THE ROAD NETWORK IN THE MOMBASA MUNICIPAL AREA: A SPATIAL ANALYSIS OF ITS EFFECTS ON LAND VALUES, POPULATION DENSITY AND TRAVEL PATTERNS

BY

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A thesis submitted in partial fulfilment for the degree of Master of Arts (Economic Geography) in the University of Nairobi.

1982

D E C L A R A T I O N

This thesis is my original work and had not been presented for a degree in any other University.

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A B S T R A C T

Few studies exist that show the relationship between urban transportation and urban structure in the developing world. As the developing countries become rapidly urbanized, there is growing need for adequate planning for a balanced urban development. Urban planners should pay attention to urban transportation for it provides access to urban areas and helps to reduce intra-urban inequality.

The present study examines the relationship between urban transport and urban structure at a micro-scale, that is, in one urban area in Kenya. The study covers the Mombasa Municipal area. The study investigates the relationship between time-distance and land values, population density and travel patterns or the number of personal trips.

In many applications, the linear distance has given way to the more revealing features of time-distance. Travel time is always more relevant in the developing countries than physical or road distances. Transport improvements in the developing countries often proceed rapidly with a correspondingly rapid impact on the structure of the space economy.

This study raises and examines three questions. They are:

1. What is the structure of land values, population density and personal trips within the Mombasa Municipal area?

2. To what extent does the transportation pattern influence the structure of land values, population density and personal trips within the Mombasa Municipal area?

3. Is the structure observed similar or different from that in industrialized cities?

Mombasa is both a pre-industrial as well as a colonial city. Therefore it offers an appropriate testing ground for the theories and findings on the urban transportation expansion and its relationship to urban structure. This study attempts to achieve three objectives:-

a) Establishing the relationship between time-distance and land values.

b) Establishing the relationship between time-distance and population density.

c) Establishing the relationship between time-distance and the number of personal trips to the city centre.

Three hypotheses are advanced and their validities tested. They are:

a) Land values decline with increasing travel time from the city centre. An inverse relationship exists between time-distance and land values.

b) Population density declines with increasing travel time from the city centre. An inverse relationship exists between travel time and population density.

c) The number of personal trips decrease with increasing travel time from the city centre. An inverse relationship exists between time-distance and the number of personal trips to the city centre.

The hypotheses are tested by means of; the description and explanation of the structure of land values, population density and trips, bivariate regression on land values, density and trips as well as the mapping of regression residuals.

Time-distance is measured from Mwembe Tayari on the Mombasa Island using Municipal Bus time. A partial correlation analysis is used to measure the relationship between bus time and the three dependent variables holding matatu time constant.

The study is limited to a time-distance analysis for bus and Matatu travel time. It excludes other transport modes such as air, rail and sea transport. These areas can be explored in future research. The study comprises seven Chapters. The first Chapter is the Introduction which explains the problem to be investigated and includes a Literature Review.

The Second Chapter deals with research Methodology and describes the techniques used to test the hypotheses and their limitations.

Chapter 3 deals with the spatial structure of the road net-work in Mombasa. This examines the main road network including bridges, causeways and ferries. It also examines the main forms of public transport, that is the bus and matatu systems.

Chapter 4, 5 and 6 deal with the structure and the factors influencing land values, population density and travel patterns in Mombasa respectively. Chapter 7 is the summary and concluding chapter. Here the main research findings are mentioned,

recommendations and conclusions are also made. The main findings of this study are:

Land values, population density and the number of home-based trips decline with time-distance from the city centre and are relatively higher on the Mombasa Island than on the mainland. This is mainly because of the good road network on the Island providing a high degree of accessibility. The Kenya Bus Travel time has a generally higher pearson correlation coefficient with land values, population density and trips than the matatu time.

The land value theory, population density function and travel patterns developed in the Western countries apply to Mombasa to some extent. But, this does not mean that urban transportation and urban structure in the developing world should be modelled after the Western city without modifications. This study attempts to show how urban transportation influences urban structure and therefore, provides a case for using transportation as a tool for structuring of Third World cities to benefit a majority of the residents.

ACKNOWLEDGEMENT

I express sincere thanks to Kenyatta University College and the Teachers' Service Commission for their assistance. Kenyatta University College awarded me a two year Scholarship which enabled me to pursue a Master's degree course in the Department of Geography of the University of Nairobi.

The Teachers' Service Commission gave me a two year study Leave extending from October, 1979 to September, 1981. This Study Leave gave me an opportunity to complete my Coursework and Field work.

Special thanks go to my two Supervisors, namely Dr. F. Rajotte and Dr. M. Hasan of the Department of Geography of the University of Nairobi for their useful guidance during the preparation of this thesis. Without their assistance, the present study would not have been completed.

The following people are also warmly thanked for their sound advice, valid criticism and for giving useful and sometimes confidential data. They are:

a) Professor R.B. Ogendo, Professor of Geography

b) Dr. A.G. Ferguson, Former Lecturer

c) Dr. J.A. Kahimbaara

d) Dr. K. Kinoti

e) Mr. P.M. Ngau

f) Mr. O.O. Mbeche

g) Mr. J. Karui-u

h) Mr. J. Steadman

i) Mr. E.G. Rwigi

j) Mr. A. Kasamu

k) Mr. Hardev Singh

l) Mr. S.O. Kiaye

m) Mr. Mbogholi

n) Mr. Mgadi Kagosha

Other individuals and institutions that helped in various ways are all thanked especially Mr. J. Mwabu and Mr. W.M. Kithama for offering me accommodation while conducting field work in Mombasa.

Lastly, but not least, I owe much gratitude to Miss Mary W. Ndegwa the Secretary who typed my work as well as thanking all my postgraduate colleagues, Messrs. Karue, Maonga, Mabonga, Mazonde, Mungai and Ndiang'ui for their inspiration and encouragement during those difficult days of M.A. Course.

The errors are mine

IRANDU, E.M.

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CHAPTER 1

INTRODUCTION

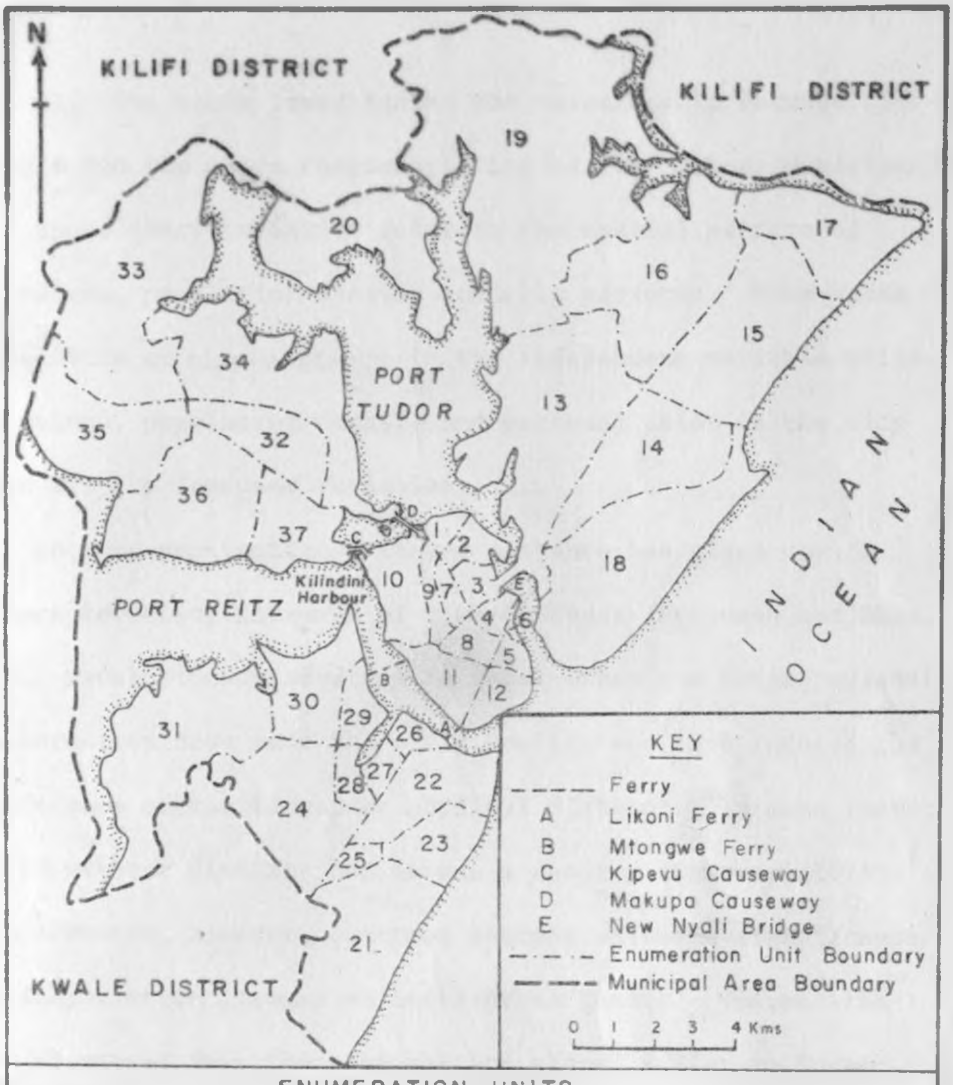
1. THE RESEARCH PROBLEM

A. THE STATEMENT AND NATURE OF THE PROBLEM

Few studies exist that show the relationship between urban transportation and urban structure in both the developing and the developed nations. Gauthier (1968) and Leinbach (1979) showed there exists a high degree of interdependence between the development of the transport network and the spatial pattern of urban development. The two studies were macro-scale in nature as they considered the impact of urban transport on a national or regional scale.

As Third World countries become urbanized, there is growing need for an adequate planning for a balanced urban development. Urban planners should pay close attention to urban transportation for it provides access to urban areas and helps reduce regional or intra-urban inequality. Areas with better transport facilities like roads or commuter bus services tend to attract denser populations, more industries and so on. Areas with poor or no transport facilities tend to lag behind.

The present study examines the relationship between urban transport and urban structure at a micro-scale, that is, in one urban area in Kenya. The study covers the Mombasa Municipal area



ENUMERATION UNITS

KEY

1. ISLAND
1. TUDOR ESTATE
2 TUDOR FOUR
3. TONOMOKA
4. BONDENI
5. MAKADARA
6. MJI-WA-KALE
7 MAJENGO
8 MWEMBE TAYARI
9. KINGORANI
10 SHIMANZI
11. GANJONI
12. KIZINGO

2. NORTH MAINLAND
13. KISAUNI
14. FRERE TOWN
15. BAMBURI
16. NGUU TATU
17. SHANZU
18. KONGOWEA
19. MWAKIRUNGE
20. MWAUNGUJA

3 SOUTH MAINLAND
21. SHIKA ADABU
22. MAWENI
23 TIMBWANI
24 VYEMANI
25 KIBANDANI
26. MIGOMBANI
27. BOMANI
28. KINDUNGUNI
29. MUEZA
30. MIDODONI
31. MWAMDONI

4 WEST MAINLAND
32. CHANGAMWE
33. MBUYU WA CHAPA
34. MIKINDANI
35. MIRITINI
36. PORT REITZ
37. KIPEVU

FIG. 1 ENUMERATION UNITS OF MOMBASA MUNICIPAL AREA

(Fig. 1). The study investigates the relationship between time-distance and the space characteristics of the Mombasa Municipal area.

Space characteristics refer to the spatial pattern of land values, population density and trip patterns. Time-space connectivity or time-distance is the independent variable while land values, population density and personal trips to the city centre are the depedent variables.

In many applications, linear distance has given way to the more revealing features of time-distance (Ferguson and Ngau, 1979). Revolutionary advances in inter-urban and inter-regional transportation have made the world smaller and have reduced the significance of the linear or physical distance. In some respects, a world without distance has become a reality (Chapman, 1979). These advances, however, contrast sharply with the significance of transportation changes at intra-urban levels. Whereas the world as viewed from the regional and global scales is indeed shrinking at the local scale functional distances as measured by time are either increasing or decreasing slowly. In many urban areas of the developing world such as Lagos in Nigeria, traffic jams increase travel time leading to time-space divergence.

The concept of time-space convergence was developed by Janelle (1969). Time-space convergence means the tendency of places to become relatively closer together in terms of travel time due to an improvement in transportation like building a bridge, or a tarmac road. By time-space divergence is meant the

tendency of places to get relatively farther apart - in terms of travel time due to traffic congestion and so on. Travel time is always more relevant in underdeveloped countries than road distances. Transport improvements in the developing countries are proceeding rapidly and have a big impact on the space economy. Travel time between the major urban areas has been reduced in the developing nations making it faster to travel and to move goods (Merchand, 1973)

This study involves an analysis of travel time by bus on the Mombasa Municipal road network as well as a description and explanation of the effect of travel time on the structure of land values, population density and personal trips to the city centre. Simple regression analysis, partial correlation analysis and the mapping of the regression residuals are used to show the relationship between travel time by the Kenya Bus and the land values, population density and trips.

Travel time by "Matatu" is also used for comparative purposes with bus time. A "matatu" is a public transport vehicle of less than 6720 pounds weight, and is exempted from the public service licence (Ministry of Environment and Natural Resources, 1979, P 1). Different transport modes like the Kenya Bus and "matatu" should have different impacts on the space charateristics, of Mombasa Municipal area.

Travel time, land values, population density and trips are all measured from one central point, that is, Mwembe Tayari on the Mombasa Island. Mwembe Tayari is chosen because:-

(a) it is the centre of Kenya Bus services company which is a major public transporter within the Municipal area.

(b) Most "matatu" operators begin and end their trips there.

(c) It is close to the point of peak land value which characterises the city centre in industrialized cities.

In this study, the term land value means the market price of a given urban site. This definition does not include the value of the development on the site. Although only unimproved site values are considered, there may be off-site improvements like a road, lighting and so on. These off-site improvements may alter slightly the land value of a given site. There is no clear cut distinction between unimproved site values and improved site values.

Most studies of urban land values have been carried out by economists, particularly land economists (Alonso, 1964, Goldberg, 1970, 1972; Alcaly, 1976). An assumption basic in the classical land value theory is that land values decline with distance from the city centre. Locations away from the city centre incur greater transport costs and thus land values decline. The land value theory is based on two assumptions:

(a) Land values are determined only by the market forces of supply and demand.

(b) Urban land market is perfect. That is, both buyers and sellers have a perfect knowledge of the prevailing market situation, there is no land speculation and no government or institutional interference. But, these assumptions are not always true. There are exceptions especially with regard to the cities of the developing nations.

The land value theory is based on the Western Capitalist city where every plot or institution is assumed to be in the market. In the cities of the developing countries, not every one is in the urban land market. Land values in the cities of the developing countries are determined by many and complex factors (Yahya, 1969, Kimani, 1972).

The urban land market is imperfect. Both in the cities of the developed as well as the developing nations, there is a lot of land speculation. Land owners or buyers are keen to know what the market value of a piece of land will be in the next few (minutes). Sometimes, there is government or local authority interference with the mechanism of urban land market.

According to the studies carried out in both the cities of the developed and developing nations, urban population density declines with distance from the city centre. That is, studies have revealed a statistically significant negative exponential relationship between density and distance (Berry et al, 1963; Brush, 1968; Muth, 1969; Ngau, 1979). Regardless of time or place the spatial distribution of population densities within cities appears to conform to a single empirically derived expression:

$$d_X = d_o E^{-bX}$$

where d_X = population density at distance X from city centre

d_o = central density

b = density gradient

E = Exponential function

Several reasons have been put forward to explain the negative exponential density gradient. They are to minimize costs

age of the central city, size and shape of the city, the automobile, need for privacy and so on.

Studies carried out in North America reveal that relatively higher population densities occur near the city centre while low densities occur in the suburbs. The people who live near the city centre are poor people and are least able to afford a private car. So, higher densities occur near the city centre in order to save transport costs. Transportation studies carried out in Latin America show that due to a high friction of distance, the wealthy people tend to live at the more accessible central locations while the periphery is ringed by slums and squatters (Wheeler and Thomas, 1973). The wealthy people in Latin American cities want to save transport costs too.

A small and compact city has a higher density than a larger and dispersed city. Cities are not circular and distortions in the shape of the city influence density structure.

The motor car has provided a lot of flexibility in locational decisions. The richer population has moved to the newer and more spacious suburbs so that the city centre is overcrowded while the suburbs are sparsely populated.

The negative exponential density gradient and the factors suggested above mainly apply to the industrialized city and do not apply adequately in the colonial cities without some modifications. A colonial city is one founded by the European colonisers. For a colonial city, there is no clearly defined distance-decay function found in industrialized cities. This is mainly due to the colonial policy and rural - urban migration.

The colonial authorities set a side separate residential areas for different races with little regard for distance from the city centre. In Nairobi for instance, the Africans lived in Eastlands, Indians lived in Parklands and Europeans lived in Westlands, during the colonial era. The density structures for the three races vary considerably today with the highest population density found in Eastlands (Ngau, 1979).

Many people leave the rural areas of the developing countries and move to the cities to look for a better way of living. Such a drift to the Third World cities influences their density structures. But, rural-urban drift is not very important in influencing density structures of industrial cities (McGee, 1967).

In an urban area, the locations of residential areas, work places or commercial centres tend to be different. A trip may be defined as a one way travel from origin to the destination for a particular purpose(s) using a given mode of transport (Hurst, 1974, p 495). Trips are made for a particular purpose or purposes such as working, shopping or education. The separation of urban activities necessitates intra-urban mobility or travel. This mobility creates a travel pattern or structure.

The suburbanization of jobs in the industrial cities of the industrialized world has led to a reversal of commuting or journey to work patterns. Instead of workers moving to the city centre, movement is becoming more and more oriented to suburbs which are the new employment centres. The motor car has made the separation of work place and residence possible. In industrialized

cities, work places tend to be separated from residences by long distance and yet, workers get to work punctually due to the availability of the car. The car has reduced travel time considerably in the industrialized cities so that various urban activities are relatively closer together in travel time. In other words, individual mobility tends to increase.

But, the travel patterns common in the industrialized cities are different from those in the cities of the less developed countries. The work places in the cities of the Third World tend to be concentrated in the city centre (CBD). So, commuting to work is usually directly towards the CBD and not the suburbs like in the Western cities or industrialized cities (Wheeler and Thomas, 1973).

Studies show that walking is the dominant mode of transport in the Third World cities. (Wheeler and Thomas, 1973; Norconsult, 1973; Berege, 1976; Ngari, 1977). The majority of people in the Third World cities are poor and cannot afford a private car. There is a lot of reliance on public transportation such as the bus in the Third World cities. Public transport provided by the urban buses is not itself adequate. In the industrialized cities, public transport is not very important.

In the light of what studies in other parts of the world have revealed about the structures and the factors influencing the structures of urban land values, population density and trips made to the city centre, three questions are raised and answers attempted in this study:-

1) What is the structure of land values, population density and personal trips within the Mombasa Municipal area? The answer to

this question explores the nature of land value gradient from the city centre at Mwembe Tayari. Investigation is made into whether value gradient declines with time-distance. The answer to this question is expected to reveal the nature of population distribution throughout the town.

Travel patterns show the main origin-destination structure This is useful in providing knowledge on the distribution of employment, schools, hospitals and recreation centres in the study area. The structure of land values, population density and trip patterns provides information on Mombasa's urban structure.

2) What factors influence the structure of land values, population density and personal trips within the Mombasa Municipal area? This shows the forces or factors influencing the structures observed. The factors are obviously many and complex. However, in this study, the main factor isolated for investigation is time-distance. Time-distance by bus is considered as the indicator of the impact of road transportation on urban structure of Mombasa. The results obtained would be useful in predicting the impact of road transport improvement on urban structure in the Third world at a given point in time.

3) Is the structure observed similar or different from that in industrialized cities?

Some Western Geographers (Garrison, 1959), economists and other scholars argue that developing nations will follow the same path of development as the present day developed countries. As a result, Eurocentric models have been applied in less developed countries

without modifications. Land value theory, population density functions and travel patterns developed in the west have been tested in the Third World countries without exceptions given to the city structures. This study shows where urban land value theory, population density functions and travel patterns developed in the Western World apply in the study area. The study also establishes the need for modifying the application of western models in Third World cities as well as stating the case for developing models for the Third World.

B. STUDY OBJECTIVES

Mombasa is both a pre-industrial as well as a colonial town. Some parts of Mombasa such as the Old Town (Fig. 1) existed long before the coming of the Portuguese in the later part of the 16th Century. Other parts like the Modern Kilindini Harbour, or high class residential areas such as Kizingo on the Island, were founded during the colonial time. The urban morphology of the Old and New Mombasa are different.

Mombasa Municipal area offers an appropriate testing ground for the above findings and theories of urban structure developed in the industrialized cities. Mombasa Island is the heart of the Mombasa Municipal area. The Island accommodates most of the commercial activities, older residences, the Kilindini Harbour and some manufacturing. Many businessmen locate their businesses on the Island. Because of the great demand for commercial land,

industrial land and residential land, the land values on the island are exceptionally high in comparison to those on the mainland areas.

Most people live on the Island and more people still want to live there. But, the Island is small and overcrowded. Today, the Island carries the highest population density within the Municipal area. The population density varies from 26602 persons per square Kilometre in the old Town on the Island to only 40 persons per square kilometre in the Mtongwe area of the South Mainland (Fig. 1). The population density considered in the study is gross density, that is, the number of persons per unit area (Km^2).

On any day, thousands of people living on the Mainland areas of the Municipal area, converge on the Island on foot, bicycles, "matatus" and buses for different trip purposes such as work or business. The Island nature of the town and the concentration of activities on the Island, influence travel patterns within Mombasa Municipal area.

This study achieves three main objectives:

(a) it establishes the relationship between time-distance and land values measured from Mwembe Tayari.

(b) It establishes the relationship between time-distance and population density measured from Mwembe Tayari.

(c) It establishes the relationship between time-distance and the number of personal trips to the CBD measured from Mwembe Tayari.

The three objectives are achieved by:-

(a) Describing the structure of land values, population density, and trips. Moreover, residual maps are also used. Regression curves show the relationship between time-distance and land values, population density and number of personal trips to the CBD.

Pearson Correlation Coefficient (r) shows the strength of relationship between the time-distance variable and land values, population density and trips.

(b) Identifying and explaining the factors that influence the spatial structures observed by means of (i) simple correlation analysis. This shows the degree of association between time-distance and land values. (ii) Partial correlation to show the effect of time-distance by bus on land value, population density and trips holding "matatu" time constant. (iii) Interpretation of interviews held with the Mombasa Municipal Council Planning and Valuation officers as well as the Municipal Engineer. (iv) Using personal knowledge gained by means of field observations.

(c) A comparison of spatial structures observed with the structures of land value, population density and trips in the cities of the industrial world. This would confirm whether the classical land value theory applies to Mombasa Municipality.

C. HYPOTHESES

Three hypotheses are advanced and their validities are tested in the study.

1) Land Value declines with increasing time-distance from the city centre. That is, an inverse relationship in hypothesized

between time-distance and land values.

2. Population density declines with increasing time-distance from the city centre. An inverse relationship exists between time-distance and population density.

3. The number of personal trips decreases with increasing time-distance from the city centre. An inverse relationship exists between time-distance and the number of personal trips to the CBD.

The three hypotheses are tested in the following ways:-

A time-distance analysis of the Mombasa Municipal road network is carried out using travel time by bus and the "matatu". This analysis shows the areas where there is less travel time by bus.

Simple regression and correlation analysis are used to establish the relationship between time-distance and land values, population density and the number of personal trips to the city centre. The regression line is a downward sloping curve showing a negative correlation. Regression on residuals are mapped to show the spatial pattern of land values, population density and personal trips.

D. SCOPE AND RESEARCH LIMITATIONS

This study covers the whole of the Mombasa Municipal area including the town proper (Island) and the three mainland areas, namely, the north, the south and the west mainland (Ref: Fig.1).

The centre of research interest is road transport and does not include other transport modes like air, rail or sea. The research for this thesis was carried out in Mombasa with a very limited research budget and was restricted to six months of research time.

In this study, only public transport is considered because it serves the majority of the population in Mombasa. Public transport involves the movement of people by the Kenya Bus Service and "matatus" that operate within the study area. Movement of goods is not considered as many different transportation firms are involved in handling goods and would be very costly and time-consuming. A public transport vehicle is one which satisfies the following conditions:-

1. Registered as a Public Service Vehicle
2. Has a well defined route
3. Has a regular time-schedule
4. Has a fixed fare structure for the routes operated.

The Kenya Bus Service (Mombasa) Limited buses satisfy all these conditions. The Kenya Bus company is licensed and given the sole monopoly to operate within the Municipal area by the Mombasa Municipal Council. The Mombasa Municipal Council has a 49% share in the company while United Transport Overseas Services has 51% share.

"Matatus" were exempted from the public service vehicle licence by presidential decree on June 1st, 1973.("Matatus" are usually owned by individuals. Although "Matatus" do not have regular

time schedule, they follow certain defined routes usually the bus routes. Some "matatus" have fare charts for the routes along which they operate.

Taxis are excluded from this study as they do not serve many people. Their impact as general passenger carriers is minimal. The taxis mainly carry tourists to and from the beaches. Private transport like the car is also excluded from this study as it does not serve a large number of people too. Most people in Mombasa as in many cities in the less developed countries are poor and either walk or rely on the bus. Unlike the Kenya buses which have a common origin and definite routes, cars have innumerable origins and destinations.

Travel time and travel cost are interrelated. The two measure the same thing, that is, the friction of space. In the study, time-distance by both Kenya Bus and the "matatu" is used throughout.

A number of research problems were encountered in data gathering. The study area was divided into 37 enumeration units (.. Fig.1) and data on land value, population density, trips to the city centre and travel-time by bus and "matatu" were gathered for each unit. This sub-division led to problems mainly because some data were not available in some units. Some enumeration units did not record any land sales. Other units were not served by either a "matatu" or bus and no accurate travel time would therefore be obtained. In such situations, estimates were made by walking to the nearest bus stop.

It was expected that land uses would be studied. However, as is always the case with urban land uses everywhere, their complexity made it difficult within the limited study time. Population data initially chosen as a possible surrogate for land use intensity, proved unsuitable, for it only explained or accounted for residential land use and not all the urban land uses. So, it was decided that instead of dealing with land use, population density, itself an essential topic to study, would be investigated. So land use was replaced by population density. Population density data were readily available from the National Population Census tables compiled by the Department of Central Bureau of Statistics of the Ministry of Economic Planning and Development, Kenya.

Many respondents interviewed gave a very poor response. Some respondents were hostile or gave wrong information. A large number of people seemed to be in a hurry to catch a bus or to arrive at work. A number of respondents could not clearly identify and name their residential locations. All these problems tended to make the data gathered less acurate than was expected.

E. LITERATURE REVIEW

Alonso (1964) suggested that studies should be carried out in the cities of less developed countries in order to develop urban models for the Third World cities and to test euro-centric models to see how applicable they were in the less developed nations.

No local model is developed in this study. This review is mainly on intra-urban transportation and its impact on urban structure.

Most studies of urban land values and their relationship with transportation have been carried out by land economists (Goldberg, 1970, 1972; Alcaly, 1976). Goldberg investigated the relationship between transportation and land values as well as the interraction between transportation and land uses. He observed that transportation improvement resulted in a decline in aggregate land values. He also found out that the use of the car tended to reduce land values in the CBD by making the periphery more accessible.

Goldberg also suggested that there are two models of the city, namely, the dispersed and the nodal city. A dispersed city is one in which accessibility in all directions is high and uniform. An example of a dispersed city is Los Angeles. A nodal city is one in which transportation costs are high due to inaccessibility. An example of such a city is New York. Many cities in both the developed and the developing world lie within these two extremes of city structures.

Mombasa is an Island town and its urban structure is almost similar to that of New York. That is, it is a nodal city. Its Island nature, makes it difficult to be well connected by road transportation.

Goldberg observed that transportation improvement in the industrialized cities tends to encourage suburbanization while transport improvement in the cities of the Third World tends

to encourage concentration and centralization.

Transportation studies carried out in Latin America reveal that due to a high friction of distance, the wealthy people reside at the more accessible central locations while the periphery is ringed by slums and squatters (Wheeler and Thomas, 1973, p 113).

Wheeler and Thomas found out that walking is the dominant mode of transportation in the cities of Latin America. They concluded that walking is the dominant mode of transport in most of the Third World cities.

In their study of the patterns of work trips in the Honduras, Wheeler and Thomas observed that all the bus routes passed through the CBD while the highest density of work place was the CBD.

City structures in both North America and Latin America differ considerably from those in Kenya or parts of Asia like India. The transportation network in the cities of North America like New York, is well developed and cannot be compared with that in Mombasa or Nairobi. The impact of transportation on urban structures is not yet fully understood. Thus, "studies of the internal spatial structure of cities in the developing world would focus on the role of transport as it influences the distribution of population - - - - at present broad and conflicting generalizations exist" (Wheeler and Thomas, 1973, p 119). It is hoped that this study will help fill some of this knowledge gap.

An important study carried out in the study area was the Mombasa Transportation Study of 1972-73. This study was carried out by Norconsult Consultants. The government of Kenya required the Mombasa Transportation study to be undertaken with the prime objectives of evaluating alternative strategies for the development of main road network for Mombasa and of recommending the optimal system for the time when Mombasa town is expected to have a population of about one million people (1996). This study found out that walking is the dominant mode in Mombasa.
Walking accounted for 61% of the total home-based trips. The study also found out that car ownership increases with rising income.

The Mombasa Transportation study (1972-73), proposed both short and long term recommendations. The main short term recommendations include the provision of additional buses on the existing and new routes, establishment of bus ways and lanes where no other form of transportation will be allowed and more and larger ferries to be provided at Likoni.

The long term recommendations include the building of bridges and roads. The Norconsult or Mombasa Transportation study recommended that a bridge should be built at Ras Kisauni to link the North Mainland with the Mombasa Island. This bridge has now been constructed and is known as the New Nyali Bridge. The study also recommended the building of another bridge at Likoni as well as a causeway at Ras Saadi to link the South Mainland with the Islands.

Several roads were proposed to improve the road network and to reduce traffic congestion on the Island. The main proposals included

the building of the North-South road from Makupa Causeway to Likoni bridge. Another road is the East-West road to link the New Nyali Bridge with the North-South road.

Koutsopoulos (1977) examined the impact of mass transit on residential property values. He used travel time as the independent variable while residential property values were the dependent variable.

Ferguson and Ngau (1979) carried out a time-distance analysis of the Mombasa Municipal Bus Network. They found that travel time by bus was influenced by the morphology of the town, nature of road as well as the socio-economic aspects of the people. The two authors observed that travel time was influenced by the Island nature of the town, especially the long waiting time at Likoni ferry linking the Island with the South Mainland.

Ferguson and Ngau, observed that narrow streets like those in the old Town affect travel time. The Islamic tradition of the coastal people is also important. Residents of Mombasa do not hurry up to get home before sun set. They like resting and this means that there is no evening peak hour in Mombasa.

2. BACKGROUND TO THE STUDY AREA

A. LOCATION

Mombasa is situated on the east coast of Kenya. It lies between Latitudes 4° 10'S and 5° 55'S and between Longitudes 39° 44'E. Administratively, Mombasa is a District. It is the smallest District in Kenya covering only 275 k.m.^{2} (Mombasa Phy. Dev. Plan, p.3). There is one local authority, the Municipal Council of Mombasa which covers the whole District. Therefore, the term Mombasa District or Mombasa Municipal area may be used interchangeably. However, for convenience, the term Municipal area is used throughout the study. Mombasa Municipal area borders with Kilifi District to the north and Kwale District to the south and the west. In the east, it borders the Indian Ocean (Fig. 2).

B. PHYSIOGRAPHY

Relief features are the major determinants in the development of Mombasa. The two large instusions of the ocean, namely Port Tudor on the east and Port Reitz on the west provide the chief reason for Mombasa's birth and continued development (Fig. 3). But, they also present the most significant problem for the future development of the town. These two creeks divide Mombasa into four physically separate areas, namely, the Island, the North, South and the West Mainlands.

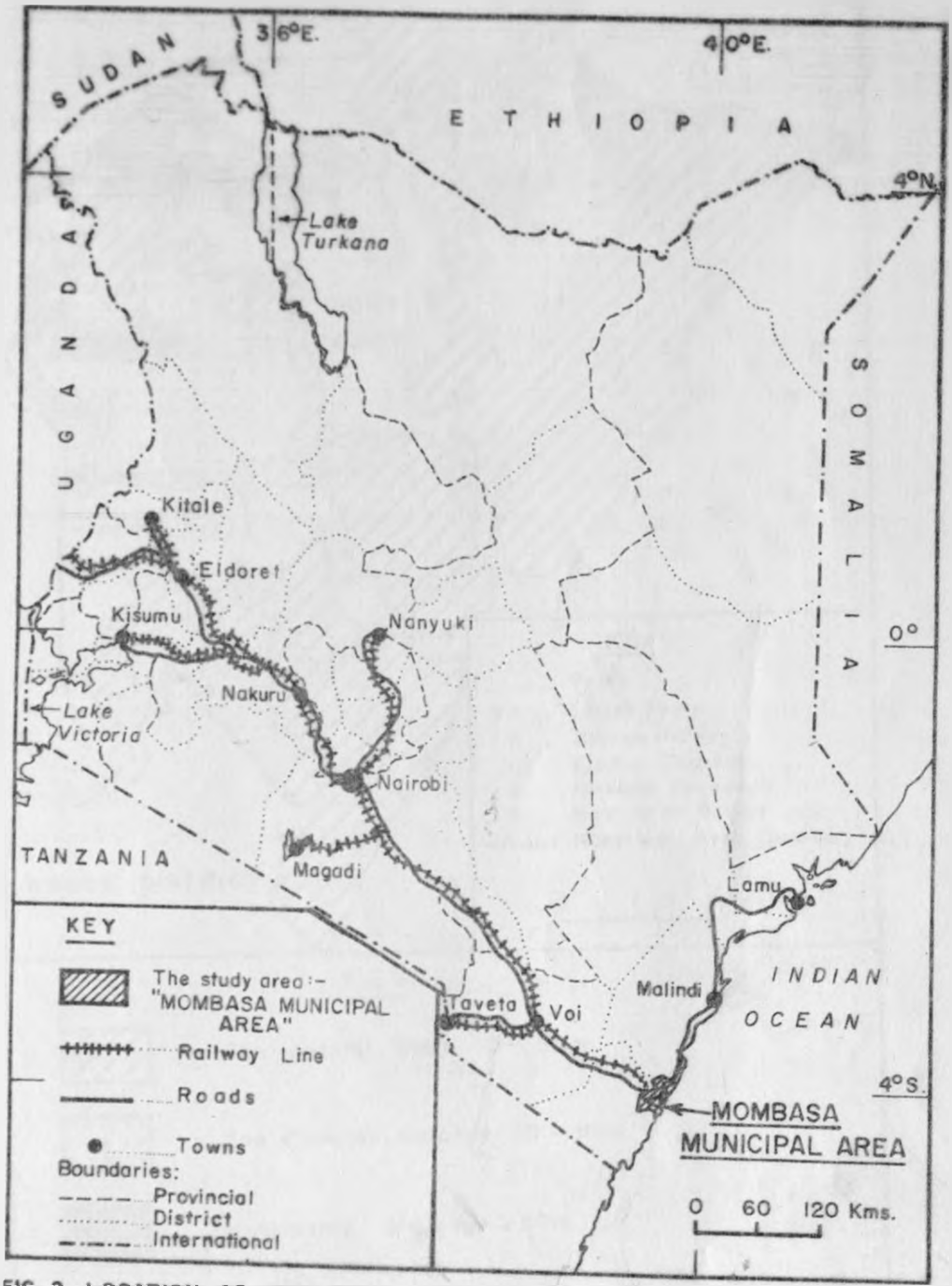


FIG. 2 LOCATION OF THE STUDY AREA - "MOMBASA MUNICIPAL AREA" IN KENYA

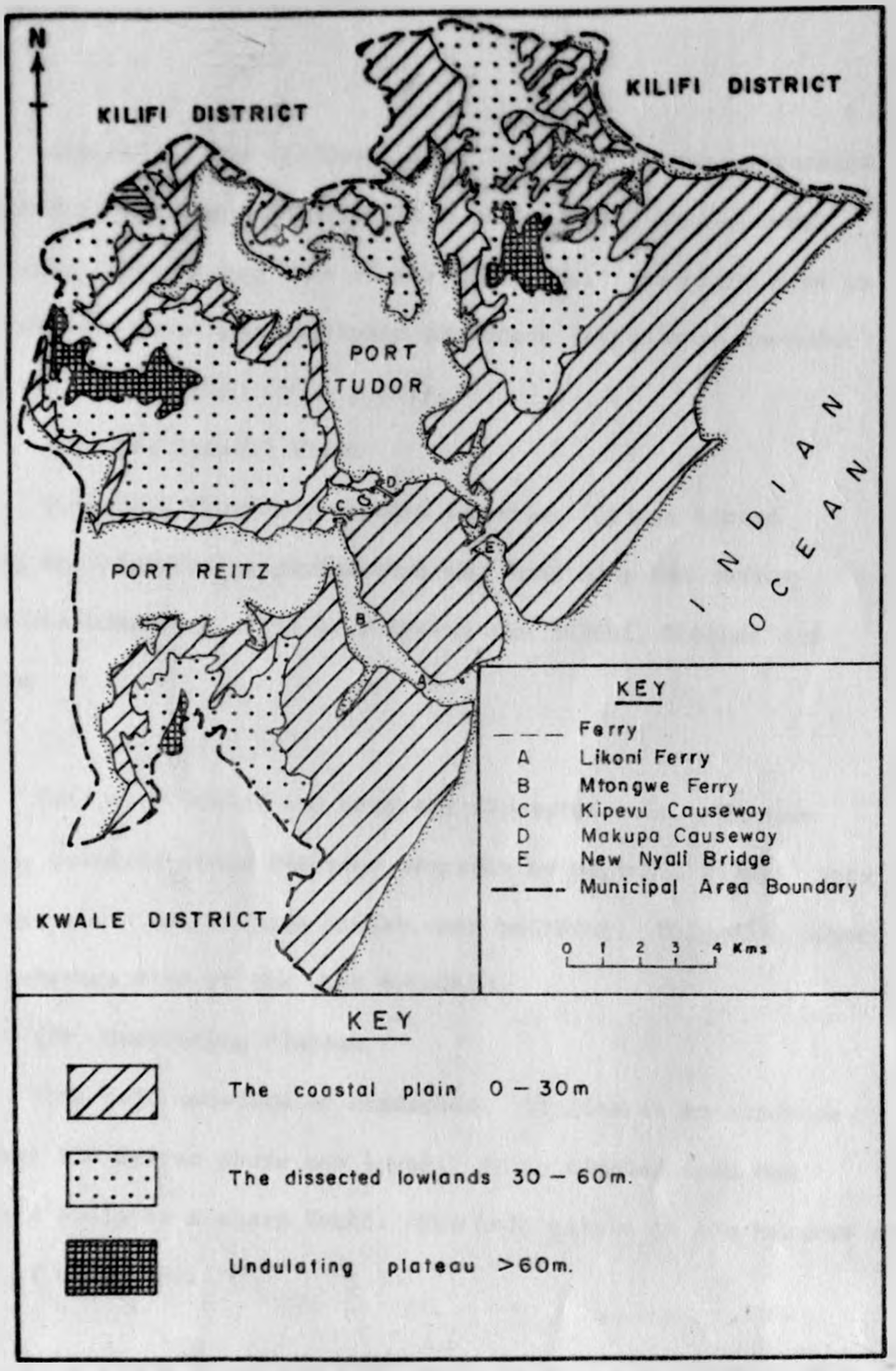


FIG. 3 PHYSIOGRAPHIC REGIONS OF THE MOMBASA MUNICIPAL AREA

Generally, the landscape is a lowland with some extensive fairly flat areas immediately after the cliffs becoming more undulating towards the west of the mainlands. The study area is divided into three physiographic divisions listed here in order from the sea (Morgan, 1973, p.192).

(1) The Coastal Plain

This is a flat belt about 6 Km wide. It was formed during the pleistocene period when the land near the Indian Ocean was submerged. The belt covers the Island, Kisauni and Mtongwe.

(2) Dissected belt

This is a broken and severely dissected belt. In some places, Jurassic shale has been overlain by Magarini sands. Here are poor sandy soils which hinder road building. This belt covers the Changamwe area of the west mainland.

(3) Undulating Plateau

This belt consists of sandstone. It lies at an altitude of about 150 metres above sea level. It is divided from the Jurassic shale by a sharp fault. The belt exists in the Mazeras area north of Changamwe.

C. CLIMATE

Due to its latitude and coastal location, Mombasa is hot and wet all the year round. It has two rainfall maxima, one in March-May and the other in October-December. The mean annual rainfall is about 1038 mm. May is the wettest month. The minimum mean annual temperature is 23.4°C and the maximum mean annual

temperature is 30.1°C. The relative humidity at 15.00 hours local time is 67% (Mombasa District Development Plan, 1979-83, p 1). The climate is influenced by the sea breezes throughout the year. The hot and damp climate of Mombasa necessitates the development of a good mode of public transport with adequate ventilation for a comfortable service. The often overcrowded "matatus" and the buses found in other urban centres of Kenya, are unsuitable in Mombasa. Work places, shopping centres, schools and other facilities should be conveniently located to minimize long distance in the hot and humid environment.

D. FUNCTIONS OF MOMBASA

Mombasa is one of the oldest towns in East Africa. Unlike many cities in Tropical Africa whose origins is closely associated with European colonisation, Mombasa is a pre-industrial city which predates the coming of the Portuguese in the 16th Century. For many centuries, it has been the centre of a thriving maritime trade in the Indian Ocean and the Persian Gulf. The first settlement in Mombasa was confined to the Island in what is today called the Old Town. The Old Town is the nucleus of Mombasa. The Island is small comprising an area of only 13 Km^2. By the 16th Century, the population of the town was probably between 10,000 - 30,000 people although the figure changed from year to year (Mombasa Development Plan, 1971). In 1979, the population was 341,118 people (Population Census, 1979). Thus, the population of Mombasa

has grown tremendously in the last few centuries. Before 1895, the majority of the people lived in the Old Town consisting of only 52 hectares (Jan Mohammed, 1977). This is the area with the highest population densities within the Municipal area today.

Before the end of the 19th Century, Mombasa was not the most important coastal town. Other coastal trading centres like Zanzibar were very important and rivalled Mombasa in trade. In fact, Mombasa formed part of the Zanzibar sphere of economic influence which included Lamu, Northern Kenya, the Lake Victoria region, Tanzania, Eastern Zaire and Zambia. Traders from all over Europe, North America, Saudi Arabia and India called at Zanzibar Port. During the period of Zanzibar supremacy, Zanzibar was the commercial ware-house in the whole of East Africa (Berg, 1971, p 338). However, as the 19th Century came to a close, a number of factors led to the decline of the Mombasa's competitors including Zanzibar. Mombasa's prominence increased due to the development of the steam ships, the construction of the Kenya-Uganda Railway and the construction of the modern Kilindini Harbour.

The Port has been regarded as the raison d'etre of Mombasa (Norconsult, 1973, p 7). For many centuries, Mombasa harbour lay on the east of the Island (Fig. 1). This is what is called the Old Harbour. It was suitable and is still used by dhows. But, the number of dhows has decreased over the years. Dhows visiting the Old harbour came from other coastal towns like Lamu and Malindi as well as from Saudi Arabia, the Persian Gulf and India. These dhows relied on the North-east and the South-east Monsoon winds for sailing.

With the development of the steamships, a new, deeper, well sheltered and spacious harbour was needed. The old harbour was used not because it provided an ideal site for harbour development but because Port Reitz was difficult for ships to sail into it due to the prevailing wind and current velocities (De Blij, 1968). The development of larger and stronger ships made Kilindini more suitable for port development. The new harbour was located on the western side of the Island and is today called the Kilindini Harbour,(meaning a place of deep water in Swahili).

The modern development of Kilindini Harbour dates back to 1895 when the decision to build the Kenya-Uganda Railway was made by the British Colonialists. The first rails were laid at Kilindini on the 30th day of May, 1896, and reached Kisumu on the shores of Lake Victoria on the 20th day of December, 1901. This is the key technological factor that explains Mombasa's rise to a position of dominance on the east coast of Africa by the end of the 19th Century. The impact of the railway on Mombasa's development as well as other parts of East Africa was revolutionary. The railway dramatically reduced transport costs, replaced human porterage and brought new areas in East Africa into Mombasa's commercial orbit thereby radically altering the existing trade patterns.

The railway was a very effective means of reducing the restricting geographical factor of distance. It led to time-space and cost-space convergences as places connected by railway in the interior became relatively closer in time and cost to Mombasa than before

(Jan Mohammed, 1977, p 53; Oloo, 1980). By the beginning of the 20th Century the whole economic system of East Africa began to undergo a series of changes which were triggered by the Kenya-Uganda Railway. Zanzibar declined as an important coastal commercial emporium. This was due to the fact that the railway brought about a dramatic re-orientation of the existing trade patterns and effectively bestowed a vast, new and potentially valuable hinterland upon Mombasa (Hoyle, 1967, p 76).

The railways provided the essential framework on which the hinterland of the East African ports are laid out. The pre-eminence of Mombasa lies in the extent and population of its hinterland, which contains the majority of the concentrations of commercial activity in East Africa. The largest concentration of population in East Africa is around Lake Victoria and most of it trades through Mombasa either via railway which directly serves its northern shore or through the Lake Steamer service to the port of Kisumu (Morgan, 1973, p 186).

The railway stimulated urban expansion within Mombasa. By 1900, Mombasa Island had become a large town and was spreading in all directions. The railway attracted banks such as the National Bank of India, hotels, retailers and secondary industries. The railway provided the sole all-weather transport link to the hinterland until the Mombasa-Nairobi road was bitumenized in 1968. Since inland origins and destinations provided the major part of port traffic, the port was laid out as a railway port and the traditional dominance of the railway is reflected in its present day lay out (Kenya Ports Authority, 1978).

The Kenya-Uganda railway opened up Kenya Highlands for European settlement. It also promoted economic development in Uganda. This led to an increase in export products like coffee, cotton and tea as well as imports like machinery and textiles. The increase in the amount of cargo handled and endless congestion in the Old Port, led to its abandonment in favour of Kilindini. This means that the focus of economic activity within the Island shifted to the West. The modern port at Kilindini handled export and import cargo to and from the interior of Kenya and Uganda while the old harbour continued to serve the dhow traffic between Mombasa and the Indian Ocean. The survival of the Old Town has been the single most important factor in shaping Mombasa's modern physical growth (Jan Mohammed, 1977, p 288-9).

Since the new port was developed on the Western side of the Island, the need to modernize the old port did not arise. Consequently, the modern business areas developed adjacent to the Old Town and very little replacement took place. Apart from remaining as a centre for dhow trade, the old Town retained small factory units, residential buildings and places of worship. So, this region fulfills commercial, religious and social functions too.

The new harbour provides the base for most industrial and commercial activity and is itself the chief employer in Mombasa. Today, the Kenya Ports Authority which runs the Kilindini Harbour employs 3500 people. The port is actually the biggest and the most important land use within the study area. The expansion of Kilindini Port will determine the future economic growth and the prosperity of Mombasa. The Port is expected to determine the

character of Mombasa and will have a marked effect on people's living conditions.

Before the closure of the border between Kenya and Tanzania in 1977, Kilindini harbour served the Moshi area of Tanzania and the copper belt of Zambia. It is likely that Kilindini harbour will serve these areas again if the border re-opens. The port is also expected to serve the West African nations may be as far as Nigeria when the planned Trans-Africa Highway linking Lagos (Nigeria) and Mombasa (Kenya) is completed. This road is expected to promote intra-African trade and the volume of sea-borne trade is expected to rise in the Kilindini Harbour.

Mombasa is also the second largest town in Kenya after Nairobi. It lies about 500 Km South-east of Nairobi. It is linked to Nairobi, the capital city of Kenya by railway as well as by road and air route. The impact of the new airport is expected to be felt in the town's tourist industry. The airport began to operate in 1978. Mombasa is also the headquarters and the regional service centre of the Kenya's Coast Province. As a regional market centre for the coast province, the town is well linked by the regional road transportation network. The town serves the rich agricultural region of Lamu, Tana River, Kilifi and Kwale Districts (Fig. 1).

The urban structure is characterised by the crowding of many functional Zones on the Island and high population density, and the urban sprawl spreading to the mainland areas (De Blij, 1968 p51).

Mombasa is a rapidly growing commercial, industrial and tourist centre.

Land within Mombasa is devoted to a number of land uses (Fig. 4). By land use is meant the urban activity on a site like industry or commerce. The main land uses are shown in Table 1.

Table 1: Main Land Uses in Mombasa Municipal Area (% Of total area)

Transportation	32
Residence	31
Industry	10
Recreation	8
Public Services	4
Commerce	4
Agriculture and under-developed land	9

Source: Mombasa Draft Physical Development Plan, 1971, Table 8 p 92.

Table 1 shows that transportation occupies more space than any other land use. This is so because Mombasa is a Port-town. The residential land use is second in importance. The average percentage for a residential land in urban areas in Kenya is 42%. It is less than average in Mombasa possibly because of the dominance of harbour and the importance of beaches not often found in other urban areas of Kenya.

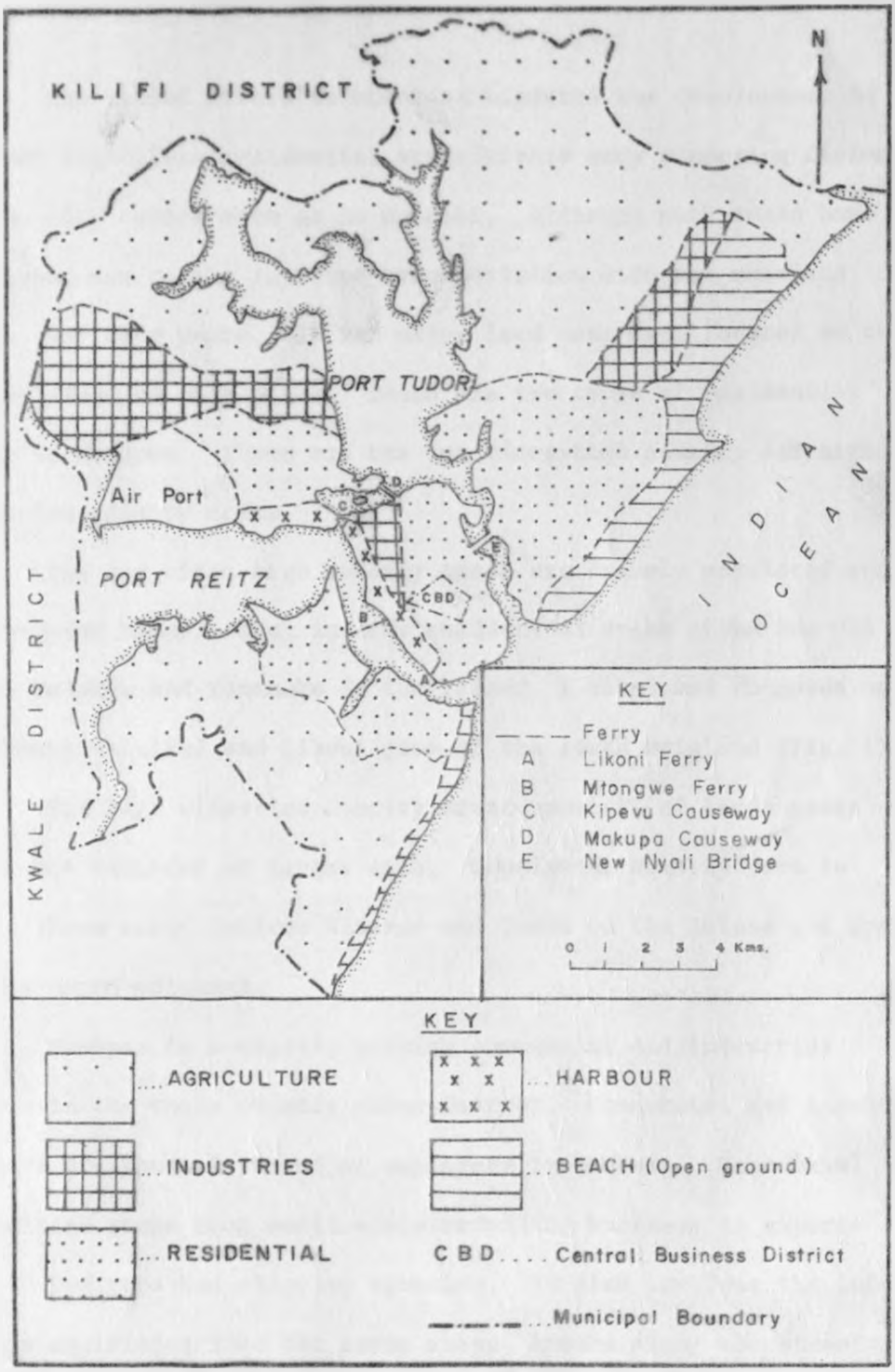


FIG. 4 MAIN LAND USE IN MOMBASA MUNICIPAL AREA

The Island nature of the town hindered the development of distant high class residential areas within easy commuting distance of the city centre such as in Nairobi. Although such areas have developed due to the improved transportation with the mainland areas, for many years, all the major land uses were located on the Island close to each other. There are two types of residential areas in Mombasa. There are the low class-high density and high class-low density areas.

The low class-high density areas are densely populated and overcrowded today. They include residential areas like the Old Town, Majengo and Tononoka on the Island, Kisauni and Kongowea on the North Mainland and Likoni area of the south mainland (Fig. 1).

The high class-low density areas consist of large plots about 0.4 hectares or larger each. Population density here is low. These areas include Kizingo and Tudor on the Island and Nyali on the north mainland.

Mombasa is a rapidly growing commercial and industrial centre in the whole country after Nairobi. Commercial and industrial sectors are some of the major employers in Mombasa. Commercial activities range from small scale retailing business to export-import business and shipping agencies. It also involves the informal sector activities like the curio shops, kiosks along the streets selling tea and so on. The main commercial district (CBD) lies half way between the Old Town and Kilindini Harbour.

Industrial activities range from the manufacture of simple items like soap and salt to the sophisticated industrial complexes like the oil refinery, dry dock for ship repair and cement manufacture.

The main industrial Districts include the Port area. Within and around the Port are located a number of industries like ship repairing. Shimanzi area on the Island is the Mombasa's main industrial zone. Here are located a variety of industries including engineering works and grain milling.

On the West mainland is Changamwe. Here is located the giant East African oil refinery which produces a variety of oil products like Kerosene, gas and Petrol. On the North Mainland, is located Bamburi industrial belt. Here is located the famous Bamburi Cement Factory.

Tourism forms one of the major industries in Mombasa. Mombasa is the centre of Kenya's coastal tourist industry. The town with its strategic position in relation to the Tsavo, Amboseli and Shimba National Parks, historical monuments of the coast and beautiful beaches attract many foreign tourists.

It is evident from the foregoing account that Mombasa has always been strongly influenced by transportation both culturally and economically. The town began as a port, then as a railway terminal and is today an international air terminal. The local road network too has a big influence on the urban development especially on the mainland areas. The Island nature of the study area presents some transportation problems whose solution would stimulate development not only in Mombasa but in the whole country.

This study is meant to show the importance of road network on the development of Mombasa. The chapters that follow show how road transportation influences the structure of land values, population density and movement within the study area.

CHAPTER 2

METHODOLOGY

This chapter introduces the methods of data collection and analysis applied in this study. A number of techniques are used. The main one is the bivariate linear regression analysis. It is used to investigate the association between time-distance and indicators of urban structure. The indicators of urban structure are land values, population density and trip pattern. Bivariate correlation analysis (zero order and first order) is used to examine the strength and direction of variable relations. Mapping techniques are used to illustrate the spatial patterns of urban characteristics in Mombasa.

1. DATA COLLECTION

Data on time-distance was required to indicate the relative accessibility of the mid-points of the enumeration units within the Mombasa Municipal area. Kenya Bus and the "Matatu" are the two major modes of public transport within the study area. These two different modes have different time-spaces. The time-distance by bus or "matatu" is important to show the relative accessibility of various points within the Municipal area.

Land values, population density and trip patterns were identified as the indicators of the structural characteristics of Mombasa. Land values, population density and trips were all

measured from Mwembe Tayari. Land values were measured in Kenya Shillings per hectare, population density was measured in number of persons per square kilometre while trips were measured as number of personal trips to Mwembe Tayari.

The study area covers the whole of the Mombasa Municipal area shown in Fig. 1. The study area consists of 37 Enumeration Units according to 1979 Population Census.

Some data which would be relevant in this study but, which prove difficult to obtain includes time-distance by bus for earlier periods such as early 1970s and 1960s, land value data for earlier periods as well as population density for early periods. The main reason why some data were difficult to get was the change of enumeration boundaries during census time. For instance, the enumeration units used in 1979 census were slightly different from those of 1962. Further, some data like time-distance by bus for earlier periods was difficult to obtain because records were not available.

A. MEASUREMENT OF ROAD TIME-DISTANCE USING KENYA BUS SERVICE

At the time of research, some data on time-distance by the Kenya Bus (Mombasa) had been gathered by Ferguson and Ngau (1979) and was readily available. However, this data was inadequate for this study. The data that was available was supplemented by more data obtained from the Kenya Bus Company at Mwembe Tayari.

A detailed study was made of the Kenya Bus time-table in order to extract data on time-distance.

Bus time-tables show the scheduled departure and arrival time for buses. This information was supplemented by measuring actual time-distance taken by buses from Mwembe Tayari. Several surveys from Mwembe Tayari to all other destinations for the main bus routes within the Municipal area were made. The purpose of the surveys was to cross check the time taken by buses to travel from Mwembe Tayari to each destination and back again. The cross-checks were done for each route during:

(a) Morning rush hour (7.30 a.m.)

(b) Lunch time " (1.00 p.m.)

(c) Evening " (5.00 p.m.)

(d) Morning non-rush hour (10.00 a.m.)

The average travel time from Mwembe Tayari to each bus station on each route was computed for all the survey periods. It was found out that the calculated time did not vary much with the actual time. So, the time indicated on the bus time-table was reliable.

Since the objective of the study was to show the enumeration units that were nearer or farther from Mwembe Tayari in terms of travel time by bus, time-distance was measured to the bus station nearest to the centre of each enumeration unit. Walking time from the mid point of each enumeration unit to the nearest bus station was added to obtain an estimate of total time-distance from Mwembe Tayari.

B. MEASUREMENT OF ROAD TIME-DISTANCE USING "MATATU"

The travel time by "matatus" was measured from Mwembe Tayari too. Most "matatus" operating within the Municipal area converge at Mwembe Tayari. A systematic sample of 30 "matatus" was obtained and travel time was estimated using questionnaires. The drivers of the sampled "matatus" were interviewed.

The data provided by questionnaires was supplimented with cross checks carried out by travelling by "matatus" from Mwembe Tayari to their destinations and back. This was important because the "matatu" drivers would drive faster or even give wrong information.

The "matatus" use the Kenya Bus routes (Fig. 6). So, travel time by "matatus" was measured along the bus routes. As with the Kenya Bus, travelling time from the nearest "matatu" stop to the mid-point of each enumeration unit was added to estimate the total time taken by "matatu" from Mwembe Tayari.

To estimate the travel time by both bus and "matatu" from Mwembe Tayari to any destination on the South Mainland, 20 minutes were added on the actual travel time. This is because 20 minutes are spent at the ferry at Likoni. The ferry is slow.

C. MEASUREMENT OF LAND VALUES

It was difficult to get data on land values. At the time of carrying out research, the land valuation roll prepared by the Mombasa Municipal Council was being updated and was not available

for study. The latest valuation roll available was for 1959 and the data contained in this roll was considered grossly out of date.

An alternative source was the Municipal Council rates which are updated annually. However, this data is highly confidential and would not be made available.

Land sales proved to be the only accessible source of land value data. Land sales do not occur everywhere all the time. Most land sales occur on the mainland areas where there is still a lot of undeveloped land.

A lot of care is needed when dealing with land sales. Sometimes, the various private land valuers and estate agents provide wrong data on land sale prices. It is not uncommon for private land agents to underestimate sale prices in order to avoid stamp duty. To avoid this problem, data were obtained from the Lands Office, in the Provincial Headquarters for the Coast Province in Mombasa.

All plots of land sold within the study area are reported to the Provincial land office. If the Provincial land office is dissatisfied with the reported value of the land, it sends its own qualified Valuers to the site to make a re-evaluation. So the land sale prices recorded in the Provincial land office are actually land values for whatever plots are sold throughout the study area and these figures were made available for this study.

A complete survey of the Provincial land registers was carried out. For each enumeration unit 5 systematically sampled land sales were obtained. It was decided to obtain 5 samples for each unit because the total sample size would be large enough for study. In

a normally distributed data, a sample size of 30 is adequate. The total sample size in the study was 185 land sales.

Some of the 37 Enumeration Units studied, did not have any land sales recorded. This was so for remote districts like Mwakirunge on the north Mainland and Shika Adabu on the south Mainland. The Enumeration Units whose land sales were not recorded were omitted from the study.

Using the data obtained from the land registers the land values were standardized by converting them to land values per hectare. The land values were then arranged in a rank order and the median value was obtained.

D. MEASUREMENT OF POPULATION DENSITY

So, in this study, population data were essential. A variety of data was required in order to comprehend the demographic characteristics of Mombasa. The main data gathered included age-sex data, number of households, population figures for each enumeration unit and population density data.

Age-sex data showed the relative ages of people as well as their sex. Age structure shows whether Mombasa's urban population is dominated by young people such as those below 20 years or by old people above 65 years.

Data on number of households was necessary because it shows the geographical distribution of population. Some enumeration units have more households per unit area than others and therefore have a higher population density.

E. MEASUREMENT OF TRIP PATTERNS

The data on the number of personal trips to the CBD, trip purpose and the mode of travel were obtained by means of Questionaires in the CBD. The CBD was chosen for a sample survey for several reasons:

(a) Visiting all the 37 enumeration units would have been more costly in terms of time and money. Some of the enumeration units are very far from the city centre.

(b) The CBD is located on the Island and is the centre of commerce, education, health services and so on.

(c) Travel time by bus was measured from the town centre. Since the study sought to relate time-distance and the number of trips to the city centre, interviews were carried out in the CBD.

196 people in all were interviewed. This sample size was adequate. In a normally distributed data, a sample size of 30 is considered as adequate.

A systematic sampling techinique was adopted. The author with one asistant moved about in the CBD each interviewing one person at 15 minutes interval. Pedestrians on the major urban streets are usually busy and impatient. As anticipated, some people were unwilling to respond to the questionnaires. They were sometimes in a hurry to catch a bus or to arrive at work and did not want to be detained by the interviewers. Some respondents were willing to answer questions while at the place of work. Those who made such an offer were followed to their working place where they willingly responded to the questionnaires.

2. DATA ANALYSIS AND PRESENTATION

The main analytical model used is the linear regression function. It was anticipated that linear model would be of the form:

$$Y = a + bX + e$$

Where

Y: dependent variable (land value, trips, density)

a: intercept

b: slope

X: independent variable (time-distance)

e: error term

It was assumed that a linear relationship exists between time-distance by bus or "matatu" from Mwembe Tayari to all other parts of Mombasa and the 3 indicators of urban structure, namely, land values, density and trips.

However, when the raw data was gathered and analysed using a scatter-gram, it was found out that a linear relationship did not exist. Instead, it was observed that a curvilinear relationship was obtained.

In order to apply the regression model the raw data had to be normalized by means of logarithmic transformation. This transformation produced a linear function showing that the original function was negative exponential. The function is:

$$\ln y = \ln a - bX$$

where

lny: natural log of y

lna: " " of a

b: Slope

X: time distance

This function shows a distance-decay function. So this model was used to test whether land values, population density and trips delcine from the city centre.

To show whether the relationship between travel time and land values, population density and the number of trips was strong or weak, positive or negative, a Pearson correlation (Zero-order) coefficient was used. The zero-order correlation coefficient was obtained using the formula(1):

$$r = \frac{\sum(X-\bar{X})\,(Y-\bar{Y})}{\sqrt{[\sum(X-\bar{X})^2][\sum(Y-\bar{Y})^2]}}$$

Travel time by the Kenya Bus and "Matatu" are highly interrelated. It is not possible to apply multiple correlation analysis in estimating the variance explained by the independent variables taken together. So partial correlation was used instead. A first-order partial correlation was used having the following expression (2):

$$r_{ij.k} = \frac{r_{ij} - (r_{ik})\,(r_{jk})}{\sqrt{1 - r_{ik}^2}\ \sqrt{1 - r_{jk}^2}}$$

where:

$r_{ij.k}$ = partial correlation coefficient between dependent variable and time-distance by bus controlling for the "Matatu" time.

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1. Blalock, Social Statistics, 1972, p. 378.
2. Ibid., p. 437.

APPRAISAL OF RESEARCH METHODOLOGY

A number of data gathering and analytical techniques were used in this study. Each technique used had its own advantages and disadvantages. The advantages and disadvantages are reviewed in this section. The study area covers the whole of the Mombasa Municipal area shown in Fig. 1. The study area consists of 37 Enumeration Units according to 1979 Population Census.

Some data which would be relevant in this study but, which proved difficult to obtain includes time-distance by bus for earlier periods such as early 1970s and 1960s, land value data for earlier periods as well as population density for early periods. The main reason why some data were difficult to get was the change of enumeration boundaries during census time. For instance, the enumeration units used in 1979 census were slightly different from those of 1962. Further, some data like time-distance by bus for earlier periods was difficult to obtain because records were not available.

3. (A) DATA COLLECTION TECHNIQUES

(i) TIME-DISTANCE ANALYSIS

In time-distance convergence studies, distance is measured in terms of travel time. Today, geographers are primarily concerned with relative locations of phenomena (Oloo, 1980). People who travel are not as much concerned with the absolute distance as they are with cost and time. People make decisions in terms of time or cost. Travel time is more relevant than physical distance because it is a measure of transport efficiency and traffic congestion.

The first order correlation coefficient shows the proportion of variance explained by a given independent variable controlling for the other independent variable.

A number of mapping techniques are used to illustrate the spatial distribution of urban characteristics. These include isochrone maps, population density and origin-destination maps together with the residual maps. An isocrhone map is one in which lines join places of equal travel time.

Regression residuals are obtained using the regression line and mapped in order to know which areas are more accessible.

The techniques used in the analysis are suitable but they have their own limitations. For instance, the linear regression model does not work with data that is not normally distributed.

Time distance by bus or "matatu" was measured from one point (CBD) instead of from several points in Mombasa such as the New Nyali Bridge, the Kilindini Harbour and so on.

The linear regression function does not account for much of the variance. In other words, its explanation power is lower than the multiple correlation and regression analysis.

Travel time is more useful than network indices like the associated number or road density.

Travel time by bus and "matatu" was measured from one central point, that is, Mwembe Tayari. This made it easy to measure travel time from the mid-points of all the 37 enumeration units to the city centre.

However, measurement of travel time from one central point is itself not adequate because other areas may also be important. Measurement of travel time by bus or "matatu" from the New Kilindini Harbour, the Old Port or the New Nyali Bridge might have provided sufficient data that would show the impact of transport improvement on urban structure in Mombasa. Since no measurement of travel time was made from the Old Port, the New Kilindini Harbour and the New Nyali bridge, it was not possible to compare land value gradient, density function and travel patterns from these areas. This was therefore a big limitation of measuring time distance from only one point in the study area. A multi-variate statistical analysis approach could possibly have been ideal were time available.

3 .(A) (ii) LAND VALUES

Land values were estimated from the land sales reported to the Coast Provincial Land Valuation Office in Mombasa. This was necessary because private land valuers often underestimate the sale price of a piece of land to avoid stamp duty. But, land sales recorded in the Provincial Land Office are fairly accurate since they are checked and confirmed by professional land valuers.

Generally, it can be said that land values just served to show that the valuers were conscious of the pattern of demand for land and its price with respect to distance. An unimproved

site value roll is prepared after a thorough research in land sales and the resulting document (Valuation Rol) is the resultant generalization from this research. In some instances, where the research is in-accurate the valuation Roll may be affected, but, if unchallenged in court according to the Valuation for Rating Act (Cap. 266), the generalization becomes legal.

Inspection of the valuation roll and land values served to confirm the existence of a distance function that has been proved elsewhere using correlation analysis. This generalization seems consistent with other findings of this study.

3.(A) (iii) POPULATION DENSITY

Population density data was readily available from the Kenya Population Census of 1979. However, census data at times, may be inaccurate. This depends on the methods used in the enumeration of the residents. Besides, the enumeration units used in 1979 were slightly different from those of 1962 or even earlier. So, comparison of population density structure over time was not possible.

The population figures were incomplete in that they did not show the total working population, place of work, and level of income and so on which would be vital data for estimating the demographic characteristics of the population of Mombasa.

3. (A) (iv) TRIP PATTERNS

Interviews were held in the CBD to estimate the travel characteristics of individuals within Mombasa. This method had the advantage of reducing time and cost that would be incurred if

housing surveys were conducted. Mombasa covers a large area and to conduct household surveys would incur considerable time and cost.

The main limitation of the method was the poor response of the samples Many respondents interviewed gave incorrect information, some appeared hostile and unco-operative, while others were in hurry to arrive at work early.

3. B. DATA ANALYSIS AND PRESENTATION

In this study, only one independent variable was considered. This variable, is travel time by bus although "matatu" time was also included. To establish the relationship existing between the independent variable and land values, population density and the number of trips (dependent variables), a simple regression analysis was used. One independent variable has its own limitations because it omits other equally important variables. Future studies may adopt a multivariate statistical analysis such as the factor Analysis or Multiple Regression Analysis in order to measure accurately the effect of other factors not examined in this study on the dependent variables. But, multi-variate statistical Analysis has its own dangers since variables may be highly intercorrelated but the dependence would be hidden. The problem of hidden dependence is great in Factor Analysis.

This study is concerned with the analysis of the relationship between urban transportation and urban structure. Time-distance is regarded as the main factor whose influence on land values, population density and number of trips is measured. Other factors which are important are revealed by the mapping of residuals.

One of the main difficulties encountered by geographers is that of assessing the influence of each of a number of factors in a particular situation. Partial correlation deals with 3 variables in which the correlation coefficient of two of them can be tested unaffected by the influence of the third which is controlled.

Since bus time and "matatu" time were highly intercorrelated it was not possible to use multiple regression analysis. Instead, partial correlation analysis was used through out to compare the relative importance of each mode.

In this study, accessibility is measured by means of travel time from one central point in Mombasa. The method used here, is the one Janelle used (1969). But, accessibility can be measured in two other ways:

(i) Population Potential:

Accessibility may be measured using population potential (Hansen, 1959; Macleod and Vincent, 1974). When accessibility is measured this way, it is defined as the potential of opportunities for interaction. This measures the intensity of interaction instead of ease of interaction (Hansen, 1959, p.73).

Population potential is a useful descriptive tool or model which shows the pattern of population distribution in an area. It also shows market potential of an area and can be used in determining industrial location. It is recommended that a future study should be carried out to related population potential in Mombasa with land values and population density. This would show the main factors influencing population density and land values in Mombasa.

(ii) Accessibility may also be stated or measured in graph theoretic terms (Vincent and Macleod, 1974). In graph theoretic terms, accessibility can be defined as the sum of the shortest number o edges connecting vertex with every other vertex in the network.

$$X_i = \sum_{j=1}^{n} d_{ij}$$

X: topologic accessibility

dij: topological distance from vertex i to all other vertices in the network.

A transportation network may be defined in the language of graph theory as a set of nodes (N) or geographic locations interconnected by a number of edges (E) or routes along which flows take place (Vincent and Mcleod, 1974, p.45).

CHAPTER 3

THE ROAD NET WORK IN MOMBASA MUNICIPAL AREA

A (1) THE SPATIAL STRUCTURE OF THE ROAD NET WORK

The main road transport route in Kenya starts from Mombasa as it is the principal Sea Port in the country. All goods coming to Kenya by sea are cleared here and transported to up-country destinations mainly by road. Some goods are carried by rail but a great deal of cargo moves from Mombasa to Nairobi and other destinations by road because of the time-saved. The average time taken by the passenger train to travel between Mombasa and Nairobi is about 13 hours. However, buses take about 7 - 8 hours to cover the same distance. Thus, road transportation is attractive both to passenger and for goods shipments due to the relatively short travel time involved.

Over the years, the amount of cargo handled by train, has been declining due to the stiff competition from road transportation. In 1974, the railway handled 33% of the total exports and imports to and from the port. In 1976, this declined to about 30% while the figure fell to only 28% of the cargo in 1977. Thus, the figures have been decreasing and today (1981), the Kenya Railways manage only 25% of the total cargo handled at the Kilindini Port (Mombasa District Development Plan, 1979-1983 p.71).

Apart from transporting goods to other parts of the country, road transportation is very important within Mombasa.

Mombasa being a rapidly growing port, a commercial as well as a tourist centre, has a big network of roads. The main roads within Mombasa are classified as:

(a) main trunk roads

(b) adopted roads

(c) unadopted roads

(a) Main Trunk Roads

These are the major roads in the town owned by the Ministry of Transport and Communications but, are maintained on the behalf of the Ministry by the Mombasa Municipal Council. These Trunk roads include Class A, B and C roads according to the Ministry of Transport and Communications. The Class A roads are International and link Mombasa with urban centres inside and outside Kenya. Class A roads of this type in Mombasa Jomo Kenyatta Avenue - Nairobi Road and Nyerere Avenue - Lunga Lunga Road.
Jomo Kenyatta Avenue - Nairobi Road links Mombasa with Nairobi, the capital city of Kenya and extends to Uganda, Eastern Zaire, Southern Sudan, Rwanda and Burundi.

Clas B roads link Mombasa, the Regional service centre of the Coast Province with the main coastal towns particularly District Headquarters. An example of such a road is Abdel Nasser - Malindi Road. This is a National Trunk Road linking Mombasa with the North Coast towns of Lamu and Malindi.

Class C Roads from the main local trunk road system within Mombasa. An example of such a road is Moi Avenue which serves the Kilindini Port. It is one of the busiest roads in Mombasa.

(b) Adopted Roads

These are mainly secondary roads owned and maintained by the Municipal Council and are too numerous to list.

(c) Unadopted Roads

These are private access roads which are maintained by the individuals and companies. But, they could be maintained by the Municipal Council if the owners apply for such a service. Feeder roads linking Mombasa town with the remote parts of the District are also included in this category. Unadopted roads are numerous although they are of less importance to the general public.

While there is an extensive network of roads in Mombasa the network density is concentrated near to the Mombasa Island - West mainland axis. Large parts of both the North and South mainland have few motorable tracks. As a result, this situation has led to unbalanced development in Mombasa (Ref. Table 2).

Table 2: Road Characteristics, Mombasa

Location	Length of Network (Kms)	Length Paved (Kms)	% of Total
Island	32.3	32.3	100
West Mainland	37.9	31.9	84
North Mainland	27.0	25.0	93
South Mainland	15.2	10.6	70

Source: Norconsult, 1973, Table 3.1, Vol. 2 p 9.

The road network map, Figure 5 and Table 2 show that the Island has a well developed road network. All roads on the Island are paved including those of the Old Town. The road density is quite high on the Island compared with other areas in the Municipal area. Table 3 gives the road densities in the study area. The Island

has more than 4 times the average road density in the Municipality.

Table 3: Road Densities in Mombasa

AREA	ROAD DENSITY (Rd Km/Km^2)
North Mainland	0.26
South Mainland	0.34
West Mainland	0.76
Island	2.29
Municipality	0.53

Road density is one of the development indicators devised by Berry (David Smith, 1977, p211). This shows that the Island is the most developed area in Mombasa. Road density is high on the Island because of the concentration of activities. The CBD is located on the Island and depends on good accessibility provided by the roads converging there. Commercial activities like retailing need a good accessibility in order to attract customers.

Kilindini Port has a well developed road network. The Port needs access roads for transporting goods and workers to and from the Port.

The industrial area at Shimanzi needs a good road network in order to function efficiently. This is the biggest industrial belt on the Island. Grain milling, brewing, ware housing and packaging industries are located here.

The high class residential areas of Tudor and Kizingo on the Island, are well served by road network. People living in these areas are expected to own cars.

The only place on the Island with a poor road network is the Old Town. These streets are very narrow and winding allowing only one vehicle to pass at a time. Some of these roads were built during the pre-motor car periods. The streets were not meant for the motor car but for walking and for "Hamali" carts (Hand Carts, Plate

The west mainland too has a good road network. The road density is 0.76 which is the second highest in the study area (Table 3). This region is linked to the Island by the Makupa and Kipevu causeways (Fig. 1). The Mombasa-Nairobi International Trunk Road passes through this area. This is a high speed road. Initially, this road passed through the densely populated Changamwe Housing Estate. But, this was dangerous to the public by causing road accidents. So a perimeter road was built to by-pass the Housing Estate (Fig. 5).

The west mainland is a rapidly growing industrial region. So, it needs a good road network to facilitate the quick and efficient movement of raw materials and finished products to and from the industrial area. The road network is also important to for transport workers to and from the place of work.

Nyali High class residential area on the North Mainland has a good road network. This area is occupied by the rich people who possess cars. The rest of the mainland is poorly served by roads. The New Mombasa-Malindi Road is a modern tarmac and high speed road linking Mombasa with the North coast. North coast is an important tourist region and this road was built mainly to promote this valuable industry. North coast is also an important agricultural region producing cotton, sugar cane, sisal as well as

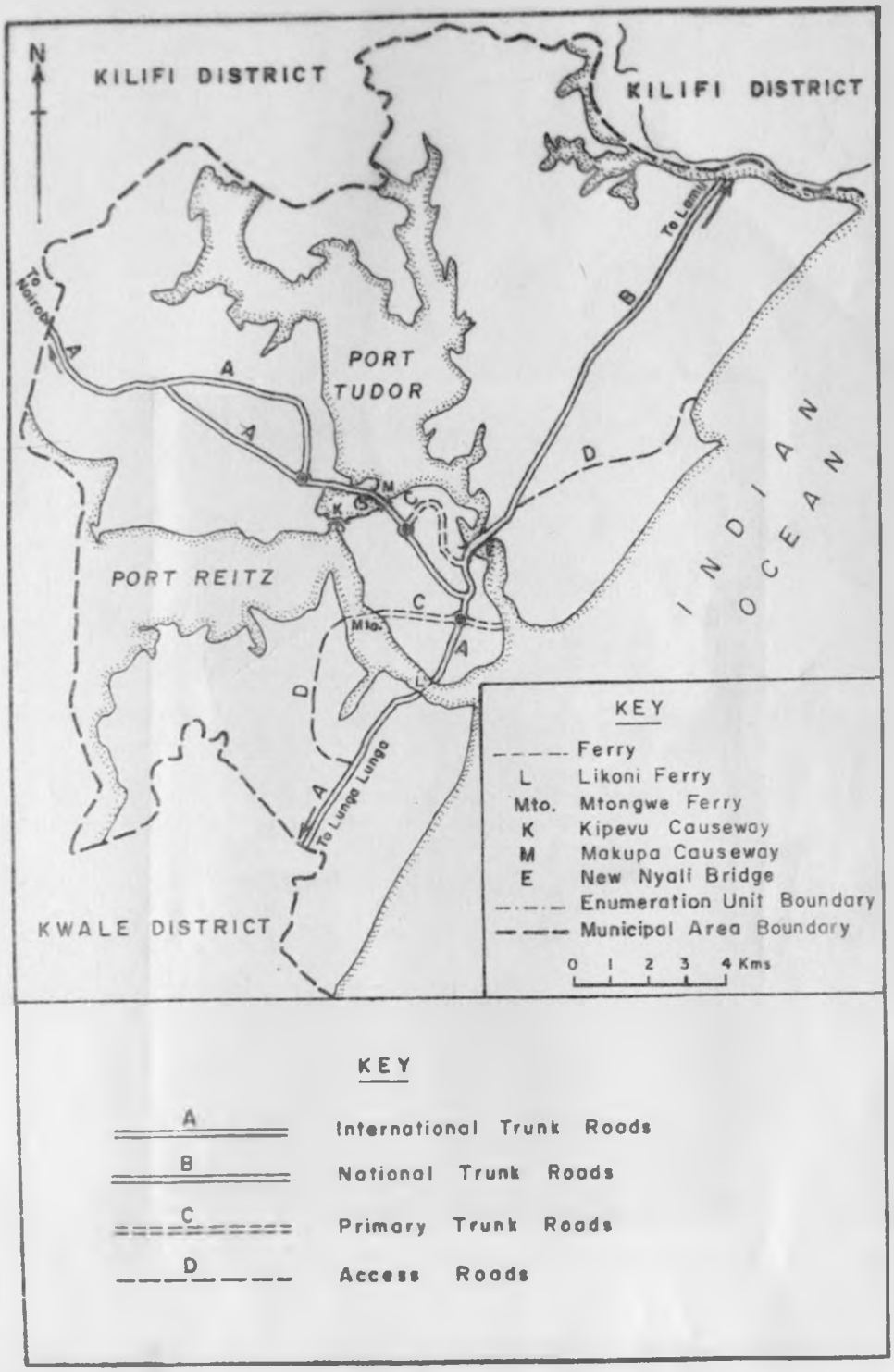


FIG. 5 MAIN ROADS IN MOMBASA

Plate 1: A typical narrow winding street of Old Town, Mombasa.

fruits. These products need a good road network to reach Mombasa which is the coast regional market centre.

The north mainland of the Mombasa Municipal area is a very important tourist centre as well as a rich agricultural area. The tourist and agricultural potential of this region can be fully exploited if a good road network exists. At the moment, this area has a very poor road network except Nyali Estate. The beaches such as the Kenyatta Beach, are poorly served by road (Plate 2). The roads serving the beaches are mainly earth roads. These need an improvement in order to enable the local people as well as the tourists to visit the beaches and the beach hotels.

The Maunguja and the Mwakirunge areas (Fig. 1) are rich agricultural regions. But, the major development constraint is lack of good road network. The Nguu Tatu - Mwakirunge Road which is just a motorable tract requires immediate attention as people living in this part of Mombasa are completely cut-off from development and from the physical contact with the Mombasa Industrial and commercial centres. The people here have the best agricultural land in the whole study area with a high potential for dairy and crop production.

For about half a century, the only link between the north mainland and the Island has been an Old Pontoon Bridge which was built by a private company known as the Nyali Estates Company. This bridge had become a bottle neck to the traffic due to congestion and traffic delays. Hence, it became necessary to build a new and a wider bridge to ease the congestion on the old bridge. The new bridge known as the New Nyali Bridge, is an Ultra-modern Multi-

Plate 2: A typical Beach access road in Mombasa.

million shilling bridge. It cost about K£ 12 million to build together with the access roads to the bridge. The bridge reaches 20 metres from the high water level in the Tudor creek (Ref. Fig. 1) and is about 150 metres long. It is the longest concrete bridge in Africa. The bridge carries a six-lane high way with the bicycle lanes and side-walks for the cyclists and pedestrians. This makes the new bridge much safer to cross than the older one. The bridge was a joint Japanese-Kenyan project.

The new bridge was opened for traffic on August 25th, 1980 by President Moi. The construction of the new bridge has reduced traffic congestion and saved travel time considerably between Mombasa and the north coast. This is a big investment which has to pay its way. Motorists expected the New Nyali bridge to be toll free but, like the old Nyali bridge, this too is toll bridge. The toll charges provide revenue to the government which will enable the project to pay its cost of construction.

The New Nyali Bridge is of great importance in the road communications not only within Mombasa and its immediate coastal hinterland but has a major role to play in Kenya's network of trunk roads. For a long time, Mombasa was confined to the Island. But, due to its modern port facilities, rapid population growth and urban sprawl, it has become vital to handle good road communications with the rest of Kenya.

It was anticipated that the two bridges, the old and the New Nyali Bridges, would operate simultaneously. However, with the opening of the new bridge, a lot of traffic was diverted from the old bridge to the new one. This diversion of the traffic

meant a considerable loss of income too. It became doubtful whether the income earned from operating the old Nyali Bridge would cover the maintenance costs.

Despite the loss of income due to the traffic diversion to the New bridge, the old Nyali Bridge had many advantages to the cyclists, motorists and pedestrians. The closure of the old Nyali Bridge, brought hardships to the residents of Kongowea, Mkomani and the whole of Nyali Estate on the North mainland. To these people, the New Nyali bridge has lengthened the journey to work. The old bridge was convenient to them because it saved travel time between the Island and their places of residence.

For instance people working at the Coast General Hospital or its vicinity and who formerly used to go to work on foot or on bicycles across the old Nyali bridge now have to go all the way to the New bridge. This has meant a longer and more expensive journey.

The south mainland is the area with the poorest road network in Mombasa. The Likoni vehicular and the Mtongwe pedestrian ferry services provide the main access to the south mainland. Crossing the Likoni ferry with vehicles is very expensive because of the toll charges. At the same time, crossing the ferry is also time-consuming (Plate 3). There is no permanent link between the south mainland and the Island. As a result, people have not been keen to settle in the south mainland. This area is sparsely populated. Private as well as public developers have been reluctant to invest in the south mainland. This has severely hindered residential, commercial, industrial and tourist development in the south mainland (De Blij, 1968, Morgan, 1973).

Plate 3: Vehicles waiting for the arrival of the ferry at Likoni, Mombasa.

A (2) FACTORS INFLUENCING EVOLUTION OF ROAD NETWORK IN MOMBASA

An examination of the spatial structure of the road network in Mombasa shows that the Island has the best road network while the south mainland has the poorest (Table 4).

Table 4: Accessibility of Public Transport in Mombasa

District	% of Population within ½ Km	% of Population within 1 Km
Island	93	99.9
North Mainland	76.8	91.8
West Mainland	71.8	88.3
South Mainland	35.8	63.1

Source: Norconsult, A.S., et al., Table 3.11, Vol. 2, p.23

It is evident from the statistics that virtually all of the Island's population has access to public transport. Accessibility decreases as one moves away from the Town centre. Most of the south mainland is inaccessible, only a very small proportion of the people are within ½ Km of a bus route.

The spatial pattern of the road network in Mombasa may be explained by a number of factors. They are:

(a) Topography

This is one of the major influences of road network in Mombasa. The Island nature of the town has made it difficult to

have a uniformly distributed network. Instead,the Island being the heart of the town has a well evolved network. The two deep sea inlets, Port Tudor and Port Reitz have played and will continue to play an important role in influencing road network in Mombasa. These sea inlets are crossed by high and long bridges such as the New Nyali Bridge as well as cause ways like the Makupa Causeway and ferries such as the Likoni Ferry. If Mombasa were an isotropic plain, there would be no need of bridges, causeways and ferries.

(b) Soils

The type of soil plays an important role in influencing road network because of the drainage. Another reason why the Island has a good road network is because most of it consists of coral soils which are well drained and permit road construction. Areas with poor sandy soils like Changamwe, have a poor road network.

(c) Social Factors

Topography and soils are the main physical factors influencing the spatial structure of road network in Mombasa. But, these are not the only factors. Social factors such as educational and health facilities are equally important. Most places in Mombasa lack such essential social facilities with the exception of the Island. Access should be available before a school or hospital is built in an area.

(d) Economic Factors

The main economic factors are:

i) Land ownership

ii) Lack of capital

iii) Land uses

Land ownership is a big problem facing road development in Mombasa. If the Municipal Council of Mombasa wants to build a road across a certain area consent must be obtained from the owners of the land. But, some land owners are absentee land lords who may not be available for negotiations.

Lack of funds is another major economic problem influencing road network. The Municipal Council of Mombasa faces an acute problem of shortage of funds to finance its various development projects including road construction and maintenance.

The type of land use also plays an important part in road network evolution. The Island has a good road network because of the concentration of land uses like the Port, the industrial area, residence and the CBD. All these different land uses need good road linkages.

Squatter or unplanned settlements too affect road network. Once a squatter settlement has been put up in an area like Kongowea in the North Mainland or Chaani, in the west mainland, it cannot easily be demolished because that is destroying people's property. Roads that would be built in those areas are built elsewhere.

(e) Historical Factors

Mombasa is an ancient city and some of its roads were built long before the era of motorized transportation. This applies to the Old Town where a different road pattern exists. Here are found very narrow streets, popularly referred to as "Kitotos" by the local residents due to their narrowness. The streets are

so narrow that only one car can pass at a time and no vehicles of more than 3 tons weight are allowed there. The Old Town streets are too narrow for lorries to pass through. In the rest of the town, an Iron-Grid road pattern typical of the Western cities is found. This is due to the fact that roads in these areas were planned in the Western style. Planning of such roads began as early as 1926 when the first comprehensive Development Plan was made for Mombasa.

Although the present road network is adequate to cope with the present traffic volume, certain areas are already strained. At the moment, there is a lot of traffic congestion in the CBD streets due to the fact that traffic here exceeds planned road capacity. There is also the problem of mixed traffic and lack of parking space(Plate 6). The CBD streets today are used by all kinds of traffic such as cars, buses, bicycles and hand carts. Traffic congestion, mixed traffic and lack of parking have increased journey time within the CBD due to reduced traffic speeds. For instance, the Kenya Bus Services have reduced their scheduled speeds from 24 Kph in the CBD to 18 Kph due to increased traffic (Norconsult, 1973, 60).

Traffic congestion is great on Digo Road, Jomo Kenyatta Avenue, Nkurumah Road, Moi Avenue and the Old Town streets. Another serious problem arising from the existing road network is uneven development in Mombasa.

In order to solve some of these problems, a transportation study was carried out by the Norconsult Consultant Engineers in 1972-74. The study was undertaken on the request of the Kenya

Government.

The study was aimed at developing a road network that would cope with the traffic demand up to the year 1996. The main recommendations of the study have been reviewed in the Literature Review in Chapter 1. The main concern here is to examine how the future road network recommendations of Norconsult Company would affect Mombasa's future road network. The recommendations more likely to affect future Mombasa's road network are the long term ones which involve the construction of bridges, causeways and the main roads.

The pattern of land uses must to a large extent dictate the system of highways rather than the opposite. As early as 1971, it was realized by the Municipal Council authorities and Planners that the future Port extensions would be the major determinant of the direction and form of Mombasa's growth.

> "If the Port expands on the west mainland, this will result in a linear form of development with all major growth occurring along the main Island - Changamwe axis - - - and with the north and south mainland areas as mainly residential/recreational suburbs. If ... Port expansion were to take place on the south mainland, then the overall form of development would be triangulated. Major growth would be directed to the south and major urban centres would develop on the south mainland" (Draft Physical Development Plan, 1971).

The Port is the single most important land use in Mombasa and the location of additional harbour facilities as the port expands

will have a major effect on transportation requirements both from the stand point of traffic generated by the Port itself and from the influence the Port will have on the location of industrial, commercial and other land uses.

The Norconsult study recognizing the importance of the Kilindini Port on the development of Mombasa provided two alternative development strategies.

(a) The strategy of concentration, and

(b) The strategy of decentralization.

According to the strategy of concentration, growth is assumed to be concentrated along the Island - West mainland axis. The concentration of employment will tend to result in a concentration of population within easy reach of work opportunities including the Island where population growth should be restricted.

The plan for decentralization assumes a greater balance between population and employment both between the Island and each of the mainland. The Port expansion is assumed to be concentrated in the south mainland. Since employment is not concentrated on East-west axis, residential population will be less on the Island.

The present study recommends the strategy of decentralization. If the present traffic congestion and overcrowding due to population growth have to be reduced on the Island and the West mainland, then the strategy of decentralization should be adopted.

The foregoing account has been an attempt to describe as well as to explain the existing local road network in Mombasa.

From the account, it is clear that the local road network is a very important determinant of urban development. The local road network plays an important role in influencing the spatial distribution of population as well as land uses.

B. PUBLIC TRANSPORTATION IN MOMBASA

In 1969, Kenya's urban population was about 1 million and the number rose to about 2 million by 1979. This rapid population growth in Kenya's urban areas is mainly due to both natural increase and rural-urban migration. This rapid population growth in urban areas has increased demand for both public and private transportation resulting in heavy concentration of vehicles in major urban centres such as Nairobi and Mombasa.

There are different transportation modes within the Kenyan urban areas. The main transport modes include public transport, private transport, pedal cycling and walking. The general trend in the bigger urban centres like Nairobi, Mombasa and Kisumu was established in 1970 by the Nairobi Urban study group and later confirmed by the Norconsult Mombasa Transportation Study (1972-74).

Public transportation to and from the rural hinterlands to the urban areas became very important after independence when the restrictions on population movements were uplifted. This led to heavy population movements particularly to the primate cities like Nairobi and Mombasa in search of better opportunities such as better and higher education and employment in both formal and

informal sectors.

In response to the high transportation demand the number of public transit vehicles such as the buses and "matatus" rose considerably. For instance, in Mombasa, the number of Kenya Buses doubled from 41 in 1965 to 82 in 1975. During the same period, Mombasa's population grew from about 200,000 (204,895) to about 300,000 (295,676). This shows that other things being equal, like family incomes and so on, the demand for the buses was rising. The estimated population of Mombasa and the number of buses is shown on Table 5.

Table 5: Population Size and Number of Buses in Mombasa, 1965 - 1975.

Year	Population[1]	Buses (KBS)[2]
1965	204,895	41
1966	214,525	42
1967	224,608	44
1968	235,165	46
1969	242,073	47
1970	250,279	55
1971	258,763	62
1972	267,535	71
1973	276,604	77
1974	285,981	79
1975	295,676	82

Source:

1. Computed from Kenya Population Census, 1962, 1969 and 1979
2. Kenya Bus Company, Mombasa.

Until 1973, the Kenya Bus, Mombasa Limited had been the monopolistic supplier of public transit facilities in Mombasa. The Kenya Bus Services was started in Mombasa in 1936 with 4 buses. Today, the company runs a fleet of about 86 buses operating 9 routes (Fig. 6). Eight routes penetrate the city centre linking it with the outlying areas of the Island and the north and the west mainlands. The ninth route operates only in the south mainland connecting with the ferry at Likoni.

About 90% of Mombasa's population lives within 1 Km of a Kenya Bus service route. The buses are relatively new. The company has introduced modern and fast buses known as Guy Victory Mk II model. These buses are quite fast and comfortable. Their fast speeds help in reducing travel time between one destination and another.

The Kenya Bus Service is a private company owned by (1995- TLC) United Transport Overseas Company with 51% of the shares. 49% of the shares are owned by the Mombasa Municipal Council.

The Kenya Bus Service runs the ferry Services at Likoni and Mtongwe. In 1965, the Kenya Bus Company owned two motorized all steel ferries with a carrying capacity of 800 persons and 34 vehicles. In 1975, the company possessed 4 motorized all steel ferries with a carrying capacity of 3300 people and 111 vehicles. Thus, the carrying capacity of the ferries has increased four fold in recent years.

In the same time period, the average number of pedestrians and cyclists using both Likoni and Mtongwe ferries has increased

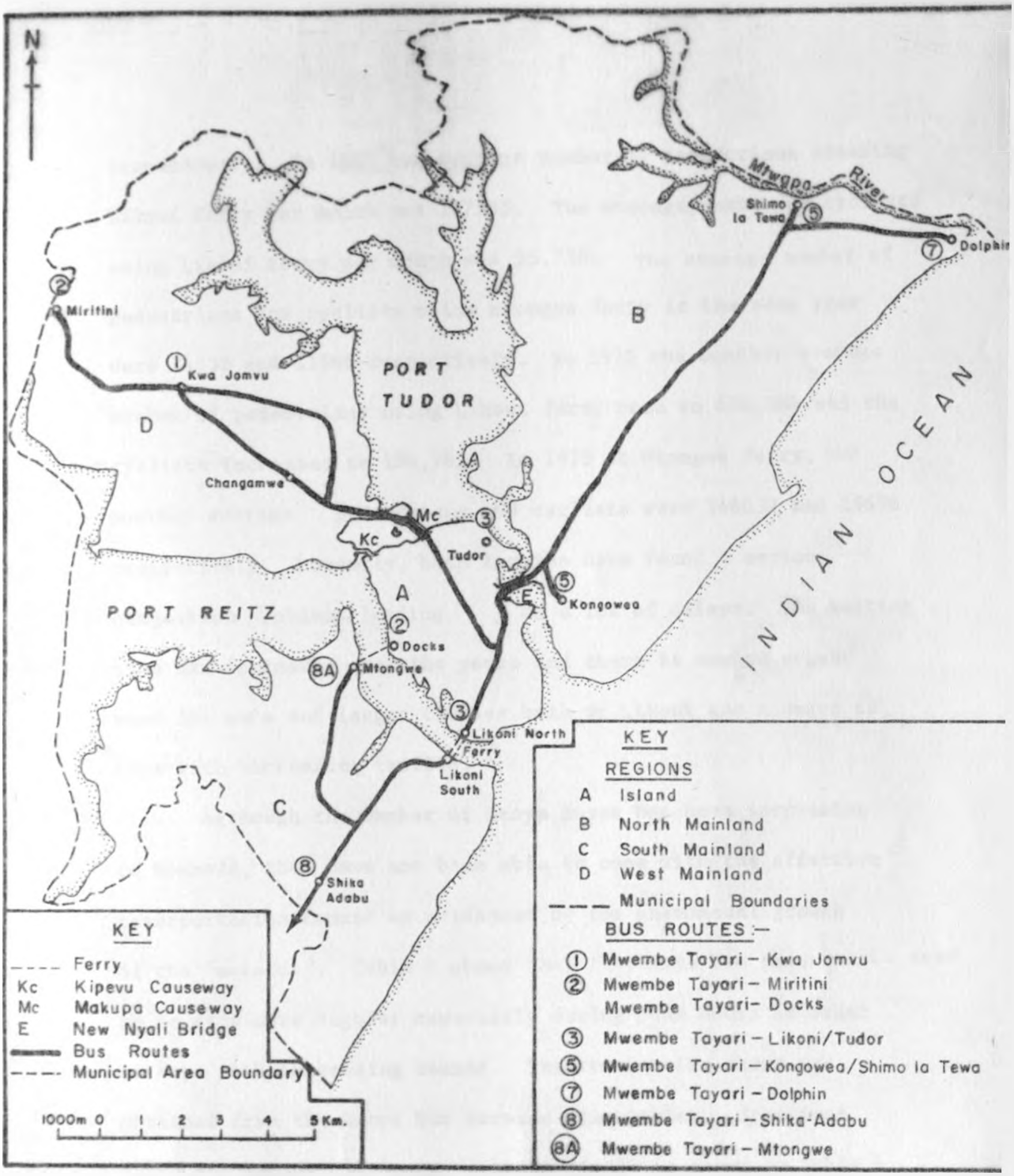


FIG. 6 KENYA BUS (MOMBASA) SERVICE ROUTES

tremendously. In 1965 the average number of pedestrians crossing Likoni ferry per month was 177505. The average number of cyclists using Likoni ferry per month was 55,738. The average number of pedestrians and cyclists using Mtongwe ferry in the same year were 74638 and 11946 respectively. In 1975 the monthly average number of pedestrians using Likoni ferry rose to 676,384 and the cyclists increased to 104,765. In 1975 at Mtongwe ferry, the monthly average pedestrians and cyclists were 346632 and 19696 respectively. Recently, both ferries have faced serious congestion problems leading to a lot of delays. The waiting time has increased over the years and there is now an urgent need for more and larger ferries both at Likoni and Mtongwe to cope with increasing traffic.

Although the number of Kenya Buses has been increasing in Mombasa, they have not been able to cope with the effective transportation demand as evidenced by the phenomenal growth of the "matatus". Table 6 shows that the Kenya Bus frequencies need to be made more regular especially during peak hours in order to cope with increasing demand. The frequencies shown are obtained from the Kenya Bus Service Time-tables. Sometimes there are delays and longer waiting time. As shown on Table 6 some routes have higher frequencies than others depending on demand.

Table 6: Bus Headway in Mombasa

Bus Route	Termini	Route Length (Kms)	Time-distance (minutes)	Frequency (Minutes)	No. of Buses (One way)
1	Likoni Ferry to Kwa Jomvu	14	30	30	28
2	Docks-Miritini	16	45	30	32
3	Likoni Ferry-Tudor	6.3	20	10	101
5	Mwembe Tayari-Shimo La Tewa (Old Road)	16.9	48	30	30
7	Mwembe Tayari-Dolphin	17.6	55	55	18
8	Likoni South-Denyenye	8.0	23	50	19
8A	Likoni South-Mtongwe	5.9	18	40	22

From the table, it can be observed that along some routes, bus frequencies are very low. People along those routes wait for a long time before getting a bus. Routes 7 and 8 have very long waiting times with a bus scheduled to arrive after every 50-55 minutes.

Apart from the Likoni ferry and the "matatus", Kenya Bus Services are very important in providing access to the South mainland which is cut-off from the city centre by lack of a permanent crossing at Likoni.

It appears from the table, that the Island particularly the city centre is well served by buses. The route with the highest bus frequency is the Likoni Ferry - Tudor route on the Island. The

scheduled but time is 20 minutes and a bus appears in every 10 minutes. In one day, 101 buses travel either way on the Likomi Ferry - Tudor route. Virtually all routes pass through Mvembe Tayari making it the most accessible point in Mombasa.

The Kenya Bus Service company in Mombasa is unable to cope with the growing demand of public transportation. This has led to the increase in the number of "matatus" in the town. Today, about 1000 "matatus" operate within Mombasa. The "matatus" have become an important feature of urban transportation. For a long time, the "matatus" were illegal but on 1st June, 1973, a Presidential decree was issued legalizing "matatus" by exempting them from the public service vehicle license requirement.

In Mombasa, the "matatus" use the same routes as the Kenya Bus Service. Both the buses and the "matatus" complement as well as compete with each other (Fig. 6).

Many passengers prefer to ride on the "matatus" because:

(a) Being highly sensitive to demand, "matatus" provide a service when they are mostly needed at frequent intervals there-by reducing the passenger's waiting time.

(b) "Matatus" stop anywhere to pick or drop a customer. They provide a door to door service and penetrate deeper into the estates where buses do not go.

(c) Of lack of alternative quick and frequent public transportation.

C. TIME-DISTANCE ANALYSIS OF BUS AND "MATATU" NETWORK

The details of how time-distance analysis was carried out are given in the Chapter of Methodology. In this Chapter, the importance of time-distance in influencing urban structure is briefly reviewed.

This study is concerned with analysing the relationship between time-distance and land value, population density and trips. The researcher was interested in identifying those areas in Mombasa that were most accessible in terms of travel time by bus and "matatus" from Mwembe Tayari.

Mombasa's morphology and communication systems render the standard distance a poor gauge of accessibility. Mombasa is an Island town. Connections between the Island and the Mainlands are few. A time-distance analysis of the bus and "matatu" networks using the various roads of the Municipal area shows a poor travel time connectivity between the Island and the three mainlands.

The Island is the most accessible in terms of travel time because no area on the Island is more than 15 minutes driving time by bus or "matatu". Tudor Four and Shimanzi are the least accessible on the Island being about 15 minutes away from the city centre. Travel time is longer for Tudor Four because of lack of a bus service. This is a high class residential area where many rich people own cars. Certainly,

the car is faster than the bus and takes less travel time to reach the city centre. However, a large number of poor people who live in the estate such as the domestic servants, do not possess cars. These people have to walk a long distance to get to the nearest bus stop. There is no direct bus connection between Mwembe Tayari and Shimanzi Industrial zone, the latter being in the North western part of the Island. As a result, travel time increases. Generally, however, the Island is more accessible than other parts of the mainland areas, which take more than 15 minutes. In some areas, travel time between the Island and the mainland areas may be 1 hour or even more.

Mwembe Tayari is regarded as the most central and accessible location due to a number of reasons:

1) It is the centre of road network. The main routes linking the Island and the Mainlands pass through Mwembe Tayari.

2) The Kenya Bus Service depot is located at Mwembe Tayari. The Kenya Bus Service is the main public transporter in Mombasa.

3) "Matatus" too are based here.

4) Other public transporters like OTC are centred here.

5) The roads on the Island are the best in the whole study area except in the Old Town where they are narrow.

6) The efforts hitherto made by the (Municipal Council), and even the central government have tended to concentrate on the improvements of roads between the Island and the mainlands. This has led to the ignoring of direct link between one mainland and another. As a result, time-distances between one mainland and the other are too great, since one has always to pass through the Island. A large number of Island roads,

such as Digo Road, and Jomo Kenyatta Avenue, are often congested due to increased traffic at peak hours. This traffic congestion lengthens journey time for commuters who want to travel from one mainland area to the other mainland areas.

The mainland areas, particularly those to the south and north mainland are poorly connected with the Island. These areas are the least accessible from Mwembe Tayari on the Island. The nearest area in north mainland, in terms of travel time, is Kisauni which is 15 minutes away by bus and about 9 minutes away by "matatu". The least accessible area in the north mainland is Maunguja which is about 73 minutes away from the city centre by bus. There is no bus service in this area and travel time is estimated by walking from the mid point to the nearest bus stop. Kisauni is the most accessible in the north mainland because it is directly connected to the Island by the New Nyali Bridge which has reduced travel time between the Island and Kisauni by about 7 minutes. Before the opening of the New Nyali Bridge in 1980, the only link between the Island and Kisauni was a narrow and congested pontoon bridge. The traffic delays on the bridge increased the journey time between Kisauni and Island by about 7 minutes. The Kenya Bus used to take 21 minutes to travel to and from Mwembe Tayari to Kisauni before the new bridge was opened. Today, the bus takes about 14 minutes to cover a similar distance. In other words, the opening of the New Nyali bridge has led to time-space convergence between the Island and the north mainland. Distances between these two areas have shrunk in terms of time.

However, the new Nyali bridge has led to Time-space divergence too. In other words, distances between the Island and some parts of the north mainland have been stretched or increased in travel time. The areas where there has been time-space divergence are Mkomani, Kongowea and Nyali Estates. These areas were directly linked by the Old bridge to the Island. On the average, the Kenya buses took about 10 minutes while today they take on average 17 minutes. Kongowea is now much further in time from the Island than Kisauni.

The south mainland is another inaccessible area. Areas near the Likoni or Mtongwe ferry are more accessible to the city centre than others. However, the ferries are very slow and increase travel time. The waiting time at Likoni ferry is now about 20 minutes while at Mtongwe it is about 30 minutes.

The time-distance analysis of the bus and "matatu" networks in Mombasa shows that travel time by both modes increases from the city centre outwards. This time-space has a great impact on Mombasa's spatial organisation. The pattern of space-economy varies from the most accessible Island area to the least accessible parts of the mainlands. The Island is the hub of a cash economy based on the western paradigm of profit maximization and monopolistic production. In the mainlands, particularly the north and the south, a subsistence economy prevails. Vast distances separating these remote areas and the Island which is the main market, make it difficult to gear production towards monetary exchange.

Thus, the difference in intra-urban accessibility brought about by road improvements, has led to a dichotomy in the space economy of the Mombasa urban area. This evolving dualism or dichotomy can be reduced by changing the existing time-space in such a way that shrinking distances would attract settlement and development in formerly unattractive districts.

CHAPTER 4

LAND VALUES IN MOMBASA

A. THEORY OF LAND VALUES:

Transportation is one of the key factors influencing the structure of land values in an urban area. This Chapter, examines the role of the local road network in influencing land values in the Mombasa Municipal area.

Most studies of urban land values and their relationship with transportation have been carried out by the land economists (Goldberg, 1970, 1972; Alcaly, 1976). The classical body of land value theory provides the economic and urban geographers with insights concerning the spatial pattern of urban land values. An assumption basic in classical theory is that land values decline with distance from the city centre (Alonso, 1964; Yeates, 1965; Kimani, 1972).

Locations away from the city centre incur greater transport costs and thus land values decline reflecting decreasing accessibility. These patterns are a result of physical changes in the structure of internal linkages such as the construction or the widening of highways and technological changes in transport media. Physical improvements tend to make one area more accessible and therefore more desirable than another that does not have the same facilities. This is because increase in accessibility tend to reduce transport costs and therefore not only provide additional funds that can be

used for the purchase of land but also increase the number of potential users and the range of uses for that particular area.

Studies carried out in Chicago show that areas without a commuter rail service or at some distance from it have lower land values (Yeates, 1965, p.58). Goldberg investigated the relationship between transportation and land values as well as the interaction between transportation and land uses. He observed that, ceteris paribus, transportation improvement would result in a increase in aggregate land values.

Goldberg also suggested that there are two models of the city, the "dispersed" city and the "nodal city". A dispersed city is an ideal one where there are no transport costs incurred by moving in any direction. In such a city, all sites would be equally accessible. Assuming an isotropic plain so that no site commands an economic rent, all sites would be equally priced and there would be no rent. An example of a city that approximates a dispersed model is Los Angeles in U.S.A.

A nodal city is an ideal one where transport costs are high so that sites at the centre would command an extremely high rent as all sites at any distance from the core would not be accessible leading to a city of very high density at the centre and zero density outside. An example approximating a nodal city is New York in the U.S.A. Most cities such as those in the developing world, lie between the two extremes of the dispersed and nodal cities. Variations in urban structures may be explained by the form of transportation as well as the transportation technology reached in

each city. The transportation technology in the cities of the Third World is still low compared with that of the industrial cities in Europe or North America. So, friction of distance is great in many Third World cities affecting land values as well as urban population densities.

Mombasa is an Island Town and all the major roads converge on the Island. Places away from the Island are not well served by road network. Transport costs are high away from the Island making land on the Island more valuable than that on the periphery. Mombasa town, approximates a nodal city due to its Island nature.

Goldberg found out that the result of transportation improvements in the cities of developed countries were different from those of the cities of the less developed countries. Transportation improvement leads to suburbanization of the industrialized cities while it leads to centralization of cities of the Third World. This is a very interesting finding which suggests that the impact of transportation on urban structure in both the industrialized city and the Third World city is different.

Transportation costs whether measured in time or money terms, have long been recognized as a crucial determinant of both the formation of cities and of spatial distribution of economic activities within urban areas (Alcaly, 1976, p.42). Transportation is the means of reducing the friction of space. Site rents and transpor costs represent the social cost of friction of space that remains.

Studies on the relationship between land values and transport services in urban areas have tended to apply the Von Thunen's model. The classical location theory has placed greater emphasis

on industrial location theory. The entrepreneur is assumed to minimize his production costs and to maximize profits. Von Thunen's work made an important contribution to the development of land value theory. Von Thunen propounded a theory of land use and land value in a purely agricultural region with only wagon transportation. Today, there are many different transportation modes each with its own different time-space which has a different impact on the space economy of a place.

Von Thunen's model refers to the spatial distribution of crops according to the yields per unit area around a central town and today, the model can be applied in an urban context. In an urban area, the Central Business District replaces the Central town of Von Thunen's model and urban land uses are arranged concentrically around it with rents and land use intensity declining with distance. According to Von Thunen, land rent is the revenue minus production and transportation costs.

Several other people have contributed in no mean way to the land value theory. They are Ricardo (1911), Hoyt (1939), Alonso (1964). Kimani (1972) and Weber et al, (1981).

Ricardo used the single-factor explanation of the land prices just like Von Thunen. Ricardo believed that the price of land or rent accruing to its owner is a function of the fertility of land.

One of the most influential analyses of residential spatial structure has been the radial-sector theory of Homer Hoyt (1939). The residential spatial structure of North American cities tends to conform to a pattern of sectors rather than concentric circles.

Transportation systems tend to divide a city into sectors and people of different socio-economic status live in different sectors. The highest rent area(s) of a city tend(s) to be located in one or more sectors of the city. The high rent area tends to pull the growth of the whole city in the same direction. Thus, the movement of the highest rent area is crucial to the understanding of the urban spatial structure (Richardson, 1977, p.12).

Hoyt's model introduces random elements like transportation which is important in bringing about the spatial variation. However, he assumed a monocentric city and tended to concentrate on high income groups. A large number of cities today, particularly in Europe and North America have more than one dominant centre. Such cities are said to be polycentric.

Alonso (1964) developed the consumer equilibrium theory. According to this theory, a household is faced with a given rent-distance function. The rent-distance function of household is a set of land rents the household would be willing to pay at various distances from the CBD in order to maintain the same level of utility every where which makes the household indifferent between locations (Fig. 7). According to this theory, the plot size depends on how far from the city centre one is.

Alonso's model is more general and has a wider application. Its assumptions are:

(a) An isotropic or featureless plain.

(b) Transportation possible everywhere.

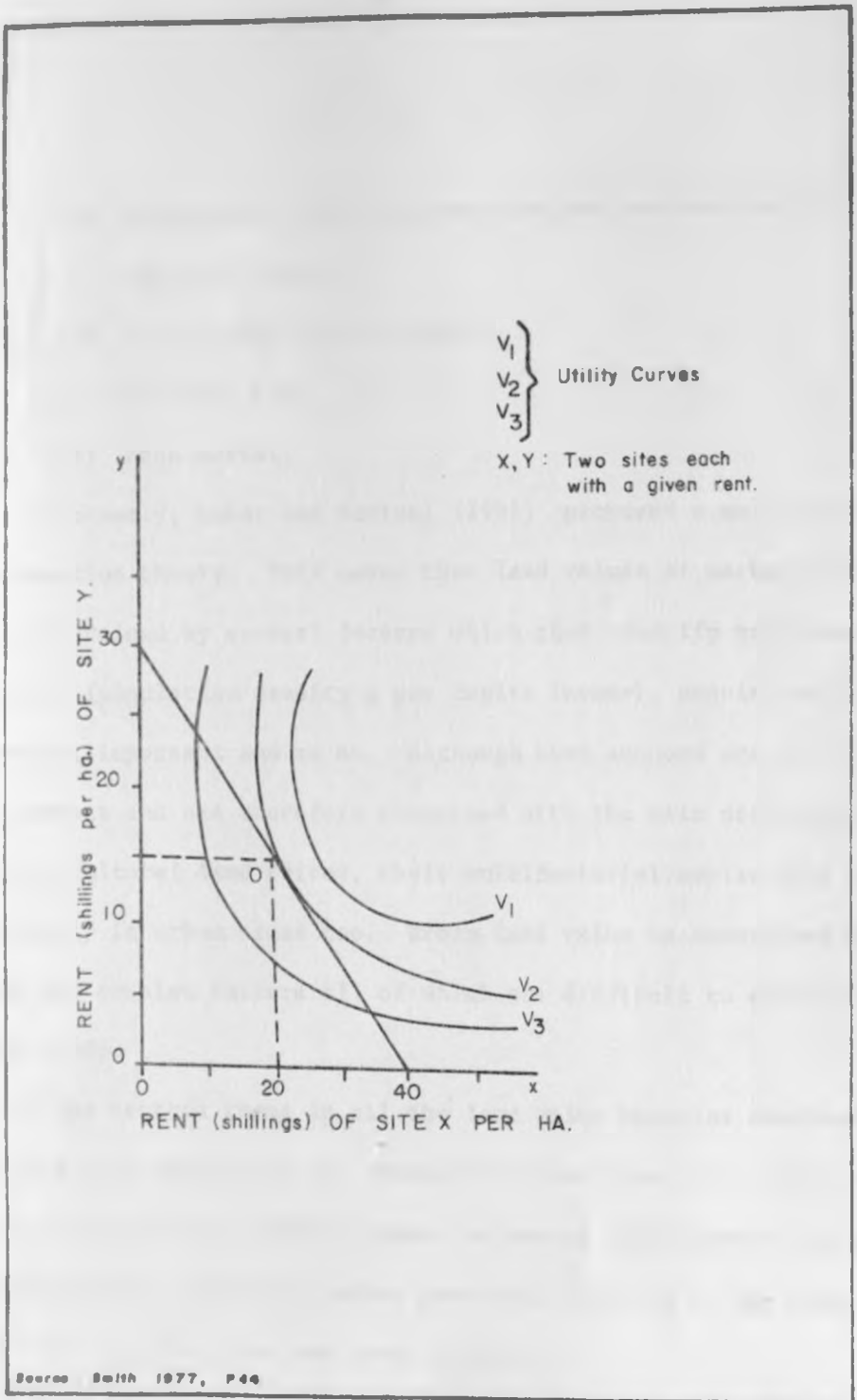


FIG.7 INDIFFERENCE CURVES TO SHOW THE RENT A HOUSEHOLD WOULD BE WILLING TO PAY AT A GIVEN LOCATION.

(c) Employment, goods and services are concentrated at the city centre.

(d) City centre is the market.

(e) Economic men

(f) Free market.

Recently, Weber and Kariuki (1981) proposed a multi-factorial explanation theory. This means that land values or market prices are determined by several factors which they identify as income density (population density x per capita income), population density, exports, important and so on. Although both authors are agricultural economists and are therefore concerned with the main determinants of agricultural land prices, their multifactorial explanation theory can apply in urban areas too. Urban land value is determined by many and complex factors all of which are difficult to examine in this study.

The central theme in all the land value theories examined is that rent appears as the charge which the owner of a relatively accessible site can impose because of saving in transport costs which the use of the site makes possible. This is to say land derives its value from two basic qualities:-

(a) Locational Matrix within which residential, commercial, industrial and other land uses are located.

(b) Land is a scarce commodity. So, there are competing land uses and the use offering the highest price takes over the land.

Land values are a direct reflection of differences in intra-

urban accessibility. Thus, high land values tend to be associated with highly accessible locations and vice-versa. From this argument, scholars hypothesize an inverse relationship obtaining between land values and distance from the city centre or from any other important centre such as a transport depot (Kimani, 1972).

Many researchers believe that the value gradient is linear in form declining at a constant rate with increasing distance (minutes, kilometres). The linear curve gives the impression that at the urban fringe, land has no value or its value may be negative. The linear land value gradient is popular perhaps because of its mathematical simplicity. Figure 8(a) shows a linear curve. It implies:-

(i) Linear curve is the only one present in the urban area.

(ii) Constant change throughout.

(iii) Either discontinuing at the urban fringe or zero rent or negative value.

Figure 8(b) shows the impact of a radial transport improvement on land values. Before transport improvement, the value gradient is very steep (SV_1D_1). However, transport improvements lead to a decline in land values, SV_2D_1. But, as residents move into the impact area to take advantage of new travel savings and as consumers demand more land due to a price decrease, there will be an upward shift to the new equilibrium SVD.

Alternatives to and somewhat more appealing than linear gradient are the negatively sloping curvilinear forms shown in

Figure 8(c) which allow for a steep gradient near the CBD and a sharp discontinuity (Koutsopoulos, 1977).

At the moment, there is a wide range of opinions amongst researchers regarding the appropriate form of the value gradient for use in empirical research. Two forms are frequently used. They are (a) The Negative exponential relationship between land rents and distance. This is the model used in this paper.

(b) Log-log model.

This model was used by Kimani (1972) in Nairobi.

The choice between the two depends on the researchers and the kind of data available. Many models related land rent at a certain location to the relative travel time to CBD from that location. Hence, the form of the rent gradient depends on the relationship between travel time and relative distance.

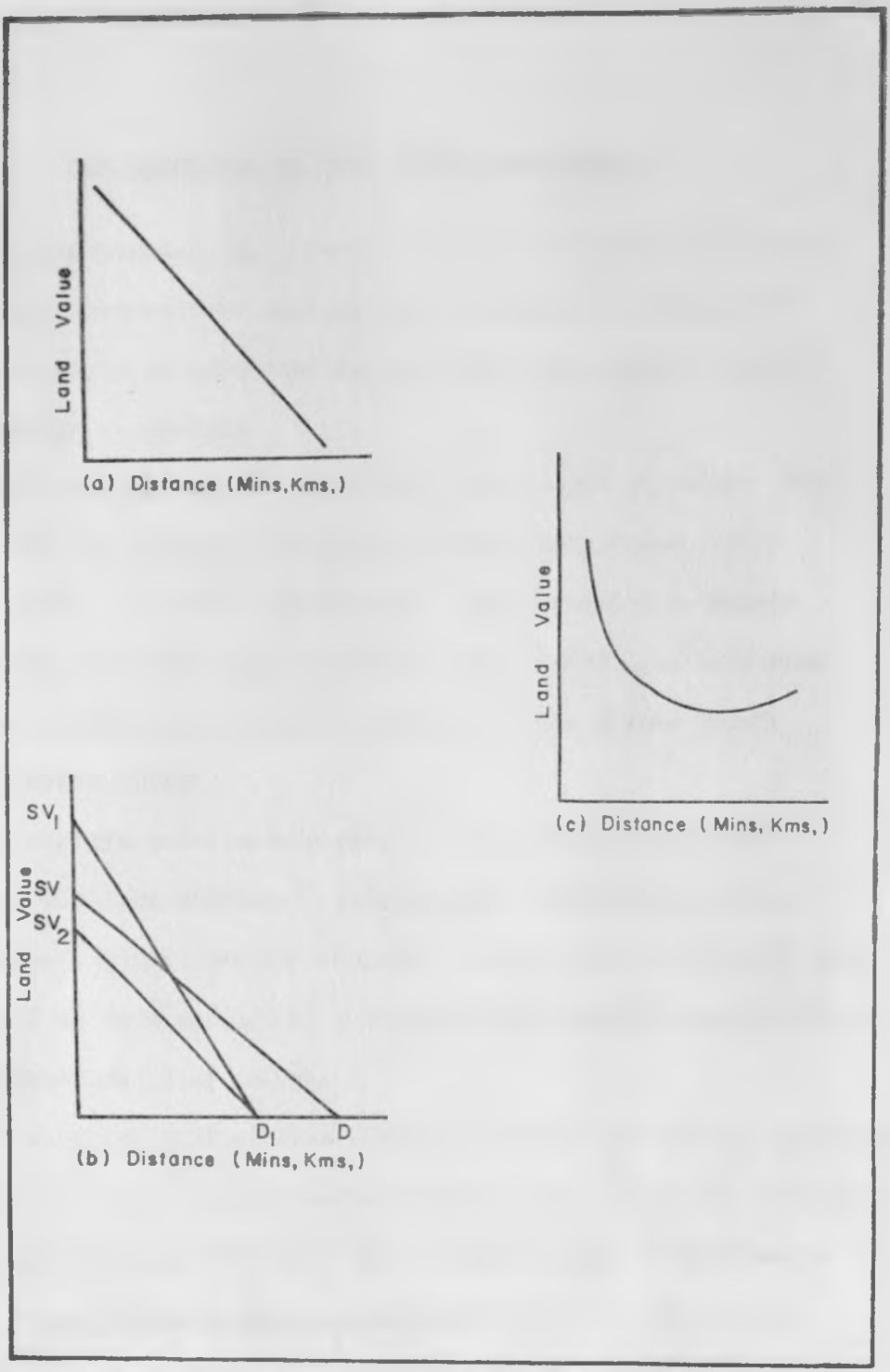


FIG. 8 : LAND VALUE GRADIENTS

B. THE STRUCTURE OF LAND VALUES IN MOMBASA

In this chapter, an attempt is made to describe and explain the spatial structure of land values in Mombasa. Further, the chapter attempts to prove whether the land value theory examined above applied in Mombasa.

Many studies carried out so far have tended to relate land values with the physical distance (Yeates, 1965; Yahya, 1969; Kimani, 1972). Some of them however, have attempted to relate travel time with land values (Koutsopoulos, 1977). In this study, distance is measured in travel time by bus from Mwembe Tayari on the Mombasa Island.

A negative relationship exists between land values and actual or physical distance. Time-distance is expected to be proportional to the physical distance. Thus, the objective of this chapter is to examine whether a negative relationship exists between time-distance and land values.

To find out whether time-distance and land values are negatively related, a scatter gram was obtained (Fig. 9a). From the scatter - gram it would appear that land values decline with time-distance. However, the relationship between time-distance and land values is non-linear or curvilinear. According to this kind of relationship, land value gradient is steeper near the city centre and flattens out or becomes gentle on the urban fringe. In other words, the rate of change of land value gradient is not constant.

The researcher was interested in carrying out regression analysis in order to find out the kind of relationship existing

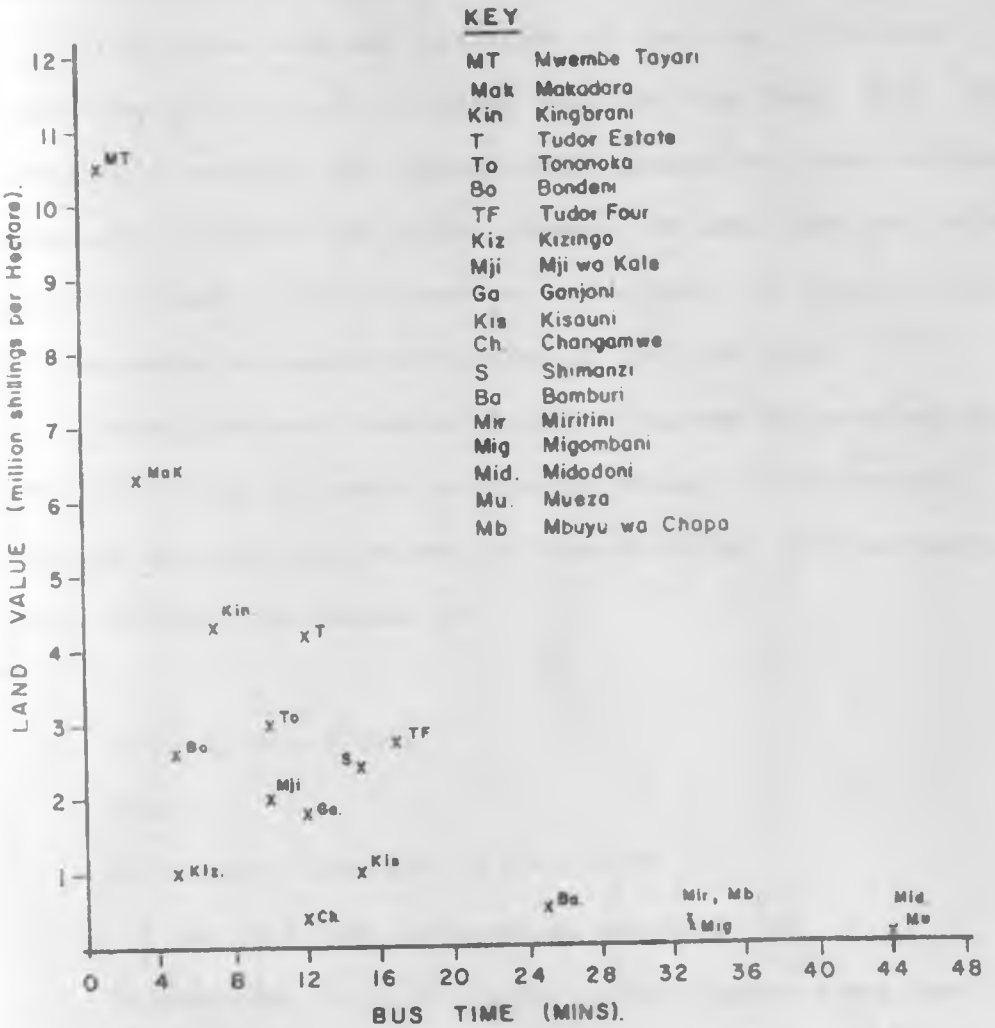


FIG. 9a RELATIONSHIP BETWEEN LAND VALUE AND BUS TIME

between time-distance and land values. Regression analysis is only possible with data that is linearly related. So, the data had to be normalized by means of logarithmic transformation.

Land value data was linearized by obtaining its natural logarithm and plotting it against real bus time (Fig. 9(b). This produced a straight line proving that although no linear relationship exists between land value and real bus time, when land value data is logged, linearity results. Therefore, the natural logarithm of land value is negatively related to real bus time.

Using the Least Squares Method, a regression curve was obtained (Fig. 10). This is useful to show the nature of relationship existing between land values and time distance. The regression model obtained for Mombasa is:

$$\ln Y = 15.33 - 0.099X$$

where:

ln: natural Logarithm of land value

X: Real bus time (independent variable)

In examining the relationship between distance and land value, Kimani (1972) used the simple regression analysis of the type:

$$\log Y = \log a + b \log X$$

Kimani found out that simple r (Pearson correlation coefficient) was - 0.824. He got r^2 of 67.9%. This simple double log model provided a remarkably high degree of the total variation in the value surface. In the present study, both the semi-log and double log models were used and the results

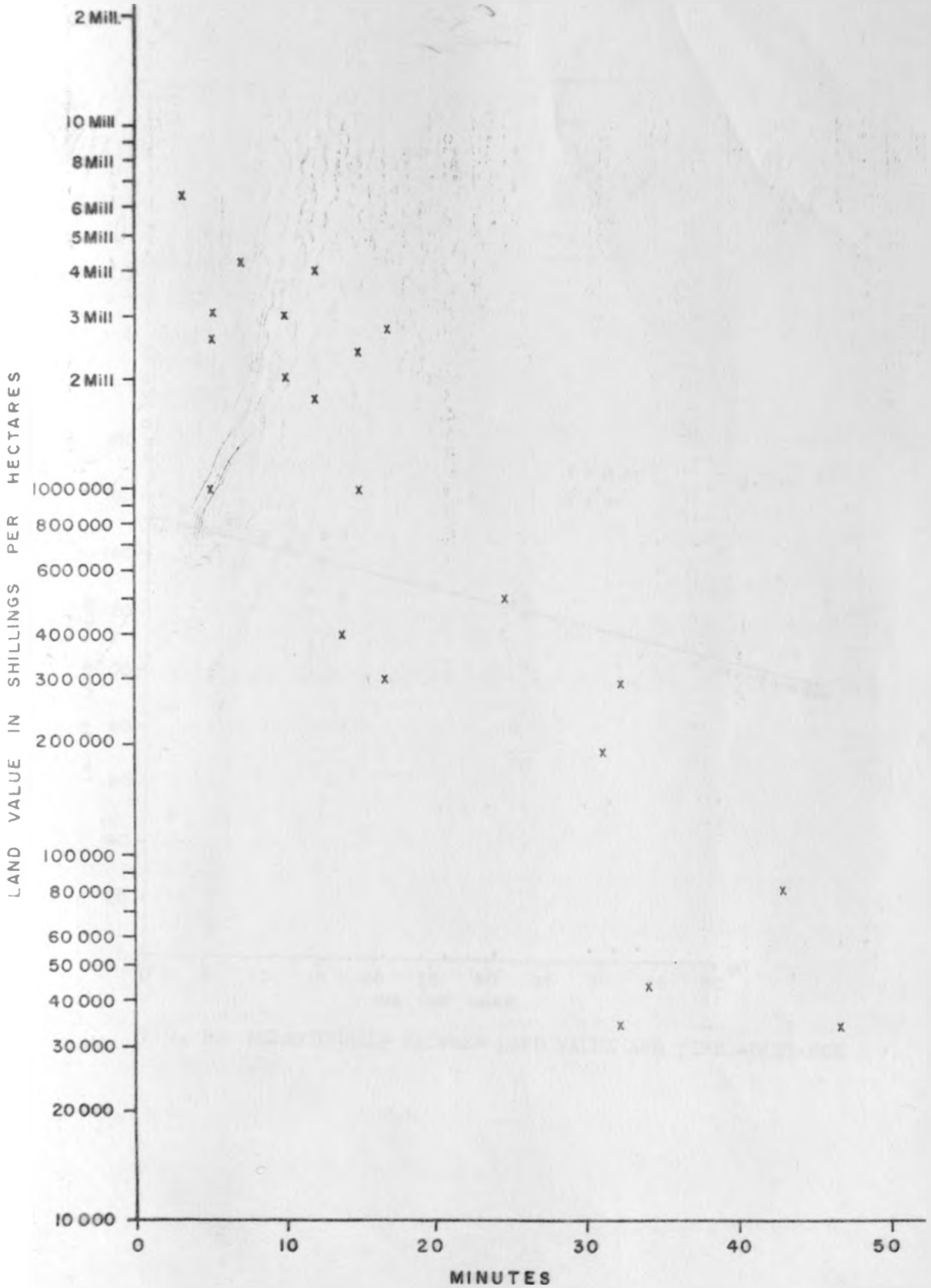


Fig 9(b) RELATIONSHIP BETWEEN LAND VALUE AND TRAVEL TIME.

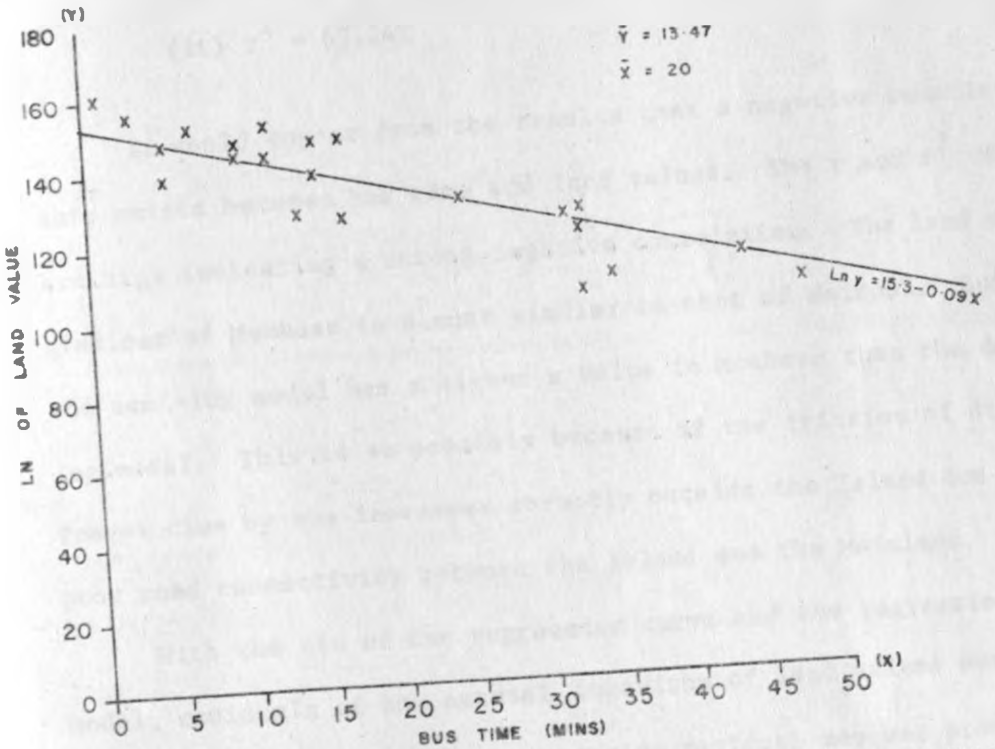


FIG. 10 RELATIONSHIP BETWEEN LAND VALUE AND TIME -DISTANCE

obtained were as shown:

(a) Semi-log model

(i) $r = -.88$

(ii) $r^2 = 77.44\%$

(b) Double log model

(i) $r = .82$

(ii) $r^2 = 67.24\%$

It would appear from the results that a negative relationship exists between bus time and land values. The r and r^2 values are high indicating a strong negative correlation. The land value gradient of Mombasa is almost similar to that of Nairobi. But, the semi-log model has a higher r value in Mombasa than the double log model. This is so possibly because of the friction of distance. Travel time by bus increases abruptly outside the Island due to poor road connectivity between the Island and the Mainland.

With the aid of the regression curve and the regression model, residuals of the natural logarithm of land values were calculated and measured. A regression residual map was produced using the regression residuals (Fig. 11). A residual map is useful in showing those areas where accessibility or time distance is not a very important determinant of land value.

The factors influencing land values are many and complex. By looking at the residual map (Fig. 11), it is clear that bus time (accessibility) is a very important determinant of land values in Mombasa. But, other factors are also important, namely, beach frontage, land uses, age of settlement, squatter settlement and so on.

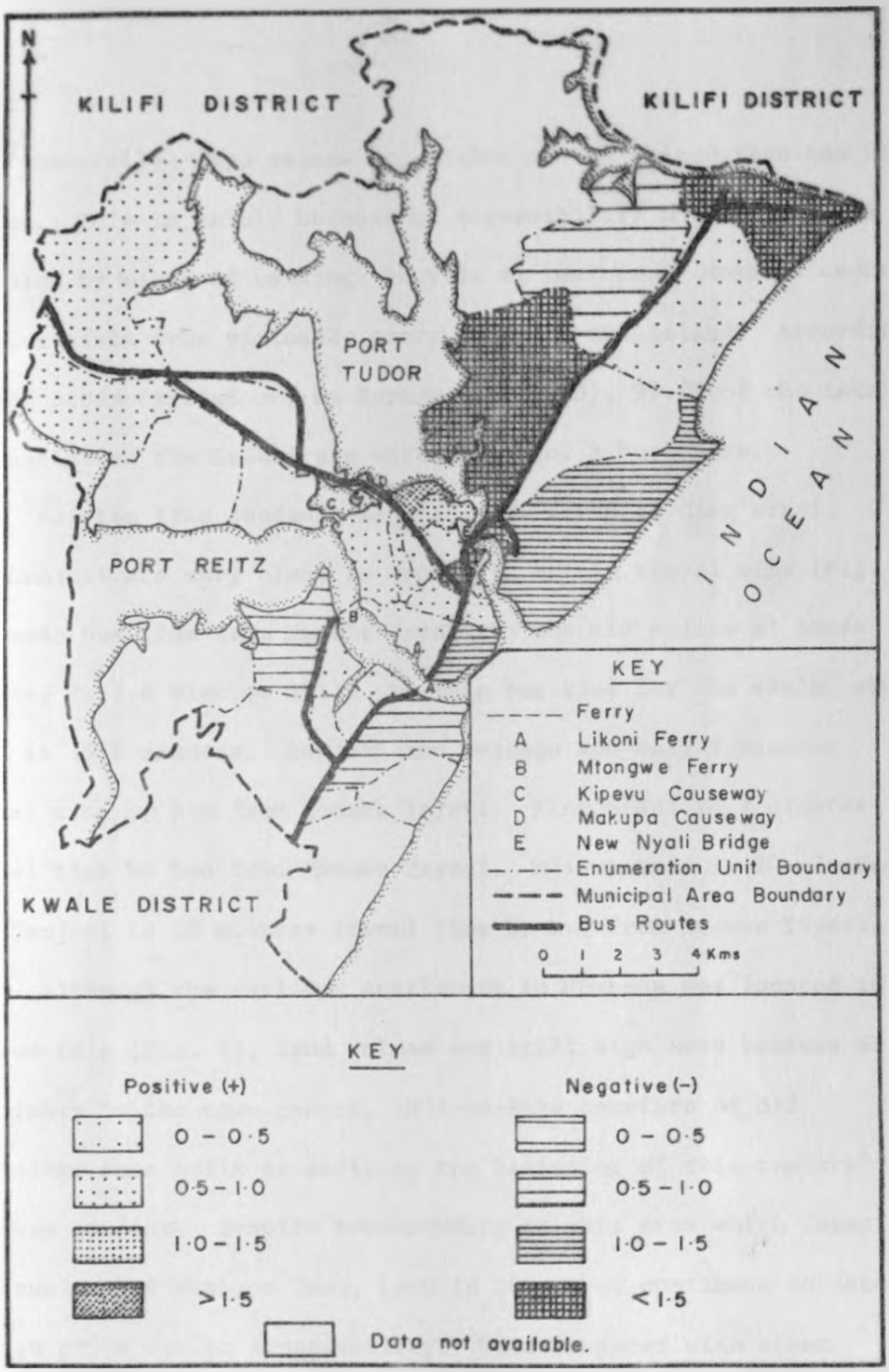


FIG. 11 REGRESSION RESIDUALS OF LAND VALUE (LOG_e)

Generally, land values are higher on the Island than one would (Fig.12 expect. This is mainly because of accessibility not only by bus but also by means of walking, bicycle or the car. Mombasa centre is accessible from virtually every point on the Island. According to the study carried out by Norconsult (1973), 99.9% of the total population on the Island are within 1 Km of a bus route.

Estates like Bondeni, Majengo, Mji-wa-Kale, King'orani, and Ganjoni are very close to Mwembe Tayari in travel time (Fig. 1). The mean bus time from Mwembe Tayari to the mid points of these estates is 7.8 minutes while the mean bus time for the whole study area is 19.8 minutes. Bondeni and Majengo are only 5 minutes travel time by bus from Mwembe Tayari. King'orani is 7 minutes travel time by bus from Mwembe Tayari. Mji-wa-Kale is 10 minutes and Ganjoni is 12 minutes travel time by bus from Mwembe Tayari.

Although the earliest settlement in Mombasa was located in Mji-wa-Kale (Fig. 1), land values are still high here because of proximity to the town centre. Mji-wa-Kale consists of old buildings some built as early as the beginning of this century or even earlier. Despite overcrowding in this area which forms the nucleus of Mombasa Town, land in this area continues to fetch a high price due to accessibility. When compared with other estates farther from the city centre in travel time, land in Mji-wa-Kale commands a higher price. This is particularly so today due to the fact that land everywhere on the Island has become scarce following population growth and resultant high demand for

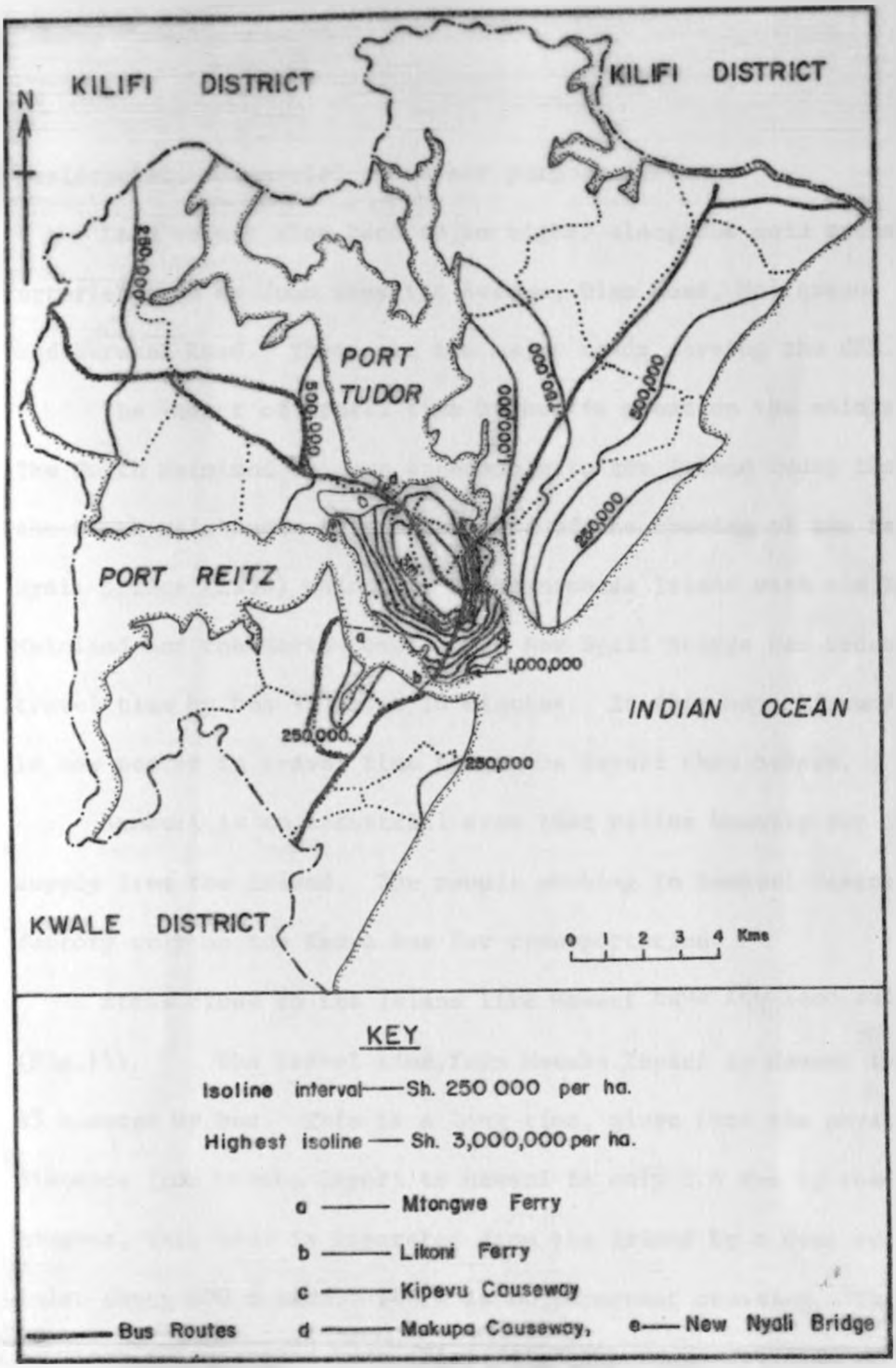


FIG. 12: LAND VALUE MAP, 1981.

residential, commercial and other purposes.

Land values also tend to be higher along the main transport arteries such as Jomo Kenyatta Avenue, Digo Road, Moi Avenue and Nkrumah Road. These are the major roads serving the CBD.

The impact of travel time by bus is great on the mainlands. The North Mainland is more accessible to the Island today than the South Mainland. This is because of the opening of the New Nyali Bridge (1980) which now links Mombasa Island with the North Mainland and the North Coast. The New Nyali Bridge has reduced travel time by bus by about 10 minutes. In this way, Kisauni is now nearer in travel time to Mwembe Tayari than before.

Bamburi is an industrial area that relies heavily for labour supply from the Island. The people working in Bamburi Cement factory rely on the Kenya Bus for transportation.

Areas close to the Island like Maweni have low land values (Fig.11). The travel time from Mwembe Tayari to Maweni is about 35 minutes by bus. This is a long time, given that the physical distance from Mwembe Tayari to Maweni is only 2.6 Kms by road. However, this area is separated from the Island by a deep sea inlet about 800 m wide. There is no permanent crossing. The ferry services are operated here (Fig. 11). One ferry operates at Likoni and the other at Mtongwe (Fig. 13). Areas closer to the ferries appear to have relatively higher land values than those away.

The type of land use influences land values. Industrial and Commercial land uses tend to have higher land values than other uses.

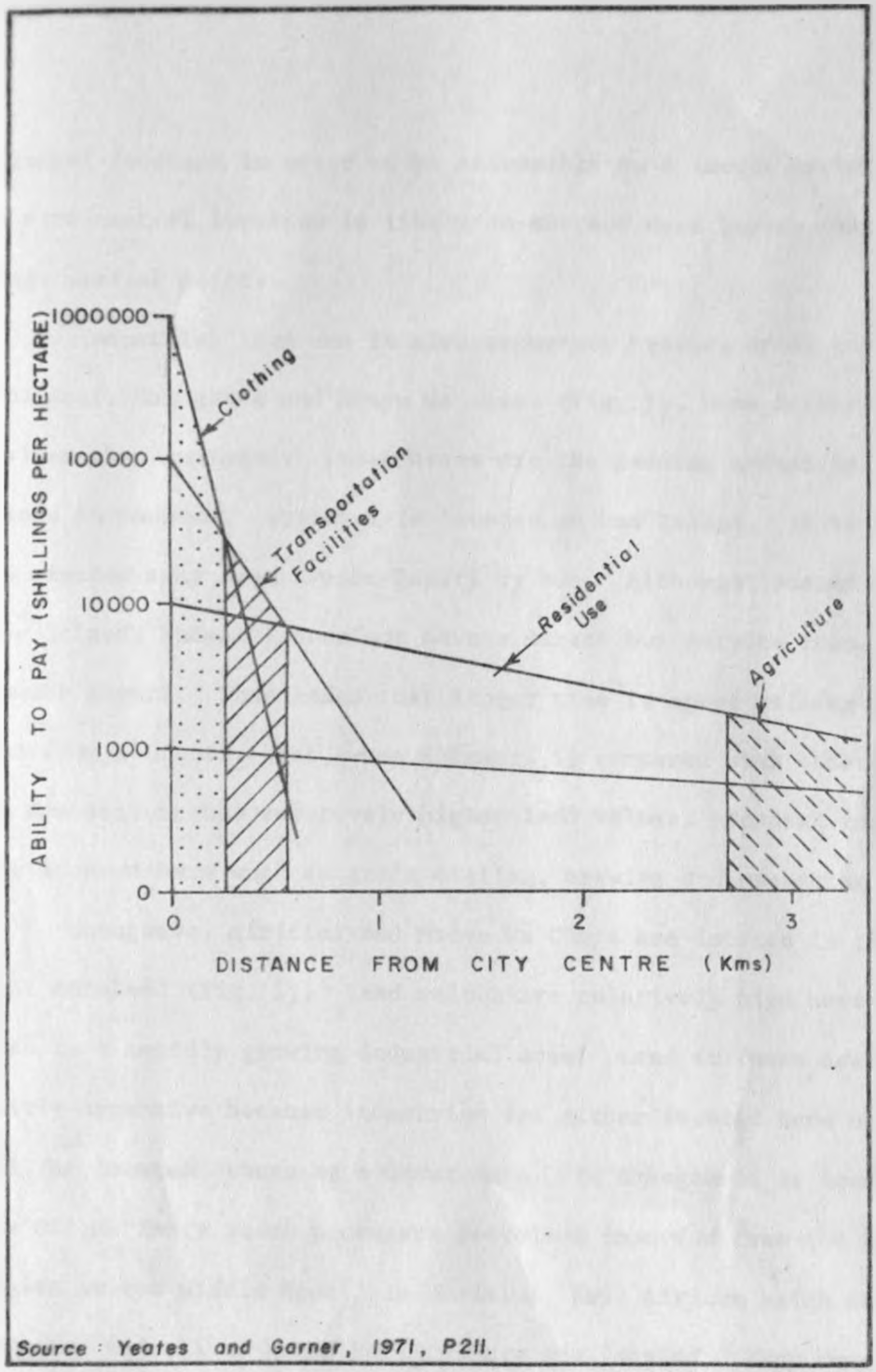
This is because commercial and industrial land uses are better able to compete for central or more accessible locations. Studies of urban land value structure in other towns like Nairobi (Kimani, 1972), have shown that for many commercial land uses, the most desirable locational property of an urban site is centrality. Maximum centrality occurs at the most accessible point, usually the city centre, where transport routes converge. Consequently, those activities which enjoy the greatest benefits from occupying accessible locations will have greater surpluses available with which to bid for land (Plate 4).

Those activities requiring the greatest centrality with respect to the urban market locate in the innermost zones while those least susceptible to accessibility considerations locate at the periphery (Yeates et al, 1969).

The relationship between land use, location and land values is shown in Figure 13. Usually, commercial land use like retailing has a higher land value than industrial use. Therefore, commercial land use occupies a more central location than industrial land use. In the area of study, the main garment shops and super markets are located on the Island usually at road intersections. The point of peak value in Mombasa is on the Island near Manor Hotel. This hotel is located at the intersection of Moi Avenue and Nyerere Avenue.

Commercial land uses such as shops, clothing stores and so on, are able to pay from a central location. They also need a

Plate 4: Lack of Land has forced developers to build high-rise buildings on the Island, Mombasa.



Source : Yeates and Garner, 1971, P211.

FIG. 13 RELATIONSHIP BETWEEN LAND USE, LAND VALUES AND DISTANCE

central location in order to be accessible to a larger market. A more central location is likely to attract more buyers than a less central point.

Industrial land use is also important because areas such as Shimanzi, Changamwe and Mbuyu Wa Chapa (Fig. 1), have higher land values than expected. These areas are the leading industrial locations in Mombasa. Shimanzi is located on the Island. It is about 15 minutes away from Mwembe Tayari by bus. Although located on the Island, Shimanzi does not have a direct bus service from Mwembe Tayari. This means that longer time is spent walking to and from Shimanzi. Yet, when Shimanzi is compared with other areas in Mombasa, it has relatively higher land values. Several industries are located here such as grain milling, brewing and packaging.

Changamwe, Miritini and Mbuyu Wa Chapa are located in the West Mainland (Fig. 1). Land values are relatively high here because this is a rapidly growing industrial area. Land in these areas is fairly expensive because industries are either located here or will be located there at a later date. In Changamwe, is located the Oil Refinery which processes petroleum imported from the Gulf Region in the Middle East. In Miritini, East African Match Box industry as well as Metal Box industry are located. Many more industries are planned to be located in these areas due to good communication network provided by road and railway. There is ample fairly flat ground for factory construction and expansion. A ready market for industrial products exists within the study area as well as the immediate coastal hinterland and in the rest of Kenya.

Plate 5: Agricultural Land use in predominant on the Mainland areas.

Studies carried out in Chicago (Yeates, 1965) reveal that proximity to the beach is a very important determinant of land values. A similar pattern seems to exist in Mombasa. Land near a beach or near a sea frontage, seems to have relatively higher land values than land away from the beach. This is particularly so in Kongowea, Bamburi and Timbwani areas. Kongowea and Bamburi lie on the North Mainland while Timbwani is located on the South Mainland. These three areas contain beautiful beach frontages on which are located some of the most important tourist class hotels on the Kenyan coast. Sea frontage increases value attached to a piece of land. This is so because of good view and cool sea breeze during the day. In some beaches, hotels are built which increase the value of land. The importance of sea frontage is even greater in a Tropical region like Mombasa. During the day, it may be very hot but a cool sea breeze moderates the temperature so that areas near the sea become cooler than areas away from the sea. Many people particularly the rich people would like to live in such plots with a sea frontage. Such a high demand would raise the value of the beach plots.

Alonso (1964, p 167) stressed the importance of micro-climate such as the sea breeze in influencing land values. He observed that the less developed countries are generally warm and that people would tend to take advantage of cooler areas in a city. Ngari (1977, p.266) observed a similar pattern in Mombasa. He found out that areas near the sea frontage like Kisauni creek, had higher land values.

Other factors are also important in influencing land values. Such factors include availability of piped water, sewerage system, electricity, extent of pollution and squatter settlements.

Mombasa's main source of water supply are Mzima Springs 240 Km (150 miles) away from Mombasa in Taita-Taveta District. Since the population of the town is growing, the demand for water is also growing. The densely populated areas like Majengo on the Island, Changamwe on the West Mainland and Kongowea on the North Mainland, lack adequate water supplies. Water is very essential for drinking and other domestic uses. Areas with enough water tend to have a higher land value than others. This is particularly so, on the Island. The Island has higher land values than other areas in Mombasa not only because of its centrality but also due to adequate water supplies. The Ministry of Water Development has installed water kiosks in various parts of the Mombasa Municipal area. Most of these water kiosks which sell water to the urban residents, are privately owned. The distribution of water kiosks is quite uneven. Mombasa Island has 40 water kiosks, 18 of which are government owned; the North Mainland has 20 water kiosks, and West Mainland has only 15 of them. The South Mainland does not have any water kiosks (Mombasa Development Plan, 1979-82, p.86). So, apart from the poor transportation link between the Island and the South Mainland, lack of adequate water makes the area unattractive to private as well as government land developers. The effect of this is that land values remain low.

Availability of an adequate sewerage system may influence unimproved site value. An area with a sewerage system generally commands a higher value than one without. Mombasa has a poor sewerage system (Ibid, p.128). The existing sewage systems serve approximately only 20% of the town's population. Another 20% of the population is served by septic tanks and the majority (60%) still use pit latrines. Areas with a better sewage system are Majengo, Changamwe, Miritini and Kongowea (Fig. 1).

Environmental pollution is another important factor determining land values in Mombasa. Pollution caused by the smoke produced by motor-vehicles and industrial effluents, tend to reduce land values in a place. Areas near Makupa causeway such as parts of Kipevu and Mikindani (Fig. 1), have low land values because of pollution. This area is virtually empty and undeveloped because of the noise, smell and smoke from the vehicles moving along the Nairobi - Mombasa Road.

Old vehicles thrown in the backyard of certain areas like Majengo and Old Town, tend to reduce land values of those areas.

Noise pollution is pronounced in Port Reitz and the neighbouring Changamwe (Fig. 1) because of the nearness of the Moi International Airport. Big Jumbo Jets when landing or taking off make a lot of noise. People have tended to avoid settling in such areas. Land values here are much lower than would otherwise be the case without noise pollution.

In the developing countries the control of land is determined by free market forces to a lesser extent than in the developed countries. Social and political power has played and continues to play a significant part. Politicians take the desirable land leaving poorer areas. Squatters occupy the poorer and less valued parts of the cities usually, the urban periphery. Squatters although weak as individuals constitute a strong social force in groups that few governments and no force of the market place can stop (Alonso, 1964, p.167).

In Mombasa, there are many squatter settlements. About 60% of the settlements on Mombasa Island are categorized as the squatter settlements. Many of the squatter settlements occur in Majengo, King'orani, Old Town and Bondeni on the Island, Chaani in Changamwe and Mikindani on the West Mainland and Kongowea (North Mainland). Urban market forces do not actually apply in squatter settlements. Therefore, the value of land in such areas is either not known or is much lower than in other areas.

The need to study the spatial patterns of urban land values has been long recognized by many scholars including city planners. The importance of such a study is clearly summed up by the following statements. "It is clear that an understanding of the patterns and processes of variations in land values is essential to an explanation of the structure of cities in guiding policy decisions, directing city growth and development" (Kimani, 1972, p.107).

During the present period of radical or social revolution, urban planning should be geared towards providing social justice

by enabling an equitable distribution of employment opportunities, schools, housing and so on. Even when land value structures observed in industrialized cities are found to obtain in Third World cities, this does not mean that there is social justice in the city. The land value model developed in the Western cities should be applied in Third World cities with caution for the model is developed in a capitalist economy. This kind of Euro-centric model assumes a free enterprise economy which is geared towards profit maximization and that there is competition between land uses. Not all residents of the cities of the Third World are in the market. Many people are poor and cannot afford to compete for land. So, competition tends to perpetuate the spatial inequality in development for not every area can compete.

Although this study has shown that the land value theory developed in the West applies in Mombasa, Third World cities should not be modelled after the Western city without some modifications. This study does not advocate the maintenance of the status quo where all the development is concentrated at the city centre. The primary function of the city under capitalism, that of generating profits and concentrating wealth, seems inconsistent with the provision of what the masses require to satisfy their basic needs like food, shelter, or clothing (Smith, 1977, p.23).

Concentration of activities apart from providing economies of scale also leads to the dis-economies and undesirable results like regional inequality or the core-periphery dichotomy. The concentration of roads and traffic (cars, buses etc.) on the

Mombasa Island would lead to the traffic congestion and result in the time-space divergence (Plate 6).

The study provides a case for using road transportation as a tool which should bring about equity and higher living standards of the people both on the Island and the Mainlands by increasing mobility and spatial interaction within the study area. From the study, it would appear that the bus is an important mode of public transportation which strongly determines land value structure.

Plate 6: Lack of parking space in the CBD has led to traffic congestion. Plate 6 shows attempts being made to solve parking problems in the city centre by building a car park (Ambalal House,Mombasa).

CHAPTER 5

POPULATION DENSITY IN MOMBASA

A. DENSITY STRUCTURE

In this chapter an attempt is made to predict and explain the population density gradient in the Mombasa Municipal area. The chapter also attempts to establish whether the density functions observed in other cities apply in Mombasa. The similarities and the differences noted are explained and their implications to urban development in the Third World cities in general and Mombasa in particular are considered.

Transportation studies carried out in Latin America (Wheeler and Thomas, 1973) show that due to a high friction of distance, the wealthy people reside at the more accessible central locations while the periphery is ringed by slums and squatters. This shows that urban transportation has a key role to play in the spatial distribution of population. But, the exact relationship between urban transportation and population distribution is not known,

> "Studies of the internal spatial structure of cities in the developing world could focus on the role of transport as it influences the distribution of population and land use; at present broad and conflicting generalization exists." Wheeler and Thomas, 1973, 119)

This chapter is intended to fill in some of the gaps in the urban transportation studies.

There are two distinct population density patterns in the Mombasa Municipal area. The first density pattern consists of high population density areas. These are mainly located on the Island where the average population density for the whole Island is about 10,170 persons per square kilometre. Enumeration units like Makadara and Mji-wa-Kale have a higher than average population density for the Island (Figure 14). The density for Makadara is 26,602 persons per square kilometre while Mji-wa-Kale has about 25,887 persons per square kilometre.

Other enumeration units have a relatively high population density such as King'orani and Majengo with densities of 18,606 persons/Km^2 and 21,280 persons/Km^2 respectively.

Low density areas are mainly outside the Island, that is, on the mainlands. The average population densities there are low compared with those of the Island. For instance, the average density of the north mainland is 798 persons per square kilometre, the one for the south mainland is 862 persons per square kilometre and for the West mainland is 1,663 persons per square kilometre (Kenya Population Census, 1979).

From these three density patterns it would appear that in the area of study, population density generally declines with increasing distance from the town centre on the Island. A similar trend has been observed in Nairobi by Ngau (1979).

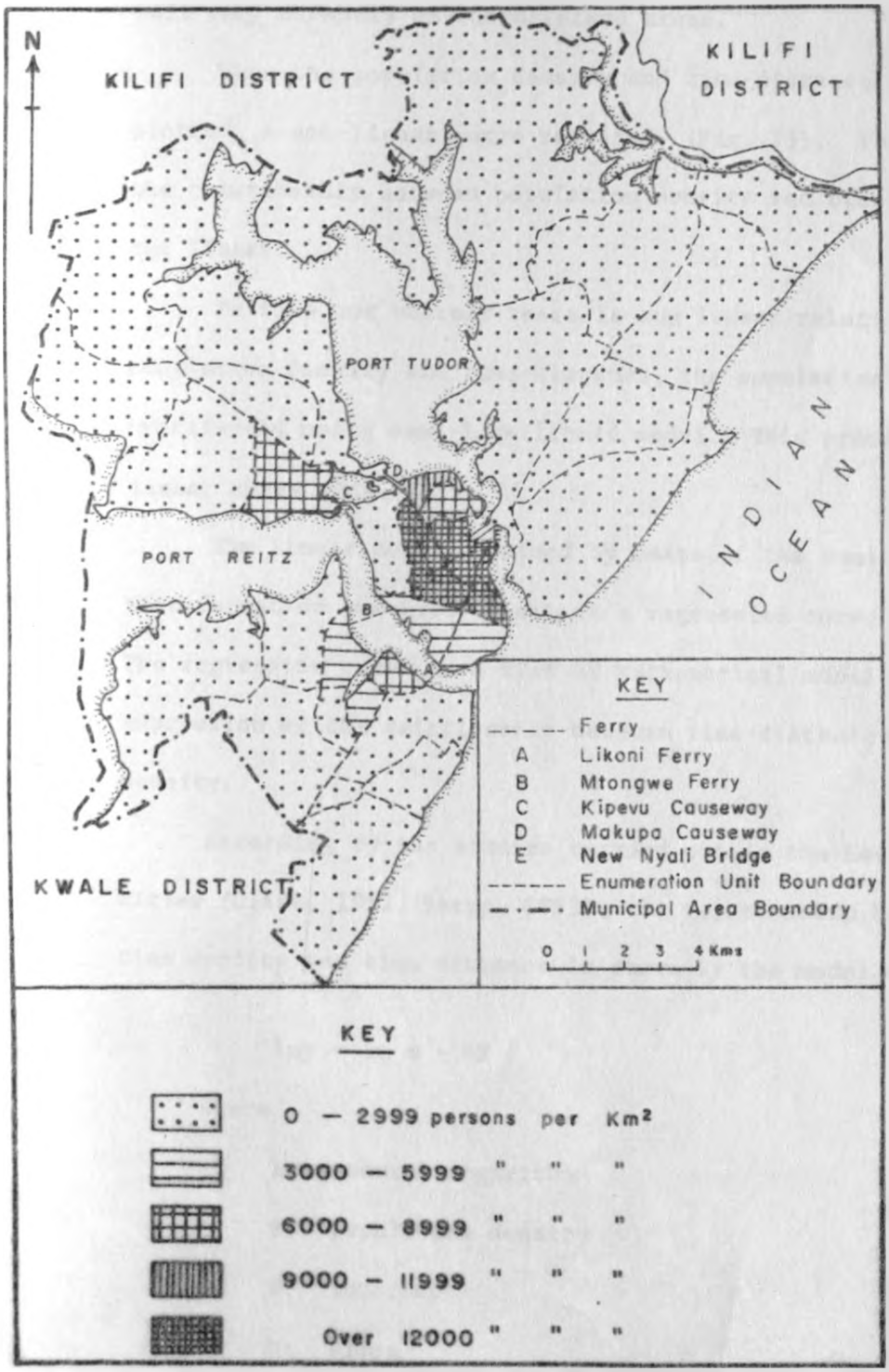


FIG. 14 POPULATION DENSITY MAP OF MOMBASA MUNICIPAL AREA 1979

The population density structure of the Mombasa Municipal area shows a clear distance-decay function. Population densities fall very abruptly on the mainland areas.

When the population density and time-distance by bus was plotted, a non-linear curve resulted. (Fig. 15). This shows that the relationship between population density and time-distance is not linear.

To find out whether there is any linear relationship between population density and time-distance, the population density was transformed using semi-logarithmic model. This produced a negative linear curve (Fig. 16).

The linear model obtained by means of the semi-logarithmic transformation was used to obtain a regression curve (Fig. 17). The regression curve is a kind of Mathematical model or a graphical expression of the relationship between time-distance and population density.

According to the studies carried out in the North American cities (Clark, 1951, Berry, 1963), the relationship between population density and time distance is shown by the model of the form:-

$$\ln y = \ln a - bX$$

where

ln: natural logarithm

y: population density

a: intercept

b: slope

KEY:

MT.	Mwamba Tayari	Fr	Frere Town
Mak.	Makadara	PR.	Port Reitz
Mji.	Mji-wa-Kale	Ba.	Bamburi
Maj.	Majengo	Bom.	Bomani
Be.	Bondeni	Mi.	Miritini
Kin.	Kingorani	Ng.	Nguu Tatu
To.	Tononoka	Ma.	Maweni
TF.	Tudor Four	Ki	Kidunguni
Ga.	Ganjani	V.	Vyamani
Kip.	Kipevu	Mid.	Midodoni
Ch.	Changamwe	Sha.	Shanzu
Sh.	Shimanzi	Mu.	Mueza
Ki.	Kizingo		
Ko.	Kongowea		

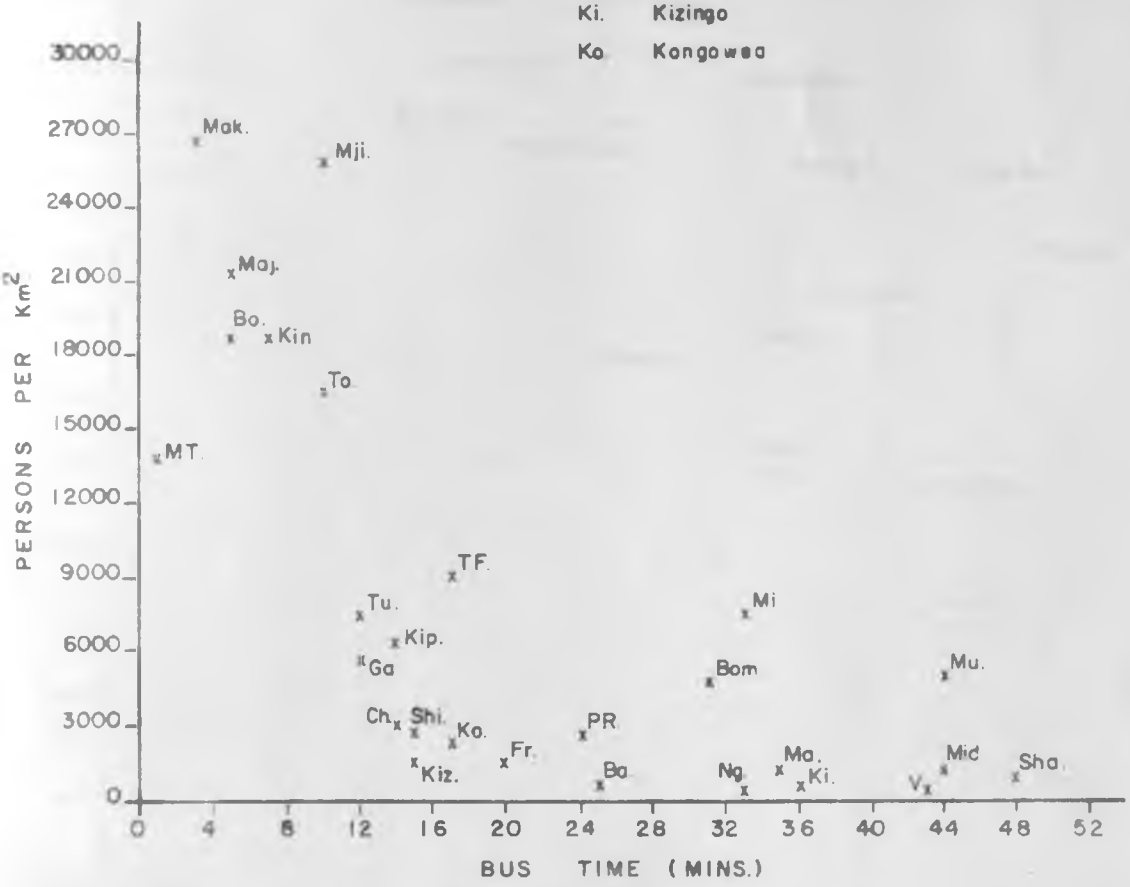


FIG: 15 RELATIONSHIP BETWEEN POPULATION DENSITY AND TIME-DISTANCE

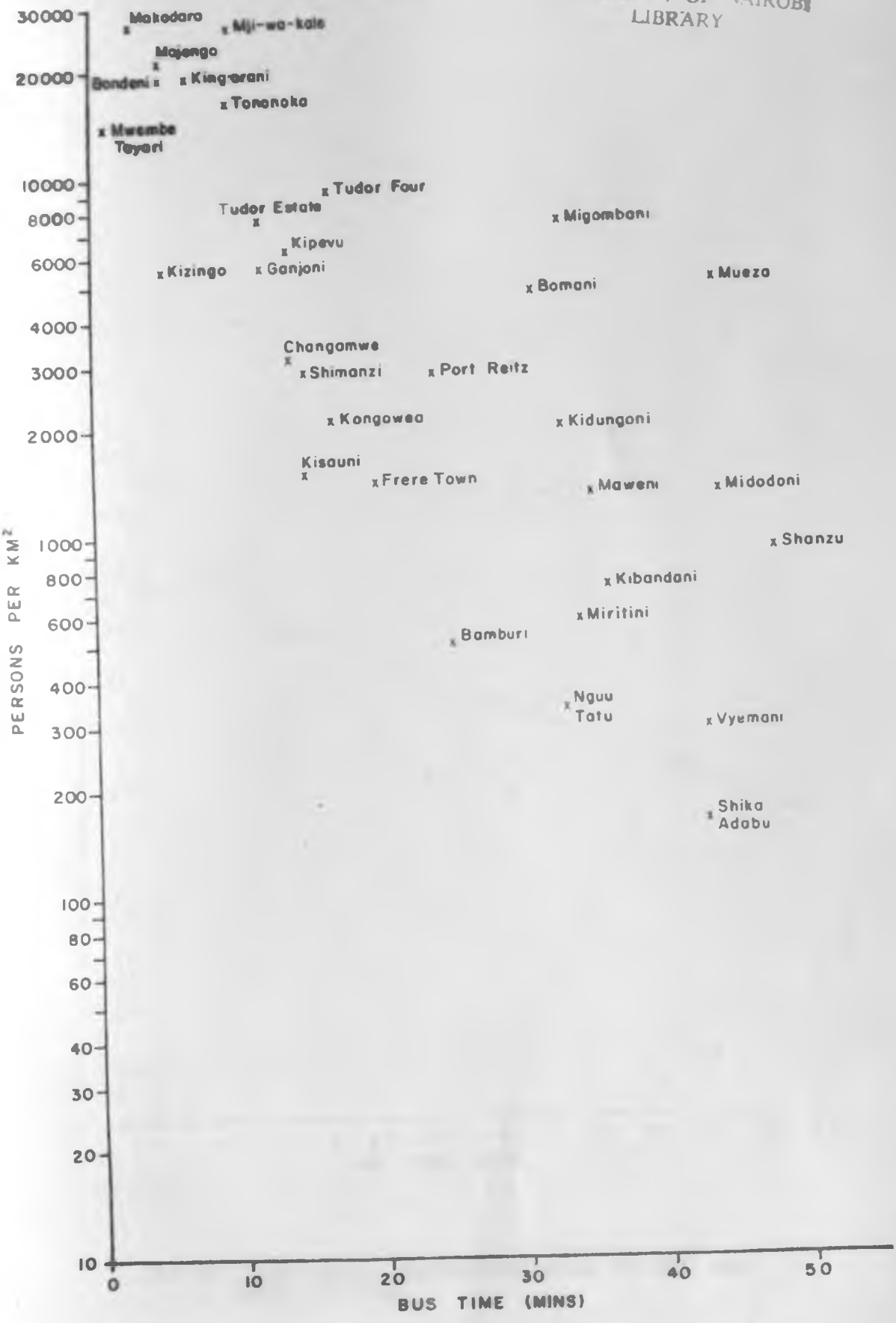


FIG.16 RELATIONSHIP BETWEEN POPULATION DENSITY AND TIME-DISTANCE

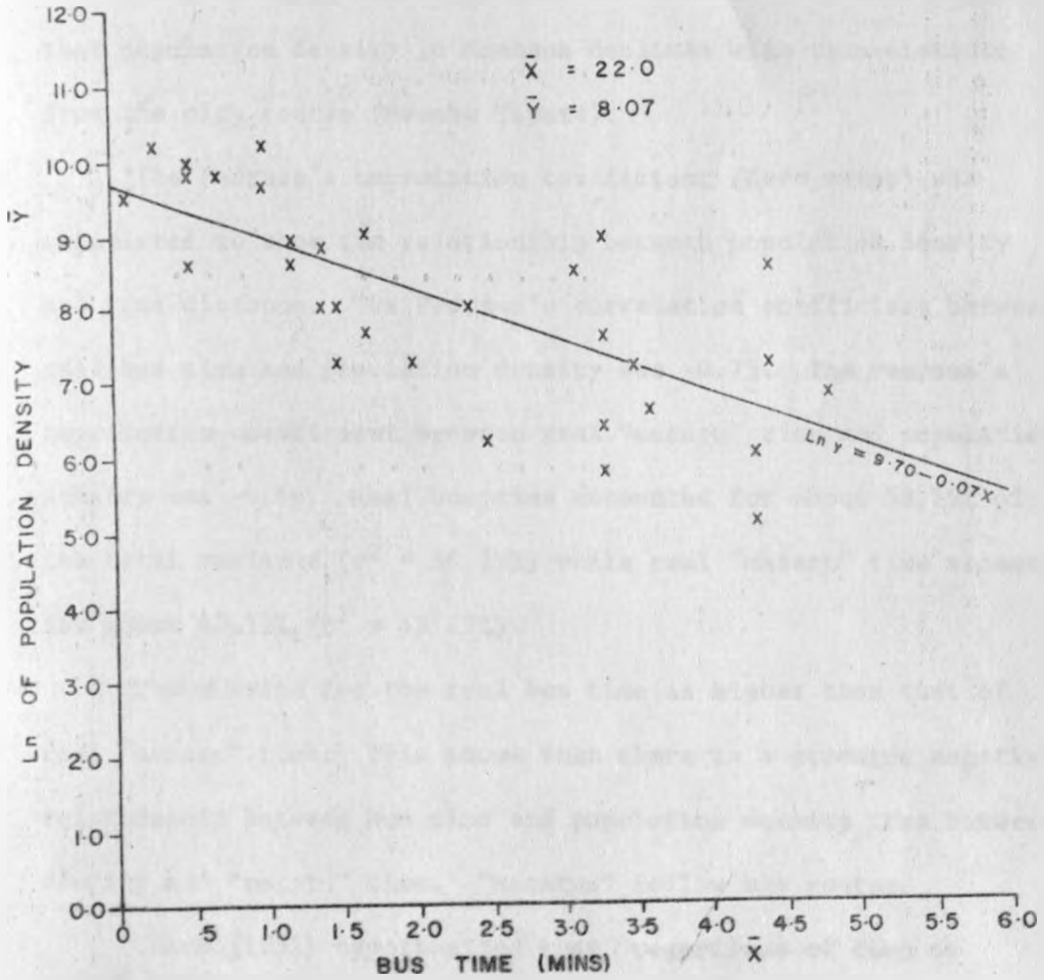


Fig 17. RELATIONSHIP BETWEEN POPULATION DENSITY AND TIME- DISTANCE.

This negative exponential function was found to exist in Mombasa when data was linearized using logarithmic transformation. The hypothesized negative exponential model is of the form: $d_x = d_o e^{-bx}$ The resulting equation for Mombasa after logarithmic transformation is:

$$\ln y = 9.77 - 0.79X$$

This model is similar to Clark function. It shows clearly that population density in Mombasa declines with time-distance from the city centre (Mwembe Tayari).

The Pearson's correlation coefficient (Zero order) was calculated to show the relationship between population density and time-distance. The Pearson's correlation coefficient between real bus time and population density was -0.75. The Pearson's correlation coefficient between real "matatu" time and population density was -0.66. Real bus time accounted for about 56.19% of the total variance (r^2 = 56.19%) while real "matatu" time accounted for about 43.13% (r^2 = 43.13%).

The r value for the real bus time is higher than that of real "matatu" time. This shows that there is a stronger negative relationship between bus time and population density than between density and "matatu" time. "Matatus" follow bus routes.

Clark (1951) hypothesized that "regardless of time or place the spatial distribution of population densities within cities appears to conform to a single empirically derived expression:

$$d_x = d_o e^{-bx}$$ (Berry et al, p.389).

But, Clark did not provide a theoretical rationale for such a negative exponential model, usually written as $lnd_X = lnd_o - bX$ (Ibid, p 390). The theoretical rationale for the existence of such a model is based on the urban land use theory. Each urban activity derives utility from a site in accordance with the site's location. Utility may be translated into the ability to pay for that site. Land prices diminish outwards and as they do regardless of other changes, land inputs will be substituted for other inputs and intensity of land use will diminish. Thus, declining residential densities should be expected. Many parts of the city are devoted to different residential land uses such as high class or low class residential areas. Land consumed by each household tends to increase with distance from the city centre. Hence, population densities decline.

B. FACTORS INFLUENCING POPULATION DENSITY STRUCTURE

The population density structure observed in Mombasa is influenced by a number of factors. This chapter attempts to to show the influence of transportation on density pattern. Other factors are also examined, for example, the age of the settlement, colonial policy, land use, proximity to the sea, availability of housing and other social amenities.

The regression residual map (Fig. 18) shows that areas well served by the municipal buses have generally higher population densities (Fig.18). This would seem to indicate that the spatial pattern of population distribution in the Municipal area is closely related to accessibility. The highest population densities occur on the Island because of its centrality. Enumeration units like Mwembe Tayari, Tudor Estate and Ganjoni on the Island; Timbwani on the South Mainland and Mbuyu wa Chapa, Port Reitz and Kipevu on the West mainland have low residual values indicating that travel time to the city centre is very important there.

The mean bus time from Mwembe Tayari to all the mid points of the enumeration units in the Municipal area is about 29.3 minutes. This shows that many enumeration districts are within half an hour's travel time to Mwembe Tayari using the Municipal bus. About 21 units are more than 29.3 minutes away from the city centre while 16 enumeration units are less than 29.3 minutes away from the city centre.

The enumeration units lying within 29.3 minutes travel time from Mwembe Tayari are the Tudor Estate, Tudor Four, Tononoka, Bondeni, Makadara, Mji-wa-Kale, Majengo, Mwembe Tayari, King'orani, Shimanzi, Ganjoni, Kizingo, Kisauni, Frere Town, Bamburi, Kongowea,

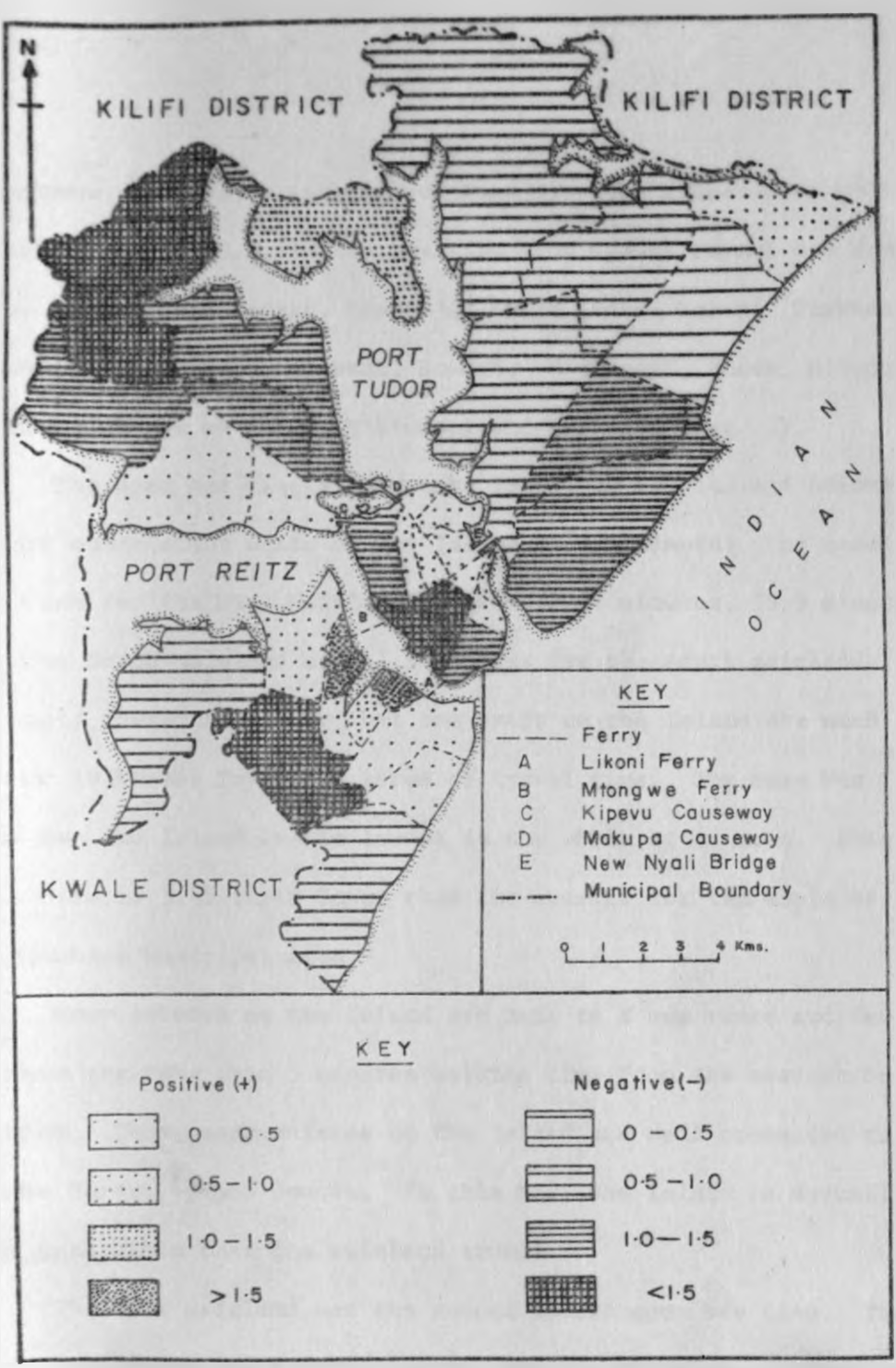


FIG.18 RESIDUAL MAP OF POP. DENSITY (LOG_e)

Changamwe, Port Reitz and Kipevu (Fig. 1). The enumeration units lying more than 29.3 minutes bus time from Mwembe Tayari are Nguu Tatu, Shanzu, Mwakirunge, Maunguja, Shika Adabu, Maweni, Timbwani, Vyemani, Kibandani, Migombani, Bomani, Kidunguni, Mueza, Midodoni, Mwandoni, Mbuyu wa Chapa, Mikindani and Miritini (Fig. 1).

The mean bus time from Mwembe Tayari to all the mid points of the enumeration units on the Island is 8.5 minutes, the mean bus time for the West Mainland areas is 28.7 minutes, 35.5 minutes for the North Mainland and 41.9 minutes for the south mainland. It would therefore appear that the areas on the Island are much closer to Mwembe Tayari in terms of travel time. The mean bus time for the Island is the lowest in the whole study area. This mean time is 3.45 times lower than the average for the whole of the Mombasa Municipal area.

Many estates on the Island are near to a bus route and few of then are more than 5 minutes walking time from the nearest bus station. Thus, many estates on the Island are well connected to Mwembe Tayari by bus routes. In this way, the Island is actually more accessible than the mainland areas.

The West mainland has the second lowest mean bus time. The time is close to the average for the whole study area. This seems to suggest that the West mainland too is well connected to the city centre by bus services. The West mainland is linked to the Island by two causeways namely, Makupa and Kipevu (Fig. 1). This good transportation link between the Island and the West mainland, has tended to encourage denser settlements on the west mainland.

The South Mainland is the least accessible area in the study area in terms of travel time. It has the highest mean time. It takes on average about 2/3 hour to get to any area on the South Mainland from the city centre. Such a long journey tends to discourage dense settlements and this area has the lowest population densities in the whole of the Mombasa Municipal area (Fig. 14). As has been observed elsewhere, the tendency of a population to concentrate may be based upon the concept "that the cost of any movement across space, measured either in terms of the time ... expended, increases with the length of the movement ..." (Amato, 1969, p66). Upto now, many Mombasa residents tend to avoid settling in the Likoni area of the South Mainland because of the poor travel time connectivity with the Island. Many people are afraid of the water since there is no permanent link here.

The importance of accessibility in influencing population distribution in Mombasa is obvious in remote and inaccessible areas such as the Nguu Tatu and Mwakirunge in the North Mainland as well as Mwandoni and Shika Adabu areas of the south mainland (Fig. 18). These areas are poorly connected to Mwembe Tayari. There are no bus services here and people have to walk for a long time sometimes even for half an hour before getting to the nearest bus station. Such inaccessibility has tended to discourage a dense population. These are actually some of the most sparsely populated areas in Mombasa. Their population densities are very low resembling those of the neighbouring rural areas in Kilifi and Kwale Districts (Fig. 1).

Although population densities are generally lower on the Mainlands, they are relatively high in the areas close to the Ferry at Likoni and Mtongwe (Fig. 1). Mueza has a very high residual value (Fig. 18) of +2.23. This is so mainly because of the proximity of the Mtongwe ferry. This essential transport facility enables a large number of people to cross to the Island quickly, thus, saving travel time. The Kilindini docks are very close and offer employment to a large number of people. Since Kilindini Port is an important employment centre, many workers like to live near the place of work. Other estates near Likoni ferry like Migombani, Bomani and Kidunguni have positive residuals due to easy access to the Island provided by the Likoni ferry (Fig. 1).

The age of the settlements also determines population density structure. Mji-wa-Kale and Makadara have high population densities because they form the nucleus or the origin of the town. The two areas form what is today called the Old Town (Fig. 1). The Old Town was inhabited as early as the beginning of the 20th Century or even earlier. By A.D. 1900, the settlement began to spread in all directions of the Island. As years passed, densities continued to rise in the Old Town.

As more and more people poured into the Island from the Mainlands, new dwellings sprang up outside the Old Town. New development took place along a S.E. - N.E. axis. One of the crucial arteries, Jomo Kenyatta Avenue (Makupa Road) ran and still runs in this direction, providing a link to the mainland. African housing first developed along this road. This formed the basis for the

development of Tononoka, Mwembe Tayari and Majengo estates (Fig. 1). These estates today are densely populated.

In the 1920's population began to shift away from the Old Town. This trend was further accelerated by the advent of the major town planning scheme in 1926. Many Indian merchants abandoned the Old Town to settle along the Jomo Kenyatta Avenue (Makupa Road) and Digo (Salim) Road after the institution of the town planning scheme. It was the African community which contributed most to the urban sprawl by dispersing in a northerly direction. In 1928, the drift of the population to the mainland was continuing.

Even after the construction of the Old Nyali Pontoon bridge (1929) and Makupa Causeway (1930), the vast majority of the population (about 75%) of the Municipal area, preferred to live on the Island rather than the mainland. But, the construction of the two bridges did stimulate some development at Changamwe and Kisauni in the form of houses, shops and the secondary industries (Jan Mohammed, 1977, p275). This tended to attract higher population densities.

The type of the land use plays an important role in influencing population density in Mombasa. Mwembe Tayari, Bondeni and some parts of Ganjoni form the CBD. In these areas, commercial land uses such as retailing and hotels, dominate. Residential land uses occur much farther from the CBD. Since commercial land uses are concentrated in the city centre (CBD), population densities here are low. A few Indian businessmen live on the upper floor of their shops within the CBD.

Industrial land use is a very important factor influencing the pattern of density in Mombasa. Major industrial districts like Shimanzi, Bamburi, Changamwe and Miritini (Fig. 1) have relatively low densities. This is so because industrial activities occupy the space for residential purposes. For instance, the oil refinery at Changamwe covers a lot of space that could be used for residential purposes, hence low densities in this area. At Shimanzi on the Island, a lot of space is occupied by warehouses, storage sheds and factories. So, there is little or no space for residential land use.

Another important land use that has influenced population density structure in Mombasa is the Kilindini Harbour. This harbour has profoundly influenced the growth of Mombasa. Growth which for many centuries was confined to the Old Town and Old Port (Fig. 18), was shifted to the Western side of the Mombasa Island following the development of the new Port at the end of the 19th Century. A large number of industries such as ship repairing are located here and estates were planned in such a way that they would provide cheap labour at the docks. This led to the development of majengo and King'orani. These areas, together with Port Reitz and Kipevu contain a relatively dense population.

Agricultural land use dominates inaccessible areas of Mwakirunge and Nguu Tatu areas of the North Mainland, Mikindani on the West Mainland and the Mwandoni and Shika Adabu areas of the South Mainland (Fig. 18). These areas have low residual values. Nguu Tatu has a residual value of -1.36, Mwakirunge and Shika Adabu

both have residual values of -1.28 while Mwandoni has a residual value of -1.02.

Due to the inaccessibility of these areas from the city centre, agricultural land use is the main economic activity of the people here. Agricultural land use tends to reduce population density. Population densities in Nguu Tatu, Mwakirunge, Shika Adabu and Mwandoni are very low. Nguu Tatu has a density of 329 persons per square kilometre (3.29 persons per ha.), Mwakirunge has a density of 74 persons per square kilometre (0.74 persons/ha.), Shika Adabu has 16.2 persons per square kilometre while Mwandoni has the lowest density with only 40 persons per square kilometre (0.40 persons/ha.).

These density figures are quite low compared with the average density of the whole Mombasa Municipal area. The average density for Mombasa is 1622 persons (162.2 persons/ha) per square kilometre. Besides inaccessibility, these areas have large plantations of coconuts and cashew nuts. In such plantations, population density must be low (Plate 5). In other areas, few people live in small houses. In these areas, population densities are similar to those in the rural areas where settlements are scattered.

Colonial influence played an important part in influencing density structure. Lack of space did not permit the creation of many racially segregated estates such as in Nairobi. African and European estates were built close to each other. However, some areas on the Island and the North Mainland, were set up for Europeans.

Due to Mombasa's coastal location, no part was higher and cooler than the other to attract European settlement (Kinoti, 1980). But, areas with a sea frontage, proved attractive to European settlement. Such estates are Kizingo and Tudor on the Island and Nyali on the North Mainland (Fig. 1). These were big garden estates covering about 0.4 hectares or more. These were classified as high class-low density areas.

However, areas set a side for Africans like Majengo and King'orani, are today densely populated. These areas were set up during the colonial times to settle railway and dock workers who mainly came from upcountry areas like central and western Provinces of Kenya. In the course of time, these areas have become densely populated.

Sea frontage is also very important in determining density in Mombasa. Due to its coastal location, Mombasa like other tropical towns is hot all year round. However, areas near the sea, are cooler due to the influence of the cool sea breeze during the day. Sea shores attract denser populations. During the colonial times, areas with a sea frontage were mainly inhabited by Europeans. Estates like Kizingo and Tudor on the Island, and Nyali on the North Mainland were some of these attractive areas. Timbwani on the South Mainland has a sea frontage too. Apart from tourist class hotels on the Shelly Beach, the African communities live and cultivate along the shoreline to take advantage of the sea frontage. Alonso (1964, p167), found out that micro-climate like the sea breeze had a big impact

on urban structure especially in the warm tropical lands.

Unplanned settlements or squatter settlements too, affect population density structure. Squatter settlements are buildings or structures illegally put up in an area particularly by the low income group. These low income group are usually the people without any formal or wage employment. Majority of them are engaged in informal sector activities like selling wood carvings and tea in the streets. According to the estimates of the Planning Department of the Mombasa Municipal Council, the number of occupants in each room is on the average of 6 or more people. The rooms themselves are very tiny. So, there is overcrowding.

The squatter settlements exist on the Island in places such as Majengo, King'orani, Tononoka, Mwembe Tayari and Old Town (Fig. 18) on the Island and in Mikindani and Chaani (Changamwe) on the West mainland and Likoni area on the south mainland. These settlements occur as a result of inadequate housing in the town following an increase in population as well as the nature of land ownership. Many Municipal authorities in Kenya today, including Mombasa face a major financial constraint. Lack of adequate funds have meant that the Municipal authorities cannot adequately provide cheap housing for every one. Since majority of the town's population are poor people who cannot afford to pay for high house rents, they improvise their own housing. Hence, the predominance of the squatter settlements in the study area.

Most land in Mombasa is privatel
has therefore been difficult. No ten
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from time to time. Thus, Municipal Council policies like housing and Zoning regulations, affect density pattern in Mombasa.

Availability of essential social services like education and health, coupled with public utilities like water and electricity, also influence density structure. The South Mainland has no single secondary school while the West Mainland has only one secondary school. Most Primary and Secondary schools are situated on the Island. People tend to live on the Island because of the availability of educational facilities for their children.

There are many other factors that determine population density such as the desire for privacy for the high income groups, environmental pollution and nearness to Golf or other recreational facilities. The factors are many and cannot all be discussed here.

Wheeler and Thomas (1973) stressed the importance of urban transportation in influencing urban structure. From their study, it would appear that road transport is an important factor in determining the spatial pattern of urban population distribution. Third World countries are experiencing rapid urbanization with rising urban populations. In Kenya, in 1979, the total urban population was about 2 million people, accounting for about 13% of the total population (Population Census, 1979). The increase in urban population is due to the natural increase as well as to rural-urban drift. The two main destinations of rural immigrants are Nairobi and Mombasa. These are the two biggest towns in Kenya and both are rapidly growing industrial centres. They attract many job seekers from the rural areas.

Rapid population growth in urban areas had led to many social and economic problems. Unemployment in urban areas has been increasing every day leading to poverty for many people. At the same time, there has been inadequate housing, public transport, schools, hospitals and water supplies. The basic infrastructure and essential social services are now strained and further population increase would lead to a decline in living standards.

An understanding of the urban population density structures and the influences affecting the structures is essential to enable urban planners to allocate adequate facilities according to the needs in various parts of the town. This would be important in order to achieve equity and to promote living standards.

Squatter settlements such as Majengo carry high population densities. These areas need redevelopment. Houses need to be improved in order to provide a decent habitation. More and better services need to be provided in these areas such as education, health services as well as adequate water supplies.

It has become a serious problem in urban areas of the Third World to control rural-urban migration. Any improvements in housing, education, and wage structures in urban areas have attracted more immigrants from the rural areas. To reduce this rural-urban migration, rural development programmes should be initiated. Emphasis of rural or urban development alone might not help much in solving the problems posed by the rural-urban migration. Urban and rural development should be integrated. Development should be taken to where people are. Improvement of housing and the increase of job opportunities in the urban areas while poverty and squalor prevail in some rural areas does not solve the problem of rural-urban migration.

The density function for Mombasa is negative exponetial too showing that population density declines with time distance from the town centre. As shown in Figure 14, highest density occurs near the town centre, a radius of about 8.5 minutes. On the Mainlands, the population density declines very rapidly. This is because of the influence of physiography on road links between the Island and the Mainlands.

It can be concluded that population density gradient in Mombasa declines with time-distance from the town centre as hypothesized and the density function is influenced by several factors some of which were not possible to investigate due to lack of time.

CHAPTER 6

TRAVEL PATTERNS IN MOMBASA

A. SPATIAL STRUCTURE OF TRAVEL PATTERNS

Travel Patterns like the land values and population density already discussed, form a good indicator of the urban structure. Travel Patterns in the urban areas of both the developed and the less developed countries are complex and are influenced by many factors. Individuals in urban areas make decisions to move about and the combination of these decisions make a travel pattern. Travel patterns within the cities of the developed countries are often different from those in the Third World cities. This seems to suggest a difference in the urban structure of the cities in the developed and the developing World. Such a study is worth investigating in order to adequately plan for urban development in the Third World, of which Kenya is one.

This chapter attempts to describe and explain the spatial structure of travel patterns within Mombasa and a comparison of travel patterns observed in Mombasa and those in industrialized cities. The spatial structure of travel patterns is related with time-distance. The number of the individual trips is related to the time-distance by bus. The Zero order (r) and the first order correlation coefficients ($r_{01.2}$) and the coefficient of determination (r^2) are obtained and interpreted. The residual maps

are drawn and an explanation of their patterns attempted.

In this study, data from the sample survey carried out by the author as well as the Mombasa Transportation study were used. Data obtained in the sample survey were compared with the Norconsult data.

The data obtained in the sample survey carried out by the author included ethnic and cultural background, age structure, number of people working, place of work, residence, number of personal trips, trip purpose and mode of travel.

Data on ethnic origin of the people interviewed in the CBD was essential to show whether rural-urban migration was a major factor accounting for travel patterns observed. The analysis of data on the ethnic origin of the samples revealed several features. These features are shown on Table 7.

Table 7: Ethnic and Cultural Profiles of Respondents

Ethnic Groups	No. = 196	%
Central Kenya Bantu (Kikuyu, Kamba)	62	31.6
Coastal Bantu (Digo, etc.)	47	24
Western Bantu (Luhya,etc.)	11	5.6
Nilotics (Luos)	19	9.7
Asians (Indians, Arabs)	5	2.5
others/non-response	52	26.6

Source: Field work

Table 7 shows that a large number of rural immigrants came to Mombasa to seek work, to do business and so on. The travel characteristics of such immigrants from upcountry, are likely to be slightly different from those of the original residents of Mombasa.

Table 8 shows the main modes of transportation used by the people in Mombasa. From the table it would appear that walking is still a very important mode in Mombasa.

Table 8: Modes of Transport (N=196)

Mode	%
Walking	25.5
Bus	12.8
Matatu	7.1
Buses/matatu	25.5
Others (cycles)	6.7
Non-Response	22.4

Source: Field work

Due to long distances existing between some residences and work places, walking is not always possible within reasonable time. So, at times people will increasingly use and rely on the "matatu" and the buses. "Matatus" and the buses are used more at the end of the month when workers have their pay. At the end of

the month in Mombasa is the period of peak demand for travel.

The importance of walking in Mombasa was also observed by the Norconsult study (1972-74). According to this study, 61% of the home based trips were made on foot. (Table 9).

Table 9: Distribution of Trips by Mode

Mode	% of Total trips
Walking	61
Car	18
Bus	14
Cycle	7
Others (Matatu)	Not available
Total	100

Source: Norconsult et al, 1972-4, Vol.1, p.2

Walking is a major form of transportation in many cities of the Third World. Many people travel on foot in Mombasa like in many other Third World cities because of poverty. Many people are too poor to afford to buy a car or to ride a bus.

Car ownership tends to reduce the number of trips made on foot, by bus or bicycle. But, due to the increasing cost of fuel such as petrol, it is likely that the car will become less attractive and more riders may use the "matatu" or the bus.

The Kenya Bus Company in Mombasa has introduced newer and faster buses. Increased speed of the buses coupled with increasing cost of the car maintenance, have tended to make public transportation more attractive. For a long time, the Kenya Bus Company in Mombasa had the sole monopoly of ferrying passengers within the town. Today, the Bus Company faces a stiff competition from the "matatus". This competition has reduced the relative importance of the bus in Mombasa as some potential riders now travel by the "matatus".

Mombasa Island accommodates a large percentage of the total people living in the Mombasa Municipal area. Table 10 shows the place of residence for the people interviewed in the CBD. Most people reside on the Island because of good transportation.

Table 10: Place of Residence (% of the Total Sample) N=196

Island	31.6
North Mainland	23
South Mainland	15.3
West Mainland	13.8
No response	16.4

Source: Field Work

Table 11 shows the working places of the people interviewed. This was necessary to show the main employment centres.

Table 11

Working Place	% of Total Sample (N=196)
Island	62.8
West Mainland	2.6
North Mainland	2.6
South Mainland	7.0
No response	31.1

Source: Field work

From Table 11, it would appear that most of the people interviewed worked on the Island. Those working in other places accounted for a relatively small percentage of the total sample. The interviewing was done on the Island. It is likely that since interviews were held here, the percentage of the people working on the Island would be slightly higher. But, it is unlikely that the pattern would be different even if household interviews were held because most employment at the moment is concentrated on the Island.

Working is the main trip purpose in Mombasa. Table 12 shows the distribtuion of trip purposes of the samples.

Table 12:	Trip Purpose	%
N=196	Working	44.4
	Business	16.8
	Schooling	5.6
	Others (recreation)	12.7

The destination of a trip, the mode of travel, the time of the day when trip is made and the distance one is willing to travel depend to a large extent on the trip purpose. Table 13 shows the distribution of trips by purpose according to the study carried out by Norconsult (1972-74). The results of the Norconsult study revealed that working and schooling were the most important trip purposes in Mombasa. Table 12 based on the author's field work data, shows a similar pattern where work is again the main trip purpose.

Table 13: Trip Distribution by Purpose N=196

Purpose	% of total trips
work	29.6
school	17.6
others (business)	9.6
Non-home based	42.2

Source: Norconsult et al, 1972-74.

According to the Norconsult study, 50% of the home-based trips are to and from work, and 1/3 of the home based trips are to and from school. Trip purpose is closely related to the mode of travel (Omar, 1977) such as car availability. For families with cars, work trips constitute 43% of all home based trips while for car less families, work trips from 55% of all home-based trips. Car owners can make non-essential trips such as recreation or social visits because of increased mobility provided by the car.

Car-less people are highly immobile. These people can manage to make essential trips such as working or schooling.

Young people are mobile because they are strong. These are the ones looking for work. The young and energetic people can travel long distances looking for work. This study showed that the majority of people interviewed were aged between 16 and 30 years. This is shown on Table 14.

Table 14: Age Structure of People Interviewed (N = 196)

Age (Years)	Percentage
11 - 15	1.5
16 - 20	24
21 - 25	27.6
26 - 30	19.9
31 - 35	8.7
36 - 40	5.6
41 - 45	4.6
46 - 50	1.0
> 50	7.1

Source: Field work

It is likely that the travel behaviour of the young may be different from that of old people. This kind of finding is important because of the growing need to cater for transportation demands of the aged and the disadvantaged. When travel characteristics of such people are well known, Urban Planners and engineers can plan adequately to cater for the needs of such people.

B. FACTORS INFLUENCING TRAVEL PATTERNS IN MOMBASA

In the Third World cities, the friction of distance is great due to the inadequacy of public transport, low level of car ownership, poor nature of roads and increasing urban sprawl making journey time longer. Analysis of the relationship between time-distance and the number of personal trips in Mombasa show a clear distance-decay function. But, the Pearson's correlation coefficient (r) and the coefficient of determination (r^2) values are low indicating that other factors not measured are equally important. These factors are also explored.

Figure 19 shows that the number of trips decline with distance from Mombasa centre. But, the relationship between the number of trips and time-distance is curvilinear and not linear as expected. To carry out the regression analysis to show whether time-distance and trips are positively or negatively related, the raw data is linearized using the natural logarithmic transformation (Fig. 20). Both the semi and the double logarithmic functions are applied to find out which is a better function. When data is normalized using the natural logarithmic transformation, linearity seems to exist between the $\log_e$ of trips and $\log_e$ of the bus and "matatu" time. The results show that the double logarithmic model seems to be a better fit. (Table 15). This table shows a summary of the simple correlation coefficients (r), coefficient of determination (r^2) and b values produced when regression analysis is carried out.

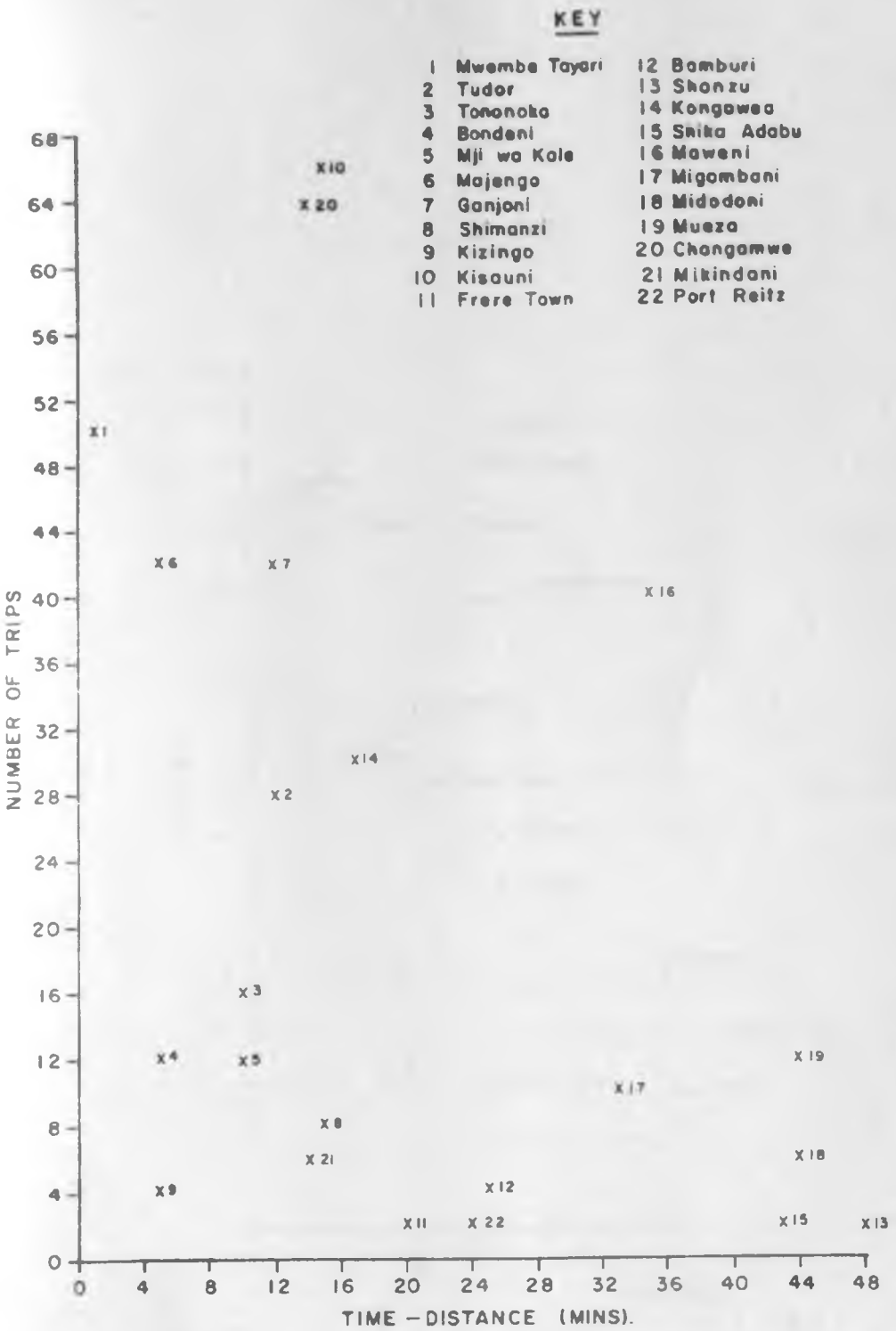

FIG. 19 RELATIONSHIP BETWEEN PERSONAL TRIPS AND BUS TIME.

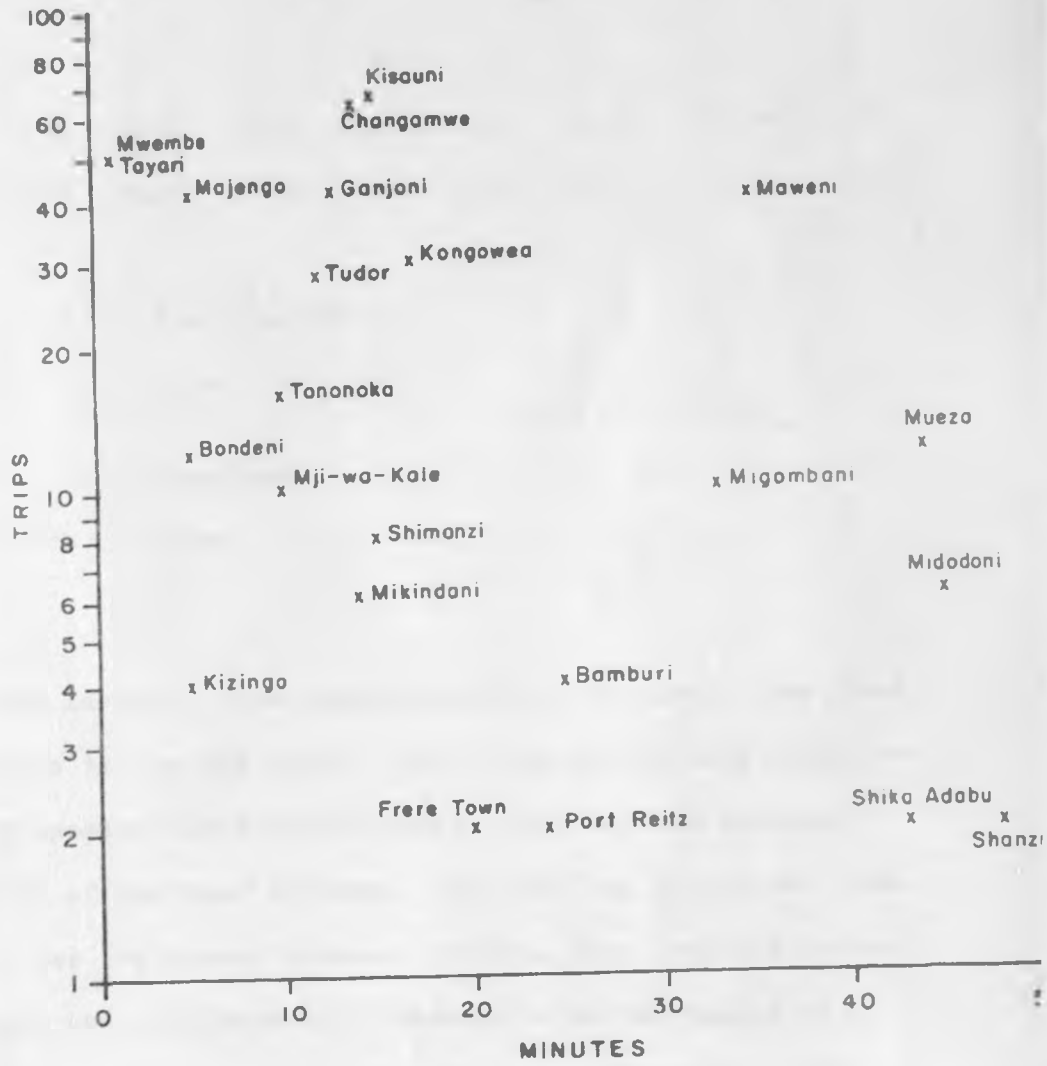

FIG. 20 RELATIONSHIP BETWEEN LOG_E OF TRIPS AND BUS TIME

Table 15: Summary of Correlation and b Values

Mode	r		r^2		a		b	
	1	2	1	2	1	2	1	2
Bus	-0.46	-0.44	20.9%	19.1%	3.22	3.98	-0.038	-.57
Matatu	-0.42	-0.46	17.8%	21.4%	3.12	4.0	-.04	-.62

1 - Semi log model

2 - double log model

a - intercept

b - slope

From table 15, three main observations are made. The first observation is that the simple r and r^2 values for both modes are low. It appears that time-distance by real bus time explains only 20.9% of the total variance. Only the $\log_e$ of "matatu" time accounts for the highest variance (21.4%). But, this too is low. This shows that trip pattern in Mombasa is not influenced by time-distance alone. The Principal factors affecting the rates of the personal trip production are the car and family incomes. Persons with a car generate an average of 1.46 trips per day compared with 0.14 trips per day for the car less (Norconsult, 1973).

Those people with a high income too 1 produce nearly twice as many trips as families in the lowest income group. In Mombasa,

the lowest income group in 1972 earned less than 300 Kenya shillings per month, while the higher income group earned about 1200 Kenya shillings per month during the same period. It would appear that friction of distance apart, the car and income levels are the major factors influencing trip generation and distribution in Mombasa.

Trip purpose is also important in trip generation. People are usually willing to travel long distances taking even half an hour or more for essential trips like working or schooling.

The second observation made by looking at the table is the double logarithmic function appears to be a better fit. This model is of the form:-

$$\ln y = \ln a - b \log X$$

In the case of Mombasa, the equation is:

$\ln y = 4.0 - 0.62 \log X$. This model gives a higher r value of -0.46, a higher percentage of explained variance (r^2) of 21.4% and a steeper b coefficient of -0.62. In this analysis, the $\log_e$ of "matatu" time has a stronger negative relationship with $\log_e$ of trips.

A third observation made from Table 15 is that although it was anticipated that real bus time would have a higher r value than real $\log_e$ of "matatu" time, it was found out that the "matatu" time had a stronger negative correlation with the number of trips. This is possible because of the frequency of the "matatu" service. The number of trips made depends on the frequency of

transport mode. The "matatus" make many trips per day because they do not have scheduled times like the buses. The "matatus" have the advantage of saving travel time for passengers.

Figure 21 shows the regression line or the line of the best fit. The line shows the accuracy of the time-distance in predicting the number of personal trips.

By means of this regression line, residuals are calculated and mapped in Figures 22 (a) and 22 (b). Figure 22 (a) is the residual map of $\log_e$ of trips and bus time while Figure 22 (b) is the residual map of $\log_e$ of the trips and $\log_e$ of "matatu" time. The two residual maps are almost similar although Figure 22 (b) is more informative for it is based on a better model.

From the two residual maps, the main travel patterns can be deduced. The most accessible point in the whole town is Mwembe Tayari. The surrounding enumeration districts, Mwembe Tayari is equally accessible from other districts for virtually all transport routes in the town converge here. Since Mwembe Tayari area is close to the city centre, it would be expected that the number of personal trips made to the city centre would be more. This is the pattern shown in Figure 22 (a). People living close to the city centre may take more trips to the city centre for different purposes such as work, shopping and so on. These people do not need to wait for a bus or "matatu" for they can walk.

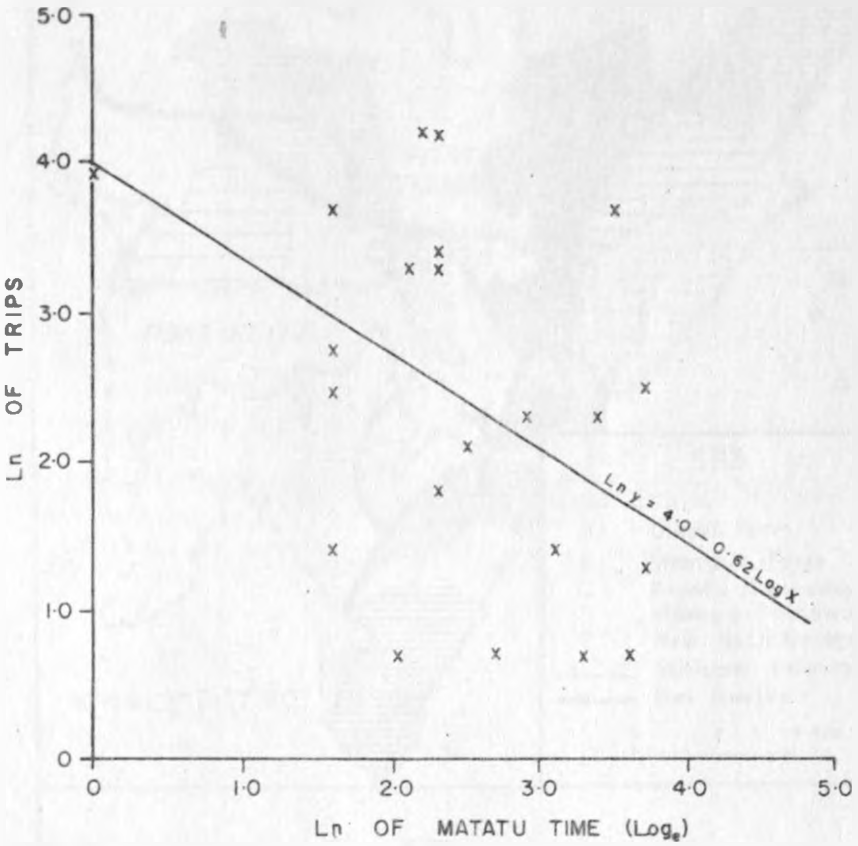

FIG: 21 RELATIONSHIP BETWEEN TRIP AND TRAVEL TIME

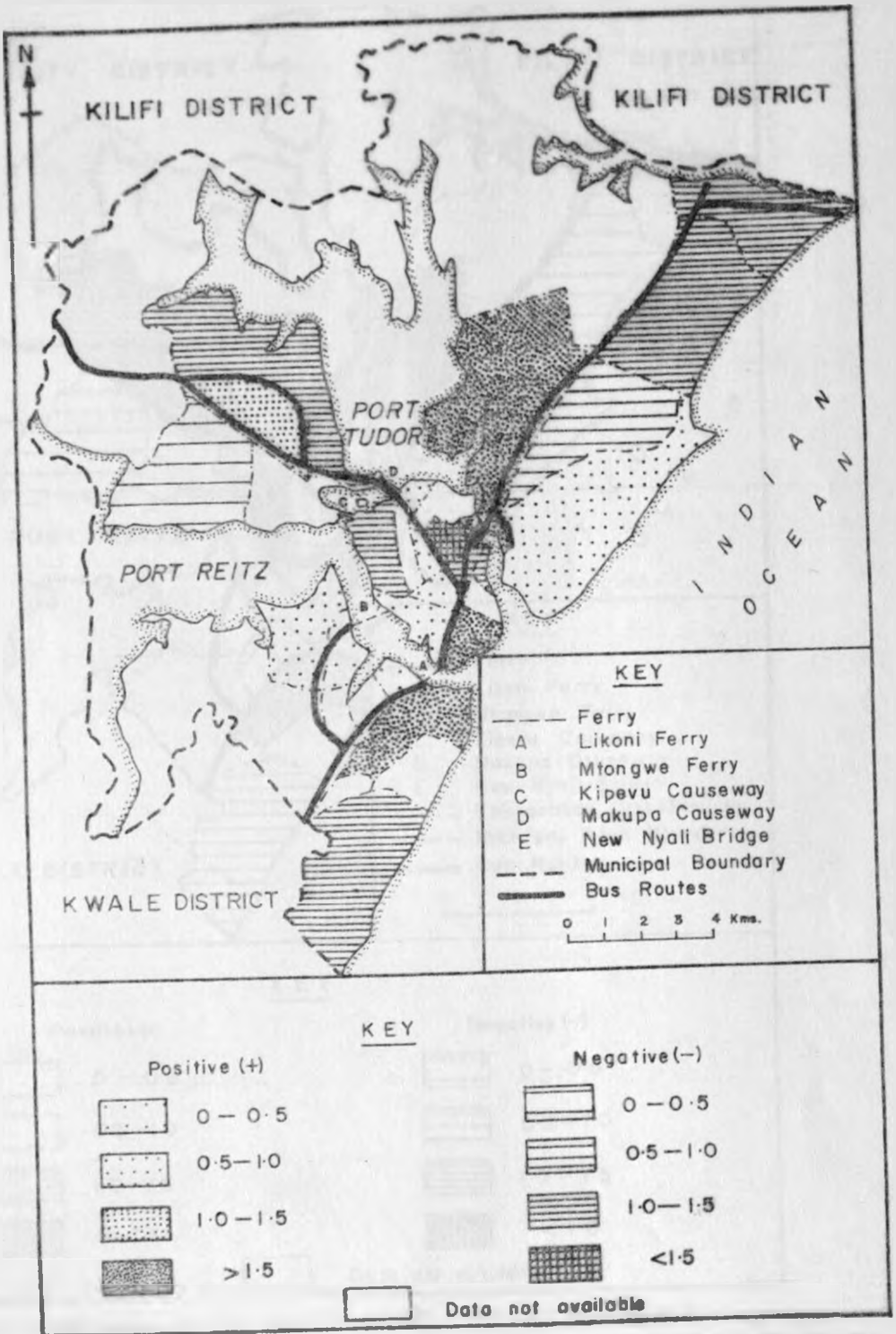

FIG. 22(a) RESIDUAL MAP OF TRIPS(LOG_e OF BUS TIME)

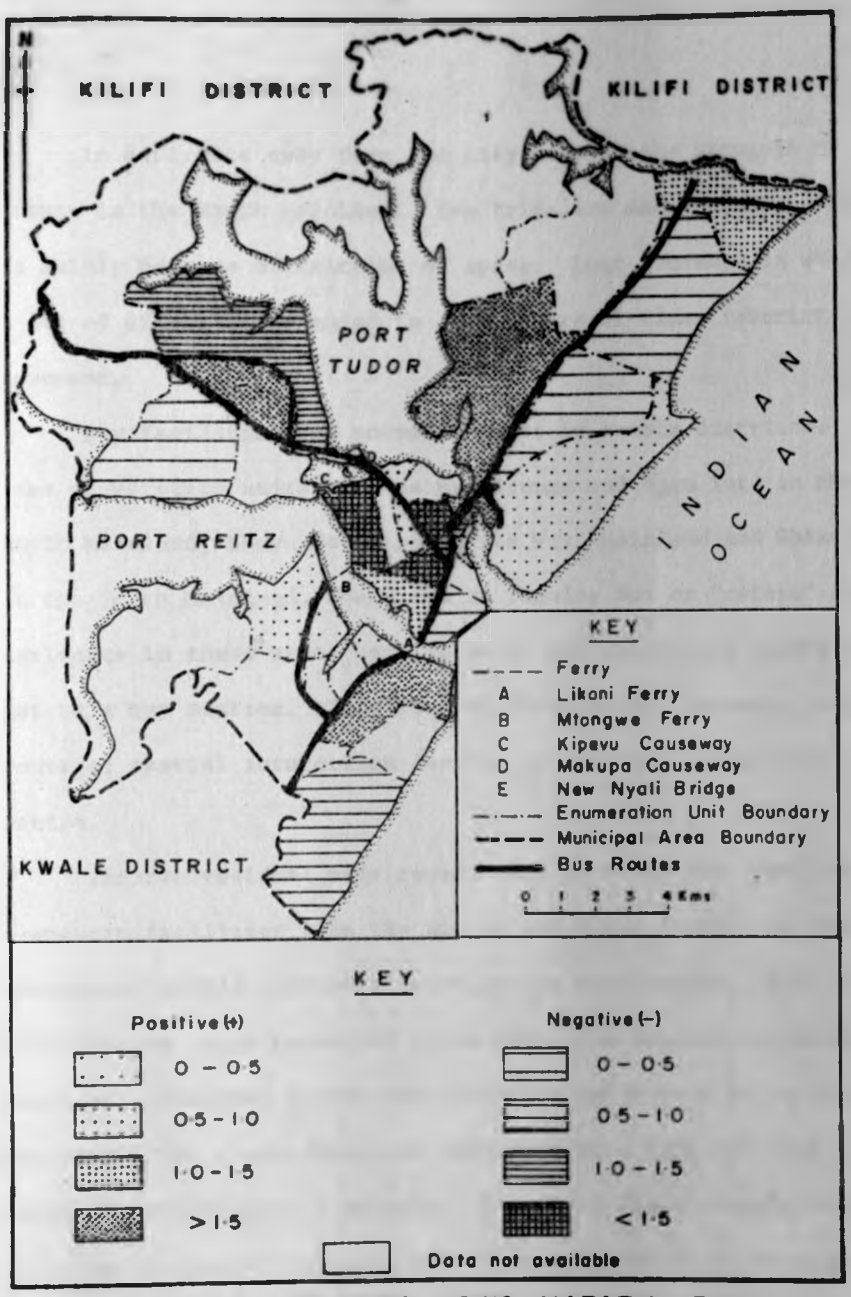

FIG. 22b RESIDUALS OF TRIPS USING MATATU TIME

In districts away from the city centre like Maunguja or Shanzu in the North Mainlands, few trips are made per day. This is mainly because of friction of space. Long journeys in which a lot of effort is expended in form of travel time, restrict movement.

Few facilities for movement exist in remote districts. In some enumeration units such as Mwakirunge and Nguu Tatu in the North Mainland, Mbuyu Wa Chapa in the West Mainland and Shika Adabu in the South Mainland, there are no regular bus or "matatu" services. Residents in these areas have to cover long distances before they get to a bus station. This lack of facility for movement discourages spatial interaction leading to few trips made to the town centre.

The two residual maps reveal that in areas with good public transport facilities like the bus or any other facilities like the ferry, people make more trips to the city centre. This is shown by the large number of trips made from Kisauni in the North Mainland, Changamwe in the West Mainland and Maweni in the South Mainland. The three districts mentioned have high positive residuals reaching +1.5 or more. People in these areas make many trips per day mainly because of the high degree of accissibility of these districts to or from the city centre. These areas are the best served by buses and "matatus" in Mombasa.

A high speed bridge allowing fast movement of traffic has been opened to link Kisauni with the Island. This is the New Nyali Bridge. The opening of this bridge has brought places in Kisauni much nearer to the Island in terms of travel time. Reduction in journey time might be one main reason why many trips are made to

the city centre from Kisauni.

The West Mainland is linked to the Island by a causeway, the Makupa Causeway. This cause-way allows fast movement of vehicles and people to and from the Island. The Likoni area is linked to the Island by a ferry. The ferry permits people to cross to and from the Island. The facility enables people to make more trips to the city centre than would otherwise be the case.

In enumeration units near to the important employment centres, the number of trips made to the city centre is small. This is possible because the people living these prefer to work near their place of residence than travelling long distance to work in the city centre. This applies to Port Reitz close to Kilindini Harbour which offers a lot of employment.

There is a very strong correlation between the bus and the "matatu" time. So, both factors could not be used in Multiple regression analysis due to their Multi-colinearity. To measure the effect of time-distance by bus on the number of personal trips holding other factors constant, partial correlation analysis was carried out. The results show bus time controlling for "matatu" time, accounts for a higher variance than "matatu" time. Table 16 shows the results of partial correlation analysis holding the "matatu" time constant.

Table 16: Partial Correlation Coefficients

Mode	r(real time)	$r_{(\log_e \text{ of time})}$
Bus	-0.215	-0.192
Matatu	-0.05	0.03

This chapter has attempted to show the relationship between time-distance by bus and the number of personal trips made towards one destination, the city centre. "Matatu" time was included in the analysis for comparison purposes. The hypothesis advanced and tested in this chapter is that the number of personal trips decrease with increasing time-distance from the city centre. This hypothesis was found to be valid to some extent. But, r values were low indicating a possibility that other factors not examined in the study were important.

CHAPTER 7

CONCLUSION

1. SUMMARY OF FINDINGS

Few studies exist that show the relationship between urban transportation and urban structure in the cities of the Third World. The present study has examined the relationship existing between urban transport and urban structure at a micro-scale or local urban centre level. Similar studies in the past were macro-scopic in nature involving all or several of the cities in a given country. This study has been undertaken because today, people in the Third World are becoming more and more concerned with the spatial organization of development (Leinbach, 1975).

One of the most critical problems is the tendency for extreme economic Polarity as investments flow towards well established core region centres. The imbalance may be reduced or prevented by creating new investment opportunities in peripheral areas or by altering the configuration of channels through which information, people and commodities move. Such strategies of regional development must utilize the transportation system as a mechanism for re-organisation.

Janelle (1969) introduced an important concept of Time-space convergence whose relevance in the developing world is great. Transport improvements are taking place rapidly with a lot of impact on the space economy. This study has related time-

distance with the three main space characteristics, namely, land values, population density and the number of personal trips. The study examines the impact of travel time on the urban economic geography of Mombasa.

The study involved:

a) A detailed time-distance analysis of the Mombasa road network using bus time. The "Matatu" time was used for comparison purposes. This was in order to find out which of the transport modes has a greater impact on urban structure and development. Data on bus time were obtained from bus time-schedules and cross checked by field surveys.

b) An explanation of the effect of travel time on the spatial characteristics. The study achieved three main objectives:

i) It attempted to establish the relationship between time-distance and land values. Time-distance was measured from Mwembe Tayari and land values were obtained for all the 37 Enumeration units in the Mombasa Municipal area. The nature of the land value gradient was then determined in the study area.

ii) It attempted to establish the relationship between time-distance and population density measured from Mwembe Tayari. Data on population density was obtained from the Kenya Population Census, 1979. The study examined the nature of population density function in Mombas

measured from a central point and measured at a given point in time (1979). The study did not establish the nature of density functions over time due to lack of bus time data. The Kenya Bus Company (Mombasa) did not have data for previous years such as 1969.

iii) It attempted to establish the relationship between time-distance and the number of personal trips to the CBD measured from Mwembe Tayari.

These three objectives were achieved by means of field research, use of questionnaires and the application of regression analysis and mapping techniques. A distance-decay function was hypothesized throughout the study. An inverse relationship between the independent variable (time-distance) and the 3 dependent variables, namely, land values, population density and trips was expected to obtain. A negative exponential relationship was anticipated.

1. (A) RELATIONSHIP BETWEEN LAND VALUES AND TIME-DISTANCE

An assumption basic to classical and neo-classical land value theory is that land values decline with distance from the city centre. Locations away from the city centre incur greater transport costs and thus land values decline with distance away from the city centre. But, this theory does not apply very well in Third World colonial cities without modifications. The urban land market is very imperfect with a lot of institutional intervention

such as the Municipal Council Zoning regulations and so on. This theory is based on a Western capitalist concept where the "invisible hand of Adam Smith" operates in the allocation of scarce resources. Free enterprise assumes that every one is in the urban land market. But, this is not always true.

A scattergram of time-distance by bus with land values in Mombasa produced a curvilinear curve indicating that land values decline with time-distance although the nature of the relationship was non-linear. Many researchers believe that the value gradient is linear in form declining at a constant rate with increasing distance (Kms or minutes). But, the linear curve gives the impression that at the urban periphery, land is valueless or is negative. It also assumes the value gradient is uniform throughout the city. Alternative and somewhat more appealing than the linear gradient is the negatively sloping curvilinear form (Koutsopoulos, 1977). This is the form obtained when a scattergram was obtained for time-distance and land values.

When raw land value data was normalized by means of semi-logarithmic transformation, linearity resulted. This shows that although land values and time-distance are not linearly related, when land values are logged ($\log_e$), linearity results. This showed that the function was exponential.

Using the least squares method, a regression curve was obtained for Mombasa of the form:-

$$\ln y = 15.33 - 0.099X$$

where $\ln y$: Natural logarithm of land value ($\log_e$)

X: Real Bus Time.

This is a negative exponential model which confirms that a negative relationship exists between bus time and $\log_e$ of land values.

In this study, the Pearsonian correlation coefficient (r) of -0.88 was obtained when $\log_e$ of land values was regressed with real bus time. The r^2 value was 77.44%. This shows that a strong negative exponential relationship exists between real bus time and $\log_e$ of land values. Land values are generally higher on the Island which is the most central and accessible area in the whole study area. The land values were generally low in the Mainlands where access to the city is not very good. This pattern is revealed by the regression residual map.

1. (b) RELATIONSHIP BETWEEN POPULATION DENSITY AND TIME-DISTANCE

Generally, population density declines with distance away from the city centre in Mombasa. The Clark function applies in the study area. The Clark density function is of the form:

$$\ln y = \ln a - bX.$$

The density function of Mombasa was found to be of the form:

$$\ln y = 9.77 - 0.079X$$

In this study, only Clark's function was tested. Newling's function and the second order function for Polycentric cities, were not tested.

When the physical distance is transformed into time-distance and related to population density ($\log_e$), no difference in the density function is observed. This shows that time-distance can actually be used in the place of physical distance. In time-space convergence studies, the time-distance metric is more revealing than the physical distance. Where people live will be determined more by the time taken to travel to the city centre and other parts of town than by the physical distance between places.

The Pearson's correlation coefficient was found to be negative. The correlation (simple) coefficient between travel time by bus and the population density was found to be -0.749. This high r value is similar to that obtained in North American cities (Berry et al, 1963) as well as in the Indian cities (Brush, 1968).

An examination of the residual map suggested that several factors affect population density patterns in Mombasa. Distance decay function is one of the main factors. Transportation is a means of overcoming the friction of space. Areas in Mombasa with good accessibility provided by the "matatus" and the bus, have relatively higher population densities. The availability of jobs, age of the estate, sea frontage and so on are other important factors which although not measured in the study, needed some discussion.

1. (C) RELATIONSHIP BETWEEN TRAVEL PATTERNS AND TIME-DISTANCE

Travel patterns in urban areas of both developed and less developed countries are complex and are influenced by many factors, such as the car availability, level of income, distance-decay and so on.

Travel patterns common in industrial cities are different from those in the cities of the less developed countries. The main differences observed are:

i) Walking and not driving the car is the dominant mode of transport in the Third World cities (Wheeler and Thomas, 1973; Berege, 1976; Ngari, 1977).

ii) Reliance on public transport such as the bus is greater in the cities of the Third World countries. But, in the industrialized cities, private transport provided by the car is very important.

iii) Suburbanization of jobs in the industrial cities has led to a reversal of commuting patterns. Most employment opportunities are now moving to the suburbs. Instead of workers moving to the city centre, movement has become more oriented to the suburbs. In the cities of the Third World, most activities and employment opportunities are still concentrated at the city centre. Therefore, movement patterns are focussed to the city centre.

Analysis of the data obtained from the sample survey conducted in the CBD of Mombasa, shows clearly that the travel patterns and mode of travel are different in both industrialized and Third World cities. In Mombasa, 62.8% of the people interviewed worked on the Island. This shows that the Island is the main centre of employment. This is expected given the concentration of activities here and good access.

When data is normalized by means of logarithmic transformation, linearity seems to exist between $\log_e$ of trips and $\log_e$ of the bus and "matatu" time. Double logarithmic function seems to be a better estimate. The regression model of Mombasa is:

$$\ln y = 4.0 - 0.62 \log X.$$

The Pearson's correlation coefficient (r) for the $\log_e$ of trips and "matatu" time is highest. This r value is r = 0.46. The r^2 is 21.4%. It was anticipated that the r values for real bus time would be higher than for real and $\log_e$ of "matatu" time. But, the analysis showed that the r value for $\log_e$ of trips and $\log_e$ of "matatu" trips has a lower negative correlation coefficient.

Two residual maps were drawn to show travel patterns within Mombasa Figure 22 (a) and 22 (b). The two maps are almost the same and show the importance of accissibility in influencing trips in Mombasa.

5. CONCLUSION

The classical land value theory states that urban land values declines with distance from the city centre. This trend has been observed in Mombasa. Land values are highest on the Mombasa Island which is the most central and accessible position in the town. Due to the island nature of the town, land values are much higher than they should be.

Accessibility to the city centre by bus seems to be a very important factor influencing land values and hence land utilisation in Mombasa. Commercial land is more valuable than agricultural land and both are located in different areas in Mombasa. Most commercial land is on the Island (CBD) while agricultural land lies on the periphery of the town in the Mainlands.

The Pearson's correlation coefficient is strong negative. The coefficient for semi-log function is -0.88. This shows that a strong negative correlation exists between time-distance and land values in Mombasa. The correlation coefficient of $\log_e$ of land values and bus time (real) is the highest in Mombasa. It is higher than that for population density. This is mainly because of the growing land scarcity in Mombasa particularly on the Island.

Therefore, a significant regularity seems to exist between land values and time-distance in Mombasa as hypothesized in the western based land value theory. In this way, the hypothesis that land values decline with increasing distance from the city centre has been proved.

The other 2 hypotheses advanced in this study are:

a) Population density declines with increasing time-distance from the city centre.

b) The number of personal trips decreased with increasing time-distance from the city centre. Efforts were made to substantiate both hypotheses.

In 1963, Berry, Simmons and Tenant conducted a study on population density functions of a large number of North American cities as well as several non-western cities. According to this study, it was observed that population densities within cities appear to conform to a single empirically derived expression: $d_x = d_o e^{-b_x}$ or Clark function. The commonest form of the negative exponential model is in the log form:

$\ln d = \ln d_o - bx$ This equation is a logical outcome of urban land use theory.

Each urban activity derives utility from a site in accordance with the site's location. Utility may be translated into the ability to pay for a site. The most desirable locational property of urban sites is centrality. (Maximum accessibility in the urban area since transport routes converge here). Land prices (values) decline outwards and as they do, regardless of other changes, land inputs may be substituted for other inputs and intensity of land use will diminish. Thus, declining residential densities should be expected.

The rich in Western cities live at the periphery on cheap land and consume more land at lower densities than the poor do who live at the centre. Improved transportation in the western cities has accelerated urban sprawl.

3. CONTRIBUTION OF THE STUDY

Many studies have been carried out on urban transportation in the developed nations of Europe and North America. But, few such studies have been carried out in the cities of the Third World. Studies in the developed nations show that transportation improvements have a big impact on the city structures. The impact of transportation improvement on city structures in the Third World is not fully understood.

Some scholars have made some contribution that is relevant in this study. Taaffe, Morrill and Gould (1963) developed a model of the process of transport development. This model explains the evolution of an internal transport network in former colonies. The model is relevant in explaining the growth of Mombasa into a principal sea port in Kenya as well as being the gate-way to Eastern and Central Africa.

The framework on which the present study is based is derived from Janelle (1969). Janelle developed the model of time-space convergence. This shows the process by which places adapt both to the locational structure and the characteristics of their social, economic and political activities to changes in time-space connectivity. This model is relevant in Mombasa where there is real and urgent deman for accessibility in the mainlands as well as the rest of Mombasa's coastal hinterland.

Most of the urban transportation studies carried out so far assumed that transportation improvement in the developing nations leads to time-space convergence similar in nature to that of the developed nations. However, before such an assumption is proved correct, more empirical data is needed. At present very few time-space convergence studies have been carried out in the developing nations. No study carried out so far has attempted to show the relationship between time-space convergence and the space characteristics of an area. This study has shown how land values structure, population density and travel patterns change in a relative space. This is the main contribution of this study. It is hoped that by means of this work, geographers will gain more knowledge on time-space convergence as well as understand more fully the impact of urban transportation on land values, population distribution and intra-urban mobility in Third World cities.

Urban planners and highway engineers will benefit from this study by realizing that modelling Third World cities after the industrialized cities has its serious shortcomings. Other alternati exist for urban spatial organization other than the one based on a Western capitalist concept. Local or traditional transport modes should in such cases be given more attention by urban Planners and Engineers as they play a big role in influencing urban structure and development.

4. RECOMMENDATIONS AND AREAS OF FURTHER STUDY

The study has shown that time-distance is very important in influencing land values, population density and travel patterns. Accessibility is highest on Mombasa Island while the Mainlands are poorly connected by road. Travel time by bus and "matatu" from many parts of the south and North Mainlands to the city centre on the Island is great.

In order to promote development in the mainland areas of Mombasa, it is strongly recommended that road networks should be developed and improved in these areas so as to increase travel speeds in the mainlands. Improved transportation in the mainlands will make them more attractive for settlement and will help reduce residential and industrial congestion on the Island. It will also attract industries and other forms of activities that will generate income and employment in the mainlands and help in stemming rural-urban drift in the neighbouring areas.

The mainlands should be linked directly by roads to facilitate quick movement and to promote intra-regional trade and to reduce reliance of the peripheral areas on the centre.

Mombasa is Kenya's main sea port, hence, the contribution of Mombasa in national development is great. An adequate understanding of the role of Mombasa in national development can be gained if more transportation studies are carried out. Several research areas may be explored:

1) Air, rail and sea transportation system have not been examined in this study. The role of Port Expansion in Mombasa's

development, the importance of containerization in cargo handling and commuter rail service can be studied.

2) Internal or Kenya domestic air network based in Mombasa and its role in promoting coastal tourist industry is another possible research topic. Other studies may be on:-

3) The importance of the Old Harbour in coastal trade and in promotion of fishing industry.

4) The establishment of an efficient public transportation service in Mombasa.

5) The ecological impact of transportation in Mombasa for shipping and road transportation have serious environmental consequences.

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APPENDIX 1

LAND VALUES , 1981

	Enumeration Unit	Kenya Shillings (Per Hectare)	Log_e
1.	Tudor Estate	4,237,288	15.26
2.	Tudor Four	2,750,000	14.83
3.	Tononoka	3,005,804	14.91
4.	Bondeni	2,604,167	14.77
5.	Makadara	6,369,427	15.67
6.	Mji-wa-Kale	2,016,574	14.52
7.	Majengo	3,019,323	14.92
8.	Mwembe Tayari	10,521,885	16.17
9.	King'orani	4,310,345	15.27
10.	Shimanzi	2,458,211	14.71
11.	Ganjoni	1,839,049	14.42
12.	Kizingo	1,040,898	13.85
13.	Kisauni	1,010,101	13.82
14.	Frere Town	N/A	-
15.	Bamburi	509,599	13.14
16.	Nguu Tatu	34,857	10.45
17.	Shanzu	34,458	10.41
18.	Kongowea	305,818	12.63
19.	Mwakirunge	N/A	-
20.	Maunguja	N/A	-
21.	Shika Adabu	N/A	-
22.	Maweni	44,118	10.69
23.	Timbwani	N/A	-
24.	Vyemani	N/A	-

APPENDIX 1 (cont'd)

25.	Kibandani	N/A	-
26.	Migombani	196,850	12.19
27.	Bomani	N/A	-
28.	Kidunguni	N/A	-
29.	Mueza	75,000	11.22
30.	Midodoni	80,000	11.29
31.	Mwandoni	N/A	-
32.	Changamwe	400,640	12.90
33.	Mbuyu wa Chapa	291,177	12.58
34.	Mikindani	N/A'	-
35.	Miritini	297,761	12.61
36.	Port Reitz	N/A'	-
37.	Kipevu	N/A'	-

Key

N/A - No data available

N/A' - No data available for land acquired by Government.

Source: Provincial land office, Mombasa.

APPENDIX II

POPULATION DENSITY, 1979

	Enumeration Unit	Density (Persons/Km^2)	Log_e
1.	Tudor Estate	11,672	9.37
2.	Tudor Four	7,682	8.95
3.	Tononoka	16,429	9.70
4.	Bondeni	18,606	9.83
5.	Makadara	26,602	10.18
6.	Mji-wa-Kale	25,887	10.16
7.	Majengo	21,280	9.97
8.	Mwembe Tayari	13,732	9.53
9.	King'orani	18,606	9.83
10.	Shimanzi	2,878	7.96
11.	Ganjoni	5,683	8.65
12.	Kizingo (Island)	5,497	8.61
13.	Kisauni	1,539	7.34
14.	Frere Town	1,457	7.28
15.	Bamburi	441	6.09
16.	Nguu Tatu	329	5.80
17.	Shanzu	924	6.82
18.	Kongowea	2,137	7.67
19.	Mwakirunge	74	4.30
20.	Maunguja	154	5.04

APPENDIX II (cont'd)

	North Mainland		
21.	Shika Adabu	162	5.09
22.	Maweni	1,338	7.20
23.	Timbwani	230	5.44
24.	Vyemani	394	5.98
25.	Kibandani	722	6.58
26.	Migombani	7,471	8.92
27.	Bomani	4,763	8.47
28.	Kidunguni	2,155	7.68
29.	Mueza	5,000	8.52
30.	Midodoni	1,295	7.17
31.	Mwandoni	40	3.69
	South Mainland		
32.	Changamwe	3,102	8.04
33.	Mbuyu wa Chapa	241	5.48
34.	Mikindani	654	7.13
35.	Miritini	582	6.37
36.	Port Reitz	2,827	7.95
37.	Kipevu	6,359	8.76

Source: Central Bureau of Statistics, Nairobi.

A P P E N D I X III

BUS TIME (MINUTES) FROM MWEMBE TAYARI TO MID-POINTS OF ENUMERATION UNITS, March 1981

	Enumeration Unit	Bus Time
1.	Tudor Estate	12
2.	Tudor Four	17
3.	Tononoka	10
4.	Bondeni	5
5.	Makadara	3
6.	Mji-wa-Kale	10
7.	Majengo	5
8.	Mwembe Tayari	1
9.	King'orani	7
10.	Shimanzi	15
11.	Ganjoni	12
12.	Kizingo	5
	(Island)	
13.	Kisauni	15
14.	Frere Town	20
15.	Bamburi	25
16.	Nguu Tatu	35
17.	Shanzu	48
18.	Kongowea	17
19.	Mwakirunge	53'
20.	Maunguja	73'

APPENDIX III (cont'd)

(North Mainland)	
Shika Adabu	43
Maweni	35
Timbwani	55'
Vyemani	43
Kibandani	36
Migombani	33
Bomani	31
Kidunguni	33
Mueza	44
Midodoni	44
Mwandoni	64'
(South Mainland)	
Changamwe	14
Mbuyu wa Chapa	53'
Mikindani	34'
Miritini	33
Port Reitz	24
Kipevu	14

1: Walking time to the nearest bus station added

Source: Field work.

APPENDIX IV

QUESTIONNAIRES

UNIVERSITY OF NAIROBI

DEPARTMENT OF GEOGRAPHY

I. QUESTIONNAIRE FOR MOMBASA MUNICIPAL COUNCIL

TOWN PLANNING OFFICERS

Officer Interviewed _____.

Date Interviewed _____.

1. Which are the main factors considered in Planning and building roads in Mombasa Town?
   a) Economic .....
   b) Social .....
   c) Political .....
   d) Physical .....
2. What Problems if any do you face in planning for roads in Mombasa Town?
3. How important is road network in influencing the location of activities like residential, shops or Schools in Mombasa Town?
4. In which direction is Mombasa Town likely to expand in the next Ten Years?
5. How important will road transport be in influencing the future expansion of the town?

6. What effects might this change of direction have on land values and land use in the Town?

II. QUESTIONNAIRE FOR MATATU OPERATORS: (Questions to be asked at the Town Centre Terminal)

VEHICLE MAINTENANCE AND COST

1. How many trips do you make from this terminal to other parts of the Town per day?
2. How much money do you spend on Petrol per week?

NATURE OF THE ROUTES OPERATED BY MATATUS

3. Along which route(s) do you operate?
   a) within the Municipality? .....
   b) outside the Municipality? .....
4. Are there some routes you operate that are not operated by other Public Service Vehicles like Kenya Bus Service? Yes/No. If Yes, which routes are these?
   a) ----------
   b) ----------
   c) ----------
   etc ----------
5. Which time of day do you transport the largest number of passengers?
6. Where along the route(s) do you obtain the largest number of passengers?

7. What do you feel about the nature of road(s)

   a) In good conditions ----------

   b) Needing repair ----------

   c) Badly needing repair ----------

8. Do you think the nature of road affects journey time?

   Yes/No. If Yes, Minutes saved ----------

   Minutes lost ----------

9. Do you think the nature of road affects transport costs?

   Yes/No. If Yes, Cost of fuel saved ----------

   Cost of fuel incurred ----------

MATATUS AND OTHER FORMS OF PUBLIC TRANSPORT SERVICES

10. Why do you think some passengers prefer your services?

   a) To save time

   b) Cheaper services

   c) Comfort

   d) Any other reasons ----------

11. Do other Public transport modes like Kenya Bus Services, Taxis etc;

   a) Compete with you?

   b) Complement your Services?

12. If other Public transport modes compete with you, which of them is the biggest competitor?

   a) Kenya Bus Services

   b) Taxis

   c) Others (specify)

III. SAMPLE SURVEY IN CBD: MOMBASA ISLAND

Socio-economic Background:

1. Are you a Kenya citizen? Yes/No. If Yes, state your ethnic group. If No, will you please, state your country of origin?
2. What is your approximate age?
3. Do you work? Yes/No. If Yes, how many and where do you work?
4. Do other members of the household work? Yes/No. If Yes, how many and where do they work?

TRAVEL CHARACTERISTICS

5. What is the total number of trips made by all household members per day to the city centre (including any domestic workers)?
6. What are the trip purposes?
   a) Single ----------
   b) Multiple purposes ----------
7. Do you own a car?
   Yes/No. If No, how do you travel to the city centre?
   If Yes, how much money do you spend on your petrol per week?
8. Do you consider time to be very important in your journeys?
   Yes/No. If Yes, why?
9. Would you make more trips per day to the city centre if travel time and cost were reduced?

RESIDENTIAL LOCATION. WORK PLACE AND OTHER PLACE PREFERENCES

10. a) Residence ---------- (Ward)

    b) Have you changed your residential location in the past? Yes/No. If Yes, why did you move and where did you move to?

11. Would you change your present residential site if travel time and cost were increased? Where would you move to?

12. Have you changed your work place in the past? Why? Where did you go to work?

13. Are there places you would like to visit within Mombasa Town but are difficult to get to due to great travel time and cost?
    Which places are these?

IV. EFFICIENCY OF PUBLIC TRANSPORT SERVICES

1. Do you use any form of Public Transport Services? Yes/No. If Yes, which one?

    a) Kenya Bus Services

    b) Matatu

    c) Taxi

    d) Other (specify)

2. a) What do you feel about Public Tranport services?

        i) Adequate

        ii) Inadequate

b) What form of public transport service is really inadequate?

i) Kenya Bus Service

ii) Matatu

iii) Taxi

iv) Others (specify)

c) Would you use a private car then? Yes/No.

3. What do you think should be done to alleviate the existing inadequate public transport problem in Mombasa Town?

a) More K B S Buses needed on the roads

b) More K B S buses and Matatus needed

c) More Matatus needed

d) Improving road conditions, widening roads etc.

e) More K B S, Matatus and better roads.

4. Do you use any ferry services in the Town? If Yes, which one?

a) Mtongwe

b) Likoni

5. a) What is your view about Likoni ferry services? Do you feel that more ferry services are needed or would you prefer a bridge instead?

b) Would you please, indicate where you would like a bridge to be built to link Likoni with Mombasa Island?

Why do you prefer this location?

6. Do you use any bridge within the Town? Which one?

   a) Old Nyali Bridge

   b) New Nyali Bridge

7. a) What are the benefits of the bridge that you use?

   b) What are the costs of the bridge that you use?

EFFECTS OF PROXIMITY OF A ROAD NET WORK

1. What would you regard as the real benefits of being near road?

   a) ----------

   b) ----------

   c) ----------

   etc. ----------

2. What would you regard as the major disadvantages of being near road?

   a) ----------

   b) ----------

   c) ----------