages). Other properties of network as cost of construction, route capacity and road surface which are not amenable to graph theory are temporarily left behind and

only the presence or absence of connectivity between nodes are considered.

The graph theoretic approach to network analysis has been considered relevant in this study because of the following reasons: It is flexible and simple to apply; it considers the route along which movement takes place and hence, tries to account for relative accessibility of a node to other nodes in the network and at the same time can be related to socio-economic variables and other characteristics of such areas. By means of valued graphs, we can also build in other properties of route such as distance, cost and time into the model. Finally the graph theory can provide us with a standard of assessing the most accessible centres within urban area through the calculation of shortest paths. Taking these centres as given, one is able to examine the possible urban influence of any public service, for example, mass transit bus service, that may be found in them.

Thus, Garrison (1960), Kansky (1963), Ward (1969), Taaffe and Gauthier (1973), and Agwu (1987), all acknowledged the usefulness of graph theoretic indices in describing network growth over time, comparing networks and describing the structure of network.

1.4.3 The concept of level-of-service (L.O.S)

Generally it is not easy to exhaustively define the level-of-service concept otherwise known as concept of quality of service indicators because different people, and different urban regions may put different emphasis on various components of the concept. For instance, on the part of transport consumers (the travellers), the dimension of level-of-service (L.O.S) considered are travel time, bus frequency, comfort, terminal standards, bus stop facilities, interchanges between routes and services among others (George, 1979; Ume, 1991). Travel time usually contains several different elements. For a transit trip, it includes walking into the station or bus stop, waiting time for bus services, travelling time in the transit vehicle, and walking time to the destination (Jende hsu and Surti, 1976).

The comfort and convenience of public transport system could be measured in the vehicle in terms of seating comfort and jolting. They could be measured to and from bus stop and at the bus stop in terms of terminal location, shelter provided, and traffic safety (World Bank, 1987; Ume, 1991). Other elements in the measurement of level-of-service of public transport vehicles, for example, mass transit bus are: journey times and travel expenditure. The above enumerated variables (components) of level-of-service concept, clearly show the various dimensional approaches of the concept.

However, for the purpose of this study, we shall examine the level-of-service (quality of service indicators) of mass transit bus services in Enugu as perceived by bus users by considering these variables: (a) waiting time at the bus stop, (b) walking distance or time to the nearest bus stop and (c) frequency of bus arrival to the major centres. We have chosen these variables because they help to determine the level of personal accessibility to mass transit bus services in different major centres in the study areas.

1.5 Working hypotheses:

In line with the research problem, we posit the following hypotheses:

1. The lengths of waiting time for the arrival of buses at the bus stops and the frequency of arrival of buses do not vary with the level of accessibility of major centres to the mass transit bus network in Enugu.
2. There is no significant relationship between the frequency of arrival of buses and waiting time for the arrival of buses in the major centres.

1.6 Literature review:

Everywhere in the world, there is a fascinating similarity in the attitude displaced by those who live or work in large towns and cities to the problems of personal movement

to, from and within those urban centres. These problems notwithstanding, the developing countries as a whole are now witnessing an increasing movement of population from the rural areas to the towns and cities, and the problems of providing mass transit is far from being solved in the developing countries more than is the case in advanced countries (Adenji, 1983a). For many centuries, towns and cities all over the world were predestrian-traffic-dominated, with only horse drawn carriages supplementing walking. Most urban centres were protected behind walls or ramparts, all distances within settlement, were very short and most people worked where they lived (Adenji, 1983b).

Several studies in developed and developing countries have attributed the socio-economic development of any society to an efficient transport system. Onibokun (1987) had attributed the spatial order and socio-economic development of West Germany to comprehensively developed and integrated planned system of transportation. Also, Owen (1976) considered that the low level of development in the developing countries is due to lack of efficient organized transport system. Chapin (1976) regarded transport as essential a service which enables people, firms and various other entities to carry out their activities at sites selected for those purposes in separate locations. Buchannan (1983) considered transport as an essential ingredient for the

survival of modern society and without which there would be no life in the city. Transport provides a key to the understanding and operations of many other systems at many different scales, and is an epitome of the complex relationships that exist between the physical environment, patterns of social and political activity, and levels of economic development (Hoyle and Smith, 1992).

Many studies have evaluated the importance and the need for public transport. Nash (1976) observed that the demand for public transport in developed countries is necessitated due to the problems of transport in urban areas. Oladoja (1983) reviewed the importance of public transportation in urban centres with reference to Ibadan and concluded that improved level of public transport resulted in increased urban mobility of the masses, reduced congestion and also contributed to the efficient use of urban resources.

However, some studies have reported the inadequacies of public transport facilities in the cities. World Bank, (1986) and Turton, (1992) reported that, although there was heavy demand for urban transport due to the rapid increase in population in the developing countries for the past two decades, many cities were unable to meet the demand. Many cities in Nigeria and other West African countries have either none or only developed conventional bus services and

most passenger transport is provided by minibuses or shared taxi (Adenji, 1983a). Wiredu (1989) in the study of minibuses in an African city, reported that the half-million population of Benin City is currently served by 600 minibuses on 20 routes operated by many small undertakings. According to McNeil (1975) inadequacies of public transport manifest themselves visibly by over loaded buses, long queues or fights at bus stops, long walk to work and exorbitant prices in local shops.

Many other authors have identified the bus as key to urban mobility in the attempt to solve urban transportation problems. Volvo (1979) used the concept of modern city bus system to plan, develop and implement an efficient urban transport system in Lahore, Pakistan. The bus and coach council of London (1983/84) and Tolley and Turton (1995), favoured the use of bus for mass transport for the following benefits: The bus can be used in the mobility of everyone, reduction in congestion, positive importance on commerce and industry, fuel saving and reduction of pollution, ensuring safety of the people, flexibility and low cost of operation and maintenance. In fact, Hellewell (1984) in his review of the current position of Brazilian public transport, revealed that buses account for 88 percent of the transportation modes which carried about 650,000 people per day.

However, Wilber and Associates (1965) discredited the bus system by accusing it of indiscriminate stops to meet the needs of the large number of passengers and limited manoeuvrability which cause greater dislocation of traffic flows than the small journey types of vehicles.

Several authors have used the concept of accessibility in transportation studies. Jones (1984), considered the particular case of accessibility by the use of public transport in the urban area of Tyne and Wear in England and observed that car ownership, the nearness of bus stops, the frequency of the bus services and usefulness of the destination are some of the major factors that affect the level of public transport use and provision. Black (1977) in studying access and travel in seven Sydney suburbs, Australia, observed that for most purposes school, shopping, leisure, social, recreational, medical and personal business, people make short trips (in distance and in time) as their accessibility increased.

Different authors have considered the relationship between an area's accessibility and level of car ownership. Dunphy (1974), found a significant correlation between accessibility to employment by public transport and car ownership. Schindler and Ferrari (1976) obtained a significant correlation between car ownership and the ratio of

employment accessibility by public transport to that by private transport. Williams (1976) and Leonardi (1978), identified accessibility with the consumer surplus or benefit that people achieve from using the transport and landuse system.

Accessibility concept has been used in the evaluation of several alternative bus system (Pike et al, 1976), of a proposed commuter mail line (Popper and Hoel, 1976); of two proposed urban relief roads (Koenigs, 1975), in the general development of transport policy of an area (Martin and Daly, 1978); in the identification of areas where existing bus services did not provide adequately for the inhabitants (Ochajna and Brownlee, 1977) and relative accessibility of centres to the road network (Agwu, 1987).

In the study area, few transport studies have been carried out. These include Nweke (1979), who examined journey to work in Enugu; Osondu (1985) who looked at the traffic flow and road linkage pattern; Ojukwu (1985) who carried out the study on the relationship between traffic and incidence of road traffic accidents, and Ugwu (1984) who looked into the influence of socio-economic activities on the spatial distribution of traffic flow in Enugu.

From our foregoing discussions of past researches on urban transportation in both developed and developing world

cities, the bus as a key to urban mobility has been highlighted. We also noticed a number of studies of public transport in different cities of the world using the concept of accessibility. Although, many studies of urban transportation have been carried out in the city of Enugu, none of them considered how mass transit bus network is accessible to major parts of the city and how the inhabitants in the areas get access to the services of mass transit buses. This is necessary in order to identify areas where the existing bus services are not adequate for the inhabitants so as to make suggestions for effective and equitable distribution of bus services in Enugu.

Therefore, it is against this background of lack of research into the problems of bus services in Enugu, that we have decided to embark upon this particular research - to examine the accessibility of major centres to the mass transit bus services in Enugu.

1.7 Research Methodology:

1.7.1 Major centre:

In developing the research design, the operational definition of a major centre on the mass transit bus network in Enugu was adopted based on the following criteria:

i) residential areas: These are the residential areas with a minimum population of 5,000 based on 1992 Enugu State

population estimates using 5% annual growth rate of 1963 census figures.

ii) employment centres: They are the various foci of employment where at least 500 workers are employed estimated from number of employment houses available in a centre.

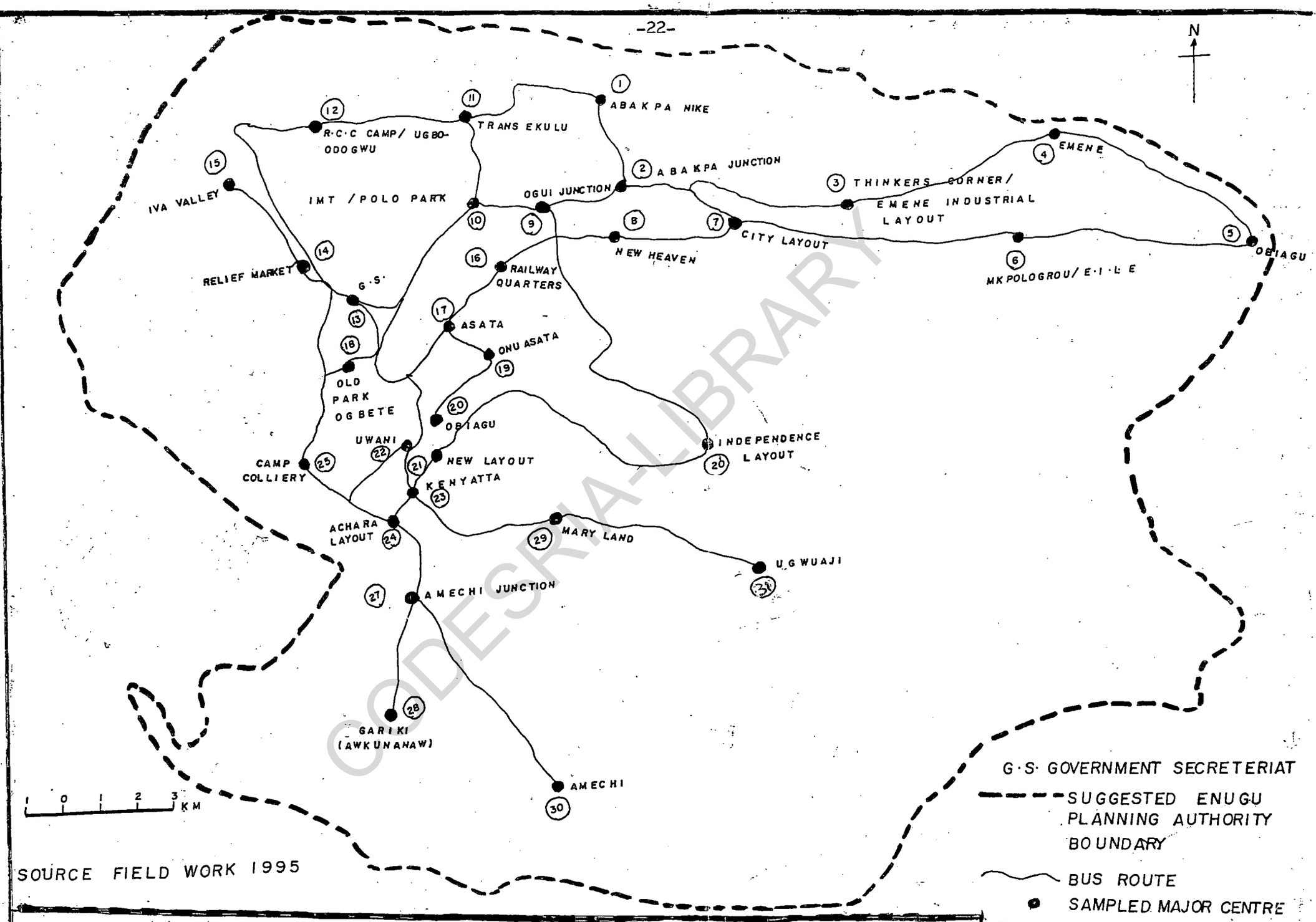
iii) market centres: All the markets having at least 100 lock-up stores were included in this group.

iv) educational centres: These are the centres where schools are located with 2000 student enrolment.

These activity centres were adopted as major centres because they are traffic - generating points/areas - originating and terminating points of outward and home ward bus commuter trips respectively in Enugu. Based on the adopted operational definitions of a major centre, 31 major centres were identified as shown in figure 1.

1.7.2 Links or edges or loops:

In this study, all the major arteries and minor arteries of roads that are used by mass transit buses for intra-urban public passenger transport services in Enugu which connect the major centres were taken to be links or edges or loops (lines or routes that link places together).



SOURCE FIELD WORK 1995

Fig. 1· LOCATION OF SAMPLED MAJOR CENTRES

1.7.3 Data on accessibility variable:

In order to consider the relative accessibility of major centres to the mass transit bus network, three maps that closely reflect the nature of road linkages and traffic pattern in Enugu were collected from Land and Survey Division of the Ministry of work, Land and Transport Enugu. These maps are: the map of Enugu Planning Authority Area, 1:50,000 published in March 1975; Enugu and Environs - Tourist Guide map, 1:35,000 published in 1994 and Enugu Perspective Master Plan - road/traffic pattern, 1:25,000. These maps were used to identify roads and bus routes linkage patterns in Enugu. Another method employed in the identification of bus route linkages was by riding on the buses from one place to another. The approved intra-city bus routes by the Transport Company of Anambra State (TRACAS) in 1987 and by the Enugu State Transport Company (ENTRACO) in 1994 were of great assistance in the identification of bus routes in Enugu. The road distance between two consecutive major centres was determined by using thread or string to measure the distance on the map and using the appropriate scale given to work out the actual distance.

Another measurement that was carried out was the measurement of travel-time by bus between major centres. The bus travel-time was determined by riding on buses by investigators from one place to another employing stop watches.

1.7.4 Data on bus users' variables:

The bus users' questionnaire (Appendix A) was used to collect data on bus users' variables such as the length of waiting time for the arrival of buses at the bus stop for each of the major centres; time and distance taken by bus users to walk from origin/destination points to reach the nearest bus stops to catch a bus; bus trip purposes; bus fare payable per trip, age, sex and occupation of the bus users and other transportation problems, bus users encounter along bus routes. At least 30 bus users were administered with the questionnaire in each of the 31 identified sample major centres. Interview was also applied to extract the data from bus users as contained in the questionnaire. The questionnaire was administered to the bus users randomly as they arrived at the bus stops to catch a bus.

1.7.5 Data on bus operators' variables

The bus operators' questionnaire (Appendix C) was used to collect data on bus operators' variables such as types of buses used by the operators, plying bus routes, trip fare and number of buses owned by each operator. The questionnaire was administered to private individuals, corporate bodies and government agencies operating buses for intra-urban mass transit services in Enugu.

1.7.6 Data on bus frequency arrival:

Using hourly bus frequency arrival count profoma (Appendix B) the number of buses arriving in each of the 31 major centres to carry passengers to different points or places in Enugu were collected between 6.00 a.m. and 6.00 p.m. The counting of arrival of buses was done by stationing investigators at the bus stops on routes in each of the major centres. Where a major centre is connected by multiple bus routes, different investigators were employed to man each of the routes. Buses arriving from one direction of bus traffic flow to each bus stop were counted. Big buses and minibuses were counted separately. These data were collected from September 6th - 14th, 1995.

1.7.7 Data on location of bus stops and bus stop facilities:

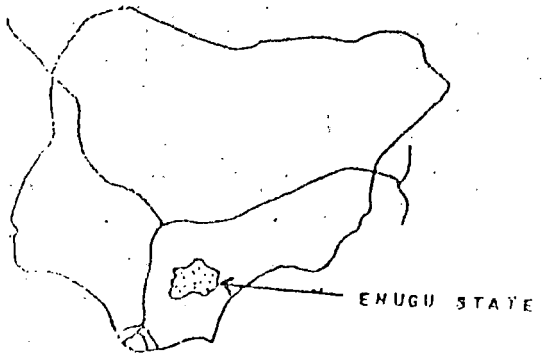
The location of bus stops along the bus routes connecting the major centres was carried out by the combination of riding on buses and walking by investigators. Names of bus stops were collected by asking bus conductors, passengers in the buses during alighting and boarding of passengers along the mass transit bus routes. Personal experiences of the investigators supplemented the oral interview in the identification of bus stop locations and their names.

Bus stop spacing (i.e. distance between two consecutive bus stops) was determined in each of the major centres by using tape measurement. Tapes graduated in metres were used to measure distance along bus routes between two consecutive bus stops. Samples of 3 or 4 bus stop spacings were measured in each of the major centres and an average bus stop spacing was obtained for each centre. Using observations and photographic techniques, data on bus stop facilities were obtained and recorded.

1.8 The Study Area:

1.8.1 Location and size:

The study area is Enugu, the capital of Enugu State, Nigeria. Enugu is made up of two Local Government Areas - the Enugu North and South Local Government Areas. The city lies approximately between Latitudes $6^{\circ}21'$ and $6^{\circ}30'$N and Longitudes $7^{\circ}26'$ and $7^{\circ}37'$E of the equator and Greenwich meridian respectively. It is bounded on the north by Igbo-Etiti and Izi-Uzo Local Government Areas; on the east and south by Nkanu Local Government Area and on the west and south-west by Udi Local Government Area (see Fig. 2). "It lies on the plains close to the foot of east facing escarpment of Enugu - Awgu Cuesta" (Okoye, 1975 p. 50). The growth impulses of Enugu is likely to spread far and wide



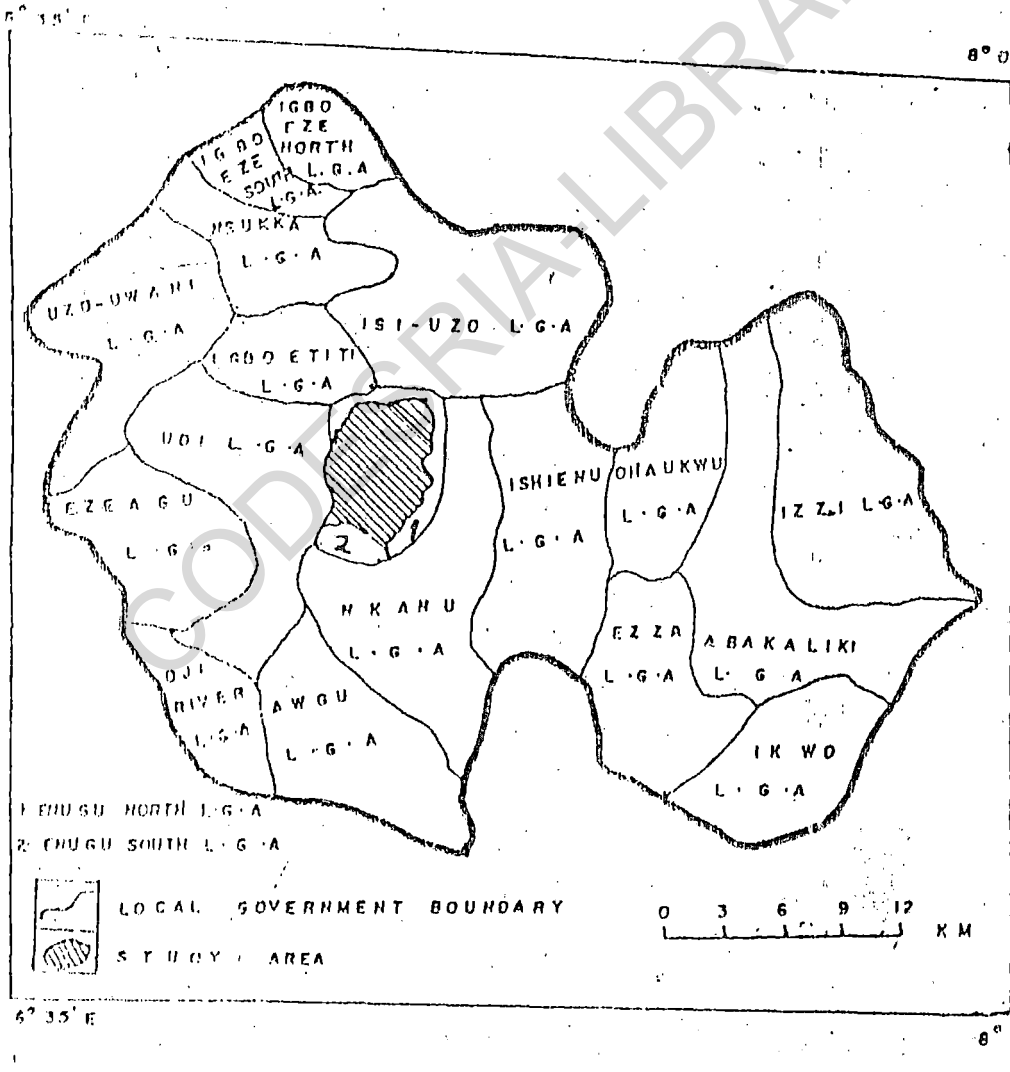


FIG. 02: MAP OF ENUGU STATE SHOWING THE POSITION OF ENUGU

because it is the capital of Enugu State. The present study does not cover the whole area of Enugu North and South Local Government Areas - rather it covers the area under the suggested Town Planning Boundary for Enugu (see Fig. 3) with the total land area of about 182 square kilometres.

1.8.2 Growth and development:

The origin of Enugu dates back to 1909 when coal was first discovered near Udi by a group of geologists sponsored by the then colonial government (Jennings, 1959). The opening of different coal mines - Udi siding in 1915; Iva in 1917 and another in 1922; Hayes in 1951 and Ekulu in 1960 - attracted many miners and traders to the city and helped its population to increase.

Although the coal industry provided the initial impetus for the growth of Enugu, events of the following decades show that it was more than a mining town. For instance, in 1929 the administrative headquarters of Southern Protectorate in Calabar was transfered to Enugu and in 1939, it became the headquarters of the former Eastern Provinces of Nigeria. The introduction of regionalization in Nigeria during the fifties resulted in Enugu becoming the capital of former Eastern Region of Nigeria. After the creation of

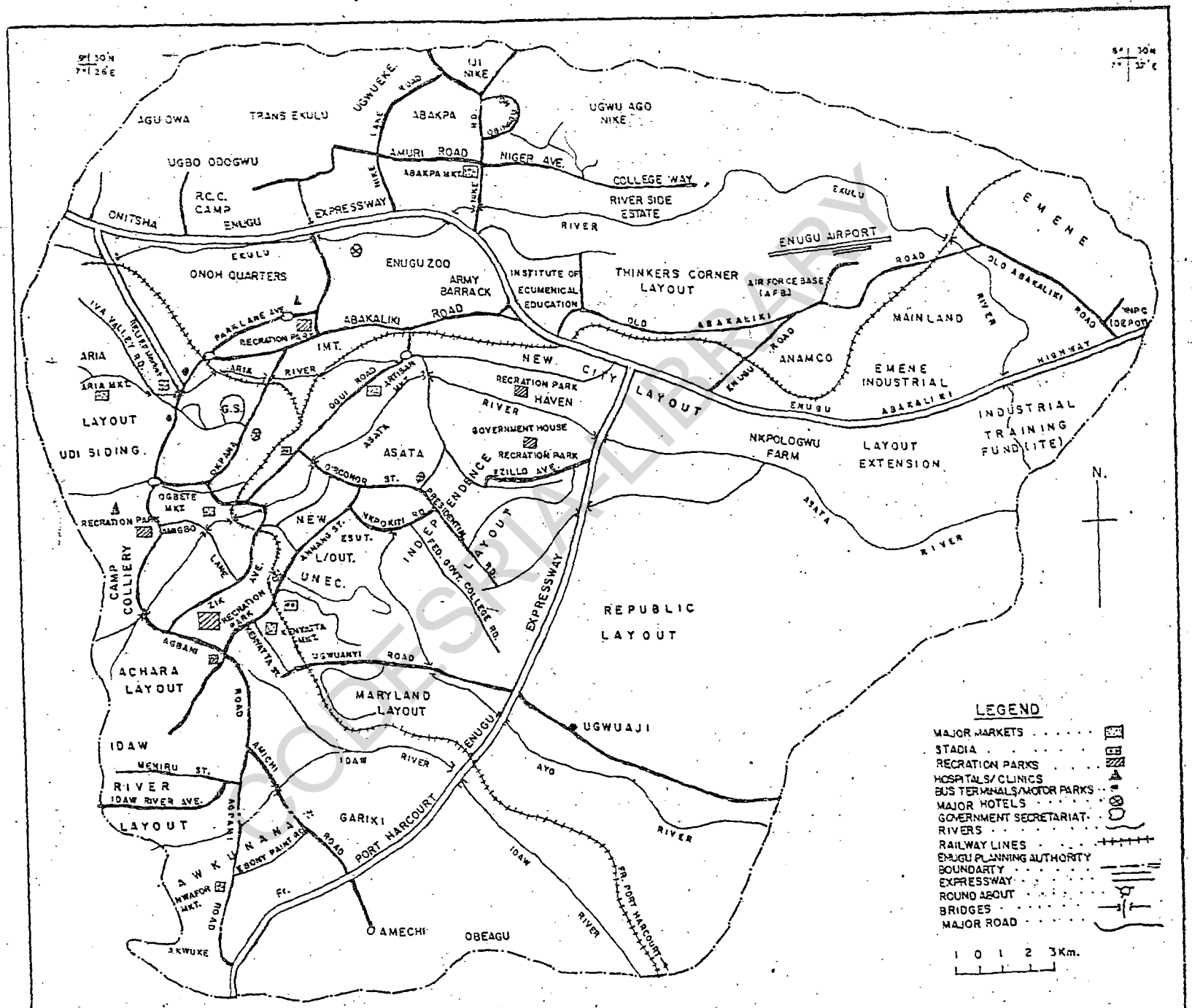


FIG 3: ENUGU: SHOWING ROAD LINKAGES TO VARIOUS LAND USES

of twelve states out of the former regions in 1967, Enugu became the capital of former East Central State, a position it functionally assumed at the end of the civil war. It also became the capital of old Anambra State after the creation of 19 States on 3rd February, 1976. The old Anambra State was split into two states - the present Anambra and Enugu States were created in 1991 - and Enugu became the capital of Enugu State. Thus, Enugu since the past sixty years had been an administrative headquarters. Now, the city plays the tripple role of being the capital of Enugu State, the headquarters of Enugu North and South Local Government Areas.

Enugu being one of the major metropolitan centres in Nigeria, has experienced rapid population growth over the years. During the past decades, the spectacular growth of population of Enugu has placed tremendous burden on transportation in a short period of time. In 1909, the city's population was less than 100 inhabitants. The city's population grew to 63,212 in 1953 and 138,475 in 1963. Udo (1978) estimated population of Enugu to be 169,340. The results of 1991 census show that Enugu has a population of 465,072. The implication of the present population of Enugu which is little less than half million inhabitants, is the high demand for public passenger

transport services, especially by mass transit bus that can adequately link and serve major parts of Enugu.

The growth and development of Enugu over the years have been reflected in the internal socio-economic and physical structures of the town. The physical structure of the city is reflected in differential landuse types, such as those devoted to industrial, commercial, educational, recreational, residential and transportational uses. Enugu is served with road types connecting various landuses in it (Fig. 3). Thus efficient interactions between those various landuses in the city depend on efficient intra-urban transportation for all activities, taking place in them essentially for those involving the movement of persons in a criss-cross manner.

CHAPTER TWO

INTRA-URBAN BUS TRANSPORT SERVICES IN ENUGU

2.1 The growth and development of mass transit bus system in Enugu

Intra-urban mass transit bus services have been improving along with the development of Enugu during the last four decades. In 1960s, the public passenger transport services were dominated by private cars and taxis with few mass transit bus services, for instance, Udoye Bus Service of Enugu (Mba, 1992). Also in the 1970's, about 90% of urban passenger modes were by private cars and taxis in Enugu (Okpala, 1977). Between 1980's and now, the intra-urban mass transit bus services have improved slightly. Government agencies, corporate bodies and private individuals, have been involved in the provision of buses of different capacities for intra-urban mass transit bus services in Enugu. The East Central State Government in the 1970s introduced the Oriental Bus Line and later, the Coal City Bus Services (Ume, 1977). The Transport Company of Anambra State Limited (TRACAS) in September 1989, approved fifteen bus routes to the city's major residential-to-work transportation problems (see Table 2 and Fig. 4).

Out of the fifteen bus routes, 6 of them (i.e. routes No. 10 - 15) were proposed ones, while the other nine routes (routes No. 1 - 9) were operating routes by TRACAS using

TABLE 2: Approved intra-city bus routes in Enugu by the Transport Company of Anambra State (TRACAS)

Route No.	Route Description
1	Emene - Ogui Road - Old Park - Relief Market.
2.	Abakpa - Okpara Avenue - Old Park - Relief Market
3	Abakpa - Garden Avenue - Colliery Avenue - Relief Market.
4	New Haven - Ogui Road - Old Park - Relief Market.
5	Abakpa - Ogui Road - Old Park - Relief Market.
6	Gariki - Zik Avenue - Okpara Avenue - Colliery Avenue - Relief Market.
7	Gariki - New Layout - Independence Layout - Abakiliki Road - Colliery Avenue - Relief Market.
8	Emene - Abakiliki Road - Okpara Avenue - Old Park - Relief Market.
9	Gariki - Coal Camp - Prison - Aria Road - Relief Market.
10	Ogui Junction - Abakpa Junction - TRACAS Express - Eke Obinagu.
11	Abakpa - Ogui Road - O'Conor Street - Obiagu Road.
12	Abakpa - Nike Hotel - Housing Estate - Ekulu Express - Relief Market.
13	Mary Land - Timber Shed - Kenyatta Market - Zik Avenue - Amigbo Lane - Akwata - UNTH - Relief Mkt.
14	UNEC Gate - Kenyatta - Edozien - Akwata - UNTH - Relief Market.
15	Abakpa - Fire Service - Independence Avenue - Rangers Avenue - A.T.V. - ESUT - Obiagu Road - Ogui Road - Okpara Avenue - Abakpa.

SOURCE: Transport Company of Anambra State, Planning Office Enugu, 1989.

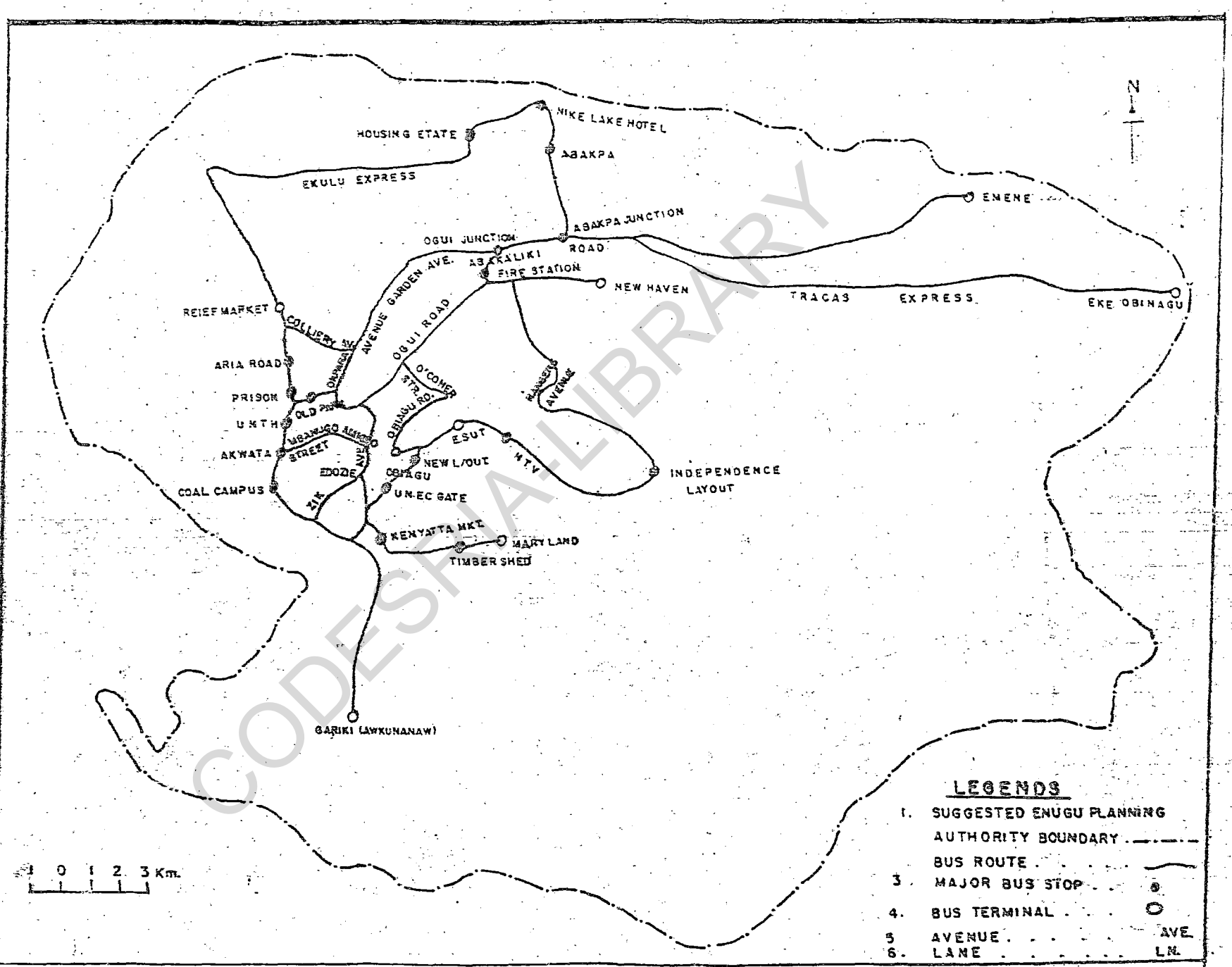


FIG. 4 APPROVED INTRA CITY BUS ROUTES IN ENUGU BY TRACAS 1989

only six MB 0365 buses up till 1991 when the company stopped intra-urban bus services in Enugu. Other private mass transit bus operators were also plying the same routes along with TRACAS buses.

After the spliting of Transport Company of Anambra State Limited (TRACAS) into Enugu State Transport Company Ltd. (ENTRACO) and Transport Company of Anambra State Limited (TRACAS) due to the creation of new States in 1991, ENTRACO in 1994, approved only four routes out of the nine functional routes formerly approved by the old Transport Company of Anambra State (TRACAS) (see Table 3 and fig. 5) to alleviate mostly civil servants' intra-urban transportation problems in the city. The approved bus routes by ENTRACO were functional only at two periods in a day - between 6.00 a.m. and 9.30 a.m. and between 3.30 p.m. and 5.00 p.m. Outside these two periods in a day, ENTRACO withdrew its buses from intra-urban transport services and deployed them to inter-city routes. By the tail end of 1995, ENTRACO stopped operating intra-urban bus services in Enugu in any form.

2.2 Bus route linkages in Enugu

During the field work, 19 functional intra-urban bus routes were identified as shown in Table 4. These intra-urban bus routes link various land uses in Enugu. The intra-urban bus route network covers the major arteries on

TABLE 3: Approved intra-city bus routes in Enugu by the Enugu State Transport Company (ENTRACO)

Route No.	Route Description
1	Gariki - Amechi Junction - Mayor - Amokwe - Amawbia - Esso - Osondu - Edozie - Edinburgh - P & T Quarters - Health - Relief Market.
2	Emene (Oye Emene) - Thinkers Corner - Abakpa Junction - Army Gate - Ogui Junction - School Board - IMT/Polo Subway - Secretariate - Relief Market.
3	Nike Road - Abakpa - Mami Market - Abakpa Junction - Army Gate - Ogui Junction - School Board - IMT/Polo - Subway - Secretariat - Relief Market.
4	Gariki - Esso - Coal Camp - Akwata - C.P.S./ UNTH - Aria Road - Agric - Relief Market.

SOURCE: ENTRACO Planning Office Enugu, 1994

Enugu city road network. The major arteries are trunk A and trunk B roads while very few trunk C and street roads are covered by bus route network. The total length of intra-urban bus route network in the city of Enugu is approximately 218.7 kilometres. This length of urban bus

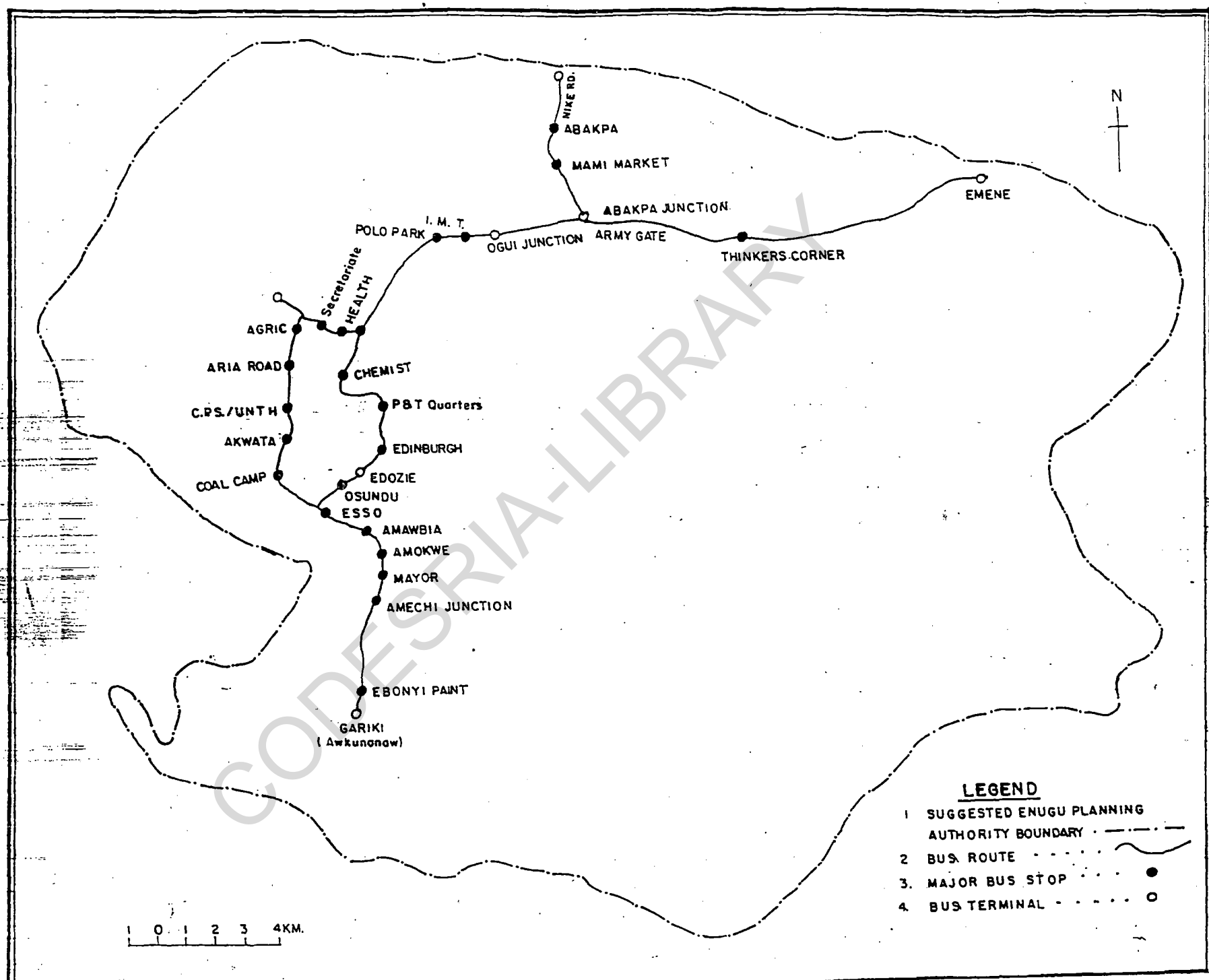


FIG. 5 APPROVED INTRA CITY BUS ROUTED IN ENUGU BY ENTRACO 1994

TABLE 4: General description of intra-urban bus routes in Enugu

Route No.	Route Description	Approximate Length (in Km)
1	Abakpa Nike - Abakpa Junction - Ogui Junction - IMT/Polo Park - Subway - Old Park - Kingsway Road - Relief Market	12
2	Abakpa Nike - Federal Housing - Trans Ekulu Bridge - IMT/Polo Park - Subway-Old Park	9.5
3	Abakpa Nike - Abakpa Junction - City Layout - New Haven - Ogui Road - O'Conor Street - Obiagu.	15.1
4	Abakpa Nike - Abakpa Junction - Ogui Junction - Ogui Road - O'Conor Street - Obiagu.	11.1
5	Abakpa Nike - Federal Housing - Trans Ekulu Express - Relief Market.	11.1
6	Abakpa Market - Ugbo Paul - Ugboezeji	2.4
7	Oye Emene - Thinkers Corner - Abakpa Junction - Ogui Junction - IMT/Polo Park - Subway - Old Park - Kingsway Road - Relief Market.	17
8	Oye Emene - Thinkers Corner - Abakpa Junction - Mami Market - Trans Ekulu Express - Relief Market.	18
9	Eke Obinagu - Oye Emene - Thinkers Corner - Abakpa Junction - Ogui Junction - IMT/Polo Park - Subway - Old Park - Kingsway Road - Relief Market.	20
10	Eke Obinagu - TRACAS Express - City Layout - Abakpa Junction - Ogui Junction - IMT/Polo Park - Subway - Old Park - Kingsway Road - Relief Market.	17.5
11	New Haven - Ogui Road - Main Market Road Park - Kingsway Road - Relief Market.	11.1

12	Obiagu - O'Conor Street - Ogui Road - Main Market - Old Park - Kingsway Road - Relief Market.	8
13	Gariki - Achara Layout - Zik Avenue - Main Market - Okpara Avenue - Colliery Avenue - Relief Market.	13
14	Gariki - Achara Layout - Kenyetta - New Layout - Independence Layout - Ogui Junction - IMT/Polo Park - Subway - Colliery Avenue - Relief Market.	21
15	Gariki - Achara Layout - Camp Colliery - Akwata - CPS/UNTH - Prison - Kingsway Road - Relief Market.	10.5
16	Amechi Junction - Express Round About - Eke Otu Amechi.	3
17	Relief Market - Iva Velley	2.5
18	Relief Market - Express Round About - RCC Camp - Ugbo Odogwu	5
19	Relief Market - Secretariate - Okpara Avenue - Main Market - Zik Avenue - Edozie Street - Kenyatta Market - Maryland - Ugwuaji.	11

SOURCE: Fieldwork, 1995

route is relatively inadequate when compared with the population of 465,072 inhabitants distributed in an area of about 182 square kilometres it is supposed to serve. There are more bus route linkages in the inner city areas than in the peripheries as can be seen in Fig. 6. This is because of the concentration of economic activities, schools, churches, and hospitals interspersed with residential areas within the city centre.

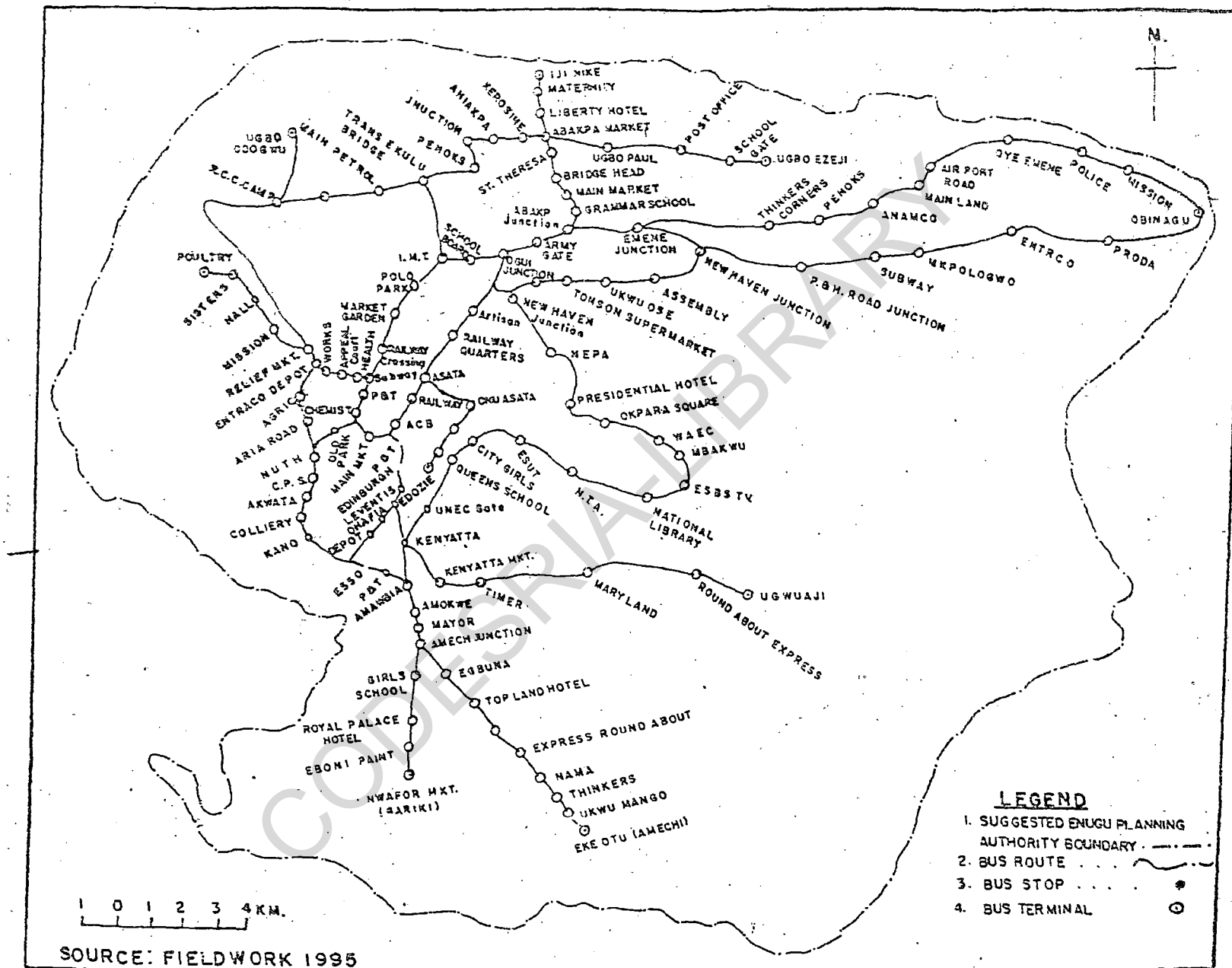


Fig. 6: LOCATION OF BUS STOPS IN THE CITY OF ENUGU

2.3 Bus stop location and facilities in Enugu

Bus stop is simply defined as the fixed stopping place for buses for boarding and alighting of passengers. Bus stops are also considered as the sum total of facilities and their locations where road-haul traffic is originated, terminated and/or interchanged before, during or after the road-haul movement, including the servicing of facilities for the vehicles and equipment in which the traffic is moved. Such a grouping of facilities does, usually occur at the end of a route but it also occurs frequently at one or more intermediate points along the route.

However, in the city of Enugu, the bus stops are located at major traffic generators such as schools, hospitals, employment, recreational and residential centres along bus routes in different parts of the city as shown in Fig. 6. The bus stops have little to offer in terms of facilities such as bus stop sheds and mechanics for servicing the vehicles at the bus stops. Only few bus stops have sheds (plate 1). The bus stops that have bus stop sheds include School Board, IMT/Polo Park, Subway, Okpara Avenue Round About, Ogui Junction, Iji Nike, WAEC, Army Main gate, Abakpa Junction, ESUT, Works, Agric, Amawbia, Aria road, New Market and Edozie bus stops. Most of the bus stop sheds are dilapidated (Plate 2) and water-logged during the rainy season.

PLATE 1: Subway bus stop along Okpara Avenue with bus stop shed.

PLATE 2: Dilapidated Bus Stop Shed.

2.3.1 Bus stop spacing

Bus stop spacing is defined as the distance between two consecutive bus stops. Bus stop spacing varies significantly from city to city. For example, in Washington D.C. it is 268.2 metres, in Los Angeles and California, it is 402 metres and in Richmond, Virginia, it is 134 metres (Demetsky and Lin, 1982). In the city of Enugu, the bus stop spacing varies from one part of the city to another as shown in Table 5. The average bus stop spacing in Enugu was found to be approximately 336 metres.

In parts of Ogui Junction, IMT/Polo Park, Relief Market and Old Park (Ogbete), the average bus stop spacing is less than 200 metres. In parts of Thinkers Corner/Emene Industrial Layout, Obinagu, Mkpologwu/E.I.L.E., Trans Ekulu, R.C.C. Camp/Ugbo-Odogwu, New Layout, Kenyetta, Maryland, Amechi and Ugwuaji, it is above 400 metres. Other major centres in the city have average bus stop spacings ranging from 205 metres to 375 metres.

Closely spaced bus stops provide short walking distance to bus transit, but they tend to increase the jerkiness of the bus ride and bus travel times along bus routes. The bus stops are closely spaced in the inner city areas, for example, Old Park (175 metres) and widely spaced in the major centres at the city peripheries, for example, Amechi (550 metres).

TABLE 5: Bus Stop Spacing in Enugu

Node Number	Name of Major Centre	Average Bus stop spacing (in Metre)	Type of Major Centres
1	Abakpa Nike	250	Residential and Market
2	Abakpa Junction	375	Employment and Educational
3	Thinkers Corner/ E.I.L.	405	Educational and Employment
4	Emene	355	Residential and Market
5	Obinagu	440	Residential, Market and Employment
6	Mkpologwu/E.I.L.E.	520	Employment and Educational
7	City Layout	208	Residential
8	New Haven	205	Residential
9	Ogui Junction	185	Employment and Residential
10	IMT/Polo Park	175	Educational, Residential and Recreational
11	Trans Ekulu	420	Residential
12	R.C.C. Camp/Ugbo Odogwu	440	Residential
13	Government Secretariat	250	Employment
14	Relief Market	195	Market and Employment
15	Iva Valley	350	Residential and Employment
16	Railway Quarters/ Artisan Market	334	Residential and Market
17	Asata	250	Residential and Recreational
18	Old Park (Ogbete)	175	Market, Residential and Employment
19	Onu Asata	250	Residential
20	Obiagu	355	Residential

Node Number	Name of Major Centre	Average Bus stop spacing (in Metre)	Type of Major Centres
21	New Layout	425	Residential and Educational
22	Uwani	300	Residential and Employment
23	Kenyatta	450	Residential and Market
24	Achara Layout	345	Residential and Employment
25	Camp Colliery	260	Residential and Employment
26	Independence Layout	305	Educational, Employment and Residential
27	Amechi Junction	275	Residential and Educational
28	Gariki (Awkunanaw)	365	Residential and Market
29	Maryland	460	Residential
30	Amechi	550	Residential
31	Ugwuaji	540	Residential

SOURCE: Fieldwork, 1995

2.4 Provision of mass transit bus services in Enugu

Bus services are the dominant mode of motorized transit in the intra-urban movement of persons in the city of Enugu. Bus services for the movement of passengers within the city are provided mainly by individual entrepreneurs and partly by few government agencies and companies or firms as shown in Table 6.

Individual entrepreneur bus operators account for about 65% of the bus provision for intra-urban passenger transport services in the city of Enugu. Private bus companies or firms contribute about 35% in the provision of buses for intra-urban movement of persons in the city. They operate mainly big and medium sized buses (see table 6). These companies or firms own a fleet of 2 - 7 buses each.

Few publicly owned and operated bus services (Government owned mass transit bus) do not, in recent times, provide permanent bus services for intra-urban passenger transportation in Enugu. They occasionally deploy few of their buses to different intra-urban bus routes in the city when they do not have enough passengers for inter-city transport services. The major periods these services are offered are between 6.30 a.m and 9.30 a.m. and between 3.30 p.m. and 7.30 p.m. The Enugu State Transport Company (ENTRACO) was deploying some of its buses to few routes in the city during the peak periods

TABLE 6: Major Operators of Intra-Urban Bus Services in Enugu

	Name of Operator	Type of Vehicle	Number of Vehicle in Circulation	Capacity of each Vehicle
1	Small Joe Enterprises	Mercedes Benz Luxurious single-Deck Bus 608D	5	100
2	C to C and Sons Ltd.	Mercedes Benz-Luxurious single deck bus 608D	4	100
3	Chi-Oma Bus Transport Service	(a) Mercedes Benze Luxurious single-deck Bus 608D	2	100
		(b) Mercedes 508D and MB0365 buses	2	45
4	Silk Investment Transport Service	(a) Austine Luxurious Single deck bus	2	80
		(b) Mercedes Benze 508D	3	45
5	Ije Oma Bus Transport Service	(a) Mercedes Benz 911, Locally Constructed body	1	110
		(b) Mercedes Benze 508D Bus	3	45
6	Chukwudi Ndu Transport Service	(a) Fiat Luxurious Single deck Bus	2	100
		(b) Mercedes Benze 508D	3	45
7	Chinaelo Motors	(a) Austin Luxurious single-deck bus	2	100
		(b) Mercedes Benze 508D	2	45

	Name of Operator	Type of Vehicle	Number of vehicle in Circulation	Capacity of each vehicle
8	Small Small Bus Service	Mercedes Luxurious single-deck 608 bus	4	100
9	Ezigbo & Sons Bus Transport Division	(a) Mercedes Benz, Luxurious single-deck 608D bus (b) Mercedes Benz 508D	5 2	100 45
10	Skyline Express	Austin Lucurious Bus and Mercedes Benz 608D	6	100
11	O.M.E. Transport	Mercedes Benz Luxurious Single-deck 608D bus	5	120
12	Eastern Mass Transit	(a) Peugeot J5 (b) Mercedes Benz 508D	2 5	18 45
13	Abakpa Nike Community Bank Mass Transit	Toyota Hiace	2	18
14	Enugu North Local Government Mass Transit	Mercedes Benz 508D	6	45
15	Ezeagu Local Government Mass Transit	Nissan Urvan E20	2	18
16	Nsukka Local Government Mass Transit	Mitsubishi L300	1	14

	Name of Operator	Type of Vehicle	Number of Vehicle in Circulation	Capacity of Each Vehicle
17	Onitsha South Local Government Mass Transit	Mercedes Benz L207D	4	45
18	Individual Entrepreneur Operators	Operators in this group own one or two buses each. Most of them drive their buses by themselves. They own 14 - 18, or 20 seater mini and medium-sized buses consisting of Volkswagen Kombi, Datsun E20, Daihatsu, Toyota Hiace, Mitsubishi L300, Toyota Commuter, Toyota Coaster and Toyata Civilian buses.		

SOURCE: Fieldwork, 1995

only when there was fuel scarcity so as to alleviate the intra-urban transport problems of civil servants but this was stopped in 1993.

2.5 Capacity of Urban Buses

The capacities of urban buses in Enugu are in three categories - Minibuses with capacities of 14 - 18 passengers; medium buses with capacities of 36 - 45 passengers and big buses with capacities of 80-120 passengers as shown in Table 6. Standing/sitting ratios of 3:1 are not uncommon in both medium and big buses in Enugu during the peak periods, when the passengers can squeeze in and hang onto them.

Minibuses include Nissan buses, Peugeot J5, Toyota Hiace and Mitsubishi buses (plate 3). They are the most ubiquitious of all passenger carriers in Enugu. Medium-sized buses (plate 4) include Mercedes Benz 508D and 207D buses. Big buses (plate 5) comprise of Mercedes Benze single-deck Luxurious 608D buses, Mercedes Benz 911 with the body locally constructed in form of Luxurious buses, Fiat and Astin Luxurious buses.

2.6 Bus fare systems

During the research, with the use of questionnaire (Appendix A) and personal experiences, we found out that the governmment of Enugu State approved a flat fare of ₦5.00 per trip for all buses operating in the capital city of Enugu since 1994. But in practice, more than one bus fare are charged by different bus operators in Enugu. The flat fare of ₦5.00 per trip is charged by all the government owned mass transit bus and private mass transit bus operators, operating big buses. It was also found out that they were charging ₦10.00 per trip when the prices of petrol and gas were increased. The second bus fare system is distance-based fare (i.e. fare increasing arbitrarily with increase in distance of the bus commuters' journeys). This system is practised by min-bus operators. They charge between ₦5.00 and ₦10.00 per trip

PLATE 3: Minibuses with the capacity of 14 passengers each.

PLATE 4: Medium--sized 508D Mercedes Benz buses with the capacity of 45 passengers each, 21 sitting and 24 or more standing.

PLATE 5: An example of big buses used for intra-urban passenger transport services in the city of Enugu with a capacity of 80 - 100 passengers.

depending on distance of the trip when the petrol price is normal and between ₦10.00 and ₦20.00 when the petrol price has increased.

This increase in the normal bus fare from ₦5.00 to ₦10.00 per trip is mostly practised during the peak traffic flow hours of between 6.30 a.m. and 9.30 a.m. and between 3.30 p.m. and 7.30 p.m. Whenever the minibus operators are compelled by different government agencies to charge the normal fare of ₦5.00 per trip, they resort to reducing the length of bus routes thereby forcing many bus users to change buses during their journeys and pay more than one bus fare. The non-conformity of many minibus operators to charge the normal fare of ₦5.00 per trip, has significantly reduced the personal accessibility of the bus users to the services of mass transit bus in many parts of Enugu especially at the city peripheries. This situation has forced many people to walk up to 3 km or more to go to work or to where they can board a bus to reduce paying more.

CHAPTER THREE

QUALITY OF BUS SERVICES INDICATORS (INDICES)

3.1 Introduction:

Despite the vital role that buses are able to play in any urban area, their services are frequently insufficient to meet demand and the services that are provided suffer from low output. To determine the quality of any public transport service, for example bus service, the concept of level-of-service (L.O.S) has to be employed and the components of the concept investigated and evaluated. The concept of level-of-service otherwise referred to as service standard (Ume 1991), quality of service indicator (World Bank, 1987) is not exhaustively defined because different people and different urban areas may lay emphasis on various components of the concept as explained in section 1.4.3.

In this research, we examined three of the components of the level-of-service of bus transport services in the city of Enugu. The variables (components) considered include (a) passenger waiting time for bus at bus stops, (b) passenger walking distance or time to the nearest bus stop at the origin and destinations and (c) frequency of bus services to each of the major centres. We decided to consider these three variables of the level-of-service of bus passenger transport in Enugu because they affect the personal accessibility to bus services and they are the most generally

accepted quality of bus service indicators of any public carrier. The three variables were examined in all the 31 sample major centres in Enugu in order to determine the spatial variations of mass transit bus services in the city.

3.2 Waiting time for bus:

An important characteristic of a public transport service is the time a passenger has to wait before getting on a vehicle. For the purpose of this research, waiting time for bus is defined as the time a passenger spent at the bus stop between the passenger's arrival at a bus stop with the intention of catching a bus and the time the bus he eventually boarded departs from the bus stop. Variations in passenger waiting time for buses at the bus stops are brought about by operational changes of bus services. Bus users find long waiting time at bus stops for the arrival of buses exceptionally very irritating and therefore, most likely to cause them to withdraw their patronage (Coe and Jackson, 1977) and to find alternative if any or suffer that permanently. The average passenger waiting time the world over as devised by World Bank, ranges from 5 - 10 minutes indicating high quality of bus services and the maximum time passengers are expected to wait for the arrival of buses at bus stops, ranges from 10 - 20 minutes indicating moderate quality of bus services. When the passenger waiting time is above

20 minutes, it indicates poor quality of bus services as passengers have to wait for a long time before getting a bus to board and travel (World Bank, 1987). This method, devised by the World Bank in measuring the quality of bus services in the cities, based on passenger waiting time, will be adopted in this research.

The passenger waiting time for bus is greatly affected by a number of factors. One of the factors is the bus service frequency. It is expressed as the number of bus arrivals per unit time (hour). The higher the bus service frequency, the shorter the waiting time of passengers and vice versa. Another factor is the capacity of buses. It is defined as the number of passengers a bus can carry at a time. It takes longer time for the big buses to load and off-load passengers than the minibuses because of the differences in their capacities, and this, will in turn, affect the passengers' waiting time. The number of potential bus users demanding for bus services in an area influences waiting time for bus. When the demand for bus services is greater than the supply in an area, the length of waiting time tends to be long. Again, if the supply of bus services is higher than the demand for it, then, the loading time of bus will increase and consequently, it will increase the length of waiting time of passengers. One other factor that affects the waiting time for bus, is the location of a place in relation to the bus

network of bus services. Areas that are highly accessible to the bus network, tend to experience high bus service frequency which will facilitate the boarding of the buses easily by the bus commuters. The reverse will be the case if the areas are poorly linked by bus routes. The passengers that use intermediate bus stops, along bus routes, for catching a bus, usually spend more time before boarding it than those using the bus terminals. This is as a result of the fact that most of the buses will be fully loaded with passengers before reaching the intermediate bus stops. Other factors include volume of traffic and the nature of bus routes.

The primary source of information and data about the passenger waiting time for bus at bus stops in the city was from the questionnaire (Appendix A) which was administered to passengers (bus users) in the 31 sample major centres in the study area. The questionnaire was administered to bus users found in different bus stops within each of the sample major centres. At least 30 bus users from each of the sample centres were administered with the questionnaire. One of the problems encountered during the collection of data was that most passengers were in a hurry and were not ready to answer any question.

The data collected about passenger waiting time for buses at the bus stops were analysed by using the arithmetic

mean method to find the mean of passenger waiting time for bus in each of the 31 major centres. The mean is a value which is a typical representative of a set of data. Since such a typical value tends to lie centrally with a set of data, it is a measure of central tendency.

Table 7 shows the mean passenger waiting time for bus in each of the major centres in the city of Enugu. Fig. 7 shows lines of equal mean passenger waiting time in Enugu. It is interesting to observe that 10 - minute line of equal mean passenger waiting time, encloses an area with the lowest mean passenger waiting time for bus in the city, indicating high quality of bus services in the area. The area comprises these major centres: Old Park (9.84 minutes), City Layout (9.91 minutes), New Haven (10.6 minutes), Government Secretariat (10.15 minutes), Abakpa Junction (10.85 minutes) and Ogui Junction (10.69 minutes). These major centres enjoy shortest passenger waiting time in the study area because they are located within the city centre area and as a result, they experience high frequency of buses - big, medium and minibuses.

Other major centres comprising IMT/Polo Park, Relief Market, Abakpa Nike, Emene, Railway Quarters/Artisan Market, Asata, Onu Asata, Obiagu, New Layout, Kenyatta, Achara Layout, Camp Colliery, Independence Layout, Amechi Junction and

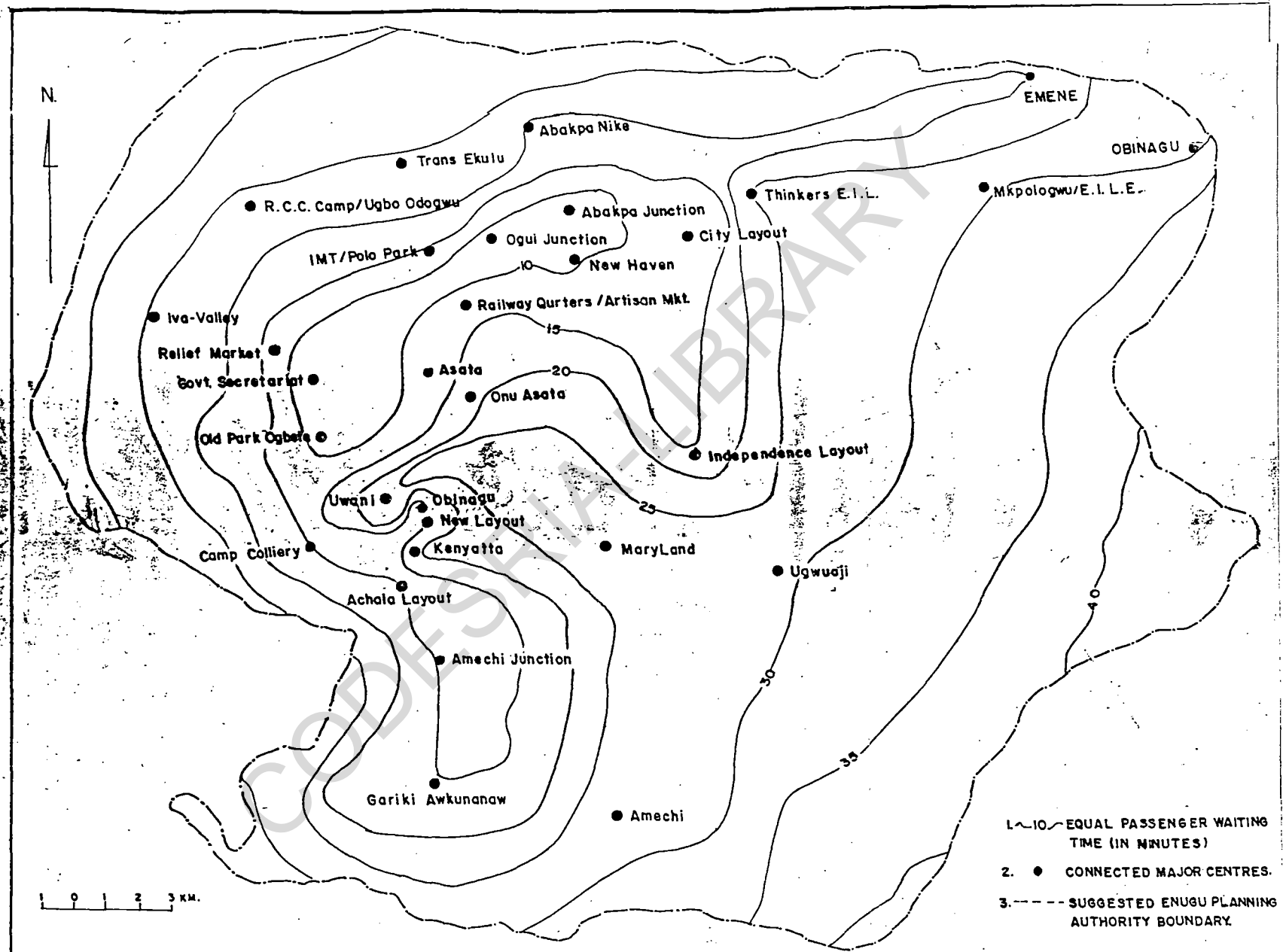
TABLE 7: The mean passenger waiting time for bus in major centres in Enugu

Node Number	Name of Major Centre	Mean Passenger Waiting Time (in Minutes)
1.	Abakpa Nike	15.53
2.	Abakpa Junction	10.85
3.	Thinkers Corner	21.44
4.	Emene	16.49
5.	Obinagu	29.12
6.	Mkpologwu/E.I.L.E.	26.63
7.	City Layout	9.91
8.	New Haven	10.60
9.	Ogui Junction	10.69
10.	IMT/Polo-Park	12.30
11.	Trans Ekulu	20.74
12.	R.C.C. Camp/Ugbo-Odogwu	25.50
13.	Government Secretariat	10.15
14.	Relief Market	12.53
15.	Iva Valley	21.28
16.	Railway Quarter/Artisan Market	12.87
17.	Asata	12.06
18.	Old Park (Ogbete)	9.84
19.	Onu Asata	15.67
20.	Obiagu	13.50

Node Number	Names of Major Centre	Mean Passenger Waiting Time (in Minutes)
21.	New Layout	12.05
22.	Uwani	22.58
23.	Kenyatta	19.60
24.	Achara Layout	12.80
25.	Camp Colliery	15.39
26.	Independence Layout	14.50
27.	Amechi Junction	13.39
28.	Gariki (Awkunanaw)	14.03
29.	Maryland	30.16
30.	Amechi	26.30
31.	Ugwuaji	30.31

SOURCE: Fieldwork, 1995

Gariki Awkunanaw, enjoy mean passenger waiting times, ranging from 11 to 20 minutes and they are located in the area that lies between 10 - minute line and 20 - minute line of equal mean passenger waiting time for bus. This indicates moderate bus services in the major centres. All the major centres, located from 20 - minute line of equal mean passenger waiting time towards the peripheries of the study area, suffer long waiting time for bus. This long waiting time increases as one moves towards the peripheries. Major centres



SOURCE: FIELDWORK, 1995

Fig. 7: ENUGU SHOWING AREAS OF EQUAL PASSENGER WAITING TIME.

involve in this group include Ugwuaji (30.31 minutes), Maryland (30.16 minutes), Obinagu (28.3 minutes), Mkpologwu/ E.I.L.E. (26.63 minutes), Amechi (26.30 minutes), Uwani (22.58 minutes), Thinkers Corner (21.44 minutes), R.C.C. Camp/Ugbo-Odogwu (25.5 minutes) and Iva Valley (21.88 minutes). Factors contributing significantly to the long waiting times for bus in these centres, as was observed during the fieldwork, include low bus service frequency, low connectivity of bus routes, low capacity of buses serving some of the centres and majority of them are located at the peripheries of the study area, and as a result, only few bus operators are prepared to carry passengers to such centres.

3.3 Passenger walking distance:

Passenger walking distance from origin or destination to the nearest bus stop is one of the important elements that determine the quality of mass transit bus services in any given urban area. It is one of the determinants of bus commuter's travel time. Walking distance of a bus passenger can be defined as the distance a passenger walks before reaching the nearest bus stop to his point of origin

or destination to catch a bus for a ride. The extent by which bus passengers walk before reaching the nearest bus stops to them depends on the spacing between adjacent transit bus routes and the spacing between adjacent bus stops (Jende hus and Surti, 1976). If the total bus services in a place is spread, passenger walking distance will be short and if the bus services are concentrated in few routes, that means long walks by the bus passengers (Faulks, 1990). The World-wide average bus passenger walking distance ranges from 300-500 metres for dense urban areas and between 500 - 1000 metres for low dense urban areas (World Bank, 1987).

From the bus users' questionnaire (Appendix A) data for bus commuters walking distances to the bus stops nearest to them were collected by administering the questionnaire to bus users found at different bus stops within the 31 sampled major centres in Enugu. Using arithmetic mean method, the average passenger walking distance was determined in each of the 31 sample major centres. The smaller the average, the shorter the walks and the bigger the average, longer the walks by the bus passengers.

The results of the analysis of the bus passengers' average walking distances in all the major centres, are displayed in Table 8. Fig. 8 shows the spatial variations in mean passenger walking distance in the study area.

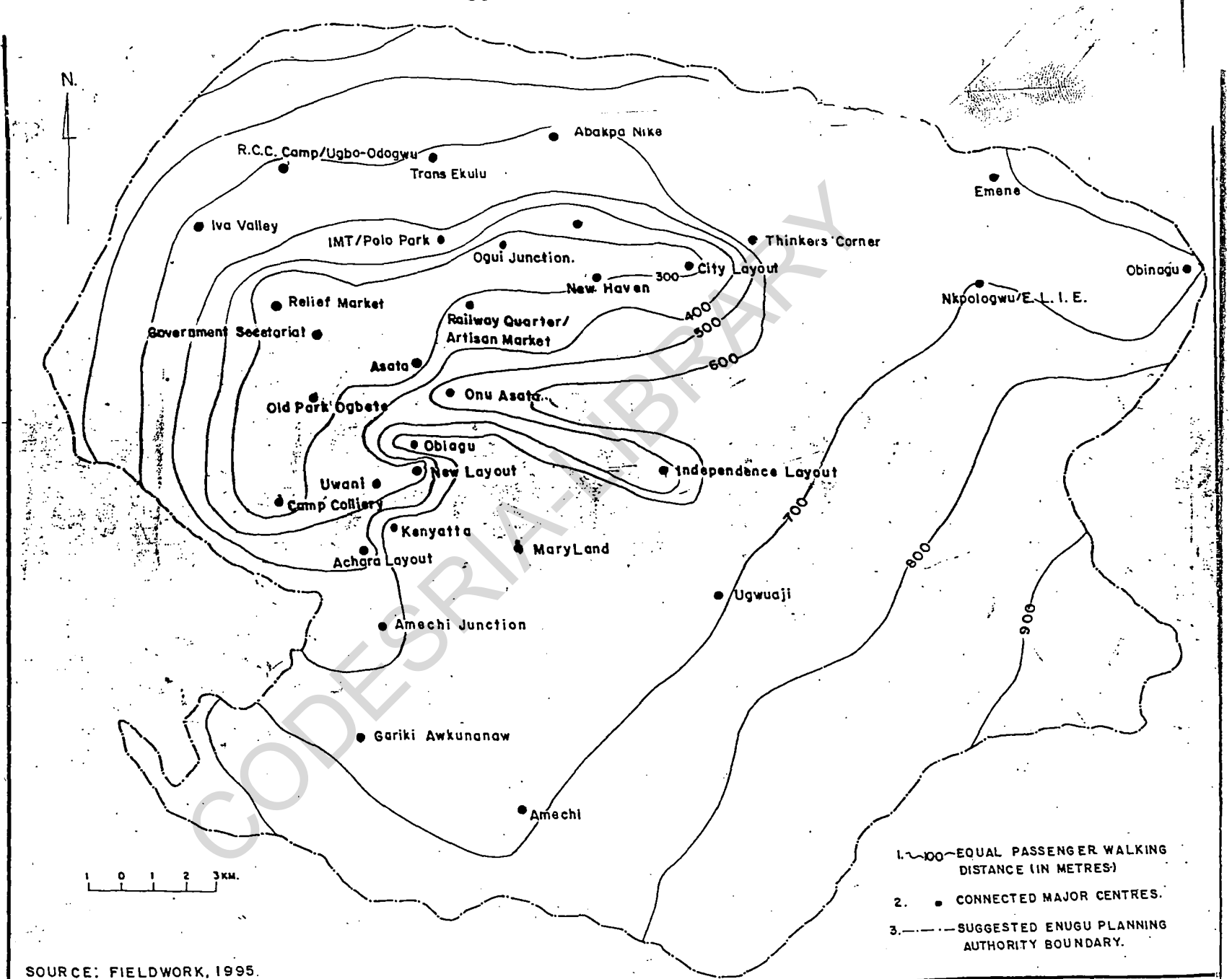
TABLE 8: Bus passenger mean walking distance in the major centres in Enugu

Node Number	Name of Major Centre	Mean walking Distance of Bus Passengers (in Metre)
1.	Abakpa Nike	501.27
2.	Abakpa Junction	343.74
3.	Thinkers Corner	606.20
4.	Emene	605.20
5.	Obinagu	664.73
6.	Nkpologwu/E.I.L.E.	519
7.	City Layout	292.59
8.	New Haven	253
9.	Ogui Junction	271.24
10.	IMT/Polo Park	475.43
11.	Trans Ekulu	528.78
12.	R.C.C. Camp/Ugbo-Odogwu	591.21
13.	Government Secretariat	297.24
14.	Relief Market	281.8
15.	Iva Valley	563.75
16.	Railway Quarters/Artisan Market	311.4
17.	Asata	290.82
18.	Old Park (Ogbete)	300.64
19.	Onu Asata	669.75
20.	Obiagu	669.75

Node Number	Name of Major Centre	Mean Walking Distance of Bus Passengers (in Metre)
21.	New Layout	367.55
22.	Uwani	326.72
23.	Kenyatta	630.78
24.	Achara Layout	454.75
25.	Camp Colliery	296
26.	Independence Layout	436.68
27.	Amechi Junction	513.21
28.	Gariki (Awkunanaw)	661
29.	Mary Land	673.5
30.	Amechi	620.66
31.	Ugwuaji	600.4

SOURCE: Fieldwork, 1995

From Table 8 and Fig. 8, it is worthy to observe that major centres with the smallest mean passenger walking distances include New Haven (253 metres), Ogui Junction (271.8 metres), Relief Market (281.8 metres), Asata (290.82 metres), City Layout (292.59 metres), Camp Colliery (296 metres), Government Secretariat (297.24 metres) and Old Park (300.64 metres). This group of major centres is enclosed by 300 - metre line of equal mean passenger walking distance (Fig. 8).



SOURCE: FIELDWORK, 1995.

Fig. 8: ENUGU SHOWING AREAS OF EQUAL PASSENGERS WALKING DISTANCE

The potential bus users in the above named centres reach the bus stops nearest to them easily because of the short distances involved.

Between 300-metre line and 600-metre line of mean passenger walking distances, lie the major centres having fairly high passenger walking distance in the study area. These centres include Abakpa Nike, Iva Valley, Onu Asata, Amechi Junction, Mkpologwu/E.I.L.E., R.C.C. Camp/Ugbo-Odogwu and Trans Ekulu. It is also observed from Fig. 8 that the major centres experiencing the highest mean passenger walking distances in the study area include Maryland (673.5 metres), Obiagu (669.75 metres), Obinagu (664.73 metres), Gariki-Awkunanaw (661 metres), Kenyatta (630.7 metres), Amechi (620.66 metres), Thinkers Corner (606.20 metres) Emene (605.30 metres) and Ugwuaji (600.4 metres). They are found in the area lying between 600 - metre line and 700 - metre line of equal mean passenger walking distances. Most of the bus commuters in the area trek long distances before getting to the nearest bus stops to them to catch a bus. One significant factor responsible for this, as was observed during the fieldwork, is the lack of many bus routes traversing such centres as illustrated by Fig. 6.

3.4 Bus service frequency:

Another source of variation in the level of quality of bus services is the frequency of buses (Jones, 1984). The regularity of buses in a place for services enhances personal accessibility of bus passengers to the services of the buses and vice versa. Bus service frequency as it is used in this research, means the number of buses that arrive in the major centres with the intention of carrying passengers for intra-urban movements. The extent by which bus passengers wait at bus stops for the arrival of buses is significantly affected by the regularity or irregularity of buses at bus stops. The aim of determining the bus service frequencies in the major centres is to know the degree to which the number of buses available for services vary spatially in the study area and their relationships with the bus waiting time in the major centres.

The data on bus service frequencies were collected from all the 31 sample major centres as described in section 1.7.6 with the designed proforma (Appendix B). The number of buses that arrived in each of the major centres was recorded hourly. The buses counted were grouped into two - minibuses and big buses (for both medium and big buses). The two groups were counted differently. The total of each group of buses counted was first calculated and secondly, the

total of buses of the two groups put together was also calculated as displayed in Table 9. The percentages of minibuses and big buses of the total buses put together were calculated for each of the 31 sample major centres in the study area. Finally, the bus service frequency index of each of the 31 sample major centres was determined by calculating the mean of bus service frequencies of buses (both big and mini-buses put together) by dividing the total bus service frequencies by the total number of hours involved during the recording of bus frequency of service data. The total number of hours involved in this analysis is 12 hours (6.00 a.m. - 6.00 p.m.).

Table 9 gives the calculated mean bus service frequencies for 31 major centres in the study area. The mean bus service frequency (number of buses arrived per hour) calculated for each centre, varied from one centre to another as demonstrated in Fig. 9. From Fig. 9, it is interesting to note that the bus service frequency decreases from the centre towards the peripheries of the study area. The 100 - line of equal bus service frequency encircles the major centres with the highest mean bus service frequencies in Enugu, comprising Old Park (MBSF = 240.6), Relief Market (MBSF = 148.8), Ogui Junction (MBSF = 128.2), Abakpa Junction (MBSF = 114), Abakpa Nike (MBSF = 112.5), IMT/Polo Park (MBSF = 107.3), and Government

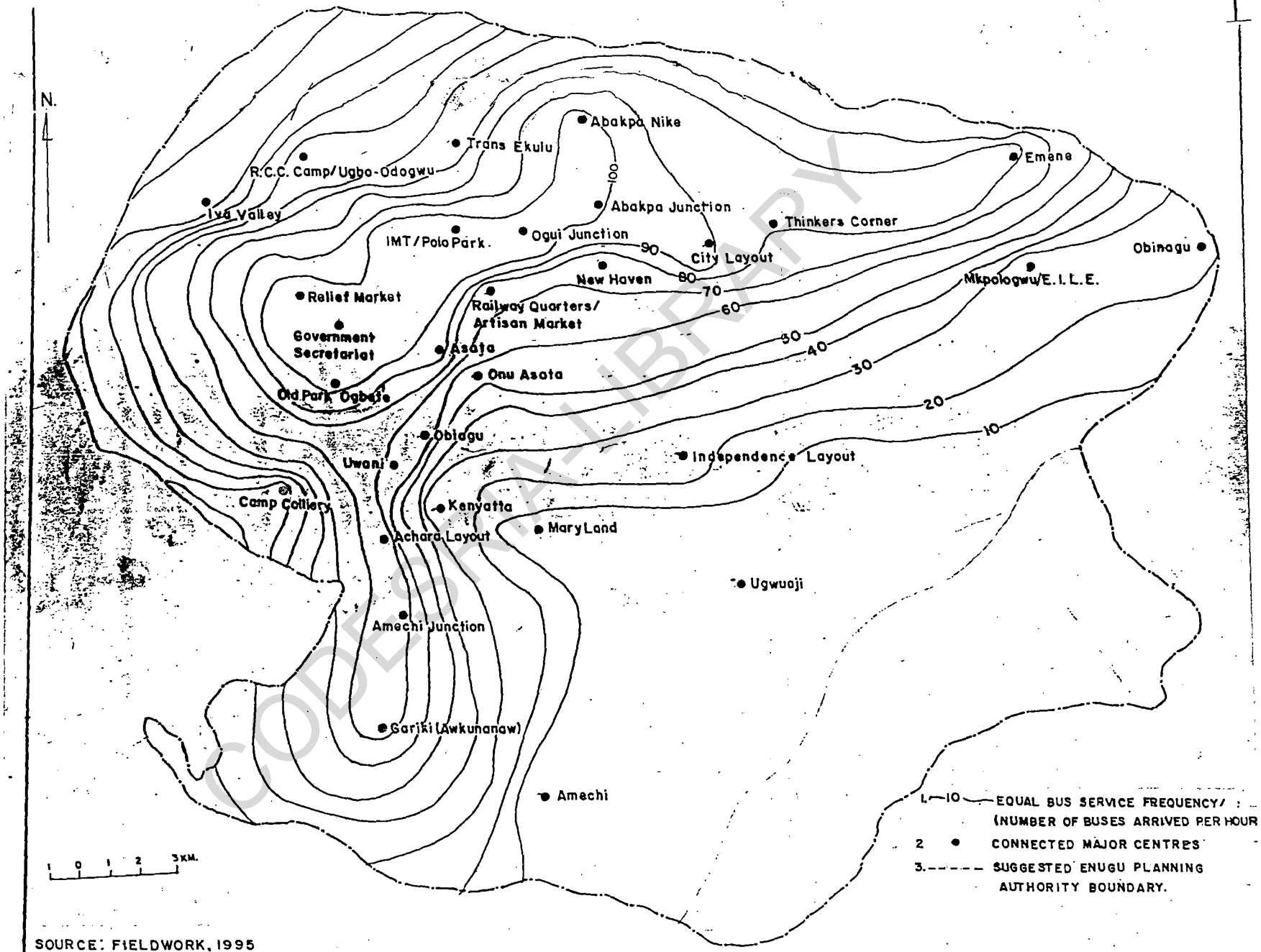
TABLE 9: CALCULATION OF MEAN BUS SERVICE FREQUENCIES (SERVICE FREQUENCY INDICES) IN MAJOR CENTRES IN ENUGU (FIELD WORK, 1995)

Node No.	Name of Major Centre	Type of Bus	6 - 7am	7.01 - 8am	8.01-9am	9.01-10am	10.01-11am	11.01-12 noon	12.01-1pm	1.01-2pm	2.01-3pm	3.01-4pm	4.01-5pm	5.01-6pm	Total by Bus type	Total of All Buses	MBSF (hr)	% of B.B.F.	% of M.B.F.
1.	Abakpa Nike	Big bus	8	9	6	4	3	1	-	2	2	7	6	10	68	1357	112.5	5	95
		Minibus	100	1500	140	110	90	86	87	64	68	92	142	154	1283				
2.	Abakpa Junction	Big bus	4	6	-	3	8	6	-	4	-	6	7	11	55	1368	114	4	96
		Minibus	80	145	122	114	94	86	78	93	102	116	137	146	1313				
3.	Thinkers Corner	Big bus	4	6	5	3	2	1	1	-	3	4	4	5	38	979	81.6	3.9	96.1
		Minibus	60	113	90	88	91	49	54	50	58	89	98	101	941				
4.	Emene	Big bus	4	5	4	3	5	2	1	3	4	3	6	7	46	1041	86.8	4.4	95.6
		Minibus	59	102	94	89	91	68	63	54	61	83	170	121	995				
5.	Obinagu	Big bus	3	2	3	1	2	1	-	2	1	-	3	2	20	297	24.8	7.2	92.8
		Minibus	25	29	27	26	21	18	19	20	14	24	28	26	277				
6.	Mkpologwu/ E.I.L.E.	Big bus	3	4	1	-	-	-	2	-	1	-	2	4	17	287	23.9	5.9	94.1
		Minibus	23	40	44	15	10	14	11	12	15	28	28	30	270				
7.	City Layout	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-	1100	91.6	0	100
		Mibibus	79	115	105	98	96	80	54	66	81	96	116	114	1100				
8.	New Haven	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-	936	78	0	100
		Minibus	80	121	92	66	58	48	51	43	47	87	111	132	936				
9.	Ogui Junction	Big bus	18	29	27	28	25	19	14	19	22	26	30	28	285	1538	128.2	18.5	81.5
		Minibus	79	121	119	120	101	95	80	68	88	111	130	141	1253				
10.	IMT/ Polo Park	Big bus	25	29	30	26	24	18	19	21	23	28	31	24	298	1287	107.3	23.2	76.8
		Minibus	64	94	101	74	79	77	66	65	67	90	101	111	989				
11.	Trans-Ekulu	Big bus	4	2	5	3	2	-	1	-	3	7	6	9	42	822	68.5	5.1	94.9
		Minibus	61	80	70	57	49	51	44	36	6	74	91	102	780				
12.	R.C.C. Camp/ Ugbo-Odogwu	Big bus	2	3	3	1	-	-	-	-	1	2	4	6	22	637	53.1	3.5	96.5
		Minibus	46	65	64	44	39	46	41	39	47	55	60	71	615				
13.	Government secretariat	Big bus	34	48	49	30	29	28	48	40	38	40	50	48	484	1236	103	39.2	60.8
		Minibus	40	79	68	60	57	52	40	47	64	70	78	88	752				
14.	Relief Market	Big bus	64	88	54	61	51	56	48	43	48	63	68	80	724	1785	148.8	40.6	59.4
		Minibus	66	108	96	88	72	68	58	71	92	88	113	141	1061				
15.	Iva Valley	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-	129	10.8	0	100
		Mibibus	9	16	14	15	12	8	7	4	5	8	13	18	129				
16.	Railway Quarters/ Artisan Market	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-	899	74.9	0	100
		Minibus	51	98	96	87	66	59	46	48	51	97	90	110	899				

17.	Asata	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-			
		Minibus	69	120	121	92	103	90	79	68	84	112	130	120	1190	1190	99.2	0	100
18.	Old park (Ogbete)	Big bus	54	80	96	88	98	101	65	73	92	94	98	83	1021				
		Minibus	90	150	180	154	148	140	134	118	161	179	201	203	1867	2888	240.6	35.4	64.6
19.	Onu Asata	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-				
		Minibus	62	65	57	59	46	51	44	39	41	52	66	78	660	660	55	0	100
20.	Obiagu	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-				
		Minibus	45	74	72	68	71	58	61	65	49	51	54	69	737	737	61.4	0	100
21.	New Layout	Big bus	19	25	28	24	25	18	20	21	17	22	27	23	269	269	22.4	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
22.	Uwani	Big bus	44	68	64	59	60	55	58	54	61	65	74	69	731	731	60.9	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
23.	Kenyatta	Big bus	19	28	35	24	20	18	10	15	18	27	23	19	247	247	20.6	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
24.	Achara Layout	Big bus	58	80	94	84	76	64	61	55	53	63	87	98	873	873	72.8	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
25.	Camp Colliery	Big bus	14	16	13	14	10	11	12	9	16	18	21	22	176	176	14.7	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
26.	Independence Layout	Big bus	22	30	28	26	79	20	12	16	24	26	24	21	268	268	22.3	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
27.	Amechi Junction	Big bus	44	72	86	78	71	58	55	51	61	64	78	89	807	835	69.6	96.6	3.4
		Minibus	3	4	3	2	-	1	-	2	1	3	4	5	28				
28.	Gariki (Awkunanaw)	Big bus	62	112	99	84	67	76	48	57	61	76	89	104	945	945	78.8	100	0
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-				
29.	Mary Land	Big bus	-	-	1	-	1	-	-	-	-	2	1	2	7				
		Minibus	-	-	-	2	-	1	-	2	-	1	3	4	13	20	1.6	35	65
30.	Amechi	Big bus	-	-	-	-	-	-	-	-	-	-	-	-	-				
		Minibus	4	6	4	2	1	2	3	2	1	5	4	7	41	41	3.4	0	100
31.	Ugwuaji	Big bus	-	1	2	-	1	-	-	2	-	2	3	4	15				
		Minibus	-	-	-	-	-	-	-	-	-	-	-	-	-	15	1.3	100	0

SOURCE: FIELDWORK, 1995

Key: MBSF = Mean bus service frequency
BBF = Big bus frequency
MBF = Minibus frequency.



SOURCE: FIELDWORK, 1995

Fig. 9: ENUGU SHOWING AREAS OF EQUAL BUS SERVICE FREQUENCY.

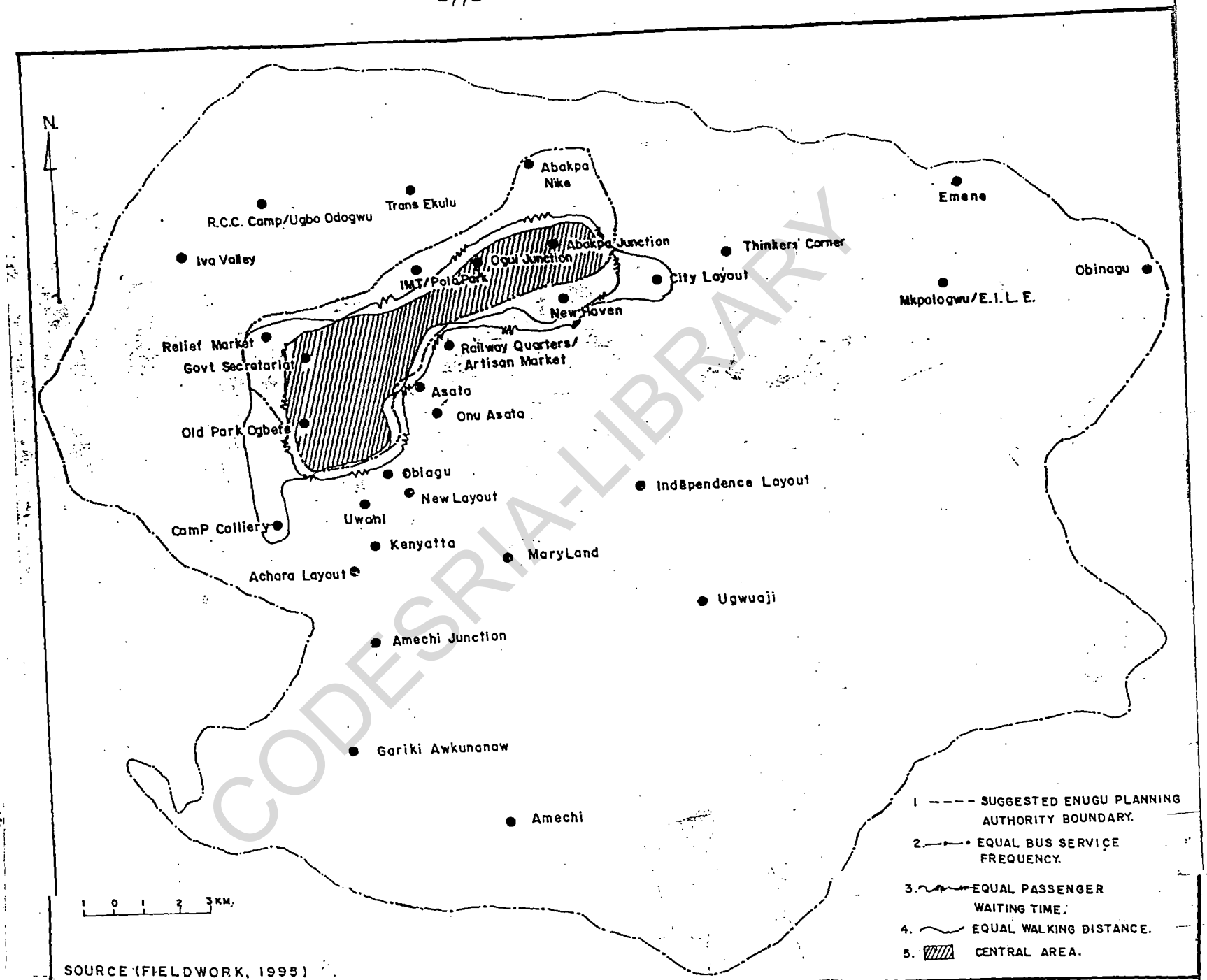
Secretariat (MBSF = 103). Between 100 - line and 60 - line of equal mean bus service frequencies, lie major centres that enjoy moderate bus service frequency. Major centres in this group are City Layout, Thinkers Corner, Emene, New Haven, Trans Ekulu, Raiway Quarters/Artisan Market, Asata, Obinagu, Uwani, Achara Layout, Amechi Junction and Gariki Awkunanaw. Moving away from 60 - line of equal mean bus service frequency towards the peripheries, are found major centres experiencing very low bus service frequencies. Such centres include Ugwuaji (MBSF = 1.3), Mary Land (MBSF = 1.6), Amechi MBSF = 3.1), Iva Valley (MBSF = 10.8) and Camp Colliery (MBSF = 14.7).

It is important to note that the bus service frequencies in the major centres are the service frequencies of either minibuses or big buses or both (Table 9). In New Haven, Iva Valley, City Layout, Obiagu, Railway Quarters/Artisan Market, Asata, Onu Asata and Amechi, only the minibus services are accessible to the inhabitants of the areas, while in Gariki-Awkunanaw, Independence Layout, Achara Layout, Kenyatta, Uwani, Ugwuaji, New Layout and Camp Colliery areas, only the big bus services are accessible to their inhabitants. Other major centres not included in the two groups mentioned above, both the services of mini and big buses, are accessible to the people living in them in varied proportions as explained by the calculated percentages of mini and big buses service frequencies in Table 9.

3.5 The spatial pattern of the core areas

Three core areas of shortest passenger waiting time for bus, shortest walking distance to the nearest bus stops and the highest bus service frequency in the study area were established as illustrated in Figs. 7, 8 and 9. Attempt was made to establish a central area for the three identified core areas. This was done by superimposing the three maps of Figs. 7, 8 and 9 as demonstrated in Fig. 10. From Fig. 10, it is observed that the central area of the three core areas lies within the Old Park - Ogbete - Government Secretariat - Ogui Junction - Abakpa Junction axis. This is the area in the city of Enugu where potential bus users enjoy the best bus services.

Many factors were found to be responsible for the existence of the central area (Fig. 10) during the fieldwork. The central area is the Central Business District (CBD) of Enugu which is the business-commercial core of the city characterized by the greatest concentration of business offices housed in both massive and tall buildings, governmental and Judicial offices, airline booking offices, wholesale and retail stores and petty traders' shops. The area is also housing the Enugu State Government Secretariat, Enugu North Local Government Headquarters, Churches, hospitals and the Ogbete Main Market. The central area has the highest density of roads in the city.



SOURCE (FIELDWORK, 1995)

Fig. 10: SUPERIMPOSED MAP SHOWING A CENTRAL AREA ENJOYING HIGHEST BUS.

It was also observed that the commercial houses were interspersed with residential houses. As a result of the high concentration of economic and social activities in the area, it is the terminating point of a large number of bus commuter trips from the rest of the study area, most of the day, and the originating point of numerous commuter trips homewards, especially between 3.30 p.m and 7.30 p.m.

3.6 Relationship between bus service frequency and Waiting time index

In establishing relationship between bus service frequency and passenger waiting time indices an analysis of correlation between the two variables was carried out. Correlation describes the degree of association or strength of relationship between two or more variables. This is usually measured by calculating the correlation coefficient which expresses the linear relationship between two random variables X and Y and denoting it by r. The variables X and Y are assumed to have joint probability distribution (X, Y). The most commonly used measure of linear correlation between two variables is called the Pearson Product - Moment Correlation Coefficient. Mathematically this is expressed as:

$$r = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{\left[N\Sigma X^2 - (\Sigma X)^2\right]\left[N\Sigma Y^2 - (\Sigma Y)^2\right]}} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

where r is the correlation coefficient between X and Y; X is the bus service frequency index; Y is the passenger waiting time index; N is the number of observations. The correlation coefficient also tells us the direction of the relationship. If the two sets vary in the same direction r will be positive, whereas if they vary inversely r will be negative. The r-value ranges from 0 to 1, the higher it is, the stronger the relationship is supposed to be, while its significance (whether it is a chance occurrence or not) is tested by means of t-test.

Appendix D-1 shows the calculation of the correlation between bus service frequency and passenger waiting time indices. The correlation coefficient (r) is given as $r = -0.650$ which shows that it is a negative linear relationship between the two variables. The negative correlation means that the greater the bus service frequency index value, the smaller the passenger waiting time and that the linear relationship is strong. In other words major centres experiencing high bus service frequencies, enjoy short waiting times for buses and the reverse is the case for centres that experience low bus service frequencies. This is consistent with the observation in the study area. The correlation coefficient (r) is significant at 5% probability level (see appendix D-2). To determine the level of

explanation provided by bus service frequency, we computed the coefficient of determination r^2 or $(0.650)^2$ which is about 0.42 or 42%. This means that the bus service frequency alone explains about 42 percent of the variation of the passenger waiting time for mass transit buses in the whole of the study area. The remaining 58 percent cannot be explained by variation in bus service frequency and so is due to other factors such as accessibility to the bus network, capacity of buses, volume of traffic, demand and the nature of bus route as explained in section 3.2.

CHAPTER FOUR

STRUCTURAL ANALYSIS OF BUS ROUTE NETWORK IN ENUGU

4.1 Network as a graph

In reality networks are highly complex spatial systems. Only by substantial simplification of their reality are we able to study some of their characteristics (Taaffe and Gauthier, 1973). In studying transport networks, we use a type of geometry known as topology, which is concerned with the relative positions and relationships between points and lines. This requires changing transport network into an abstract form known as a graph. In doing so, some information about the network such as capacity of route, type of use and cost of construction will be deliberately discarded. As such, graph theory makes no direct reference to the real world, nevertheless it has potential usefulness in empirical analysis. It provides some measures of the structural properties of a real world system if that is idealized as a set of points (vertices) connected by set of segments (edges).

Properties which characteristise ordinary or planar graphs and thus transpertation systems treated as planar graphs are as follows:-

i) a network has a finite number of places called nodes, vertices or centres. Thus the residential, educational, recreational, commercial, employment and market centres are regarded as points on the network in this study.

ii) each route joins only two different nodes and are called links or edges. Thus, bus routes are regarded as links or edges;

iii) routes are two-way or undirected planar graphs which may of course be directed; and

iv) two edges cannot intercept at a point that is not a vertex.

On the basis of such abstraction, various indices may be calculated which describe either the connectivity, centrality of network spread or accessibility. The graph theory approach to network analysis has been considered relevant in this study because of the reason as explained in section 1.4.2.

At this point, the analysis is divided into three sections:

1. calculation of indices of connectivity which may be considered as network specific indices;
2. construction of indices of nodal accessibility which of course provides us with levels of accessibility for individual nodes on the bus network. These are node specific indices; and
3. establishment of the relationship between accessibility and some bus service indicators.

4.2 Connectivity of bus network in Enugu:

Connectivity expresses the degree to which a network permits direct movement between its various nodes and therefore, it is an aggregate measure relating to the network structure as a whole. Many indices of connectivity with varying degrees of sensitivity as aggregate measure of inter-connectedness of network otherwise called network specific indices can be calculated namely:

$$\text{Cyclometic number } (\mu) = e - v + P \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

$$\text{Beta index } (\beta) = \frac{e}{v} \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

$$\text{Gamma index } (\gamma) = \frac{e}{3(v-2)} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

$$\text{Alpha index } (\alpha) = \frac{e - v + 1}{2v - 5} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

$$\text{Connectivity index } (C) = \frac{e}{\frac{1}{2} v (v-1)} \times \frac{100}{1} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

where e is the number of edges or links; v is the number of vertices or nodes and P is the number of subgraphs.

Cyclomatic number is the measure of the number of circuits in the transportation or the number of links in the system excess to the number required to tie the vertices together in a minimal way.

The beta index expresses the number of edges present in a network in relation to the number of vertices to be connected. It therefore indicates the number of links

leading in and out of each node. The higher the value of the beta index the greater the connectivity of the network.

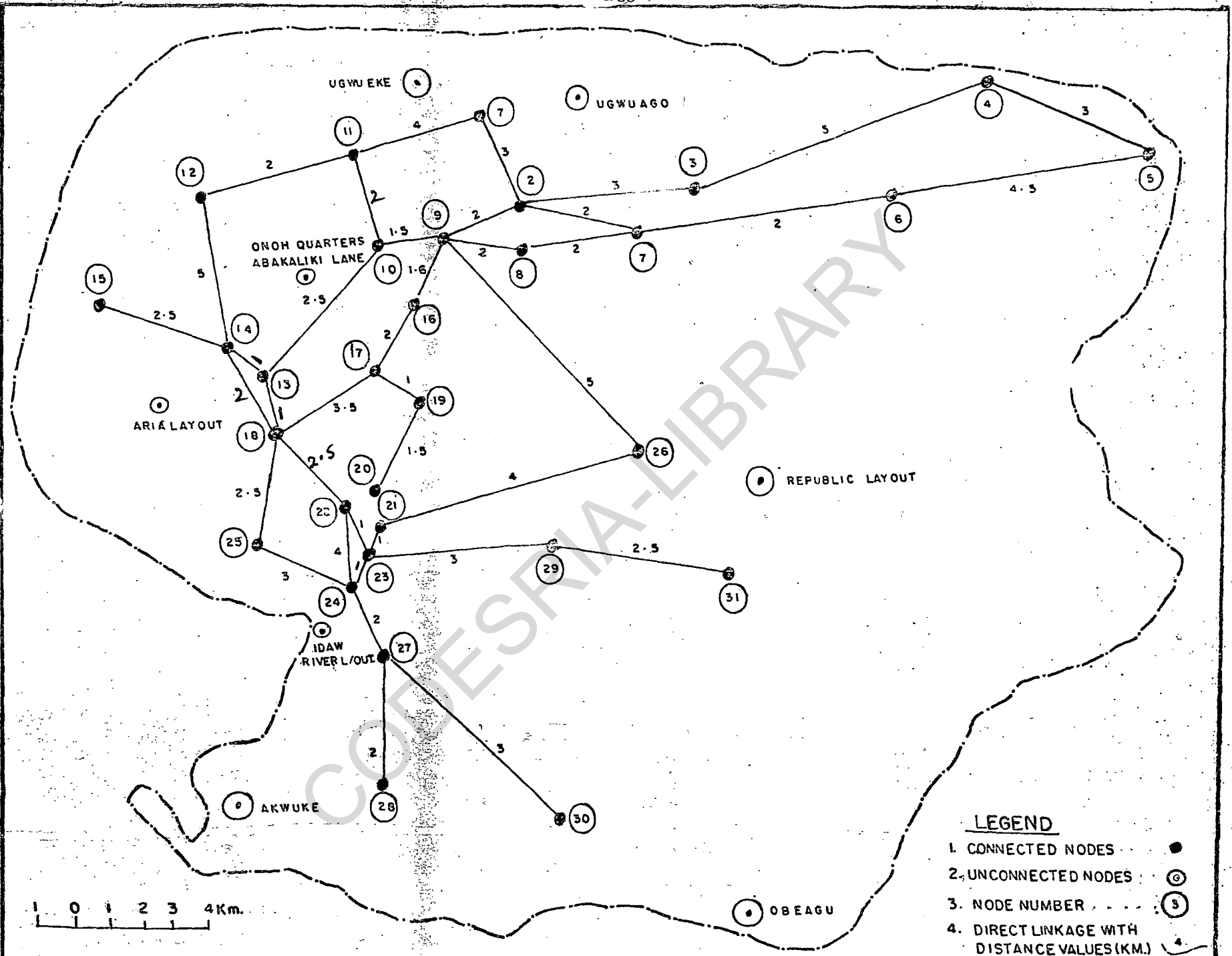
The gamma index is the ratio of the number of edges in a network to the maximum which may exist between specified number of vertices. This is more sensitive than the beta index to indicate network growth or complexity as addition of single vertex increases the number of positive edges by three. The numerical values of gamma index range between 0 and 1 (or 0 and 100%).

The alpha index is closely related to the gamma index, but it is a ratio based on the number of circuits in a network. A circuit is a path that begins and ends at the same node but never crosses its own route nor passes along the same edge twice. Circuits are considered to represent more complex networks than branches, hence the alpha index is the most sensitive of the primitive indices to indicate network growth or complexity (Werner, 1968). The numerical value range of alpha index is between 0 and 1 (or 0 and 100%).

Connectivity index (C) measures the degree of completeness of the linkages (edges) between various vertices (nodes) in a network. The connectivity index (C) values range from 0 to 100%. The higher the index value, the more the linkages between various vertices in the network and the smaller the index value, the fewer the linkages between various vertices in the network.

From Fig. 6, the graph representation of bus network in Enugu was abstracted as shown in Figs. 11 and 12 and indices of connectivity were calculated. To appreciate the graph representation of the bus network in Enugu, it is important to reiterate that all the major centres were first selected based on the method outlined in section 1.7.1 (i.e. residential, market, employment and educational centres), and the fact that they were all directly connected by bus routes by 1995. By direct connection is meant that it is possible to move from one node to another without passing through any other sampled nodes. It is important to note that some major centres which met the criteria for selecting major centres were not included because they were not connected by bus routes. Such centres include Idaw River Layout, Ugwu Ago, Aria Layout, Republic Layout and Ono Quarters/Abakiliki lane (Fig.11). These centres are highly inaccessible to the services of bus mass transit in the city.

Table 10 shows the calculated values of connectivity of mass transit bus network in Enugu. The number of edges (e) in the network is equal to 39 while the number of vertices (v) is equal to 31.



SOURCE (FIELDWORK 1995)

Fig.7: GRAPH REPRESENTATION OF BUS ROUTE NETWORK: WITH ROUTE DISTANCE VALUES (BASED ON Fig. 5

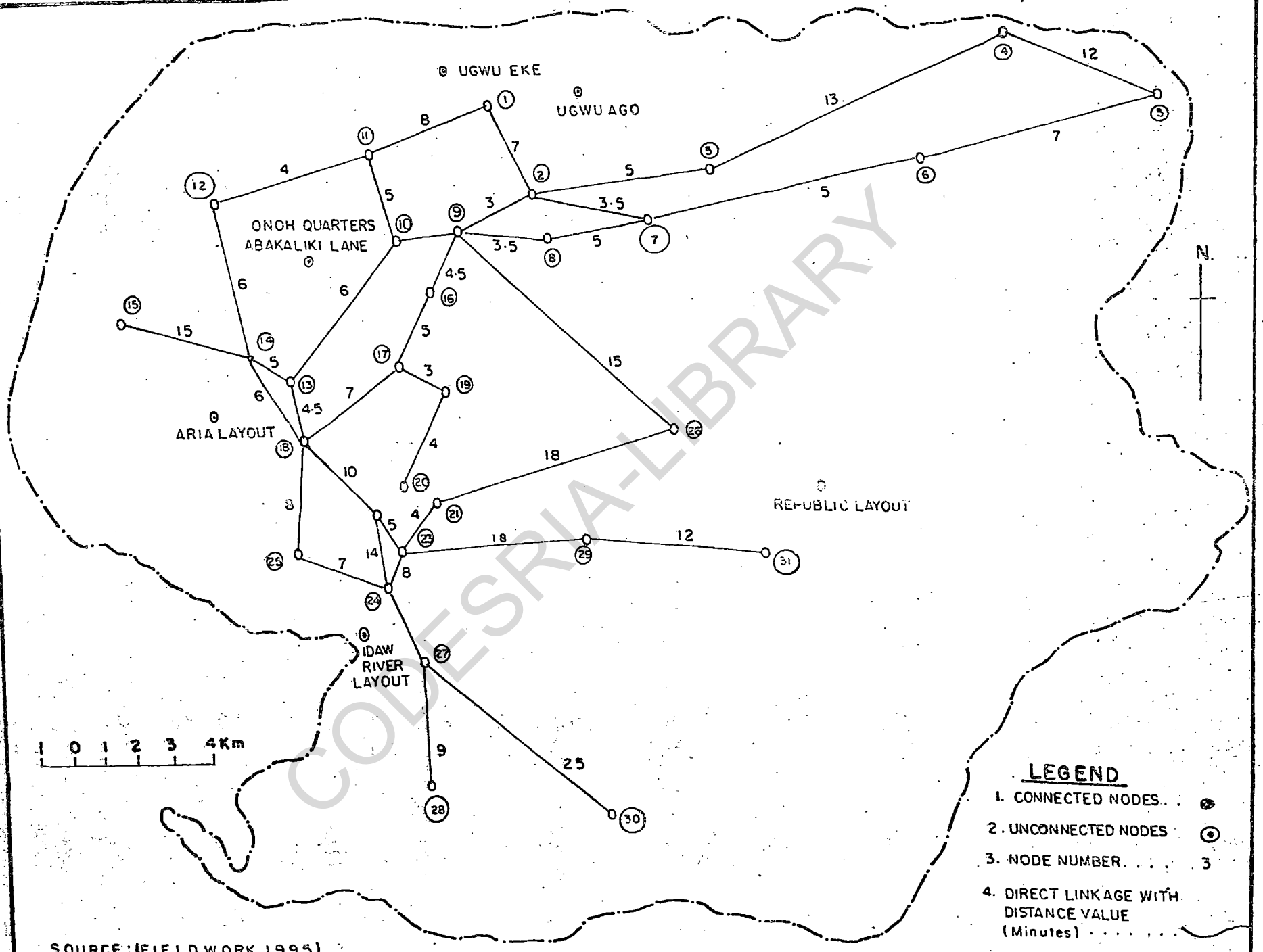


Fig 8: REPRESENTATION OF BUS ROUTE NETWORK: WITH ROUTE LINKAGE VALUES (BASED ON Fig 5)

TABLE 10: Indices of connectivity of mass transit bus network in Enugu.

Names and Symbols of Indices	Values of Indices
Cyclomatic Number (μ)	9
Beta index (β)	1.26
Gamma index (γ)	44.8%
Alpha index (α)	15.8%
Connectivity index (C)	8.4%

SOURCE: Fieldwork, 1995.

We can observe from Table 10 that:

1. the cyclomatic number of the mass transit bus network is 9 (i.e. nine fundamental circuits linking some major centres in Enugu) and since this number is considerably lower than the maximum number of circuits (i.e. 2v - 5) possible which is 57, it means that the connectivity of mass transit bus network in Enugu is very low.
2. the beta index is relatively low 1.26 showing that the number of links leading in and out of major centres in the city is very small.
3. the gamma index shows that the bus network in Enugu is 44.8% connected. This also explains the fact that connectivity of mass transit bus network in Enugu is little below average.

4. the alpha index shows the bus network circuitry is 15.8% of the maximum of circuits (i.e. 57) possible in the network. This also goes to explain the low connectivity of mass transit bus network in the city.
5. the connectivity index (C) of the bus mass transit network in Enugu is 8.4%. This index shows that the connectivity of mass transit bus network in Enugu is very low.

4.3 The pattern of major centres accessibility to the bus transit network in Enugu:

As the indices of connectivity indicate the level of complexity or connectedness of bus transit network, the indices of major centres accessibility explain the relative accessibility of one major centre to all others in the network. The pattern of bus route linkage between the centres in the network provides a certain degree of accessibility in respect of each individual centre and also in respect of the network as a whole. A high level of accessibility means that it is possible to travel by bus from centre to centre by shortest possible bus route.

In order to calculate the indices of nodal (i.e. major centre) accessibility, the graph is first turned into an nxn matrix of directly connected nodes (major centre). The directly connected nodes may be valued or not (Taaffe et al,

1973). The cell entries may indicate either topologic distance or road distance, travel-time or cost that is to be tranversed between a pair of nodes. Unconnected nodes in the valued graphs are indicated by infinity (∞), while the diagonal cell entries have zero. In the matrix of unvalued graph representing presence or absence of connection respectively, this initial connection matrix is called the C - matrix.

From this C-matrix, a matrix of shortest paths between each pair of nodes can then be computed. Shimbel (1953) developed a technique of computing this shortest path matrix, using topologic distance. His technique which is briefly sketched here involves powering the C-matrix to the diameter of the network. According to the Shimbel method, the powering process involves a row-by-column multiplication of the C-matrix and after each interation, it is checked to see whether non-zero elements appear. If so, the power of that matrix is entered in the appropriate row and column of a D-matrix. When there are no longer zero elements, the diameter is reached and the row of final matrix which forms the shortest path matrix is summed up to give the accessibility index. This index called Shimbel index can be represented as:

$$Ai = \sum_{j=1}^{n} dij \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

where Ai is the accessibility index of node (major centre); n is the number of vertices or nodes in the network; and dij is the value associated with the shortest path i to j. Since the index records the shortest path, the smaller the value, the greater the accessibility of that node to the network. The Shimbel index implies that the shorter the distance (measured in number of links) between two nodes, the more accessible that node is.

However, the Shimbel index was not calculated in this study because distance measured merely in the number of links irrespective of the length was hardly considered as realistic. Rather, actual values of road distance and travel-time were employed to value the graphs. Tables 11 and 12 represent the C-matrices with bus route distance values and bus travel-time values, respectively.
In powering the valued graph, instead of element-by-element multiplication of the C-matrix, it is element-by-element addition of the rows and columns such that:

$$Iik.Ijk = Min\ (Iik + Ijk) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

where Iik is the link from origin, to any intermediate K points; Ikj is the link from destination j to any intermediate point. The minimum of this element-by-element addition is recorded in the appropriate row and column of a new D-matrix. Thus the cell entries of the

TABLE 11: CONNECTIVITY MATRIX WITH BUS ROUTE DISTANCE VALUES (IN KM)

NODE NO	NODE TITLE (NAME OF MAJOR CENTRE)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1.	ABAKPA NIKE	0	3									4																				
2.	ABAKPA JUNCTION	3	0	3				2		2																						
3.	THINKERS CORNER		3	0	5																											
4.	EMENE			5	0	3																										
5.	OBINAGU				3	0	4.5																									
6.	MKPOLOGWU/E.I.L.E.					4.5	0	2																								
7.	CITY LAYOUT		2				2	0	2																							
8.	NEW HAVEN							2	0	2																						
9.	OGUI JUNCTION		2						2	0	1.5						1.6										5					
10.	IMT/POLO PARK									1.5	0	2		2.5																		
11.	TRANS EKULU	4									2	0	2																			
12.	R.C.C. CAMP/UGBO-ODOGWU											2	0																			
13.	GOVERNMENT SECRETARIAT										2.5			0					1													
14.	RELIEF MARKET												5	1	0	2.5			2													
15.	IVA VALLEY														2.5	0																
16	RAILWAY QUARTERS/ ARTISAN MARKET									1.6							0	2														
17.	ASATA																2	0														
18.	OLD PARK (OGBETE)													1	2			3.5	0				2.5			2.5					
19.	ONU ASATA																			0	1.5											
20.	OBIAGU																			1.5	0											
21.	NEW LAYOUT																					0		1			4					
22.	UWANI																		2.5				0	1	4							
23.	KENYATTA																					1	1	0								
24.	ACHARA LAYOUT																						4	2	0	3						
25.	CAMP COLLIERY																								3	0						
26.	INDEPENDENCE LAYOUT									5												4					0					
27.	AMECHI JUNCTION																								2			0	2			2
28.	GARIKI (AWKUNANAW)																											2	0	2	3	
29.	MARY LAND																							3						.0		2.5
30.	AMECHI																									1		3			0	
31.	UGWUAJI																													2.5		0

*Empty cells indicate infinity or no direct connection.

TABLE 12: CONNECTIVITY MATRIX WITH BUS TRAVEL-TIME VALUES (IN MINUTES)

NODE NO	NODE TITLE (NAME OF MAJOR CENTRE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	ABAKPA NKE	0	7									3																				
2	ABAKPA JUNCTION	7	0	5				3.5		3																						
3	THEYERS CORNER		5	0	13																											
4	EMENE			13	0	12																										
5	OBINAGU				12	0	7																									
6	MKPOLOGWU/E.I.L.E.					7	0	5																								
8	CITY LAYOUT		3.5				5	0	5																							
8	NEW HAVEN							5	0	3.5																						
9	OGUI JUNCTION		3						3.5	0	4						4.5										15					
10	IMT/POLO PARK									4	0	5		6																		
11	TRANS EKULU	8									3	0	4																			
12	R.C.C. CAMP/UGBO-ODOGWU											4	0		5				4.5													
13	GOVERNMENT SECRETARIAT										6			0	5				6													
14	RELIEF MARKET												6	13	0	15																
15	IVA VALLEY														15	0		5														
16	RAILWAY QUARTERS/ARTISAN MARKET									4.5							0	0	7	3												
17	ASATA																5	0	9													
18	OLD PART (OGBETE)																	7	0													
19	ONU ASATA																			0	4		10			8						
20	OBIAGU																			4	0											
21	NEW LAYOUT																		10			0		4			18					
22	UWANI																						0	5	14					16		
23	KENYATTA																					4	5	0	8							
24	ACHARA LAYOUT																						14	8	0	7		4				
25	CAMP COLLIERY																								7	0						
26	INDEPENDENCE LAYOUT								15													18					0			25		
27	AMECHI JUNCTION																								4			0	9		25	
28	GARIKI (AWKUNANAW)																											9	0			
29	MARYLAND																							16						0		12
30	AMECHI																											25			0	
31	UGWUAJI																													12		0

Empty cells indicate infinity or no direct connection.

D-matrix record the values of indirect connections between origin and destination. The subsequent powering of D-matrices gives 2-step, 3-step, 4-step, etc connections until the diameter of the network is reached. The diameter is reached when the most distant nodes are connected. The row of the final matrix D is summed to obtain an index of accessibility measured in terms of shortest paths in (a) kilometres and (b) minutes from one node to all other nodes in the network. Structurally, the operation is similar to that of Shimbel index, but it has the advantage of being more related to actual distance values (Taaffe, 1973). The node with the smallest minimum distance is regarded as the most accessible. By ranking the nodes in terms of degree of accessibility, a herarchy of accessibility surfaces can be got.

Using Boolean rules (i.e. $X + Y = \min (X.Y)$, successive powers of the valued matrix D were calculated. The shortest paths and major centre (nodal) accessibility for the whole network of 31 major centres (nodes) were obtained.

Appendices E and F represent the shortest path matrices calculated from the connectivity matrices (C-matrices) in Tables 11 and 12 based on road distance (Fig.11) and travel-time (Fig.12) for the network in

Enugu respectively. By summing the rows of these shortest path matrices, we obtained the indices of accessibility. In table 13, (derived from Appendix D2) the major centres are ranked according to their levels of accessibility in bus network. The higher the index, the less accessible the node and vice versa.

From Table 13, it is interesting to observe that in terms of overall bus route distance, the most accessible major centres in the bus network in Enugu are Government Secretariat (Ai = 209.1), Old Park (Ai = 211.5), IMT/Polo Park (Ai = 217.4) and Ogui Junction (Ai = 220.1), while the least accessible are Obinagu (Ai = 430.5), Emene (Ai = 453.9), Amechi (Ai = 430.5) and Gariki (Ai = 401.5). Surprisingly, Obiagu, located in the urban area of Enugu scored Ai = 303.8, thereby taking the 18th position in the rank order.

Fig.13 shows lines of equal accessibility to the bus services based on bus route distance. From the map, it is observed that the 250 line encloses an area with the highest level of accessibility to the bus services in the city comprising Asata, Old Part (Ogbete), Relief Market, Government Secretariat, IMT/Polo Park, Uwani, Railway Quarters/Artisan Market, Camp Colliery and Ogui Junction. These are areas in Enugu that could be easily reached by bus from any part of the city.

TABLE 13: Rank order of major centre (nodal) accessibility using road distance of bus network in Enugu

Node Number	Node Title (i.e. Name of Major Centre)	Accessibility index (in Km)	Rank Order
13	Government Secretariat	209.1	1
18	Old Park (Ogbete)	211.5	2
10	IMT/Polo Park	217.4	3
9	Ogui Junction	220.1	4
17	Asata	226.2	5
22	Uwani	233.5	6
16	Railway Quarters/Artisan Market	234.2	7
14	Relief Market	236.1	8
25	Camp Colliery	249.5	9
23	Kenyatta	252.6	10
2	Abakpa Junction	259.5	11
19	Onu Asata	260.3	12
8	New Haven	265.5	13
11	Trans Ekulu	270.4	14
21	Independence Layout	273.4	15
24	Achara Layout	299.3	16
7	City Layout	302.5	17
20	Obiagu	303.8	18
12	RCC Camp/Ugbo-Odogwu	307.1	19

15	Iva Valley	308.6	20
21	New Layout	318.9	21
22	Abakpa Nike	321.5	22
29	Mary Land	334.5	23
30	Thinkers Corner	335.5	24
27	Amechi Junction	342.5	25
6	Mkpologwu/E.I.L.E.	352.5	26
31	Ugwuaji	399	27
28	Gariki (Awkunanaw)	401.5	28
30	Amechi	430.5	29
4	Emene	453.9	30
5	Obinagu	475.5	31

SOURCE: Fieldwork, 1995.

Immediately after the central area of the city, there is a group of moderately accessible centres consisting of Onu Asata, New Haven, Abakpa Junction, Trans Ekulu, Onoh Quarters/Abakiliki lane, Aria Layout, Kenyatta, Achara layout and Idaw River Layout. There are however, areas such as Onoh Quarters/Abakiliki lane, Idaw River Layout and Aria Layout which are in this group that are not connected by bus transit routes. These could be considered as potential centres of moderate accessibility to the bus transit services in the city if they are linked by bus routes.

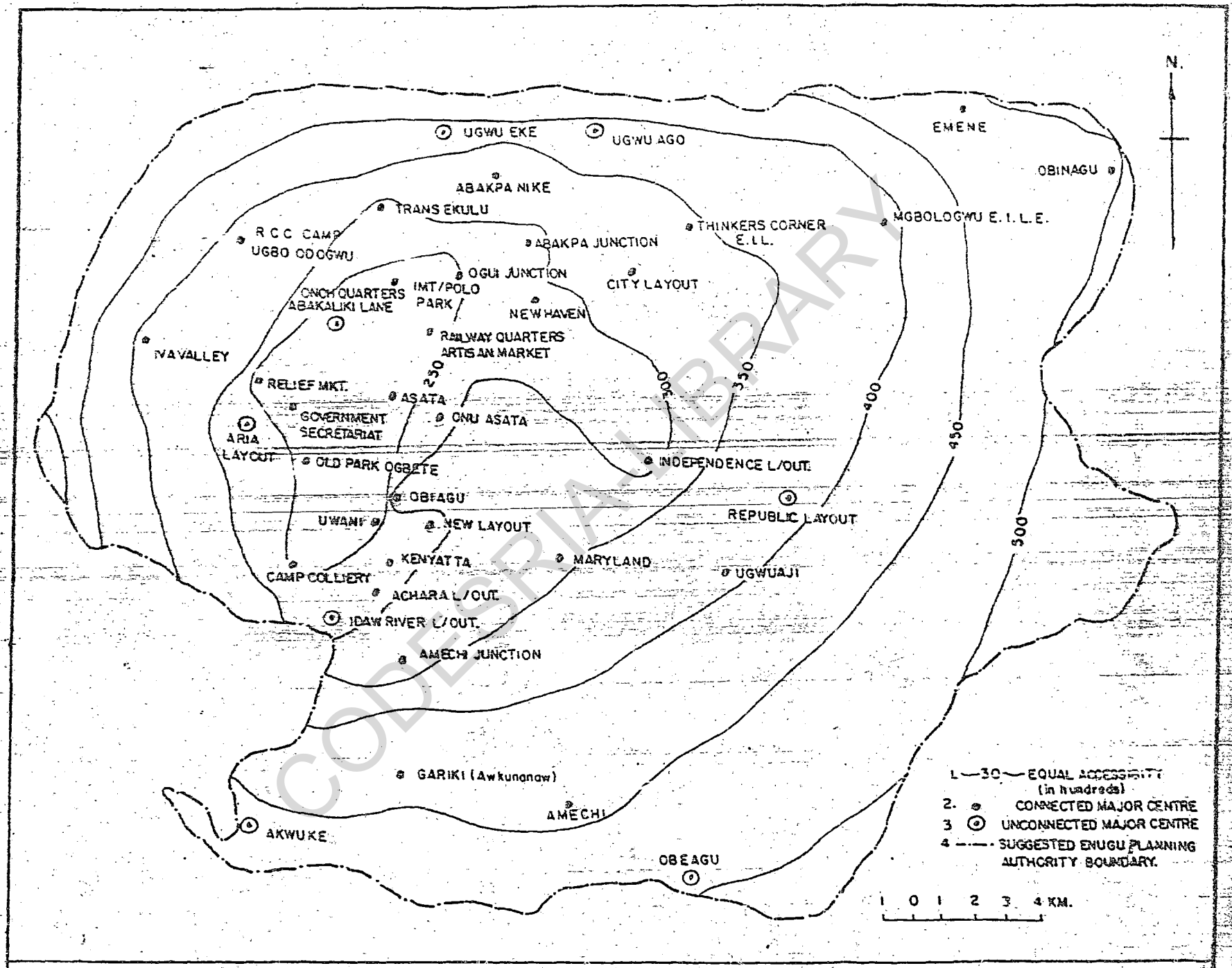


FIG. 3 ENUGU SHOWING AREAS OF EQUAL ACCESSIBILITY TO BUS SERVICE BASED ON BUS ROUTE DISTANCE. (FIELD WORK) 1995

From the 300-line, accessibility to the bus transit services in Enugu decreases rapidly outwards indicating that centres in these areas are relatively less accessible to the bus transit services. They constitute the peripheral centres of the city. It is important to point out that among the peripheral centres, some of them are not linked by bus transit routes, thereby making them highly inaccessible to the bus transit services in the city. Such centres include Republic Layout, Ugwu Ago and Ugwu Eke, Obeagu and Akwuke.

Attempt was made to determine the accessibility indices of the major centres using bus travel-time between the centres. This is to find out variations if any between the major centres of accessibility to the bus network based on bus route distance and that based on bus travel-time and suggest reasons for such variations. Appendix F represents the associated shortest path matrix based on bus travel-time. By summing the rows of these shortest path matrix, we obtained the vector of accessibility indices. In Table 14 (derived from Appendix F) the major centres are ranked according to their levels of accessibility in the mass transit bus network in Enugu. From Table 14, it is observed that Government Secretariat (Ai = 591); Old Park (Ai = 616.5); IMT/Polo Park (Ai = 638) and Asata (Ai = 640 are the most accessible major centres to the mass transit bus network

TABLE 14: Rank order of major centre (nodal) accessibility based on bus travels time along the bus network in Enugu

Node Number	Node Title (i.e. Name of Major Centre)	Accessibility index (in Km)	Rank Order
13	Government Secretariat	591	
18	Old Park (Ogbete)	616.5	2
10	IMT/Polo Park	638	3
17	Asata	640	4
9	Ogui Junction	679.5	5
16	Railway Quarters/Artisan Market	690.5	6
14	Relief Market	708	7
19	Onu Asata	717	8
25	Camp Colliery	724	9
22	Uwani	742	10
2	Abakpa Junction	747	11
12	R.C.C. Camp/Ugbo Odogwu	757	12
8	New Haven	768	13
11	Trans Ekulu	769	14
23	Kenyatta	792	15
24	Achara Layout	801	16
7	City Layout	813	17
20	Obiagu	833	18
1	Abakpa Nike	852	19
3	Thinkers Corner	874	20

26	Independence Layout	910	21
6	Mkpologwu/E.I.L.E.	940.5	22
27	Amechi Junction	1026	23
21	New Layout	1092.5	24
15	Iva Valley	1135	25
5	Obinagu	1191.5	26
4	Emene	1217.5	27
28	Gariki (Awkunanaw)	1286	28
29	Maryland	1323.5	29
31	Ugwuaji	1687	30
30	Amechi	1750	31

SOURCE: Fieldwork, 1995.

in Enugu based on bus travel-time. On the other hand, the least accessible centres to the mass transit bus services in the city based on bus travel-time include Amechi (Ai = 1750), Ugwuaji (Ai = 1687), Maryland (Ai = 1323.5) and Gariki (Ai = 1286).

Fig. 14 shows lines of equal accessibility to the mass transit bus services in Enugu based on bus travel-time. From the map, it is observed that 700-line encloses the most accessible centres in the city. They are the centres that can be easily reached by mass transit bus in the shortest possible time from any part of Enugu. Between 700 -

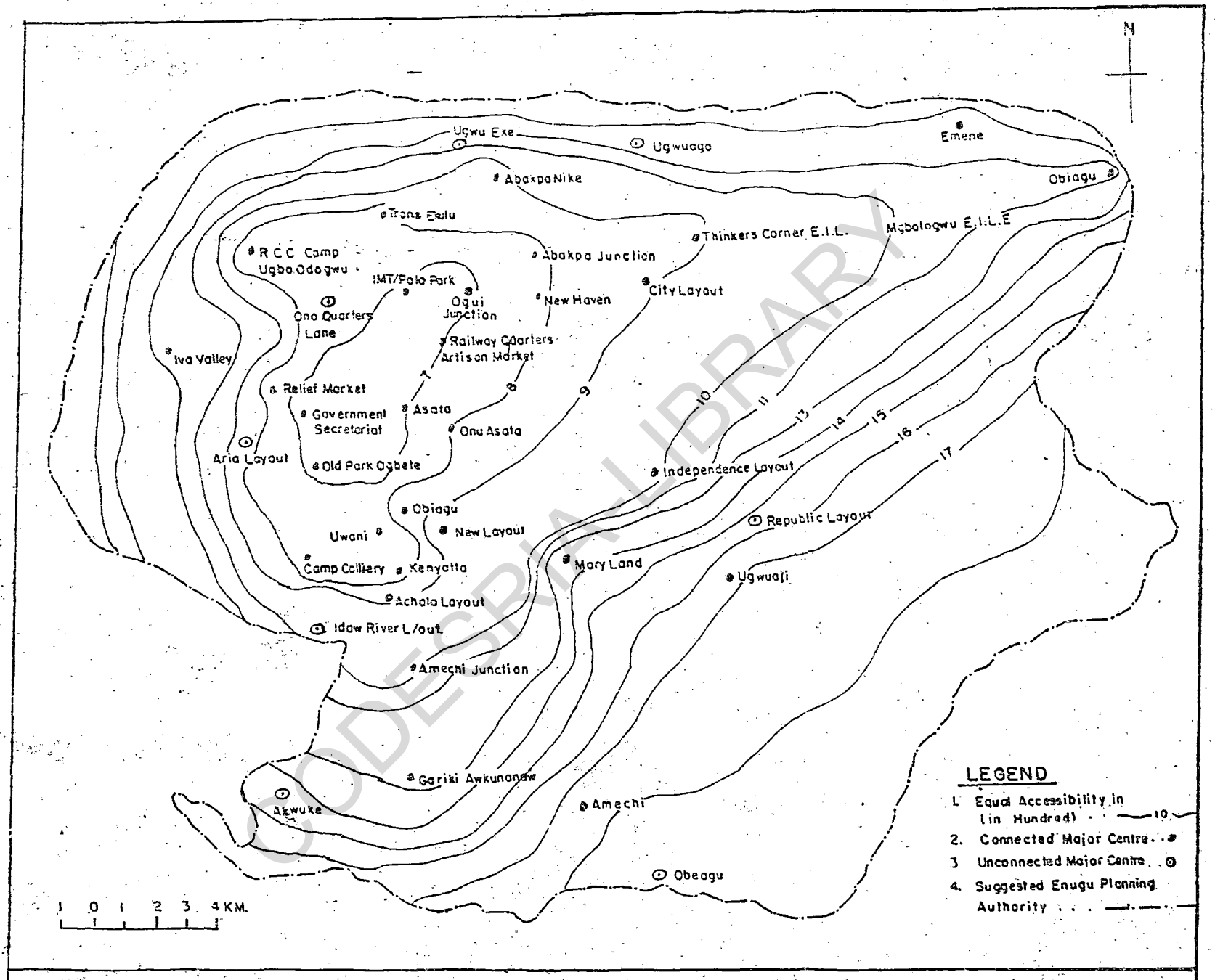


Fig 4: ENUGU SHOWING AREAS OF EQUAL ACCESSIBILITY TO BUS SERVICES BASED ON BUS TRAVEL TIME (FIELDWORK) 1995.

line and 800 - line is the area where moderately accessible centres are located. The centres located within this range are reached by mass transit bus from any part of Enugu in a relatively shortest possible time. From 800-line of equal accessibility, the accessibility of centres to the mass transit bus services starts to decrease towards the city peripheries in terms of bus travel time. This means that centres located above 800-line of equal accessibility entail spending more time to reach them by mass transit bus from any part of the city and this situation increases as one moves towards the peripheries.

4.4 Comparison between the pattern of accessibility of major centres to the mass transit bus network based on bus route distance and bus travel-time

From Tables 11 and 12 and Figures 13 and 14, it is observed that accessibility of major centres to the mass transit bus network based on both bus route distance and bus travel-time show progressive decrease in accessibility of the centres from inner city areas towards the city peripheries. It is also observed that some major centres that are higher in accessibility rank order and in equal accessibility lines based on bus route distance are lower in accessibility rank order and in equal accessibility lines based on bus travel-time. Such major centres include Ogui Junction, Uwani,

Kenyatta, Independence Layout, Mary-land, Ugwuaji and Amechi. The drop in accessibility rank order and in equal accessibility lines based on bus travel-time by these centres could be due to bad roads (Plate 6) and traffic congestion for those centres within the inner city areas and bad roads only for those centres within the peripheries of the study area. Another reason responsible for such drop, could be the fact that buses plying the routes linking such centres are of high capacities. This is because big buses take long time to load and off-load their passengers and this affects the travel-time of bus.

Other centres comprising Obinagu, Emene, Asata, R.C.C. Camp/Ugbo-Odogwu, Camp Colliery, Onu Asata, Railway Quarter/ Artisan Market, and Abakpa Nike are better accessible to the mass transit bus network based on the bus travel-time than that based on bus route distance. This could be for two factors. One of the reason could be the fact that the centres are linked by relatively good roads. The other reason could be the fact that most of the centres are served by minibuses having low capacities which take short time to load and off-load their passengers. The remaining major centres that are not in the two groups mentioned above, maintained the same accessibility levels when measured by bus route distance and by travel-time.

PLATE 6: Bus running on one of the bad roads in the city of Enugu.

4.5 Relationships between Bus route distance accessibility and some bus services indicators (indices)

In determining relationships between bus route distance accessibility and some bus service indicators (indices), an analysis of correlation between the variable was carried out. Correlation as we discussed earlier in section 3.6 measures the degree of association or strength of relationship between the variables. The variables considered in this section include bus route distance accessibility index (as independent variable), passenger waiting time and bus service frequency indices (as dependent variables).

Appendix G-1 shows the calculation of the correlation between bus route distance accessibility and passenger waiting time indices. The correlation coefficient (r) is given as r = 0.587 which shows it is a positive linear relationship between the two variables and 5% probability level is significant (see Appendix G-2). The positive correlation means that the greater the accessibility index value (hence the less accessible the centre is), the higher the level of passenger waiting time for the arrival of mass transit buses. This is in line with the observation in the study area.

To determine the level of explanation provided by accessibility, we computed the coefficient of determination which gave us about 0.34 or 34% implying that the bus route

distance accessibility factor alone explains about 34% of the variation in the passenger waiting time for mass transit buses in the whole of the study area while the remaining 66% cannot be determined by variation in route distance accessibility and so is due to other factors. This reminds us that earlier in section 3.6, it was verified that bus service frequency factor explained 42% variation in the passenger waiting time for buses throughout the study area. Thus, the factors of bus route distance accessibility and bus service frequency are significant contributors to the variation in passenger waiting time for the arrival of mass transit buses in Enugu.

Appendix H-1 shows the calculation of the correlation between bus route distance accessibility and service frequency indices. The correlation coefficient (r) is given as r = -0.468 which shows it is negative and at 5% probability level is significant (see Appendix H-2). The negative correlation means that the greater the accessibility index value (hence the less accessible the centre is) the lower the level of bus service frequency. The calculated coefficient of determination of the relationship is given as 0.22 which indicates that bus route distance accessibility explains about 22% of the variation in the bus service frequency in the study area, while the remaining 88% cannot be explained

by variation in route distance accessibility and so is due to other factors such as population distribution and economic activities.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of findings

In this research, we have tried to describe the accessibility pattern of major centres to mass transit bus network in Enugu and the relationships with the level-of-service of mass transit bus in Enugu.

By application of the principle of graph theory, it was possible to reduce the complex nature of network into a form that enabled us to examine its complexity and accessibility to the major centres in Enugu. Based on the network, we observed that the connectivity of mass transit bus network in Enugu is relatively low as indicated by the primitive indices of connectivity such as the cyclomatic number, gamma, alpha, beta and connectivity indices.

Using the valued graph approach, we calculated the indices of accessibility based on bus route distance in kilometres and bus travel-time in minutes. These indices which are node specific were based on summing the shortest path distance and shortest bus travel-time from one node (major centre) to all other nodes (major centres) of the network and by ranking them, a hierarchy of nodes of decreasing relative accessibility was established. We noticed three groups of major centres based on their level of accessibility to the transit bus network. The first group comprises the most accessible major centres found around Old Park (Ogbete),

Government Secretariat, IMT/Polo Park, Ogui Junction, Asata and Uwani areas. Secondly are the centres that are moderately accessible found around Abakpa Junction, Trans Ekulu, Onu Asata, Achara Layout, Kenyatta and New Haven areas, while the third group comprises the less accessible centres found around Abakpa Nike, R.C.C. Camp/Ugbo-Odogwu, Obiagu, Gariki Awkunanaw, Mary Land and Emene axis. The less accessible major centres are mostly found within the peripheries of the study area, except Obiagu which is found in the inner part of the city. We also observed some centres scattered in the study area that are inaccessible to the mass transit bus services. This is because they are not linked by mass transit bus routes. Such centres include Aria, Republic, Idaw Rivers, Ugwu Age, Ugwu Eke Layouts and Ono Quarters/Abakiliki lane.

We also observed that some major areas were less accessible to the mass transit bus services when bus travel-time was used to calculate the accessibility indices than when bus route distance was used. Centres in this group include Ogui Junction, Uwani, Kenyatta, Iva Valley, Independence Layout, New Layout, Mary Land, Ugwuaji and Amechi. This variation is because of bad roads linking the major centres and traffic congestions prevalent in such centres.

In establishing relationships between the accessibility indices and the bus service indices of passenger waiting time and bus service frequency, we found a strong relationship between accessibility indices and passenger waiting time indices and weak relationship was observed between accessibility indices and bus service frequency indices. We also noticed that some major centres, even though they are less accessible to the mass transit bus network, experienced high bus service frequency. This is because of high demand for bus servicesin such area as they are among the major residential areas in Enugu. Prominent among such centres are Abakpa Nike, Gariki (Awkunanaw) and Emene.

We made attempt to trace the development of mass transit bus services from 1960 to date and identified only 19 functional intra-urban bus routeswith the total length of 218.7 kilometres serving about 182 square kilometres of an area inhabited by more than 465,072 people. We also identified the location and spacing of bus stops in Enugu and noticed that bus stops have little to offer in terms of facilities such as bus stop sheds and mechanics for servicing the vehicles at the bus stops. The existing bus stop sheds are dilapidated and most of the bus stops are water logged during the rainy season. We also observed the variations of the bus stop spacings from one centre to another. The

average bus stop spacing varied from less than 200 metres in the central area to more than 400 metres in the peripheries of the study area. The average bus stop spacing for the study area as a whole, was found to be 335.9 metres.

Further attempt was made to find out the level-of-service (L.O.S.) of mass transit bus in the 31 sampled major centres by considering three components of level-of-service (L.O.S) - bus service frequency, passenger waiting time and walking distance or time. It was found that these components varied from one centre to another, indicating variations in the level of services of mass transit bus in different parts of Enugu. We also observed a central area where potential bus users enjoy the shortest waiting time for bus, shortest walking distance to the nearest bus stops and highest bus service frequency, indicating an area with the highest quality of bus services in the study area. Major centres found within the central area include Old Park (Ogbete), Government Secretariat, Ogui Junction and Abakpa Junction. The central area was found to be characterized by the greatest concentration of business offices, Governmental and Judicial offices and major markets. Moving away from the core area toward the peripheries of the city, the quality of bus services was observed to be decreasing progressively.

In comparison between passenger waiting time indices and bus service frequency indices, a strong relationship between

them was found, showing that areas with high bus service frequency enjoy short passenger waiting time for the arrival of buses and vice versa.

Attempt was made to find out the bus fare charged. It was discovered that a flat fare of ₦5.00 per trip was approved by the State Government in 1994. Only the operators of big buses charged the approved bus fare of ₦5.00 per trip, while the minibus operators were not complying with the Government approved bus fare. The non-conformity of minibus operators to charge ₦5.00 per trip, was found to be reducing the personal accessibility of bus users to the services of mass transit buses in Enugu especially, in the city peripheries.

We went further to find out the providers of mass transit bus services in Enugu and noticed that bus services are provided mainly by individual entrepreneurs and partly by few government agencies and firms. They operate few buses ranging from one to ten in number. It was observed that the capacities of urban buses are in three categories - minibuses (14 - 18 passengers), medium buses (36 - 45 passengers) and big buses (80 - 120 passengers). Standing/sitting ratios of 3:1 are not uncommon during the peak periods when the passengers can squeeze in and hang onto them.

On the basis of these findings, some recommendations towards mass transit bus network improvement and bus service improvement as a whole, are made in the next section.

5.2 Implications of observations and Suggestions for Planning:

The first set of observations of low connectivity of mass transit bus network, inaccessibility and less accessibility of some major centres to the network imply that some areas are completely deprived of the services of mass transit bus, while some areas are not adequately covered by bus routes especially in the peripherial areas of Enugu. A number of strategies are needed to remedy the situation. We suggest that efforts should be geared up by both the State and Local Government Authorities, when funds are available, in the construction of link roads in some areas especially in those newly planned developing and undeveloped layouts in the city peripheries (Fig. 15). This will facilitate the routing of mass transit buses to such areas now and in future so as to enhance the accessibility of the areas to the mass transit bus network in the city. We also recommend that the State Government in conjunction with the Local Government Authorities should set up a body in the Transport Division of Enugu Town Planning Authority to be in-charge of routing of buses, implementation and control.

Further implications of our observations which concern the variations in passenger waiting time, walking distance/ or time, bus service frequency in the study area are that potential bus users in some centres mostly in the peripheries

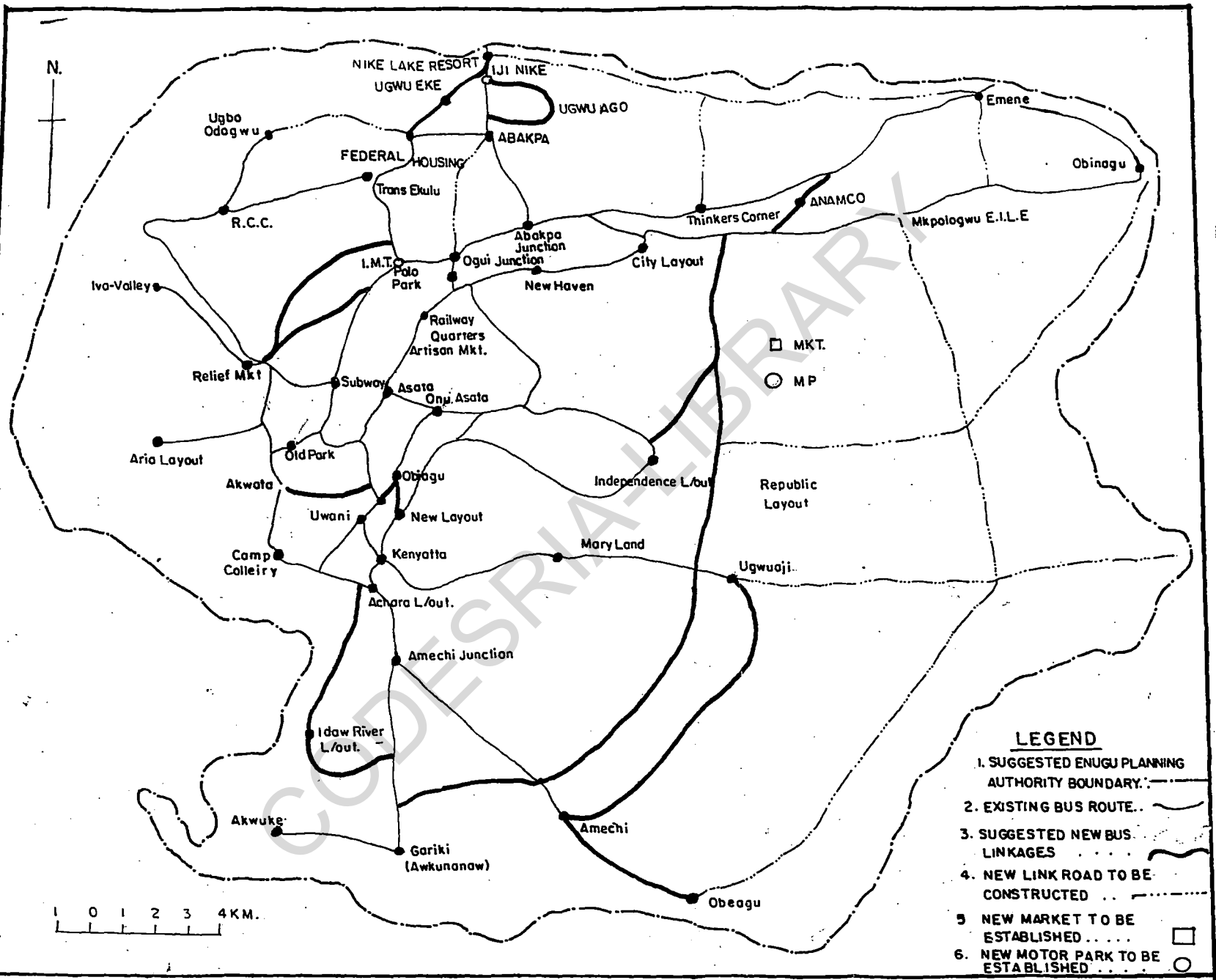


Fig. 11: SUGGESTED BUS SERVICES IMPROVEMENT PROJECTS (FIELDWORK) 1995

spend long time before getting buses to travel, walking for long distances before getting to the bus stops nearest to them to catch buses for their journeys and the number of transit buses serving the centres are grossly inadequate. All these variations greatly limit personal accessibility to the services of mass transit buses in such centres.

Strategies to correct these imbalances should involve extension of mass transit bus routes to link those major centres that were not linked before by bus routes, for instance, Idaw Rivers, Ugwu Eke and Ugwu Ago (Fig. 15) and to those major centres that recorded high mean passenger walking distances, for example, Gariki Awkunanaw (661 metres), Obiagu (669.75 metres and Ugwuaji (600.4 metres) as can be seen from Table 8. To make the new extension of bus route linkages functional, we suggest eleven new bus routes involving both the new and the old bus route linkages as displayed in Table 15. We also suggest that the cost-benefit analysis of the new suggested bus routes should be carried out to determine their desirability. These suggestions, if implemented, will greatly help to spread the services of bus in the study area and avail the majority of its inhabitants, the opportunity to use buses for intra-urban movements.

We further suggest that the mass transit bus companies owed by the State and Local Government Authorities operating intra-urban transport services, should be privatized to make

TABLE 15: New suggested mass transit bus routes in Enugu

Route No.	Route Description
1	Abakpa - Nike Lake Hotel - Federal Housing - Trans-Ekulu - Polo Park - Parklane Avenue - Works Road - Relief Market.
2	Abakpa - Abakpa Junction - Ogui Junction - I.M.T./ Polo Park - Abakiliki Lane - Works Road - Relief Market.
3.	Nike Road - Obinagu Road - Ugwu Ago - Abakpa Market - Abakpa Junction - Ogui Junction - IMT/ Polo Park - Garden Avenue - Okpara Avenue - Old Park.
4	Obiagu - UNEC Gate - Annang Street - Presidential Road - O'Conor Street - Ogui Road - Main Market - Old Park - Relief Market.
5	Abakpa - Abakpa Junction - Ogui Junction - Ogui Road - O'Conor Street - Presidential Road - Annang Street - UNEC Gate - Obiagu.
6	Gariki - Agbani Road - Idaw Rivers Layout - Ozalla Street - Coal Camp - Akwata - UNTH - Aria Road - Relief Market.
7	Independence Layout - UNEC Gate - Obiagu - Edinburgh Road - Zik Avenue - Amigbo Lane - Akwata - UNTh Aria Road - Relief Market.

8	Nwafor Market - Ebonyi Paint Road - Amechi Espress Junction - Ugwuaji Express Junction - Port Harcourt Express - ANAMCO - Oye Emene Market.
9	Zik Avenue - Edinburg Road - Obiagu - Onu Asata - Presidential Road - Okpara Square - WAEC - Ezilo Avenue - Port Harcourt Express - ANAMCO - Oye Emene Market.
10	Nwafor Market - Ebonyi Paint Road - Amechi - Ugwuaji
11	Relief Market - Secretariat - Main Market - Zik Avenue - Amigbo Lane - Akwata - Aria Road - Relief Market.

SOURCE: Fieldwork, 1995

them more functional. The government authorities should assist the companies by giving them loans to help them maintain old buses and procure new ones. This will help to reduce the inadequacy of buses in certain parts of Enugu especially during the peak periods.

Both the State and the Local Government Agencies responsible for the maintenance of link roads in the study area, should be properly funded to enable them maintain damaged roads so as to encourage bus operators to ply such roads and make their services available to the inhabitants of the areas linked by the roads. The maintenance of urban roads will also reduce bus travel-time in Enugu and make bus services very fast.

The implications of the existence of a central area with the highest level of bus services and high concentration of commercial and social activities, are that the central area is being over-loaded with business and social activities and bus services at the deteriment of the other parts of the city. Traffic congestions are also prevalent in the area especially during the peak periods. To solve these problems, we suggest the decongestion of business and social activities in the central area by locating new markets and motor parks in the other parts of the city (Fig. 15), mapping out new layouts at the peripheries for residential, governmental and recreational purposes. These strategies will help in no small measure to open up new areas of economic and social activities and to spread the bus services in the city and reduce the volume of traffic and traffic congestions in the central area.

Other implications of the observations of variations of bus stop spacings and low mass transit bus capacities are that the personal access to the bus services by bus users, is limited by low bus capacities being used and some bus users walk for long distances before getting to the nearest bus stops to them to catch buses for their travels. The poor bus stop facilities also implies that bus users suffer from beating of rain and scorching of sun while waiting for buses at bus stops. These problems can be solved by providing bus

stop sheds at different bus stops; adequate location of more bus stops should be created to reduce the distance walked by the bus commuters. Also, operators of low capacity buses should be encouraged by the government to form combines and give them soft loans to assist them procure big buses of high capacities making it possible for more persons to be moved at a time by buses from one major centre to another. Provision of high capacity buses will increase bus users' access to the bus services especially during the peak periods.

The implications of observation of arbitrary charging of bus fare per trip by minibus operators are that personal access of captive bus riders is reduced and they are forced to trek long distances when they cannot pay high bus fare. To solve the problems, we suggest that State and Local Government authorities in conjuction with National Union of Road Transport Workers (NURTW) should constitute a body or agency charged with the work of fixing and enforcing of bus fare in the city of Enugu.

The suggestions we have made above to improve the accessibility of major centres and the personal accessibility of bus users to mass transit bus services in Enugu, based on the analysis of this work, are in line with some of the suggestions put forward by the bus users during

the field work (Appendix A) as shown in Table 16. This also shows that the inhabitants of Enugu do perceive the problem of inadequacy of mass transit bus service and crave for solutions.

From Table 16, the provision of more buses by government mass transit bus companies has the highest value with 281, followed by maintenance of roads with the value of 251 and provision of bus spare parts has the least value of 49. This pattern of suggestions by the bus users has explicitly shown the need and the urgency required of the government to participate effectively in the provision of mass transit bus services in the study area.

5.3 Limitations of the study and suggestions for further work:

This research was limited by a number of constraints. One of such constraints is in the area of data collection and construction of indices of components of the level of service of mass transit bus. For want of sufficient data and time limitations, we deliberately considered only a selected components of level-of-service of mass transit bus and for easy computation, we simply added the collected data of each of the chosen components and divided by the number of occurrences of such data to find the average. It would have been much more realistic to consider many more

TABLE 16: Frequency of suggestions by bus users on the best ways to solve the problem of inadequacy of mass transit bus services in Enugu.

(*See KEY for interpretation of the variables)

Node Number	Node Title (Name of major Centre)	S_1	S_2	S_3	S_4	S_5
1.	Abakpa Nike	9	10	3	6	1
2.	Abakpa Junction	8	9	5	8	-
3.	Thinkers Corner	10	11	3	5	2
4.	Emene	13	14	3	10	4
5.	Obinagu	19	6	1	9	-
6.	Mkpologwu/E.I.L.E.	1	3	4	5	-
7.	City Layout	2	9	-	4	-
8.	New Haven	-	4	2	-	2
9.	Ogui Junction	4	14	4	6	3
10.	I.M.T./Polo Park	3	2	4	4	-
11.	Trans-Ekulu	15	10	6	9	1
12.	R.C.C. Camp/Ugbo-Odogwu	17	11	2	8	1
13.	Government Secretariat	4	6	1	5	1
14.	Relief Market	6	12	9	15	-
15.	Iva Valley	20	14	-	8	2
16.	Railway Quarters (Artisan Market)	1	10	4	9	3
17.	Asata	2	8	6	5	5
18.	Old Park (Ogbete)	10	10	4	9	6

19.	Onu Asata	8	9	4	7	2
20.	Obiagu	9	11	4	8	1
21.	New Layout	14	11	2	6	4
22.	Uwani	12	14	1	4	-
23.	Kenyatta	10	8	2	8	1
24.	Achara Layout	2	11	4	9	-
25.	Camp Colliery	1	4	-	4	-
26.	Independence Layout	5	8	2	4	4
27.	Amechi Junction	2	3	-	5	-
28.	Gariki (Awkunanaw)	4	5	4	6	7
29.	Mary Land	19	9	-	4	-
30.	Amechi	13	14	2	4	-
31.	Ugwuaji	16	11	-	4	-
	Total	251	281	86	198	49

SOURCE: Fieldwork, 1995

*Key for the interpretation of variables:

S_1 = Maintenance of urban roads.

S_2 = Provision of more buses by government mass transit bus companies.

S_3 = Fixing and enforcing of urban bus fare by government.

S_4 = Extension of bus routes.

S_5 = Maintenance and provision of bus spare parts.

components of the level of service of mass transit bus and use other methods of measuring the components.

Another area of limitation is in the model used in the research. The graph theoretic approach like other theories or models is limited. It is not only limited in its level of network abstraction but in the way a centre is defined. A node or centre in graph theory is defined as a point along a network which implies that the centres are homogeneous entities linked by transport network in spite of the fact that they are hardly homogeneous.

The collection of population data limited to some extent the analysis of this research. Our efforts to collect 1991 detailed population figures of the study area needed for the analysis in this research proved abortive as the government had not ordered the National Population Commission (NPC) to officially release such data by the time the data for this research were collected between 1994 and 1995. Even the 1963 census figures collected were not comprehensive and for that reason, population data were dropped in the analysis. It would have been better if the pattern of population distribution was related to the pattern of mass transit bus network accessibility to the major centres.

Finally, we reiterated the need for mass transit services especially by bus to be accessible to a greater majority of persons living in any urban environment in Nigeria especially

now that it is not easy to come-by any type of vehicle to be used as private car in the Third World countries. However, for a more and stable data on how mass transit services by bus can be accessible to a greater number of persons of different groups living in the study area and other urban areas of developing countries, it is necessary to collect data over a period of time and include different modes. At this juncture, we recommend other areas of research into the urban mass transit problems in Enugu and other cities in Nigeria and elsewhere. The areas include:-

(a) The accessibility of public transport to the transport poor (the elderly and deformed persons).

(b) The pattern of travel demands and the relationship with the pattern of population distribution.

(c) Provision of urban mass transit facilities; and

(d) Financing and managing of mass transportation in urban area.

A knowledge of the above listed problem areas in the field of urban transportation will greatly help the transport planners to provide a better mass transit system that will be accessible to different groups of a greater majority of persons living in the study area and other urban areas in Nigeria in future.

BIBLIOGRAPHY

ADEFOLALU, A.A. (1981): "Intra-Urban Transport Services in Lagos". Spatial Expansion and Concomitant Problems in the Lagos Metropolitan Area. Oyeleye (Ed). No. 1/Occasional Publications, Department of Geography, University of Lagos, Nigeria.

ADENJI, S.A. (1983): "Urban Development and Public Transport in Nigeria". Third World Planning Review. Vol. 5, No. 4 pp. 383 - 394.

ADENJI, S.A. (1983): "The Demand for Public Transport". Mimeograph N. I. S. E. R., Ibadan P. 1.

AGWU, B.O. (1987): "Relative Accessibility of Centres to the Road Network in Imo State". Unpublished M.Sc. Thesis, University of Nigeria, Nsukka.

ARMSTRONG-WRIGHT, A. (1993): Public Transport in Third World Cities. London - HMSO 1st edition.

BLACK, J. (1977): Public inconveniences access and travel in seven sydney suburbs, Australia, Australia National University.

BUCHANNAN, A.F. (1969): Traffic in Town H.M.S.O. London.

BUS AND COACH COUNCIL, (1983): "The Bus: The Key to Urban Mobility". A Documentary of a Bus Company. London.

CHAPIN, P.S. (1976): Urban Landuse Planning: Urban University of Ilinnoise Press.

CHORLEY, R.J. and HAGGATT, J. (1967): "Models in Geography". London.

COE, G.A. and JACKSON, R.L. (1977): "Measurement of Waiting Time in Assessments of Operational Changes in Bus Services" Transport and Road Research Laboratary Supplementary Report. No. 298, Crowthorne, Berk.

DALY, M.T. (1975): "Measuring accessibility in a rural context", in White, P.B. (ed), Rural Transport Seminar. Transport study group, Polytechnic of Central London, London.

de LANNOY, W. and VAN OUDHEUSDEN, D. (1978): "The accessibility of nodes in Belgian road network" Geojournal Vol. 2, No. 1 pp. 65 - 70.

DEMETSKY, M.J. and LIN, B.B. (1982): "Bus stop Location and Design" Transportation Engineering Journal of A.S.C.E - Proceeding of the American Society of Civil Engineers. Vol. 108, NO. TE4. pp. 313 - 325.

DUNPHY, R.T. (1973): "Transit accessibility as a determinant of automobile ownership". Highway Research Record. No. 472, pp. 63 - 71.

FAULKS, R. (1990): "Bus Provision in Developing World Cities". Developing World of Transport. Margaret (Ed) Grosvenor Press International pp. 94 - 97.

GARRISON, W.L. (1960): "Connectivity of the Interstate Highway System". Papers and Proceedings of the Regional Science Association. Vol. 6, pp. 121-137.

GEORGE, E.G. (1979): "Perceptions of Public Transportation" Public Transportation: Planning, Operations, and Management. George and Lester (Eds) Prentice-Hall INC. Englewood Cliffs, New Jerry.

HACK, J.S. (1976): "Landuse tranport interaction: a new approach to accessibility". Development Plans, Regional Strategies and Development of the Environment Working Note. No. 151 London.

HELLEWELL, S. (1984): "Public Transport: Brazilian Style". Transport, Vol. 5, No.2, pp. 24 - 25

HOYLE, B.S and SMITH, J. (1992): "Transport and Development", in Hoyle B.S and Knowles R.D. (ed). Modern Transport Geography. Belhaven Press, London and New York. pp. 11 - 30.

IGRAM, D.R. (1971): "The concepts of accessibility: a search for operational form". Regional Studies. Vol. 5, pp. 101 - 107.

JENDE HSU, A.M. and SURTI, V.H.M, (1976): Demand Model for bus Network Design" Transportation Journal of ASCE. Vol. 102, No. TE3.

JENNINUS, J.H. (1959): "Enugu - A geographical outline". Nigerian Geographical Journal. Vol. 3.

JONES, S.R. (1981): "Accessibility Measures: a Literature review". Transport and Road Research Laboratory TRRL. Report L.R. 967, Crowthorne.

JONES, S.R. (1984): Accessibility and Public Transport Use". Transport and Road Research Laboratory TRLL Report. LR 832, Crowthorne.

KANSKY, K.J. (1963): Structure of transport networks: relationships between network geometry and regional characteristics. University of Chicago, Department of Geography, Research Paper No. 84.

KOENIGS, J.G. (1975): "A theory of Urban accessibility: a new working tool for urban planners". Paper to PTRC Annual Meeting. London (PTRC).

LEONARDI, G. (1978): "Optimum facility Location by accessibility maximizing". Environment and Planning A. Vol. 10 pp. 267 - 305.

MARTIN, B.V. and DALY, P.M. (1978): West Yorkshire Transportation Studies 1: The analytic approach Traffic Engineering and Control.

MBA, H.C. (1992): "Inter and Intra Urban Transit Services in Nigeria: A Critical Evaluation" Eds. H. Chike Mba, Joy U. Agbazi and K.O. Efobi, Principle and Practice of Urban and Regional Planning in Nigeria, Mekslink Publishers Nigeria Awka, pp. 73 - 83.

McNEIL, D. (1976): "Urban Transport Planning in Developing Countries". Alternative Approaches and Guide for Further Research. pp. 1 - 59.

MINISTRY OF ECONOMIC DEVELOPMENT: Office of Budget and Planning, Research and Statistics Department, Government House Enugu. Enugu State Population Estimates, 1992 by Local Government areas and authonomous communities. Page 5.

MITCHELL, C.C.B. and TOWN, S.W. (1976): "Accessibility of various social groups to different activities". Transport and Road Research Laboratories. Crowthornes Berkshire.

NASH, C.A. (1976): Private Versus Public Transport. Macmillan Press, London. pp. 6 - 30.

NIGERIA, MINISTRY OF ECONOMIC DEVELOPMENT: First National Rolling Plan (1990-92), Lagos.

NWEKE, G.A. (1979): Journey to Work in Enugu. Unpublished B.Sc. Project, University of Nigeria, Nsukka.

NYSTUEN, J.D. and DACEY, M.F. (1961): "A Graph Theory Interpretation of Nodal Region Regions". Papers of the Regional Science Association. Vol. 7, pp. 29 - 42.

OCHAJNA, A.D. and BROWNLEE, A.T. (1977): "Simple indices for diagnosing rural transport problems". Traffic Engineering and Control. pp. 482 - 485.

OGBAZI, J.U. (1992): "Urban Transportation Planning". Eds. H. Chike Mba, Joy U. Ogbazi and K.O. Efobi. Principle and Practice of Urban and Regional in Nigeria. Mekslink Publishers Nigeria, Awka, pp. 64 - 72.

OJUKWU, N.G. (1986): The Relationship Between Flow and incidence of Road Accidents: A Case of Enugu, Unpublished B.Sc. Project, University of Nigeria, Nsukka.

OKPALA, D.C.I. (1977): Urban Traffic Management in Nigeria: The Necessity For Mass Transit Priorities". Transportation in Nigeria National Development. Onakomaiya and Ekanem (Eds) N.I.S.E.R. Ibadan.

OKOYE, T.O. (1975): "Enugu" in G.E.K. Ofomata (ed). Nigeria in Maps: Eastern States. Ethiope Publishing House Benin City, Nigeria.

OLADOJA, A. (1983): Urban Transport in Rapidly Growing Nigeria Cities: A Case Study of Ibadan. Unpublished Masters in Urban and Regional Planning MURP. Dissertation, University of Ibadan.

OMATSEYE, S., DEMOLA, A. CHUKWURA, H. and AINA, O. (1989): "Mass Transit: A dream Turns A Nightmare" African Concord. 13 February, Vol. 2, NO. 48, pp. 14-24.

ONIBOKUN, A.G. (1987): Spatial Planning Administration in the Federal Republic of Germany: Lesson for Nigeria. Published by N.I.S.E.R. and Friedrich Ebert Foundation, W.Germany.

ONOKALA, P.C. (1995): "The effect of Landuse on Road Traffic Accidents in Benin City, Nigeria". Journal of Transport Studies. Vol. 1, No. 1, pp. 35 - 45.

OSONDU, C.C. (1985): Road Traffic in Enugu: An Analysis of Traffic Flow and Road Linkage Pattern. Unpublished B.Sc. Project, University of Nigeria, Nsukka.

OWEN, W. (1966): "Strategy for Mobility: The Brookings Institute". Transport Research Programme, Washington D.C.

PIKE, D.H., FULLER, P.E, and WHITE, M. (1976): "Telford Transportation Study: An aid to the preliminary evaluation of long term public transport options" Traffic Engineering Control. pp. 52-3

POPPER, R.J. and HOEL, L.A.(1976): "Mobility Evaluation for Urban Public Transportation". Transportation Planning and Technology 3, pp. 131 - 41.

SCHINDLER, R and FERRARI, M.G.(1967) "Auto Ownership as affected by transportation system alternatives" Traffic Engineering, pp. 24-8

SMERK, G.K. (1974): Urban Mass Transportation, A Dozen Years of Federal Policy. Indiana University Press, Bloomington and London.

TAFFE, E.T. and GAUTHIER, H.L. (1973): Geography of Transportation. Foundation of Economic geography Series; Englewoods-Clift M.J.

TRANSPORT COMPANY OF ANAMBRA STATE LTD (1989): Internal Memoradum - Tracas Limited 12 months. Operations Sept. 1988 - August 1989. Vol. 1 planning Office Enugu.

TOLLEY, R.S. and TURTON, B.J. (1995): Transport Systems, Policy and Planning. First Edition. Longman Scientific and Technical, London.

TURTON, B.J. AND KNOWLES, R.D. (1992): "Urban Transport Problems and Solutions in Hoyle B.S. and Knowles R.D. (e.ds). Modern Transport Geography. Belhaven Press, London and New York. pp. 81 - 102.

TURTON, B.J. (1992): "Urban Transport Patterns" in Hoyle B.S. and Knowles R.D. (eds). Modern Transport Geography. Belhaven Press, London and New York. pp. 67 - 79.

UDO, K.R. (1978): A Comprehensive Geography of West Africa: Heinemann Educational Books (Nigeria) Ltd. Ibadan 1st ed.

UGWU, C.A. (1984): "The Influence of Socio-economic activities on the spatial distribution of traffic flow in Enugu". Unpublished B.Sc project, University of Nigeria, Nsukka.

UME, E.C. (1977): "Transport Problems, Programmes, and Proposal in Anambra State in Onakomaiya, S.O. and Ekanem, S.F. (eds). Transportation in Nigeria National Development: Proceeding of a Conference Held at the University of Ibadan, pp. 550 - 561.

UME, E.N. (1991): A Geographical Appraisal of the Effect of Government Bus Transit Programme in Ibadan. Unpublished B.Sc. Project, University of Nigeria, Nsukka.

VOLVO. N. (1979): "Model Urban Lahove Pakistan" An Initial Study.

WARD, M.W. (1969): Trends in Geography - An Introductory Survey. Chapter 16. Pergaman Press. PP. 164-172.

WERNER, C. (1968): "The role of topology and geometry in optimal network design" Regional Science Association Papers and Proceedings Vol. 21, pp. 173 - 189.

WILBER and ASSOCIATES. (1965): "The Interaction between Public Transportation and other Social Activities" - A System Approach Transportation Research, Vol. 12, pp. 83 - 89.

WILLIAMS, H.C.W.L. (1976): "Travel demand models, duality relations and user benefit analysis". Journal of Regional Science. Vol. 16, No.2, pp. 147- 66.

WIREDU, Y.K. (1989): "Minibuses in an African city", Paratransit. 4 22- 3

WORLD BANK (1986): "Urban Transport" A World Bank Policy Paper. Washington D.C. 20433, U.S.A. pp. 1-44

WORLD BANK TECHINICAL PAPER (1987): Bus Services: reducing costs, raising standards. No. 68

APPENDIX A

QUESTIONNAIRE FOR BUS USERS

1. Name of Bus Stop: .....

2. Name of Major Centre of Bus Stop Location .....

3. Sex: (a) Male (b) Female

4. Age: (a) Under 12 years (b) 13 - 24 years
   (c) 25 - 59 years (d) 60 years and above.

5. Occupation Status: (a) Farmer (b) Civil servant
   (c) Trader (d) Student (e) Others (specify)
   .....

6. How long do you usually wait in this bus stop before getting a bus to move you?
   (a) 0 - 4 minutes (b) 5 - 10 minutes (c) 11 - 20 min.
   (d) 21 - 30 minutes (e) More than 30 minutes

7. Is this waiting time? (a) short enough, (b) long
   (c) too long.

8. How far do you walk from your home/office (origin/ destination) to this bus stop?
   (a) 0 - 300 metres (b) 301 - 600 metres
   (c) 601 - 900 metres (d) 900 - 1000 metres and above.

9. How long does it take you to walk to this bus stop?
   (a) Less than 5 minutes (b) 5 - 10 minutes
   (c) 11 - 20 (d) 21 - 30 minutes (e) More than 30 mins.

10. How many times do you usually travel by bus in a week?
    (a) 1 - 2 times (b) 3 - 4 times (c) 5 - 7 times.

11. Your trip purpose most of the time using bus is:
    (a) work (b) shopping (c) Religious (d) Educational
    (e) Recreational (f) Others (specify) .....

12. Do you usually get Enugu State Transport Company (ENTRACO) bus in this bus stop to move you? (a) Yes (b) No.

13. If yes, how long do you normally wait in this bus stop before getting ENTRACO bus to move you?

(a) less than 10 minutes (b) 11 - 20 minutes

(c) 21 - 30 minutes (d) More than 30 minutes.

14. How much do you pay as fare per trip using ENTRACO bus?

(a) less than ₦5.00 (b) ₦5.00 (c) More than ₦5.00.

15. How much do you pay as fare per trip using other buses?

(a) ₦5.00 (b) ₦10.00 (c) More than ₦10.00.

16. Do you have private car?

(a) Yes (b) No.

17. When the services of buses are not readily available, what is your alternative mode usually used for your trips?

(a) bicycle (b) motorcycle (c) taxi

(d) private car.

18. What do you see as the major problems facing the bus transport service in Enugu?

(a) .....

(b) .....

(c) .....

19. What are your suggestions for solving such problems?

(a) .....

(b) .....

(c) .....

APPENDIX B

BUS SERVICE FREQUENCY PROFORMA

1. Name of Bus Stop: .....

2. Name of Major Centre of Bus Stop Location:

.....

3. Number of Buses Arriving:

PERIOD	(a) BIG BUS	(b) MINI BUS	TOTAL a + b
6 - 7 am	.....	.....	.....
7.01 - 8 am	.....	.....	.....
8.01 - 9 am	.....	.....	.....
9.01 - 10 am	.....	.....	.....
10.01 - 11 am	.....	.....	.....
11.01 - 12 noon	.....	.....	.....
12.01 - 1 pm	.....	.....	.....
1.01 - 2 pm	.....	.....	.....
2.01 - 3 pm	.....	.....	.....
3.01 - 4 pm	.....	.....	.....
4.01 - 5 pm	.....	.....	.....
5.01 - 6 pm	.....	.....	.....

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APPENDIX C

BUS OPERATORS' QUESTIONNAIRE

1. Type of Operator:
   (a) Government agency; (b) Corporate body
   (c) Individual.

2. Name of Operator: .....

3. Number of buses in circulation .....

4. Types of buses:

Type of Bus	Number
Big bus	
Medium bus	
Minibus	

5. Capacities of buses:

Bus Type	Number Sitting	Number Standing	Total
Big bus			
Medium bus			
Minibus			

6. Route(s) plied in Enugu

   (a) .....
   .....

   (b) .....
   .....

   (c) .....
   .....

7. Bus fare charged per trip .....

8. Is the bus fare fixed by:

   (a) The operators themselves;
   (b) Local Government;
   (c) State government;
   (d) National Union of Road Transport Union (NURTU).

9. What are the major problems facing bus operators in the city of Enugu?

   (a) .....

   .....

   (b) .....

   .....

   (c) .....

   .....

10. What are your suggestions for solving these problems?

   (a) .....

   .....

   (b) .....

   .....

   (c) .....

   .....

APPENDIX D - 1: CORRELATION BETWEEN MEAN BUS SERVICE FREQUENCY (X) AND MEAN PASSENGER WAITING TIME (Y)

NODE NO	NODE TITLE (NAME OF MAJOR CENTRE)	MEAN BUS SERVICE FREQU-ENCY (X)	MEAN PASS-ENGER WAITING TIME (Y)	XY	X^2	Y^2
1.	ABAKPA NIKE	113	15.53	1754.89	12769	241.1809
2.	ABAKPA JUNCTION	114	10.85	1236.90	12996	117.7225
3.	THINKERS CORNER	82	21.44	1758.08	6724	459.6736
4.	EMENE	87	16.49	1434.63	7569	271.9201
5.	OBINAGU	25	29.12	728	625	847.9744
6.	MKPOLOGWU/E.I.L.E	24	26.63	639.12	576	709.1569
7.	CITY LAYOUT	92	9.91	911.72	8464	98.2081
8.	NEW HAVEN	78	10.60	826.80	6084	112.36
9.	OGUI JUNCTION	128	10.69	1368.32	16384	114.2761
10.	IMT/POLO PARK	107	12.30	1316.10	11449	151.29
11.	TRANS EKULU	69	20.74	1431.06	4761	430.1476
12.	R.C.C. CAMP/UGBO-ODOGWU	53	25.15	1351.50	2809	650.25
13.	GOVERNMENT SECRETARIAT	103	10.15	1045.45	10609	103.0225
14.	RELIEF MARKET	149	12.53	1866.97	22201	157.0009
15.	IVA VALLEY	11	21.28	234.08	121	452.8384
16.	RAILWAY QUARTERS/ ARTISAN MARKET	75	12.87	965.25	5625	165.6369
17.	ASATA	99	12.06	1193.94	9801	145.4436
18.	OLD PARK (OGBETE)	241	9.84	2371.44	58081	96.8256
19.	ONU ASATA	55	15.67	861.85	3025	245.5489
20.	OBIAGU	61	13.50	823.50	3721	182.25
21.	NEW LAYOUT	22	12.05	265.10	484	145.2025
22.	UWANI	61	22.58	1377.38	3721	509.8564
23.	KENYATTA	21	19.60	411.60	441	384.16
24.	ACHARA LAYOUT	74	12.80	947.20	5476	163.84
25.	CAMP COLLIERY	15	15.39	230.85	225	236.8521
26.	INDEPENDENCE LAYOUT	22	14.50	319.	484	210.25
27.	AMECHI JUNCTION	70	13.39	937.30	4900	179.2921
28.	GARIKI (AWKUNANAW)	79	14.03	1108.37	6241	196.8409
29.	MARY LAND	2	30.16	60.32	4	909.6256
30.	AMACHI	3.4	26.3	89.42	11.56	691.69
31.	UCWUAJI	1.3	30.31	39.403	1.69	918.6961

ΣX = 2136.7

ΣX^2 = 226383.25

ΣXY = 29905.543

ΣY = 528.81

ΣY^2 = 10299.033

N = 31

Correlation Coefficient (rxy) is given as:

$$rxy = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{(N\Sigma X^2 - (\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}}$$

$$= \frac{31 \times 29905.543 - (2136.7 \times 528.81)}{\sqrt{(31 \times 226383.25 - (2136.7)^2\ (31 \times 10299.033 - (528.81)^2}}$$

$$= \frac{927071.83 - 1129908.3}{\sqrt{(7017880.8 - 4565486.9)(319270.02 - 279640.02)}}$$

$$= \frac{- 202836.5}{\sqrt{(2452393.9)(39630.)}}$$

$$= \frac{- 202836.5}{311750.49}$$

$$= - 0.6506373$$

Hence the correlation coefficient (rxy) between mean bus service frequency and mean passenger waiting time is - 0.651.

APPENDIX D - 2: TEST OF SIGNIFICANCE FOR THE CORRELATION COEFFICIENT BETWEEN MEAN BUS SERVICE FREQUENCY AND MEAN PASSENGER WAITING TIME.

The Student's "t" test is given by:

$$t = \frac{r\sqrt{n-2}}{\sqrt{(1-r^2)}}$$

Where $r = -0.678$

$n = 31$

Hence $$t = \frac{0.678\sqrt{29}}{\sqrt{1 - (0.678)^2}}$$

$$= \frac{0.678 \times 5.38}{\sqrt{1 - 0.4597}}$$

$$= \frac{3.648}{0.5403}$$

$$= 6.8$$

Ho: there is no relationship between mean bus service frequency and mean passenger waiting time.

H_1: there is relationship between the two.

Degree of freedom (df) = (n-2) = 29

Calculated value = 6.8

At 29 df $t_{0.05}$ = 1.70

Since 6.8 is greater than 1.70, we reject Ho and accept H_1.

Thus there is a strong relationship between mean bus service frequency and mean passenger waiting time.

APPENDIX E: FINAL MATRIX OF SHORTEST BUS ROUTE DISTANCES PATH IN ENUGU (IN KILOMETRE)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Acc. Index
1	0	3	6	11	14	7	5	7	5	6	4	6	8.5	11	13.5	6.6	8.6	9.5	9.6	11.1	14	12	13.5	15.5	12	10	17	19	16	20	20.5	321.5
2.	3	0	3	8	11	4	2	4	2	3.5	7	9	6	7	9.5	3.6	5.6	7	6.6	8.1	11	9.5	12.5	14.6	9.5	7	16	18	15	19	17.5	259.5
3.	6	3	0	5	8	7	5	7	5	6.5	11	12	9	10	12.5	6.6	8.6	10	9.6	11.1	14	12.5	15.5	17.6	12.5	10	19	21	18	22	20.5	335.5
4.	11	8	5	0	3	7.5	9.5	11.5	10	11.5	15	17	14	15	17.5	11.6	3.5	15	14.6	16.1	19	17.5	20.5	22.6	17.5	15	24	26	23	27	25.5	453.9
5.	14	11	8	3	0	4.5	6.5	8.5	10.5	12	15.5	17.5	14.5	15.5	18	12.1	14.1	15.5	15.1	16.6	19.5	18	21	23.1	18	15.5	24.5	26.5	23.5	27.5	26	475.5
6.	7	4	7	7.5	4.5	0	2	4	6	7.5	11	13	10	11	13.5	7.6	9.6	11	10.6	12.1	15	13.5	16.5	18.6	13.5	11	20	22	19	23	21.5	352.5
7	5	2	5	9.5	6.5	2	0	2	4	5.5	9	11	8	9	11.5	5.6	7.6	9	8.6	10.1	13	11.5	14.5	16.6	11.5	9	18	20	17	21	19.5	302.5
8.	7	4	7	11.5	8.5	4	2	0	2	3.5	5.5	7.5	6	7	9.5	3.6	5.6	7	6.6	8.1	11	9.5	12.5	14.6	9.5	7	16	20	15	19	17.5	265.5
9.	5	2	5	10	10.5	6	4	2	0	1.5	3.5	5.5	4	5	7.5	1.6	3.6	5	4.6	6.1	9	7.5	10.6	12.6	7.5	5	14	16	13	17	15.5	220.1
10.	6	3.5	6.5	11.5	12	7.5	5.5	3.5	1.5	0	2	4	2.5	3.5	6	3.1	5.1	3.5	6.1	7.6	10.5	6	7	9	6	6.5	11	13	10	14	12.5	217.4
11.	4	7	11	15	15.5	11	9	5.5	3.5	2	0	2	4.5	7	9.5	5.1	7.1	5.5	8.1	9.6	12.5	8	9.5	11.5	8	8.5	13	15	12	16	14.5	270.4
12.	6	9	12	17	17.5	13	11	7.5	5.5	4	2	0	6	5	7.5	7.1	10.5	7	8.5	12	14.5	9.5	7.5	9.5	9.5	10.5	14.5	16.5	13.5	17.5	16	307.1
13.	8.5	6	9	14	14.5	10	8	6	4	2.5	4.5	6	0	1	3.5	5.6	4.5	1	5.5	7	13	3.5	4.5	6.5	3.5	9	8.5	10.5	7.5	11.5	10	209.1
14.	11	7	10	15	15.5	11	9	7	5	3.5	7	5	1	0	2.5	6.6	5.5	2	6.5	7	14	4.5	5.5	7.5	4.5	10	9.5	11.5	8.5	12.5	11	236.1
15.	13.5	9.5	12.5	17.5	18	13.5	11.5	9.5	7.5	6	9.5	7.5	3.5	2.5	0	9.1	8	4.5	9	9.5	16.5	7	8	10	7	12.5	12	14	11	15	13.5	308.6
16.	6.6	3.6	6.6	11.6	12.1	7.6	5.6	3.6	1.6	3.1	5.1	7.1	5.6	6.6	9.1	0	2	5.5	3	4.5	10.6	8	9	11	8	6.6	13	15	12	16	14.5	234.2
17.	8.6	5.6	8.6	3.5	14.1	9.6	7.6	5.6	3.6	5.1	7.1	10.5	4.5	5.5	8	2	0	3.5	1	2.5	12.6	6	7	9	6	8.6	11	13	10	14	12.5	226.2
18.	9.5	7	10	15	15.5	11	9	7	5	3.5	5.5	7	1	2	4.5	5.5	3.5	0	4.5	6	14	2.5	3.5	5.5	2.5	8.5	7.5	9.5	6.5	10.5	9	211.5
19.	9.6	6.6	9.6	14.6	15.1	10.6	8.6	6.6	4.6	6.1	8.1	8.5	5.5	6.5	9	3	1	4.5	0	1.5	13.6	7	8	10	7	9.6	12	14	11	15	13.5	260.3
20.	11.1	8.1	11.1	16.1	16.6	12.1	10.1	8.1	6.1	7.6	9.6	12	7	7	9.5	4.5	2.5	6	1.5	0	15.1	8.5	9.5	11.5	8.5	11.1	13.5	15.5	12.5	16.5	15	303.8
21.	14	11	14	19	19.5	15	13	11	9	10.5	12.5	14.5	13	14	16.5	10.6	12.6	14	13.6	15.1	0	2	1	3	6	4	5	7	4	8	6.5	318.9
22.	12	9.5	12.5	17.5	18	13.5	11.5	9.5	7.5	6	8	9.5	3.5	4.5	7	8	6	2.5	7	8.5	2	0	1	4	5	6	6	8	4	9	6.5	233.5
23.	13.5	12.5	15.5	20.5	21	16.5	14.5	12.5	10.6	7	9.5	7.5	4.5	5.5	8	9	7	3.5	8	9.5	1	1	0	2	5	5	4	6	3	7	5.5	255.6
24.	15.5	14.6	17.6	22.6	23.1	18.6	16.6	14.6	12.6	9	11.5	9.5	6.5	7.5	10	11	9	5.5	10	11.5	3	4	2	0	3	7	2	4	5	5	7.5	299.3
25.	12	9.5	12.5	17.5	18	13.5	11.5	9.5	7.5	6	8	9.5	3.5	4.5	7	8	6	2.5	7	8.5	6	5	5	3	0	10	5	7	8	8	10.5	249.5
26.	10	7	10	15	15.5	11	9	7	5	6.5	8.5	10.5	9	10	12.5	6.6	8.6	8.5	9.6	11.1	4	6	5	7	10	0	9	11	8	12	10.5	273.4
27.	17	16	19	24	24.5	20	18	16	14	11	13	14.5	8.5	9.5	12	13	11	7.5	12	13.5	5	6	8	2	5	9	0	2	7	3	5.5	342.5
28.	19	18	21	26	26.5	22	20	18	16	13	15	16.5	10.5	11.5	14	15	13	9.5	14	15.5	7	8	6	4	7	11	2	0	9	5	8.5	401.5
29.	16	15	18	23	23.5	19	17	15	13	10	12	13.5	4.5	8.5	11	12	10	6.5	11	12.5	4	4	3	5	8	8	7	9	0	10	2.5	334.5
30.	20	19	22	27	27.5	23	21	19	17	14	16	17.5	11.5	12.5	15	16	14	10.5	15	16.5	8	9	7	5	8	12	3	5	10	0	9.5	430.5
31.	20.5	17.5	20.5	25.5	26	21.5	19.5	17.5	15.5	12.5	14.5	16	10	11	13.5	14.5	12.5	9	13.5	15	6.5	6.5	5.5	7.5	10.5	10.5	5.5	8.5	2.5	9.5	0	399

Appendix F: FINAL MATRIX OF SHORTEST BUS ROUTE DISTANCE PATH (IN MINUTES)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Acc. Index
1	0	7	12	25	37	15.5	10.5	15.5	10	13	8	12	19	18	33	14.5	19.5	23.5	22.5	26.5	43	33.5	38.5	38.5	31.5	25	43	51.5	63	67.5	75	852
2	7	0	5	18	30	8.5	3.5	8.5	3	7	15	19	13	18	33	7.5	12.5	17.5	15.5	19.5	36	27.5	32.5	32.5	25.5	18	52	61	56	77	68	747
3	12	5	0	13	25	13.5	8.5	13.5	8	12	20	24	18	23	38	12.5	19.5	22.5	20.5	24.5	41	32.5	37.5	37.5	30.5	23	57	66	61	82	73	874
4	25	18	13	0	12	19	21.5	26.5	21	25	33	37	31	36	51	25.5	32.5	35.5	33.5	37.5	54	45.5	50.5	50.5	43.5	36	70	79	74	95	86	1217.5
5	37	30	25	12	0	7	12	17	20.5	22.5	30	34.5	26.5	33.5	48.5	37.5	28	33	31	35	51.5	43	48	48	41	48	67.5	76.5	71.5	92.5	83.5	1191.5
6	15.5	8.5	13.5	19	7	0	5	10	13.5	15.5	23.5	27.5	19.5	26.5	41.5	16	21	26	24	28	44.5	36	41	41	34	26.5	60.5	69.5	64.5	85.5	76.5	940.5
7	10.5	3.5	8.5	21.5	12	5	0	5	8.5	10.5	18.5	22.5	14.5	21.5	36.5	11	16	21	19	23	39.5	31	36	36	29	21.5	55.5	64.5	59.5	80.5	71.5	813
8	15.5	8.5	13.5	26.5	17	10	5	0	3.5	7.5	12.5	16.5	13.5	18.5	33.5	8	13	18	16	20	36.5	28	33	33	26	18.5	52.5	61.5	56.5	77.5	68.5	768
9	10	3	8	21	20.5	13.5	8.5	3.5	0	4	9	13	10	15	30	4.5	9.5	14.5	12.5	16.5	33	24.5	29.5	29.5	22.5	15	49	58	53	74	65	679.5
10	13	7	12	25	22.5	15.5	10.5	7.5	4	0	5	9	6	11	26	8.5	13.5	10.5	16.5	20.5	37	20.5	25.5	25.5	18.5	19	29.5	38.5	57	54.5	69	638
11	8	15	20	33	30	23.5	18.5	12.5	9	5	0	4	11	10	25	13.5	18.5	15.5	21.5	25.5	42	25.5	30.5	30.5	23.5	24	35	43.5	62	59.5	74	269
12	12	19	24	37	34.5	27.5	22.5	16.5	13	9	4	0	19	6	21	17.5	19	12.5	22	26	46	22	27	27	20	28	31	40	43	56	55	757
13	19	13	18	31	26.5	19.5	14.5	13.5	10	6	11	19	0	5	20	14.5	11.5	4.5	14.5	18.5	43	14.5	19.5	19.5	12.5	25	23.5	32.5	35.5	48.5	47.5	591
14	18	18	23	36	33.5	26.5	21.5	18.5	15	11	10	6	13	0	15	27.5	13	6	16	20	56	16	21	21	14	37.5	25	34	37	50	49	708
15	33	33	38	51	48.5	41.5	36.5	33.5	30	26	25	21	20	15	0	42.5	28	21	31	35	71	31	36	36	29	52.5	40	49	52	65	64	1135
16	14.5	7.5	12.5	25.5	37.5	16	11	8	4.5	8.5	13.5	17.5	14.5	27.5	42.5	0	5	12	8	12	37.5	22	27	27	20	19.5	31	40	43	56	69.5	690.5
17	19.5	12.5	19.5	32.5	28	21	16	13	9.5	13.5	18.5	19	11.5	13	28	5	0	7	3	7	42.5	17	22	22	15	24.5	26	35	38	51	50	640
18	23.5	17.5	22.5	35.5	33	26	21	18	14.5	10.5	15.5	12.5	4.5	6	21	12	7	0	10	14	47.5	10	15	15	8	31.5	19	28	31	44	43	616.5
19	22.5	15.5	20.5	33.5	31	24	19	16	12.5	16.5	21.5	22	14.5	16	31	8	3	10	0	4	45.5	20	25	25	18	27.5	29	38	41	54	53	717
20	26.5	19.5	24.5	37.5	35	28	23	20	16.5	20.5	25.5	26	18.5	20	35	12	7	14	4	0	49.5	24	29	29	22	31.5	33	42	45	58	57	833
21	43	36	41	54	51.5	44.5	39.5	36.5	33	37	42	46	43	56	71	37.5	42.5	47.5	45.5	49.5	0	9	4	12	19	18	16	25	20	41	32	1092.5
22	33.5	27.5	32.5	45.5	43	36	31	28	24.5	20.5	25.5	22	14.5	16	31	22	17	10	20	24	9	0	5	14	21	27	18	27	21	43	33	742
23	38.5	32.5	37.5	50.5	48	41	36	33	29.5	25.5	30.5	27	19.5	21	36	27	22	15	25	29	4	5	0	8	15	22	12	21	16	37	28	792
24	38.5	32.5	37.5	50.5	48	41	36	33	29.5	25.5	30.5	27	19.5	21	36	27	22	15	25	29	12	14	8	0	7	30	4	13	24	29	36	801
25	31.5	25.5	30.5	43.5	41	34	29	26	22.5	18.5	23.5	20	12.5	14	29	20	15	8	18	22	19	21	15	7	0	37	11	20	31	36	43	724
26	25	18	23	36	48	26.5	21.5	18.5	15	19	24	28	25	37.5	52.5	19.5	24.5	31.5	27.5	31.5	18	27	22	30	37	0	34	43	38	59	50	910
27	43	52	57	70	67.5	60.5	55.5	52.5	49	29.5	35	31	23.5	25	40	31	26	19	29	33	16	18	12	4	11	34	0	9	28	25	40	1026
28	51.5	61	66	79	76.5	69.5	64.5	61.5	58	38.5	43.5	40	32.5	34	49	40	35	28	38	42	25	27	21	13	20	43	9	0	37	34	49	1286
29	63	56	61	74	71.5	64.5	59.5	56.5	53	57	62	43	35.5	37	52	43	38	31	41	45	20	21	16	24	31	38	28	37	0	53	12	1323.5
30	67.5	77	82	95	92.5	85.5	80.5	77.5	74	54.5	59.5	56	48.5	50	65	56	51	44	54	58	41	43	37	29	36	59	25	34	53	0	65	1750
31	75	68	74	86	83.5	76.5	71.5	68.5	65	69	74	55	47.5	49	64	69.5	50	43	53	57	32	33	28	36	43	50	40	49	12	65	0	1687

APPENDIX G-1: CORRELATION BETWEEN BUS ROUTE DISTANCE ACCESSIBILITY INDEX (X) AND MEAN PASSENGER WAITING TIME (Y)

NODE NO	NODE TITLE (NAME OF MAJOR CENTRE)	BUS ROUTE DIST-ANCE ACCESS-IBILITY X	MEAN PASS-ENGER WAI-TING TIME Y	XY	X^2	Y^2
1.	ABAKPA NIKE	321.5	15.53	4992.895	103362.25	241.1809
2.	ABAKPA JUNCTION	259.5	10.85	2815.575	67340 .25	117.7225
3.	THINKERS CORNER	335.5	21.44	7193.12	112560.25	459.673[illegible]
4.	EMENE	453.9	16.49	7484.811	206025.21	271.92[illegible]
5.	OBINAGU	475.5	29.12	13846.56	226100.25	847.9[illegible]
6.	MKPOLOGWU/E.I.L.E.	352.5	26.63	9387.075	124251.25	709.1[illegible]
7.	CITY LAYOUT	302.5	9.91	2997.775	91506.25	98.20[illegible]
8.	NEW HAVEN	265.5	10.60	2814.3	70490.25	112.36
9.	OGUI JUNCTION	220.1	10.69	2352.869	48444.01	114.276[illegible]
10.	I.M.T/POLO PARK	217.4	12.30	2674.02	47262.76	151.29
11.	TRANS. EKULU	270.1	20.74	5601.874	72954.01	430.1476
12.	R.C.C. CAMP/UGBO-ODOGWU	307.1	25.50	7831.05	94310.41	650.25
13.	GOVERNMENT SECRETARIAT	209.1	10.15	2122.365	43722.81	103.0225
14.	RELIEF MARKET	236.1	12.53	2958.333	55743.21	157.0009
15.	IVA VALLEY	308.6	21.28	6567.008	95233.96	452.8384
16.	RAILWAY QUARTERS/ ARTISAN MARKET	234.2	12.87	3014.154	54849.64	165.6369
17.	ASATA	226.2	12.06	2727.972	51166.44	145.4436
18.	OLD PARK (OGBETE)	211.5	9.84	2081.16	44732.25	96.8256
19.	ONU ASATA	260.3	15.67	4078.901	67756.09	245.5484
20.	OBIAGU	303.8	13.50	4101.3	92294.44	182.25
21.	NEW LAYOUT	318.9	12.05	3852.312	101697.21	145.2025
22.	UWANI	233.5	22.58	5265.425	54522.25	509.8564
23.	KENYATTA	255.6	19.60	5009.76	65331.36	384.16
24.	ACHARA LAYOUT	299.3	12.80	3831.04	89580.49	163.84
25.	CAMP COLLIERY	249.5	15.39	3839.805	62250.25	236.852
26.	INDEPENDENCE LAYOUT	273.4	14.50	3964.3	74747.56	210.25
27.	AMECHI JUNCTION	342.5	13.39	4586.075	117306.25	179.2921
28.	GARIKI (AWKUNANAW)	401.5	14.03	5633.045	161202.25	196.8409
29.	MARY-LAND	334.5	30.16	10088.52	111850.25	909.6250
30.	AMECHI	430.5	26.3	11322.15	185330.25	691.69
31.	UGWUAJI	399.	30.31	12093.69	159201.	918.69[illegible]

ΣX = 9306.1

ΣX^2 = 2953170.1

ΣXY = 167129.24

ΣY = 528.81

ΣY^2 = 10299.033

N = 31

Correlation Coefficient (rxy) is given as:

$$rXy = \frac{N\Sigma XY - (\Sigma X)(\Sigma Y)}{\sqrt{(N\Sigma X^2-(\Sigma X)^2)(N\Sigma Y^2 - (\Sigma Y)^2)}}$$

$$= \frac{(31 \times 167129.24) - (9306.1 \times 528.81)}{\sqrt{(31 \times 2953170.1)-(9306.1)^2)(31x10299.033-(528.81)^2}}$$

$$= \frac{5181006.4 - 4921158.7}{\sqrt{(91548273 - 86603497)(319270.02 - 279640.02)}}$$

$$= \frac{259847.7}{\sqrt{(4944776)(39630)}}$$

$$= \frac{259847.7}{\sqrt{1.95961 \times 10^{11}}}$$

$$= \frac{259847.7}{442675.36}$$

$$= 0.5869938$$

Hence the correlation coefficient (rxy) between Bus route distance accessibility and mean passenger waiting time is 0.587.

APPENDIX G - 2: TEST OF SIGNIFICANCE FOR THE CORRELATION COEFFICIENT BETWEEN BUS ROUTE DISTANCE ACCESSIBILITY INDEX AND MEAN PASSENGER WAITING TIME

The student's test is given by

$$t = \frac{r\sqrt{n-2}}{\sqrt{(1-r^2)}}$$

where $r = 0.587$

$n = 31$

Hence $$t = \frac{0.587\sqrt{29}}{\sqrt{1-(0.587)^2}}$$

$$= \frac{0.587 \times 5.39}{\sqrt{1-0.3446}}$$

$$= \frac{3.16393}{0.6554}$$

$$= 4.8$$

Ho: there is no relationship between bus route distance accessibility and passenger waiting time.

H_1: there is a relationship between the two.

Degree of freedom (df) = (n-2) = 29

Calculated Value = 4.8

At 29df t0.05 = 1.70

Since 4.8 is greater than 1.70, we reject Ho and accept H_1

Thus there is a good relationship between bus route distance accessibility and passenger waiting time.

APPENDIX H - 1: CORRELATION BETWEEN BUS ROUTE DISTANCE ACCESSIBILITY INDEX (X) AND MEAN BUS SERVICE FREQUENCY (Y)

NODE NO	NODE TITLE (NAME OF MAJOR CENTRE)	BUS ROUTE DISTANCE ACCESS-IBILITY (X)	MEAN BUS SERVICE FREQU-ENCY (Y)	XY	X^2	Y^2
1.	ABAKPA NIKE	321.5	113	36329.5	103362.25	12769
2.	ABAKPA JUNCTION	259.5	114	29583	67340.25	12996
3.	THINKERS CORNER	335.5	82	27511	112560.25	6724
4.	EMENE	453.9	87	39489.3	206025.21	7569
5.	OBINAGU	475.5	25	11887.5	226100.25	625
6.	MKPOLOGWU/E.I.L.E.	352.5	24	8460	124256.25	576
7.	CITY LAYOUT	302.5	92	27830	91506 .25	8464
8.	NEW HAVEN	265.5	78	20709	70490.25	6084
9.	OGUI JUNCTION	220.1	128	28172.8	48444 .01	16384
10.	IMT/POLO PARK	217.4	107	23261.8	47262.76	11449
11.	TRANS EKULU	270.1	69	18636.9	72954.01	4761
12.	R.C.C. CAMP/UGBO-ODOGWU	307.1	53	16276.3	94310.41	2809
13.	GOVERNMENT SECRETARIAT	209.1	103	21537.3	43722.81	2809
14.	RELIEF MARKET	236.1	149	35178.9	55743.21	22201
15.	IVA VALLEY	308.6	11	3394 .6	95233.96	121
16.	RAILWAY QUARTERS/ ARTISAN MARKET	234.2	75	17565	54849.64	5625
17.	ASATA	226.2	99	22393.8	51166.44	9801
18.	OLD PARK (OGBETE)	211.5	241	50971.5	44732.25	58081
19.	ONU ASATA	260.3	55	14316.5	67756.09	3025
20.	OBIAGU	303.8	61	18531.8	92294.44	3721
21.	NEW LAYOUT	318.9	22	7015.8	101697.21	484
22.	UWANI	233.5	61	14243.5	54522.25	3721
23.	KENYATTA	255.6	21	5367.5	65331.36	441
24.	ACHARA LAYOUT	299.3	74	22148.2	89580.49	5476
25.	CAMP COLLIERY	249.5	15	3742 .5	62250.25	225
26.	INDEPENDENCE LAYOUT	273.4	22	6014 .8	74747.56	484
27.	AMECHI JUNCTION	342.5	70	23975	117306.25	4900
28.	GARIKI (AWKUNANAW)	401.5	79	31718.5	161202.25	6241
29.	MARY-LAND	334.5	2	669	111890.25	4
30.	AMECHI	430.5	3.4	1463.7	185330.25	11.56
31.	UGWUAJI	399	1.3	518.7	159201	1.69

ΣX = 9306.1

ΣX^2 = 2953170.1

ΣXY = 588913.7

ΣY_2 = 2136.7

ΣY^2 = 226383.25

N = 31

Correlation Coefficient (rxy) is given as:-

$$rxy = \frac{N(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{(N\Sigma x^2-(\Sigma x)^2)(N\Sigma y^2-(\Sigma y)^2)}}$$

$$= \frac{(31 \times 588913.7) - (9306.1 \times 2136.7)}{\sqrt{(31x2953170.1 - (9306.1)^2)(31x226383.25 - (2136.7)^2}}$$

$$rxy = \frac{18256325 - 19884344}{\sqrt{(91548273 - 86603497)(7017880.8 - 4565486.9)}}$$

$$= \frac{- 1628019}{\sqrt{(4944776)(2452393.9)}}$$

$$= \frac{- 1628019}{\sqrt{1.21265 \times 10^{13}}}$$

$$= \frac{- 1628019}{3482318}$$

$$= -0.4675101$$

Hence the correlation coefficient (rxy) between bus route distance accessibility and bus service frequency is -0.468.

APPENDIX H - 2: TEST OF SIGNIFICANCE FOR CORRELATION COEFFICIENT BETWEEN BUS ROUTE DISTANCE ACCESSIBILITY AND MEAN BUS SERVICE FREQUENCY

The student "t" test is given by:

$$t = \frac{r\sqrt{n-2}}{\sqrt{(1-r^2)}}$$

where $r = 0.468$
$n = 31$

Hence $$t = \frac{0.468\sqrt{29}}{\sqrt{1-(0.468)^2}}$$

$$= \frac{0.468 \times 5.39}{\sqrt{1-0.2190}}$$

$$= \frac{2.5223}{0.8837}$$

$$= 2.854$$

$$= 2.9$$

Ho: there is no relationship between bus route distance accessibilit and bus service frequency.

H_1: there is a relationship between the two.

Degree of freedom (df) = (n - 2) = 29

Calculated Value = 2.9

At 29 df $t_{0.05}$ = 1.70

Since 2.9 is greater than 1.70, we reject Ho, and accept H_1. Thus there is weak relationship between bus route distance accessibility and bus service frequency.