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**THE TRUNK A NETWORK IN NIGERIA: THE ISSUES OF
CONNECTIVITY AND ACCESSIBILITY**

by

OWEN RICHARD OWEN

A dissertation submitted in partial fulfillment of the
requirements for the degree of

DOCTOR OF PHILOSOPHY
in
URBAN STUDIES

Portland State University

1988

TO THE OFFICE OF GRADUATE STUDIES :

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AN ABSTRACT OF THE DISSERTATION OF OWEN RICHARD OWEN
for the Doctor of Philosophy in Urban Studies presented on April 21, 1988.

Title: The Trunk **A** network in Nigeria: The Issues of Connectivity and
Accessibility

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This study concentrated primarily on how the changes in the trunk **A** transportation network configuration in Nigeria alter both the hierarchy of the network system and the connectivity of the network itself.

Using the graph theory, the study looked at the network development in Nigeria in 1949, 1961, 1976, and 1982. The period covered in the study spanned from the colonial to the post colonial eras.

Road maps of each of these years were the primary sources of data. The maps were translated into abstracted networks and subsequently converted into square matrices, and analyzed. The analysis resulted in the establishment of the network connectivity and the accessibility of individual nodes.

Gamma and alpha indices were used to determine the complexity (the degree of connectivity) of networks in each of the study periods. The sporadic changes in the number of nodes and linkages resulted in the fluctuation of the network connectivity. This type of fluctuation is a common problem in network development within the developing economies. Political and administrative factors exert stronger influence in shaping the content and the outcome of transportation programs than the Taaffe, Morrill and Gould (1963) and Lachene (1965) models imply.

The sporadic fluctuations in the number of nodes, linkages and in the values of the gamma and alpha indices suggest that neither the sequence of network development or its supposed discrete nature is appropriate to post-colonial development. There is a significant difference between network development during the colonial and post colonial eras. During the colonial era, there was a strong connection between network development and primary economic activities. The conditions during the colonial era support the link between the network and economic development as illustrated in Kansky (1963) work. The post colonial era in the other hand, is marked by the need for both social and political integration. Thus, the pattern of network development

in Nigeria in the eighties is quite consistent with Friedmann (1975) assertion that social and political factors should be assigned a higher scores than economic in the development model for Third world.

After nearly ninety years of network development, the trunk **A** network system in Nigeria is in transition. It is now moving from elementary into an advanced stage of development. One of the things that is likely to at least slow down the rate of such transformation is the political sub-division of the nation into a smaller constituent units, coupled with lack of political predictability.

From most indications, network development is moving away from concentration in relatively few nodes to a system that imposes a grid on the nation. The imposition of such a grid is likely to induce and enhance the interregional linkages and competition. Such phenomenon is indeed healthy in the light of the existing imbalance in terms of responsibilities between the three levels of government. It is also a good approach towards redressing the existing regional disparities as regional integration is very likely to bring about incentives and opportunities for a fair competition.

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CHAPTER I

INTRODUCTION

The experience of decades of development has demonstrated that innovation, people, and products are transmitted more readily and effectively if movement is easier (El-Aroud, 1980). Transportation, as the nervous system of a regional organism (Friedmann, 1964), must provide for the accessibility of the "center" as well as the rapid circulation among the various parts of the region. Consequently, transportation is one of the essential ingredients in the process of development. There are many reasons for investing in highway infrastructure in developing countries. Even the experiences of the industrialized nations support such a development strategy (Mansourkhaki, 1980). The strategy is based upon the need to acquire the benefits of savings in vehicle operating costs as well as savings in road maintenance costs.

Furthermore, provision of basic access to support agricultural development or improve health and educational services is also quite compelling. Taking these together, the enhancement of the social well-being of the population and, especially the disadvantaged rural residents, underscores the importance of transportation. Since the location of and accessibility to the transportation system do play a significant role in the economic and social structure of any country, it is important that policy makers and planners should have appropriate and adequate information on both the nature of and the process of transportation network development. This should include the knowledge of the different factors that shape the network development.

STATEMENT OF THE PROBLEM

An ideal-typical sequence of network development in Third World nations was first postulated by Taaffe, Morrill and Gould in 1963 and confirmed by a separate work done by Lachene in 1965. This work focused exclusively on overall network configuration. It was not concerned with individual place accessibility, consequently, place accessibility changes implicit in the hypothesized sequence were not specified. Moreover, the model does not seem to reflect the magnitude of political and administrative influence inherent in the process of network development in the Third World. This study focuses on how changes in the configuration of the trunk A road network over time affect the connectivity of the trunk A network as a whole, and the internal accessibility of the individual nodes within the trunk A network system in Nigeria.

This study takes its lead from the ideal-typical model. It starts with the expectation that the ideal typical sequence will be evident in the development of the trunk A highway system in Nigeria over a period of some thirty three years. The ideal-typical sequence as a theoretical construct states that there are four stages of network development. It was postulated by Taaffe, Morrill and Gould (1963), as a direct result of studying the history of network development in both Nigeria and Ghana. The four-phase ideal typical model states that the initial phase of transport network development is characterized by scattered ports follows by the development of few penetration lines. The second stage is marked by the beginning of concentration on a few ports. The third phase is one of interconnection of the penetration lines. At this point, the nodes in the hinterland begin to be linked with one another, and subsequently, a certain

high-priority trunk lines emerge. The fourth stage is primarily characterized by alternative connections being disproportionately distributed among some few selected nodes.

It is, however, important to note that like many other traditional or classical transportation planning models, the ideal-typical sequence is an economically driven model. Furthermore, what Taaffe and his colleagues observed in Ghana and Nigeria was a colonial network structure, designed for very specific and narrow objectives. Thus, the ideal-typical sequence as any other technically driven model focuses more or less on a single optimizable goal. Due to the narrow focus of the model, it is less than adequate in explaining the post independent network structure in Nigeria. There are a number of factors that shape the network development in developing countries. The major ones are politics, national defence, equity, economics and the distortion due to the external source of finance (Filani and Osayimwese, 1974). Those factors will be explained in some details in the subsequent section. This study assumes that the connectivity and accessibility of the road network structure will be a product of the interplay of those factors. After four separate national development plans, with the fifth one ready to go into operation on January of 1989, there are some significant changes in the road network structure. It is important to investigate how those changes had affected the connectivity and the accessibility of the network structure, and also to find out if the expectations established by the ideal-typical model are still valid.

THE MULTIPLE FACTORS THAT INFLUENCE TRANSPORTATION PRACTICES

Studies on investments in transportation facilities, especially highways (Dickey, 1983), have shown substantial multiplier effects. For example, adequate transportation networks have the potential to enlarge the market and even introduces changes into the marketing system. It can also contribute to changes in forms of political and economics demands (Schloss, 1983). Professional economists are traditionally concerned with the allocative efficiency as scarce resources must be utilized to the greatest effect in order to reduce the real costs of transporting people and goods (Banister, Hall, 1981). There is also an economic argument that investment in transportation facilities should be done in a way that it brings about reduction in travel costs, and consequently, such savings could then be used in a more profitable ventures. It is unfortunate that transportation facilities are too often thought of only in economic terms, when in fact they exert pervasive influence upon political and military events.

For decades, transportation planning models were primarily technically oriented without adequate consideration to both political and administrative dimensions (Binder, 1971). Unfortunately, some of the assumptions, especially those inherent in the optimization of purely economic goal are no longer politically acceptable. The interface of transportation with other problem domains presents a very complex picture. Much of the complexity of transportation planning is due to the impacts that transportation decisions exert on the lives of the people concerned. For too long, it was assumed that technical planning could be isolated from the peoples' values, aspirations, and ambitions (Dickey, 1983). However, such reasoning together with the

associated technical fix does not stand up anymore in the face of politicized citizen activism. The entrenchment of the bureaucratic apparatus in the modern society is a common fact, and bureaucracy itself is said to be complex and in some cases very frustrating (Hartwig, 1983). Thus, the impetus of bureaucratic rationality towards the success or failure of programs in general, and transportation in particular is no longer debatable.

Historically speaking, it is unrealistic to focus transportation decisions on a single, optimizable goal, as does the ideal-typical model. Transportation affects almost everybody everyday (Commission Report, 1975). Thus, political intervention in transportation development is inevitable (Lansing, 1966). Wolfe (1963), argues that a crisis of our time is an imbalance between the highly advanced state of the technology of transportation and the primitive state of political institutions. He presents extensive documentation on how politics and transportation interact with one another in war and peace within a nation and among different nations.

Provision of transport infrastructure as one of the oldest and best-accepted functions of government (Hartwig, 1983), can be successfully utilized to solve other non-transportation problems. For example, in United States over one billion dollars was invested in highways in the Appalachian region (Friedmann, 1968), primarily to induce economic development. During the depression of 1930-1940 Federal funds did go into highway construction in cities, not in recognition of their now serious transportation problems, but simply to provide work (Smerk, 1965). In Nigeria, investment in transportation has been effectively used for political and social cohesion. Conversely, non-transportation solutions may also be used in solving transportation problems

(Dickey, 1983). Transportation as a public tool has therefore, been used quite effectively in some instances to achieve both economics and non-economic objectives. Musgrave (1959) in his exposition of public finance theory, asserted that public sector can participate directly for stabilization, income distribution, and resource allocation in a nation. One of the most effective tools that the public sector can utilize in such participation is transportation, (O'Sollivan, 1979); (Abouchar, 1977). There is evidence in the post-colonial network structure in Nigeria to suggest that investment in the transport sector has been utilized for economic, social and political advancement of the nation, rather than in pursuit of a narrowly defined economic development.

The interaction of the political and administrative factors in transportation planning in the developing countries has not been adequately accounted for in the traditional planning model (Schloss, 1983). However, recent literature on development and modernization does stress the role of political considerations and administrative factors in determining both the content and the outcome of development programs. Transport projects attract the interest of many active participants because tradeoffs between goals are politically sensitive (Dickey, 1983), and because they usually require large investments (Schloss, 1983). Furthermore, the design and construction of many transport projects in developing nations are undertaken by aid-donor countries. Such donors are likely to impose their political criteria in either the planning or implementation of those projects.

THE COLONIAL LEGACY AND THE STRUCTURAL FORM OF TRANSPORTATION IN NIGERIA

A clear understanding of the spatial and structural form of transportation in Nigeria is predicated upon the knowledge of the colonial influence on the country's transportation system. Prior to British administration in Nigeria, there was an indigenous urban system (Mabogunje, 1965), based on long distance trade carried on largely by foot. This system was seriously undermined and stultified when the British superimposed a transportation superstructure designed primarily for the export of primary commodities. Both the spatial and structural form were considerable and well established by the time of the political independence in 1960. The system was so entrenched that initial locational advantages enjoyed by certain areas had not only survived many years of post independence development, but many of those places still dominate the network hierarchy. The agricultural activities that the colonial transportation system engendered accounted for well over half of gross domestic product and were the main source of export earnings and public revenues at the time of independence (Economist Intelligence Unit, 1987).

The initial design of the transportation system was so out of touch with the indigenous interest and aspiration that in the wake of independence, the nation found herself looking outward (Filani, 1981), to Europe rather than inward in terms of national socio-economic development and integration. The inherited colonial transportation pattern has indeed exerted an enormous and a long lasting influence on the nation's space economy. The design and routing of the network linkages were done in such a way that the end result was a corridor-type transportation system. The linkages were virtually north-south, and east-west linkages were simply ignored. For decades, the major terminal

points were located on the coast and linked directly to sources of exportable products. The regional inequality implicit in the uneven distribution of natural resources was accelerated and perpetuated by the very pattern of network development. Consequently, the over concentration on the southwest-north transport linkages lingered.

Changing the colonial pattern of network system has not been an easy task. Taking interest in the development of the feeder routes, notably, the farm-to-market and the rural-to-rural linkages is not happening readily, even though such deficiency has been acknowledged for quite some time. It took a bloody thirty month civil war that seriously threatened the very nationhood of Nigeria to get the government attention on the need for east-west linkages. Nigeria is said to be one of the world's most ethnically diverse societies, with over two hundred and fifty ethnic groups (Economist Intelligence Unit, 1987). In designing a functional network system for a nation like Nigeria, the transportation needs and the aspirations of these diverse groups has to be considered as an important factor. Particularly, attention has to be given to the social, economic, and political dimensions of the ethnic factor.

Network development in Nigeria has seen many years of vigorous effort that involve enormous resource investment. It has also faced with multiple problems. The politics of relocation of the nation's capital has exerted very significant impact on the network structure. The debate for the relocation of the capital began in 1912 among the colonial administrators (Moore, 1984). The call for the relocation of the national capital though politically motivated was for a geographically central, strategically safe and ethnic-wise neutral location. A careful selection of the site were to offer an opportunity of having a spatial

linkages that will give a functional cohesion to the national system of cities. For example, linking a geographically central national capital with the state capitals would have created a convergence of transportation network. Such a phenomenon would very likely transform the colonial oriented space-economy, to one that is not only functional but locally desirable.

Unfortunately, the overriding concern of the committee charged with the site selection was the maintenance of the committee members' relationship with the nation's military and political leaders and to satisfy various private interests (Moore, 1984). By 1982, it became quite obvious that regional access was not evenly distributed as expected, rather the main access to the new capital was via Kaduna, subsequently, business people from the north had the advantage of competing for contracts at the site. The predominance of northern influence in the construction of the new capital has made Abuja to be perceived as a northern rather than a national capital. Thus, an effort that was meant for unity and for the harmonious co-existence of the different peoples of Nigeria is now presenting some negative consequences. Instead of bring the people together, Abuja may turn out to be rather perilous to the stability and growth of the nation. Nevertheless, the impact of the "Abuja factor" on the network structure is quite significant.

There is also a serious problem with regards to the availability of the needed specialized skill and an appropriate experience. According to Filani and Osayimwese (1974), up till 1971 road projects planning was treated solely as an engineering exercise, there was not even one single economist among the project planners. Thus, projects recommended for final selection were generally ill-prepared. The other area of serious problem that has plagued

transportation planning in Nigeria for years is what Hartwig (1983) called bureaucratic rationality. There are some serious problems with the organizational set up of the transport ministries. The existing organizational arrangement is characterized by division between the ministry of transportation and the ministry works and housing. Ministry of works and housing is responsible for roads while the ministry of transportation is responsible for railways, ports and inland waterways as well as civil aviation. It is ironic that even though road transport is the dominant mode in the nation, it does not fall within the portfolio of the ministry of transportation. However, ministry of works, as a service ministry, is the one that performs civil and building construction services to the ministry of transportation. The bureaucratic rituals coupled with inter public agencies' completion does not allow for adequate cooperation among these two ministries.

THE NEED FOR MEASURING THE EFFICIENCY OF THE ROAD NETWORK SYSTEM

In developing countries, investment in the transport sector continues to represent a large part of national development programs. It is important that decisions about such investments should be made on the basis of best possible information (Bulman, and Robinson, 1977). The economic consequences of building roads to particular geometric and structural standards are inadequately investigated at the project appraisal stage, largely because knowledge of the interaction between the various factors involved is more often than not, very inadequate. To effectively and meaningfully improve any system in any country, the researcher must be able to measure the efficiency of that system (Mansourkhaki, 1980).

In dealing with the issue of efficiency, especially with regards to systems that are still going through the developmental process, the issues of connectivity and accessibility become extremely important. Topologically speaking, connectivity is defined as the degree of cohesiveness or the degree of connectedness while the accessibility is measured in terms of the sum total of both direct and indirect linkages associated with individual nodes (Taaffe and Gauthier, 1973).

There are many economic indicators that can be used as a tool for evaluation and comparison of different economies, consequently, those economies can be categorized as developed or undeveloped. Kansky (1963) stresses that the transportation network of any area cannot be divorced from the geographic characteristics of that area. Further, he hypothesized that there is a direct relationship between network complexity and the degree of economic development.

There are well defined transportation indicators that measure the complexity of transportation networks. Garrison (1960), was among the first to develop some graph indices that serve as transportation indicators. These indices had been effectively used in categorizing networks into different categories. Transportation engineers have also used the same indices in creating some numerical criterion that enables them to classify network configurations as spinal, grid and delta (see TABLE I). This classification based on graph-theoretic indices varies from a set of nodes with no interconnection at one extreme to a set of nodes in which every node is either directly or indirectly connected to all other nodes in the network system.

TABLE I
NUMERICAL CLASSIFICATION OF NETWORK
BY GAMMA AND ALPHA INDICES

For gamma

spinal:	$\frac{1}{3} \leq \gamma \leq \frac{1}{2}$	where $v \geq 4$
grid:	$\frac{1}{2} < \gamma < \frac{2}{3}$	where $v \geq 4$
delta:	$\frac{2}{3} \leq \gamma \leq 1$	where $v \geq 3$

For alpha

spinal:	$\alpha = 0$	where $v = e+1$
grid:	$0 < \alpha < \frac{1}{2}$	where $v \geq 3$
delta:	$\frac{1}{2} \leq \alpha \leq 1$	where $v \geq 3$

Source: GEOGRAPHY OF TRANSPORTATION

Given that investments in transportation in the developing countries are tailored toward addition and improvement of links (El-Aroud, 1980), the need and the importance of understanding the underlying sequence of such development serves as one of the prime reasons behind the study. Insight on how the addition and deletion of linkages in a network affect both the connectivity of the network as a whole and the accessibility of individual places within the network system offers useful practical and theoretical information for planning purposes. There is always a real concern that capital investments that lead to additions and changes in transportation network structure may likely create a wave of shocks that can be felt throughout the entire transportation and economic systems. One possible consequence of these shocks is always the alteration in the spatial structure of the network. Such phenomenon has the potential of producing many series of changes in the pattern of internal accessibility for many of the urban centers of the network. Subsequently, such changes in internal accessibility may very likely disrupt the existing patterns of spatial competition in the country and may also affect relative rates of regional growth.

NIGERIA AS FIELD CASE

Nigeria is selected as a field case in part, because of the fact that the two countries that Taaffe, Morrill and Gould (1963) used in their study to postulate the ideal-typical sequence were Nigeria and Ghana. Furthermore, network development in Nigeria especially, the trunk **A** network has received an enormous infusion of capital in the post-colonial period. Consequently, there are significant changes in the network configuration. It is pertinent therefore, to

note that the main purpose of this study is to investigate how such changes in trunk **A** network configuration has altered the network hierarchy from one study period to another. It is equally importance to note that there are three categories of roads in Nigeria (trunk **A**, **B** and **C**), and the decision to analyze only the trunk **A** is based on the fact that it is the sub-sector that most of the available resources are spent. Trunk **A** network system is the "main road" network system in the nation, and some of the linkages are part of the trans-African Highways. This is brought about by the continuous effort on the part of the government to link Nigeria not only with her immediate neighbors but also with other African countries (Barbour, Oguntinyinbo, Onyemelukwe and Nwafor, 1982). The difference between the amount spent in the trunk **A** and the amount spent in all others is so much that this study assumes that the trend in the trunk **A** sub-sector is a national trend.

ORGANIZATION OF DISSERTATION

This dissertation is organized into six chapters. The first chapter deals with the statement of the problem, the multiple factors that influence transportation practices in the process of development, the colonial legacy and the structural form of transportation in Nigeria, the need for measuring the efficiency of the road network system, Nigeria as a field case, and the organization of dissertation. Chapter II deals with the review of previous studies, and the importance of accessibility. Chapter III discusses geopolitical structure, transportation and the political entity of Nigeria, the history of transportation within planning and development in Nigeria, investments in road

network development, and the objectives and philosophy of transportation in Nigeria

Chapter IV deals with graph theory, the important indices of graph theory, and the selected graph indices. Chapter V deals with the selected study periods and the analysis, and changes in internal hierarchy. Chapter VI contains the summary, alternative perspective to transportation practices in Nigeria, and the conclusions.

CHAPTER II

LITERATURE REVIEW

THE REVIEW OF PREVIOUS STUDIES

One of the critical factors in the growth of developing economies, is the improvement of internal accessibility through the expansion of a transportation network (Taaffe, Morrill and Gould, 1963). This expansion process was found to be a continuous process of spatial diffusion characterized by an irregular or sporadic progress influenced by economic, social, and political forces. Due to the complex and intricate nature of the network development, programs to increase the efficiency of moving goods and people should not be implemented hastily but rather in a coordinated sequence over time (El-Aroud, 1980).

Consequently, the manner and nature of the stages of network development therefore becomes very important due to the fact that the success of an activity is in part, conditioned by its relative location, among other things (Garrison, 1960). The process of network development by itself, and the subsequent changes in the configuration of the network may induce changes in the relative location of the existing urban centers. These induced changes are bound to impact the success of activities within the centers. Furthermore, the strategic position of some areas will be enhanced while that of others will be diminished as the network develops (Garrison, Berry, Marble, Morrill and Nystuen, 1959).

A network provides defined channels of movement for the flows of goods and people between places. The importance of movement in every day life cannot be overstated. Interaction between people and places requires access, and access is only possible if there are connecting links. The layout of the network and the characteristics of its elements, determines how accessible places will be to each other (Kissling, 1969). The other argument frequently advanced to justify expenditures on network development is the importance of network accessibility to regional growth. To promote economic development, the government is committed to a reduction in transfer costs as a means of overcoming barriers that limit the geographical spread of the different activities of the economy (Gauthier, 1969).

The study of the growth process of networks identified as "node connecting sequences" offers an insight into the process which results in the connection of nodes of the entire system and also provides the interpretation of the process itself (Hebert and Murphy, 1971). However, since certain locations may grow at the expense of others, the outcome can be a set of high-priority linkages among the largest centers.

It has alternatively been suggested that it is most realistic to think of network development as a process, rather than a series of discrete historical stages (Rostow, 1964). At any given time, a country's total transport pattern may show evidence or characteristic of all the different phases of a network growth. For example, lateral interconnection may be going on in one region while at the same time new penetration lines may be developing in another. The ideal-typical sequence typology asserts that perhaps the most important single phase in the transportation history of a developing country is the

emergence of the first major penetration lines from the sea coast to the interior (Taaffe, Morrill and Gould 1963). Later phases typically evolve around the penetration lines and ultimately, there is a strong tendency for them to serve as the trunk-line routes for more highly developed systems.

It is pertinent to note that the ideal-typical model of network development postulated by Taaffe, Morrill and Gould (1963), and the model developed by Lachene (1965), are quite similar. Both models assert that the growth of transport networks accentuates concentration of activities in a few centers and high priority or "main street" connections between these places emerges. The study by Black (1967), supports in general terms the model advanced by both Taaffe, Morrill and Gould (1963) and Lachene (1965), and it goes on to emphasize the fact that certain factors do indeed tend to emphasize particular nodes in the growth process at the expense of other nodes. Haggett (1969), suggested that this selective process of node interconnection could be accounted for by the large capital expenditures expended for a successively large capacity network, a process which inevitably necessitates selection of a subset of nodes as being highly connected. As a basic premise Gauthier (1968), asserts that there is a high degree of interdependence between the development of a transportation system and the geographic pattern of urban economic growth.

The need for a deliberate and comprehensively coordinated programs for network development is underscored by direct and indirect impact that such investment can exert at both regional and national levels of the economy. Since transportation investment involves money expended for construction and maintenance of transportation fixed as well as variable facilities, it is therefore,

safe to assume that such investment is likely to create jobs. Creation of jobs may have a positive impact on the GNP, and this turn will affect the living standard of the people. For example, in 1960 the USA invested some \$48.7 billion (Mansourkhaki, 1980), in the transport sector. This was roughly some 9.6 percent of the national product of some \$506 billion. It is important to note that in 1960 USA population was some 181 million with a per capita gross national product of about \$2800.00. The per capita transportation investment was about \$270.00. Thus, it is not too difficult to imagine how many jobs might have been created. Furthermore, as long as capital investment that leads to additions and changes in a transportation network is capable of inducing shocks that can be felt throughout the entire transport system, and as long as one possible consequence of these shocks is likely to be the alteration in the spatial structure of the network, then the need for effective coordination of such investments will persist. If extreme care is not taken, the change in the internal accessibility of the network may impose enormous regional disparities. Such disparities will in turn create social friction that is not likely to be conducive to the stability of many of the Third World nations. The induced disparities may be explained, in part, by the fact that the subsequent alteration in the pattern of internal accessibility alters the relative importance of the existing urban centers of the network. In other words, such changes in internal accessibility may significantly disrupt the existing patterns of spatial competition in the region, and ultimately exert some influence on the relative rates of urban and regional growth.

Cowan and Fine (1969), suggested that the actual connections of an expanding network are always less than potential connections, and went on to

suggest that the process over time is defined by a logistics curve. Cope (1967), noted in his study of the London underground system that the growth of the network could be grouped into three stages described as expansion, consolidation, and rationalization.

A closer look at these different studies strongly suggests that there is some sort of governed pattern as suggested in the ideal-typical model over the evolution of the topological structure of networks (Erdos and Reny, 1959). However, the nagging question has been whether or not the pattern is systematic and discrete or simply sporadic and continuous.

THE IMPORTANCE OF ACCESSIBILITY

According to Bierman (1973), transportation is responsible for the unification of geographically separated points, in other words, transportation is a system of linkages connecting different points in a spatially organized area. Consequently, spatial interaction is accomplished with different sectors of the economy and different parts of the region. The ultimate goal is to obtain maximum utility for minimum cost in the process of providing the cheapest possible means of transporting goods and people. Every society at a given state of technology will attempt to develop a transport network to minimize the total disutility of the distance. Subsequently, activities will competitively locate in relation to the network in such a way to maximize the total utility of the system. It follows that differing needs and abilities to move goods and services will result in differing arrays of central places and market areas. According to Owen (1964; 1966), lack of accessibility to transportation facilities will inhibit progress. For example, vegetables and other perishables cannot be grown because

transport needs to be quick and reliable to enable producers to move the products. Inal (1979), re-emphasized that efficient movement of people and goods over space is a must for a socially and economically integrated society. Mahayni (1972); 1977), contended that since transportation provides the link between markets separated over space, the balance of their growth will be controlled to a certain degree by their relative accessibility. It follows that for such markets and their products to compete with each other, the difference in prices of homogeneous products should not be greater than the marginal cost of transporting them. If the difference is equal to the marginal cost then, there will be an interregional flow of commodities. Kraft, Meyer and Valette (1971), argued that it has become axiomatic to say that growth and the momentum at which it occurs depends among other things, on geography and location of activities within a nation. Thus, the development of a region is directly related to its ease of access to resources and to outside markets or, more generally, to its physical position relative to other regions.

According to Wilson, Bergmann, Hirsch and Klein (1966), transportation is deemed as a strategic sector in the Third World development programs, especially at the early stage of development. This notion is reinforced in that a transport base was created prior to, or coincident with rapid growth in the industrialized nations. Beside the observed correlations between rising gross national product per head and some indices of transport mobility, there are also the non-economic dimensions of transportation which have equally strong appeal. These include elements like national cohesion, political and social unity, military and logistic needs. Wilson and his colleagues (1966), argue strongly that improvement in transport capacity permits faster, safer, cheaper,

and more dependable service which in turn allows a greater movement of goods and people per unit time. It is therefore true that improvement in transportation in any of the four dimensions mentioned above will lead to a reduction in the total resources required to produce and distribute a given volume and pattern of output per time period. In most instances the transport facility served directly or indirectly to bring more land into productive use. This is important for an economy that is still dominated by agriculture. Transportation systems should be carefully and comprehensively designed due to their enormous impact in overcoming the frictions imposed by geography, as well as their impact in shaping the distribution of activities which ultimately influence the share each region contributes to the national product.

Meow (1977), argues that the importance of transportation in national development is generally accepted although the extent to which it can play a catalytic role may be questioned. It should be noted that transportation is not only a form of social infrastructure, it is also a form of capital formation that deserves special attention by any society wishing to further its economic growth. Galbraith (1965), in a reference to economic development, argues that a highly efficient transportation, and a reliable source of power are indispensable for development. With those things available, something is bound to happen, but in their absence, we are certainly less sure. It is now a common truism based on the number of empirical studies that innovations as well as people and products, are transmitted easier if movement is easier (Ridley, 1968). Other studies have given boost to the concept of growth-point strategy which says that prosperity generated by the growth points will eventually spread outward into the less favored areas over time (Smith 1971);

Friedmann (1975); Myrdal (1957) and Hirschman (1958), have all contended that economic growth can be transmitted from the core into the periphery through a hierarchical system of settlements, the creation of which helps to achieve the spatial integration of the economy. It is therefore important to note that this hierarchy is reinforced, and in part defined, by the relative location of nodes within the transportation network.

CHAPTER III

SOME SELECTED ISSUES AND THEIR RELEVANCY TO TRANSPORTATION DEVELOPMENT IN NIGERIA

GEOPOLITICAL STRUCTURE

The political entity known as Nigeria today came into existence in 1914 as a colonial creation. Its boundaries were arbitrarily imposed, cutting across both ethnic groups and cultural units with little or no consideration at all to the peoples' history and past experiences. One of the major problems of the constitutional development in the nation has therefore been the issue of determining the size of the constituent unit of the federation. The question of the creation of a nationhood in one hand, and dealing with the internal boundary adjustment in the other has been quite tedious and difficult since the independence in 1960.

The Nigeria's basic federal structure was worked out in the constitutional conferences in London in 1953 and in Lagos in 1954. The nation was divided into three regions with regional headquarters at Kaduna, Enugu and Ibadan for northern, Eastern, and Western regions respectively, with Lagos as the national territory. Due to a persistent demand by minorities in the western region in particular, the republican constitution of 1963 created the fourth region known as the Mid-west, with Benin City as its capital. The constitution gave an extensive power to the regions, therefore, leaving the central administration weak and ineffective. Due to the weakness of the central administration, the

individual regions took little or no interest in national unity. Instead, there was enormous inclination to secure dominance over the whole nation.

The size of the nation itself and the out-size nature of the constituent units together with the administrative hardships interposed by physical distance, poor transportation and communication systems did not allow the central administration to respond effectively and efficiently to the aspirations of those at the periphery. The general concern was that such circumstance did indeed threaten the political, the economic, and the social survival, as well as the general stability of the nation.

In 1967 the federal government subdivided the nation into smaller units known as "State". This was partly an attempt to fulfill the aspirations of the minorities as well as being a deliberate effort to reduce the size of the constituent units which was perceived as a real threat to the stability of the nation. The establishment of the twelve states structure subsequently upgraded some seven more urban centers to serve as capitals for the new states. In 1976, Nigeria was further subdivided into nineteen states, with Abuja being selected as the new national capital. This exercise enabled another eight urban centers to be upgraded in order to serve as seats of new state governments. Thus, within the first sixteen post independent years, the nation's geopolitical structure has changed from three-region structure in 1960 to a four-region structure in 1963, and then through a twelve-state structure in 1967 to nineteen-state structure in 1976 (see Figure 1). In September of 1987, the nation's political structure was readjusted through the creation of two new states. The practice of readjusting the political structure of the nation at this

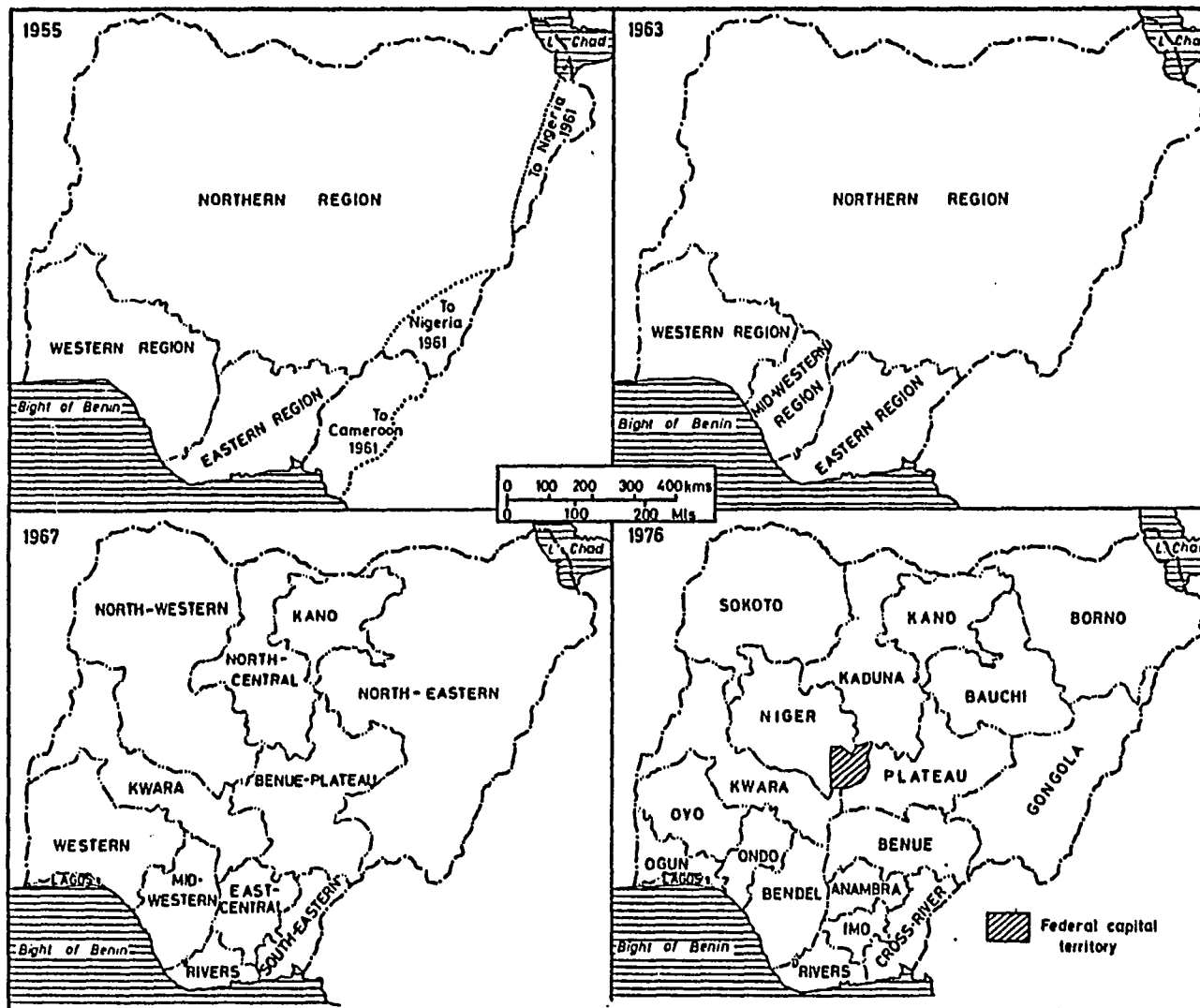


Figure 1. Changes in the political constituent unit in Nigeria

moment seem to be a continuous exercise. The act of subdividing the nation into smaller constituent units has indeed a number of ramifications. One of these is the influence it has on shaping the configuration of the network structure. The relative locations of those political capitals in the accessibility hierarchy is a clear evidence of how much influence such subdivision had exerted and will continue to exert in the process of network development. It is however, important to note that Logan in 1972 argued that the transportation system and the system of state capitals did not mesh, and he pointed out specifically that the newly created state capitals of 1967 were not the focal points in the respective states. The fact is that the present network configuration and the resulting accessibility hierarchy does indeed contradict the Logan's assertion.

Nigeria has so far existed as a politically independent nation for some twenty eight years. Ten of those years had been under civil administrations while the remaining eighteen years had been under the military autocracies. It has not been possible to isolate network development from the impact of the incessant coups and counter coups that has come to characterize politics in Nigeria. The high political turn over coupled with its inherent unpredictability has resulted in abandonment of many road projects, due in part, to different emphasis in priorities by successive governments.

TRANSPORTATION AND THE POLITICAL ENTITY OF NIGERIA

The Nigerian policy makers inadvertently or otherwise agree with O'Sullivan's (1979), position that transportation should be regarded as the most effective tool that can be used in enhancing the geographical, socio-cultural,

and historical integration of a diversified nation such as Nigeria. It is a long standing policy position within the policy making circle in Nigeria that the concern over the transportation development be centered on how to design a transportation system that will create a nation that is desirable, workable and conducive for the political coexistence of different culture and people of Nigeria.

In plan after plan, the emphasis continues to be that the very basis of political coexistence implies that the organization of the nation's spatial economy must continue, at least in some ways, to be built on the foundation of the modern transportation system. The colonial orientation which the original design was based on has changed significantly in some respects. For example, the colonial design was primarily structured to enhance the process of tapping and evacuating agricultural and mineral export commodities. It was also meant to facilitate the distribution of the imported manufactures. Presently, consideration is also being given to the importance of inter-regional trade, as well as political and social integration of the nation. The network in 1982 indicates major changes in its configuration. The accessibility is much more evenly distributed, thus, the progress in the areas of social and political integration is quite tremendous. There is a recognition of the need for rural integration. into the national network grid. The establishment of the Directorate of Foods, Roads and Rural Infrastructure (DFRRI) is a clear indication of a genuine effort in this direction. At the moment, the current military administration is examining through the Constitution Review Committee, the possibility of giving constitutional status to DFRRI (West Africa, 1987).

THE HISTORY OF TRANSPORTATION WITHIN PLANNING AND DEVELOPMENT IN NIGERIA

The use of planning in the whole spectrum of development in Nigeria is regarded as both necessary and essential. The documents of the first national development plan enunciate the argument that there is no country anywhere in the world in which the society is completely free from some form of deliberate efforts to speed up the process of development. The document also contends that planning decisions taken at the time in question, will constitute an investment in the later part of the 20th century and thereafter. It goes on to caution strongly that unless genuine efforts are made, that the future may find Nigeria locked into poverty and misery (Government Printer, 1962). It was in recognition of the vital role of planning that national planning was consequently adopted as the foundation upon which the future economic and social growth of Nigeria will be based. The 1962 plan then goes on to assert that, it is only by having a series of national plans that the nation will be able not only to raise the standard of living of the people, but also to transform the national economy into a modern, diversified and virtually self-sustaining system. Thus, the basic objectives of planning in Nigeria, at least in theory, are not merely to accelerate the rate of economic growth and the rate at which the level of living of the population can be raised, it is also to give her an increasing measure of control over her own destiny.

It was the need to achieve the above stated national objectives that led the policy makers and planners to accept transportation as one of the most effective tools that any government can use in guiding and directing the national development. It is pertinent to note that such sentiment does fit well with the position taken by transportation experts like Patrick O'Sullivan.

O'Sullivan (1979), asserts that the control or promotion of the expansion of transport facilities is perhaps the most powerful geographically-specific instrument that government can use in guiding economic development, he goes on to state that transport is not only important but fundamental in structuring our material existence. To underscore the importance of transportation in the process of development in Nigeria, the Stanford Research Institute issued a report in 1961 titled "Economic Coordination of Transportation Development in Nigeria". The report states that the economic history of Nigeria is largely the story of the opening of its vast area by various forms of transportation, bearing in mind that all economic activities rely on the transport system for the movements of both their physical inputs and outputs. All the four previous national plans as well as the fifth plan that takes effect in January of 1989 are designed under the assumption that development process depends to large extent on the efficiency of a country's transportation network.

Generally, the initial effort to develop adequate transportation to serve the growing commerce and industry in the country started early in the colonial era. It centered mainly on the use of the Rivers Niger and Benue for navigation. This was closely followed by the construction of railways in 1898. The two modes of transportation remained the major arteries of commerce for well over half a century. It was not until the late sixties that modernized highways and air transportation moved into the center of the mechanics of movement of goods and people in Nigeria. Some of the factors that propelled the prominence of highways in Nigeria include a deliberate neglect of the rail system by government, and a decline in inland waterways due to incessant droughts,

coupled with the wide-spread conservation of water resources which feed the two most important rivers in the nation, the Niger and the Benue.

The 923,768 square kilometers of land area that makes up what is known as Nigeria today had several empires, dynasties, and kingdoms before the advent of colonial rule. The pre-colonial geo-political configuration was to a large extent determined by environmental factors. Consequently, those different societies had a rather different means of moving goods and people (Ademoyega, 1962 ; Ogunjumo, 1981).

One common feature that was readily found in those societies was the existence of "bush path." Modern road building began around 1900, and it was then that a deliberate effort was made to develop bush paths into a motorable roads. The coordinated road development commenced in 1925 when the Communication Board was established to prepare plans for skeleton trunk road system between the major administrative centers of the nation (Barbour, Oguntinyinbo, Onyemelukwe and Nwafor, 1982).

The initial phase of road development was designed to facilitate the assemblage of local export crops, such as groundnuts, cotton, cocoa and palm produce from the hinterland to the railway stations, these commodities were then shipped by rail to the seaports. The other reason for road development was to facilitate the internal movement of colonial officials, as well as fostering an effective administrative, economic, and military control of the nation.

After the political independence of 1960, the road network began to assume much greater importance in national transportation development. A system that at first was only designed to complement rail and water transportation was now assuming an independent primacy. From the early

sixties, road traffic began to compete seriously with rail traffic, and by the end of the first national development plan period in 1968, the road network had already superseded the railway system (Taaffe, Morrill and Gould, 1963). Based on the use of the passenger-mile and ton-mile as units of measurements for passenger and freight indices, the road transport currently accounts for about two-thirds of all commodities moved to and from all the seaports in the country. It also handles more than ninety-five percent of all other internal movement of goods and persons (Barbour, Oguntinyinbo, Onyemelukwe and Nwafor, 1982).

INVESTMENTS IN ROAD NETWORK DEVELOPMENT

According to the the Third National Development Plan, of all sectors of the economy, the transport sector makes one of the heaviest claims on the available capital development funds. One-fifth of the 1962-68 capital outlay program and a third of the 1970-74 public sector capital program were devoted to the transport sector. The increasing importance of road traffic is clearly reflected on the amount allocated to road network in relation to other modes. Of the total amount earmarked for transport sector during 1962-68 plan period, 58.0% was spent on road network. During the 1970-74 plan period, road network accounted for some 67.0% of transport allocation. The 1981-85 plan period was not different from the previous ones. 60.0% of the capital investment in transport sector was earmarked for highway (see TABLE II).

The 1975-80 plan period even witnessed a much greater investment in this sector, of the N7.3 billion allocated for transportation, some N5.34 billion or some 73% was actually spent on road network (see TABLE III), while the

remaining 27% was shared among air, rail and water transportation (Central Planning Office, 1975; Barbour, Oguntinyinbo, Onyemelukwe and Nwafor, 1982). The practice of high investment in land transportation is still the practice of government even during the last quarter of the eighties. The statistics on the capital expenditures for 1986 and 1987 show that 86% and 88% respectively were allocated for land transportation. The projected expenditure for 1985 through the year 2000 indicates that the government is determined to continue singling out highway as the high priority mode of transporting goods and people in the country (see TABLE IV).

The evolution of road transport development in Nigeria shows a drastic transformation from bush path, through narrow, poorly drained and winding roads, into high quality multi-lane bituminous carriageways. Between 1951 and 1972, the nation's road network showed a substantial improvement in both the total length and in quality (see TABLE V).

All along the local authorities have been responsible for most of the road construction and maintenance in the country (see TABLE VI). By 1972 the total length of road under the local governments jurisdiction was three times as much as those under the the state governments, while the states' share was twice that of the federal government (Filani and Osayimwese, 1974). The implication of the federal-state-local imbalance vis-a-vis the responsibility for road construction and maintenance becomes quite obvious. It is ironic that the agencies which are least able to construct and maintain roads in terms of funds and personnel were left with the largest responsibility. During the 1975/80 plan period for example, of the N7.3b spent on transportation, the federal government spent N6.3b or some 86% of the fund, while all other units of

government spent the remaining N1.0b or some 14% of the fund, (see TABLE III). Thus, it is not surprising and should not be surprising that construction performance is generally poor and maintenance to a large extent, has been generally sub-standard at best. It was the recognition of this problem that led to a major shift in policy during the third national development plan. The federal government decided to take over some selected state roads. As a result of such take over, the federal road increased in length from a total of 11,000 kilometers to 27,000 kilometers between 1975 and 1980. Apart from attempting to redress the imbalance between the different units of government, the aim of such measure was to ensure that the nation will be provided with a fairly dense mesh of primary arterial roads of first-class quality, which, with the railway system, will bear the vastly increased movement of goods and persons (Government Printer, 1975).

TABLE II
CAPITAL INVESTMENTS IN TRANSPORT SECTOR FOR 1962-1985
(N000,000)

Plan Period	Plan Outlay Total	Allocation Sub-Sectors		% of Total Outlay			
		Highway	Railway	Highway	Railway	Water	Air
1962-1968	309.092	179.27	30.9	58.0	10.0	25	7.0
1970-1974	472.398	331.80	43.9	67.0	9.3	13	10.7
1975-1980	967.541	7124.00	986.1	70.6	9.4	10	10.0
1981-1985	1047.462	7400.00	1622.0	60.0	25.0	9	6.0

source: NIGERIA NATIONAL DEVELOPMENT PLAN 1962

TABLE III

TRANSPORTATION CAPITAL PROGRAM FOR 1975-80

(N MILLION)

	Sub-sectors	Total	1975-76	1976-77	1977-78	1978-79	1979-80
Roads	Federal	4355.960	979.924	1123.474	966.144	739.924	546.494
	All States	984.476	210.798	254.054	223.158	178.188	118.278
Railways		885.020	35.052	52.004	261.556	267.704	268.704
Civil Aviation		476.980	59.630	100.560	126.800	83.850	106.140
Nigeria Airways		50.950	12.600	18.750	10.100	8.000	1.500
Inland waterways	Federal	47.541	9.901	12.160	11.188	8.695	5.597
	States	44.250	12.370	12.655	13.110	4.220	1.895
Maritime Service		13.730	2.260	4.070	3.300	2.300	1.800
Shipping		118.090	17.820	33.370	26.300	20.300	20.300
Ports		322.010	47.460	71.700	83.000	66.400	53.450
Government Coastal Agency		4.061	1.020	1.091	0.870	0.540	0.540
	All States	1028.726	223.168	266.709	236.268	182.408	120.173
	Federal	6274.342	1165.667	1417.179	1489.258	1197.713	1004.525
	All Governments	7303.068	1388.835	1683.888	1725.526	1380.121	1124.698

Source: THIRD NATIONAL DEVELOPMENT PLAN

TABLE IV
THE PROPOSED SUB-SECTORAL ALLOCATIONS FOR
1985-2000

Mode of Transportation	N.D.P. in (%)	1985/ 1989	1990/ 1994	1995/ 2000
Highways	78.90	72.60	65.00	70.20
Railways	3.90	3.80	14.20	13.00
Ports	2.80	5.80	7.50	4.60
Waterways	2.70	3.80	3.30	3.00
Airports	4.10	5.60	2.60	2.30
Others	6.60	8.40	7.40	6.90

source: NIGERIAN RAILWAY CORPORATION AND
NATIONAL TRANSPORT DEVELOPMENT

TABLE V

TOTAL LENGTH OF EXISTING ROADS, 1951-1972

Year	Bituminous		Earth/Gravel		Total	
	Kms.	Mls.	Kms.	Mls.	Kms.	Mls.
1951	1782	1114	42632	26645	44414	27759
1962	11053	6908	60818	38011	71870	44919
1968	15200	9500	73280	45800	88480	55300
1969	15758	9849	75200	47000	90958	56849
1971	16122	10076	75088	46930	91210	57006
1972	18109	11318	77266	48291	95374	59609

source: SECOND NATIONAL DEVELOPMENT PLAN

TABLE VI
ROAD-KILOMETRAGE ACCORDING TO FEDERAL, STATE
LOCAL SHARE IN 1972

	Paved	Unpaved	Total
FEDERAL	6477	4130	10607
STATE	8832	12336	21168
LOCAL	2890	60800	63600
TOTAL	18109	77266	95375

Source: ORGANIZATION OF TRANSPORT PLANNING IN NIGERIA

THE OBJECTIVES AND PHILOSOPHY OF TRANSPORTATION IN NIGERIA

The transportation objectives were spelt out for the first time in 1965 in a federal government White Paper on transport development as coordinated development, economic efficiency and by implication, the support of national objectives like the opening up and binding together of the nation. As a matter of public policy, a continued development of efficient dynamic and flexible transport service is seen as vital to economic growth, expanding productivity and a general progress of the nation.

The responsibility for road construction and maintenance reside with various governmental units. Roads with federal responsibility as stated earlier are called trunk 'A'. The States are responsible for trunk 'B' roads while the local governments are responsible for trunk 'C' roads. However, the practice of classification and declassification of roads seems to have occurred for the first time after 1949. The trunk A roads are essentially North-South routes linking the main seaports with their up-country hinterland and the East-West routes connect major urban centers thus, they form the main national grid (Central Planning Office, 1975). It is pertinent to note that there has been an extensive classification and declassification of roads since the political independence in 1960. Such phenomenon does have a tremendous impact on the configuration of the network structure as could be seen from the drastic fluctuation in the number of nodes and linkages, (see TABLE VII). The administrative practices of classification and declassification of roads is a deliberate public policy option available to the government in order to bring about the needed social and

political integration of the nation. This is one public policy that has a tremendous positive impact.

However, there are instances in which the objectives are extremely general in nature and without mechanics for effective operationalization and evaluation. The task of pinpointing anything that coherently constitute the national transportation philosophy for example, is simply arduous. Soon after the civil war in 1971, the federal government put in place a program of reconstruction, rehabilitation and reconciliation as a comprehensive approach to redress the ills that might have led to, and those resulting from the civil war. As a matter of public policy, transport sector was accorded the highest priority status in the second national development plan (Government Printer, 1972). Such policy can be partly explained by the fact that there was urgent need to rehabilitate the badly damaged and insufficiently maintained transport facilities. Another major policy development was the decision by the government to set up a Highway Authority. The main purpose of the agency was to improve the management and construction of federal highways. There were other smaller construction agencies that were set up to work in partnership with the private construction companies. It was the continuous government concern over the deplorable state of transport facilities maintenance that the Kampsax Highways Commission was set up during the second plan period to find ways of improving the existing arrangements of highway maintenance.

TABLE VII
 NUMERIC VALUES OF NODES, LINKAGES, AND
 CYCLOMATIC #

YEAR	1949	1961	1976	1982
LINKAGE	277	107	223	106
NODE	202	98	217	73
CYCLOMATIC #	79	10	8	34

$$\text{Gamma} = e/3(v-1) = 277/3(202-1) = .459$$

$$\text{Alpha} = \mu/2v-5 = 79/(2*202-5) = .198$$

$$\text{Gamma} = e/3(v-1) = 107/3(98-1) = .368$$

$$\text{Alpha} = \mu/2v-5 = 10/(2*98-5) = .052$$

$$\text{Gamma} = e/3(v-1) = 223/3(217-1) = .344$$

$$\text{Alpha} = \mu/2v-5 = 8/(2*217-5) = .019$$

$$\text{Gamma} = e/3(v-1) = 106/3(73-1) = .491$$

$$\text{Alpha} = \mu/2v-5 = 34/(2*73-5) = .241$$

The first progress reports of the second national development plan issued in 1972 were full of inherent problems associated with centrally planned programs of many developing nations. The analysis on state by state progress revealed problems ranging from a complete abandonment of approved projects to inability of effective program implementation. The report went on to indicate that progress under new projects were slowest in implementation due to the fact that approved projects were not properly studied and designed before approval was given.

During the 1970-1974 plan period, there were fourteen new projects to be executed. During the second half of the plan period, actual construction was in progress on two, one was out to tender, four were at final engineering stage, three were being surveyed and nothing was said about the remaining four (Government Printer, 1972). There has been a good deal of project spill-over from one plan period to another. In the North Central state for example, only feasibility studies were completed in all the six proposed roads at the time the first progress reports were issued.

The reports in summary pointed out that the main problems with the implementation of programs are inadequate executive capacity in terms of civil engineers and other technical staff. The issues of foreign exchange control and procedures at the federal level were also noted in the reports as real sources of problems especially, with regards to quick deliveries of ordered plants and equipments. There are also reports on cases where actual road designs were completed without feasibility studies of any kind. As a result of such practices, the estimated cost of those projects were grossly inadequate. This therefore explains in part the reason behind sharp increases in the eventual costs of

those projects. It is this type of approach towards planning that seriously undermine planning in most of the third world as a whole. Subsequently, planning practices in some cases are nothing more than a psychological show case. Despite the common problem of inefficient allocation of resources to transport sector, it is important to note that if indeed a certain rate of growth and a particular spatial arrangement of growth patterns is accepted as a national objective, that a careful planning of transportation investment can play an extremely important part.

One of the most misunderstood and confusing aspects of transportation development in Nigeria is the issue of transportation philosophy. By philosophy, this study implies a sets of logical rationalization that governs transportation practices. Since the fourth national development plan came to an end in 1985, preparation has been underway for the fifth plan. The plan was made public in October of 1987 and was to take effect on January of 1988. However, the President in his new year address to the nation postponed the launching of the plan until January of 1989. The postponement was necessitated by economic reality. The problem of transportation philosophy in Nigeria came into light in the position papers submitted by different transportation related agencies. For example, the Nigerian railway corporation asserts that the neglect of the rail system by successive administrations in Nigeria since 1962 has incapacitated the internationally accepted mass transportation system thus, leaving both air and highways to fill in the gap, unwittingly all along pattern of the transportation philosophy of the United States of America (Nigerian Railway, 1985). Responses to a question concerning what the transportation philosophy in Nigeria is are likely to be

vague, inconsistent, incoherent and broad at best. The debate on what the content of the next plan document should be seem to give the impression that there is a recognition of the complexity of the transportation problem in the nation. However, a clear understanding of the consequences of its complexity and how it could be effectively dealt with is not quite clear. The Nigerian railway corporation position paper concludes that Nigeria is still yet to fully appreciate her fundamental transport problems so as to evolve a suitable transportation philosophy and policies to meet the great challenge ahead. Unfortunately, after many decades of implementing series of planning programs, planning agencies cannot state explicitly and of course, in simple terms what the transportation philosophy of the nation is. more so, that the Nigerian Railway Corporation has to resort to using the study that was conducted for the nations of European Economic Community (Nigerian Railway, 1985), in order to get more funding is simply not the best course of action to pursue.

CHAPTER IV

GRAPH THEORY, AND ITS APPLICATION

GRAPH THEORY

Graph theory, a branch of topology fathered by the Swiss mathematician, Euler, took its origin from the paper Euler wrote in 1736 on "Seven Bridges of the Prussian City of Konigsberg". The second classic work on the network analysis was done by Cayley in 1879. However, what is said to be the first comprehensive treatment of network topology was carried out by Konig in his paper titled "Theorie der Endlichen und Unendlichen Graphen" in 1936. It is the study of this branch of network treatment that came to be called graph theory. The theory is closely related to algebra and matrix theories, and as implied in the Euler's 1736 paper, it is often used to study transportation problems (Haggett and Chorley, 1969).

The theory was rapidly developed during the three decades following Konig's seminal work and has since been summarized in a range of texts like Ore (1963); Flament (1963); Berge (1962); Busacker and Saaty (1965); Harary, Norman and Cartwright (1965). Although the application of graph theory to geography has come within the last decade of the sixties, it has already revolutionized the approaches to the study of transport networks (Chorley and Haggett, 1967).

Graph theory has found relevance in a variety of problems. Beside the obvious applications to design of electrical circuits, transportation analysis

(Avondo-Bodino, 1962; Ford and Fulkerson, 1962) or in the analysis of linguistic structure (Busacker and Saaty, 1965), it is also used in describing patterns of social interaction which goes back to Kurt Lewin's principles of topological psychology (1936). Furthermore, the use of directed and valued graphs have extended from economics out into fields of management like critical-path analysis as well as PERT techniques (Battersby, 1964).

During the past several years a more consistent set of summarizing measures of transportation network characteristics has been developed in order to provide a better basis for the comparison and evaluation of networks. Such endeavor has drawn heavily on the concept of graph theory during the decades of sixties and seventies (Taaffe and Gauthier, 1973). Unfortunately, while interest in the use of this theory is still very strong in other areas of usage like communication and physical sciences, the use of these techniques in transportation analysis is unfortunately, not common in the eighties. This may be partly explained by the changes that had occurred during the past twenty years. The present transportation problems in the West which includes among others, congestion, is not simply amenable to graph theory. Nevertheless, Toh's article on "An Efficient Accessibility Model" which was published in 1984 is a current example of the continued usefulness of graph theory in scientific inquiry on transportation networks.

These techniques are still among the most effective in answering questions concerning how changes in the configuration of a transportation network affects both the connectivity of the system as a whole and the internal accessibility of individual nodes within it (Hebert and Murphy, 1971). The need for offering an effective, and a systematic mechanics for ranking the

accessibility and centrality of nodes within network systems in the developing economies is still very high. Consequently, it underscores the continuous importance of these techniques for many more years to come.

Kansky (1963), hypothesized relationships between network complexity and the degree of economic development. This hypothesis was tested with data from some twenty-five countries, of which Nigeria was one. The result clearly indicated that economic characteristics are a major factor influencing the structure of transportation networks. Garrison and Marble (1964), in their study of the connectivity of a transportation network concluded that the structure of transportation networks may be explained in large part on the basis of the relative location of the neighborhoods and regions. Garrison (1960), in his study of connectivity of the Interstate Highway System was able to compare the individual centers in terms of their comparative accessibility and subsequently, he established the hierarchy of cities within the network system. Others who have utilized this theory in their empirical studies include Pitts (1963), who discussed and explained the centrality of Moscow. Garrison (1959; 1960); Taaffe and Gauthier (1973); Kissling (1969), have also used this theory to evaluate the effects of changes in transportation networks. Hebert and Murphy (1971) used graph theory to study the changing patterns of accessibility of the air transport network structure in eighty United cities. The intention was to determine if the US government's policy of promoting hub and spoke networks for air traffic led to greater accessibility for the hub airports. This study uses graph techniques for a similar, but a more complex analysis of the realization of administrative goals in network structure.

Despite the importance of the identification of transportation linkages in terms of capacity, type of use, and the cost of construction, those characteristics do not lend themselves readily to analysis by graph techniques, and as stated earlier, this is part of the reason why the model has not been extensively utilized in the eighties. Transportation systems in the west have been extensively developed already, the changes that have occurred in the West during the past two decades have been extremely dramatic therefore, the transportation needs and problems have witnessed a shift in the industrialized world. One of the more serious problems during the decade is the question of congestion, and of course, congestion as I have said earlier is not readily amenable to graph theory. However, the situation in the developing world is different. The transportation system is still undergoing the process of initial development. The need for research is even greater today than before, and using a graph theoretic model is quite germane in terms of cost and the model flexibility.

The network system was analyzed at four different periods of time (1949, 1961, 1976 and 1982). In each case, the road network treated as a representation of a finite graph was translated into a square matrix. Operationally, the network was then specified by a connectivity matrix. The elements of the matrix were binary operators **0, 1**, with nonzero element designating the existence of a direct connection between two nodes. The rows of the connecting matrix represented the original nodes while the columns represented the destination nodes.

The periods selected were chosen to cover a long span of time, from the colonial era to the peak of Nigerian post independence economic prosperity. The first road map in Nigeria was produced in 1949. 1961 was just a year after

political independence, and 1976 was a time of the most intensive post independence economic activity. The enormous increase in the economic activity at that time could be traced to Arab Nations' oil embargo of 1973 which gave Nigeria the opportunity of being an important oil supplier to the West. Nigeria's oil production increased from 600,000 barrels per day to 2.4 million barrels per day, and at the same time, the price per barrel jumped by over 700% (Business International, 1979). The availability of road maps at those time periods was the other reason for selecting those periods. The maps are produced by the National Atlas of Nigeria under the auspices of the Federal Department of Surveys.

The basic assumptions made with respect to the network were:

1. A network has a finite number of places
2. Each route is a set consisting of two places
3. Each route joins two different places
4. At the most, only one route may join a pair of places
5. No distinctions are made between the 'initial' and the 'terminal' places of routes, in other words, routes are two-way.

THE IMPORTANT INDICES OF GRAPH THEORY

Graph theory has provided methods for analyzing networks, and the identification of certain structural properties of the networks. There are a range of topological measures developed for the description of networks. Kansky (1963); Haggett and Chorley (1969), have provided summaries of the more important ones together with details of their computations. Garrison (1960), distinguishes two main groups of parameters, the first one describes the

network as a whole and the second ones are parameters that deal with individual vertices on the network.

In dealing with a growth process of networks identified as "node connecting sequences" some of the issues that stand out very prominently are the degree of connectivity among all the vertices and the aggregate accessibility of the entire network system. The degree of connectivity is probably the most important structural property of a network (Taaffe and Gauthier, 1973).

SELECTED GRAPH INDICES

Gamma and Alpha: The abstraction of network as graph, in other words, the conversion of the network into a set of nodes which are related by and incidence function according to a configuration of linkages, makes the computation of these indices possible.

$$\gamma = e/3(v-1) \quad 4.1$$

$$\alpha = e-v+p/2v-5 \text{ or } \mu/2v-5 \quad 4.2$$

where:

γ = gamma

α = alpha

e = edges

v = nodes

μ = cyclomatic number (number of fundamental circuits in the system)

These two indices (gamma and alpha) are the two most important indices that measure the cohesiveness or connectedness of a network.

Accessibility: The treatment of networks within the graph theoretic context offers many possibilities, some of which have to do with a higher level of abstraction, the relative ease with which large numbers of complex networks can be handled and compared, and in greater flexibility. It also offers the ability to switch problems from one "naturally occurring" mode to another where solutions can be readily obtained. The ability to translate networks into matrices in order to tap the powerful resources of matrix algebra is a tremendous benefit (Haggett and Chorley. 1969).

Although it is possible to derive topological measures of individual vertices within a small network by direct measurements from the map, however, it is not possible to do this with the complex network. An effective way of dealing with the complex network is through the process of conversion of network into incidence or connection matrix, and then manipulate the matrix through the use of matrix algebra. This is an area that Shimbel has made a tremendous contribution towards using graph theory in the analysis of network system. He wrote his first article in 1951 and another one in 1953 in which he offered mathematical proof to the use of the principle of matrix algebra in analyzing network structure. Pitts (1965), has also demonstrated clearly the effectiveness of using matrix algebra in the derivation of measures that describe the relative locations within a network structure.

Accessibility is explicitly defined as a function of the topological structure of the network, in other words, it is the sum total of both direct and indirect linkages associated with individual nodes. The powered connection matrix, **C**,

contains elements indicating the number of ways in which the node X_i may be reached from X_j in exactly n steps. The row sum of the powered matrix would indicate the possible number of ways in n steps for any node X_i to be reached from any other node in the system. The solution matrix or matrix T obtained by mean of summing up all the powered matrices will therefore provide a complete information on all possible multiple-link connections.

$$T = C^1 + C^2 + C^3 + \dots + C^n \quad 4.3$$

The summation of the elements in T across any row or down any column produces a vector of numbers indicating the accessibility of each node on the network, thus,

$$A(iC) = \sum_{j=1}^n \text{distance}(ij) \quad i = 1, \dots, n \quad 4.4$$

$$D(C) = \sum_{i=1}^n \sum_{j=1}^n \text{distance}(ij) \quad i = 1, \dots, n \quad 4.5$$

where:

$A(iC)$ = accessibility of i th place (distance is measured in terms of the number of the linkages between i and j)

$D(C)$ = the measure of the accessibility of the network as a whole

These indices are found to be higher for more extensive and complex network. For example, a small value of alpha implies that the network in question is yet to be designed to provide a number of alternative connections to the nodes within the network system, while the value of gamma is directly proportional to the degree of the complexity of the network. The concept of connectivity has therefore been found to be most meaningful when a given network is either compared with other networks or its growth is viewed through time. Furthermore, since the expansion or intensification of transport linkages between nodes is in some cases directly related to increases in demand for transportation facilities to move goods and people, the degree of connectivity is found to be indicative of the complexity of the spatial order that it imposes on the region it serves.

The planning of large-scale, locationally-fixed transportation system is indeed complicated process that involves the relationship between physical and financial resources, activities and people over a long planning horizon. Therefore, to insure that citizenry is able to pursue certain activities, the scarce resources must be allocated among alternative uses within the socio-economic planning environment with the best available information. It is only in so doing that the specific objectives can be achieved.

CHAPTER V

ANALYSIS OF ROAD NETWORK DEVELOPMENT BASE ON GRAPH THEORY: CASE STUDY OF THE TRUNK A NETWORK IN NIGERIA

THE SELECTED STUDY PERIODS AND THE ANALYSIS

The four periods studied (1949, 1961, 1976 and 1982), were carefully selected in order to provide a reasonable span of time to cover both the colonial and post colonial eras of road network development. The study reveals that actions that alter the structure of network do also alter the accessibility of the individual nodes within the network system. The drastic fluctuation in the number of nodes, linkages as well as in the values of gamma and alpha indices is directly contrary to any suggestion to the effect, that the sequence of network development is discrete in nature. It is rather naive to talk about, let alone expect an ideal situation in a complexed social environment. It is pertinent to note that by 1949, Nigeria has already embarked on network development for almost half a century. Thus, the study could not capture the very first step in the postulated sequence. However, base on the direction of the lines of penetration as reveals in the analysis, it can be safely reduced that the lines of penetration began from the seaport and moved inland.

The 1949 abstracted network (see Figure 2) contains at least two hundred and two nodes as well as some two hundred and seventy seven linkages. The analysis indicates the radiation of lines of penetration from the south western portion of the country towards the northern hinterland. The accessibility hierarchy was quite predictably dominated by nodes mainly from

the South-western and those from the Northern regions of the country (see TABLE VIII).

The six most accessible nodes were Kabba, Omu Aran, Ado Ekiti, Bauchi, Jos and Owo. The pattern and the domination of the accessibility hierarchy by those nodes from the south-western region suggests, among other things, that the origin of those lines of penetration were from the sea coast. Some 67% of the six most accessible nodes was from the south western region, with the remaining 33% coming from the northern region (see Figure 3). Furthermore, the continuous importance of those nodes over the years attests to the Taaffe, Gould and Morrill (1963) assertion that the initial penetration lines are of outermost importance in the process of network development.

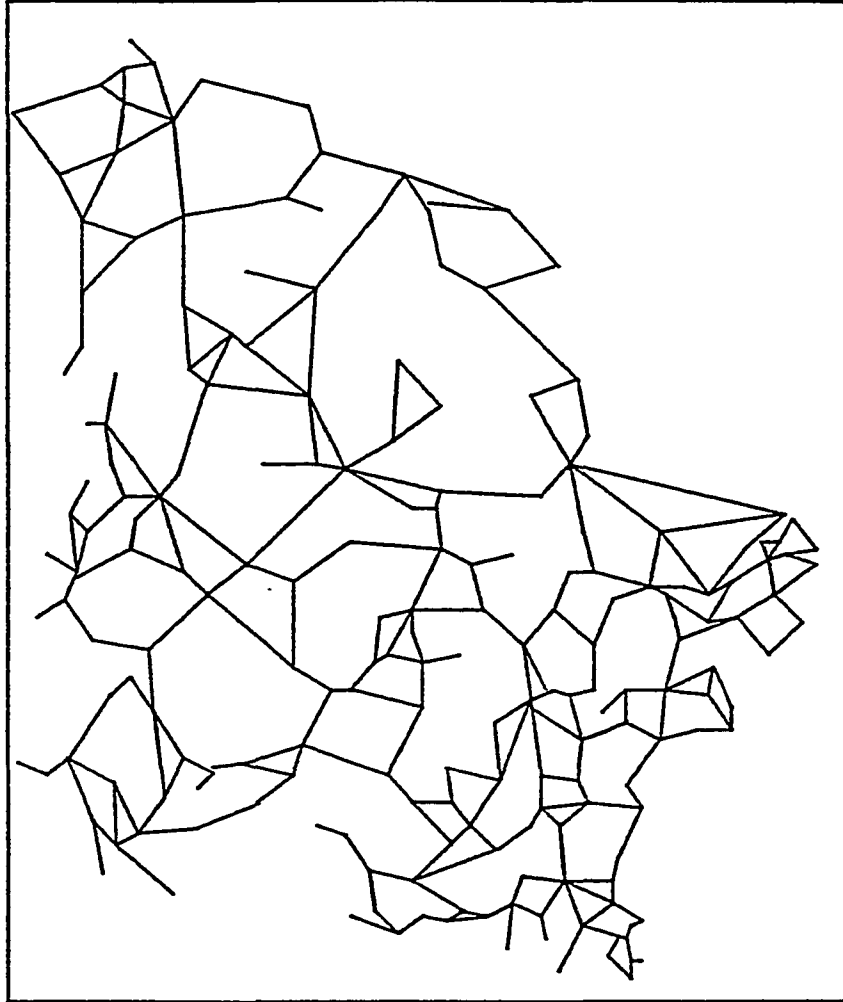


Figure 2. Abstracted road network of 1949

TABLE VIII
NETWORK HIERARCHY IN 1949

Node	ACC. INDEX(%)	Node	ACC. INDEX(%)	Node	ACC. INDEX(%)
KABBA	3.457	OKITIPUPA	0.676	BASHAR	0.317
OMUARAN	2.887	DAMASAK	0.641	YELWA	0.317
ADO EKITI	2.705	ABAKALIKI	0.634	AWGU	0.307
BAUCHI	2.123	LANTEWA	0.631	OKAKA	0.307
JOS	2.116	KUSHERIK	0.617	NAFADA	0.306
OWO	1.988	GBOKO	0.604	IKOTEKPENE	0.303
BADAN	1.845	MARTE	0.590	ABRAHA	0.298
ISAN MAKUTU	1.762	OGBOMOSHO	0.586	IKEJA	0.296
AKURE	1.743	GUMEL	0.577	AHA	0.296
OKENE	1.660	BICHI	0.573	AFIOCHUKU	0.292
ILESHA	1.639	ISEYIN	0.559	KWALE	0.285
FOGGO	1.617	MANGONU	0.555	OTUKPA	0.272
ONDO	1.539	BENIN CITY	0.554	UDI	0.271
ZARIA	1.528	OTTA	0.551	OTURKPO	0.268
KANO	1.477	DAMBARTA	0.542	PAKO	0.262
KARI	1.457	YASHI	0.541	ZUNGERU	0.259
IFE	1.421	JEBBA	0.531	BDA	0.258
LOKOJA	1.420	ENUGU	0.523	BADEGGI	0.251
ILORIN	1.399	DIKWA	0.509	KEBBI	0.250
DARAZO	1.333	AGBOR	0.507	ORLU	0.246
KAHOWA	1.319	KSH	0.501	JEGA	0.246
SHAGAMU	1.308	ALALLUKO	0.495	DONKO	0.227
ABEOKUTA	1.165	OKIGWI	0.488	MINNA	0.225
AZARE	1.163	GASHUA	0.472	KATSINA ALA	0.224
OSHI	1.109	CALABAR	0.471	WUKARI	0.224
GOMBE	1.076	LAGOS	0.470	SAPELE	0.223
UEBU-ODE	1.049	GUSAU	0.452	TAPA	0.219
NDEJI	1.038	MAKURDI	0.426	DUTSI	0.217
FUNTUA	1.037	FRILUA	0.423	KAM	0.216
POTISKUM	1.001	ABUJA	0.386	ADO	0.214
GUBIO	0.994	KEFFI	0.379	DAURAWA	0.211
MAIDUGURI	0.977	TIBCHI	0.379	BIRNIN KEBBI	0.208
BDA	0.924	TEGINA	0.372	IBETO	0.203
WUDIL	0.878	AKWANGA	0.360	WARRI	0.201
MALUMFASHI	0.870	KATSINA	0.357	SHAKI	0.200
DAMATURU	0.856	BOSSO	0.355	NASARAWA	0.198
UYERE	0.840	ONISHERE	0.353	JABO	0.196
IGPORIN	0.837	KONTAGORA	0.340	ABAJI	0.195
WAMBA	0.831	IDOFA	0.339	ILARO	0.195
GEDAM	0.811	BOKANI	0.338	GAWU	0.194
PANYAM	0.782	NUMAN	0.338	ZURMI	0.191
LANLATE	0.753	AUCHI	0.333	DAURA	0.187
KADUNA	0.736	ANKA	0.329	KAFN	0.185
NUNKU	0.706	KACHIA	0.328	KAJAMA	0.183
ALAPA	0.692	UMUJAHIA	0.320	NSUKKA	0.182
OYO	0.690	BU	0.319	OWERRI	0.182

TABLE VIII (CONTINUED)

Node	ACC. INDEX (%)	Node	ACC. INDEX (%)	Node	ACC. INDEX (%)
JERIYA	0.180	YOLA	0.111	LOKO	0.060
MAIGATARI	0.173	FOKKU	0.110	WAWA	0.058
HADEJIA	0.173	DANKAMA	0.108	GWADABAWA	0.056
UYO	0.169	ANKPA	0.104	BAURE	0.055
OSHOGBO	0.166	YELWA	0.098	MARADI	0.053
IMERE	0.161	OPOPO	0.098	MAHUTA	0.048
SOKOTO	0.154	ONITSHA	0.094	OKUTA	0.047
NGURU	0.153	SHARI	0.094	MUBI	0.047
ZURU	0.153	AGENEBODE	0.093	MATSENA	0.045
NGALA	0.151	TA. MAFARA	0.090	KANGIWA	0.043
ABA	0.150	AHOADA	0.082	MAYO	0.039
ASABA	0.150	ORON	0.078	BAMA	0.020
ITU	0.150	GULU	0.077	ICHEU	0.019
ABAK	0.150	DAH	0.077	KALMOLO	0.018
UGHELLI	0.147	P.HARCOURT	0.075	BUSSA	0.017
GOMBI	0.139	EKET	0.074	YASHIKERA	0.014
TAKUM	0.137	IIESHA	0.074	TOUNGO	0.013
ARGUNGU	0.131	KAMBA	0.067	JALINGO	0.012
MALINCHI	0.129	GWASERO	0.067	SERTI	0.004
UZEBBA	0.123	BADAGRI	0.063	KIAU	0.001
IDHROKO	0.121	KOTON KARI	0.063		
AWKA	0.116	ANYANGBA	0.061		

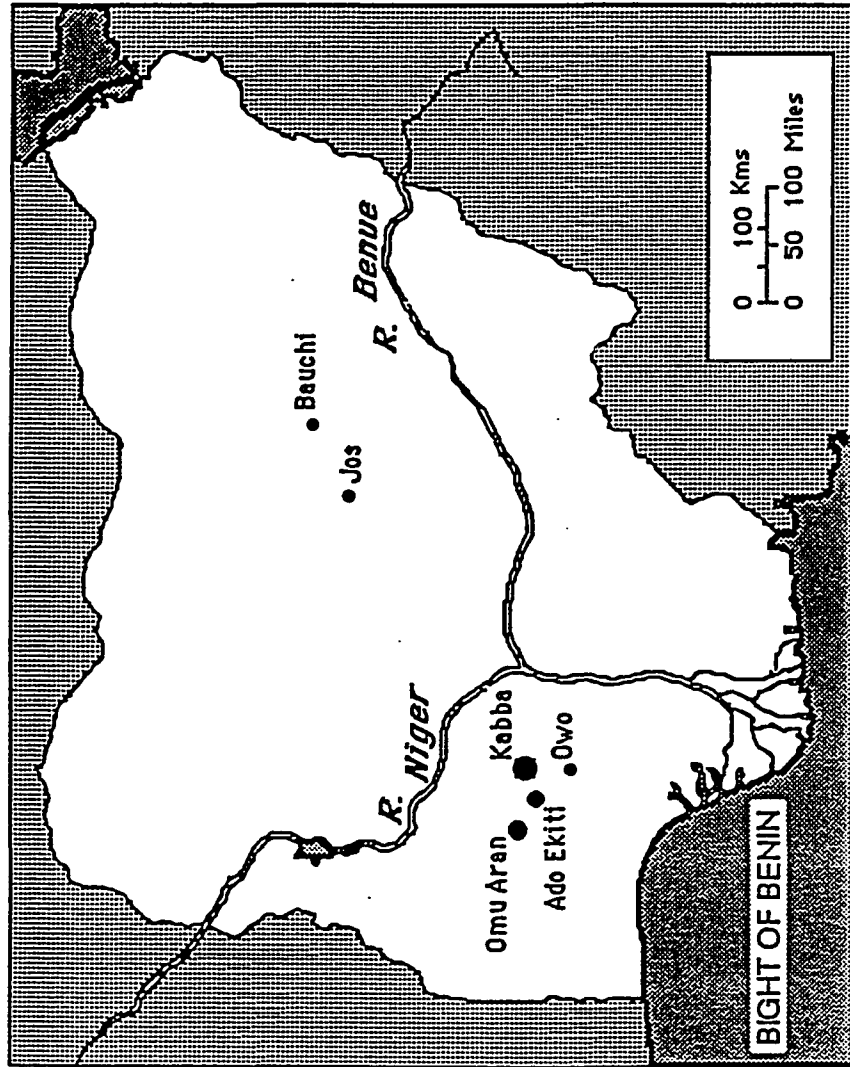


Figure 3. Map showing the six most accessible nodes in 1949

Agriculture was the foundation of economic "take off" in Nigeria and has remained the largest sector of employment to date (Business International, 1979). Nigeria main cash crops are mainly, palm oil, cocoa, rubber, groundnuts, cotton and palm kernels. The production of these crops exhibits a remarkable spatial pattern according to the nation's ecological zones. Crops like cocoa, oil palm, and rubber are restricted to the south while others like groundnuts, and cotton are confined to the northern savannah zone, (Barbour, Oguntinyinbo, Onyemelukwe and Nwafor, 1982). Exportation of cocoa, which was introduced into Nigeria during the late nineteenth century, was actually one of the commodities that secured Nigeria a place on the map of international trade. The cocoa plantations were exclusively located in the south western region of Nigeria, and the region still dominates cocoa establishments to date. Nigeria's exports since the late 1960's have been dominated by crude oil (Economist Intelligence Unit, 1987), with cocoa as one of the most important export commodities. Consequently, the reason why places in the region dominated the accessibility hierarchy in 1949 is indeed appealing in economic sense.

The direction of the penetration of lines as is revealed in the analysis does provide reason to believe that the first stage in the postulated sequence holds in the case of network development in Nigeria. The lines of penetration were radiating from the sea ports, notably, the Lagos seaport into the south west hinterland so as to enhance the process of shipping the cocoa produce to the seaport for onward shipment to the final destination in Europe and beyond.

The degree of the complexity of the network as revealed by the values of alpha and gamma was quite low. The implication of this is that, even after about

a half a century of a significant and consistent investments in highway development, the network was still at elementary stage of development (see TABLE IX). The general distribution of the accessibility was extremely less than even. The first twenty or some ten percent of the most accessible nodes accounts for some thirty-seven percent of the entire network accessibility. The next fifty one nodes or some twenty five percent of the next more accessible nodes accounts for some thirty eight percent of the total accessibility, while the remaining one hundred and thirty one nodes or some sixty five percent of all the nodes accounts for just some 25% of the total accessibility (see Figure 4).

The extremely skewed nature of the accessibility of the the network system does not support any suggestion that the network at the time in question was designed with due consideration given to the geographical and social integration of the nation. The percentage difference between the most accessible and the least accessible nodes is almost one hundred percent. Furthermore, the average accessibility of the bottom one hundred and thirty one nodes in the accessibility hierarchy is only 0.01% (see Figure 5).

The analysis of the network system in 1961 reveals further penetration. However, the penetrations were now moving towards the central portion of the northern region of the country. The change in the network configuration (see Figure 6) altered the internal accessibility of the network. For example, the number of nodes shrank from over 200 to just about 98, while the linkages shrank from almost 300 to some 107 (see TABLE VII). Nodes from the northern part of the country now dominated the accessibility hierarchy (see TABLE X).

TABLE IX
NUMERIC VALUES OF THE NETWORK AS GIVEN BY GAMMA
AND ALPHA INDICES

	1949	1961	1976	1982
GAMME	45.90%	36.80%	34.40%	49.10%
ALPHA	19.80%	5.20%	1.90%	24.10%

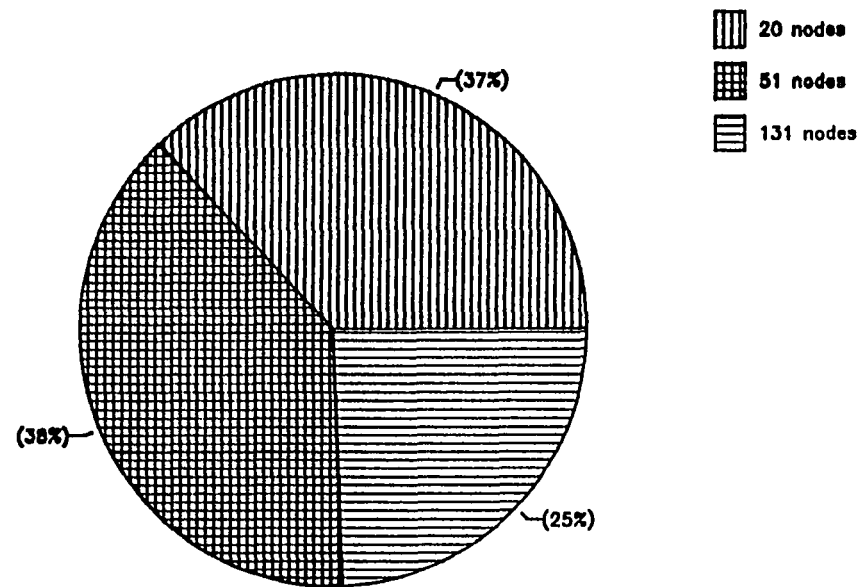


Figure 4. Grouping the accessibility into three categories in 1949

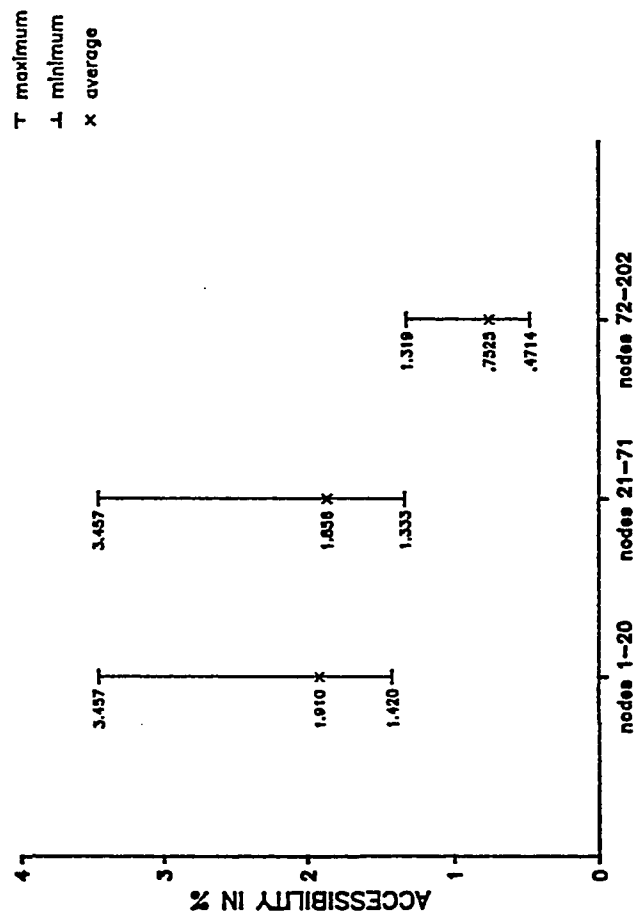


Figure 5. Maximum, minimum, and average accessibility in 1949

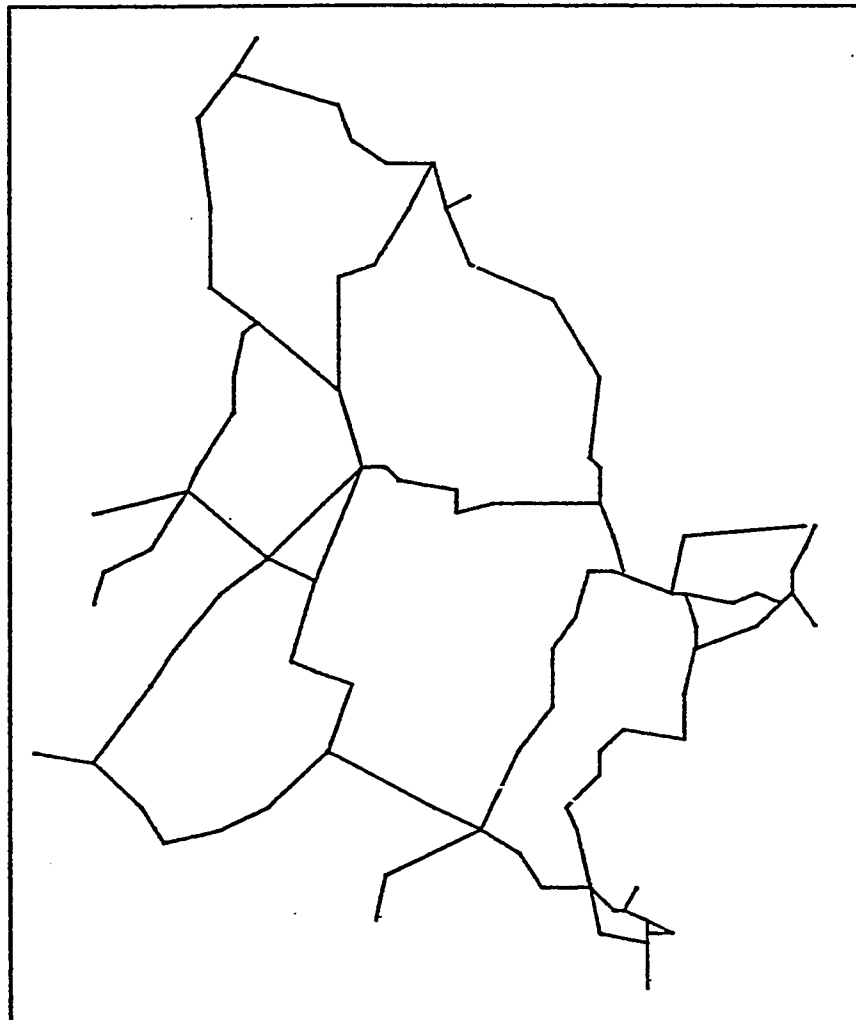


Figure 6. Abstracted road network of 1961

TABLE X
NETWORK HIERARCHY IN 1961

NAME	ACCESS. INDEX (%)	NAME	ACCESS. INDEX (%)	NAME	ACCESS. INDEX (%)
ZARIA	7.806	LORIN	0.882	YASHIKERA	0.272
KADUNA	6.172	OGBOMOSH-O	0.764	OWERRI	0.266
JOS	6.170	WAMBA	0.722	LOKOJA	0.260
KANO	5.4341	JEBU-ODE	0.722	ONITSHA	0.255
BAUCHI	3.7571	DROKO	0.617	GOMBI	0.254
FUNTUA	3.479	TEGNA	0.581	YELWA	0.250
BUKURU	2.724	DAMATURU	0.581	ANKPA	0.245
MANDO	2.717	NUMAN	0.577	MUEI	0.244
WUDIL	2.451	SOKOTO	0.574	ENUGU	0.232
YASHI	2.389	ILESHA	0.567	GECKO	0.226
KAFI	2.389	JIBIYA	0.558	OYO	0.223
DAURA	2.360	JEBBA	0.553	AYANGBA	0.215
KORODU	2.256	EGEE	0.532	JEGA	0.200
KEJA	2.243	YOLA	0.461	UMUJAHIA	0.199
GOMBE	1.988	KAIAMA	0.447	JEDA	0.197
GLSAU	1.876	AKWANGA	0.430	KOKO	0.191
BADAN	1.870	KONTAGORA	0.428	AGEO	0.179
LAGOS	1.870	MADUGURI	0.413	BELI	0.178
OTTA	1.740	MAYO BELWA	0.372	KOTEKPENE	0.174
SHAGAMU	1.591	AKURE	0.372	YANDEV	0.170
BRININKUDU	1.591	KABBA	0.366	FCN	0.162
KURU	1.566	JIBIRU	0.360	TAKUM	0.161
KUSHERIKI	1.264	TAMBAWEE	0.349	BENIN CITY	0.161
PARU	1.259	AUADE	0.341	AWKA	0.156
ABECKUTA	1.227	OTUKPA	0.335	DAR-AL-JIMEIL	0.153
MSAU	1.213	BAMA	0.324	ABAKALIKI	0.143
KATSINA	1.180	UMUVO	0.323	PT. HAROCURT	0.129
POTISKUM	1.119	LAFIA	0.302	OKIGAM	0.120
OYO	1.082	OTURKPO	0.292	UYO	0.119
ROGGO	1.042	ILLELA	0.287	CALABAR	0.071
TURE	1.021	MAKURDI	0.287	UDI	0.063
FE	0.981	ABA	0.283	OFON	0.054
MAINCHI	0.908	JALINGO	0.278		

All the six most accessible nodes (Zaria, Kaduna, Jos, Kano, Bauchi and Funtua), were clustered around a relatively small section in the north (see Figure 7). The pattern and composition of the accessibility hierarchy reveals the direction of the lines of penetration. The penetration lines were now moving further and further away from the sea coast to the interior. Once again

economic rationalization was more compelling in explaining the changes in relative location of nodes that had occurred between 1949 and 1961. At this moment in time, Nigerian cash crops production particularly groundnut was highly intensified (see TABLE XI). Cotton produce was also making an impact among the export commodities. In 1965, out of the 263.25 tons of domestic export, cocoa accounted for some 16.22% while groundnuts and raw cotton accounted for some 20.44%. By 1966, of the 277.52 tons of domestic export, cocoa's share dropped to some 10.1%, while groundnuts and raw cotton stayed at some 20% (Economist Intelligence Unit, 1968). The climatic conditions in the north are of course, quite suitable for conducting such economic activities. The significant variations in climate throughout the country is such that these kind of economic activities will not be viable in the south-west nor in the south or south-eastern parts of the nation. Thus, these goods were exclusively produced and are still being produced in the northern part of the country. It is therefore, not surprising to see the accessibility shifting accordingly to reflect the new economic trend.

The values of both gamma and alpha were still relatively small. Thus, suggesting that the network was still at elementary stage of development. As the penetration was still in progress in an inward direction, the interconnection of nodes was also going on in extremely few selected nodes. What was going on therefore, could be more accurately described as branching out to incorporate new nodes into the network system. While the network was branching out in one hand, some of the existing nodes were being eliminated from the network system. The ideal-typical model unfortunately, does not seem to have anticipated this kind of development.

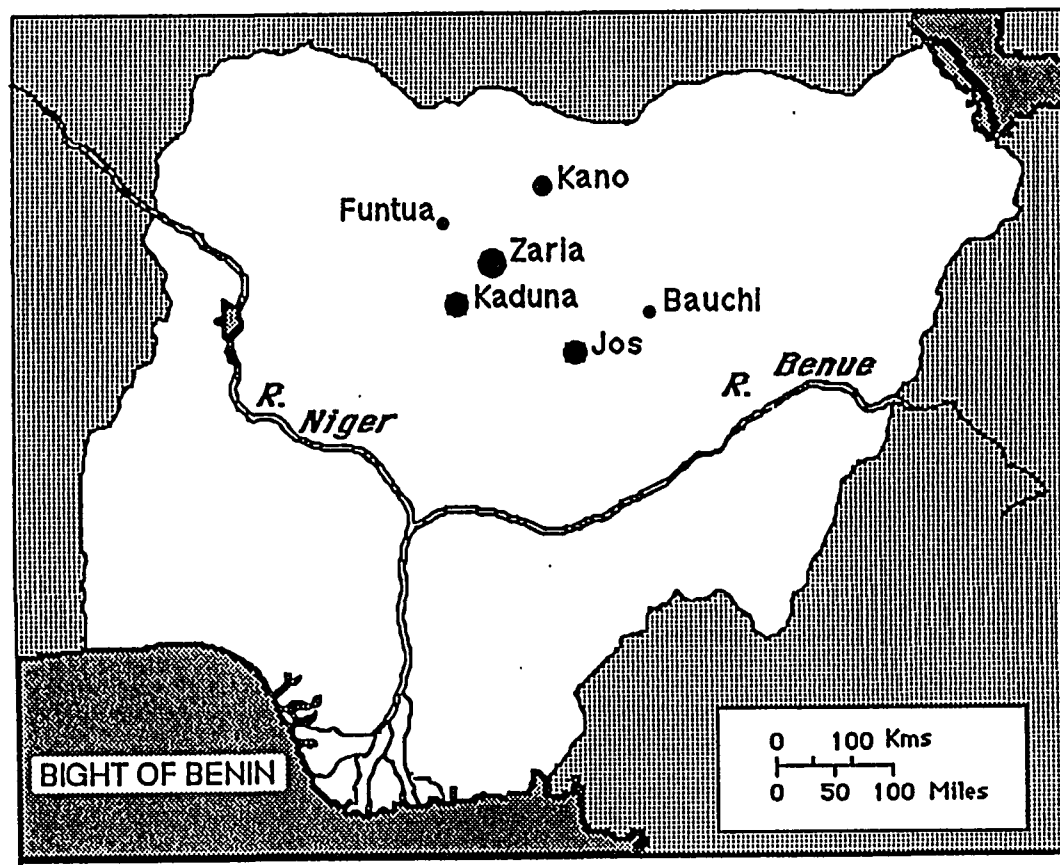


Figure 7. Map showing the six most accessible nodes in 1961

TABLE XI

EXPORTS OF NIGERIA'S CASH CROPS BY WEIGHT 1960-1970
(IN THOUSANDS OF TONS)

	Palm Oil	Palm Kernels	Rubber	Groundnut	Cotton	Cocoa
1960	183.0	197	58.5	432	43.4	160
1970	008.0	185	60.1	279	45.8	196

Source: NIGERIA IN MAPS

The network in 1961 despite its decline in the number of nodes and linkages as well as in the over all complexity, surprisingly, exhibits multiple characteristics that could be readily seen in a network that is still at an elementary state of development. For example, the most accessible node in the network (see Figure 8), accounts for almost eight percent of the entire accessibility. The first ten most accessible nodes or some ten percent of the total number of nodes accounts for over forty percent of the accessibility. The least accessible node among this particular group accounts for over two percent of the network accessibility, with an average accessibility of well over four percent. Thus, it is quite obvious that there were relatively significant degree of interconnectedness among some selected nodes. Therefore, it is safe to assume that such phenomenon will certainly induce the emergence of certain high-priority trunk lines which is indicative of the existence of the second, the third, and the forth stages of the ideal-typical sequence model.

The accessibility as in the previous case was generally unevenly distributed. The first ten most accessible nodes, as stated earlier, account for forty three percent accessibility. The next twenty five nodes or some twenty six percent of more accessible nodes accounts for thirty seven percent of the accessibility, while the remaining sixty three or some sixty five percent of nodes accounts for only twenty percent of the accessibility (see Figure 9). Such degree of skewness obviously supports the assertion by Haggett (1969) that some locations are likely to grow at the expense of others, and subsequently, the process of network growth will accentuate concentration of activities in few centers. While the most accessible node accounts for almost 8% of the network accessibility, the least accessible node accounts for a mere 0.05%.

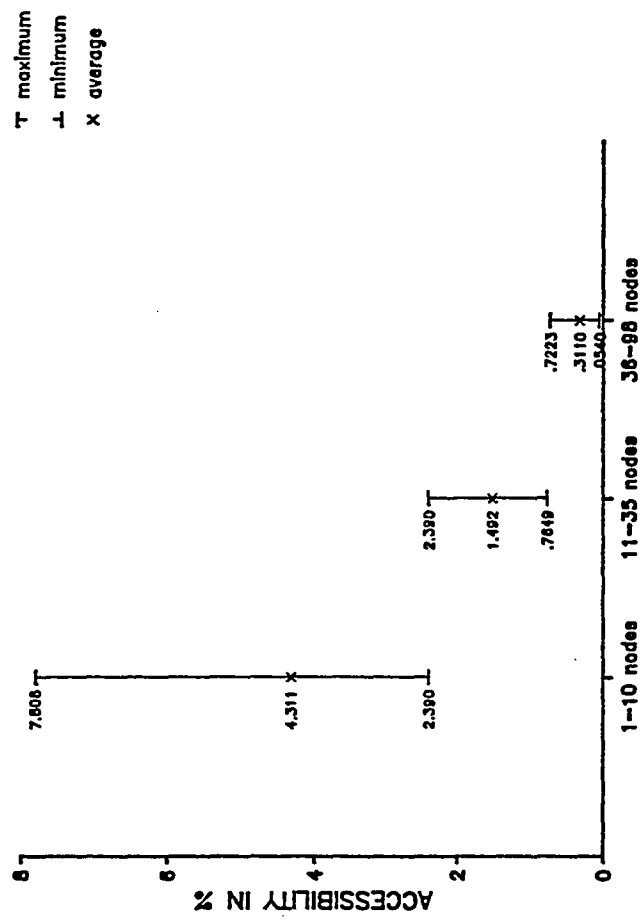


Figure 8. Maximum, minimum, and average accessibility in 1961

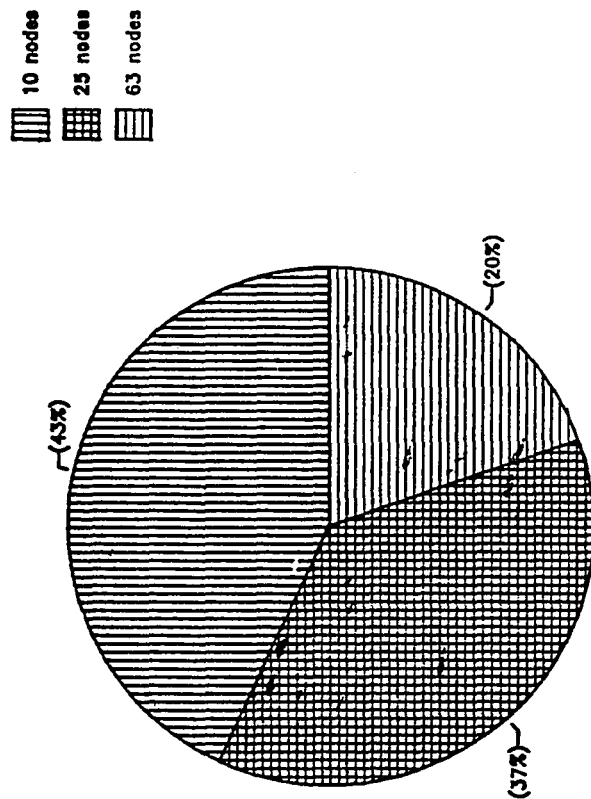


Figure 9. Grouping the accessibility into three categories in 1961

The network in 1976 witnessed the most extensive effort in its expansion and development by the federal government as well as the state and local governments. This was barely five years after the end of the civil war. The war did cause an extensive destruction of different forms of infrastructure. The destruction of notably transportation infrastructure occurred much more in what was known at that time as the eastern region. For three years, the eastern region was subjected to a severe air, water and land bombardment by the federal troops as the civil war raged on. The deplorable state of things in the region aroused an urgent need for a comprehensive approach in addressing the problem. The need was so compelling that the federal government responded immediately with a comprehensive programs as part of the 1970-75 National Development Plan.

The vigorous programs of reconstruction, reconciliation, and rehabilitation embarked upon by the federal government put the eastern region at the center of road construction. The state governments were instructed by the federal government that their road programs should be designed to dovetail into the federal network. As stated earlier, the all-important function of the trunk **A** road as handed down by the colonial administration was the facilitation of the evacuation of produce. At the outset of the seventies, the reconstruction of the war damaged infrastructure and the linking of states in order to integrate the nation and consequently facilitate political stability through the enhancement of the inter-state commerce and social interactions were now moved to the top of the agenda. The states road programs were expected to fit into the federal network so as to form a national road network grid that ultimately will enhance the industrial, administrative, social and political development of

the nation. The network in 1976 was made up of at least two hundred and seventeen nodes and some two hundred and twenty three linkages (see Figure 10). The effort to expand the network system to achieve the above stated goals resulted in a significant increase in the number of nodes and linkages. The increase in size of the network however, was accompanied by a sharp reduction in the degree of the complexity of the network as indicated by the values of both gamma and alpha, (see TABLE IX). While on one hand the network witnessed massive expansion and a decline in its complexity, the accessibility on the other hand shifted from the northern region to what was known then as the eastern region (see Figure 11 and TABLE XII).

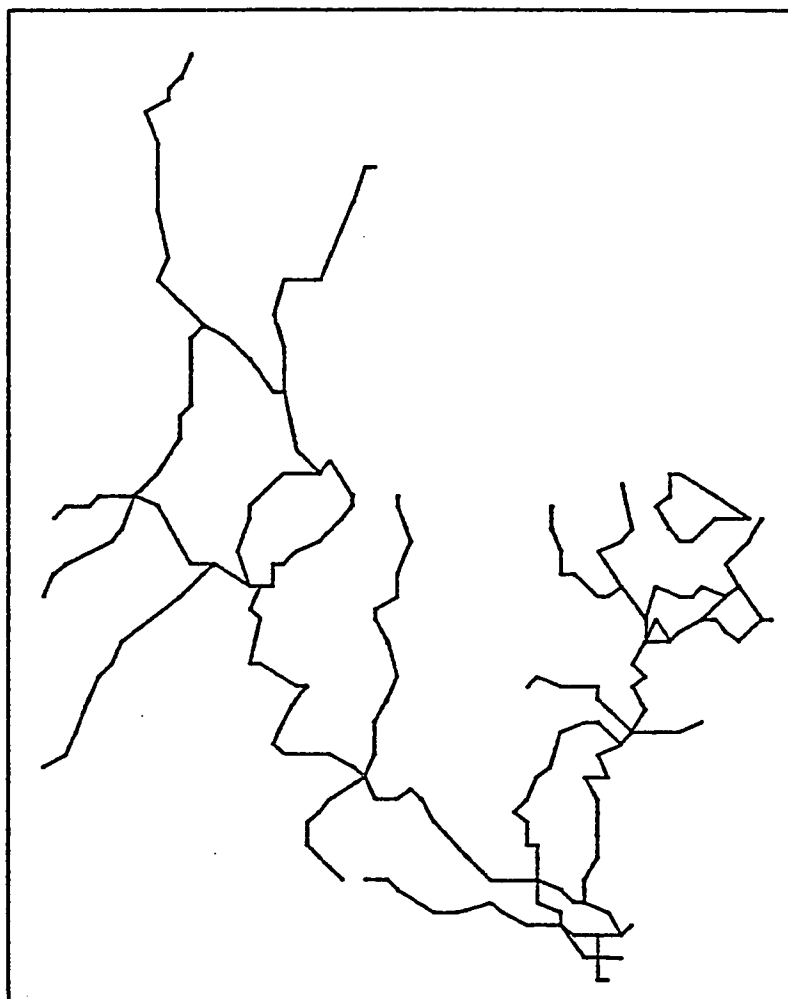


Figure 10. Abstracted road network of 1976

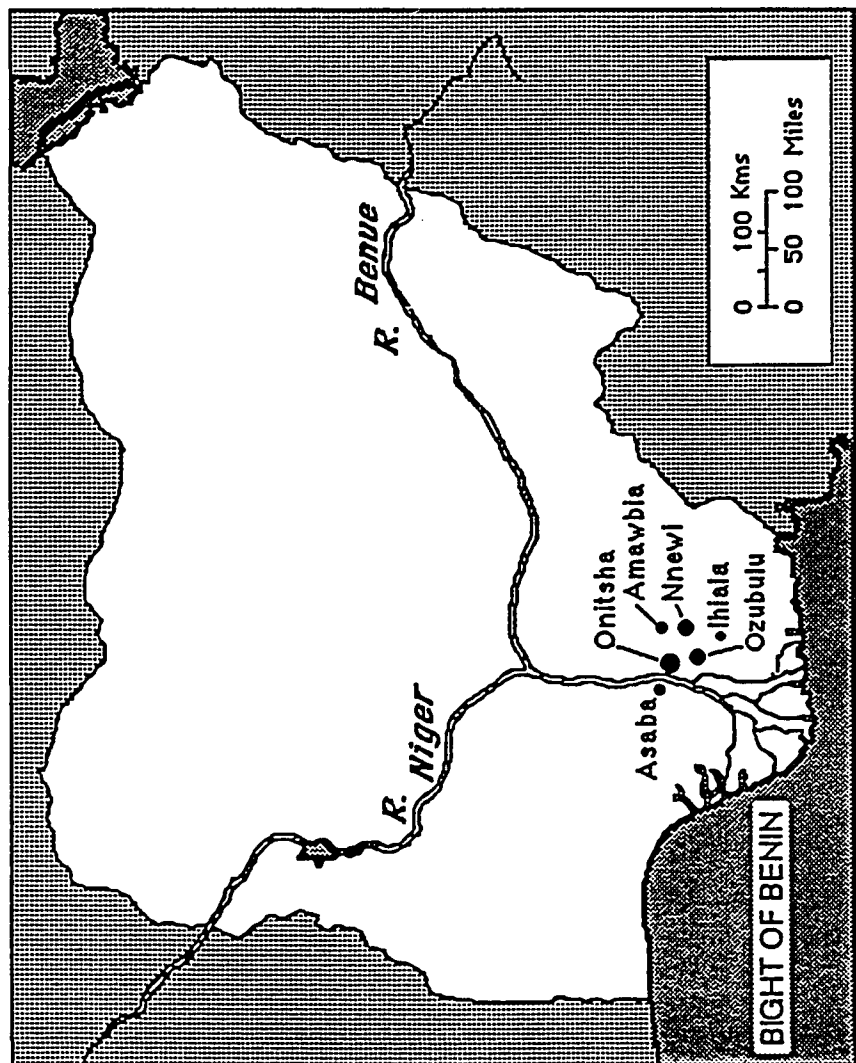


Figure 11. Map showing the six most accessible nodes in 1976

TABLE XII
NETWORK HIERARCHY IN 1976

NODE	Acc. Index (%)	NODE	Acc. Index (%)	NODE	Acc. Index (%)
ONITSHA	5.266	BICHI	0.698	GUBI	0.336
OZUBULU	4.247	DAMBARTA	0.694	GAIGA	0.336
NNEWI	3.647	SHIKA	0.666	BUKURU	0.315
AMAWBIA	3.314	ETITI	0.641	OBOLO	0.305
ASABA	2.504	JEBBA	0.618	IDHROKO	0.296
HALA	2.170	RUMUOGBA	0.614	NKALAGU	0.294
BENIN CITY	1.784	FE	0.613	LORIN	0.293
UDI	1.722	BOKANI	0.610	EKPOMA	0.276
AWGU	1.623	KUDU	0.610	IKORODU	0.269
ABEOKUTA	1.491	EBAN	0.605	ALKALERE	0.267
BADAN	1.454	KADUNA	0.581	ABUDUO	0.265
ULI	1.360	BURUKU	0.580	PORT HARCOURT	0.261
KANO	1.324	UKEHE	0.570	GBONGAN	0.255
RIGACKUN	1.319	ENUGU	0.565	SHAGAMU	0.255
OVERRI	1.313	AGEGE	0.557	ADO AWAYE	0.254
OLUKU	1.312	BAUCHI	0.552	IGPORIN	0.250
ISELE-UKU	1.273	JOS	0.521	BIRNIN KUDU	0.243
ZARIA	1.209	IGOR	0.520	OWO	0.243
NGWO	1.131	UMUNELU	0.499	OWENA	0.242
UMUJVO	1.129	PAMBEGUMA	0.472	ZALANGA	0.223
MOKWA	1.117	SAPELE	0.470	KABCHI	0.222
ODEDA	1.054	OGBOMOSHO	0.469	BDA	0.221
KAWO	1.053	ELELE	0.467	LANGAIANGA	0.219
OLODO	1.039	TORO	0.462	GIMI	0.211
ABUDU	1.004	ERUWA	0.455	RIMI	0.210
ERUA	0.923	KIFE	0.450	KUFANA	0.205
KURA	0.909	PERU	0.450	UYO	0.205
HUNKUM	0.903	GWARAM	0.430	NEWBUSSA	0.202
UGBENU	0.901	KACHAKO	0.423	BIRNIN GWARI	0.202
OKIGWE	0.887	TSAN YAWA	0.403	SANDAMU	0.193
ITORI	0.870	BODE-SHADU	0.402	WARRI	0.187
IGBO-ORA	0.800	ADO	0.402	OROKAM	0.170
OYO	0.786	FON	0.400	SAMAM	0.169
APOMU	0.779	OFOJU	0.400	BAPA	0.168
ISHARA	0.779	KEJA	0.398	FE	0.167
UMUNEDE	0.778	KOTEKPENE	0.394	ODOGBOLU	0.166
ILARO	0.777	KAZAURE	0.392	BADAGRI	0.164
GAMAGIRA	0.760	PIZHI	0.382	AGBEDE	0.162
ABA	0.747	WUGA	0.381	ISEYIN	0.158
UHERE	0.742	GWA	0.379	LAGOS	0.157
IGBOGOR	0.742	FUNTUA	0.373	DARAZO	0.154
AGB-BOJIBOJI	0.740	BABINDA	0.372	KONTAGORA	0.154
MBERICHI	0.732	BAMBAFU	0.370	EZZANGBO	0.153
UMUAHIA	0.730	MUSHIN	0.357	AKURE	0.153
WUDIL	0.708	LAPAI	0.338	AGAIE	0.152

TABLE XII (CONTINUED)

NODE	Acc. Index(%)	NODE	Acc. Index (%)	NODE	Acc. Index (%)
ORE	0.150	TEGNA	0.090	MADUGURI	0.055
JEMMA	0.146	AUCHI	0.090	TMAFARA	0.055
ARNAIDO	0.144	DALURA	0.086	NUMAN	0.052
GUSAU	0.138	OFON	0.086	OSOSO	0.052
KUSHERIKI	0.136	IZOM	0.083	ADO	0.049
KARI	0.131	POTISKUM	0.081	DALOFI	0.048
MSAU	0.129	ABAKALIKI	0.081	IGBOHO	0.047
UOFIN	0.127	BLURI	0.076	JIBIYA	0.047
WAWA	0.123	ZOFD	0.072	BIMASA	0.041
KAFANCHAN	0.122	MAFU	0.071	KEFFI	0.039
IESHA	0.119	AGO-ARE	0.070	OTURKPO	0.038
KACHIA	0.117	ABUJA	0.068	KONDUGA	0.038
ILARA	0.116	DAMATURU	0.068	NKOMFAP	0.034
KATSINA	0.115	CALABAR	0.068	JIMETA	0.033
UEBU-ODE	0.114	OBAN	0.068	KISHI	0.031
GOVEE	0.112	EKANG	0.068	KAIAMA	0.030
OMOTOSHO	0.112	AJASSO	0.068	KELAPRAEL	0.028
BAFI	0.109	DONGALA	0.068	GLDI	0.027
IPETU-UESHA	0.106	CHANA	0.068	BAMA	0.027
KLUAMA	0.104	NKO	0.068	OKENE	0.022
OTUKPA	0.103	UGEP	0.068	ALIABE	0.018
KAGARA	0.102	OKURKA	0.068	YOLA	0.016
OKUTA	0.099	AKAMKPA	0.068	BATABI	0.015
ALAKUKO	0.097	KALI	0.064	SOKOTO	0.014
LANZAI	0.096	BENISHEIKH	0.064	AKWANGA	0.014
MASAMA	0.095	OCHOBO	0.063	DIFCHARI	0.014
MARIGA	0.094	ALNO	0.061		
KAJOLA	0.093	TASHA	0.059		

The six most accessible nodes were Onitsha, Ozubulu, Nnewi, Amawbia, Asaba and Ihiala. All the six nodes clustered around a very small portion in the region. Like any other network at elementary stage of development, the accessibility was concentrated in few selected nodes. For example, the first twenty two nodes or some ten percent of all the nodes accounts for some forty three percent of the network accessibility. The next sixty five or thirty percent of the more accessible nodes accounts for some forty percent of accessibility, while the remaining one hundred and thirty or sixty percent of all nodes accounts for merely seventeen percent of the accessibility (see Figure 12). The most accessible node accounts for over five percent of the entire accessibility;

while the least accessible node accounts for just about one one-hundredth of a percent (see Figure 13).

The result of the analysis of the 1976 network once again, raises a serious question concerning the discrete nature of network development. The problem of predicting the stages of network development in the developing nations is as uncertain as the task of predicting political stability in those nations. By 1976 road network in Nigeria has witnessed some seventy six years of development. However, the network configuration base on the values of gamma and alpha indices indicates that the network complexity in 1976, despite the enormous expansion was actually lower than either in 1949 or 1961. Thus, it suggests that the classification of network configuration as either spinal, grid, or delta base on the numerical value of gamma and alpha indices may provide much more insight to stages of network development in the post colonial era than the ideal-typical model does. One of the most interesting discoveries at this point is that the changes in the configuration of the network for the first time, could no longer be adequately explained by just economic rationalization alone. The social, and political factors tend to have come to play much more significant role. This is very importance because it marks the turning point in the network evolution in Nigeria. It was an unmistakable shift from colonial orientated to an indigenous inspired approach to network development. This was an approach in which the local aspiration was more paramount than the external interest.

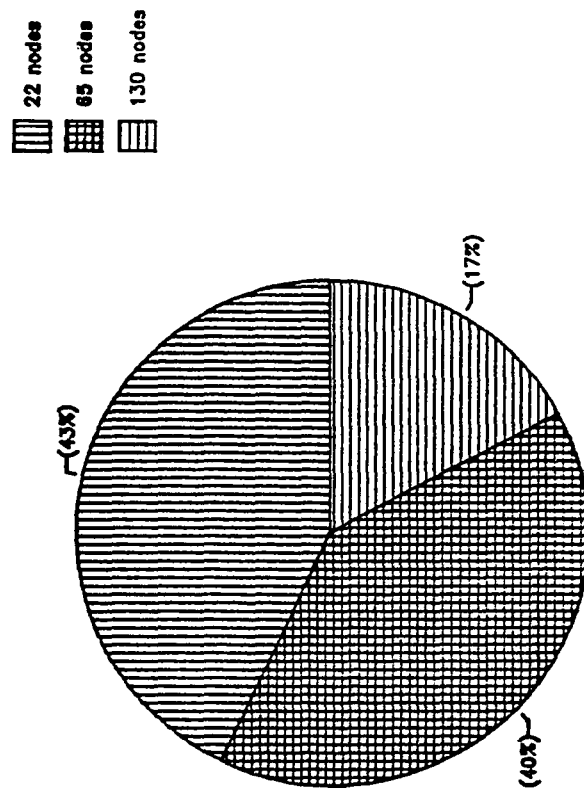


Figure 12. Grouping the accessibility into three categories in 1976

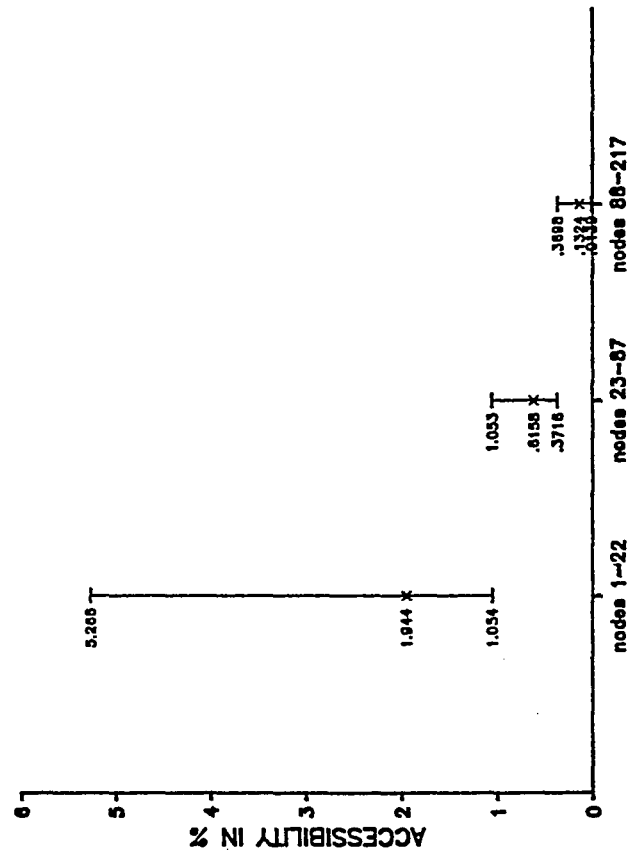


Figure 13. Maximum, minimum, and average accessibility in 1976

Analysis of the 1982 network structure reveals some major changes in the network system in Nigeria. The network has ceased from expansion and has contracted sharply (see Figure 14). The number of nodes for example, dropped from well over two hundreds in 1976 to just about seventy three, (see TABLE VII above), while the number of linkages dropped from two hundred and twenty three to one hundred and six, that is, some 66% deduction. It is however, important to note that, the ratio of linkage to node actually increased during the same period by 41% (the calculation is based on the information from TABLE VII). What happened was that the reduction in the number of nodes offers more alternative connections to the existing ones. Consequently, the value of alpha increased from less than 2% in 1976 to 24.1% in 1982, a very drastic increase. The analysis also reveals that the processes of consolidation of the entire network as well as relative concentration in some selected nodes were well underway. The accessibility at this time was much more evenly spread across the nation (see Figure 15 and TABLE XIII).

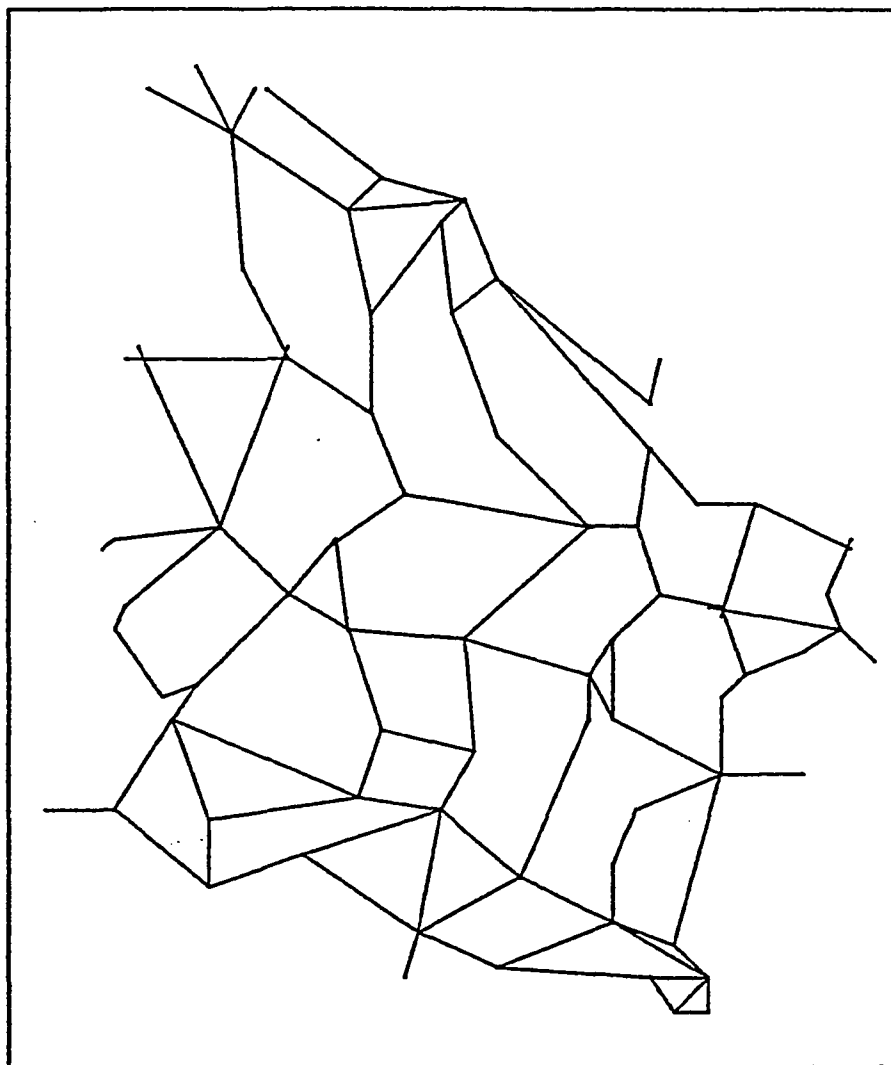


Figure 14. Abstracted road network of 1982

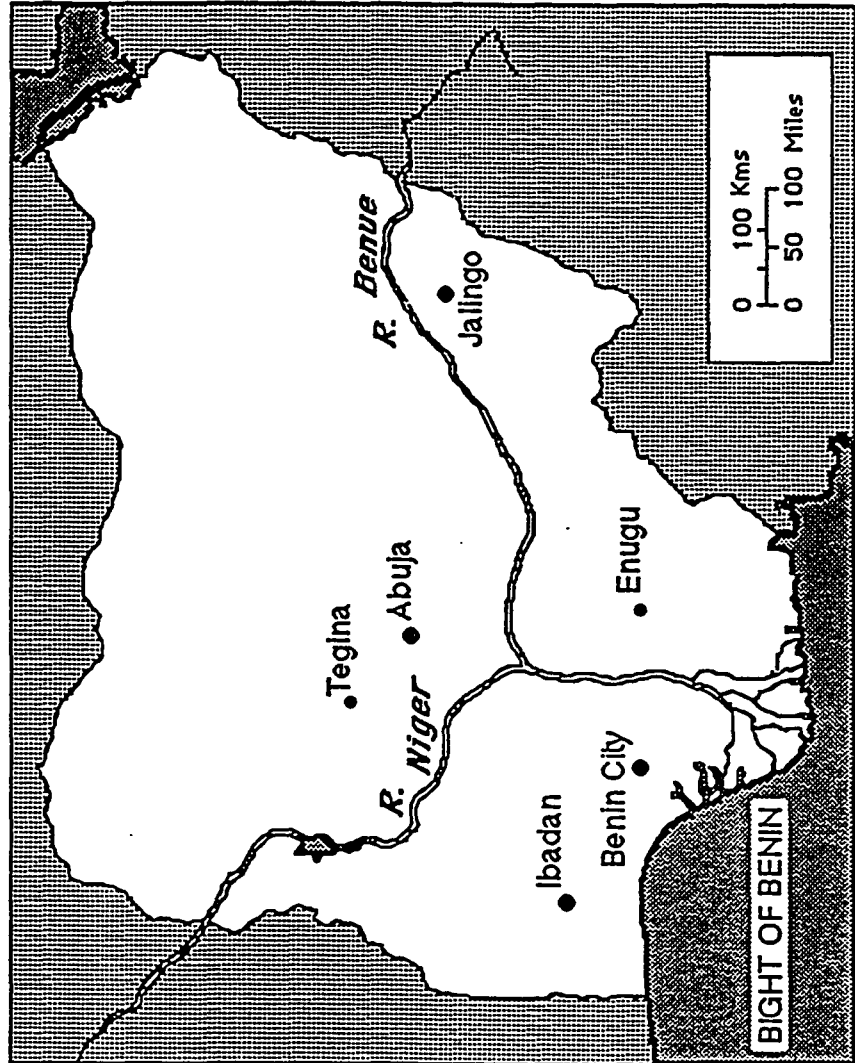


Figure 15. Map showing the six most accessible nodes in 1982

TABLE XIII
NETWORK HIERARCHY IN 1982

NODE	ACCESSIBILITY INDEX (%)	NODE	ACCESSIBILITY INDEX (%)
BADAN	4161	LORIN	1.058
ABUJA	4101	OTUKPO	1.005
JALINGO	4.009	GOVBE	0.969
BENIN CITY	3.730	CHIKOCHIKO	0.967
TEGNA	3.319	FE	0.926
ENUGU	3.042	WARRI	0.913
MOKWA	3.006	BADAGRI	0.907
KAIAMA	2.825	GOVBE	0.906
BU	2.698	OVERI	0.832
JOS	2.587	NAMEA	0.812
KAFI	2.540	BISSOULA	0.784
ZARIA	2.532	BAMA	0.706
OKENE	2.504	TAKUM	0.662
SHAGAMU	2.339	POTISKUM	0.646
LAGOS	2.249	SHENDAM	0.644
KANO	2.174	SHAKI	0.589
ABA	2.123	KOM	0.560
ABEOKUTA	2.108	NGURU	0.554
AKURE	1.973	JIBIYA	0.511
MADUGURI	1.938	SOKOTO	0.508
GUMI	1.789	YELWA	0.492
NUMAN	1.737	BIRNIN KONTI	0.445
BAUCHI	1.707	JEBBA	0.344
MARKUDI	1.690	KANTAGORA	0.324
YOLA	1.602	IKOTEKPEKE	0.313
LOKOJA	1.555	BIDA	0.309
ASABA	1.502	CALABAR	0.292
PAMBEKUA	1.432	FORT HARCOURT	0.292
ALINDE	1.393	GAMBORI	0.280
KADUNA	1.385	MONGONU	0.278
NEWZURAK	1.299	CHINKADA	0.233
OGOJA	1.278	BIRNIN	0.151
AYANGBA	1.265	KAURA	0.111
ILARO	1.236	KATSINA-ALA	0.0996
GLSAU	1.222	DAURA	0.095
ONITSHA	1.205	KONGOLAM	0.037
KATSINA	1.157		

Furthermore, the continuous importance of the old selected nodes from the southwestern, the northern and now the central parts of the nation is indeed, a significant finding in this study. This phenomenon once again, and in a very consistent manner, confirms Taaffe, Gould and Morrill (1963) assertion that the initial lines of penetration are the most critical ones in the whole process of network development.

The distribution of accessibility was for the first time much more evenly distributed than in any of the previous cases. The least accessible node accounts for almost four-tenths of one percent of the entire accessibility. In 1949 for example, the least accessible node accounts for one one-thousandth of one percent. In 1961, it was five one-hundredth of one percent, and in 1976, it was one one-hundredth. In other words, the accessibility of the least accessible node in 1982 was greater than the second best which occurred in 1961 by about eighty six percent.

The first eighteen or twenty five percent of the most accessible nodes account for some fifty two percent of the entire accessibility. The next eighteen more accessible nodes accounts for some twenty seven percent of the accessibility, while the remaining thirty seven or some fifty percent of the nodes accounts for the remaining twenty one percent of the accessibility (see Figures 16). The redistribution of the accessibility was quite drastic. There were many more of alternative connections to a greater number of nodes than in any of the three previous cases. The individual nodes' share of the accessibility showed a significant increase relatively to the previous cases (see Figure 17).

From many indications, the more equitable distribution of accessibility does indeed suggest the good faith effort on the part of the government not only

to enhance the economic development of some high potential areas, but also to integrate the nation both politically, and socially. Secondly, the configuration of network in 1982 base on the values of gamma and alpha indices suggest that the degree of the complexity of network is on the rise. In 1949 the ratio of linkages to nodes was 1.37, in 1961 the ratio of linkages to nodes was 1.09, in 1976 the ratio was 1.03 and in 1982 the ratio increased to 1.45 (the calculations are based on the information from TABLE VII). The complexity of the network is a function of the ratio between the linkages and nodes. The alpha value of 24.1% as stated earlier is a clear indication that generally, alternative connections to nodes and more importantly, those nodes that tend to occupy rather unique positions on the network are on the rise. Furthermore, since gamma measures the degree of connectivity, the values of 49.1% therefore means that the network as a whole is about 50% of a perfect connectivity. However, it is important to bear in mind that the values of those indices only suggest that the process is in the right direction, but it does not simply suggest in any way, that the network has attained an advanced stage of development. It takes a minimum values of 66% and 50% for gamma and alpha respectively for a network to be classified as having attained the advanced stage of development.

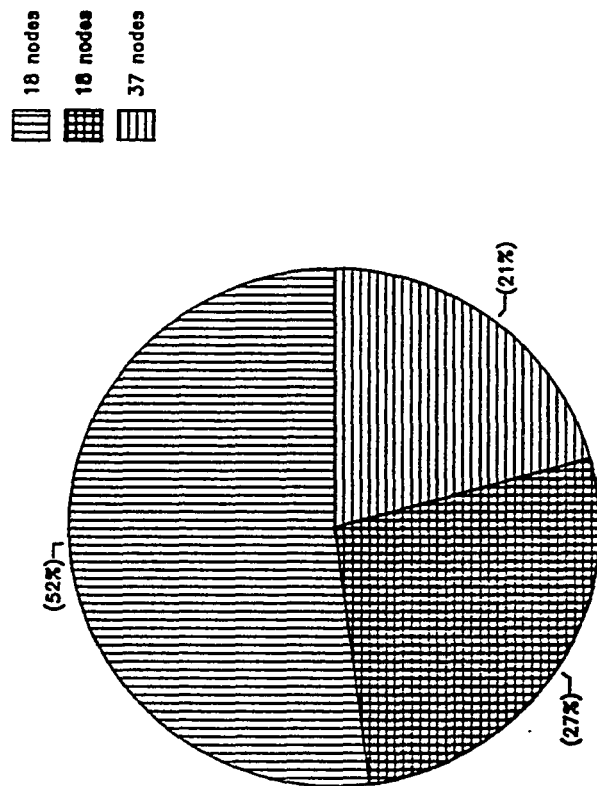


Figure 16. Grouping the accessibility into three categories in 1982

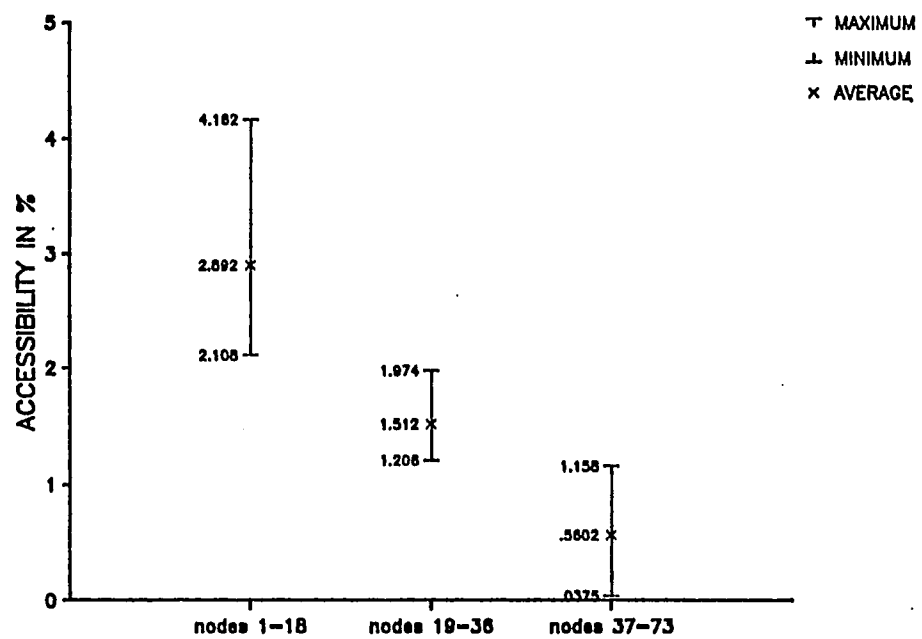


Figure 17. Maximum, minimum, and average accessibility in 1982

CHANGES IN INTERNAL HIERARCHY

The series of changes in the internal accessibility had been quite dramatic. The network at different periods of time has witnessed both extensive expansion in some cases, and consolidation in the others. There have been elimination and addition of nodes as the network develops through the years. The elimination of nodes is primarily due to the practice of classification and declassification of certain links as trunk **A**, and as stated earlier, the impact of the high turn-over in the administration might have been quite significant.

There were some two hundred and two nodes in the system in 1949 and by 1961, the number of nodes dropped to ninety eight. Of the ninety eight nodes, seventy four percent of them was part of the 1949 network system, and of course, this is translated to some 74 nodes which is about 37% of the nodes in 1949. Although the number of nodes in 1976 was roughly the same as those of 1949, only thirty six percent of the nodes was part of the original network. The thirty six percent is translated to some seventy eight nodes. Furthermore, although the network in 1982 shows an extensive consolidation as the number of nodes decreased from 202 in 1949 to some 73 in 1982, surprisingly, seventy seven percent of the nodes in 1982 was part of the network system in 1949.

Only thirty four or some seventeen percent of the original 202 nodes appeared in all the networks system analyzed in this study (see TABLE XIV). Based on the 1963 census (the last acceptable census in Nigeria) those thirty four nodes were the centers of population concentration, and they have continued to be the centers of population attraction ever since.

TABLE XIV

CHANGES IN INTERNAL ACCESSIBILITY AMONG THE NODES THAT
APPEARED IN ALL THE STUDY PERIODS

NODE	1949 ACC. INDEX IN (%)	1961 ACC. INDEX IN (%)	1976 ACC. INDEX IN (%)	1982 ACC. INDEX IN (%)
ABA	0.159	0.283	0.747	2.123
ABECKUTA	1.165	1.227	1.491	2.108
AKURE	1.743	0.372	0.153	1.973
BAUCHI	2.123	3.757	0.552	1.707
BENIN CITY	0.554	0.161	1.784	3.730
CALABAR	0.471	0.070	0.068	0.292
DAURA	0.187	2.360	0.086	0.111
ENUGU	0.523	0.232	0.565	3.042
GOMBE	1.076	1.988	0.112	0.969
GUSAU	0.452	1.876	0.138	1.222
BADAN	1.845	1.870	1.454	4.161
FE	1.421	0.981	0.167	0.926
KOTEPKENE	0.303	0.174	0.394	0.313
ILORIN	1.399	0.882	0.293	1.058
JEBBA	0.531	0.553	0.618	0.344
JIBIYA	0.180	0.558	0.047	0.511
JOS	2.116	6.170	0.521	2.587
KADUNA	0.736	6.172	0.581	1.385
KAIMA	0.183	0.447	0.030	2.825
KANO	1.477	5.434	1.324	2.174
KARI	1.457	2.360	0.131	2.540
KATSINA	0.357	1.180	0.115	1.157
LAGOS	0.470	1.870	0.157	2.249
MAIDUGURI	0.977	0.413	0.055	1.938
NUMAN	0.338	0.577	0.052	1.737
OTURKPO	0.269	0.292	0.038	1.005
OWERRI	0.182	0.266	1.313	0.832
P. HARCOURT	0.075	0.129	0.261	0.292
POTISKUM	1.001	1.119	0.081	0.646
SHAGAMU	1.308	1.591	0.255	2.339
SOKOTO	0.154	0.574	0.014	0.508
TEGINA	0.372	0.581	0.090	3.319
YOLA	0.111	0.461	0.016	1.602
ZARIA	1.528	7.806	1.209	2.532

As could be seen from TABLE XIII, there were few cases (Aba, Abeokuta and Port Harcourt) in which the accessibility index showed a consistent increases through the years, but in most cases, there were rather sporadic fluctuations in the relative accessibility. An interesting pattern emerged between 1976 and 1982. Each of the thirty four nodes except Ikot Ekpene, Jebba and Owerri showed increases in accessibility when 1976 is used as the base year. Between 1949 and 1961, there were some four cases (Jos, Kaduna, Kano and Zaria) in which there were significance positive changes in the nodal accessibility, the four nodes were all from the north. The pattern of nodes with significance changes between 1976 and 1982 were different from those of 1949 and 1961. Those thirteen nodes with significance changes (Aba, Enugu, Ibadan, Jos, Kaima, Kari, Lagos, Maiduguri, Numan, Shagamu, Tegna, Yola and Zaria) were spread across the nation. Thus, the distribution of accessibility in 1982 was much more evenly spread all over the nation.

CHAPTER VI

SUMMARY, ALTERNATIVE PERSPECTIVE, AND CONCLUSIONS

SUMMARY

The process of development as a whole is a very complex one due in part, to the different elements that come into play. Furthermore, the protracted and inconclusive debate with regards to the exact role that transportation plays in the process of development is not about to come to an end. The reason for this is partly because the World Bank statistics for example, indicate that there are instances in which transport has led effectively and there are instances that it has not (Willoughby, 1977). However, the point that has consistently survived this vigorous debate is that increase in the rate of movement of goods and people is likely to contribute significantly to a healthier economy, (Mansourkhaki, 1980).

This study base on the analysis of the pattern of accessibility distribution during at least the first sixty years of network development in Nigeria shows clearly that economic consideration was dominating the decision making process until the seventies, and this is quite consistent with Kansky's hypothesis. It was soon after the civil war in 1971 that concrete steps were taken to broaden consideration to include social and political integration as prime objectives of network development at a national scale. This is not only consistent with Freidmann's theory, but it also highlight the enormous impact that political and administrative factors exert on the whole process of

transportation development. The shift in the accessibility distribution as revealed in the analysis of both 1976 and 1982 network structures clearly shows some differences both in the goal and the objective between the colonial and post colonial network developments in Nigeria. This shift in the the goals and the objectives of transportation development is responsible for the network system not following the ideal-typical model. The ideal-typical sequence is indeed an economic driven theoretical model that was designed to explain the colonial network development in Nigeria. It should not therefore, be surprising to observe that the network system in the eighties does not follow the ideal-typical model.

The study leans support to O'Sullivan (1979) assertion concerning the effectiveness of using transportation as a tool to control and direct development. It does not however, support any assertion that may directly or indirectly imply a discrete nature of stages of network development. The apparent discrete nature that the theoretical model tends to portray has consistently remained the most damaging deficiency of theoretical constructs. It is somehow naive, and historically inexpedient to postulate a model that is said to be "ideal" and "typical" to explain something as pervasive as transportation within a complex social environment. In 1961 for example, the study reveals the existence of the multiple characteristics of virtually every postulated stage. Fifteen years later, that is, in 1976 the network actually declined in its complexity despite a significant increase in both the number of nodes and linkages. The decline in the complexity was due to the resulting configuration of the network as a direct result of the enormous expansion that the network was going through. For the stages of network to be discrete, the degree of network complexity would have

to be directly proportional to the sequential stages. The numeric values of the network as portrayed by gamma and alpha indices should be positively related to the stages in the sequence. However, those indices actually declined in both 1961 and 1976 from what they were in 1949 but began to rise again in 1982.

The analysis clearly supports Rostow (1964) assertion that the sequence of network development should be realistically seen as a process rather than as a series of discrete stages. The fluctuation in the numeric values of the indices, as well as in the number of nodes and linkages clearly attest to Cope (1967) description of the process of network development as being characterized by expansion, contraction, and consolidation.

The clustering of the most accessible nodes in a relatively small area during the first three periods in the study is indicative of the characteristic of a network at elementary state of development. This is specially true in the developing economy. Furthermore, it is one of the most serious problems that commonly plague, and may unfortunately, continue to plague planning exercises in many developing nations. The continuous fluctuation in the numeric values of gamma and alpha is the most serious phenomenon that clearly suggests that the stages of network development is not discrete or sequential in any sense of the word. Predicting the rate of network growth might turn out to be an exercise in futility, particularly in the Third World, due to the inability in controlling and coordinating the numerous competing and sometimes conflicting elements that affect the shape and size of the network configuration. The differences in the distribution of the accessibility during the colonial and post colonial eras were quite drastic. Economics ceased from being the number one concern to just one of the several factors that influenced

network development. The prominence of the Abuja on the 1982 network hierarchy is a clear test of the enormous impact that politics exert on the entire process of network development in Nigeria. Abuja moved into the center stage of the network hierarchy as a result of the government desire to make the new national capital to be accessible to all the regions. The Abuja factor has a significant influence on the 1982 network structure in particular, and raises hope for the convergence of the transportation network which will eventually create a national system of cities.

ALTERNATIVE PERSPECTIVE ON TRANSPORTATION PRACTICES IN NIGERIA

Generally speaking, the essence and the importance of access to employment, school, health facilities, adequate residential environment among other things are not debatable, but what tends to have been almost lost in the process of transportation policy debate is that most transportation investments and policies have long gestation periods and operating lives, consequently, they have too wide and deep an impact on virtually all other spheres and aspects of living to warrant taking long-rang planning casually. The practice of disproportionate over-investment in road transportation is nothing unique about Nigeria or the Third World in general. The history of development in even the industrialized nations is also characterized by disproportionate over-investment in the transport sector, notably, the highway. Mansourkhaki (1980) has documented transportation investments in USA from 1946-1977, in Canada from 1946-1976, in England from 1952-1978, and in Japan from 1954-1977. Each of these cases shows a significant disproportional investment in road transportation. It is important to note that this list was drawn from Owen (1961),

study in which those four countries were classified among the most mobile, and of course, most industrialized nations in the world.

At the third world conference on transportation held in Rotterdam in 1977, Willoughby from the World Bank talked about how the world financial body tends to single out transportation as a unique area to be given serious attention as the developing countries struggle for development. The pattern with which loans are granted by the World Bank is also indicative of the importance the world financial body attaches to transportation sector of the developing economies.

However, what is extremely troublesome and sometimes perplexing is the degree with which the need for empirical research has been either trivialized or in some cases, is simply ignored in the planning process. It is in recognition of the importance of research in transportation planning that this study reviews certain elements like the political backgrounds of Nigeria, as well as the national transportation objectives and philosophy within the context of the national development programs. It is the position of this study that any transportation program that does not have adequate information on these elements is likely to be more of a psychological show case than a realistic approach towards solving the problem of movement of goods and people. For example, lack of consultation with the local residents in designing, and executing projects may likely lead to a situation in which completed projects turn out to be more like white elephants than of any use to the communities in which they were designed for.

To underscore the importance of research is the issue of socio-economic impact of a transport facility in the area it opens up or makes more accessible.

This debate has been long and inconclusive between those who see transport as a leading sector, capable of inducing other economic activities and those who see transport investments as needing to respond only to a given traffic demand. The debate is invigorated by the point made earlier, and that is, the World Bank data indicates that there are indeed instances in which transport has led effectively and there are instances that it has not (Willoughby, 1977). Thus, this situation seriously underscores the need for a comprehensive and or multi-sectoral regional development programs base on a thorough research. Research is needed to help develop a framework, properly parsimonious in data requirements, for optimal selection of roads in an undeveloped area and secondly, for identifying the critical minimum of complementary public action required in different circumstances

It was in recognition of the need for research information in transportation development that partly caused the World Bank in 1968 to invite the United Kingdom Transport and Road Research Laboratory (TRRL) to participate in a co-operative research effort to investigate the inter-relationship between road construction costs, vehicle operating costs, and road maintenance costs in developing countries (Bulman and Robinson, 1977).

Earlier, the World bank had awarded a contract to the research unit from Massachusetts Institute of Technology to construct a model that relates road construction and maintenance costs to the cumulative cost of vehicle operation over the design life of a road (Moavenzadeh, 1972). The model clearly identified the areas where knowledge about the relationships between important parameters of road and vehicle behavior in tropical developing countries were inadequate. It also indicated that vehicle operating costs are

very sensitive to vehicle type, road geometry, and surface condition. There was also evidence that resources were often allocated inefficiently due to discontinuous and uncoordinated planning expertise, transplantation of inappropriate solutions optimized for developed countries, lack of adequate data, distortions due to the external financing sources, and other deficiencies in the planning process, (Carter, Chadda, and Schonfeld, 1984). Presently, there is a computer model known as Road Transport Investment Model (RTIM). This model can calculate for any road project the sum of the construction costs, the road maintenance costs, and the vehicle operating costs over the "design life" of the project. A model like this can permit the designer to minimize the sum of construction costs, maintenance costs, and vehicle operating costs by enabling designer to select the optimum choice of geometric standard and road type, either earth, gravel or bituminous surfaced.

Despite the availability of this type of technology and its flexibility, there is not much in either the Nigeria's National Planning Documents or the actual planning practices to indicate or suggest that such technology is being adequately tapped. This kind of attitude is indeed, a sad commentary on planning endeavor in Nigeria. Some of the available state-of-the-art transportation planning presently used in developed countries, such as Urban Transportation Planning System (UTPS) are applicable in developing countries as long as there are competent personnel, adequate data, adjustments in some parameters that are specific to each country, such as the value of time, usage rates, interest rates, demand elasticities as well as a set of alternatives that are appropriate to individual countries (Dickey, 1983). It is equally important to be aware of the consequences of technological

dependency. There should be no illusion that technology is socially and culturally neutral. Therefore, technology transfer that is likely to lead to the stultification of the growth of the indigenous technological capability may not be for the best interest of the importing country in the long run.

Some of the foreign designers in many instances have been very much preoccupied with the need for a high benefit-cost ratios in their design services to the Third World. The need for a high benefit-cost ratio may not necessarily be a bad objective to pursue. However, any high benefit-costs ratio that is not complemented by minimum-cost course of action could very much lead to misallocation of scarce resources. This is one the reasons why there is a continuous doubt that designs proposed by foreign consultant engineers may not be to the best adapted standards for developing countries. The other issue has to do with the persistent doubt concerning taking sufficient advantage of the scope for stage construction. It is a common fact that technology is hardly culturally neutral, and by the same token, the design and the construction of network should not be expected to be culturally neutral. Thus, it is the fear that the maximum feasible use of local resources may not have been adequately taken into consideration in such design process that sustains what this study considers as the "nagging" question. For the foreseeable future, the question will continue to be whether or not the standard used in the western industrialized nations may be most appropriate for the developing nations. It seems to an extent, that the problems of Third World development have confounded the foreign experts for decades, partly because these problems have been unfortunately treated largely as technical and economic matters that could be effectively addressed through infusions of capital and foreign

expertise. This attitude tends to represent a flawed understanding of even how the advanced industrial economies achieved their own development and grossly underestimates the role that political and cultural factors play in the process of modernization.

Realistically speaking, there are instances in which solution to transportation problem in the rural areas of the Third World may not call for an expensive, and wide paved roads. Unfortunately, such approach has been adopted in too many cases. The fact is that, if the rural growth center for example, is going to become a production, processing, and service center, and if it hopes by the establishment of even a modest range of diversified enterprises, to increase the total areal employment, then careful attention should be given to designing a functional constellation of commuting routes (Johnson, 1970). This approach will not only meet the transportation need of the local people, but it will also minimize the cost of providing transportation infrastructure, and consequently, releases the scarce resources for other competing needs. Furthermore, one way of measuring the efficiency of a transportation system is to look at the degree of the integration of the "system of cities" on the one hand, and the degree of the relationship between them and their respective countrysides on the other Filani (1981).

It has been consistently shown that transport is an important absorber of scarce resources either at individuals or national level (Wilson, Bergmann, Hirsch and Klein, 1966). Therefore, ill-timed, misdirected, or misplaced transport investment is likely to have a serious impact upon the whole economy. A thorough review of Nigeria national development programs show that these endeavors have been consistently plagued by ill-timing of programs, some

programs have been misdirected, and misplaced. The importance of research as stated earlier has been either trivialized or simply ignored. And as if these were not enough, the policy makers and planners are still struggling to find out exactly what constitute the national transportation philosophy. Comparisons that are inappropriate are still being used in the process of formulating policies concerning transportation. For example, using the study that was conducted for European Economic Communities (EEC) with regards to the shares of energy consumption by various modes of transport to influence transportation policy in Nigeria is simply a bad practice. The differences between Nigeria and the nations of EEC are so wide and varied that it is almost unthinkable that such comparison could even be contemplated. Furthermore, using this sort of inappropriate analogy to influence transportation policy is likely to have a long term negative implications. The problem that this type of practice produces will certainly be compounded by long duration of gestation of transportation investment.

The transportation objectives must be explicitly spelled out in a way that they can be operationalized if the massive infusion of resources in this sector is to be meaningfully materialized. There must be geographical information in terms of the type of soil, and the nature of climate in the country. Road design and construction must be sensitive to those geographic elements if they are to be durable. The other area of problem that needs equally, serious attention is the non-economic objectives of transportation development. Even though this study indicates that relative progress has been made in this area, there is still a need to state those objectives explicitly in a way that it is not too difficult to implement them effectively. The absence of the ability to effectively evaluate

these objectives will likely deprive the policy makers and the planners the opportunity of even detecting mistakes made, let alone correcting such mistakes.

Since Nigeria as well as many other Third World nations are relying by necessity, on the importation of construction equipments, expatriate for design and construction of projects, foreign financing among other things, it is therefore safe to argue that the problems that plague development in the Third World are likely to persist as long as foreign advisers hired decide merely to translate into the local language or institutional nomenclature a manual from North America or Europe. In other words, the existing problems may continue to plague transportation development in many of the Third World nations for a foreseeable future. This is not just an attempt to deny the necessity of the expatriate expertise in the Third World development, and of course, such dexterity is needed. The real issue is that as long as consultant teams keep on drawing blue-print of projects without reference to local capacities, and without making effort to fully understand and update it and gather the requisite data on a regular basis, then prediction of the future course of transportation will continue to be clouded with uncertainty.

The decisions to invest in transportation facilities must also take into consideration the time dimension, knowing too well that investment in transportation is likely to constrain investments in alternative sectors like health, education, housing, and food supply (Carter, Chadda and Schonfeld, 1984). Poor transportation is very likely to retard development, due to the fact that adequate transportation service is definitely one of several essential ingredients for accelerating the economic growth of a country. To this end, to minimize the

possibility of waste, the number, type and location of transportation facilities to serve a country should be based on a comprehensive coordinated development plan. Since the transportation improvement that lower transport costs significantly affect market distribution and help to attract new industries, it is of uttermost important that due consideration be given to improved access to raw materials, markets, laborsheds, employment, school, health facilities, and other basic essentials in the process of transportation planning.

For transportation system to be effective and efficient, the question should never be limited to how much to be invested. It is also of equal importance and helpful to find out where and how the investments should be appropriately made. Base on the past practices, a critical appraisal of the cost/benefit impact of past sectoral allocations may very much reveal that thus far, undue emphasis might have been placed and furthermore, resources might have also been concentrated on a transportation sub-sector which has a much more expensive option. This study therefore suggests that among other things, mode selection should be made from multi-dimensional criteria. Furthermore, transportation plan should be derived from a broader national goals, bearing in mind that an expansion of the transport system as an independent goal would make no sense at least in an economic context (Owen, 1964). The fact is, if a country is deficient in the factors conducive to growth, no amount of transportation planning and infrastructure can create the economic growth that is desired.

CONCLUSIONS

The analysis indicates a drastic shift in the network spatial structure. There is a shift from an outward looking to an inward looking network system, and from what Filani (1981) called a corridor-type network structure to one that is more evenly spread out. The system is much less economically driven. Consequently, the current trunk A network system in Nigeria does not follow the ideal-typical model. This model may be ideal, but certainly, it is not typical within the context of the post colonial era in Nigeria. However, it should be noted that the shift did not come easily. Up till the seventies, the network was still characterized by a corridor-type pattern of development. Furthermore, it is not surprising to note that the current network structure does not follow the ideal-typical. The nation has to be willing to give up some degree of economic optimization for the political survival of the country.

After well over eighty years of a rather vigorous interest in transportation network development, the road network in Nigeria is just about to move into transitional period. The network is only now moving from elementary to advance stage. Precisely speaking, the network is currently at an advanced level of the spinal stage. It is not quite clear how long it might take for the network to be transformed completely from the elementary to the advanced stage of development. A reliance on history tends to suggest that it might take quite sometime, especially, in the light of the current economic plight, and political unpredictability. However, the values of graph indices do suggest clearly that the development is moving in the right direction. Any attempt to further sub-divide the nation into smaller constituent units (see Figure 1) will certainly slow down the rate of such transformation. Such development, that is,

that is, a slow down in the rate of network transformation, will be partly due to the inevitable change in the degree of network complexity. It may lead to decrease or increase in the number of nodes and linkages, and consequently, there will be either positive or negative fluctuation in the numeric values of gamma and alpha. It must be emphasized that the problem of fluctuation in the complexity of network due to the interplay of political and administrative forces, especially, in a politically unstable environment will hamper the ability to predict the stages of network development.

The study supports the assertion that the sequence of network development in a relatively political unstable environment is sporadic and continuous. Although transportation is one of the most debated and written about subjects of our time, the number of factors that come into play in the process are just too many, and sometimes with conflicting interests. The study reveals a common weakness of network development in the Third World, and this has to do with the concentration of accessibility in relatively few nodes. The excessive concentration of accessibility in few nodes within a very small portion of the network structure, does not argue well for the much dramatized practice of national development programs. The unavoidable consequence of such phenomenon is that development is very much likely to be skewedly distributed. Furthermore, the chance of inducing regional competition that may be very healthy to the regions and the national economy at large is likely to be diminished. Lack of opportunity for such regional competition directly or indirectly deprives the people of a very good chance for an increase in the standard of living.

Nigeria has however, made tremendous progress in using investment in transportation as a tool for social, and political integration. The infrastructure in place now has already encouraged and will certainly continue to encourage interregional trade as well as other social cooperation. The need for this type of cooperation is essential for the stability of a heterogeneous society like Nigeria. The analysis of the network in 1976 clearly attests to O'Sullivan's assertion that transportation is one of the most effective tools a government can use in inducing and enhancing different forms of societal integration. The rapidity and the effectiveness of reconciliation that followed the end of the secessionist war in Nigeria has remained a miracle ever since. A closer look at the accessibility distribution in 1976 suggests that investment in transportation was deliberately used to allay fear in the minds of the former secessionists, and to once again instill a sense of belonging in them. It is also plausible that certain projects might have been embarked upon partly as a result of the logistic problems encountered by the federal troops as they tried to liberate the eastern region from the rebel forces. Nevertheless, Nigeria is indeed a practical case that demonstrates the fact that transportation may not only be directly or indirectly used to redress the past social or economic ills, but it can also be effectively used in guiding and directing the political destiny of a nation. Thus, it underscores the need for a carefully design transportation system. A nation whose politics have been dominated by ethnic and regional antagonisms (The Economist Intelligence Unit, 1987), with serious ramifications at all levels, could find some comfort in using transportation as an effective manipulator.

It must be emphasized that virtually nothing can be effectively substituted for accurate information in planning practices. Many noble and laudable

programs like the Universal Free Primary Education, Operation Feed the Nation, Green Revolution, Accelerated Food Production Program, Back-to-Land campaign, School-to-Land Program, among others collapsed not necessarily because of lack of good intentions, but seriously due to lack of factual information. The other reasons includes lack of genuine commitment on the part of public officers charged with implementation, lack of appropriate expertise, adequate level of funding, and of course, a clear-cut policy objectives. The cost of acquiring such appropriate information may be high, but it should be accepted as a task that must be done.

REFERENCES

- Abouchar, Alan 1977. Transportation Economics and Public Policy: with Urban Extensions, New York, John Wiley.
- Avondo-Bodino, G. 1962. Economic Application for the Theory of Graph, New York, Science Publishers.
- Banister, David and Peter Hall. 1981. Transport and Public Policy Planning, London, Henry Ling Ltd.
- Barbour, K. M., Oguntinyinbo, J.S., Onyemelukwe, J.O.C. and Nwafor, J.C. 1982. Nigeria In Maps, London, Hodder and Stoughton.
- Battersby, A. 1964. Network Analysis for Planning and Scheduling. London, Macmillan.
- Berge, Claude 1962. The Theory of Graphs and its Applications, London Methuen and Co LTD.
- Bierman, Don E. 1973. The Oder River: Transport and Economic Development, Evanston, Northwestern University Transportation Center
- Binder, L. 1971. Crises and Sequences in Political Development, New Jersey, Princeton University Press.
- Black, W. 1967. "Growth of the Railway Network of Maine: A Multivariate Approach," Discussion Paper 'Series, #5, Department of Geography, University of Iowa.
- Bulman, J.N. and Robinson, R. 1977. "A Road Transport Investment Model for Developing Countries," Proceedings of the 3rd World Conference on Transportation Research, Martinus Nijhoff, The Netherlands Institute of Transport, 311-318.
- Busacker, R. and Saaty, T. 1965. Finite Graphs and Networks, New York, McGraw Hill.
- Business International, 1979. Nigeria: Africa's Economic Giant, South Africa, Business International Corporation.
- Cayley, G. 1879. "On the Colouring of Maps" Royal Geographical Society. Proceedings, 1, 259-261.

- Carter, E.C., Chadda, H.S. and Schonfeld, P.M. 1984. "A Comparison of Transportation Planning in Developing Countries" Transportation Quarterly, Vol. XXXVIII, #1, 60-85
- Central Planning Office, 1975. Second National Development Plan, Lagos, Federal Government Printing Press.
- Chorley, Richard J., Haggett Peter. 1967. Models in Geography, London, Methuen & Co LTD.
- Commission Report. 1975. Toward more Balanced Transportation: New Intergovernmental Proposals, Washington D.C., US Government Printing Press
- Cope, D.R. 1967. "A Network of the Growth of the London Underground System and Its Relation to Population Changes, 1963-1972" University of Cambridge, B.A. Dissertation.
- Cowan, P. and Fine, D. 1969. "On the Number of Links in a System," Regional Studies, Vol. III, 235-242.
- Dickey, John W. 1983. Metropolitan Transportation Planning, New York, Hemisphere Publishing Corporation.
- Economist Intelligence Unit, 1968. Country Profile: Nigeria, London, The Economist Publications Ltd.
- Economist Intelligence Unit, 1987. Country Profile: Nigeria, London, The Economist Publications Ltd. #1.
- El-Aroud, Ali Soliman 1980. "Road Network Investment Model for Developing Countries," Pennsylvania State University, PhD Dissertation.
- Erdor, P. and Renyi, A. 1959. "On the Evolution of Random Graphs," Publications of the Mathematical Institute of the Hungarian Academy of Sciences, Vol. IV, 17-60.
- Filani, M.O. and Iz. Osauiyimwese 1974. "The Organization of Transport Planning in Nigeria" The Nigerian Journal of Economic and Social Studies, Vol. 16, #3 387-402
- Filani, M.O. 1981. "Towards More Efficient Transportation Networks in Nigeria," The Nigerian Journal of Economic and Social Studies, Vol. 23, #2, 209-224.
- Flament, C. 1963. Application of Graph Theory to Group Structure, New Jersey, Englewood Cliffs.

- Ford, L.R. JR and D.R. Fulkerson, 1962. Flows in Network, Princeton, Princeton University Press.
- Friedmann, John 1964. "The Concept of a Planning Region: The Evolution of an Idea in the United States," Regional Development Planning, Cambridge: MIT Press, 230.
- Friedmann, John 1975. "The Spatial Organization of Power in the Development of Urban Systems," Regional Policy Readings in Theory and Applications, Cambridge, Massachusetts: The MIT Press.
- Galbraith, K.E. 1965. Economic Development, Cambridge, Massachusetts: Harvard University Press.
- Garrison, W.L., B.J.L. berry, D.F. Marble, J.D. Nystuen, and R.L. Morrill 1959. Studies of Highway Development and Geographic Change, Seattle, University of Washington.
- Garrison, W.L. 1960. "Connectivity of the Interstate Highway System," Regional Science Association, Papers and Proceedings, 6, 121-137
- Garrison, W.L. and F.D. Marble 1964. "Factor Analytic Study of the Connectivity of a Transportation Network," Regional Science Association Papers, 12, 231-238.
- Gauthier, H. 1968. "Least Cost Flows in A Capacitated Network," Northwestern University Studies in Geography, #16
- Gauthier, H. 1969. "Transportation and Growth of the Sao Paulo Economy," Journal of Regional Science 8, 77-94.
- Government Printer, 1962. First National Development Plan, Lagos, Federal Government Printing Press.
- Government Printer, 1975. Third National Development Plan, Lagos, Federal Government Printing Press.
- Haggett, Peter and Richard J. Chorley 1969. Network Analysis in Geography, London, Edward Arnold.
- Harary, F., R.Z. Norman, and D. Cartwright 1965. Structural Model: An Introduction to the Theory of Directed Graphs, New York, Wiley.
- Hartwig, Richard E. 1983. Roads to Reason: Transportation, Administration, and Rationality in Colombia, Pittsburg, University of Pittsburg Press.

- Hebert, Bud, and Elaine Murphy 1971. "Evolution of An Accessibility Surface: The Case of the domestic United States Air Transport Network," Proceedings of the Association of American Geographers, Vol. 3, 75-80
- Hirschman, A.O. 1958. Strategy of Economic Geography, New Haven, Yale University Press.
- Inal, Ayhan Mustafa 1979. "Transportation and Regional Growth: A Methodological development with Turkey as A Case Study," PhD Dissertation, University of Pittsburgh.
- Johnson, E.A.J. 1970. The Organization of Space in Developing Countries, Cambridge, Massachusetts, Harvard University Press.
- Kansky, K.J. 1963. Structure of Transportation Network: Relationship Between Network Geometry and Regional Characteristics, University of Chicago: Department of Geography, Research Paper #84.
- Kissling, C.C. 1969. "Linkage Importance in a Regional Highway Network," Canadian Geographer, #13, 113-127.
- Kraft, Gerald; John R. Meyer and Jean-Paul Valette 1971. The Role of Transportation in Regional Economic Development. Lexington, Massachusetts: Lexington Books.
- Lachene, R. 1965. "Networks and the Location of Economic Activities," Regional Science Association, Papers, 14, 183-196.
- Lansing, John B. 1966. Transportation and Economic Policy, New York, The Free Press.
- Lewin, Kurt 1936. Principles of Topological Psychology, New York, McGraw-Hill.
- Logan, M.I. 1972. "Key Elements and Linkages in the National System: A Focus for Regional Planning in Nigeria," Planning for Nigeria, Ibadan: Ibadan University Press, 16-39.
- Lösch, A. 1954. The Economic of Location, New Haven, Yale University Press.
- Mahayni, Ghaleb Raid 1972. "Passive and Dynamic Concepts of Transportation Planning in Developing Countries, PhD Dissertation, University of Washington.
- Mahayni, Ghaleb Raid 1977. "Reorienting Transportation Planning Rationale in Developing Countries," Traffic Quarterly, Vol. XXXI, #2, 351

- Mansourkhaki, Ali 1980. "Transportation Investment Strategy: A Key Element in the Long Range Macro Transportation Planning for a Developing Country," PhD Dissertation, University of Kansas.
- Meow, Seah Chee 1977. "Infrastructural Growth and Development Planning: A Comparative Study of Road Infrastructure in the National Development of Asean Countries," Proceedings of the 3rd World Conference on Transpiration Research. Martinus Nijhoff, The Netherlands Institute of Transport, 502-511.
- Moavenzadeh, F. 1972.. "Investment Strategy for Developing Areas: Analytical Model for Choices of Strategies in Highway Transportation," Department of Civil Engineering, Research Report #72-62, Cambridge, Massachusetts Institute of Technology.
- Moore, Jonathan 1984. "The Political History of Nigeria's New Capital," The Journal of Modern African Studies, #22, 167-175.
- Musgrave, Richard A. 1959. The Theory of Public Finance, New York, McGraw-Hill.
- Myrdal, Gunnar 1957. Economic Theory and Underdevelopment Regions. London, Jerold Duckworth and Co.
- Nigeria Railway 1985. The Nigerian Railway Corporation and National Transport Development. Lagos.
- Ogunjumo, E.A. 1981. Transportation Development in Nigeria. New York, Cornell University.
- Ore, O. 1963. Graphs and Their Uses. New York, Random House.
- O'Sullivan, Patrick; Gary D. Holtzclaw and Gerald Barber 1979. Transportation Network Planning. Guildford, Biling and Sons Ltd.
- Owen, Wilfred 1964. Strategy for Mobility. Washington D.C., The Brooking Institution.
- Owen, Wilfred 1966. "Road Transportation and Food Production," Highway Research Record , #125.
- Owen, Wilfred 1968. Distance and Development, Washington D.C., The Brooking Institutions.
- Pitts, Forrest R. 1963. "A Graph-Theoretic Approach to Historical Geography," Paper Presented at Annual Meeting of the Association of Pacific Coast Geographers in Los Angeles.

- Ridley, T.M. 1968. "An Investment Policy to Reduce the Travel Time in a Transportation Network," Transportation Research, Vol. 2, #2, 409-424.
- Rostow, W.W. 1964. The Stages of Economic Growth. Cambridge, Cambridge University.
- Schloss, Aran. 1983. The Politics of Development, Lanham, University Press of America.
- Smerk G.M. 1965. Urban Transportation: The Federal Role, Bloomington, Indiana University Press.
- Shimbel, Alfonso 1951. "An Application of Matrix Algebra to Communication Nets," Bulletin of Mathematical Biophysics, Vol. 13, 165-178.
- Shimbel, Alfonso 1953. "Structural Parameters of Communication Networks," Bulletin of Mathematical Biophysics, vol. 15, 501-507.
- Smith, David M. 1981. Industrial Location. New York, John Wiley and Sons.
- Taafe, Edward J., R.L. Morrill and P.R. Gould (1963) "Transport Expansion in Underdeveloped Countries: A Comparative Analysis," Geographical Review, 53, 503-529.
- Taafe, Edward J. and Howard L. Gauthier, JR 1973. Geography of Transportation, Englewood Cliffs, Prentice-Hall INC.
- Toh, Rex 1984. "An Efficient Accessibility Model: Applications for Airline Network Analysis," Journal of Travel Research, Vol. XXII, #3, 31-36.
- West Africa, 1987. "Nigeria's Five-Year Plan," West Africa Magazine, London, 1018.
- Willoughby, Christopher R. 1977. "A Development Bank's view," Proceedings of the 3rd World Conference on Transport Research, Martinus Nijhoff, The Netherlands Institute of Transport.
- Wilson, George W., Barbara R. Bergmann, Leon V. Hirsch and Martin S. Klein. 1966. "Transportation and Development: General Considerations," Development Research Digest, Vol. IV, #2, 2-7.
- Wolfe, Roy I. 1963. Transportation and Politics, New Jersey, Nostrand company.

APPENDIX

PROGRAM USED IN MANIPULATING THE MATRICES

INTEGER F(XX,XX),N(XX,XX),M(XX,XX),S(XX,XX)	RIM00010
INTEGER V,L,ITEM,P,R	RIM00020
COMMON F,N,M,S,V,L	RIM00030
*	RIM00040
READ(5,*)V,L	RIM00050
WRITE(6,*)'V=',V,'L=',L	RIM00060
WRITE(6,*)	RIM00070
WRITE(6,*)	RIM00080
WRITE(6,*)'THE MATRIX F IS'	RIM00090
DO55I=1,V	RIM00100
DO56J=1,V	RIM00110
S(I,J)=0	RIM00120
56CONTINUE	RIM00130
55CONTINUE	RIM00140
READ(5,*,END=68)((F(I,J),J=1,V),I=1,V)	RIM00150
	RIM00160
DO11I=1,V	RIM00170
DO21J=1,V	RIM00180
N(I,J)=F(I,J)	RIM00190
21CONTINUE	RIM00200
11CONTINUE	RIM00210
68WRITE(6,77)((N(I,J),J=1,V),I=1,V)	RIM00220
77FORMAT(1X,12I10)	RIM00230
*	RIM00240
DO15P=1,L	RIM00250
IF(P.EQ.L)GOTO20	RIM00260
WRITE(6,*)'THEC^',P+1,'MATRIXIS'	RIM00270
20DO30I=1,V	RIM00280
DO25J=1,V	RIM00290
S(I,J)=S(I,J)+N(I,J)	RIM00300
25CONTINUE	RIM00310
30CONTINUE	RIM00320
IF(P.EQ.L)GOTO15	RIM00330
CALLMATLY	RIM00340
15CONTINUE	RIM00350
*	RIM00360
WRITE(6,*)	RIM00370
WRITE(6,*)	RIM00380

WRITE(6,*)	RIM00390
WRITE(6,*)'SUMMATRIX'	RIM00400
WRITE(6,*)	RIM00410
WRITE(6,*)	RIM00420
WRITE(6,200)((S(I,J),J=1,V),I=1,V)	RIM00430
200FORMAT(1X,12I10)	RIM00440
WRITE(6,*)	RIM00450
WRITE(6,*)	RIM00460
WRITE(6,*)'THEROWSUMSOFC+C^2+...+C^',L,'ARE'	RIM00470
R=0	RIM00480
WRITE(6,*)	RIM00490
DO45I=1,V	RIM00500
DO50J=1,V	RIM00510
R=R+S(I,J)	RIM00520
50CONTINUE	RIM00530
WRITE(6,*)'ROW',I,'SUMIS',R	RIM00540
R=0	RIM00550
45CONTINUE	RIM00560
*	RIM00570
STOP	RIM00580
END	RIM00590
*	RIM00600
*	RIM00610
SUBROUTINE MATLY()	RIM00620
DIMENSIONF(XX,XX),N(XX,XX),M(XX,XX),S(XX,XX)	RIM00630
INTEGERF,N,M,S,V,L	RIM00640
COMMONF,N,M,S,V,L	RIM00650
*	RIM00660
DO5I=1,V	RIM00670
DO10J=1,V	RIM00680
M(I,J)=0	RIM00690
DO15K=1,V	RIM00700
M(I,J)=M(I,J)+F(I,K)*N(K,J)	RIM00710
15CONTINUE	RIM00720
10CONTINUE	RIM00730
05CONTINUE	RIM00740
WRITE(6,*)	RIM00750
WRITE(6,201)((M(I,J),J=1,V),I=1,V)	RIM00760
201FORMAT(1X,12I10)	RIM00770
DO20I=1,V	RIM00790
DO25J=1,V	RIM00800
N(I,J)=M(I,J)	RIM00810
25 CONTINUE	RIM00820
20 CONTINUE	RIM00830
RETURN	RIM00850
END	RIM00860