THE DEVELOPMENT OF ROAD TRANSPORT SYSTEM IN KENYA

BY

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A thesis submitted to the University of Nairobi (Faculty of Arts)in fulfilment for the Degree of Doctor of Philosophy in Transport Geography

1986

DECLARATION

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

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This thesis has been submitted for examination with my approval as the University Supervisor

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DEDICATION

This thesis has been dedicated to my loving wife, Mrs. Josephine Debrah Ogonda, who has persevered many hardships for the last 25 years of our married life, during which time, I have constantly been a scholar. I dedicate the thesis to her as a token of my deep appreciation and love for her.

The thesis is also dedicated to our four daughters: Bertha, Molly, Dolly and the young Mercy who have struggled with us all these years. May they live to write better theses than their "daddy".

TABLE OF CONTENTS

Page

ABSTRACT xiii

ACKNOWLEDGEMENTS xviii

LIST OF TABLES..................................... xx

LIST OF FIGURES xxiii

CHAPTER ONE

INTRODUCTION

A. The Research Problem 1

B. Definitions of Concepts and Terms 5

C. Literature Review 7

1. Introduction 7

2. Theoretical Sources of Material 9

3. Empirical Sources of Material 19

a. Impact Studies 19

b. Movement Studies 29

c. Network Development Studies 34

4. Summary and Evaluation of the Literature .. 39

a. Summary of Empirical Findings 39

b. Evaluation of Theoretical and Empirical Literature 43

D. Objectives of the Study 53

E. The Scope and Limits of the Study 53

F. References 55

CHAPTER TWO

Page

THEORETICAL FRAMEWORK, HYPOTHESES AND THE STUDY AREA.

A. Theoretical Framework 61

1. The Transport Development Model 61

2. The Operational Concepts in the Model 63

a. Demand for Transport 63

b. The Societal System 65

c. The Transport System 69

B. Hypotheses 73

1. Operationalisation of the Concepts in the Hypotheses 74

C. The Study Area 75

1. Introduction 75

2. The Geographic and Economic Features Relevant to the Development of Road Transport System .. 77

a. Physiographic Basis for Transport Development.. 77

b. Population and Urbanisation 81

c. The Economic Structure 84

D. Notes and References 89

CHAPTER THREE

METHODOLOGY

A. Introduction 93

B. Data Collection Techniques 94

1. The Collection of Road Transport Data 95

2. The Collection of Socio-Economic Data 98

3. The Problems and Difficulties Encountered in Data Collection 104

Page

C. Data Processing and Analysis 112

1. The Computation of Composite Indices of Development 112

a. The Selection of Indicators of Development . 112

b. The Selected Indicators and Indices 114

c. Further Selection by Intercorrelations Among the Indicators 116

d. The Construction of a Composite Index of Development 122

e. The computation Procedure 123

2. Transaction Flow Analysis 128

3. Dominant Flow Analysis 132

4. Correlation and Regression Analyses 135

5. Computer Programmes 140

D. Data Presentation 143

1. Qualitatively Designed Maps and Diagrams ... 143

2. Quantitatively Designed Maps and Diagrams .. 143

E. Notes and References 147

CHAPTER FOUR

THE GROWTH AND DEVELOPMENT OF THE ROAD NETWORK SYSTEM.

A. Introduction 151

B. The Origin and Development of the Road Network 153

1. The Network System Before 1900 153

a. The Growth of Caravan Routes 153

b. The Mackinnon Road and Sclater Road 154

2. The Network System, 1900 - 1920 157

a. Political and Economic Background to the Construction of Roads in Kenya 157

b. Major Lines of Connection. 159

Page

3. The Network System, 1921-1940 167

4. The network System After 1940 140

5. Special Road Programmes 178

a. Rural Access Roads Programme 178

b. Secondary and Minor Roads Programme 178

c. Special Purpose Roads Programme 179

6. A Comparison of the Observed Kenya Data to the Ideal - Typical Sequence Model of Transport Network Development 180

7. The Distribution and Density of the Road Network System 182

a. High Density Peak - Zones (1a), (1b) 184

b. Medium Density Plateaus or Slopes - Zones (2a), (2b) 187

c. Low Density Pits or Depressions -Zones(3a),(3b).. 187

C. The Relationships Between the Development of the Road Network and Some Selected Factors.189

1. Variables 190

2. Statistical Analyses and Interpretation.... 191

D. Summary 198

E. Notes and References 200

CHAPTER FIVE

MOVEMENT OF PEOPLE

A. Introduction 203

B. The Inter-District Passenger Movement Patterns 205

1. The Movement Potential Map of Kenya 206

2. The Analysis of the Inter-District Passenger Flows 209

Page

C. The Inter-Provincial Passenger Movement Patterns 222

1. Passengers Attracted to Nyanza Province .. 224

2. Passengers Attracted to Nairobi Province .. 226

3. Passengers Attracted to Coast Province 227

4. Passengers Attracted to Rift Valley Province 228

5. Passengers Attracted to Central Province . 229

6. Passengers Attracted to Eastern Province .. 230

7. Passengers Attracted to Western Province .. 230

8. Passengers Attracted to North-Eastern Province 231

D. Modelling Passenger Movements 236

1. The Variables 240

2. Statistical Analysis and Interpretation.. 241

E. Summary 247

F. References 249

CHAPTER SIX

MOVEMENT OF COMMODITIES

A. Introduction 251

B. The Inter-District Commodity Movement Patterns 253

1. The Analysis 253

2. Road Trade Balances 273

3. Dominant Flow Analysis 281

C. Measures of Relative Complementarity 281

1. Expected Shipment of Commodities generated by Transaction Flow Analysis 285

Page

2. Absolute Deviations of commodity shipments to Nairobi 286

D. Modelling of Commodity shipments 292

1. The Variables 293

2. Statistical Analysis and Interpretation... 294

E. Summary 297

F. References 300

CHAPTER SEVEN

PATTERNS OF DEVELOPMENT AND THEIR RELATIONSHIPS TO THE DEVELOPMENT OF ROAD TRANSPORTATION IN KENYA.

A. Introduction 301

B. The Patterns of Development: Results and Interpretation 303

1. Patterns of Development 303

2. The Relationships Between the Level of Road transport Development and Other Levels of Development 313

3. Statistical Analysis and Interpretation .. 321

C. Summary 336

D. References 339

CHAPTER EIGHT

CONCLUSIONS

A. Intoduction 341

B. Major Findings and Contributions 343

1. Major Findings as Revealed by Tested Hypotheses and the Results of Correlation and Regression Analyses 343

2. Major Findings Not Hypothesised, But Revealed by Other

Page

Techniques of Data Analysis and Presentation.... 348

3. Contributions Made by the Study 354

C. Concluding Remarks and Recommendations ... 360

1. Concluding Remarks 360

2. Recommendations 364

3. Suggested Future Research Areas 366

D. References 370

SELECTED BIBLIOGRAPHY 372

APPENDICES 385

1. Matrix of Correlation Coefficients Between Indicators of Development 386

2. Stages in the Development of Road Network . 389

3. Inter-District Movement - Passengers 395

4. Inter-Provincial Road Trade Balances, March, 1983 396

5. Commodity Shipments to Nairobi by Road, March, 1983 399

6. Absolute Deviations of Shipments of Commodities to Nairobi 402

7. The Relationship Between Volume of Commodity Flows to Nairobi and Employment Earnings, Distance and Vehicles generated .. 404

8. Inter-District Movement - Commodities 406

9. The Ranking of Districts on Composite and Sectoral Indices 407

10. The Relationships Between Composite Index and Other Indices of Development 415

Page

11. The Relationships Between Road Transport Index and Indices of Population, Agricultural, Industrial and Commercial and Communication 419
12. Original Data Matrix 422
13. Sources and Explanation of Variables 437

ABSTRACT

The main purpose of this study is to examine the development of the road transport system of Kenya and its relationships with socio-economic components of development. Five major lines of investigation are pursued; and to these are tied more closely the hypothesised relationships for testing and validation. First, the study examines the origin, growth and development of the road network system. This identifies the major stages of its evolution and compares them with the ideal-typical sequence model of network growth and development. These form the basis for the assessment and evaluation of the relationships between the network's patterns and selected indices of socio-economic development according to the administrative district units. The fourth line of investigation involves the analysis of the patterns of passenger and commodity flows. Lastly, composite indices of socio-economic development are calculated, ranked, compared and the districts classified according to their levels of development. These are then related to the level of road transport development.

The main thrust of the study involves designing a simple conceptual model specifying the interrelationships between transport and development, within the framework of which, four hypothesised relationships are formulated. The validity of these relationships are examined and tested by correlation and regression methods of analysis with respect to quantitative cross-sectional data. The technique of dominant flow analysis is applied to traffic

movement data to identify dominance-dependence associations among the districts and provinces, while transaction flow analysis is used to generate the "more than" and"less than" expected levels of interaction. One of the methodological features of the study is the use of the taxonomy methodology as a means of amalgamating data relating to variable values measured in different units. A number of interesting findings are highlighted and pertinent conclusions drawn from them.

The study finds that the Kenya road network system has evolved through three main stages: penetration lines,development of feeders and lateral interconnections, and the emergence of high priority linkages. The first stage in Taaffe model, "scattered ports," is irrelevant to the development of road network. With respect to the pattern of road network densities, three concentric zones with their bases in western and central Kenya, and at the coast can be delineated. The stepwise multiple regression analysis applied to the network data confirms the results of simple correlation analyses that population and land area are the major determinants of the spatial variation in the pattern of road network. The addition of the index of agricultural development in the equation increased the level of explanation by only about 1 per cent.

The dominant flow analysis shows that Kenya can be divided into three macro-functional regions based on Kisumu, Nairobi and Mombasa towns, with nested hierarchies defined around Eldoret, Nakuru and Embu towns. The application of the gravity model formulations to the movement data demonstrates that distance and population are the major determinants of the volume of movement. The effects of other socio-economic factors seem to be obscured by the effect of population. The major conclusion drawn with respect to commodity flows by road is that, in a system of trade transaction, it can be misleading to evaluate the strength of connections between places if the only yardstick is the magnitude of the sizes of shipment. Better evaluative criteria are the quantitative indices of complementarity.

The study finds that the development of road transport is closely interrelated with socio-economic components of development. This has been demonstrated graphically by the linear pattern of the array of points. It has been found that the districts with higher scores on the index of road transport tend to score highly on other indices of development. The resulting patterns show that more developed districts are concentrated in Western, Nyanza and Central Provinces, the major differentiating elements in the levels of development being differences in the population sizes and densities of the districts, the predominant type of agricultural practices and access to closer networks of transportation routes. The results of the stepwise multiple regression analysis show that the indices of transport, education, agricultural, communication and health explain 99 per cent of the variation in the overall pattern of development in Kenya, the key factor being the index of transport. A similar analysis using the index of transport as dependent variable reveals that indices of population, agriculture and industrial and commercial together, explain 75 per cent of the total variance, with population index being the most important element. It is, therefore, concluded that transport/development relationship is a two -way interaction process.

On the basis of these findings, major conclusions can be drawn and recommendations suggested. The negative correlations between areal sizes of the districts and indices of development indicate that larger district areal sizes are a retardation to development. This is crucial in Kenya with regard to the allocation of development funds under the new policy of " District Focus for Rural Development ". The large, but less developed districts will have to get larger shares of development funds if the existing gap between them and the smaller, but more developed districts has to be closed. Functional regions could be a better approach to development planning in Kenya as oppesed to the current district and provincial boundaries which are, if anything, ethnic group boundaries. The findings of this study further, suggest that larger districts and provinces could be sub-divided into smaller units for effective administration and and implementation of development plans. The isolation of the coast and northern Kenya from the rest of the country could be reduced by developing an alternative all-weather road through Machakos and Kitui towns to the districts in the Lower Tana River Valley and all-weather road links between the districts in the north and the more developed districts in the south. In this way, the isolated districts with their livestock products, potential irrigable lands and tourist attractions could be integrated with the core areas of national development. Finally, this study recommends an integrated study of road and rail networks of Kenya to find out their relative impact on development and shares in the movement of goods and people.

ACKNOWLEDGEMENTS

This thesis has been produced as a result of enthusiastic support and unrelenting encouragement from a number of persons and organisations, without which the work would not have taken its present shape. The author would like to express special thanks to the following institutions and/or organisations for their invaluable support. For funding, I wish to thank bounteously the National Council for Science and Technology of Kenya for offering a research grant which enabled me to finish the preparation of the thesis in unthinkably shorter time than was expected. Similar thanks go to the British Council for their three month's fellowship award to the University of London. This fellowship made it possible for me to collect some of the hard-to-comeby archival materials in the British Museum Library and set me on the path to writing the thesis.

The moral support, criticisms and helpful discussions came from Professor R.B. Ogendo, my university supervisor and academic friend. His advice ensured that the thesis did not lack a high standard of academic satisfaction and a Kenyan touch. In this respect, special thanks also go to Dr. D.A. Obara of the University of Nairobi, Geography Department, for his useful criticisms and discussions on the quantitative elements of the thesis.

These acknowledgements would be incomplete without thanking Mr. Agallo Ochieng of the Ministry of Transport and Communications, Roads Branch, for providing me with data on traffic movement from the Kenya National Origin-Destination Traffic Survey Data File for March, 1983. For the great job of typing the thesis, my heartfelt thanks go to Mrs. Mary Oballa, for the backbreaking job of data preparation for processing Miss Elleen Wambui for cartographical work Mr. G. M. Murache and for computer programming Mr. H. Masime. All these individuals are, however, absolved from responsibility of association with any errors of commission or omissions that are detectable or undetectable in the thesis, as any of these are entirely mine.

R.T. OGONDA

LIST OF TABLES

Table		Page
1.1	Transport and development	11
1.2	Percentage increase in road kilometrage, population and cotton production in the three regions, 1946-56	20
1.3	Transport impact studies	40
1.4	Movement studies	41
1.5	Network development studies	42
3.1	Average correlation of each indicator with the other 25 indicators	119
3.2	Correlation between each of the 18 core indicators and the composite index of development	121
3.3	A hypothetical passenger flows showing the associated matrix	134
4.1	The relationship between network index and population, agriculture and land area..	194
4.2	Matrix of correlation coefficients between the four variables	196
4.3	Multiple coefficients of correlation......	196
4.4	Regression coefficients	197
5.1	Distribution of passenger movement by public carriers, 1983	206
5.2	Distances travelled by passengers	213

Table | Page

5.3 District population bands and percentage of passengers generated and attracted 214

5.4 Inter-provincial movement of passengers, March, 1983 223

5.5 Percentage of passengers attracted to each province, March, 1983 225

5.6 The relationships between volume of passenger and population, distance and vehicles generated 242

5.7 Matrix of correlation coefficients between the four variables 244

5.8 Multiple coefficients of correlation 244

5.9 Stepwise regression coefficients 244

6.1 Tonnage of commodity groups as a proportion of total inter-district commodity receipts and shipments 254

6.2 Movement of maize by road, receipts and shipments, March, 1983 259

6.3 Movement of Wheat by road, receipts and shipments, March, 1983 261

6.4 Movement of coffee by road, receipts and shipments, March 1983 262

6.5 Movement of tea by road, receipts and shipments, March, 1983 263

6.6 Movement of refined sugar by road, receipts and shipments, March, 1983 .... 265.

Table Page

6.7 Movement of cement by road, receipts and shipments, March, 1983 266
6.8 Movement of soda ash and soda products by road, receipts and shipments, March, 1983 268
6.9 Movement of petroleum fuels and petroleum products by road, receipts and shipments, March, 1983 269
6.10 Movement of all commodities by road, receipts and shipments March, 1983 274
6.15 Matrix of correlation coefficients between the four variables 295
6.16 Multiple coefficients of correlation 295
6.17 Stepwise regression coefficients 295
7.2 The ranking of provinces on the composite index of development 309
7.3 The relationships between road transport development and other levels of development 320
7.5 Matrix of correlation coefficients between the eight variables 329
7.6 Multiple coefficients of correlation 332
7.7 Stepwise regression coefficients 332
7.9 Multiple coefficients of correlation 335
7.10 Stepwise regression coefficients 335

LIST OF FIGURES

Figure		Page
1.1	Idealised Process of transport development	16
2.1	A conceptual model of the development of road **transport**	62
2.2	The location of Kenya in Africa	76
2.3	Kenya districts including Nairobi Province ..	78
3.1	The location of the 1983 Kenya National O/D Survey points	99
3.2	Graph of dominant flows	134
4.1	Caravan routes, Mackinnon and Sclater Roads before 1900	155
4.2	The development of the Kenya road network ..	160
4.3	The Kenya road network, 1978	183
4.4	The road density surface map of Kenya	185
4.5	Districts levels in road network development.	186
5.1	Population potential map of Kenya	208
5.2	Total number of passengers generated and attracted in the flow system	210
5.3	The inter-district passenger flow map	211
5.4	Map of dominant passenger flows	216
5.5	Inter-provincial movement of passengers, March, 1983	233

Figure Page

6.1 Inter-district movement of commodities 279

6.2 Inter-provincial commodity flow map 280

6.3 Map of dominant commodity flows 282

6.4 Commodity shipments by road to Nairobi, March, 1983 287

6.5 Complementarity indices for shipment of commodities to Nairobi, March, 1983 289

6.6 Absolute deviations of shipment of commodities to Nairobi, March, 1983....... 290

7.1 District scores on the composite index of development 304

7.2 The relationship between road transport and general development level 315

7.3 The relationship between road transport and population level 322

7.4 The relationship between road transport and agricultural development level 323

7.5 The relationship between road transport and industrial and commercial development level..324

7.6 The relationship between road transport and communication development level 325

7.7 The relationship between road transport and education development level 326

7.8 The relationship between road transport and health development level .... 327.

CHAPTER ONE

INTRODUCTION

A. THE RESEARCH PROBLEM

Regional inequalities are an important aspect of the spatial dimensions of development, especially in a developing country such as Kenya. In Kenya, general problems associated with regional inequalities in the pattern of development are clearly evident. This is not only reflected in the unequal distribution of road transport facilities , but also in the unequal distribution of other elements of the country's development. A visual comparison of the road map of Kenya and maps showing the areal patterns of other development parameters shows that they are co-variant.

This study makes an attempt to describe , analyse and explain the spatial pattern of the road transport system of Kenya from the historical and present perspectives. Statistical techniques of analysis will be applied both to give a detailed description of its patterns and to suggest some of their underlying causes. The main purpose in this exercise is to assess and evaluate the strength, nature and form of the relationships between the parameters of road transport development and socio-economic dimensions of development using the parameters of road transport development both as dependent and independent variables.

The relationship between transport system and development has been a subject of considerable theoretical interest and practical importance both in the developed and developing countries of the world (Hoyle, 1973, pp. 8-18). The interaction between the level and pattern of a country's transport resources and the average level of living of its people is a critical factor affecting their economic and social wellbeing. That transport is a critical factor in the promotion of a country's development is no longer an issue for debate. This is especially so in Kenya where there has been widespread concern for the development of the road transport system in the context of the desire to promote rapid economic, social and political development.

The views about the nature and form of the relationship between transport and development have changed considerably overtime. This change in view has been the product of considerable intellectual debate among transport scholars both in the disciplines of geography and economics (Hunter, 1968, pp. 123-27; Wilson, 1966, pp. 1-16; Storey, 1970). It has been argued that transport is a result rather than a cause of economic and social development or that it is both a cause and a result of development. Such arguments seem to be oversimplification of a complex relationship. Transport/

development relationship should be viewed as a two-way interaction process which depends upon the type of economy involved and the level of economic and social development at which transport development is desired or effected. In temporal terms or sequence, transport may be provided ahead of development or it may follow development. Basing the argument on this premise it can, therefore, be asserted that the provision of the transport infrastructure in any given country at any given time can be a precondition for development or the result of the development that has taken or is taking place and for whose dynamism transport is a prerequisite. The problem involved here is that of the identification of the dependent and independent variables; the chicken - and - egg controversy, so to speak!

Many factors seem to be generally associated with the varying characteristics of any given transport system. To isolate which factors are really relevant in the determination of the spatial characteristics of a transport system would involve a careful selection of the most important factors which should be subjected to either bivariate or multivariate analysis. Such analyses can be done over a period of time or at a particular point in time, thus providing the necessary insight into the underlying factors that have produced the observable regional variations in the growth and development of transport facilities.

The choice of this research problem was inspired by three fundamental considerations:

1. The general significance of the role of the road transport vis-a-vis other modes of transport in the economic, social and political development of this country. This is emphasised by the fact that in Kenya, more roads are being built today where rail links would have been more economically viable in the past.

2. The general lack of comparable studies and information of this nature in this country. Such studies, though with different emphases, have been carried out in the case of Uganda and Tanzania (Smith, 1970, Hawkins, 1962, Hofmeier, 1973, Chiteji, 1980).

3. The need for clear and objective understanding of the fundamental human factors that should be considered in the provision and allocation of resources for the development of road transport facilities now and for the future needs of this country. Such an understanding is necessary and can provide the road transport planners with evaluative tools for the rational allocation of scarce resources for the development of the road transport system on the basis of national and regional needs.

It is , therefore, the cherished hope that the study will provide a systematic framework for the description and explanation of the spatial pattern of the road infrastructure in relation to development parameters relevant, especially, to Kenya and generally to other countries.

B. DEFINITIONS OF CONCEPTS AND TERMS

It is pertinent at this stage to give operational definitions of concepts and terms so far used and which are going to be used so that their meaning can be clarified within the context of the problem under investigation. Other concepts and terms have been defined in the relevant sections of the thesis.

1. Transportation: This refers to the movement of goods and people. A distinction should be made between transportation and communication; as many people tend to use the latter when they mean the former. Communication involves the flow of information and ideas and its modes include telephones, telegraphs, radios, televisions, letters and satellites, while transportation modes are roads, railways, airways and pipelines.

2. Transport Facilities: These are the stock of transport equipment. In road transport, they include mobile equipment such as cars, buses, lorries etc., and fixed stock such as kilometres of road length, bridges, garages and filling stations. The fixed stock is also referred to as the transport infrastructure.

3. Road : This can be little more than a path or trail, but for the purpose of the analysis in this study, a road will refer to the paved and unpaved class A, B, C , D , and E roads of the Kenya net system.

4. <u>Network structure:</u> This refers to a set of relations between nodes and routes both in respect to each other and to the network as an organised whole. Structure denotes the layout, geometry and density pattern of the network. It implies some recognised order and organisation.

5. <u>Node</u>: Topologically, a node may represent a terminal, an intersection, or a junction on a road network regardless of whether or not it is occupied by a settlement.

6. <u>Interaction:</u> Interaction involves relations and connections that bind places on a transport network together. The volume and intensity of such relations and connections between spatially separated places can be shown graphically by proportional lines and other cartographical techniques.

7. <u>Development</u>: Development consists of evolving system of factors or variables that influence and are influenced by each other directly or indirectly. In this study, development is conceptualised as a set of interrelated indicators of social and economic progress towards desirable goods and values to which can be assigned numerical values. Such indicators measuring the concept of development may be operationally defined as kilometres of road length per unit area, employment earnings in agriculture and in the industrial sector, population growth rates, school enrolment ratio, the number of hospital beds per 1000 population etc.

C. LITERATURE REVIEW

1. INTRODUCTION

There are two ways in which the literature review on a major research such as this can be approached: first, is to examine useful theoretical materials relevant to the problem under investigation and second, is to select relevant empirical case studies and to examine to what extent they are in accord or otherwise with the theoretical postulates. Pursuant to these two approaches, this literature review has been divided into three parts: the first part deals with theoretical background information and the second part surveys the relevant empirical literature on transport development and its relationships with development. These first two parts examine the literature materials in terms of their theoretical and methodological approaches, findings and conclusions as they stand with very little comments given.

The third part makes a summary of the findings and gives a critical evaluation of the theoretical and empirical materials, pointing out as far as possible general agreements and disagreements . among transport scholars and at the same time makes an attempt to indicate the missing gaps in the current body of knowledge and how it is proposed to fill in some of the gaps in the present study.

Until the 1950's the literature in transport geography consisted mainly of descriptive accounts of transport modes, network layout and flows and the role of transport in the promotion of economic and social development of countries (Hurst, 1974, pp. 4). Very little attempt was made to explain the changing spatial structure of transport modes, networks and flows in relation to the factors affecting and being affected by the changes. A generalised view of the role of transport in the promotion of economic development has been proposed by Hunter(1968, pp. 123-124). In his work on Soviet Transport Experience, Hunter had this to say,

> "Countries in early stages of economic development can learn from Soviet experience one lesson of fundamental importance: transport investment is a concomitant of, not a precondition for economic development. ... Transport capacity can be expanded as the demand for it grows rather than being provided in advances."

This Hunter's view on the role of transport in economic development seems to shake the very foundation of a widely held view that the provision of transport facilities is a prerequisite for economic development. It is known that the functioning of an economy requires the use of transport, and that, as economies develop, specialised production increases and relatively more transport is required. To establish the nature of this relationship, it might be possible to analyse economies with varying structures and levels of development, see how transport is used, and discover how the variations in its use relate to other determinants of spatial variations. However, this approach would prove to be a complex undertaking because of the many ways in which transport is used in an economy. As Hurst (1974, p. 383) points out, the role of transport is not, however, unambigous. Rather than being autonomous, it is always a part of something else. Without resources to be utilized, access has no meaning. Investment in transport facilities needs to be related to what it is going to be used for and to who is going to use it. In this sense, then transport seems to be a neutral factor in the promotion of development.

2. THEORETICAL SOURCES OF MATERIAL

In their attempts to erect a theoretical foundation for the study of transport and development relationship, Storey (1970) and Wilson (1966, pp. 6-10) have come up with three causal possibilities for transport/development relationship. According to Storey, these are,

(a) A positive effect (+), where new directly productive activities are the direct result of providing transport facilities.

(b) A neutral effect(O), wherein transport facilities do not themselves call forth directly productive activities and subsequent increases in the levels of economic growth.

(c) A negative effect (-), wherein the presence of transport facilities eliminates directly productive activities and effectively reduces the level of economic growth.

Wilson, however, categorises these causal possibilities as:

(a) A positive stimulus for further development.
(b) A middle case, where there may be a deceleration of growth accompanying new transport investment.
(c) A negative case, where absolute declines in the level of per capita income in a country are recorded.

Storey goes a stage further to add temporal components to the three causal possibilities. These are:

(a) The provision of transport facilities predates economic growth in temporal terms (PRE).
(b) The provision of transport facilities is concomitant with economic growth (CON), and
(c) The provision of transportation postdates economic growth (POST).

Table1.1 shows a possibility matrix of causal and temporal factors as proposed by Storey. The letter X in the matrix indicates a precondition or a prerequisite for development. However, evidence seems to suggest that letter Y in the matrix may well be a more reasonable representation of reality.

TABLE 1.1 TRANSPORT AND DEVELOPMENT

CAUSAL FACTORS

TEMPORAL FACTORS	POSITIVE (+)	NEUTRAL (O)	NEGATIVE (-)
PREcondition	X		
CONcomitant		Y	
POSTdate			

SOURCE: Storey - 1970

The theoretical framework proposed above about the three causal possibilities of transport/development relationship suggests that the provision of transport facilities can be a prerequisite for development or can have a catalytic effect, being a concomitant of economic development. In the latter case, transport facilities can be provided or expanded as the demand for it grows rather than being provided in advance. But it should also be noted that transport/development relationship can be a two-way process in that transport can also postdate development in temporal terms. In this case, transport can follow development, generating other forms of development activities along its course.

Cooley (1894) in his attempt to erect a theoretical framework for studying transport/development relationship claimed that the character of transportation as a whole and in detail at any particular time and throughout history, is altogether determined by its interrelations with physical, economic and social forces and conditions. To understand transport means simply to analyse these interrelations. Cooley goes on to say that one cannot hope to understand transportation without at the same time understanding the geographical facts that condition it. As the physical facts are permanent, relative at least to the social and economic facts which the study of transport must embrace, a theory of their influence forms the ground work of the theory of transportation. He concludes by noting that because transport underlies social and economic development, it is in turn determined by that development.

It was the geographer, Edward Ullman (1956) who made a theoretical breakthrough to establish a broadly based approach to the study of transport geography. He summarised the work on the gravity model and its various formulations into three useful concepts, each one addressed to the question of why linkages and flows between some centres are stronger than between other centres. The concepts are complementarity, intervening opportunity and transferability.

(a) Complementarity

In order to have movement between two areas, there must be demand in one and supply in the other, and demand and supply must be specifically complementary. By specific complementarity is meant, the existence of a marketable surplus of a given commodity or service in a given area and a demand backed by purchasing power in another area. Complementarity is thus, the first factor in an interaction system because it makes possible the establishment of transport routes. It is a function of both natural and cultural areal differentiation.

(b) Intervening Opportunity

Ullman argues that complementarity generates interchange between two areas only in the absence of intervening opportunity. By intervening opportunity is meant the existence of an alternative source of supply of the required good or service. Under certain circumstances, intervening opportunity might ultimately help to create interaction between distant complementary areas. This can happen when a nearby complementary source makes the construction of a transport route profitable by paying for part of the cost of constructing a route to the more distant place.

(c) Transferability

A final factor necessary in an interaction system is distance, measured in real terms of time or cost. If the distance between market and supply were too great and too costly to overcome, interaction would not take place in spite of perfect complementarity, and absence of intervening opportunity. Thus, alternative goods would be substituted where possible; tea would be demanded instead of coffee.

Although no consistent spatial models of transport development are available at the present, certain regularities in the sequence of transport network growth and development have been proposed (Taaffe etal. 1963). Taaffe and his co-workers were the first to construct a model which represents a generalised description of transport network development in developing countries. Their model is an inductive one based largely on data concerning Ghana and Nigeria. The network growth and development as proposed by the three authors (Figure 1.1) proceeds in a four - phased sequence, thus:

(a) Scattered Ports - This initial stage (A) of transport development is marked by a number of small coastal ports and trading centres. Each port has a limited hinterland and there are few trading connections between them, except for occasional fishing boats and irregular traders. Small trails or footpaths extend towards the interior from the coastal ports to their limited hinterlands. These trails form a number of independent networks.

(b) Penetration Lines - The second phase of development (B) is a critical one as major lines of penetration develop from certain ports and connect with the interior centres. Feeder lines begin to develop and the economy of agglomeration permits the major port to enlarge its hinterland by pirating the hinterlands of smaller adjacent ports. This is the phase of port concentration.

(c) Interconnection - The third phase of development pattern (C) is basically one of interconnection. Small nodes a long the penetration trunk lines and feeder lines develop as interior centres. As the feeder networks continue to develop around the ports and interior centres, some of the larger feeders begin to link up as intermediate centres grow up between the coastal and interior settlements. As this interconnection continues, there is a tendency towards specialisation and expansion of markets for urban centres. The urban centres most successful in competing over this network experience accelerated growth in development and generate, in turn, demands for improved transport facilities to each other.

(d) High-Priority Linkages - The fourth phase (D) is the development of trunk lines and high-priority linkages between the largest centres. These linkages will be the outcome largely of the spatial competition that developed during the interconnection phase. Those linkages will have the best roads (bitumen surface, dual carriage ways) the heaviest traffic and the most frequent public carrier services. This phase follows the development of fairly a complete network. The most marked characteristic of the phase is the dominance of road over rail network and is, followed by steady rise in the importance of road traffic, first complementing the railway then competing with it.

The authors point out that it is most realistic to think of the sequence of transport development as a process rather than a series of discrete historical stages. Thus, at one given point in time a country's total transport pattern may show evidence of all phases. They give an explanation that this expansion is from its beginning a continuous process of spatial diffusion influenced by many specific economic, social and political forces. They suggest that in underdeveloped countries there appear to have been three major reasons for the penetration

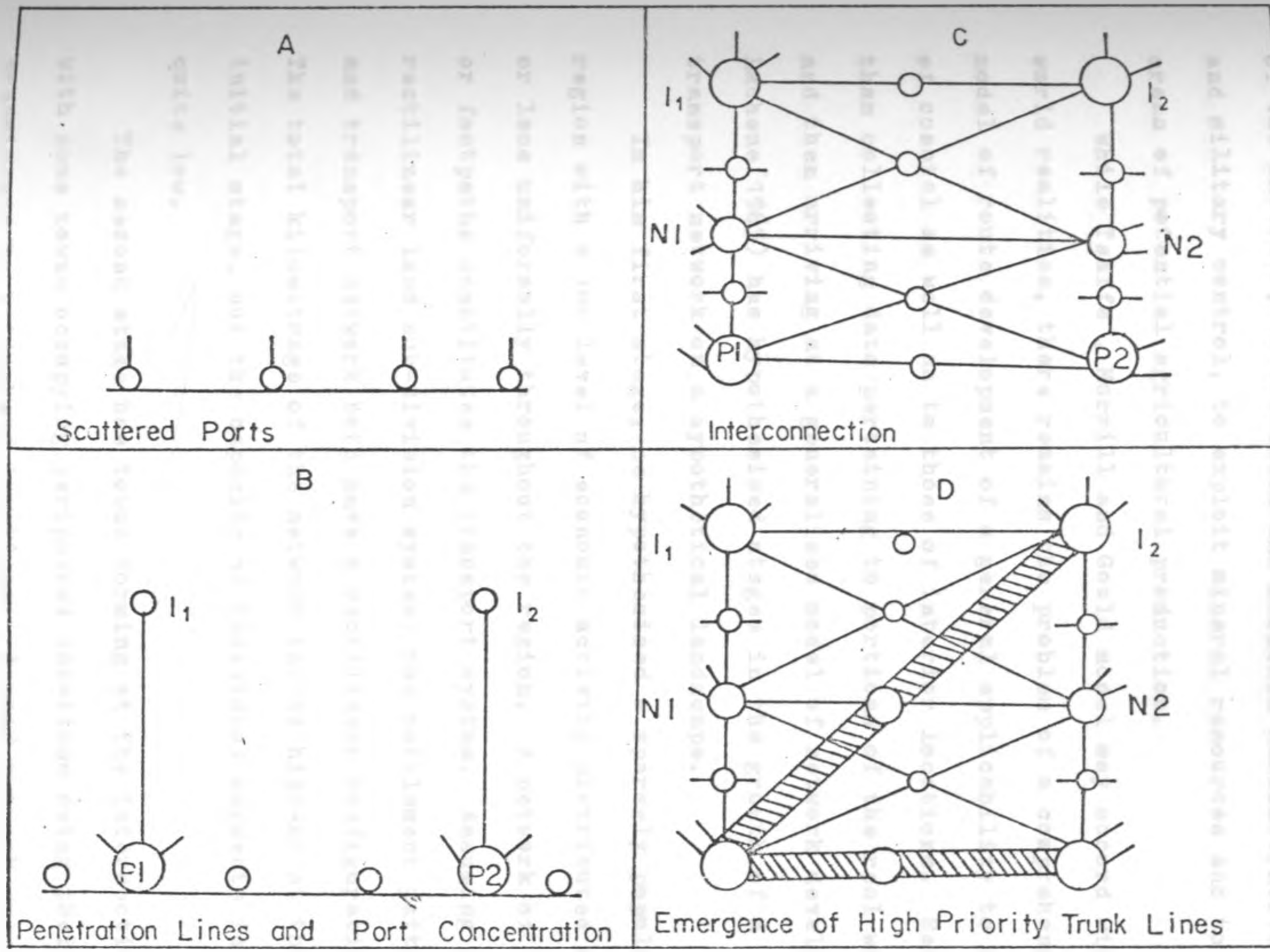

FIGURE I.1 IDEALISED PROCESS OF TRANSPORT DEVELOPMENT

SOURCE: Taaffe et al 1963

of the interior, to establish and maintain administrative and military control, to exploit mineral resources and to develop areas of potential agricultural production.

While Taaffe , Morrill and Gould model may accord with some world realities, there remains the problem of a comprehensive model of route development of a general applicability to nation s of coastal as well as to those of interior locations. Rather than collecting data pertaining to portions of the real world and then arriving at a generalised model of network development Lachene(1965) has hypothesised stages in the growth of a transport network on a hypothetical landscape.

In his first stage, he hypothesised a sparsely populated region with a low level of economic activity distributed more or less uniformally throughout the region. A network of trails or footpaths constitutes the transport system. Assuming a rectilinear land sub-division system, the settlement pattern and transport network both have a rectilinear configuration. The total kilometrage of the network is the highest at this initial stage, but the capacity of individual segments is quite low.

The second stage has towns forming at the intersections, with some towns occupying peripheral locations owing their preeminence to bridgehead locations. A road network superimposed directly upon the original trails links the settlements. Some of the trails have become paved roads, and the total distance of this paved road network is smaller than that one of the original dirt-grid road. Lachene points out that at this stage route capacity exceeds the potential traffic. By the end of the second stage, economic activity becomes strongly concentrated in the urban centres and the gradual depopulation of the countryside results in the abandonment of some of the older trails.

In stage three, the process of differential growth of nodes culminates in the emergence of three dominant urban centres. These are connected by a superior, more expensive route network such as free way. The total length of this network is the shortest of the entire sequence.

3. EMPIRICAL SOURCES OF MATERIAL

(a) Impact Studies

The first part of this literature review has been devoted to an examination of some of the approaches to theory and model building in the study of transport and development relationship. In this section a selection has been made of some of the empirical studies carried out so far applying the theoretical approaches to transport study in different areal contexts. The literature materials chosen are those that are particularly relevant to the problems of this study. They are by no means the most important materials so far produced in this area of research.

In a study of road transport and agricultural development in Western Kenya, Birdsall(1968) found that agricultural production appears to increase sharply in areas in which transport facilities have been improved. He attributed this to low transport costs that farmers whose land were close to roads enjoyed. He went on to add that road transport was also important in that it encourages the broader outlook that is necessary for a revolution in farming and marketing methods. He, however, admitted that such cause - and - effect relationships were difficult to determine with certainty, because it is not easy to distinguish between rises in production caused by better transport and those that were only coincidental to road improvement, but which could have occurred even without efficient means of transport as other factors may have been responsible.

In West Nile District of Uganda, Smith(1959) examined the effects of the construction of feeder roads on changes in population, cotton acreage per capita and incomes from Cotton for the areas of Terego, Madi and Jonam. Between 1948 and 1952 a series of feeder roads were built in Madi and Jonam. They were all dirt roads, generally unused during the rainy season. Terego had no new roads built until 1958. During the period of the study the main difference between Madi and Jonam on the one hand and Terego on the other was the feeder road construction in the first two areas. The results of the study are summarised in Table 1.2.

TABLE 1.2 PERCENTAGE INCREASE IN ROAD KILOMETRAGE, POPULATION AND COTTON PRODUCTION IN THE THREE REGIONS, 1946-56

AREA	ROAD KILOMETRAGE (1946-56)	POPULATION (1946-1956)	COTTON ACREAGE PER CAPITA 1946-1956	INCOME FROM COTTON (1946-1956)
JONAM	400	70	380	525
MADI	200	20	364	373
TEREGO	0	12	-38	230

SOURCE: Wilson, G. E. etal. pp. 155

Each of the three variables showed relative rates of increase according to the rate of growth of road kilometrage. He concluded that the increase in income from cotton was due partly to a sharp rise in cotton prices which virtually doubled between 1948-49 and 1955-56, but this does not change the general consistency of the rates of change with road investment. The price rise does explain the increase in income from cotton in Terego despite a 38 per cent reduction per capita in acreage with only a 12 per cent rise in population.

In a study of the effects of the construction of a road connection from Arusha via Makuyuni to Oldeani in Tanzania towards the end of the 1920's, Hofmeier (1973, pp. 253-270) claimed that the road was the necessary precondition for European settlement and for the beginning of commercial agriculture in the adjacent areas. He went further to say that the creation of a modern agriculture oriented towards the world market was only made possible in the Southern Highlands of Tanzania when the Great North Road from Dodoma via Iringa and Mbeya to the Zambian border was built. His conclusion was that it is only after the provision of such basic transport facilities that it can be possible for more general development processes with their long-run effects to be set in motion.

In the same work, a study was carried out along the north-south link road between Sengera and Chalinze that was completed to bitumen standard in 1969. A series of household interviews were conducted in the settlement along the northernmost end of the road in 1968. Of the 67 interviewed households in three villages, 22 were asked about the reasons for their coming to these locations and about their evaluation of the advantages and disadvantages of being near the road. All of the interviewed persons had resided only since the construction of the road in 1961 or shorter at their present locations. The answers to the separate questions about the advantages of life along such a road included the easy transportation of sick persons to the next town and hospital, the easy access to markets for their agricultural products and the chance for sale of fruits along the road side. In addition, access to towns and in some cases the availability of suitable free land for settlement figured prominently as the advantages of improved conditions of communication. None of the settlers found any particular disadvantages connected with the building of the road. Hofmeier came to the conclusion that a number of influences, economic, social and political can result from new road construction and improvements in the immediately adjacent areas, including considerable generation of traffic volumes. The other more indirect influences of individual road projects upon other sectors of the economy can, however, not easily be isolated from the other factors of influence to allow for a more evaluative treatment.

In order to determine the specific impacts of new and improved roads Chiteji(1980, pp. 106-9) carried out interviews in fourteen major settlements in Morogoro District of Tanzania, where settlers were basically farmers and traders. The settlements were selected on the basis of their size and also because of their proximity to a major rural feeder road. The outcome of these interviews indicates that the building of roads had considerably influenced the level of development in these areas. Prior to the establishment of roads passing through the villages, the people produced only enough to feed their families or to trade with their immediate neighbours. However, after the construction of the roads, people began producing surplus crops for sale. His conclusion was that an improvement in the transport situation can result into the movement from subsistence to modern commercial agriculture. Transport improvement was also found to have a marked social impact. Chiteji also reported that after the first road entered and passed through one of the settlements, it became possible to receive school supplies and inspectors from Morogoro more frequently than before. Moreover, when the road was completed, bus operators extended their routes to serve them, a dispensary was established and the availability of doctors and, the visits of agricultural advisers were ensured.

A study of Economic Benefits of Ramnad - Mandapam Road in Southeast India by the Ministry of Transport and Communications of India (1961) came out with similar results to the ones reviewed above. The study involved an examination of the impact of a short paved all - weather road 34 kilometres in length paralleling a railroad. Before the road was built, a narrow path and a railway joined the towns of Ramnad and Mandapam. It was found that for almost every agricultural product previously produced there were substantial increases in output in sample villages located at varying distances from the highway. As far as cultivated acreage was concerned the substantial increase in the area was said to be due to the fact that the construction of the road made it profitable to bring under plough the lands which were hitherto marginal. In spite of an almost 60 percent increase in acreage under cultivation, the output of cereals and other crops did not rise by anywhere near this amount, but in general, output increased at all the recorded distances from the road, with the biggest relative increases occurring in villages 5 and 6 kilometres from the road.

In the field of industry, the increased output of the principal products such as baskets, pottery, cloth, firewood and fish which ranged from 11 percent to 108 percent was interpreted as being due mainly to the construction of the new road. In a sample of 28 villages, it was found that the value of land for house construction had increased in about 70 percent of the sample villages. Total number of shops had risen since the road was constructed. Furthermore, there was an increase in the number of elementary schools and student enrolment. The number of post offices had also increased and a number of dispensaries were opened.

Drewes examined four areas in the Western Montana of Central Peru, that are all physiographically similar and oriented to the market in Lima(Drewes, 1958). The author analysed the extent to which the present and past characteristics of each area with respect to population, levels of living, patterns of production, imports and exports are related to the differences in transport facilities. The four settlements were at varying accessibility advantages to Lima. The data available suggested a closer correlation between accessibility and the rate of population growth. Drewes concluded that transportation exerts a direct influence on population growth as well as on the amount and variety of cash crop production which in turn generates exportable surpluses and the ability to import a greater amount and variety of goods. After comparing the relative economic characteristics of the four areas, the final conclusion reached was that modern transportation is indispensable to the economic development and successful settlement of an area; but other factors are just as indispensable.

The case studies reviewed adopted the 'before' and 'after' approach to the study of transport/development relationships and show that changes in the socio-economic development follow the construction and improvement of transport capacity. The cases have used a combination of cross-sectional and time series analysis, with heavy emphasis on the latter. A different approach has been adopted by Garrison and Sorguc et al. (Garrison, 1956; Sorguc et al. 1976) applying regression analysis to cross-sectional data.

Garrison carried out a study of experimental measurement of geographical relationships between rural roads and location utility in three Washington counties with reference to the location of agriculture and rural non-farm residence. The underlying concept of the study was that property values are an index of the utility of a place and one of the major factors influencing the utility of any place is its location relative to other places. Roads affect property values by determining the location of places relative to each other. Variation in the quality of roads are reflected in the variations in relative location and hence in variation in property values.

The empirical work under review was designed to measure co-variations of property values and relative location via roads of different quality. The author, therefore, undertook to study the functional relationships between property values and characteristics of the location and site of the rural residences. Regressions were run measuring location via roads of different quality in simple distance terms, in terms of kilometres travelled per year and in terms of the inverse of kilometres travelled per year. The latter showed the strongest association with property values. Marked differences were noted between the depreciating effects upon land values of kilometres travelled per year by rural farm residents over paved and over gravel and dirt roads.

As was expected, location utility diminished more rapidly, and hence property values fell more quickly, the greater the number of kilometres travelled per year over dirt and gravel roads as compared with paved roads. Location with respect to place of usual convenience - goods shopping determined simultaneously, was the most significant of the locational referents for the rural farm residents. For non-farm residences, it was again noted that property values diminished more rapidly as kilometres travelled over roads of poorer quality increased. In this case, the most significant of the locational referents were location with respect to place of work and place of usual shopping.

A second set of measurement related property to travel. Garrison was unable to find any statistical relationship between trip frequencies and either distance travelled or type of road over which the trips were made. He, therefore, concluded that a highway improvement would not result in an increase in the number of trips made by the rural residents.

In a study of the relationship between socio-economic development and transportation in Turkey, Sorguc and his associates used cross-sectional analysis to determine the association between road transportation and development. Their work was based on 52 indicators of socio-economic development from which a composite index and eight indices representing its components were constructed for the 67 provinces of Turkey. In order to see how far the road transport and communication and other indices affect the composite index of development, multiple linear regression and correlation analyses were carried out. The multiple correlation coefficient was 0.995 and the zero order correlation coefficient with the road transport and communication index was 0.98. Other indices also yielded comparatively high correlation coefficients with the composite index. Sorguc et al. concluded that although high correlation coefficients between each of the indices and the composite index are of limited value, due to the fact that no statistically representative data exist specifically for the general index, the relatively higher weight of some indices in the correlation is obvious. These were indices of transport and communication, education and demography.

To shed light on these relationships, a spearman rank correlation analyses were carried out between transport and communication index and other sectoral indices. The analyses showed that strong relations exist between socio-cultural development and transport and communication and also between commercial and financial development and transport and communication. The authors concluded that, according to the Turkish experience, there is a very strong relationship between socio-economic development and transportation, the most important element being highways.

(b) Movement Studies

The notions of complementarity, intervening opportunity and transferability have been suggested as building blocks and useful concepts in interpreting interaction systems in general (Ullman, 1956). But the ideas of complementarity and intervening opportunity have proved difficult to express precisely (Smith, 1964; Porter, 1964). Since Ullman offered no formal equation for his model, many people have assumed that the complementarity between two areas is directly proportional to the product of the masses of the two areas as is the case in the gravity model. Similarities and differences in the quantity of a given commodity shipped from areas A and B to a third area C do not necessarily provide a complete understanding of the existence of complementarity. One often wishes to obtain an indication of the relative importance in terms of complementarity of the volume of goods moving from the two areas to the third area. Such an understanding of the degree of complementarity can only be established if a quantitative measure of such relationships were computable. Smith has made an attempt to develop such a measure within the context of the gravity model. The purpose of his paper was to describe a measure of the relative significance of complementarity expressed in goods flow between areas using agricultural commodity flow to the six New England states in the U.S.

To express relative complementarity Smith generated expected levels of goods flow using the gravity model estimated shipments, then compared these with the actual shipments by regression analysis. The ratio of actual to expected flow, then yielded an index of complementarity. A pattern of commodity flow was then established and described by mapping the results. The states which shipped more commodities to the six New England States than was expected on the basis of the gravity model formulation were interpreted as strongly complementary in their production patterns to those of New England States, and the reverse was the case for those states which shipped less than was expected. He concludes by emphasising that quantitative assessment of complementarity is necessary if the concept is to be used to greatest advantage in the analysis of commodity flow. To achieve this, notions of demand, potential flow, actual shipments and friction of distance should be taken into account in a combined gravity model and regression analysis.

Among the models used in the analysis of spatial interaction, the gravity model has certainly received the most attention (Isard, 1960; Taaffe and Gauthier, 1973; Chisholm and O'Sullivan, 1973). Alcaly (1967) has examined the effect of aggregation over modes of travel on the classical gravity model. The parameters of the model were estimated on the basis of 1960 cross-section of sixteen California city pair routes. Travel times and costs were used in some of the regressions. The regression was estimated separately for air, rail, bus and automobile travel, the aggregate equation combining all the four modes of travel was also estimated. It was found that the model performed better as measured by the coefficient of determination when the flows by all modes were aggregated. But even in the case of individual modes, the coefficient of determination in each case was more than 0.86. His conclusion was that the gravity model is more powerful in describing and predicting mass behaviour in spatial interaction. A similar conclusion was also reached by Mera (1971) who found that the gravity model yielded better fits when applied to aggregate commodity flows than when applied to disaggregated flows.

In models of this sort, the attractive measures of the model are extended to incorporate other independent variables which are likely to affect the amount of travel between i and j. In most cases socio-economic and/or transport supply factors are incorporated in a more extended version of the model. In a study of the travel characteristics of road users in Malawi, Fouracre and Sayer (1977) used the extended version of the gravity model formulation to explain the total trips in both directions between Blantyre and Lilongwe and rural zones of traffic generation. In addition to the usual gravity model parameters, they incorporated nine other socio-economic and transport supply factors. These included vehicle ownership, annual income, road kilometrage, road area density, bus journey kilometrage, bus journey density, bus route density, road population density and service density. The variables were subjected to multiple regression analysis. The regression equation showed that the most significant factors for both Blantyre and Lilongwe were population, distance, service density and road population density for Blantyre and population, distance, road area density and vehicle ownership for Lilongwe.

The coefficient of multiple determination for Blantyre was 0.93 and for Lolongwe it was 0.79. The majority of the variation in trip making between Blantyre and the rural zones was explained by the distance variable which accounted for 82 per cent of the total variation. For the Lilongwe equation, the distance factor explained 61 per cent of the variation in trips. Fouracre and Sayer, however, admit that the variables included were significantly correlated with one another and in the event distance explained most of the variation in trip generation. They point out that this correlation between variables was to be expected, though the exact nature of the causal effects is difficult to determine. In conclusion, they suggest that the model formulation might be successfully employed elsewhere as a variety of different explanatory variables can be incorporate to describe the attraction between towns and rural zones.

Howe (1966) has made a detailed and extensive study of the characteristics of rural traffic generation and distribution in Kenya. He found that the dominant influence of the road traffic generation and distribution is the size and location of towns. On the basis of his finding based on regression analysis, he came to the conclusion that in spite of development planning emphasis on agricultural areas, it is evident that inter-town roads must be given careful attention because of the high volume of travel that takes place on them. In terms of vehicle distribution among individual towns, population appears to be the most important determining variable. However, in connection with travel between non-urban areas, population was not as reliable an attraction parameter as would be expected.

Empirical research and cartographic analysis have been used to identify basic geographical patterns of flow, particularly complex flow systems (Hay, 1973, pp.117). A number of scholars have attempted to define procedures for the identification of hierarchical structures in flow systems (Taaffe, 1962; Nystuen and Dacey, 1961; Soja, 1968) . Working with volumes of long distance telephone calls between forty city-pairs in state of Washington during one week in June 1958, Nystuen and Dacey were able to verify the existence of a flow structure which corresponded rather closely with the nodal organisation of the state. The procedure makes use of an origin-destination matrix of flows. The first stage involves ranking locations according to the total incoming flow. The second stage defines the dominant flow from each location as the largest outgoing flow. If this dominant flow is to a smaller centre, the origin centre is termed independent, but if the dominant flow is to a bigger centre, the flow is termed nodal. Big and small are defined in terms of the size of the total incoming flows from all places in the study area. The nodal flows may then be mapped and a range of patterns will result from simple dominance of all centres by one centre through an integrated hierarchy in which one centre dominates all other centres directly or indirectly to an absence of hierarchy in which a large number of independent centres exists.

Nystuen and Dacey found that the nodal regions derived by their analysis agree in general with expectations. Seattle was the dominant centre, with nested hierarchies existing around Spokane and Yakima. Portland formed a system of its own by capturing some of the nearby cities. There were two small and independent hierarchies defined on Pasco and Moses Lake. The finding is in conformity with current theories of nodal regions and central place hierarchies (Berry and Garrison, 1958). Large places have a larger number of connections than small places.

(c) Network Development Studies

The four-stage Taaffe- Morrill - Gould transport development model has been applied in a number of real world situations with varying degrees of fit and lack of correspondence (Burghardt, 1969; Stanley, 1970; Hoyle, 1970). Burghardt's paper examined the development of the road network in the Niagara Peninsula, Ontario from the time of permanent white settlement until the introduction of the railway. The study falls into two major divisions. The first portion deals with the historical analysis of the development of the network. The second portion compares the observed data to the model put forward by Taaffe, Morrill and Gould, in addition to the models of Christaller and Losch. This review deals specifically with the historical analysis and the comparison with Taaffe, Morrill and Gould model.

According to Burghardt, the development of the road pattern in the Niagara Peninsula was strongly affected by the original Indian trails and water routes. In the first stage, penetration, the original Indian trails were heavily relied upon. The trails became the lines of penetration and the axes of settlement. The road system consisted principally of trunk lines with few feeder lines. Trails predominated and few wagon tracks existed.

In the second stage, organisation, the inherited primitive network was greatly expanded and the key lines were improved. The establishment of administrative centres led to the construction of a few roads designed to afford contact between outlying areas and these centres. The development of major lines became more marked as few major arteries were widened, graded and bridged. Feeder lines began to appear on a local scale.

In the third stage, full occupance,the areas away from the rivers were occupied. The settlement of the interfluves and the decline of river transportation led to the clearing of road allotments in the survey pattern and thus allowed the underlying land-holding grid to appear in the road network. As a result, the many lesser river roads disappeared or adjusted to the underlying grid.

Burghardt argues that not only time as a sequence but also time as a duration was a key variable in the development of the Peninsula road network. How, then does this sequence compare with the Taaffe - Morrill - Gould model? Phase one of the Taaffe - Morrill - Gould model postulates the presence of many small ports, each with its own small trading field. Burghardt considers the four entry points along the Niagara River to be analogous to the trading ports of Taaffe model. Phase two postulates the emergence of a few major lines of penetration. The major lines of penetration in the Niagara Peninsula belong to Phase One rather than Phase Two because the major lines pre-existed and helped channel the penetration. Phase Three of the Taaffe model postulates the growth of feeder routes and lateral inter-connection. In the case of Niagara Peninsula, the baseline lateral connection appears to belong in an earlier phase. Phase Four shows the emergence of 'high-priority linkages'. The experience of the Niagara Peninsula suggests that these linkages developed concurrently with, not notably after, the rise of the more important centres.

The major conclusion of Burghardt's study is that it does not show all the phases comparable to the ideal-typical sequence of network development model as proposed by Taaffe and his associates. He, however, admits that the Taaffe model deals with different scales of space, time and technology unlike the Niagara study. Moreover, the model applies to tropical or sub-tropical coastal nations with a particular political history and subjected to colonial exploitation.

In the studies of Stanley and Hoyle, it was found that the expansion of transport facilities in Liberia and East Africa approximates the ideal-typical sequence suggested by the Taaffe model. The correspondence specifically refers to the construction and expansion of road network in the case of Stanley and rail network in the case of Hoyle's study.

Transport networks are demonstrably part of the development infrastructure and the distribution of countries with high and and low densities may be reasonably linked to their general levels of economic development. Haggett (1969, pp. 75-79) has explored this hypothesis by adopting the economic-demographic development scale developed by Berry (1960) based on the values in the Ginsburg atlas (Ginsburg, 1961, pp. 110- 19). Haggett plotted ninety-five countries along the shorter demographic x-axis and along the longer technological y-axis. On this continuum, countries with high and low road and rail densities were superimposed. The road density pattern showed a cluster of high-ranking countries at the upper end of the development spectrum. The pattern for railway density followed in general the same pattern. At the bottom end of the economic-demographic scale were strung most of the underdeveloped countries thus confirming the validity of the hypothesised relationship.

A more comprehensive investigation of the network/development relationship has been carried out by Garrison and Marble(1962). They used measures of network structure derived from the concept of graph theory; applied them to empirical evidence to test the hypothesis that transport network structures are closely related to social and economic development and physical characteristics of countries. Using multiple regression and correlation analyses they related the indices of network form for selected twenty-five countries to Berry's demographic-technological scale, size, shape, and relief of the countries. For all the network indices, the technological level was the single most important independent variable, explaining more than two-thirds of the total variation. Shape was the second most important explanatory variable followed by size and relief. The demographic status was the least significant. They concluded that highly connected transport networks are associated with economically and socially more developed countries and vice versa. A similar conclusion has been arrived at by Kansky when he used the same technique of analysis in the exploratory and explanatory phases of his study (Kansky, 1963, Chapters III and IV).

Applying a slightly different approach in terms of the variables used, Taaffe, Morrill and Gould (1963) investigated the distribution of highway density in Ghana and Nigeria and related this to population and area of administrative units. The best linear regression used the logarithms of the independent variables and explained 75 per cent and 81 per cent of the observed variation in Ghana and Nigeria respectively. Total population accounted for more of the variation in total road kilometrage than area accounted for. In both Ghana and Nigeria it accounted for 50 per cent and the addition of area as an independent variable accounted for 20 per cent more. The authors then mapped the pattern of residuals from the regression and associated them in qualitative terms with 'hostile environment, rail competition, interregional highways and commercialisation of agriculture.

At an urban level of observation, Borchert (1961) has examined the spatial correlates of network density. He related route density to distance from the centre of the twin-cities of Mineapolis-St. Paul, the period of development and the size of land-holding plots. The strongest association was with the size of land-holding plots.

4. SUMMARY AND EVALUATION OF THE LITERATURE

(a) Summary of Empirical Findings

The tables below give a summary of the major empirical findings as reviewed in the preceding sections.

DEVELOPMENT ELEMENT	Birdsall 1968	Smith 1959	Hofmeier 1973	Chiteji 1980	MOTCO INDIA 1961	Drewes 1958	Garrison 1956	Sorguc 1976
Agriculture	x	xx	x	x	xx	xx		x
Population		xx				xxx		x
Income		x						
Settlement			x		xx	x		
Health Facilities			x	x	x			x
Education Fac.				x	x			xx
Traffic Generation			x	x	O			
Manufacturing					xx			xx
Fishing					x			
Trade and Comm.					x			xx
Postal Services					x			
Property Values							xxx	
Overall Develop.								xxx

NOTES: xxx indicates very strong influence on element
xx indicates strong influence on element
x indicates moderate influence on element
O indicates no significant influence on element

TABLE 1.4 MOVEMENT STUDIES

TRAFFIC GENERATION FACTORS	Smith 1964	Alcaly 1967	Fouracre and Sayer 1977	Howe 1966
Population	xx	xx	xx	xx
Distance/Cost/Time	xx	xx	xxx	
Vehicle ownership		x		
Annual Income		O		
Road Kilometrage		O		
Road Density		x		
Bus Journey Km.		O		
Bus Journey Density		O		
Bus Route Density		O		
Road Population Density		x		
Service Density		x		

NOTE: XXX Very strong influence on movement

XX Strong influence on movement

X Moderate influence on movement

O No significant influence on movement

TABLE 1.5 NETWORK DEVELOPMENT STUDIES

NETWORK DEVELOPMENT FACTORS	Burghardt 1969	Haggett 1969	Garrison & Marble 1962	Taaffe 1963
Administration	xx			x
Settlement	xx			
Economic Development		xx	xxx	
Population/Demography		xx	0	xx
Size			x	x
Shape			x	
Relief			x	
Mining				x
Agriculture				x

NOTE: XXX Very strong influence on network Development

XX Strong " " " "

X Moderate " " " "

0 No significant " " " "

(b) Evaluation of Theoretical and Empirical Literature

(1) Theoretical Literature

That a certain amount of transport facilities is essential to allow the development of a modern economy is generally accepted. But there is, however, no general agreement among transport scholars about the actual amount of transport necessary and its causal relationship with regard to the influence it exerts on economic growth and development. This lack of agreement has been occasioned by the belief in certain quarters that transport is a result rather than a cause of economic and social development. Others claim that it can be both a cause and a result of development.

In their attempts to resolve this problem, Wilson and Storey erected a theoretical framework of three causal possibilities on the basis of which they examined the role of transport in economic development. Wilson categorises them as positive stimulus, middle and negative cases. For Storey these are positive, neutral and negative effects. The two latter categories of Wilson can conveniently be classified as negative effects, depending on the degree of the decline or decrease of economic growth. The positive case of causal and temporal precedence in Storey's Possibility Matrix does represent a commonly held view of transport as a precondition or a prerequite of development, and as such transport should be viewed as a leading sector in the process of development. In causal terms, this means that transport influences economic activities. In temporal terms transport precedes the development of economic activities. In reality, these assertions can be true to some extent, at least in early stages of economic development. The development of agriculture and settlement in Kenya in the early years of this century would scarcely have been possible if the building of Uganda Railway did not precede development. In this case, transport can be said to have been a precondition for the development that followed.

The neutral/concomitant intersection in Storey's Possibility Matrix indicates that transport plays a neutral role in the development process, developing concomitantly with the expansion of economic activities. This proposition can be true when the expansion of transport facilities is an integral part of the socio-economic development to be initiated. This case should be relevant in both early and later stages of economic development. Much of the road construction in Kenya from 1920 to the present time can be said to have followed this pattern of development. It was concomitant with and stimulated development.

Wilson, however, reminds us that in all cases involving transport and development, there is a large element of contingency (Wilson, 1966, pp. 10). He argues that in every case, certain things may happen, but again they may not. This would seem to suggest that neither Storey's nor Wilson's proposed possibilities are always inevitable.

In their model, Storey and Wilson have isolated one factor (transport) from a complex system of interdependency in the economic system. Transport has been taken as the sole cause of economic development while in fact, transport is just one of the many factors that work in combination to promote economic development. It is not, therefore, logical to isolate one factor in the economic system and ascribe all the results to it alone.

Ullman's theoretical approach to the understanding of why linkages and flows between some places are stronger than between other places is a useful tool and a satisfactory base from which the analysis of linkages and flow can proceed. But the model has certain inherent flows that make it less useful than the general conceptualisation of movement it proposes to explain. For example, some of the concepts in the model such as, complementarity and intervening opportunity are difficult to explain and express precisely (Stouffer, 1940; Porter, 1964; Smith, 1964). Moreover, the concepts of complementarity, intervening opportunity and to some extent transferability as defined by Ullman, do not always apply in most real world interaction systems.

Ullman explains that complementarity is a function of both cultural and areal defferentiation. To some extent, this is true. But mere differentiation by itself does not always generate the flow of goods, people or ideas between places. One has to consider the many parts of the world which have no interaction of any kind with one another, although they are culturally and areally different and specifically complementary. There is indeed, if any, very little interaction between African States and the States of South America, yet they satisfy the conditions of complementarity. The same case can be argued for lack interaction among African States. The historical backgrounds of the nations and their political alignments have to be taken into consideration. The concept of intervening opportunity can be rather elusive. Consider the case of Kenya importing maize all the way from the United States, while the intervening opportunity represented by Zimbabwe could provide the supply of the same goods. Even the concept of transferability does not always work in all situations. Goods of light weight and of high value can be transported long distances regardless of the high costs of transfer. The trade in gold between South Africa and the United States is a case in point. The concepts of Ullman's three-factor typology of spatial interaction, however, provide a reasonable base from which movement related factors could be investigated. But because of the differential operations of the economic, social and political systems of nations, the factors should be treated with caution.

There is little doubt the ideal-typical sequence model of Taaffe and his associates provides a very useful summary of certain regularities in the growth and development of internal route systems of the ex-colonial coastal states. But any stage-of-growth approach to model building, or whatever, can be criticised on the grounds of artificially partitioning what, in fact, is a continuous and evolutionary growth process. Moreover, in its totality, the model does not seem to accord with some of the real world facts. Burghardt who investigated its relevance to the Niagara Peninsula, concluded that the sequence observed was different in the North American context. The question is, how far is it applicable outside Ghana and Nigeria in particular, especially to other ex-colonial nations in general? How far is the division into the four stages justified? This study will make an evaluation of its applicability in the Kenya context.

Alan Hay has criticised the model on the grounds that the sequence appears to have strong geometrical symmetry but lack internal logic. The theory seems to be concerned primarily with connectivity while the accompanying empirical study is concerned with density. However, although the model seems to be impressionistic, it is not easy to manipulate or test. Given the fact that all models represent simplifications, these weaknesses may have been unavoidable. There is likely to continue a good deal of academic discussion over how many stages should be recognised and where the significant breaks, if ever, occur. The model will continue to stimulate the study of the growth of transport networks in the developing world, whether interior or sea-board nations.

The Lachene model, aside from being strictly a hypothetical one, seems to be applicable to mid-continental nations in which large-scale rural to urban migrations have taken place, such as in North America and Europe. His approach is based on plausibility and common sense, rather than inevitable logic leading to particular events and relationships. The question, such as, why did the node or route develop here and not there cannot be answered. His major purpose was to study the relationship between the geographical distribution of economic activities and transport networks. The hypothetical model of network development seems to have been appended at the end of his main topic of study as an after-thought simply to illustrate the relationship between the growth of towns and the development of transport networks. He, however, admits that he did not have a statistical check in view and as such the model lacked refinement, as he confined himself to selecting the simplest and most obvious relationships.

(ii) Empirical Literature

The case studies reviewed in the literature on the impact of transport on development show the events that followed the construction and expansion of transport capacity as if transport was the cause of the occurrence of the events - a one-way causal process. In Drewes's study, the observed relationship between population growth and the provision of transport facilities does not demonstrate that improved transport causes population growth. It is very difficult to prove this claim. It is equally plausible to argue that the greater the population, the greater the demand for more transport facilities. In this event, transport and population are mutually interrelated as cause and consequence of each other. This two-way relationship must be recognised instead of ascribing a unidirectional causation to factors that are interdependent and mutually determining.

In the case of Uganda, the most that can be said is that increased cotton output and population were associated with the expansion of transport capacity. In this case, some unspecified relationships appear to exist, the nature of which we do not know. The observed relationships between roads and cotton production on the one hand, and population on the other, do not necessarily imply that roads were the cause of greater production and increased population. The opposite could have been the case. The economic development that followed the provision of transport facilities could be explained in terms of a combination of factors in conjunction with the highways. The role of transport should be viewed from that perspective. Similar arguments could be advanced for the other cases of transport impact studies. Perhaps, Sorgue's examination of the proportional contribution of transport to the variation in development vis-a-vis other relevant factors, is a more logical approach to the analysis of transport/development relationship.

Movement and network development studies such as those of Alcaly (1967), Fouracre and Sayer (1977); Haggett (1969), Garrison and Marble (1962) and that of Taaffe et al. (1963) looked at movement and network development as a function of socio-economic development and physical factors. In the case of movement, it is clear that movement volume between any two places is directly proportional to the product of the two masses (population) and inversely proportional to the distance separating them. Thus, cause and effect relationships are clearly determined and specified. But the nature of the relationships between network development and socio-economic factors are sometimes difficult to specify precisely. Both network development and socio-economic development are interrelated as cause and effect of each other as was argued under impact studies. The best conclusion that can be reached is that, generally functional relationships exist between network and socio-economic development. The two variable are areally associated, that is, wherever one occurs the other one will also be found.

In conclusion, the researcher wishes to point out some of the shortcomings and missing gaps in some of the literature so far reviewed and show how to fill in the gaps.

Transport/development relationships models as proposed by Wilson and Storey have one shortcoming, in that they were not accompanied and backed by empirical data for testing and verification. In the case of the negative effects of transport on development, none of the literature materials reviewed support the proposition. The researcher is of the opinion that if overinvestment in transport development can lead to an overall decline in a country's per capita income, this can only be explained in terms of misdirection or misallocation of. development resources, which in any case can happen in any sector of the economy.

To test the validity of the positive and neutral or middle case of transport/development relationships, a conceptual model of the development of transport system has been designed to be subjected to empirical testing and verification to shed light on the nature and form of the relationships.

The concept of complementarity in Ullman's bases for interaction has been criticized on the grounds of being difficult to explain and express precisely. It is proposed in this study to express the concept quantitatively in terms of the volume of goods moving from a set of areas to one destination by the use of transaction flow analysis.

One of Hay's criticisms levelled against Taaffe-Morrill-Gould model is that the model is not easy to manipulate or test. This is however possible, at least not via statistical testing. The model's fit or otherwise to the Kenyan situation will be tested by comparing the observed data to the ideal-typical sequence model of transport development as postulated by Taaffe and his associates.

Transport is only one of the many factors that promote economic development. The unanswered question is what is the proportional contribution of transport vis-a-vis other socio-economic factors' contributions to the variations from place to place in development in general? This study will find out this by the application of rigorous statistical analyses to isolate the relative significance of the influence of transport and other relevant socio-economic factors by simulteneously treating them together using the multivariate techniques of multiple regression and correlation analyses.

Sorguc' study of the relationships between transportation and socio-economic development in Turkey using composite indices of development used the unweighted combined indicator values. The researcher is of the opinion that before such indicators of development are combined to generate composite indices, they have to be weighted so that the degree of importance that each indicator will have in the measurement of the whole should be reflected. This gap will be filled in by weighting the indicators before finally combining them as composite indices.

D. OBJECTIVES OF THE STUDY

The broad objectives of this study are:

1. To trace the origins and development of the road network system of Kenya in relation to economic, social and political forces that have influenced its present pattern.
2. To compare its sequence of development with the ideal-typical sequence of network growth and development model proposed by Taaffe, Morrill and Gould.
3. To assess and evaluate the relationships between the network development and selected economic, social and physical characteristics of the district units of observation.
4. To identify the geographical patterns of the inter-district passenger and commodity flows and relate these to traffic generation factors.
5. To construct composite indices of socio-economic development in an attempt to establish the nature and form of their relationships with the index of road transport development.

E. THE SCOPE AND LIMITS OF THE STUDY

In this study, the origins and development of the road network system will be treated, traced and observed at the national level of aggregation. For the purpose of analysis of the spatial variations in the patterns of flows, the current 41 adminstrative districts of Kenya have been used as the basic units of observation. Because of the geographical scale of the area under study, only class A, B, C, D, and E roads of the Kenya national network system have been subjected to analytical statistical treatment in the study. Roads falling within the above five categories of classification have been studied and analysed up to the Kenya national boundary with the neighbouring states.

The intra-urban road network and flow systems have been excluded from this study as urban areas have their own specific transport problems. This is particularly so as the systems of classifying rural and urban roads can raise acute problems of differences in the operational definition of roads. To study the two systems of road would, therefore, make it difficult to compare the network structures of the rural district roads and the single- and multiple-lane highways and streets of the urban districts. The Intra-urban transport system with its specific problems is, therefore, a topic which merits a study of its own as has been done in the case of Nairobi City by the present researcher(Ogonda, 1976). However, the inter-urban route system as part of the national system has been given full treatment. Thus, the objectives 3 and 5 exclude the analysis of the urban districts of Nairobi and Mombasa as units of observation.

No attempts have been made to study problems or aspects of the road transport system that transcend the national boundary. In respect to other modes of transport such as the railways, airways, waterways and pipelines only those specific aspects which have direct links and relevance to this study have been considered. This study is , therefore, basically concerned with the varying spatial character of the road transport phenomenon as it relates to other aspects of the societal system. The purely economic aspects such as cost-output relationships, pricing and public control of the road transport industry are beyond the scope of this study.

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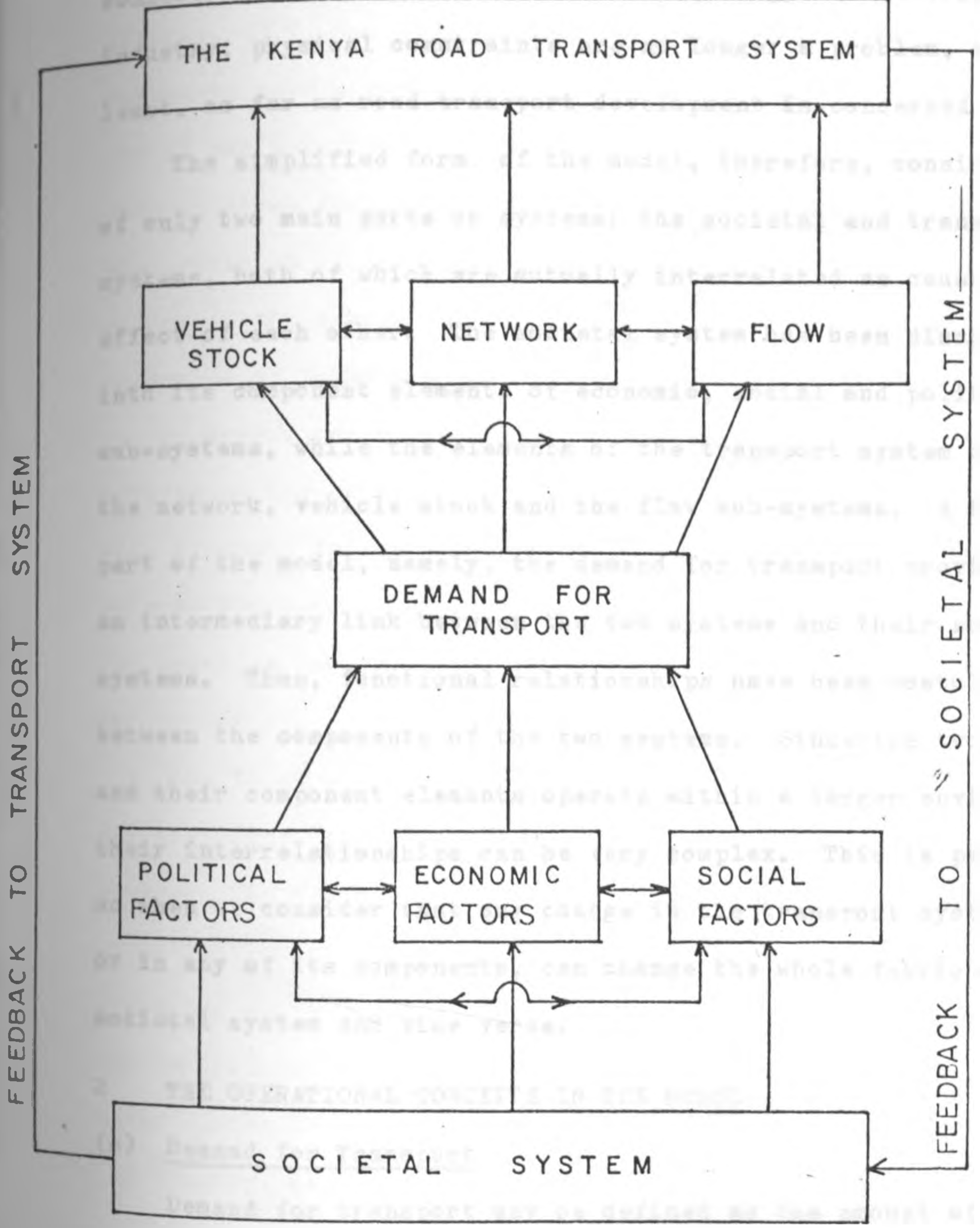
CHAPTER TWO

THEORETICAL FRAMEWORK, HYPOTHESES AND THE STUDY AREA

A. THEORETICAL FRAMEWORK

1. THE TRANSPORT DEVELOPMENT MODEL

This study is based on the theory that the character of a transportation system, as a whole and in detail, is determined by its interaction with the economic, social and political forces and conditions. To understand the basic characteristics of a transport system and the factors underlying the process of its growth and development, requires a functional and systematic analysis of the nature of their interrelationships. In the absence of a sound theoretical framework in which to arrange the components of transport and socio-economic system, a simple conceptual scheme has been designed to illustrate the nature of their interrelationships (Figure 2.1). This model represents an extended version of Hay's elements in the spatial analysis of transport problems (Hay, 1973, pp. 2), a simplification of White and Senior's conceptual framework for a transport system (White and Senior, 1983, pp. 6) and some of the elements of Rimmer's transport system model (Rimmer, 1974, pp. 292). The model has one fundamental assumption, and that is, the physical factors have, if any, very negligible influence on the development of road transport system. This assumption is justified on the grounds of parsimony and in view of the existing technological developments in the transport industry. Parsimony



A CONCEPTUAL MODEL OF THE DEVELOPMENT OF TRANSPORT SYSTEM

FIG. 2.1

in the sense that to incorporate the physical elements into the model would make it a little more complex, and taking into consideration the current state of technology in the transport industry, physical constraints are no longer a problem, at least, as far as road transport development is concerned.

The simplified form of the model, therefore, consists of only two main parts or systems: the societal and transport systems, both of which are mutually interrelated as cause and effect of each other. The societal system has been disaggregated into its component elements of economic, social and political sub-systems, while the elements of the transport system comprise the network, vehicle stock and the flow sub-systems. A third part of the model, namely, the demand for transport provides an intermediary link between the two systems and their sub-systems. Thus, functional relationships have been postulated between the components of the two systems. Since the two systems and their component elements operate within a larger environment, their interrelationships can be very complex. This is particularly so when we consider that any change in the transport system or in any of its components, can change the whole fabric of the societal system and vice versa.

2 THE OPERATIONAL CONCEPTS IN THE MODEL

(a) Demand for Transport

Demand for transport may be defined as the amount of transport service which an individual, a group or an organisation is prepared to buy at a given price. As Thomas puts it, this is not necessarily the amount of transport requirement that people actually have or would like to have. It is the amount they would choose to have under certain assumed conditions (Thomas, 1974, pp. 19). Demand is, therefore, a variable dependent upon a number of demand factors such as economic, social and political or other institutional considerations. Some of these factors can have positive or negative effects on the provision of transport facilities. Positive effects can emerge if the demand for transport is met by the creation or expansion of transport facilities. This may generate an increase in the demand reflected in the volume and speed of movement, thus activating the activities in the societal system which in turn will generate further the demand for transport, such that the interaction becomes an accelerating and a continuous process. The negative factors have the effects which lessen the demand for transport.

The first stage in the development of any transport system is, therefore, the demand for movement. For the most part, however, the demand for transport is derived, being a means to satisfy other ends, and it can vary both in space and time depending on the levels of activity in the areas of demand. In its spatial context, demand is essentially a matter of distribution from a set of origins to a set of destinations. Its density, represented in the form of flows in a given area or a long a route, can be expressed in terms of passenger volume or commodity tonnage and vehicle flows. The density of demand can show wide variations in geographical space and is generally a function of the distances separating the points of origin and destination and their relative complementarity. The demand for transport is, therefore, taken as the basis for an explanation of the growth and development of any transport system. The supply of both network and vehicle stock is a response to demand, while demand, network and vehicle stock are the determinants of the spatial pattern of flows. The relationships between these phenomena can involve much circular causation, however.

Patterns of demand can also vary considerably in time. Consider the diurnal variations in the demand for transport by commuters giving rise to marked peaks of demand in the morning and evening rush hours, with comparatively lean traffic in the intervening hours. Similar variations can be experienced weekly or seasonally. The significance of all these spatial and temporal variations in the demand can have important implications for the spatial patterns of networks, vehicle stock and flows and for the overall nature of the relationship between the transport and the societal systems.

(b) The Societal System

The societal demand for transport services can be disaggregated into its economic, social and political dimensions. It would seem unrealistic to artificially separate a system of inter-dependent variables as in general the motive for the provision of transport facilities is to serve the societal system as a unified whole. Sometimes, the sole purpose for the provision of transport facilities is to facilitate movement of administrative, military equipment and personnel. However, such transport facilities have been known to serve a combination of other purposes for which they were not originally intended. For the purpose of this study, such a division can be justified on the grounds that it can provide a considerable insight into the identification of the relevant societal factors that have had significant influence on the variation in the spatial pattern of transport facilities.

(1) Economic Factors

These include the demand for transport to serve the agricultural, industrial, commercial and other service activities of the economy. In terms of economic considerations, transport can always only be a derived factor that is dependent upon or dictated by a whole range of economic demand variables. But as has been noted, transport can also determine the nature and the location of economic activities. In fact, there is something of a symbiotic relationship between the development of transport facilities and economic development.

It has been noted that road densities are positively associated with the degree of economic activity, in that more economically developed areas tend to have higher densities of road networks than the less developed areas. This hypothesis was usefully explored by Hagget (1969, pp. 76 - 79) when he superimposed countries with high and low road and rail densities on the economic - demographic development scale as developed by Berry (1960). In terms of movement of people and goods specific complementarity has been postulated as the basis for interaction and the cause of the emergence of transport routes between spatially separated areas (Ullman, 1956). Moreover, the quantity and quality of the vehicle stock in a given area is determined to a large extent by income and the population of an area. So the growth and development of transport system must be explained in terms of the degree and levels of economic development of countries.

(ii) <u>Political - Cum - Administrative Factors</u>

Already considered is the extent to which economic factors can affect the spatial pattern in the provision of transport facilities; but much more important than this is the influence of administrative and political factors. In virtually all the countries of the world, the construction and maintenance of public roads is the responsibility of the central or local governments, providing funds normally from their own tax resources or through foreign donors for specific road projects.

Government's interventions in all aspects of the road transport industry can take various forms. The maximum weight of vehicles permitted on certain roads is the weight which can be supported by the weakest bridge or the strength of the road pavement. To ensure minimum standards of service the operators of public transport are required by law to provide transport services according to time schedule and not on the basis of a full load factor. Moreover, the regulations governing monopoly and competitions in the transport industry ensure that rate and fare charges are as uniform as possible throughout the country. Other forms of administrative - cum - political influence on the provision of transport facilities include laws imposing differential customs duties on certain categories of imported vehicles, laws discriminating against the movement of certain categories of goods and those that restrict movements across national boundaries. The Presidential Decree of 1973 which allowed free entry into matatu[1] business and the recent ban on the movement of heavy commercial vehicles at night are some of the ways in which politics and government administrative machinery can influence the growth and development of transportation system. Politics and bureaucratic machinery can also determine what transport facilities go where and why. Unfortunately, most of these political and administrative factors influencing transport development can present insurmountable and serious operational definition as some of the elements can not be easily defined and measured. However, the fact that they exist makes them even more powerful than the economic forces considered above.

(iii) Social Factors

Social and cultural forces can also have a considerable influence on policy decisions affecting the demand for transport. A case in point is the need to provide transport facilities linking the location of social facilities such as schools, health centres, churches, holiday and sporting centres. Moreover, the motive for the provision of transport facilities may be governed simply by the fact that they are needed to improve the mobility and social welfare of the people. In fact, population distribution has been found to be one of the most significant determinants of the spatial pattern of transport networks (Taaffe et al., 1963). It is also the most important determinant of the volume of traffic flow and the distribution of vehicle capacity. In combination, economic, political and social factors of the societal system are the basic inputs into the analysis of transport/development relationship.

(c) The Transport System

An industry as vital to the society as transport cannot function in void. The transport system and its component elements can only be brought into existence by the demand of the economy and the society it is going to serve. The development and change in the transport system is inextricably linked with the changes taking place in the societal system. Thus, transport system can be regarded as a system affecting and being affected by the societal system of which it is apart. It has measurable inputs into the societal system in the form of fixed networks and terminals and mobile equipment in the form of vehicles. Similarly measurable, are its output in the form of flows of vehicles, passengers and commodities.

The distribution of economic activities generally follows the distribution of transport facilities. This is not to say that transport is the most important single factor determining the location of economic activities. Other factors are equally important. But for transport, its cost and price are the main determining variables in the decisions affecting the location of economic activities. In all economic activities, the total cost of all the transport operations involved in assembling raw materials and distributing the finished products in relation to the final price paid for the commodity will have a very important effect on the location of the particular activity. Other things being equal, the activity will locate at the point where transport costs are minimal. These transport cost factors were important elements in the formulation of theories of the location of economic activities (VonThunen, 1926; Weber, 1909; Hoover, 1948).

The influence of transfer costs on the location of manufacturing industries can be taken as an example. Considered in terms of either raw materials or the finished products, industries normally experience relatively high costs of transport, usually reflected in the consumer prices of the finished products. The costs of materials and the procurement of power and fuel may be regarded as part of the transport costs. Transport costs should thus be considered as an integral part of the productive process, as such costs may constitute a fairly large fraction of the total costs. For that reason, varying transport costs in different areas if not overshadowed by other more powerful locational factors tend to focus industries in areas where such costs are minimal. Transport orientated industries are, therefore, best located where the costs of raw materials assembling and those of distributing the finished products together, is least (Ojany and Ogendo, 1973).

(1) Transport Network

The concept of transport network includes the geometrical layout, the location of intersections, nodes and terminals, the density and length of routes and the relative accessibility and connectivity of the individual nodes on the network system. The elements of transport networks can be measured in terms of total kilometrage, density per unit area or in terms of graph theoretic indices such as beta, cyclomatic number, gamma and alpha indices (Garrison, 1960; Kansky, 1963). These consistent measures of network structure and form have attracted wide applicability in recent works on network analyses and can be used to describe and compare the degree of development of one network with others in the same region or different regions; alternatively, they can be related to socio-economic and physical characteristics of the regions (Garrison and Marble, 1962). The density and structure of a given transport network are not only determined by the characteristics of regions, but can also determine the spatial pattern of socio-economic activities in the regions. Within the transport system, the quantity and capacity of the network is determined by the vehicle stock capacity, volume of flow and the level of transport technology; transport system inter-dependency, as it were.

(ii) Vehicle Stock

This is the mobile transport equipment. It includes cars, lorries, buses, and motorcycles. Generally, the distribution of these transport stock is most closely related to income, population and size of the area, and to a large extent, to the pattern of the distribution of the transport network.

(iii) Flows

In studying the growth and development of a transport system, a considerable amount of attention is devoted to how much moves where, in other words, the flow which is the very activity of transport. The demand for transportation facilities implies movement and its magnitude determines the quantity and quality of network and the supply of vehicles. As has been noted, the three elements of transport system are interrelated and mutually interdependent and as such their interdependence can involve much causal links. This can be illustrated by the fact that the provision of transport networks and vehicle stock capacity modifies the relationships between a set of locations connected by the network linkages. The set of locations channel the volume and direction of flow over the network linkages, which in turn, are modified by the volume of flow they carry.

In many studies of flows, their volumes have generally been related to population as the mass of the areas involved in the interchange and the distance separating them expressed in the original or an extended version of the gravity model formulation. Other studies use the technique of linear programming (Yeates, 1963), while others employ the technique of transaction flow analysis (Soja, 1968).

An attempt will be made within the context of the concenptual framework to tie these strands of relationships into a more general theory explaining the development of transport systems in general and specifically with reference to Kenya. A complementary approach will be adopted to determine to what extent transport development contributes to the general level of development. Such relationships will be examined statistically via the graph theoretic models, the basic regression models and the gravity models and its variant formulations, using quantitative cross-sectional analysis supplemented by evolutionary qualitative analysis.

B. HYPOTHESES

In order to test the significance of these strands of relationships, the following hypotheses have been proposed:

1. The development of the road network system is determined to a large extent by population, levels of agricultural development and the areas of the district units of observation.
2. There is a significant difference between the stages of growth of the Kenya road network system and those of the

ideal-typical sequence of network growth model.

3. The spatial variations in the volume of passenger flows can be explained in terms of socio-economic characteristics of the districts and the distances separating them.
4. The spatial variations in the volume of commodity flows can be explained in terms of socio-economic characteristics of the districts and the distances separating them.

1. <u>Operationalisation of the Concepts in the Hypotheses</u>

Hypothesis 1:

The development of the road network will be measured in terms of a composite index of road network development combining the beta index with the density of road per unit area. Population is expressed as a composite index combining total population of the district and its density per square kilometre of land, and the level of agricultural development will also be expressed as a composite index.

Hypotheses 3 and 4:

The volume of flows for passenger will be the combined passenger movements by cars, matatus and buses that were attracted from the forty districts of Kenya to Nairobi in 1983. The volume of commodity flow will be the combined flows of the eight principal commodites that were generated from Nairobi to the forty districts. Socio-economic characteristics of the districts will be measured in terms of population, employment earnings and vehicles generated, and distance will be the airline distance in kilometres.

C. THE STUDY AREA

1. INTRODUCTION.

The Republic of Kenya is located on the eastern part of the Continent of Africa and forms an important part of East Africa. The country shares a common boundary with Ethiopia and Sudan to the north, Somalia to the east, Tanzania to the south, Uganda to the west and to the south-west it is bordered by the Indian Ocean (Figure 2.2).

The country is located approximately between latitudes $4^0 21'$N and $4^0 28'$S and between longitudes 34^0 and 42^0E. With

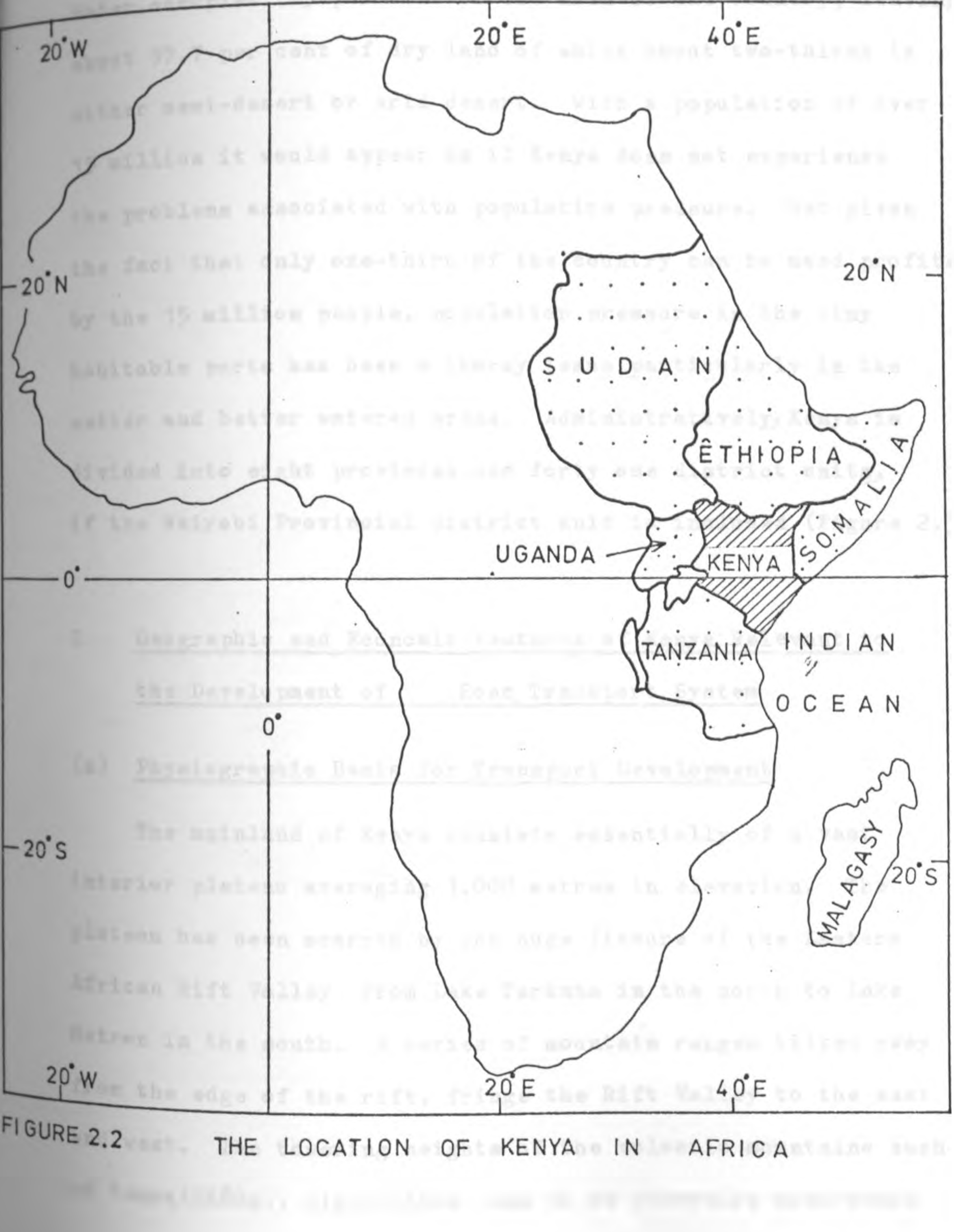


FIGURE 2.2 THE LOCATION OF KENYA IN AFRICA

an area of 582,646 square kilometres, Kenya is 2.5 times the size of Uganda and can go into the size of Tanzania 1.5 times. Water occupies 2.3 per cent of the area of the country, leaving about 97.7 per cent of dry land of which about two-thirds is either semi-desert or arid desert. With a population of over 15 million it would appear as if Kenya does not experience the problems associated with population pressure. But given the fact that only one-third of the country can be used profitably by the 15 million people, population pressure in the tiny habitable parts has been a thorny issue particularly in the wetter and better watered areas. Administratively, Kenya is divided into eight provinces and forty one district units, if the Nairobi Provincial district unit is included (Figure 2.3).

2 Geographic and Economic Features of Kenya Relevant to the Development of Road Transport System

(a) Physiographic Basis for Transport Development

The mainland of Kenya consists essentially of a vast interior plateau averaging 1,000 metres in elevation. The plateau has been scarred by the huge fissure of the Eastern African Rift Valley from Lake Turkana in the north to Lake Natron in the south. A series of mountain ranges tilted away from the edge of the rift, fringe the Rift Valley to the east and west. The towering heights of the volcanic mountains such as Kenya(5680m), Elgon(4666m) add to an otherwise monotonous

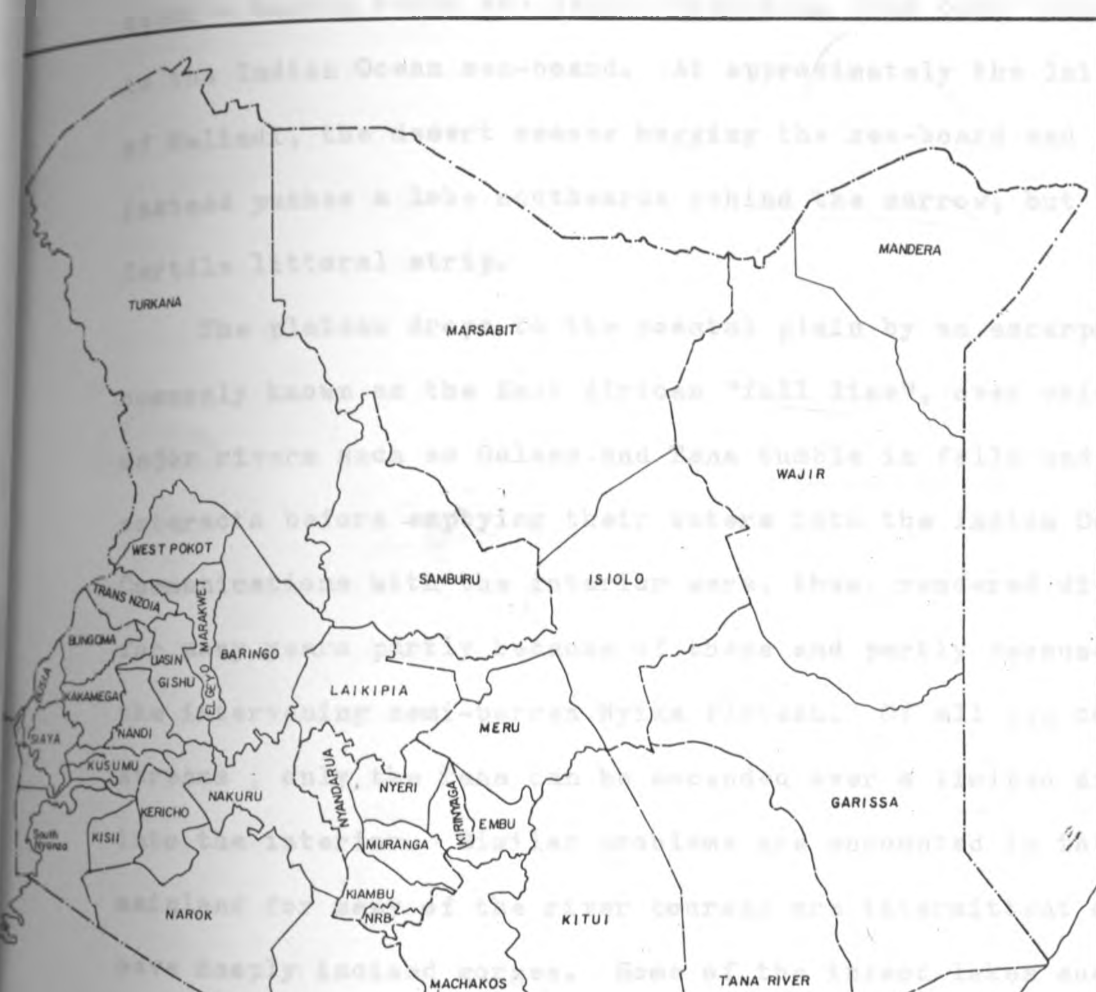


FIG.23 KENYA DISTRICTS INCLUDING NAIROBI PROVINCE

plateau surface. In the northern and north-eastern portion of the country there is an extensive patched depression of quasi - barren rocks and sands stretching from Lake Turkana to the Indian Ocean sea-board. At approximately the latitude of Malindi, the desert ceases hugging the sea-board and instead pushes a lobe southwards behind the narrow, but fertile littoral strip.

The plateau drops to the coastal plain by an escarpment commonly known as the East African "fall line", over which the major rivers such as Galana and Tana tumble in falls and cataracts before emptying their waters into the Indian Ocean. Communications with the interior were, thus, rendered difficult for many years partly because of these and partly because of the intervening semi-barren Nyika Plateau. Of all the coastal streams , only the Tana can be ascended over a limited distance into the interior. Similar problems are encounted in the mainland for many of the river courses are intermittent or have deeply incised gorges. Some of the inland lakes such as Lake Victoria provide international links with the neighbouring countries while others such as Lake Turkana are only for local interchange of persons and goods.

Throughout the country, climatic contrasts are very striking from the purely tropical humid and hot regime in the coastal belt to a gradation of temperate - to - cool zones in the highlands, while to the north and northeast of the country semi-desert conditions prevail. The varied nature of the topography contributes further to regional differentiation in the incidence and volume of rainfall which is a function of the exposure of the slopes to the prevailing moisture - laden south-east trade winds. Closely correlated with this variation in the topography, is the patched pattern of human settlement with concentrations in those areas with good amount of rain fall and potentially good soils for exploitation. A similar pattern is also reflected in the distribution of the transport network system. The complex physical background has made it difficult and costly to provide adequate and equitable amount of transport facilities throughout the country. By road or rail it is, however, possible to provide a reasonable amount of transport services for the better endowed districts only at the cost of crossing several unproductive tracts of land with little prospects of remunerative traffic. Most of the transport routes have to cross difficult terrains with steep slopes, negotiating them with dangerous bends.

The effects of climate on transport take many forms. During the wet season, the flooding and erosion of the road surface by heavy down-pours and run-off is common place. Earthworks, bridge abutments, culverts and reinforced grades are at the mercy of the sudden tropical down-pours. Even the bituminized highways have difficulties in resisting the excessive moisture and the extremes of temperatures. Most roads in Kenya are surfaced with gravel and earth. Whereas the first type tends to corrugate in dry weather through the disintegration of the soil binders, the earth roads are especially liable to become impassable channels of mud and water pools after heavy rains. In months of severe drought, especially in the dry northern parts of the country it is difficult to get water to cool the overheated motor vehicle engines as local water holes run dry, thus shortening the average life of motor vehicles.

(b) Population and Urbanisation

In common with many developing countries, the population of Kenya is still predominantly rural. About 90 per cent of the population live in rural areas and the majority of them are found in three clusters of population regions. In the western part of the country is the closely settled region of Lake Basin, from the slopes of mount Elgon to the Tanzanian border, generally west of the Central rift. A second well-defined population cluster extends northwards from the city of Nairobi over the lower slopes of the Aberdares, Mount Kenya and Nyambene Hills with an outlier cluster to the east on the Kamba Hills. A third distinct area of population concentration extends along the Indian Ocean sea-board from the Sabaki/Galana river delta southwards towards the Tanzania border. Elsewhere, rural population concentrations emerge only in isolated population islands, particularly where rainfall is high, and where ground water and water courses make it possible for crop cultivation.

All districts with population density above 100 per square kilometre are located in one of these high density areas. The lacustrine population concentration in western Kenya coincides with the agriculturally high-potential lands with sufficiently high amount of rainfall of over 100mm. per year. For example, Kisii District has a population density of over 300, Kakamega, 222 and Kisumu District 193 per Km^2. These high population density areas merge eastwards into the Western Rift highlands where average densities range from between 50 to 200 per Km^2 (World Bank, 1980). In the second population cluster, densities of 400 to 600 persons per Km^2 are found in southern parts of Kiambu District, while densities ranging from 200 to 400 persons per Km^2 are characteristic of Embu and Meru Districts. In the coastal districts, average densities range from 50 to more than 500 persons per Km^2 in the island of Mombasa. At the current rate of annual population growth (3.8%), it is likely that by the end of this century the present population of 15 million will have doubled.

The majority of Kenyans still live in the rural areas. In 1969, less than a tenth of the population were living in urban area with 2,000 or more inhabitants. Even the mid-1978 estimate of about 12.2 per cent indicates that Kenya is still one of the least urbanized countries in the world. With the 1979 population census results now officially out for urban areas, the country's level of urbanisation is likely to exceed the estimated percentage for mid-1978.

The influence of population on the demand for transport is reasonably straight forward. The larger the population, the greater will be the demand for transportation and consumer goods which must be produced and transported. This is reflected in the pattern of road network distribution, as the districts with the highest population densities are also the ones with the highest network densities. From the high density districts, there has been a general rural-to urban migration which has had the effect of increased demand for transport both for social and economic reasons. Socially, when a family member seeks urban employment strong ties are maintained between the individuals, friends and relatives in their homeland. Such social connections tend to maintain a continuous stream of travellers between the rural and urban areas. This has been emphasised by the fact that in many cases, urban employment is sought as a source of income for the purchase and development of property in the home community, as most Kenyans do not still regard urban life as permanent.

Economically, the non-availability of land for agriculture in the urban environment necessitates the importation of food and materials from the rural areas to support the urban population. These items must be carried for long distances to urban areas where better prices are offered. Furthermore, there is a general tendency of urban workers in the peripheral districts to commute daily as some people find it economical to live in their own homes since transport services between urban and rural areas have improved over the years.

The Kenya Government policy of settling people from areas of high population pressure into areas newly opened for agriculture has created another dimension of social demand for transport between resettlement areas snd home areas. Such strong family ties require communication and cross visiting in a manner similar to, but less pronounced than that entailed by urbanisation.

(c) The Economic Structure

(i) Agriculture

Agriculture is predominantly the most important economic sector of the country and will remain its basic structure for many years to come. In 1983, more than 30 per cent of the Gross Domestic Product originated from the sector, while about 60 per cent of the value of exports comprised the raw or semi and processed agricultural products(Republic of Kenya,1983). Its significance in the country's economy is further emphasised by the fact that the majority of Kenya's population in the rural areas is depe ndent on one form of agriculture or the other.

A notable feature of Kenya's agriculture is the diversity of its development orientated geological zones.About 80 per cent of the available agricultural land is considered of low potential for production. This consists mostly of hot, dry country at low altitude and is sparsely inhabited by pastoral people. The remaining 20 per cent of medium and high potential land is densely settled by people who raise a variety of crops and livestock.Most of the high and medium potential areas are in the highlands west of the Rift Valley, around Mount Kenya and the Aberdares and at the narrow coastal strip. Altitude, therefore, has an important bearing on the type of agriculture practised. At the highest altitudes around 2,000 - 3,000 metres, crops such as wheat, pyrethrum, tea and potatoes are important. At intermediate altitudes of about 1,500 - 2,000 metres, coffee and maize are important and at still lower levels, cotton, sugar-cane, rice, pineapples and a wide range of subsistence crops are grown. At the very low altitudes along the coast, a variety of tropical crops and fruits including cashew nuts, kapok, sugar-cane, cotton, coconuts and mangoes are grown. In addition to the crops, several different types of livestock are kept, ranging from the imported exotic breeds of cattle and sheep, pigs and poultry at the higher altitudes to the indigeneous breeds of zebu cattle, sheep, goats and camels, mostly found in the drier pastoral areas.

This diversity in the country's agriculture is reflected in the pattern of road network. There is generally a close correspondence between the distribution of road network and agricultural activity. Areas of high and medium potential tend to have higher densities of road network than those of low potential. Special road building programmes such as Sugar and Tea Roads and Rural Access Road Programmes have been directed towards the improvement of movement of agricultural produce in these areas (Republic of Kenya, 1980), a reflection of their potential significance in agricultural productivity.

(ii) <u>Manufacturing and Service Industries</u>

In the field of industrialisation, Kenya is still far from this compared to the major industrial nations of the world. The reason for this lies in the fact that Kenya lacks the basic raw materials such as iron ore, coal and other essential minerals that form the basis of heavy industry. Thus, such industries as are found in the country are light, consisting mainly of those that derive their raw materials from agricultural and forest resources. Three broad categories of Kenyas industrial structure can be identified as agricultural processing and manufacturing industries, non-agricultural manufacturing industries and service industries and are located mainly in the major towns.

The locational pattern of the industrial towns and centres differentiates towns of greater importance from those of lesser significance. Thirteen of the towns and centres stand out as of more significance than the rest. The leading six are Nairobi, Mombasa, Thika, Kisumu, Eldoret and Nakuru. These are followed by Kitale, Machakos, and Athi River. The last in significance are Nanyuki, Nyeri, Malindi and Naivasha. Basing this concentration of industries on district units, the most important districts are, therefore, Nairobi, Mombasa, Kisumu, Kiambu, Nakuru, Uasin Gishu, Nyeri, Kericho, Machakos, Trans-Nzoia, Kilifi and Laikipia.

The main objectives of industrialisation in Kenya have been to promote domestic production for both local market and export. At the national level, the provision of employment in the urban and rural areas, the diversification and Kenyanisation of industry and the generation of tax revenue have been some of the major considerations in the country's industrial development strategy.

In 1981, more than 13 per cent of the Gross Domestic Product was accounted for by the industrial Sector. In terms of export earnings from the sector, it is not easy to say exactly how much is attributable to the manufacturing industry as some of the industrial exports are included as part of the semi and processed agricultural exports. However, the manufacturing sector is definitely one of the leading foreign exchange earners among other Kenya's products sold in the international markets.

(iii) Tourism

Tourism has been described as the number one earner of foreign exchange for the country. The income from tourism comes in the form of balance of payment derived from the foreign exchange which tourists pay either abroad or here to meet their holiday expenses. In 1981, the foreign exchange earnings from tourism stood at K£ 90 million and formed an important source of money Kenya needed to pay for its imports. Locally, tourism generates employment opportunities in the fields of hotel staff, tourist guides and drivers, and staff employed in the national parks and game reserves. Furthermore, the Kenya Government benefits from tourism in the form of revenues derived from sales of licences and fees charged for entrance into game parks and reserves. Indirectly, agriculture, manufacturing and commerce benefit from tourism, for tourists pay for hotel accommodation, food, and purchase manufactured goods, handicraft and other products.

The major tourists attractions to Kenya are the country's bewildering ecological and cultural beauties. The attractive elements of the scenery range from the snow-capped top of Mount Kenya, the diversity of the scenery of the Great Rift Valley with its lakes and hot springs, waterfalls and the excellent beaches lining the climatically warm coastal sea-board. The open grasslands, some of which have been set aside exclusively for the conservation of wildlife, breed some of the most rare species of animals to be found in the world. Moreover, the traditional cultures of some of the Kenyan people are a source of intertainment for tourists and information for research-cum-tourist scholars. A network of radial and circular roads giving access to places of interest from a tourist point of view have been constructed to a reasonably high standard in all the areas designated as national parks and game reserves. Moreover, the importance of tourism from the point of view of the road transport industry, can be gauged by the proliferation in the tour operator companies owning different types of self-drive and Chauffer-driven motor vehicles in the major urban centres.

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NOTES

1. Immediately after Kenya was granted independence, a number of smaller motor vehicles of the combie and modified pick-up types were used in Nairobi City illegally as passenger carriers. These vehicles assumed the name 'matatu' because of their attractively low and flat rate fare charges for passengers. Under the Presidential Decree of 1973 all motor vehicles of less than 3 tonnes tare-weight were exempted from operating with the Traffic Licensing Board (T.L.B.) permits as passenger carriers. From that year the use of matatus as a means of public transport has spread throughout the country.

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CHAPTER THREE

METHODOLOGY

A. INTRODUCTION

In order to test and validate the hypothesised relationships between road transport development and the parameters of the development of socio-economic system of Kenya, a substantial methodological base has to be established both for data collection and for their processing and analysis. The choice of data collection techniques was determined by three major considerations; first, the geographical scale and size of the study area, second, the wide range of social and economic variables that had to be collected and subjected to statistical analysis and testing, and thirdly, the choice of which categories of roads to study. All these factors required the application of least costly techniques both in terms of time and money costs.

The 39 rural administrative districts of Kenya have been used as the basic areal units of observation and from them, data relating to road transportation and to the components of socio-economic development of the districts were collected. In respect to data relating to the movement of people and goods between the districts, the predominantly urban administrative units of Nairobi and Mombasa were also subjected to data collection, but mainly in connection with movement data. The two urban administrative units are, therefore, not the focus of interest as units of analysis in Chapters 4 and 7, although references to them have been made here and there whenever necessary.

But in Chapter 5 and 6, they are fully incorporated into the analysis of the pattern of the inter-district flows of passengers and commodities.

With a known universe or population of 39 or 41 (When Nairobi and Mombasa are included in the analysis) administrative units of observation, probability sampling was not necessary from such a small universe. No samples were taken from the categories A,B,C,D and E roads that are the focus of interest in this study. They were treated as total population in the respective district units of observation.

B. DATA COLLECTION TECHNIQUES

The bulk of data that have been used in this study have came from secondary sources, mainly from maps, and from published and unpublished materials. In this section, the details of the approaches followed in data collection, have been given, dividing them conveniently into two categories: the approaches that were adopted in the collection of data pertaining to transportation and those for collecting socio-economic data. The collection and analysis of road transport data have been carried out both over time and at particular points in time. From historical perspective, an attempt has been made to trace the data from late 19th century when the first modern roads, as known today, were constructed in this country up to the present time, irrespective of whether they fall under the categories A,B,C, D and E and regardless of their districts of location. But with regard to road transport data that have been subjected to cross-sectional analysis, the collection was based on the current administrative district units.

1 THE COLLECTION OF ROAD TRANSPORT DATA

A number of published and unpublished materials have been used as sources of road transport data. The most important sources of data pertaining to the evolution of road network have been the Blue Book, an annual statistical compendium published by the Colony and Protectorate of Kenya between 1901 and 1946 and the Annual Reports on the conditions and progress of the East Africa Protectorate from its establishment in 1895 to 1920, to be known thereafter as, the Kenya Colony and Protectorate Annual Reports up to 1962[1]. Other official annual publications that provided useful data on road network are the Public Works Department's Reports from 1926-1950 and Road Authority Annual Reports which succeeded it from 1951 onwards. An unofficial publication with a chapter devoted specifically to communications is a Handbook of Kenya Colony and Protectorate published in 1920 by his Majesty's Stationery Office in London[2]. This is a very useful, but rare handbook that gives a geographical description of the distribution and conditions of Kenya roads as they existed before the first World War. The East African Red Book, 1925-26, published by East African Standard in 1925 has a section on road system in Kenya and gives a capsule summary of the construction and maintenance of roads in Kenya from 1890 to 1923.

From these early sources of information on road development in Kenya, a careful selection of relevant data was made, cross-checking and counter-checking to compromise and verify the information. The names of roads constructed and their lengths were noted year by year until 1950 when the construction of most of the major roads was virtually completed. A table showing the names of the principal roads constructed from 1900 to 1950, the years in which they were completed and the length open for public traffic was prepared and from it a series of maps showing these early stages in the evolution of the road network has been drawn.

With regard to the information on the distribution of class A-E roads throughout the country and on district to district basis the major source is the Kenya Route Map, scale 1:1,000,000 published in 1978 by the Survey of Kenya. The information which was used in the construction of maps showing the distribution and density of the road network was derived from this official publication. From it, straight-line distances between the administrative district headquarters were measured or estimated. Road Reclassification System in Kenya, published in 1972 by the Ministry of Works, Roads Department, gives the information on the system of classifying roads and their definition. The official publication gives a detailed breakdown of the classified roads in the country according to their names, number and class, their surface conditions, whether bitumen, gravel or earth and the lengths in kilometres covered in each district and province. From this publication, the kilometrage of road lengths in each district were compiled and a comparison made with those shown on the Kenya Route Map and other sources of information such as Kenya Highway Transport Study, Present Conditions and Performance Vol. 1, published by the Ministry of Works. Other publications such as East Africa Royal Commission Report 1953 - 1955 and Traffic Statistics for 60 - Point Census of 1982 also gave invaluable data on road network in particular.

Data on passenger and commodity flows were obtained from the Kenya National '83' Origin - Destination (O/D) Traffic Survey Data File. This national survey was organised in March 1983 by the Ministry of Transport and Communications, Roads Department with the financial assistance from Japan International Co-operation Agency (JICA). Two traffic counts were involved: traffic volume counts and inter-districts origin-destination counts. For this study, it is the inter-district origin-destination counts data that were found relevant for the analysis. The O/D survey involved the counting of the number of motor vehicles, categorising them into passenger cars, matatus, buses, light goods, medium goods and heavy goods vehicles. The movements of passengers were divided into the three modes of public transport, that is, by passenger cars, matatus and buses. A selected number of principal commodities was also enumerated. These included maize, wheat, coffee, tea, cement, refined sugar, soda ash and soda products, and petroleum products, their volume being recorded in terms of tonnage carried.

The origin-destination survey was a 36-hour and 24-hour exercise, conducted on 19 census points and 4 control points located on the international and national road network throughout the country (Figure 3.1). The points were distributed as follows: Western Province 1, Nyanza 3, Rift Valley Province 6, Central and Eastern Provinces 5, and Coast Province 4, representing the major routes and points through which much of the inter-district and international road traffic passes. The whole exercise was carried out over a period of five weeks, spread out as follows: Western Province one week, Nyanza one week, Rift Valley one week, Central and Eastern Provinces one week and Coast Province one week, at different times to avoid the possibility of double counting. The 36-hour origin-destination counts started from 7 a.m. to 7 p.m. the following day, while the 24-hour counts began from 7 a.m. to 7 p.m. the following day without night counts. In the event of unusually heavy traffic passing through the census points, no interviews were administered, but the number of motor vehicle passing was noted. This type of organisation ensured that virtually all the motor vehicles that passed through the census points were counted so that in the end about 90 per cent of the inter-district traffic movement was counted.

2 THE COLLECTION OF SOCIO-ECONOMIC DATA

The socio-economic data were collected from a variety of sources ranging from official published and unpublished materials to unofficial publications. These came mainly from Government Ministries, parastatal organisations, private firms and individuals. The data were collected with specific reference to their availability in forms amenable for disaggregation and

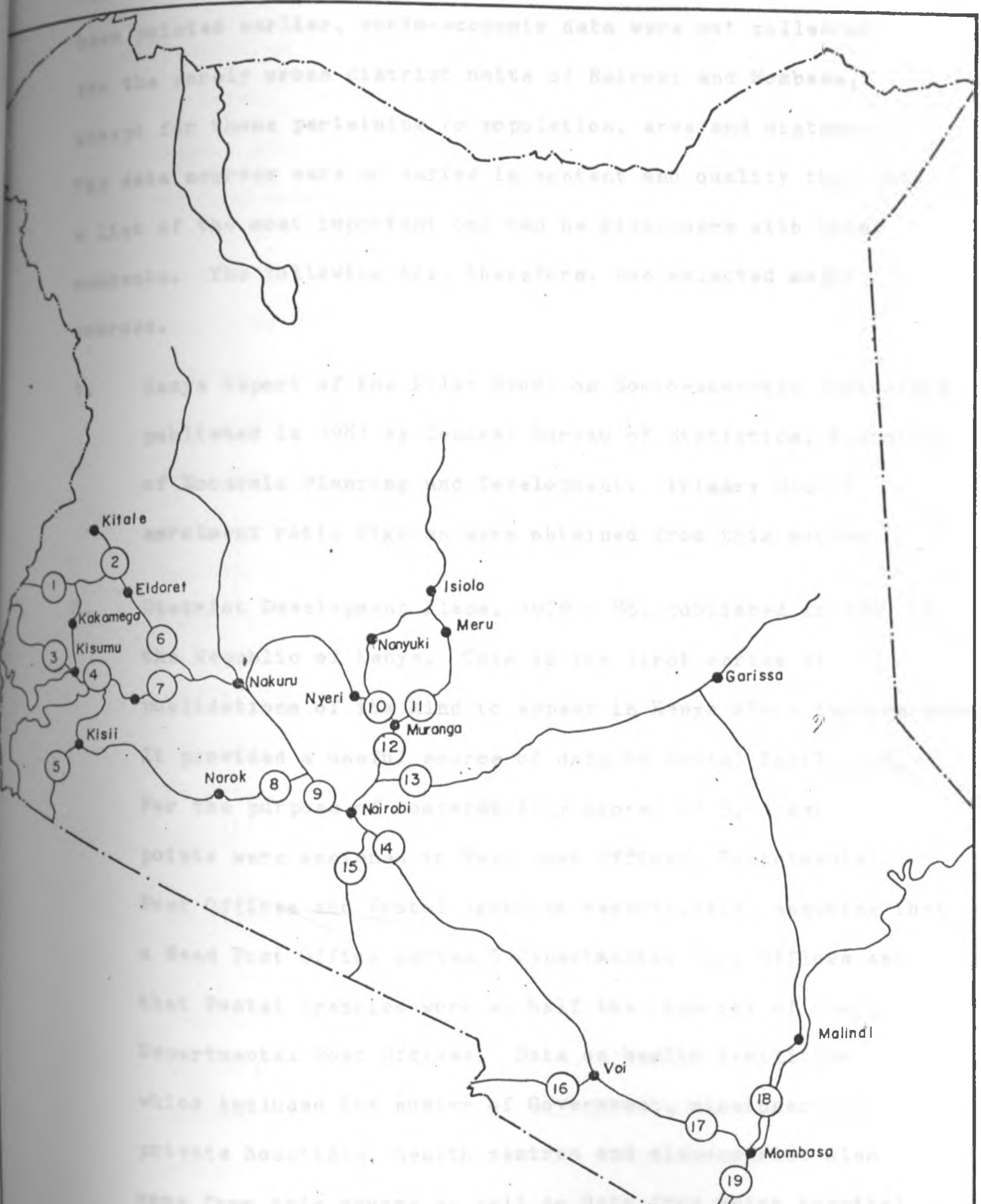


FIG. 3.1 THE LOCATION OF THE 1983 KENYA NATIONAL O/D SURVEY POINTS

aggregation into the 39 district units of observation. As has been pointed earlier, socio-economic data were not collected for the purely urban district units of Nairobi and Mombasa, except for those pertaining to population, area and distance. The data sources were so varied in content and quality that only a list of the most important one can be given here with brief comments. The following are, therefore, the selected major sources.

1. Kenya Report of the Pilot Study on Socio-economic Indicators, published in 1981 by Central Bureau of Statistics, Ministry of Economic Planning and Development. Primary School enrolment ratio figures were obtained from this source.

2. District Development Plans, 1979 - 83, published in 1980 by the Republic of Kenya. This is the first series of publications of its kind to appear in Kenya since independence. It provided a useful source of data on Postal Facilities. For the purpose of comparability scores of 5, 1 and 0.5 points were assigned to Head Post Offices, Departmental Post Offices and Postal Agencies respectively, assuming that a Head Post Office serves 5 Departmental Post Offices and that Postal Agencies work at half the capacity of the Departmental Post Offices. Data on health facilities which included the number of Government, missionary and private hospitals, health centres and dispensaries also came from this source as well as data from which hospital beds per 1000 population were calculated.

3. Population Census, 1979, Vol. 1, published by the Republic of Kenya. Each district's population was derived from the census statistics and population density per square kilometre of land area was calculated from the figures.

4. Statistical Abstracts for years 1979 to 1983 published yearly by Central Bureau of Statistics, Ministry of Economic Planning and Development. Data relating to population, land area and density of population, potential land use and others came from these annual compendium of statistics. They were also used as a reference base against which data from other sources were compared and rationalised.

5. Annual Reports of Government Ministries from 1977 to 1982, published by the Republic of Kenya. Data on total number of primary schools came from the Ministry of Education Annual Report of 1978.

6. Employment and Earnings in the Modern Sector, published in 1981 by Central Bureau of Statistics, Ministry of Economic Planning and Development. This Statistical publication was the main source of data from which percentage wage employment and percentage earnings for agriculture, and industrial and commercial figures were calculated for each district.

7. Provincial Annual Reports 1979 - 1980, published by the Republic of Kenya. Some data for wholesale and retail trade licences issued were obtained from these publications and a comparison was made with the figures reported in the District Development Plan Series, before they werefinally adopted. Data on the number of health personnel and hospital beds were obtained from these sources.

8. Development Plan 1979 - 1983, published by the Republic of Kenya. Data on service Centre Units were obtained from this source. The Service Centre Units are urban, rural, market and local centres. The centre units were weighted by factors of 3,1, 0.3 and0.1 for urban, rural, market and local centres respectively, the weights being based on the hinterland population served divided by 50,000 as a common denominator. From this source also came data on telecommunication line capacity.

9. Population Census 1979, Compendium to Volume 1, published by Central Bureau of Statistics, Ministry of Economic Planning and Development, Kenya. Population rates of growth for each of the 39 districts came from this source.

10. Kenya Highway Study Volume 1, published in 1978 by the Ministry of Works, Kenya. The potential agricultural production figures were obtained from this publication. The actual production figures in monetary value should

have been preferred, but since there were no such data for most of the districts, the potential figures were used as proxy measures for agricultural production.

11. Educational Trends 1973 - 1977 published in 1978 by Central Bureau of Statistics, Ministry of Economic Planning and Development, Kenya. Data on the number of secondary schools and secondary school enrolment were extracted from this official source.

3. PROBLEMS AND DIFFICULTIES ENCOUNTERED IN DATA COLLECTION

It was necessary in 1980, as a preliminary exercise, to mount a pilot study of a smaller scale as a form of feasibility study. This was done particularly in connection with the collection of data relating to origin and destination of traffic movements in order to assess the magnitude of the work that would be involved in the full study. The pilot study was conducted on selected sections of the international and national trunk roads leading into the districts of Kisumu, Kakamega, South Nyanza and Kisii. Because of lack of enough funds with which to engage a reasonable team of traffic enumerators, the exercise proved unworkable. Moreover, an effort to enlist the assistance of traffic police personnel did not very much succeed. In most of the cases, the police officers were not as co-operative as they were expected to be. The biggest snag in this pilot survey exercise was the unco-operative attitudes of most of the motorists and passengers, as they felt the questions were a bother and wasted their time. It, therefore, became clear that a traffic census count operated at a national level would be beyond the capacity and resources of an individually conceived project such as this one.

Fortunately, it was later learnt that the Ministry of Transport and Communications, Roads Branch, with the financial assistance from Japan International Co-operation Agencies (JICA) was planning to mount a national survey of a similar kind sometime in the early 1983. A request was, therefore, made to the officials of the Ministry if it would be possible to make use of some portions of their data after the whole exercise was over. They accepted the request, but on condition that they be given the purpose and objectives of the study and the details of how the data was going to be analysed and published. The author, therefore, had to wait for a period of almost two years before the 1983 Origin-Destination Traffic Survey Data File was made available.

With respect to data pertaining to the lengths of roads represented in the 39 administrative district units, the source materials gave so many conflicting and incomparable figures that reconciling them became almost an impossible task. However, with careful checks and counter-checks, using the more reliable Kenya Route Map published by the Survey of Kenya, the author managed to compile a more reasonable and accurate road kilometrage for each of the 39 districts. The most difficult part of data collection, was that in connection with the information pertaining to the origin and development of the road network system. As far as is known, at the moment, there is no comprehensive document in Kenya on the origin and development of the road network. Such documents as exist are in the form of annual reports and scattered individual publications, which in the majority of cases deal only with specific periods and problems, and as such only partially satisfied the requirements of this study. The annual reports available in Kenya were from 1920 onwards, but even then, there were so many missing gaps in the publication, and as such lacked historical continuity. To fill in the gaps and to collect data for years preceding 1920, the author had to take a three-months study leave in Britain to retrieve these archival materials from the British Museum Library. From these sources and others, the author managed to collect the relevant information on the origin and evolution of the road network systems although the information is by no means complete.

The author must, however, acknowledge the assistance provided by the Kenya National Archives, Macmillan Library in Nairobi, the National Museum Library of Kenya and the Africana section of the University of Nairobi Library in the procurement of some of the relevant information on the development of the road network.

In relation to data pertaining to socio-economic parameters of the country's development the source materials were overwhelmingly varied in nature, content and quality. The most authoritative sources of the data were the Statistical Abstracts, annual reports of government ministries and other related publications from parastatal bodies and private firms. Some of the data in these publications lacked clear definitions in terms of the forms in which they were to be collected. The data needed were to be collected at the district level of aggregation. Unfortunately, it seems to be the practice in Kenya, that most of the data collected are recorded at the provincial level of aggregation. So, some of the scattered district data had to be pieced together, sometimes going back as far as the original sources, a task which was not easy to accomplish. Many of the officials of the ministries and organisations were not willing to provide the required information, either because some of the information was classified or they were simply busy and could not spare the time to look for the information. Under the circumstances, some of the information had to be obtained through friends and relatives working with the ministries or organisations.

These were some of the problems faced during this formative period of the research progress. The task was a difficult one. However, the author managed to eke out some reasonably relevant data that have gone into the several analyses performed in the various chapters of this study.

Some of the data used in this study have certain shortcomings to which the attention of the reader should be drawn. Some of these limitations are likely to have some implications for the analyses, interpretations and conclusions derived from this study. The historical data on the development of the road network system lacked continuity. There were a number of missing gaps in the annual reports, especially during the First World War and between 1921 and 1926. For example, it is difficult to know which roads were built in which year, since the available information indicates only in summary form, the names and lengths of roads built between 1921 and 1926 (Table 4.5, Appendix 2).

The origin-destination survey data on passenger and commodity flows were collected on 19 census points located on the international and national trunk road network systems of the country. While it is true that a great amount of the inter-district road traffic passes through these arterial routes, it is equally true that a considerable amount of traffic moves through the primary, secondary and minor roads of the country. Since none of the 19 census points or any control points were located on these roads of lower categories, the survey data used in the analyses presented in this study may not reflect a true picture of the patterns of the inter-district traffic flow.

Furthermore, the 24-hour discontinuous counts from 7 a.m. to 7 p.m. which were carried out without night counts may have left out a considerable amount of traffic that moves on the Kenyan trunk roads at night. It is difficult to know the level of accuracy that were attained in the collection of these traffic data, unless adjustments or estimates were made to compensate for such errors of omission. That kind of information was not available with respect ot the traffic data used in this study.

Another limitation on the use of passenger and commodity flow data should be noted. The data were obtained from roadside interviews, so the origin and destination of passengers and commodities means only the origin and destination of particular movements. The same passengers or commodities could have appeared as separate movements. For example, passengers or goods moving into a district have that district as their destination.

However, when movement begins again from that district, that very district will be recorded as the origin. In this respect, the origin/destination interviews may have involved double counting. Consequently, the passenger and commodity flow data, while accurately reflecting the inter-district flow patterns may not faithfully represent the flows from first origins to final destinations.

The data on passenger and commodity flows used in this study relate to the inter-district movements by road only and not by rail and pipeline. Pipeline is especially important for the movement of petroleum and petroleum products from Mombasa to Nairobi. The implications for the exclusion of rail and pipeline data are examined in chapter 6, pages 255, 272 and 273. The author explains why this exclusion was necessary in the same chapter, pp. 296, especially in connection with the commodity flow analysis by the gravity model.

The selection of data on socio-economic indicators of development was based on three criteria (Table 7.11 Appendix 12). First the selection was based on their relevance as indicators of development within their respective dimensions or indices of development. Preference was thus given to those indicators that give wide sectoral spread in addition to their relevance. Such indicators included for example, wage employment in the agricultural, and in the industrial and commercial sectors.

Second, indicators were chosen because comparable data were available on them for the majority of the thirty nine districts that were used in the analysis of socio-economic data. Third, indicators were selected for which there are reasonably reliable data, so that in future consistent comparisons can be made through time.

The major limitation on the use of these quantitative indicators of development is lack of data on relevant indicators to be included in the construction of conceptually good proxy measures of development. Some of the indicators were selected for use in the computation of the composite and sectoral indices of development because data on the relevant candidate indicators were not available or they were missing for a large number of districts. For example, urban populations of the districts should have been preferred instead of total populations, but the urban populations of the districts for the 1979 census had not been published by 1984. Population size of a district may not be regarded as an indicator of development, but it is often used as a basis for development planning. Districts with larger population sizes are generally allocated larger proportions of development funds, provided with more schools, hospitals and so on. It was chosen as an indicator of development on this score.

The author would have preferred to use the monetary value of actual agricultural production as an indicator of agricultural production level, but since data were not available for most of the districts, the available potential agricultural production figures were used as proxy measures of the levels of agricultural production in the districts. There are other indicators, or proxies, for measurement of development, for example, per capita Gross Domestic Product, number of telephone calls, number of motor vehicles and literacy levels, but lack of data on these indicators at the district level of aggregation precluded their use. The list of data problems could be expanded, but there is no need to pursue this further. In the absence of an ideal or perfect indicators as measures of development, therefore, one must rely upon the best available indicators or proxy measures of development. Conceptual as well as statistical problems of the choice of indicators as good proxy measures of development are still unsolved (Harbison, et al., 1970); much has been accomplished, and more progress will be made in the years to come. Notwithstanding these limitations, the data on indicators used in the construction of the composite and sectoral indices of development have given consistent and reasonably accurate ranking and classification of the districts according to their levels of development.

C DATA PROCESSING AND ANALYSIS

1 THE COMPUTATION OF COMPOSITE INDICES OF DEVELOPMENT

The major task in the computation of composite indices of development involved three main operations:

(a) The selection of the best, suitable and available indicators of socio-economic development.

(b) The establishment of the relationships among the selected indicators and weighting their values before combining them into a composite index.

(c) Combining them into synthetic sectoral indices, and finally into an overall general index of development.

(a) The selection of Indicators of Development

The model of transport development proposes that the development of transportation is a function of social, economic and political forces and conditions. The indicators of transport and socio-economic development were, therefore, selected as components of development. To do this, a number of operations were performed. The two dimensions of the societal system, namely, social and economic elements were sub-divided into their sectoral sub-dimensions. The sub-dimensions of the social sector are population/demographic, educational and health, while those of the economic sector are agricultural, industrial and commercial, and communication components. The transport sector stood on its own. Political development dimension and its indicators were excluded from this analysis on conceptual and operational grounds. This is because the concept of political development was found difficult to operationally define and measure. Indicators such as political representation in parliament or local councils were found to be of little utility as measures of development as it is defined in this study.

A selection of indicators representing these seven dimensions of development was made on the basis of their relevance as indicators of development, taking into account the best, suitable and available comparative data for the thirty nine districts. A preliminary exercise in this selection involved the elimination of unrepresentative and/or duplicate indicators, leaving only those that were thought measure as far as possible different concepts within their respective dimensions. There are, however, some overlapping indicators which could not be left out as it was thought, on a priori grounds, that their inclusion would improve the results of the analysis. A total of 25 indicators survived this preliminary screening exercise.

Second, the selection was guided by the conceptual linkages with the existing studies using similar techniques of analysis (Berry, 1960; Soja, 1968; McGranahan et al., 1972). A comparison was made between the selected indicators with those that have been used in the three studies cited, and it was found that in the majority of cases, they are similar. So, because of their general acceptability as measures of development, they were selected. Of course, there were some indicators that were included in the selection simply because of their relevance as measures of development in the Kenyan context. The Service Centre Unit Concept is a particular case in point.

Third, a special preference was given to those indicators that give wide sectoral spread, for example, percentage wage employment and percentage employment earnings in the agricultural, industrial and commercial sectors were selected on that score. Lastly, indicators were selected for which there are reasonably reliable data and for which there is a likelihood that comparative data can be collected in the future so that consistent comparisons can be made through time.

(b) <u>The Selected Indicators and Indices</u>

1. ROAD TRANSPORT INDEX (X_1)

(a) Total Kilometrage of Classified Roads, (1980)

(b) Road Density Km/Km^2 (Classified Roads), 1980

(c) Connectivity Index (Beta Index), 1978

(d) Number of Passenger Generated, 1983

2. DEMOGRAPHIC/POPULATION INDEX (X_2)

(a) Total Population ('000'), 1979

(b) Population Density Per Km^2 of Land, 1979

(c) Population Growth Rates (%), 1969 - 1979

(d) Service Centre Units, 1978

3. AGRICULTURAL INDEX (X_3)

(a) Potential Agricultural Production (£'00000')

(b) Percentage Wage Employment, 1979

(c) Percentage Wage Employment Earnings, 1979

4. INDUSTRIAL AND COMMERCIAL INDEX (X_4)

(a) Percentage Wage Employment in Industry, 1979

(b) Percentage Wage Employment Earnings in Industry, 1979

(c) Wholesale and Retail Trade licences issued, 1979

(d) Percentage Wage Employment in Wholesale and Retail Trade, 1979

(e) Percentage Wage Employment Earnings in Wholesale and Retail Trade, 1979

5. COMMUNICATION INDEX (X_5)

(a) Post Office Facilities, 1979

(b) Telecommunication Line Capacity, 1978

6. EDUCATION INDEX (X_6)

(a) Total Number of Primary Schools, 1978

(b) Primary School Enrolment Ratio, 1981

(c) Total Number of Secondary Schools, 1977

(d) Secondary School Enrolment, 1977

7. HEALTH INDEX (X_7)

(a) Health Facilities, 1979

(b) Hospital Beds Per 1000 Population, 1979

(c) Health Personnel Per 1000 Population, 1979

(c) FURTHER SELECTION BY INTERCORRELATIONS AMONG THE INDICATORS

It has been shown that indicators that are empirically correlated with development, that is, those distinguishing between the relatively more developed from the relatively less developed countries along a development scale, are to be considered part of the measurement of that development whatever its definition (McGranahan et al. 1972). What then are the characteristics of development data and their relations to the development of which they are part? According to McGranahan et al., the factors or aspects whose change constitutes development must necessarily be correlated with each other in a developmental data array. The first reason for this is theoretical: development is to a large extent by its nature a system of interdependent variables. The second reason is logical or methodological: if development is what distinguishes more developed from less developed countries, and if the indicators relate to features of development that are common, then these indicators must of necessity be correlated, regardless of direct causal influence between them.

One is, therefore, faced with a major methodological problem, that is, how to select indicators of socio-economic development empirically even though they are conceptually reasonable measures of development. There must be an objective criterion against which to select, test or validate them. This problem has been dealt with by assuming that indicators with high intercorrelations on the average with other development indicators are better indicators than those with low intercorrelations. This was done by calculating the bivariate correlation coefficients among the originally selected 25 indicators of development to determine their relative strengths of intercorrelation. Indicators which had on average correlation coefficients of less than 0.30 were dropped from the original list because they are poor indicators of development (Table 3.1). The initial group of 25 indicators was then reduced to a group of 21 highly correlated indicators using this method of selection. Indicators that were rejected by this process of elimination included total kilometrage of roads (0.20), percentage wage employment in wholesale and retail trade (0.29), hospital beds per 1000 population (0.14) and population rate of growth (0.23). In general, the selection of indicators by the method used here appears to make sense in terms of the results of a later analysis, as the indicators seem to be technically superior. They generally have, with very few exceptions, very high correlations with the composite index of development (Table 3.2).

Other considerations, besides simple bivariate correlations, were also taken into account in a further selection of indicators, particularly in connection with duplicate indicators. It was assumed that if two indicators are strongly or perfectly related to one another, then they measure the same thing. In that case, only one is necessary for inclusion in the computation of the index since it completely conveys the information provided by the other. If two indicators had a correlation coefficient of more than 0.95, one had to be omitted on the grounds that they measure the same thing. This process of selection eliminated percentage wage employment earnings in industry as it correlated very highly (0.96) with percentage wage employment in industry. The other indicator eliminated on a similar ground, was secondary school enrolment; it had a correlation coefficient of 0.99 with the number of secondary schools. Another indicator, the number of service centre units, was dropped on grounds of irrelevance. Although it had a reasonably high overall, average correlation with the rest of the indicators, it did not seem to fit well under demographic/population index. Finally, a group of 18 high-correlate core indicators were subjected to the computation of the sectoral indices and the overall composite index of development. The results of the computation of composite indices of development and their interpretation are discussed at length in Chapter 7.

TABLE 3.1: AVERAGE CORRELATION OF EACH INDICATOR WITH THE OTHER 25 INDICATORS

	Indicator	Average Correlation
1.	Total Kilometrage of Classified Roads	.20
2.	Road density Km/Km^2 (Classified Roads)	.56
3.	Connectivity Index (Beta Index)	.54
4.	Number of passengers generated	.57
5.	Total population '000'	.59
6.	Population density per Km^2	.58
7.	Population rate of growth	.23
8.	Service Centre Units	.58
9.	Potential agricultural production £'00000'	.50
10.	Percentage wage employment in agriculture	.41
11.	Percentage wage employment earnings in agriculture	.37
12.	Percentage wage employment in industry	.50
13.	Percentage wage employment earnings in industry	.49
14.	Wholesale and retail trade licences issued	.62
15.	Percentage wage employment in wholesale and retail trade	.29
16.	Percentage wage employment earnings in wholesale and retail trade	.41
17.	Post office facilities	.62
18.	Telecommunication line capacity	.61
19.	Number of primary schools	.53

Indicator	Average Correlation
20. Primary school enrolment ratio	.44
21. Number of secondary schools	.59
22. Secondary school enrolment	.59
23. Health facilities	.61
24. Hospital beds per 1000 population	.14
25. Health personnel per 1000 population	.30

TABLE 3.2 CORRELATION BETWEEN EACH OF THE 18 CORE INDICATORS AND THE COMPOSITE INDEX OF DEVELOPMENT

	Indicator	Correlation
1.	Road density Km/Km^2 (Classified Roads)	.839
2.	Connectivity Index (Beta Index)	.819
3.	Number of passengers generated	.856
4.	Total population '000'	.912
5.	Population density per Km^2	.860
6.	Potential agricultural production	.741
7.	Percentage wage employment in agriculture	.581
8.	Percentage wage employment earnings in agriculture	.461
9.	Percentage wage employment in industry	.693
10.	Wholesale and retail trade licences issued	.919
11.	Percentage wage employment earnings in wholesale and retail trade	.538
12.	Post office facilities	.869
13.	Telecommunication line capacity	.886
14.	Number of primary schools	.877
15.	Primary school enrolment ratio	.656
16.	Number of secondary schools	.893
17.	Health facilities	.879
18.	Health personnel per 1000 population	.311

(d) The Construction of a Composite Index of Development

The construction of the general index of socio-economic development was the third main task in this process. High intercorrelations among a substantial number of indicators covering a wide range of agreed-upon components of development suggest the existence of a general factor of socio-economic development which should be open for measurement. There are, however, three problems in the construction of such an index: (i) the selection of the constituent indicators, (ii) their transformation or conversion to a common scale, and (iii) their weighting prior to merger. The first problem has been solved by the processes involved in the selection of the final 18 highly correlated indicators as outlined above. The second and third problems are going to be dealt with in this section.

The procedure adopted in this study to construct a composite index of development is a method which was originally designed by a group of Polish mathematicians in 1952 in order to obtain a statistical method of determining homogeneous units or "types of things" in an n - dimensional vectoral space without the use of regression, variance or correlation analysis (Harbison et al. 1970). The Polish mathematicians were convinced that this taxonomy method could be successfully applied to various fields of international comparisons and proposed it in 1968 to UNESCO. Since then, the technique has been employed by Harbison and his associates and by Sorguc and his co-workers (Sorguc et al., 1976). In the present study, some modifications have been introduced in the Harbison - Sorguc procedures particularly with respect to the combination of the values of the indicators and weighting them before finally merging them into a composite index.

The author is, nevertheless, aware of other possibilities of combining variables measured in different units to generate one or more dimensions of development. Principal components and factor analyses are other alternatives (Berry, 1960; Soja, 1968). McGranahan et al. (1972) have also used a procedure known as "Correspondence Points" to construct a single composite index of socio-economic development. In addition to all these possibilities, there is a wide range of literature demonstrating different approaches to data amalgamation if the purpose is to produce a general index of development (Harbison and Meyer, 1964; Smith, 1973a; Adelman and Morris, 1967). Our purpose for constructing a general index of development using this technique is to use its results as a basis for classifying, ordering and comparing the district's levels of development in road transportation, with the development of other sectors of the economy and with the overall development. In order to assess and evaluate the nature of the relationship between the development of road transportation and socio-economic development of the country a series of regression and correlation analyses has been performed.

(e) <u>The Computation Procedure</u>

The computation of the composite index of development and other sectoral indices has been applied to the 39 rural districts of Kenya using the selected 18 indicators grouped into 7 dimensions representing the major components of socio-economic developments. The basically urban district units of Nairobi and Mombasa have been excluded from this analysis. The reason for excluding them was to avoid the problem of skewed distribution which would occur in the data set if the data for these heavily urbanised units were incorporated into the computation. Furthermore, the operational definition of roads in the urban areas would present conceptual problems if they were included in the analysis.

The computation procedure runs as follows. In the matrix X below, N represents the total number of districts and M the total number of indicators. Each district can be considered as a vector (P_i) whose components are the indicators:

$$P_1(1,2,3, \text{----}M),\ P_2(1,2,3, \text{----}M),\ \text{----}\ P_N(1,2,3, \text{----}M).$$

In this way, each district is represented as a point or vector in M - dimensional space as shown in the matrix,

$$X = \begin{bmatrix} X_{11} & X_{12} & X_{13} & \text{--------} X_{1M} \\ X_{21} & X_{22} & X_{23} & \text{--------} X_{2M} \\ X_{N1} & X_{N2} & X_{N3} & \text{--------} X_{NM} \end{bmatrix}$$

where X_{ij} is the value of the indicator j(j=1,2,3,----M) for the district i(i=1,2,3,----N). Since each of the indicators is measured on a different unit, the values must be standardised to eliminate the effects of various units of measurement before merging them. This problem of scale conversion has been tackled by the standardisation of the original values of the indicators using the Z - score scale transformation procedure,

$$Z_{ij} = \frac{X_{ij} - \bar{X}_j}{S_j} \qquad i = (1,2,3, \text{----}N), j = (1,2,3, \text{----}M)$$

where $\bar{X}_j$ is the arithmetic mean and S_j is the standard deviation. As a result of the standardisation process, a new matrix Z is obtained in which each district is represented as standardised point or vector in M-dimensional space.

The next step involves combining the standardised scores, so that the composite index should be made specific with respect to the contribution of each indicator to the index scores. Before this is done, the indicators have to be weighted. Here the concern is with explicit weighting, since the process of scale transformation had accomplished implicit weighting. The explicit weights should reflect the degree of importance that each indicator will have in the measurement of the whole. Since development is an interrelated phenomenon in which the different factors change and grow together, the average correlation of each indicator with the other indicators is the best available criterion of the weight that should be assigned to an indicator as its contribution in the measurement of the general index. It was, therefore, decided to use the average correlation of each indicator with the others as its weight. A new matrix W is obtained showing the weighted values as represented by the standardised scores. These weighted standardised scores are combined using the standard score additive function, thus,

$$A_i = \sum_{j=1}^{m} w_j Z_{ij}$$

where w_j is a weighting parameter for the jth indicator, which is its average correlation with the other indicators.

We end up with a column vector, A_{io}, showing the pattern of development as represented by the sum of weighted standard scores. As the scores are expressed in Z - Score units, districts with positive scores can be interpreted as above average in the pattern of development and those with negative scores below average. Before we compute the composite index, we need to eliminate the negative values in the column vector A_{io}, by adding a constant greater than or equal to the largest negative value to all the values in the column vector. For the purpose of this study, we preferred adding a constant greater than the greatest negative value to avoid the possibility of ending up with a district's scoring zero in the development pattern, a situation which would appear unrealistic. After the elimination of the negative values in the column vector A_{io}, we end up with another column vector B_{io}, and by calculating the square root of all the values in the column, another column vector, C_{io}, is obtained showing the pattern of development. The same procedure should be followed when computing sectoral or sub-sets of indices.

Finally, in order to express the values in terms of percentage distribution of development levels of the districts with respect to an 'ideal' (hypothetical) district which is assumed should have the highest value, we compute a value, Co, calculated as follows:

$$Co = \bar{C} + 2S$$

This value, Co, is calculated as the arithmetic mean of the values in the column vector C_{io} plus twice the standard deviation of the elements in the column vector C_{io}. We then calculate the percentage distribution of the district's levels of development using the relation:

$$D_i = \frac{C_{io}}{Co},$$

The closer the value is to 0.00, the less developed is the district and the closer it is to 1.00. the more developed the district. The measurement is constructed in such away that it is always non-negative. It can exceed 1.00, but the probability of such an event is small, so that in the majority of cases the values will fall between 0.00 and 1.00. It should be noted that the values for all the districts do not add up to 1.00 or 100 as is normal with the sum of percentage distribution.

The general index of development can serve certain useful purposes. In the first place, it gives a more substantial picture of what is happening in general to a country or region over time than does the per capita national income which tends to show fluctuations from year to year. It provides a better criterion for dividing developed from developing countries in terms of the overall levels of socio-economic development. Moreover, it can be used in the prediction or estimation of missing scores on indicators for which data are not currently available for a given country or region. McGranahan et al. have found out that it can predict or estimate missing social as well as economic scores much better than does the per capita national income (McGranahan et al., 1972).

2 TRANSACTION FLOW ANALYSIS

The technique known as transaction flow analysis as it is described here was originally developed by Savage and Deutsch (1960) and later modified by Goodman (1963). It has proved of great use to political scientists, geographers and other social scientists interested in the analysis of flows between nations and within nations (Brams, 1966; Soja, 1968). There are, however, other kinds of transaction flows one can examine and an equally large variety of methods to apply. The simple gravity model is one form of analysis of transaction flows. Mackay (1958) has used the simple gravity model to examine the impact of distance and social or political boundaries on the flow of transaction between Quebec and the surrounding regions of Canada and the United States, with interesting results. There should, therefore, be a greater scope for geographers to apply transaction flow analysis not only to the flow of information, but also to the flows of people and commodities between nations, within nations and at local levels. In this study, transaction flow analysis has been applied in the analysis of the pattern of commodity flows between Nairobi and the other forty administrative districts of Kenya.

The transaction flow model or the indifference model, as it is sometimes called, enables one to estimate the proportion of flows between countries or regions under certain assumptions. One of the assumptions is that the specific character of the origin of transaction will not affect its destination and vice versa. All possible destinations have an opportunity to receive the transactions in proportion to their relative sizes. To put it in another way, the model presumes that the number of interactions from area A to area B will reflect only some measure of the relative attractive power of B within the entire system in which the interaction takes place. The most commonly used measure of attractiveness and the one which has been used in this study, is the proportion of all transactions made in the system which are received at a particular point or area. However, other measures such as population size or wealth can be used as can the relative figures of out-going flows. So the fundamental assumption is that a country A will send to another country B approximately the same percentage of its commodity shipment as that percentage of the total shipment which B receives from all countries combined.

As an example, let us suppose that Kenya is the destination of ten per cent of the Inter-Eastern and Central African trade. Under the assumption of the transaction flow model, Uganda, Tanzania, Zambia and all the other trading states should send approximately ten per cent of their exports to Kenya. In other words, Kenya will expect to receive essentially the same percentage of trade transaction from all the East and Central

African trading partners regardless of their state of origin. Hence, the idea of origin-destination independence. Actually, the expected percentage will be slightly higher than ten per cent since an area is not permitted in the model to have transactions with itself.

Interaction, therefore, is considered to be indifferent to all other influences within the system except the relative attractive power of its component parts. In reality, of course, such forces as the friction of distance, political boundaries, cultural and economic influences can affect considerably the pattern of trade flow. The model, however, by not initially incorporating these factors provides a means of evaluating their relative impact within the system. It identifies those pairs of areas which are interacting at higher or less than expected on the basis of their relative sizes and challenges the investigator to discover the relevant variables most closely associated with the deviations. We can then proceed to assess quantitatively the spatial associations by correlation and regression analysis. In this study, the ratio of actual to expected flow of commodities will be used as a measure of the relative importance, in terms of complementarity, of the volume of commodities moved from the forty districts of Kenya to Nairobi, thus evaluating the strength of their complementary trade or exchange relationships.

The computation of the expected flows is a very simple exercise. If we assume that T is the total number, in terms of tonnage of commodities shipped to all countries and B is the total tonnage of commodities shipped to B, A(and all other countries) ship B/T of its commodities to B. The expected flow under the assumption of origin-destination independence can then be predicted for any origin-destination pair of countries using the following formulation:

$$Fe_{ij} = (F_{i*} \cdot F_{*j}) / F_{**}$$

where Fe_{ij} = the expected flow from i to j

F_{i*} = the total out-going flow from i to all the regions

F_{*j} = the total incoming flow to j from all regions

F_{**} = the total flow in the system

The relation of the expected flow to the actual flow (F_{ij}) can then be considered in a number of ways (Hay, 1973), as follows:

Difference or deviation from actual flow $= F_{ij} - Fe_{ij}$

Ratio $= F_{ij}/Fe_{ij}$

Salience Score $= (F_{ij} - Fe_{ij})/Fe_{ij}$

The preceding description applies to the transaction flow model as it was originally developed by Savage and Deutsch, where only a country's transactions with itself are excluded from the movement of transaction flows. However, as was pointed out, Goodman has made a modification in the Savage-Deutsch model by excluding the prediction of flows between countries with non-existent exchanges of goods or information. In this study, the Savage-Deutsch model has been applied as it was originally developed.

3 DOMINANT FLOW ANALYSIS

Dominant flow analysis is a technique that makes it possible to identify from a complex system, a flow structure which may correspond more closely with the expected nodal organisation of a country (Lowe and Moryadas, 1975, pp. 214). This technique of flow analysis was developed by Nystuen and Dacey (1961) in their study of intercity telephone calls in Washingston State, U.S., and has subsequently been applied by Hay and Smith (1964) in a study of inter-town trading patterns for rail-shipped commodity groups among 25 towns in Nigeria. The method is capable of quantifying the degree of association between city or regional pairs in a manner that allows the identification of the network of strongest associations, and provides a quantitative basis for grouping towns or regions. The resulting sub-groups of cities or regions are analogous to nodal regions. It, therefore, becomes possible to specify their rank ordering and to evaluate the functional relations of the nodal hierarchy.

There are certain properties of the dominant relations between areas that must be taken into consideration in dominant flow analysis. To establish dominant centres or areas in a functional region, three conditions related to flows should be satisfied. The first condition is that a centre is independent if its largest flow is to a smaller centre. By definition, the measure of size in this context, is the total number of passengers or volume of commodities received by a centre from all the centres in the system as represented by the column totals of the matrix of flows or it could be defined in terms of the population of each centre. A centre is subordinate if its largest flow is to a larger centre. This assumes no ambiguities arise to obsecure the dominate (largest) centre of a pair. This can occur when largest flows are reflexive, that is, two centres whose largest out-connections are to each other. A second property is transivity. This property implies that if a centre A is subordinate to centre B and B is subordinate to C then A must be subordinate to C. The third and last property stipulates that a centre is not a subordinate to any of its subordinates.

The largest flow from every subordinate centre is called the nodal flow. These flows form the nodal structure of the region, thus depicting the functional association of the centres in the region. It is important to recognise that in this nodal structure, the out contact from at least one centre is zero. This centre is called a terminal centre, and in terms of urban structure, this type of centre is interpreted as central city. The described concepts in dominant flow analysis can be illustrated by a hypothetical table of matrix of flows and a graph of a nodal structure in a region (Table 3.3) and (Figure 3.1) respectively as follows:

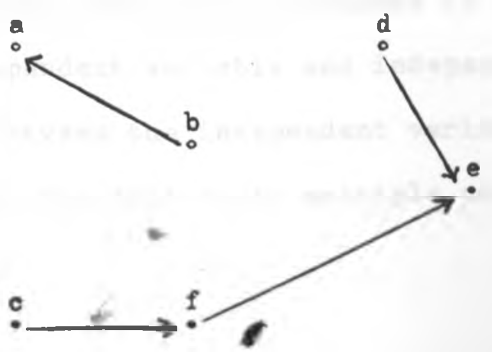
TABLE 3.3 HYPOTHETICAL PASSENGER FLOWS SHOWING ASSOCIATED MATRIX

		TO CITY					
		a	b	c	d	e	f
FROM CITY	a	0	15	*74	36	66	37
	b	69	0	28	15	48	35
	c	10	75	0	33	50	98
	d	14	43	16	0	64	38
	e	*60	35	23	29	0	40
	f	60	18	51	55	100	58
COLUMN TOTAL		213	186	192	168	328	306

Notes: Largest flow underlined

* Largest flow from these cities is to a "Smaller" city where size is determined by the column totals

FIGURE 3.2 GRAPH OF DOMINANT FLOWS



4. CORRELATION AND REGRESSION ANALYSES

The world is a very complex place. Very few of its patterns can be described or accounted for by a single independent factor. Thus, one has to think in terms of multiple causation or pattern in the dependent variable resulting from the influence of several separate independent factors. For example, the multivariate nature of transport/development relationships has been discussed at length in Chapter Two of this study. The analysis of such multiple causation by correlation and regression methods is the main focus of the discussion in this section. However, the techniques of simple and partial correlation analysis have also been discussed. A description of how and where they have been applied in this study and their nature and general use in geographical studies is briefly reviewed here. The computational mechanics of these statistical tools of analysis are explained in the basic texts such as those by Gregory (1973) and Johnston (1980).

The first hypothesis that has been subjected to these statistical tools of analysis is that the variations from place to place in the development of the road transport network are related to the variations in the population levels, levels of agricultural development and the areas in square kilometres of the district units of observation. To test the validity of this hypothesis simple and partial correlation coefficients were computed to shed light on the strength of the correlations between the dependent variable and independent variables on the hand and between the independent variables on the other hand, before mounting the full scale multiple correlation and regression analyses.

The two hypotheses (3 and 4, pp. 74; one for passenger and the other for commodity flows) which were scrutinised with the aid of correlation and regression methods is that the spatial variations in the volume of flows can be explained in terms of socio-economic characteristics of the districts and the distances separating them. A similar procedure in the use of simple and partial correlation analyses, followed by multiple correlation and regression analyses was adopted as for hypothesis one.

The other applications of correlation and regression analyses were similarly treated in chapter 7. But as has been discussed earlier, the variables involved in these analyses are measures of road transport development and socio-economic indicators of development as represented by their composite indices. Before these indicators were merged to produce their respective sectoral indices and finally the overall composite index of development, Spearman's rank correlation coefficients were computed to highlight the degree and nature of their intercorrelations. From the observation of the intercorrelations among the indicators, 18 out of the original 25 indicators were selected on the basis of the magnitude of their average correlation with the other indicators. These 18 high-correlate core indicators were combined to generate separate sectoral indices, and finally the composite index of development.

The three types of correlation analysis: simple, partial and multiple correlations can be performed using sets of areally associated data. Coefficients of simple correlation (r) describe the degree to which two of the variables are associated and coefficients of partial correlation also describe the association between two of the variables, but do so by eliminating the effect of one or more other variables which may be intercorrelated. The third, coefficients of multiple correlation (R) describe the degree to which three or more of the variables are associated. These kinds of measures of association are summary values, that is, they apply to the entire area under study and they cannot be used in mapping internal variation of the degree of association. Their role is merely to describe the degree of spatial correspondence among the areal variations of the variables as measures of the validity of hypotheses constructed for the area as a whole. Coefficients of +1.00 and -1.00 indicate respectively perfect direct and inverse correspondence of variations from place to place, while a coefficient of 0 indicates that the variables are not areally associated. The values in between +1.00 and -1.00 indicate the existence of some degree of association.

Since the coefficients of simple and partial correlation show the relative sizes of the correlation, they provide a truer description of the relative correspondence of the independent variables and the dependent variable. These relative sizes of the coefficients of simple and partial correlation have been used as a yardstick for deciding whether the independent variables with very low or very high coefficients could be incorporated or not into the multiple correlation and regression analyses that followed these preliminary testings.

The correlation analysis methods provide only summary statements for the entire area. The geographer, however, is ordinarily not satisfied with areal vagueness of such summary figures. Being interested in the character of specific areas, he wishes to know where these relationships hold close to the areal generalisation and where they do not. Linear regression equations express the average relationship that exists between the dependent variables and the variables nominated as independent. The multiple regression equation expresses a functional relationship between a dependent variable, Y, and a set of independent variables, X_1, X_2, X_3--------X_n. The basic linear multiple regression equation used in this study is of the form:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 \text{--------} + b_nX_n$$

where Y = the dependent variable,

a = a constant to be estimated,

b_1, b_2, b_3 = constant terms to be estimated,

X_1, X_2, X_3 = the first, second and third independent variables, and

X_n = the last independent variable.

Opinions differ among scholars with respect to the problems of multicollinearity in regression analysis. Some writers, including Poole and Farrell(1971), feel that any non-zero correlation between independent variables is unacceptable. But

Ferguson(1977, pp.28) argues that this is not so, and goes on to say that multiple regression is unnecessary when independent variables are mutually uncorrelated. He,however, admits that strong inter-correlations do lead to greater instability and uncertainty in the regression estimates from samples. Kim and Kohout(1975, pp. 340) add that if extreme collinearity exists (0.8 to 1.0 range), it may not be possible to calculate the coefficients.In view of these considerations, the problems of multicollinearity in regression analysis in this study have been reduced in two ways, first, by using only one of the independent variables in the highly correlated set to represent the common underlying dimension.For the purpose of this study, the highly correlated variables are those with correlation coefficients of 0.8 and above.Second, independent variables with tolerance levels of less than 0.40 have been excluded from the final multiple regression equation(see next section for explanation). It is hoped these measures will help solve the problems of multicollinearity, somewhat.

In essence, no tests of significance are required for the data used in this study for all the 41 or 39 districts of Kenya have been included.It can be assumed that the regression coefficients are the population coefficients. But it could be argued that the data pertain to particular years only or that the districts represent a sample as this is not the only possible number of districts into which Kenya can be divided. In this particular case the latter argument has been adopted and the hypotheses tested at 0.05 level of significance.

5. COMPUTER PROGRAMMES

In this study, five computer programmes were run at the University of Nairobi Computer Centre using the ICL 1900 SPSS Subprogrammes, Pearson Correlation and Regression. The Subprogramme Regression combines multiple regression and stepwise procedures in a manner which provides considerable control over the inclusion of the independent variables in the regression equation. The procedure for fitting a series of stepwise regression equations in the SPSS Subprogramme Regression has been briefly described here.

First, the largest zero-order correlation between the dependent variable and the independent variables is selected. The selected variable then enters the first step of the regression procedure. Second, the first-order partial correlation coefficients between the dependent variable and the remaining independent variables are computed, holding constant the one already in the equation. The largest of these is selected and the relevant independent variable is added to the multiple regression equation at the next step. The procedure continues, holding constant the independent variables already in the equation, until all the independent variables are fitted into the equation. In other words, the variable that explains the greatest amount of variance unexplained by the variables already in the equation enters the equation at each step.

The exact procedure for fitting a series of stepwise regression equations differ in some respects between researchers (Johnston, 1980, pp. 85 - 86). Clearly, variations in the details of the procedure can affect the order of the entry for the independent variables at the different steps. But these orders are unlikely to affect the final conclusion to any marked extent. Except in cases of extreme collinearity among the independent variables, use of the zero-order correlation rather than the first-order partials at the first step can lead to a different variable being entered at this stage.

In the stepwise procedure, two statistical criteria were specified to select which variables were to be included in the final regression equation. The two statistical criteria used were the F-ratio and tolerance levels. The F-ratio is for the test of the significance of the regression coefficient. It is the value that would be obtained if a variable were brought in the equation on the very next step. At each step in the analysis, F-ratios were computed for variables not yet in the equation. The tolerance of an independent variable being considered for inclusion is the proportion of the variance of the variable not explained by the independent variables already in the regression equation. A tolerance of 0 would indicate that a given variable is a perfect linear combination of other independent variables and a tolerance of 1.0 would indicate that the variable is uncorrelated with the other independent variables. The SPSS Subprogramme Regression excludes an independent variable from the final regression equation if its F-ratio or tolerance level is insufficient for further computation.

D. DATA PRESENTATION

Apart from tables within the chapters and those in the appendix, this study has been illustrated by 30 maps and diagrams, both qualitatively and quantitatively designed.

1. QUALITATIVELY DESIGNED MAPS AND DIAGRAMS

These consist of maps and diagrams showing,

(a) Location of Kenya in Africa,

(b) Kenya districts, including Nairobi Province,

(c) The location of the 1983 Kenya National O/D Survey Points,

(d) Caravan routes, Mackinnon and Sclater Roads,

(e) The development of the Kenya road network,

(f) The Kenya road network, 1978,

(g) The idealised process of transport development, and

(h) A conceptual model of the development of the road transport system.

2. QUANTITATIVELY DESIGNED MAPS AND DIAGRAMS

These consist of maps and diagrams showing

(a) Dominant flows. These are maps designed to identify nodal districts of dominant passenger and commodity flows. They are semi-quantitatively designed. The arrows show the out-going largest flow from each district to its dominant nodal district, but are not proportional to the volume of flows. The proportional circles represent the total incoming flows to the dominant districts from the hinterland districts. No key is provided on the maps to show the relative sizes of the circles. However, these can readily be ascertained from the accompanying tables.

(b) The road network density. Grid squares, each 4 centimetres were drawn on the Kenya road map. A simple measure of road density was adopted by counting and recording on the superimposed map the number of road junctions in each grid cell. Isolines were drawn on the map by joining points with equal number of road junctions at the chosen intervals. The shadings differentiate areas, from those with very high to those with very low network densities.

(c) District levels in road network development. A composite index of road network development combining network density per Km^2 and the beta index was computed for the 39 districts. The choropleth map was drawn using a graduated system of shading based on the standard deviations from the mean of the composite index.

(d) Population potential. The methods of designing this map are explained in Chapter 5, B(1).

(e) Total number of passengers generated and attracted in the flow system. The proportional circles show the combined number of passengers that were generated and attracted to each of the districts in the inter-district passenger flow.

(f) The inter-district passenger and commodity flows. These maps were drawn using proportional desire-lines. They appear rather noisy in that it is difficult to differentiate between the thickness of the lines. However, the maps do give an impressive graphic picture of the directions and the intensities of the flows in general.

(g) The inter-provincial passenger and commodity flows. These maps shows the inter-change of passengers and commodities between the eight provinces. The thickness of the lines is proportional to the volumes of movement.

(h) Commodity shipments by road to Nairobi. The proportional circles represent the number of tonnes that each district sent to Nairobi. Districts with no circles did not send commodities to Nairobi.

(i) Complementary indices for shipment of commodities to Nairobi. The figures on the map show the degrees of complementary relationships between the districts and Nairobi. Districts with figures of 1.0 and above had more complementary trade relationships with Nairobi than those with less than 1.0.

(j) Absolute deviations of shipment of commodities to Nairobi. The districts with unshaded (white) circles shipped more and those with shaded (black) circles shipped fewer tonnes of commodities than expected according to transaction flow analysis. The sizes of the circles are proportional to the number of tonnes by which each district deviated from the expected shipment.

(k) Districts scores on the composite index of development. The map was drawn using a graduated system of shading based on the standard deviations of the districts scores from the mean of the composite index of development.

(1) The relationships between road transport and other levels of development. These quantitative diagrams have been drawn to show the relationships between the index of road transport development and other indices of development. The joint distribution of the districts on the scores is expressed in standard deviatian units above or below the means.

NOTES AND REFERENCES

1 NOTES

1. In 1895, the British Government declared a Protectorate over what is now Kenya. This included the area between the Tana and Umba Rivers stretching as far west as a line drawn from Lake Turkana to the east of Lakes Baringo and Naivasha, down to Tanzania border and including in 1902 the area to the East of Lake Victoria. This whole area was henceforth to be known as the East Africa Protectorate. By the Kenya Annexation Order in Council of 1920, the East Africa Protectorate was declared a Colony and Protectorate. The 16 kilometres (10 miles) wide Coastal strip was known as the Protectorate of Kenya, while the remaining inland territory was known as the Colony of Kenya.
2. This handbook devotes a section to the geographical account of the distribution and conditions of the country's road network as it existed before the end of World War 1. From the names of the roads mentioned in the book, it is likely that the book was published in 1920 or thereabouts. The specific date of its publication is not indicated anywhere in the book.

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CHAPTER FOUR

THE GROWTH AND DEVELOPMENT OF THE ROAD NETWORK SYSTEM

A. INTRODUCTION

Taaffe, Morrill and Gould have noted that in the economic growth of underdeveloped countries a critical factor has been the improvement of internal accessibility through the expansion of transportation networks. This expansion is from its beginning at once a continuous process of spatial diffusion and an irregular or sporadic process influenced by many specific economic, social and political forces (Taaffe, et al., 1963). This claim can be said to be true in the case of Kenya where the construction and improvement of the road network system has been going on since the closing years of the last century. More or less similar forces suggested by Taaffe and his associates have been at work in shaping the network's spatial pattern.

The Kenya road system, apparently, has gone through a series of changes from an initial lines of trails, passing through a system of old tracks and earth roads to a complex network of gravel and bitumen highways. This change has involved the growth of ports, the construction of penetration lines, feeder lines and the intensification of interconnecting lines. The process has by no means stopped. In 1906 there were only 818 kilometres of public earth roads, in 1914 the length was 2334 kilometres, by 1920 the kilometrage had increased to 5760 and to-day the country boasts of over 50,000 kilometres of national classified roads and over 100,000 kilometres of unclassified tracks and roads. Of the classified network system, over 5,000 kilometres are bitumen surfaced (Republic of Kenya, 1979).

At some stage, the road network has undergone a complex form of evolution including birth and death cycles. This is evidently factual as few roads in Kenya to-day can be said to follow the original alignments of the trails and tracks that preceded them. Some old routes had to be abandoned because they were no longer needed as better and shorter roads with gentler gradients and good alignments have been built to replace them. The reason for this change is that a transport network is built to serve a complex network of locations and through time the network has to adjust itself to the changing patterns and characteristics of the locations, the latter which themselves should also undergo changes as a function of the evolving network.

In this Chapter the main objective is to trace the history of the growth and development of the Kenya road network system from its origin to the present time and compare its sequence of development with the ideal-typical sequence model of Taaffe, Morrill and Gould. In the course of this historical analysis, an attempt will be made to identify the specific economic, social and political forces that have had an influence on the network's growth and development. The identified and relevant factors will be subjected to rigorous statistical analysis and testing so that their relative strengths of influence can be determined and specified.

B. THE ORIGIN AND DEVELOPMENT OF THE ROAD NETWORK

1. THE NETWORK SYSTEM BEFORE 1900

(a) The Growth of Caravan Routes

For more than a thousand years before effective European contact with Kenya in the second half of the nineteenth century, the interior parts of the country did not have clearly defined routes of any commercial significance. Such routes as existed were no more than footpaths or animal trails linking one village to another or leading to watering points and grazing grounds. The intensive inter-tribal warfare that existed between the various neighbouring tribes militated against the establishment of commercial routes. Moreover, the dense forest growth between some tribal lands and the barrier formed by barren and almost desert lands in the north and north-east, and between the coast and the highlands did not make it possible for the emergence of such routes. It was the well established coastal trading ports such as Vanga, Mombasa, Kilifi, Malindi, Lamu and Patta which had trade routes of some significance linking them with their immediate hinterlands. But even the coastal ports were to a large extent independent from one another, and were in frequent conflicts over the control of coastal trade with the Arab and Indian merchants, and as such developed very few inter-port and overland trading routes between them.

With the growth of the caravan trade in the nineteenth century, penetration lines of contact were established between some of the coastal ports and the interior centres, introducing new changes and attitudes in the traditional African society. Some of the interior areas were strengthened by the increased contact with the coast, while others were severely weakened as Arab and Swahili trade in slaves disrupted their social bonds. The Akamba people, for example, found in the caravan trade the opportunity to spread well beyond their homeland and settled throughout wide areas of Kenya and East Africa.

With the coming of the Europeans in the nineteenth century first as explorers and missionaries, and later as traders, administrators and settlers, the development of communication lines began to take a new dimension. The combination of European contact and the impact of increased caravan trade resulted in the growth of certain coastal ports at the expense of others. This differential growth was particularly more marked in Mombasa, Lamu and to some extent Malindi, each one of them on or near the starting point of trade routes into the interior. The caravan trade and especially the activities of the Imperial British East Africa Company in the area between Mombasa and the lake region created a number of important trading stations in the interior; Mumias, Eldama Ravine and Machakos being the most important. There then began to appear for the first time well defined lines of penetration trade routes and the growth of important, but small nodes along the trade routes (Figure 4.1).

(b) The Mackinnon Road and Sclater Road

The first roads to convey wheeled vehicles in Kenya were

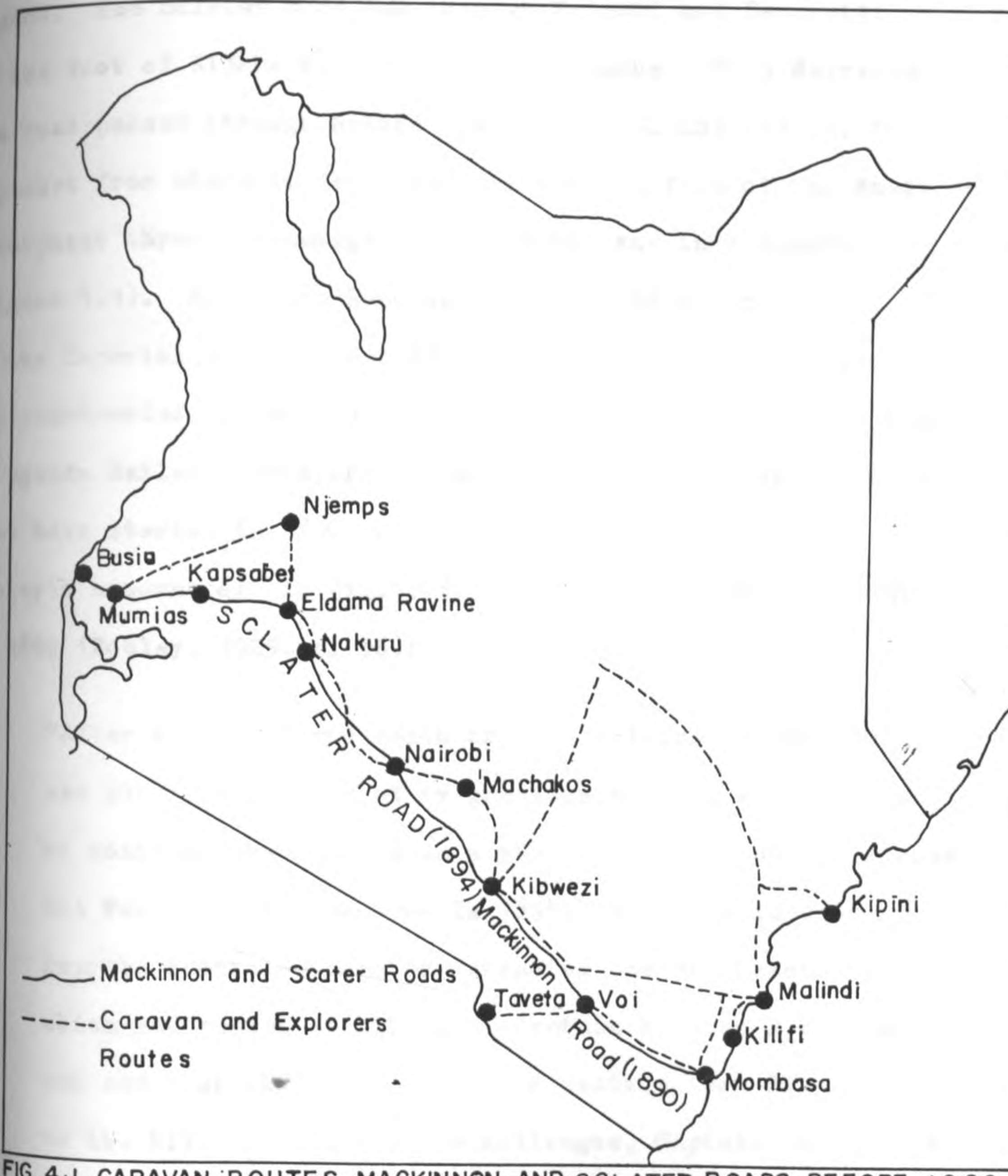


FIG. 4·1 CARAVAN ROUTES, MACKINNON AND SCLATER ROADS BEFORE 1900 the Mackinnon Road (1890), from Mombasa to Kibwezi and the Sclater Road (1894), from Kibwezi to Mumias through Busia to Uganda. The Sclater Road ran through Nairobi and Dagoretti to the foot of Kijabe hill and to Naivasha. From Naivasha the road passed through Nakuru via Gilgil, Eldama Ravine, to Kapsabet from where it descended the western face of the Nandi escarpment through Kakamega, Mumias, Busia and into Uganda (Figure 4.1). Mackinnon Road was constructed by Mr. Wilson of the Imperial British East African Company, while Sclater Road was constructed by Captain Sclater who was the leader of a team of Uganda Railway Surveyors. The construction of Mackinnon Road must have started in 1890 or thereabouts as indicated by Hobley's account of his exploration in Taita and Ukamba country in 1892 (Hobley, 1929, pp. 56):

> "After a rest of one month or two, writing up reports and plotting the map of my previous trip, I was detailed to continue the road began a year or so previously, across the Taru plains.---------- In 1894, it was decided to improve communications by extending the Mackinnon Road which had ceased at Kibwezi. Captain Sclater R.E. came out and took charge of the lower section from Kibwezi to the Rift Valley, and his colleague, Captain Smith, R.E. carried on the work into the Kavirondo".

A number of sections of the Mackinnon - Sclater Roads fell into disuse and were overgrown with bush and grass as soon as the construction of the Uganda Railway was completed. Even parts of the Sclater Road which did not coincide with the alignment of the Uganda Railway became unusable. The most affected sections were those through Uasin Gishu Plateau to Mumias, as these sections did not pass through the lands which were later settled by the white farmers. The costs of constructing the two roads have not been specified. However, an estimated figure of about £19,000 has been given for the Sclater Road in the Blue Books.

2. THE NETWORK SYSTEM, 1900 - 1920

(a) Political and Economic Background to the Construction of Roads in Kenya

Before delving into the details of the growth and expansion of the Kenya road network during this period, it would be salutary at this point to take a brief look at some of the historical events of political and economic nature that occurred prior to or concomitantly with the growth and development of roads in this country. The years before the completion of the Kenya - Uganda Railway, as it was later called, saw the spread of the British rule, which culminated in the growth of European Settlement and eventually the establishment of the White Highlands and African Reserves.

The earliest protectorate treaties were made with the coastal people, but effective administration did not in reality take place until the completion of the construction of the Uganda Railway and later spread with the construction of roads that took place in the early years of the 20th century. The effective British administration was established in Kamba country in 1897, in Kikuyu land, 1895 - 8, in Luo land and Baluhya land in 1902, after the transfer of Uganda's Eastern Province and in Maasailand in 1904. Punitive expeditions were sent out to Sotik area (1905), Embu (1906), Kisii (1907), Turkana (1910,1916), and to the Coastal Giriama (1914 - 15). The last areas to be brought under some tenuous British administrative control were the Northern Frontier District and Jubaland.

During the first phase of European settlement in Kenya from 1902 to 1908, nearly all alienated land were found around the railway towns and at points along the line not far away from it. The land open to white settlement during this period was that area between Kibwezi in the east and Fort Ternan Station in the west. The major centres of early settlement and inevitably areas of early road construction were the Nairobi area and much of the Kikuyu land especially in areas such as Ngong, Kabete, Karura, Ruiru and Thika. In addition to Nairobi and Kiambu regions, there was a second early core of settlement near the Mau escarpment between the Molo and Njoro rivers, which later spread to become focused upon the town of Nakuru.

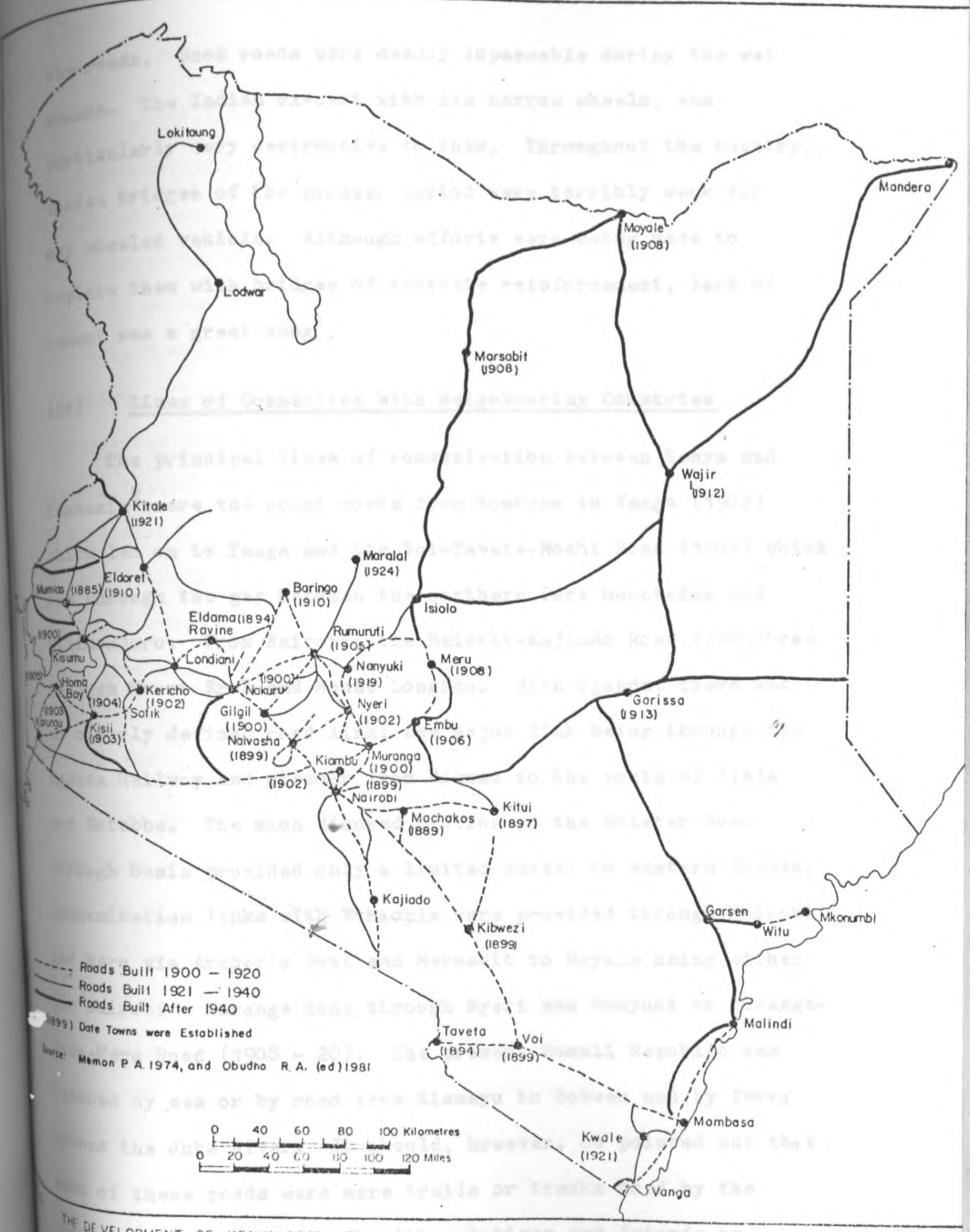
The second phase of European settlement began from 1908 to 1914, and several other areas, many of them well beyond the railway line, had been occupied by the white settlers. After 1908, large numbers of Afrikaners from South Africa moved into the Uasin Gishu Plateau and succeeded in establishing a white enclave in the highlands centring around the town of Eldoret.

By the end of World War 1, the entire railway line from east of Kibwezi almost to Kisumu ran through land alienated for European settlement. Other branch lines planned or under construction were to serve other zones of new settlement, such as in Thika area and Eldoret in the Uasin Gishu Plateau. Similarly, new road constructions had to be focused in these areas.

(b) Major Lines of Road Connection

(i) Conditions of the Roads

An attempt has been made in this section to describe the conditions and the distribution of roads throughout Kenya, showing at the same time, wher-ever possible, when the specific roads described were completed and opened for public use. The dates when some major towns were established are also shown in Figure 4.2. Generally speaking, the conditions of roads in Kenya in the years before the outbreak of the first World War, and several years thereafter were terribly bad. Considerable improvements had been made in certain districts, particularly those that had been settled by the white farmers. But more and better roads were badly needed to open up the African areas for administrative control and generally for the benefit of the indigeneous population. There were no metalled roads outside the larger towns such as Nairobi and Mombasa. The roads were of earth, pounded hard with stampers and near the towns with steam rollers. In the highlands, where the rocks were of volcanic origin, murram was used for surfacing, but elsewhere the sticky red clay soils and black cotton soils formed the surface of most of



THE DEVELOPMENT OF KENYA ROAD NETWORK

the roads. Such roads were deadly impassable during the wet season. The Indian ox-cart with its narrow wheels, was particularly very destructive to them. Throughout the country, wooden bridges of the pioneer period were terribly weak for any wheeled vehicle. Although efforts were being made to replace them with bridges of concrete reinforcement, lack of cement was a great snag[1].

(ii) Lines of Connection With Neighbouring Countries

The principal lines of communication between Kenya and Tanzania[2] were the coast route from Mombasa to Vanga (1902) which led on to Tanga and the Voi-Taveta-Moshi Road (1902) which ran through the gap between the northern Pare Mountains and Kilimanjaro. From Nairobi, the Nairobi-Kajiado Road (1920) ran through Mount Erok and Mount Longido. With Uganda, there was no clearly defined road link; the major link being through the Uganda Railway and steamer from Kisumu to the ports of Jinja and Entebbe. The much disused section of the Sclater Road through Busia provided only a limited access to eastern Uganda. Communication links with Ethiopia were provided through Nairobi and Meru via Archer's Post and Marsabit to Moyale using either the Nairobi - Muranga Road through Nyeri and Nanyuki or Muranga-Embu-Meru Road (1908 - 20). The present Somali Republic was reached by sea or by road from Kismayu to Gobwen and by ferry across the Juba River. It should, however, be pointed out that some of these roads were mere trails or tracks used by the local people to communicate with relatives and friends on the other side of the border.

(iii) Lines of Connection in the Coastal Region

Communication between different places on the coast was mainly by sea. However, a number of roads had been cleared to link places on the mainland. A cleared road ran from Mombasa to Vanga on to the Umba River in the south. To the north of Mombasa, Mombasa - Malindi Road (1902) crossed ferries at Takaungu, Kilifi creek and over the Sabaki. The Giriama country was reached from Mombasa by rail to Mazeras, Mackinnon Road having fallen into disuse after the laying out of the rail line. From Mazeras, a short road some 5 kilometres in length provided a link with Rabai from where footpaths and tracks were used to Kilifi Creek. In Lamu District, a good track ran from Kipini to Witu from where Lamu could be reached by the Mkonumbi - Witu Road (1902) and thence by dhow. The Taru desert was roadless, except for a few bush trails and local tracks.

From Voi ran the Voi-Taveta Road, which as said earlier, connected Kenya with Tanzania. This was an old caravan route by which the German settlers in the Moshi district used to import their supplies from Mombasa before the completion of the Usambara Railway in 1911. During the first World War, the road was heavily used to transport military supplies and personnel to the war front in the border. Elsewhere to the north of Voi-Taveta Road, there were no motorable lines of communication east and west of the Uganda Railway until Nairobi was reached, except the Kibwezi - Kitui Road opened in 1910.

(IV) Lines of Connection in the Eastern Highlands

The chief centres of communication in the eastern highlands were Nairobi, Machakos, Muranga, Rumuruti and Meru. A road made since the war ran south from Nairobi across the Athi plains to Kajiado on the Magadi Railway and on to Tanzania. This road was passable by motor vehicles, except in very wet weather, and by ox-wagons all seasons. Besides this road, there were several short roads in the neighbourhood of Nairobi. These included the Nairobi - Ngong Road (1902) with a branch to Dagoretti, Nairobi - Limuru Road (1909), Nairobi - Kiambu Road (1909), Kiambu - Limuru Road (1908) and the Nairobi - Juja Road (1910) to the east.

The Nairobi - Muranga Road was an earth road with bridges over the rivers. From it a branch road ran off into the settled coffee area along the Ruiru River. The Nairobi - Machakos Road followed the railway line to Athi Plains Station before branching off south of Lukenia and Mua Hills. A track ran from Kibwezi to Machakos from where the Machakos - Kitui Road (1902) crossed the Athi River by a ford, but a pulley line with a basket had to be used in wet weather.

A fairly good road, built by Chief Karuri, connected Muranga with Karuris (1908) on the foot hills of the Aberdares. A road fit for motor vehicles made a northern circuit round Mount Kenya from Nyeri to Meru (1914). From Nyeri, a track ran to Naivasha (1905) through the Aberdares and another one to Rumuruti (1910 which was then a Government Station. To Rumuruti tracks came from Gilgil (1907) and Baringo (1908) in the Rift Valley. Several roads met at Meru in addition to the ones from Nyeri and Embu, and from there a motorable road ran to the ford opposite Archer's Post. At Archer's Post, the journey began across the desert to Marsabit through Moyale to Ethiopia. A road some 27 kilometres long ran from Meru to Nyambeni Hills and another to the Government station at Garba Tulla. A fourth road went through Tharaka country to the Tana.

(V) Road Connections in the Rift Valley and the Western Highlands

A motor road went from Nairobi to the Soda works on Lake Magadi and from Magadi to Arusha in Tanzania. An ascent into the Rift Valley from Nairobi was by the road to Ngong (1902) and from there by a very steep and precipitous descent into the Kedong Valley. The main road to the Rift Valley was by the Sclater Road already examined. From the Sclater Road, a branch motor road from Kijabe went to Ngare Narok which had been established as the headquarters of the Masai Reserve and from there to Mara Post (1916). From Naivasha, a road 27 kilometres in length (1908) went round the western side of the lake and another 8 kilometres in length (1910) connected the Government farm on the eastern side of the lake. Gilgil as said earlier, was connected to Rumuruti by a road to the north. From Nakuru a road went northwards to Lake Solai (1910) from where there was a track to Rumuruti (1907). The route from Nakuru to Baringo (1907) followed the main road to Molo river. This road fell into disuse in later years after the Government Station at Lake

Baringo was transferred to Kabarnet to which a track fit for pack transport was made. The Sclater Road provided a link through Eldama Ravine to Uasin Gishu Plateau and some eighteen kilometres from Kapsabet there was a branch track to Kaimosi (1910).

A road ran northwards from Londiani to Eldama Ravine (1902) and another went to Eldoret on the Uasin Gishu Plateau (1910). The Londiani - Eldoret Road formed the only means of communication between the railway head at Londiani and the block of Afrikaner farms on the Uasin Gishu Plateau. This road, known then as 'mile 65', had a particularly bad section known as the 'Red Sea' which became a morass of thick red mud in the rains. From Eldoret, there was a track northwards through Trans-Nzoia District into the Suk plains and thence to Kacheliba, a Government post on the left bank of the Turkwel river. South of the Uganda Railway, and between it and the southern frontier with Tanzania, there were hardly any roads. From Lumbwa on the Uganda Railway, a road ran to Kericho (1905), and from there the farmers in the Sotik region had with the Government aid constructed a wagon road to Sotik (1910) which was continued to Kisii (1910).

(VI) Road Connections in the Lake Region

From Kisumu, the terminus of the Uganda Railway, a road ran to Mumias (1903). This was said to be the busiest and carried more wheeled traffic than any other roads in Kenya at the time. From Mumias, two roads went to Uganda, one through Busia and another one ran north by west to Mbale in Uganda (1914).

A track went from Mumias through Bukusu country to the Government post at Kacheliba. Another good road connected Kaimosi with Kisumu (1910).

In the present South Nyanza and Kisii Districts there were two good roads with bridges and culverts. One ran from Homa Bay to Kisii (1910) via Rangwe and another one from Kendu Bay to Kisii (1910). Transport link between Kisumu and these southern districts was by boat through Homa Bay and Kendu Bay. From Homa Bay, there was a track to Karungu (1910), then a Government post, and from Karungu a track ran to Kisii.

From this brief survey of the conditions and distribution of the Kenya road network, two major forces can be seen to have played an important role in the determination of the spatial pattern of the network system. These were the establishment of effective British administrative control throughout the country and the spread of white settlements in the Kenya Highland. A third factor, military operations in the first World War, also had an important, but short lived role. Roads such as Sotik-Amala River Road (1914), Ngong - Namanga Road (1914) and Kijabe - Mara Station Road (1916) were built basically for military operations. The military roads, however, fell into disuse as soon as the war was over because of lack of maintenance.

The days of the motor cars began to emerge towards the beginning of 1920, as there began to arrive cheap box-bodied Ford cars. Traffic on the main arterial routes began to increase in volume, so that the old tracks frequently became impassable for motor vehicles in the wet season.

travelling on the roads was so difficult and slow that Marjorie Pharazyn (Huxley and Curtis, 1980, pp. 111) had this to say in 1920:

"Kitale did not exist. Eldoret was 70 kilometres away, and the nearest railhead was at Londiani, 160 kilometres away. We had to send all our maize by ox-wagon to Londiani. This was a three-week safari and the farm work suffered by the absence of a team for that period. We rode mules for personal transport. -------- A trip to Nairobi was a major enterprise. By mule-cart to Eldoret, then by trotting ox-cart service we travelled through the dark night, stopping every sixteen kilometres to change oxen and drivers before reaching Londiani, where we transferred to the Uganda Railway. ------- The arrival of the railway at Eldoret in 1924 simplified many problems".

3. THE NETWORK SYSTEM, 1921 - 1940

The end of the first World War marked the beginning of still another phase of European settlement in the Kenya Highlands. This phase of settlement was aimed at doubling the European population then living in Kenya to counteract possible African reactionary attitudes towards the European dominance. It was feared that after being exposed to the use of the gun during the war, the Africans would be in a position to challenge the British rule over their land. The key feature of this phase of settlement was the allocation to the demobilised soldiers, land in the

Kenya Highlands under the Ex-Soldiers Settlement Schemes. Under the terms of these schemes, the ex-British Soldiers could receive farms up to 65 hectares free of purchase price on 999 - year lease at almost free annual rent, with large blocks of land available on purchase (Huxley, 1953, pp. 54 - 56). As a result of the allocation of land to soldiers, over 1,165,500 hectares of land were added to the sphere of European settlement which by 1925 encompassed over 30,720 square kilometres. Trans Nzoia, Laikipia and the Nanyuki areas received the bulk of their settlers during this period as did several areas along the railway line beyond the old Kibwezi - Fort Ternan boundary. New areas originally recognised as tribal land in Kericho - Sotik, Kaimosi, Kipkarren and northern Trans Nzoia were also opened up for European settlement.

The break with the old railway limits was then complete, but it was not long before the new settlers began to clamour for and receive branch rail lines and roads to serve new areas. This period saw the extension of the railway branch lines to Solai (1926), Eldoret (1925), Kitale (1926), Thomsons Falls (Nyahururu) in 1929, Thika - Nanyuki line (1930), Kisumu - Butere line (1930) and Eldoret - Uganda line (1928). As a result of the extension of the rail network, virtually all the European communities in the country were then located at a distance of not greater than 40 kilometres away from the railhead.

Apart from 150 kilometres of township roads and 726 kilometres of district roads in the European areas under District Councils, the maintenance of which was carried out by the District Councils out of grants from the Central Government, the total kilometrage of roads maintained by the Public Works Department (PWD) was approximately 16,558 (PWD, Annual Report, 1935). Of these roads, 11,947 kilometres in length were grant earning in the African areas, Turkana and Northern Frontier Province. In total, the country was being served by 17,434 kilometres of public roads.

By the beginning of 1929, the Municipal Boards took over the administration of township roads in Mombasa, Nakuru, Eldoret and Nairobi, while District Councils assumed control of district roads in the European settled rural areas of the districts of Nairobi, Nakuru, Uasin Gishu, Naivasha and Kisumu - Londiani. The main country road system, certain township and district roads where no local bodies had been formed, and roads in the African districts were under the control of the Central Government through the agencies of the PWD and the administrative personnel. The Central Government gave annual grants for the maintenance of District Council roads. In some African districts sums of money were allocated by the Local Native Councils from their own funds for the maintenance and improvement of roads and also for capital construction in addition to the Central Government grants (Annual Report, 1929).

An important feature in the proliferation of road kilometrage throughout the country during this period was the considerable kilometrage of roads constructed to serve the newly settled white districts of Trans Nzoia, Nanyuki and Laikipia. However, a number of penetration and interconnection lines of administrative roads continued to be built in Turkana and other districts. Major roads built in these districts included Gilgil - Thomson's

Falls Road (1921 - 26), Nakuru - Njoro - Londiani Road (1921 - 26), Eldoret - Kapsabet Road (1921 - 26), Eldoret - Kitale Road (1921 - 26) and Nakuru - Mau Summit Road (1938)[3]. The only districts outside the European Districts which attracted the colonial Government's attention in terms of road expenditure were the Nyanza Province districts of North, Central and South Nyanza, and the Coast Province districts which were connected by roads parallel to the coast north and south of Mombasa. Elsewhere, the roads were of pioneer alignment and impassable in wet weather (Table 4.5, Appendix 2).

Some considerable progress was made in road construction between 1930 and 1940 in spite of the world recession which began in the early years of 1930's. Some major construction work was carried out in the mining and tea areas, the funds for which came from the Colonial Development Funds (PWD, Annual Report, 1937). The roads constructed under the scheme were the Kisiany - Asembo Bay Road (1936), Homa Bay - Suna Road (1936), Muhuru Bay - Lolgorien Road (1936), Kisumu - Ahero Kibigori Road (1938) and Jamji - Chemagel - Lolgorien Road (1937) which was to connect the Kericho tea growing areas with Lolgorien gold mines.

4. THE NETWORK SYSTEM AFTER 1940

By 1946, the country's road network system consisted of approximately 27,162 kilometres of road, and a remarkable progress had been made in the bituminisation of some sections of the main roads with heavier traffic. Of this kilometrage, some 298 kilometres had bitumen surface. The first major roads in

Kenya to receive bitumen treatment were the Nairobi - Thika Road (1946), Nairobi - Nakuru Road (1946) and the Lumbwa - Kericho - Sotik Road (PWD, Annual Report 1946). It is, however, difficult to give the exact kilometrage of roads in existence at the time, because the actual figures varied from year to year as new roads opened up, old ones abandoned and the existing ones realigned. Some of the quoted figures encountered in official publications were somewhat misleading for they failed to differentiate between truly serviceable highways. Some stretches of unimproved, yet often passable and commonly dirt - roads included Forest Department tracks,village to village track and trail connections and some 8,000 kilometres of desert roads in the Northern Frontier Province.

The major roads built during the second World War were the Meru - Isiolo Road (1943), Turbo - Kyebaiwa Road (1943), Kyebaiwa - Malakisi Road (1943), Sotik - Tenwik Road (1945) and the Nyangusu - Kilgoris - Lolgorien - Mara Road (1945). Soon after the end of the war, the work on the Kisumu - Busia Road was started (1947).

The modernisation of Kenya's road system can be said to have started in 1948. By 1948, the overall picture was that of sunken roads and bad alignment, ill-drained and impassable roads in wet season. The need was, however, to keep the traffic moving. The realisation after the war of the need for a determined attack on the problem of improving the conditions and expanding the network system led to the appointment in 1947 of the Road Authority Committee, which produced an Interim

Report in 1948 and a final report in 1949. As a result of the recommendations of the committee, a Road Authority and a Road Fund were established in 1951. Its functions were to formulate and execute policies in relation to all matters concerning public roads in the country. It was to direct research and experiments in connection with road construction and to determine priorities to be given to road works in addition to advising Local Authorities on matters relating to works on public roads. An important financial function of the Road Authority was to manage the Road Fund and to ensure that grants were spent in accordance with the estimated expenditures. The Road Fund was to receive its resources of income from vehicle and driver's licences and petrol taxation. It also received funds and administered grants from the Government revenue, contributions from Development and Reconstruction Authority and from other unspecified sources.

Since 1948, there had been some progress in the development of Local Authorities. Seven County Councils had replaced the former seven European District Councils with their limited spheres of activities. The old Local Native Councils had been converted to African District Councils with increased responsibilities and some autonomy. There were 25 African District Councils engaged in road works. The old Public Works Department had become the Ministry of Works. It was through the County Councils, the African District Councils and the Ministry of Works that the policies of the Road Authority were put into effect, and as such the most significant changes lay in the development of the Local Authorities.

A comprehensive plan for the country's road development programme was elaborated in 1951. It called for the construction of some 1920 kilometres of two-lane 6.6 - metres wide bitumen highways, 1040 kilometres of new gravel roads, and 240 kilometres of reconstructed bitumen roads. All were to be completed within the Authority's Fifteen Years Road Development Programme at a total estimated cost of £20,000,000. Including the existing kilometrage of roads of the same type, the country's network of bitumen highways was to expand to 2344 kilometres and to some 3680 kilometres of gravel or murram roads by the year 1965. In addition, a total expenditure of £2,250,000 was envisaged to be spent on the secondary road system and £1,750,000 on Municipal and Township Roads. The problem was the sources of funds to finance such massive road programmes, as it was realised that the yearly income of the Road Authority in 1951 could only cover the normal maintenance costs of the PWD's system and provide for no more than 16 kilometres of bitumen highways per year (Kenya Colony and Protectorate, 1951). Kenya, therefore, applied in 1951 to American Economic Co-operation Administration (E.C.A) for a £2,500,000 loan to be spread over the first 5 - year programme. The application was refused by the E.C.A, probably because it was already giving a considerable financial assistance to Tanzania to help link Iringa and Morogoro by an improved highway (Dongen, 1954, pp. 130).

The lack of the E.C.A assistance forced the Authority to replace a bitumen standard for the primary road network for the time being by gravel standard for all the roads. This period saw the construction to gravel standard of the roads such as the Njoro - Mau Narok Road (1952), the Webuye - Bungoma Road (1953), the Bungoma - Uganda Border Road (1953) and the Mombasa - Lunga Lunga Road (1953). The history of the construction of a network of major interconnecting roads in Kenya appears to have been completed with the opening up of these routes. The construction of new major penetration and interconnecting routes was to be focused on the administrative roads in the Northern Frontier District (Figure 4.2) and in later years on roads that provide access into the rural areas. Programmes of bituminised highways had to preoccupy much of the Road Authority's activities throughout the second half of 1950's and up to independence in 1963.

In 1956, a bitumen road extended 56 kilometres from Nairobi to Muranga junction on the Nyeri Road, 206 kilometres to Mau Summit, and 48 kilometres to the Machakos turn off on the Mombasa Road. From Mombasa towards Nairobi, a bitumen road had been constructed as far as Mariakani. The total kilometrage of bitumen surfaced trunk and secondary roads stood only at 725 kilometres in 1956. The progress in this direction seemed to have been lamentably slow because of lack of funds.

By 1957, as a result of the Swynnerton Plan for the development of African agriculture, there was a large increase in agricultural production, calling for an urgent need to increase the kilometrage of all-weather roads, particularly in the African areas of high agricultural potential. The year saw the commencement of negotiations for a £7, million loan for bitumen programme mainly for trunk roads to be financed by contractors on a differed payment basis. The Government accepted the financial terms offered by Messrs. Mowlem Construction Company and Raymond International (U.K.) Limited for a £4 million programme (£2 million each), with a further £3 million scheme to be promoted after 1962. Priorities under the £4 million phase went to Makuyu via Sagana to Nyeri Road, Mau Summit via Eldoret to Kitale Road, Mau Summit via Kericho to Kisumu Road, Kisumu to Kakamega Road and Mariakani to Mackinnon Road. With the exception of the Mariakani to Mackinnon Road, the rest of the roads were selected on the grounds of high traffic densities and the declared policy of the Authority of linking centres of population concentration with the capital.

Of the trunk and secondary roads, approximately 850 kilometres had bitumen surfaces in 1958, and it was hoped this distance would be substantially increased under the £4 million Contractor - Finance Programme. The £4 million programme began in 1959 on the Makuyu - Nyeri Road which was completed in 1960. Work on Mau Summit-Kericho Road started in 1961, to be followed in the same year by the work on the Kericho - Kisumu Road which was completed in 1963. The work on Kisumu -

Kakamega Road and Mariakani - Mackinnon Road was all completed by the end of 1963. The bituminisation of Mau Summit - Eldoret Road was completed in 1962. This four-year road programme had involved, in total, the construction of nearly 400 kilometres of trunk roads.

An important feature of road construction work in Kenya during this period was the increasing role which Local Authorities were playing in the building of bitumen roads to link up with main trunk roads. In Trans-Nzoia, the Luseru - Kitale Road was bituminised and extended to Endebess. Other works included the construction of Machakos Road, the North-Coast Road towards Kilifi, the Solai Road, the Lake Naivasha roads and the Uplands Road. The Ndumberi - Githunguri Road was the first road to be bituminised by an African Local Authority (Kiambu A.D.C) in 1962.

In the year 1959, negotiations were also opened with the International Bank for a £1 million loan to finance the construction of roads in the African areas of high agricultural potential. This programme was to cover some 23 roads totalling approximately 800 kilometres in the Central Province, Rift Valley Province, Southern Province and Nyanza Province. The work was carried out by the Ministry of Works and the African District Councils between 1960 and 1963. In 1964 an ambitious road development plan for 1964 - 1970 was prepared by the Authority, the implementation of which would require the expenditure of £17.5 million. This amount seemed to be far in excess of the capital funds which would become available for development in the light of the need for development of other services.

However, a short term plan covering the period 1964 - 66 was prepared.

High on the priority list was the surfacing of the 140 - kilometre stretch of Athi River - Namanga Road, the 117 - kilometre Leseru - Malaba Road, and the bituminisation of the Mombasa - Nairobi Road from the Machakos turn off to Sultan Hamud. A later phase was to involve bituminising the Voi - Mackinnon Road section. The remaining 224 kilometres from Sultan Hamud to Voi was given low priority. Other roads on which bituminisation work was to be done were Kisumu - Yala Road, Nyeri - Nanyuki Road, Embu - Sagana Road, Ahero - Kisii Road, Takaungu - Malindi Road and Nanyuki - Meru Road, all of which are now fully bituminised. A special project was the construction of the Nairobi - Thika dual carriage way.

In 1970, the Kenya road network comprised 40,000 kilometres of trunk, primary, secondary and minor roads of which 4331 kilometres were of bitumen surface. The Road Development Programme for the year 1970 - 74 provided for a national network to serve the development needs of all the provinces and districts in the country. It was envisaged to spend over £43 million on roads over the five - year plan period (Development Plan, 1970). Emphasis on developing secondary and minor roads was directed towards minor roads and roads of economic development projects, such as tea, sugar, tourist and rice roads and on the specially important secondary roads which serve agricultural districts and led into trunk routes or urban areas.

5. SPECIAL ROAD PROGRAMMES

(a) Rural Access Roads Programme

The programme was initiated in 1974 as a means of pursuing important Government policies, namely, the development of rural areas and the use of appropriate labour intensive techniques in all civil engineering works (Development Plan, 1974). The programme caters for the construction of 15,000 kilometres of rural and farm to market access roads in 23 districts by 1982, with priorities given to roads recommended by the District Development Committees. The districts selected for the programme represented the most populated and agriculturally productive parts of the country. The estimated construction cost was U.S. $100 million including physical and price contingencies. Funds for the U.S. $100 million programme were to be provided from the Ministry of Works budget, by the Overseas Development Ministry (U.K.) and from USAID, which proposed to provide U.S. $6 million. Other bilateral agencies had also expressed an interest. Since its inception, some 856 kilometres of roads have been constructed. Of this total, about 150 km. have been gravelled, and the rate of construction was expected to reach its peak in 1980.

(b) Secondary and Minor Roads Programme

The Gravelling, Culverting and Bridging Programme (GCBP) was orientated towards access type roads. Under the programme, some 5,000 km. of classified D and E roads which constitute the bulk of the rural road network are being up-graded through minor realignment, provision of gravel wearing courses and improvement in drainage. Up to 1980, some 350 km. of these roads had been completed (Development Plan, 1979). The donor agencies for the programme have been USAID, the Canadian International Development Agency (CIDA) and the K.F.W - West Germany.

(c) Special Purpose Roads Programme

This programme involves the construction and/or improvement of those roads which serve specific development projects and other activities undertaken by the Government of Kenya other than Ministry of Transport and Communications. These roads are intended to serve as support, primarily to the resource categories such as sugar, tea, rice, wheat, tourism and fisheries roads, settlement roads, rural development roads, defence and Government access roads and township and municipality roads. Under the programme, the various Ministries or agencies which require specific road improvement to support their activities, finance the needed improvements. The Ministry of Transport and Communications acts only in advisory and/or contractual capacity. Since 1964, approximately 5,000 km. of Special Purpose Roads have been constructed, and of this total 340 km. are bitumen roads.

6. A COMPARISON OF THE OBSERVED KENYAN DATA TO THE IDEAL-TYPICAL SEQUENCE MODEL OF TRANSPORT NETWORK DEVELOPMENT

In Kenya, the development of the road network system does not seem to have been affected very much by the presence of other routes of transport prior to the coming of the Europeans in the late nineteenth century, and the appearance of the first modern roads. The caravan routes that were in existence in the nineteenth century did not determine very strongly the alignment of the Mackinnon - Sclater Roads (1890 - 94).

The first stage of road development in Kenya started with the construction of the Mackinnon - Sclater Roads and continued upto 1920. This stage compares well with Phase Two of Taaffe model, which postulates the emergence of a few major lines of penetration, the growth of inland towns or trading centres at the terminals and the differential growth of coastal ports. In the case of Kenya, there was only one major penetration line from Mombasa to Uganda border with a number of branching off penetration lines. Mombasa became the most important port as other ports such as Malindi and Lamu did not have road connections with the interior. Major lines of penetration were represented by the Mackinnon - Sclater Roads, the Nairobi - Thika - Nyeri Road, the Uasin Gishu Road, and the Gilgil - Rumuruti Road, to mention but a few of such lines. This period also witnessed the emergence of a number of important interior centres on the road network and on the railway among which were Nairobi, Nakuru, Eldoret, Nyeri etc. This stage of road growth and development was concomitant with the spread of the British administration and the first and second phase of establishment of the white settlement in Kenya.

The second stage of road development in Kenya can be said to have started between 1920 and 1940, and this is in accord with Phase Three of the Taaffe model which postulates the growth of feeder routes and lateral interconnections. While penetration branch lines were still being constructed to districts such as Turkana and Trans - Nzoia, routes constructed during this period, such as Thika - Kitui Road, Gilgil - Thompson Falls Road, Nanyuki - Rumuruti Roads etc., were basically lateral interconnection routes. This stage coincided with the phase of Ex-Soldiers Settlement Schemes, but it also saw the extension of connecting routes to hitherto unconnected administrative centres.

The third stage of road development started roughly after 1940 and still continues up to now. This is Phase Four of Taaffe Model which postulates the emergence of 'high priority linkages' between the most important centres. This period witnessed the bituminisation of the Nairobi - Nakuru Road and Nairobi - Thika Road (1946), later to be followed in the 1950's and 60's by intensified road construction work programmes directed towards the bituminisation of roads of high priority linkages, culminating in the building of the Nairobi - Thika dual carriage way.

This analysis of the sequence of road development in Kenya as compared to the Taaffe model, does not consider the

First Phase of the Taaffe model which postulates the existence of scattered ports as part of the development sequence of the Kenyan road network system. But if the first phase has to be considered as part of the sequence of road development in Kenya, then the Taaffe - Morrill - Gould Model fits well with the Kenyan experience. The first phase of the model is particularly relevant to the growth and development of ports.

7. THE DISTRIBUTION AND DENSITY OF THE ROAD NETWORK SYSTEM

A visual observation of the map (Figure 4.3) showing the distribution of the road network system throughout the country reveals that closer network densities are concentrated in western and central Kenya, and at the coast. Elsewhere, especially in the northern, eastern and southern parts, the network densities are very low. A comparison with the road density surface map (Figure 4.4) emphasises the close fit of the two maps. The road density surface map identifies three broad density zones, within which lie intermediate zones, namely, high, medium and low density. The shading represents the densities as measured by the number of road intersections recorded in a series of grid cells of 1600 square kilometres superimposed on the Kenya Route Map, 1:1,000,000. A striking feature about the zones is that they form concentric patterns round the western, central and coastal regions of high surface densities. This pattern seems to reflect and emphasise the sequence of growth and development of the network system through the three stages identified in the previous section.

with the differential growth of the port of Mombasa and the interior urban centres such as Nairobi, Nakuru and Kisumu, it meant that these centres acquired dominance over the surrounding areas to which road links spread as waves through spatial diffusion processes, hence the concentric patterns.

The areas of high and medium density surface lie within a belt running from north-west to south-east, covering the districts on the foothills of Mount Elgon and in the Lake Basin through the Mount Kenya and the districts surrounding Nairobi to the coast, including Mombasa and the nearby districts. Except for a gap between Voi and MacKinnon Road, this continuous belt coincides reasonably well with the main axes of the Kenya rail network and is a reflection of the critical role the rail lines played in establishing the initial framework on which the present road network pattern has evolved. Thus, from the point of view of the orientation of the trunk roads parallelling the rail lines, they serve the same areas as the rail lines to which they were intended as feeders. Using the road network maps (Figure 4.3 - 4.5), as a basis for delineating the Kenya road network density and/or development zones, three broad zones, within which are embedded intermediate zones, emerge:

(i) <u>High Density Peaks - Zones (1a), (1b).</u>

The three peaks are located in western Kenya, central and the coast, with Kisumu, Nairobi and Mombasa as the core regions, respectively. The districts covered in the western Kenya peak with

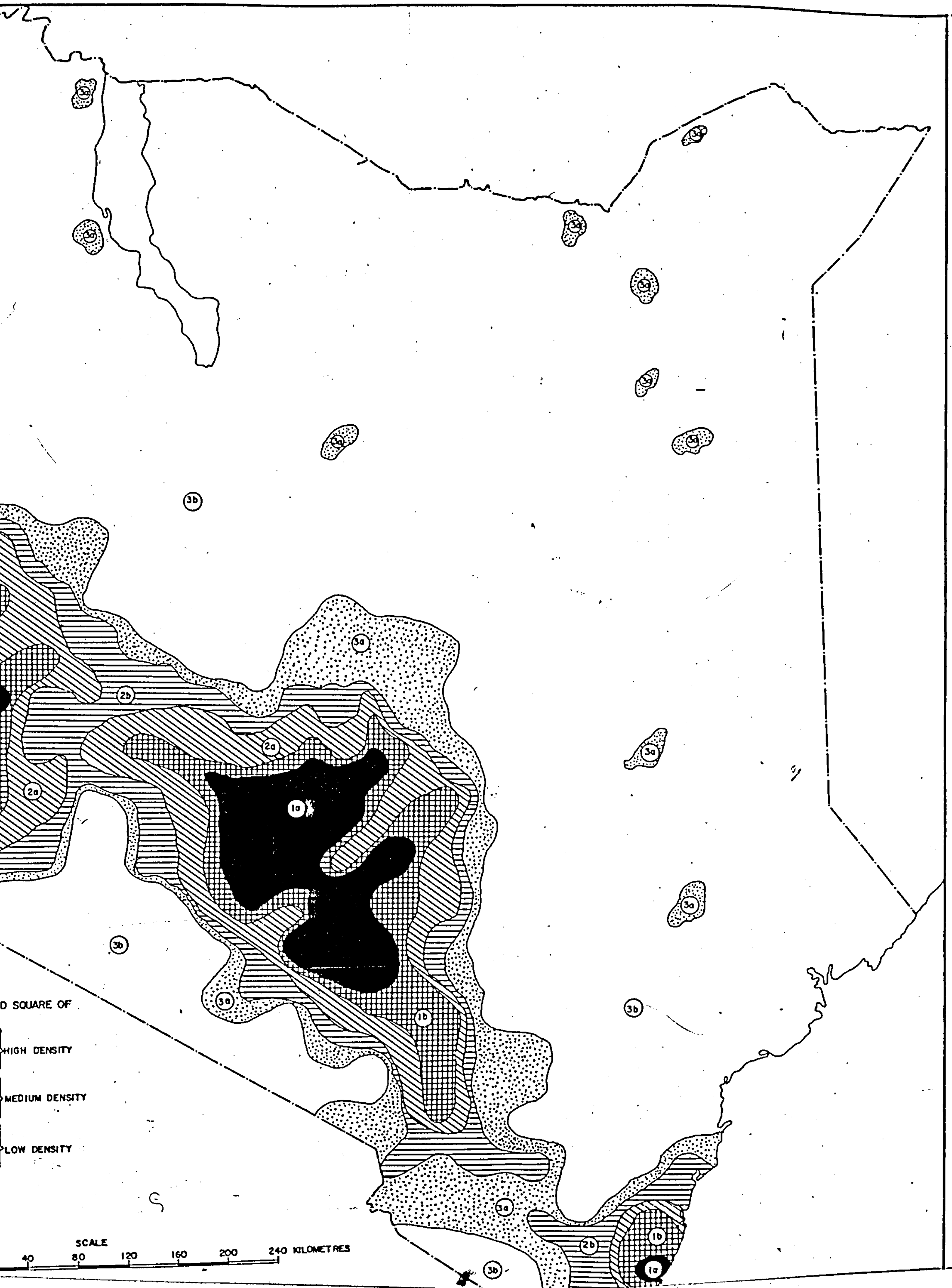

D SQUARE OF
HIGH DENSITY
MEDIUM DENSITY
LOW DENSITY
SCALE
40
80
120
160
200
240 KILOMETRES
1a
1b
2a
2b
3a
3b

FIG. 45 DISTRICTS LEVELS IN ROAD NETWORK DEVELOPMENT

road network development scores above average (Figure 4.5) include: Kisumu, parts of Siaya, South Nyanza and Kisii Districts in Nyanza; Kakamega, parts of Busia and Bungoma Districts in Western Province; Nandi and parts of Kericho District in Rift Valley Province. The districts within the central Kenya peak include all the Central Province districts and Nairobi; the eastern parts of Nakuru District; Meru, Embu, Kitui and Machakos Districts in Eastern Province, while the coastal peak covers Mombasa, parts of Kilifi and Kwale Districts. These are the core areas of high road network connectivity and development.

(b) Medium Density Plateaus or Slopes - Zones (2a), (2b).

These form concentric patterns (cells) round zones of high density peaks. The districts falling within these zones can be categorised generally as medium, but below average in road network development (Figure 4.5). In Rift Valley Province they include: West Pokot, Uasin Gishu, Elgeyo Marakwet, Baringo and parts of Trans Nzoia and Nakuru Districts; and in Coast Province, parts of Kwale, Taita/Taveta and Kilifi Districts fall under this zone. These can be described as areas of emerging and positive road network development.

(c) Low Density Pits or Depressions - Zones (3a), (3b).

These are zones within which lie districts with very low levels of road network development. All the districts in the northern parts of Rift Valley Province including the Southern districts of Narok and Kajiado fall into this category; Marsabit and Isiolo Districts of Eastern Province, all the districts of North-Eastern Province and the Coast Province districts of Lamu and Tana River are areas of low density pits. However, some islands' of network development, though still low density areas, seem to emerge in the neighbourhoods of urban areas such as Lodwar, Garissa etc; in otherwise, areas poorly served with road networks. The areas can be described as deprived and depressed in road network development.

It can, therefore, be seen that the high density peaks and medium density plateaus or slopes, representing approximately a quarter of the total area of Kenya, define areas of high population densities and levels of economic development, while the remaining three quarters of the country with road density pits or depressions are characterised by low population densities and levels of development. In fact, if the road density surface map of Kenya were superimposed on the maps showing the distributions of other components of the country's development, the patterns of distribution would be highly co-variant. An additional factor which seems to account for the differences in the levels of road network development is the areal sizes of the administrative district units. Districts in which road network densities are high are apparently those with smaller areas compared to those with larger areas. Figure 4.5 brings out clearly the nature of this road network/area relationship, and this will be examined statistically in the following section.

C. THE RELATIONSHIPS BETWEEN THE DEVELOPMENT OF THE ROAD NETWORK AND SOME SELECTED FACTORS

The geographer's interest in modern descriptive and analytical statistical methods is of special importance, especially with respect to their potential usefulness in regional analysis (Robinson, et al., 1961). Correlation techniques, including multiple correlation and regression are particularly suited to aiding the geographer in his study of the areal variations of related phenomena, since the variables always exist in complex interconnections. In the historical survey of the growth and development of the Kenya road network system and in the analysis of its density patterns, several factors were suggested as having been associated with the network's growth and development. The most important of these are the establishment of centres of British administration, the spread of white settlement and the introduction of commercial agriculture, population concentration and the growth of urbanisation and related economic/commercial activities, and land area.

The question, therefore, arises as to how to assess and evaluate the relative significance of these factors with respect to their contributions to the areal variations in the pattern of road network distribution. In this section, the statistical techniques of multiple correlation and regression procedures will be employed to isolate the relative significance of some of the identified factors. To understand areal interrelationships completely is out of question. For this reason, it has been decided to sort out what seem to be relevant factors in a logical relationship, then examine their relative significance statistically. In this and the following chapters, the main interest is on testing the significance of the hypothesised relationships and evaluating levels of explanation attained jointly by the hypothesised independent variables. Although attempts will be made to identify factors most likely to be associated with residual variance these will not involve the analysis of maps of residuals in all the cases.

1. VARIABLES

The dependent variable is an index of road network development. This is a composite measure of network development calculated by combining road network per square kilometre of land, with the beta index (a graph theoretic measure of network structure). The computational procedures of composite indices are explained in detail in chapter 3 of this work. A number of phenomena have been suggested to be closely related to transport network development. Population and areas of the reporting units of observation have been used in multiple regression analysis by Taaffe and his associates in a study of the variations in road kilometrage in Ghana and Nigeria (Taaffe et al., 1963). Other factors they suggested are commercialisation, rail competition, intermediate location, and physical environment. For this analysis, the indices of population and level of agricultural development, and land area have been selected as independent variables.

2. STATISTICAL ANALYSES AND INTERPRETATION

Before subjecting the variables to statistical analysis, the values of the area variable were transformed to common logarithms to ensure linearity in order to make the underlying mathematical base in correlation and regression analyses secure. The values of other variables were transformed through the procedures of computing composite indices. Table 4.1 shows the variables that were subjected to the statistical analyses. The hypothesis to be tested is that the variations from district to district in the levels of network development are significantly and positively related to the variations in population and levels of agricultural development and negatively to the variations in the areas of the districts.

The first stage in the analyses involved the computation of the bivariate correlation coefficients among the variables (Table 4.2) in order to establish the degree and nature of their intercorrelations. The independent variables are all significantly correlated with the index of road network development; the highest correlation, as expected being with the population factor. As hypothesised, land area is negatively correlated with the road network index. This indicates that higher densities of road networks are characteristic of districts with smaller areas, while larger districts tend to have low densities of networks. This should, generally, be expected as large sparsely populated units will require a larger per capita road investment to be served compared to small densely populated units. Furthermore, the negative correlations between area and the other independent variables suggest that large areal units are a retardation to the process of development in the other sectors of the economy as well. Thus, the preliminary test applied to the data has confirmed the existence, nature and degree of the hypothesised relationships.

The data in Table 4.1 were subjected to stepwise multiple regression analysis. The purpose of the exercise was to determine the degree of the relationship between the dependent and the three independent variables working simultaneously, and to evaluate the relative contribution of each independent variable to the variation in the dependent variable when the effects of other variables are held constant. The results are presented in Tables 4.3 and 4.4, in which the multiple correlation (R) and coefficients of determination (R^2) enable the reliability of the regression model to be estimated. The scores are added progressively down the columns such that the first value (R^2) shows the proportion of variance in the dependent variable (road network index) that is explained by the first independent variable (population) and the second value is the proportion of variance in road network index explained by population and land area together. The last score shows the proportion of total variance explained by all the three independent variables working simultaneously. The standard errors of estimates express precisely how successful the regression equation is. They are, in effect, the standard deviations of the deviations of actual from the expected values. The F-ratio are used for testing the statistical significance of the independent variables. They reveal which of the individual independent variables are contributing significant additional amounts to the explanation of the variance of the dependent variable.

From Table 4.3, it can be seen that population alone explained about 73 per cent of the internal variation in the distribution of the road network system. The addition of land area and the index of agricultural development into the stepwise multiple regression equation increased the total level of explanation to about 80 per cent These findings are in accord with the other findings (Taaffe, et al. 1963, Hofmeier, 1973; Kolars and Malin, 1970). In all these studies, population attained the highest level of explanation, followed by land area. The use of the level of agricultural development as an explanatory variable is a new addition, demonstrating the wide range of variables that can be incorporated into this type of analysis. However, it appears,as Taaffe and his associates have pointed out, that much of the impact of other relevant factors on the distribution of transport networks is expressed through their relationship to the population pattern.

An examination of the regression coefficients table shows that population is the most significant predictor of the variation in the level of road network development as judged by the standardised regression coefficient of 0.609 and the F-ratio of 32.324, which is significant at 1 per cent level. However, land area regression coefficient is only significant at 5 per cent level. The regression model has performed reasonably well; the main problem is with the failure of the agricultural development variable to reach the desired level of explanation. This may require re-examination and the use of more refined data on agricultural development in Kenya,if the often quoted claim that the dense networks of road are associated with areas of high agricultural development has to be empirically corroborated.

TABLE 4.1: THE RELATIONSHIP BETWEEN NETWORK INDEX AND POPULATION, AGRICULTURE AND LAND AREA

DISTRICT	ROAD NETWORK INDEX	DEMOGRAPHIC INDEX	AGRICULTURAL INDEX	LOG LAND AREA
BUNGOMA	0.763	0.785	0.737	3.49
BUSIA	0.733	0.739	0.649	3.18
KAKAMEGA	0.760	1.024	0.844	3.54
SIAYA	0.824	0.797	0.624	3.40
KISUMU	0.895	0.835	0.901	3.32
S. NYANZA	0.797	0.858	0.810	3.76
KISII	0.841	0.987	0.794	3.34
TURKANA	0.486	0.465	0.572	4.77
SAMBURU	0.469	0.434	0.626	4.32
W. POKOT	0.564	0.515	0.716	3.71
T. NZOIA	0.716	0.685	0.900	3.39
E. MARAKWET	0.635	0.542	0.805	3.43
BARINGO	0.506	0.519	0.760	4.03
LAIKIPIA	0.611	0.479	0.807	3.99
UASIN-GISHU	0.648	0.633	0.816	3.58
NANDI	0.750	0.667	1.038	3.44
KERICHO	0.878	0.794	1.045	3.69
NAKURU	0.709	0.706	0.833	3.85
NAROK	0.577	0.512	0.886	4.27
KAJIADO	0.594	0.476	0.631	4.32

Table 4.1

THE RELATIONSHIP BETWEEN NETWORK INDEX AND POPULATION, AGRICULTURE AND LAND AREA (CONT'D)

DISTRICT	ROAD NET-WORK INDEX	DEMOGRAPHIC INDEX	AGRICULTURAL INDEX	LOG LAND AREA
NYANDARUA	0.655	0.591	0.836	3.55
NYERI	0.820	0.765	0.709	3.52
KIRINYAGA	0.814	0.754	0.704	3.16
MURANGA	0.959	0.906	0.908	3.39
KIAMBU	0.912	0.930	0.828	3.39
MARSABIT	0.537	0.439	0.567	4.87
ISIOLO	0.263	0.411	0.608	4.41
MERU	0.672	0.813	0.903	3.99
EMBU	0.733	0.693	0.647	3.43
KITUI	0.695	0.705	0.669	4.47
MACHAKOS	0.662	0.858	0.803	4.15
MANDERA	0.388	0.449	0.553	4.42
WAJIR	0.391	0.463	0.611	4.75
GARISSA	0.435	0.460	0.624	4.64
T. RIVER	0.293	0.439	0.704	4.59
LAMU	0.378	0.419	0.755	3.81
TAITA	0.658	0.479	0.767	4.23
KILIFI	0.729	0.697	0.788	4.09
KWALE	0.679	0.576	0.780	3.92

Source: Author's own calculations from sources listed in the Appendix 12, Table 7.11; the methods of calculating composite indices of development are explained in Chapter 3 of this work.

TABLE 4.2 MATRIX OF CORRELATION COEFFICIENTS BETWEEN THE FOUR VARIABLES

VARIABLE	1	2	3	4
1. ROAD NETWORK	1.000			
2. POPULATION	0.853	1.000		
3. AGRICULTURE	0.556	0.494	1.000	
4. LAND AREA	-0.748	-0.672	-0.515	1.000

All the correlation coefficients are significant at 5 per cent and 1 per cent levels.

TABLE 4.3 MULTIPLE COEFFICIENTS OF CORRELATION

VARIABLE	R	R^2	CHANGE IN R^2
POPULATION	0.853	0.728	0.728
LAND AREA	0.885	0.783	0.056
AGRICULTURE	0.889	0.792	0.008

TABLE 4.4 REGRESSION COEFFICIENTS

VARIABLE	b[1]	b	STANDARD ERRORS OF ESTIMATES	F
1. POPULATION	0.590	0.609	0.104	32.324**
2. LAND AREA	-0.098	-0.282	0.038	6.728*
3. AGRICULTURE	0.154	0.109	0.130	1.409
(CONSTANT a)	0.536		0.191	7.899

[1]Unstandardised regression coefficients used for prediction purposes.

* Significant at the 5 per cent level.

** Significant at the 1 per cent level.

SUMMARY

The historical survey of the development of roads in Kenya shows that before 1890, the only routes of commercial significance were the caravan routes used by the Arab traders from the coastal ports to interior centres such as Machakos, Eldama Ravine and Mumias. Elsewhere, local footpaths and animal trails provided routes of link between one village and another. The first modern roads to convey wheeled vehicles were MacKinnon and Sclater Roads, constructed in 1890 and 1894, respectively.

The first stage in the development of modern roads in Kenya can be said, started with the construction of MacKinnon and Sclater Roads and continued up to 1920. This is the period when major penetration lines, including MacKinnon and Sclater Roads, were constructed to link the emerging interior administrative centres such as Nairobi, Machakos, Nyeri, Kericho, Kisumu etc, and areas of white settlement. Stage two started from 1920 to about 1940, when several lines of interconnection tied together the newly white settled districts of Trans Nzoia, Laikipia and Nanyuki with the old ones, and others built to connect the established administrative centres with one another. The third stage which represented the emergence of high priority linkages began after 1940. The bitumenisation of the Nairobi - Nakuru Road and Nairobi - Thika Road in the 1940's were major programmes which represented the emergence of high priority linkages. The stage is not yet completed. Some major bitumenisation programmes on high priority linkages have so far been completed, others are still in progress. The three stages seem to

fit reasonably well with Phases Two, Three and Four of the Taaffe model. The first Phase in their model refers to the development of ports and as such cannot be considered as the first stage in the development of the Kenya road network system. Throughout all these three stages, the major motives for the construction of roads were the need to establish the British administration, to link areas of white settlement, military operations, to link areas of mineral deposits and areas of high population concentration.

The distribution of the Kenya road network system shows that closer network densities are concentrated in Western Kenya, central and at the coast, round which concentric zones of high, medium and low density surfaces are defined (Figure 4.4). Thus a belt running from north-west to south-east, representing about one-quarter of the total area of the country can be described as high and medium in the distribution of road densities. The remaining three-quarters of the country, mainly to the north and east is characterised by extreme low density levels. The road density surface demonstrates clearly the co-variant nature of the patterns of road network distribution and the distributions of other aspects of socio-economic development of the country. A statistical analysis relating the index of road network development to the indices of population, agricultural development and the areas of the administrative units, showed that population and land area are the most significant factors explaining the variations in the distribution of road networks.

E NOTES AND REFERENCES

1. NOTES

1. Much of the account of the conditions and the distribution of roads in Kenya before 1920 is given in a book entitled, "A Handbook of Kenya Colony and Protectorate", published in 1920 or thereabout, by His Majesty's Stationery Office, London.

2. For the purpose of consistency, we shall be using hereafter the current names of the countries neighbouring and including Kenya instead of the colonial names. Other words and names such as 'Natives' are replaced by Africans etc.

3. There was a gap in the publication of the Blue Book between 1918 and 1926 when a volume was again published. It is not, therefore, possible to give specific dates for roads built between 1921 and 1926.

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CHAPTER FIVE

MOVEMENT OF PEOPLE

INTRODUCTION

A.

Before going into the details of the analysis of the inter-district and inter-provincial flows of passengers, the methods and objectives pursued in studying transportation, both as a speciality and as a part of human and/or economic geography will be examined briefly. Three major methods of studying transport geography may be noted, emphasising respectively: (1) the means of transport such as vehicles used, (2) the routes followed by the various means of transport and the resulting spatial patterns, and (3) the people or types of goods carried. An important objective is to describe the nature of transportation as a feature of the earth's surface and explain why it occurs in a given place, time and manner (Thomas, 1956). All the three methods do this. However, in moving towards the common goal of description, analysis and explanation, it should be noted that studies focused on the means of transportation stress how and why; those focused on routes and patterns stress where and why, and those devoted to the understanding of the nature and patterns of traffic carried stress what and why people and goods are transported.

Chapter Four of this work was devoted to the second approach. In this Chapter, the third method of studying what is transported where, how much, and why is going to be the main focus of analysis. This chapter deals with the analysis of the movement of people, the next chapter deals with the movement of commodities.

The question of how much moves where and why, in other words, the flow of people or goods in terms of volume and direction is one of the major concerns in the analysis of movement patterns (Leinbach, 1976, pp. 179). Attempts to find answers to this question have highlighted some fundamental principles and concepts which have provided useful bases for modelling flows and understanding movement behaviour and in the final analysis, total human spatial organisation. It was Edward Ullman (1956) in his three-factor typological approach to the explanation of movement who summarised the bases for movement into three concepts; complementarity, intervening opportunity and transferability. The three concepts have provided building blocks for the search for the answers to the question of why linkages and flows between some centres are stronger than between some other centres. The concepts, however, have some limitations.

In this chapter, an attempt will be made to describe, analyse, and explain the spatial patterns of the inter-district and provincial passenger flows using the Kenya National Origin-Destination Traffic Survey data for March 1983. To accomplish this task, cartographic analysis will be employed to illustrate the spatial patterns of the flow matrix, using the method of dominant flow analysis to identify a set of locally large flows to be examined for the presence of hierarchical structure and relationships. The identified factors giving rise to such flow patterns will be subjected to statistical analysis using the combined gravity model formulation and regression analysis.

B. THE INTER-DISTRICT PASSENGER MOVEMENT PATTERNS

The official public passenger carriers by road in Kenya are 'matatus' and buses, but the private car also carries a considerable number of people on the public roads. According to the survey data, matatus led the other modes of passenger transport in terms of the number of passengers carried (Table 5.1), though marginally compared to the share of commercial buses. This finding contrasts sharply with the findings of the National Origin-Destination Traffic Survey carried out in 1976 (Republic of Kenya, 1978). According to this survey, the overall picture was that matatus carried 6.6 per cent, private cars 16.8 and buses 45 per cent of all trips per day. The remaining 31.6 per cent was carried by light goods vehicles tour vans and taxis. This observation may not be surprising in view of the fact that there has been a considerable increase in the number of matatus on the Kenyan roads since the Presidential Decree of 1973. In fact, there are some routes where the commercial buses have been put out of business because of stiff competitions waged by the matatus. It may be suggested that matatus have taken the lead as public means of transport from the commercial buses because of the free entry into the operation of matatu business, while the operation of the commercial

TABLE 5.1: DISTRIBUTION OF PASSENGERS MOVEMENT BY PUBLIC CARRIERS, 1983.

PUBLIC CARRIER	NO. OF PASSENGERS	% CARRIED
PASSENGER CARS	18,429	16.8
MATATUS	46,872	42.6
BUSES	44,583	40.6
TOTAL	109,884	100.0

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

buses is restricted by licensing and route allocation formalities and processes. Moreover, the costs of buying and operating buses have gone up considerably over the years since the inflationary spiral set in, in the early 1970's. Furthermore, matatus are more versatile means of travel on the gravel and earth roads of the rural areas, as they stop and pick passengers anywhere and move from door to door searching for passengers.

1. <u>THE MOVEMENT POTENTIAL MAP OF KENYA</u>

Before going into the analytical details of the inter-district pattern of passenger flows, an attempt will be made to have a brief look at the expected pattern of people's movement as it would appear on the basis of the potential model formulation (Taylor, 1976, pp. 9 - 1) represented in the form of a population potential map of Kenya. The purpose of this exercise is to find out if there is any correspondence between the potential map and the maps of actual flows (Figures 5.2 and 5.3) to be discussed in a later section of the chapter.

The potential at a point may be thought of as a measure of the aggregate accessibility of a point to all other points in a region (Abler, et al., 1972, pp. 216). In symbolic form it can be expressed as:

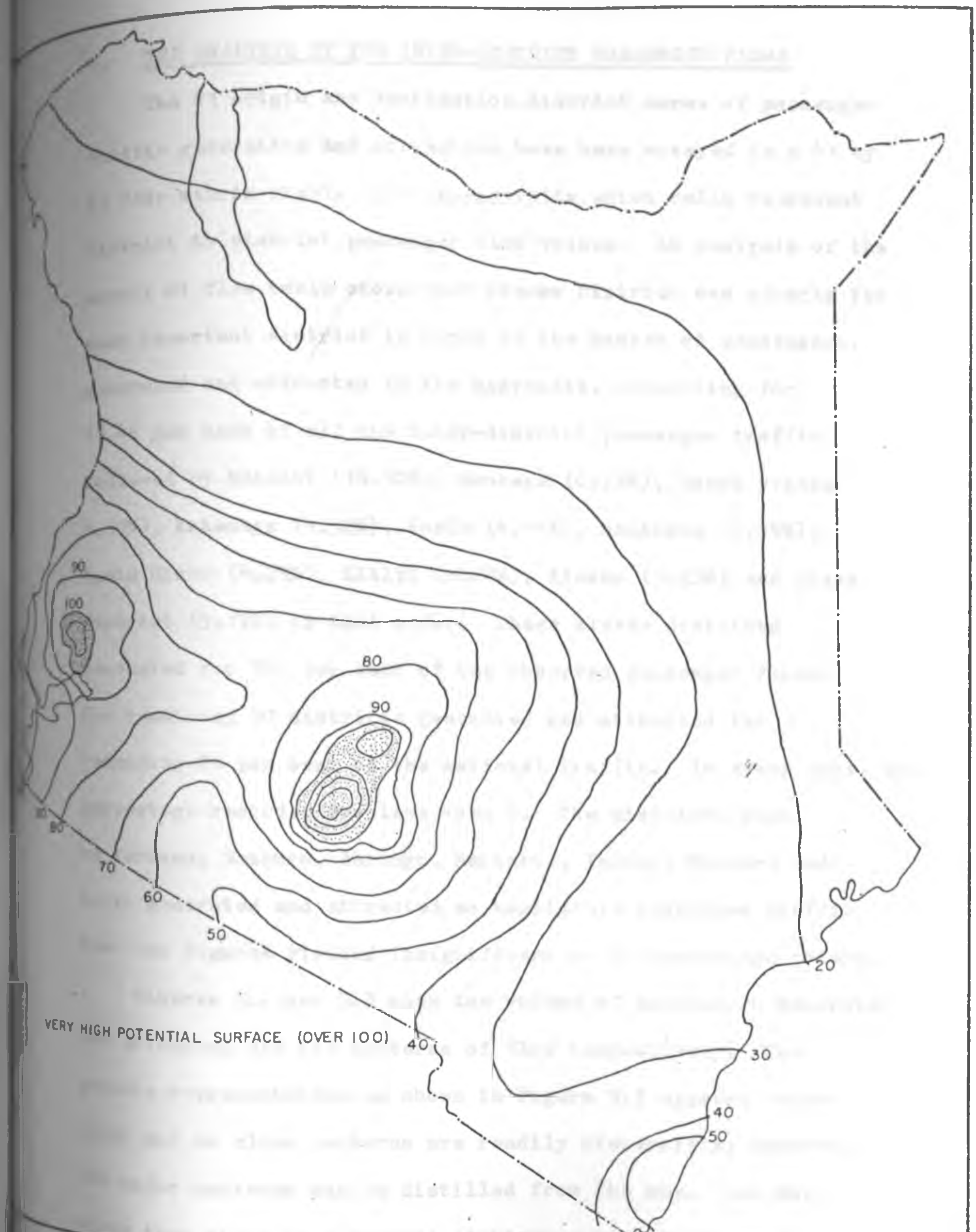
$$V_i = \sum_{j=1}^{n} \frac{M_j}{d_{ij}}$$

where, V_i = the total potential at i

M_j = the size of another place in the region

d_{ij} = the distance separating i from j

Thus, V_i is a summation of the effects of all the n places on place i including the effect of i on itself. When applied to population as the size of places, potential is a measure of the nearness of people to one another in the aggregate and measures the relative position of each place with respect to all other places in the region. Figure 5.1 is an isarithmic map of movement potential. One would expect places with high potentials for movement, to correspond closely with those places with high actual movements. In other words, regions appearing high on the potential map surface such as Central Kenya and Western Kenya should also appear high on the actual movement maps. The similarities and differences will be examined after the analysis of the inter-district passenger flow patterns.

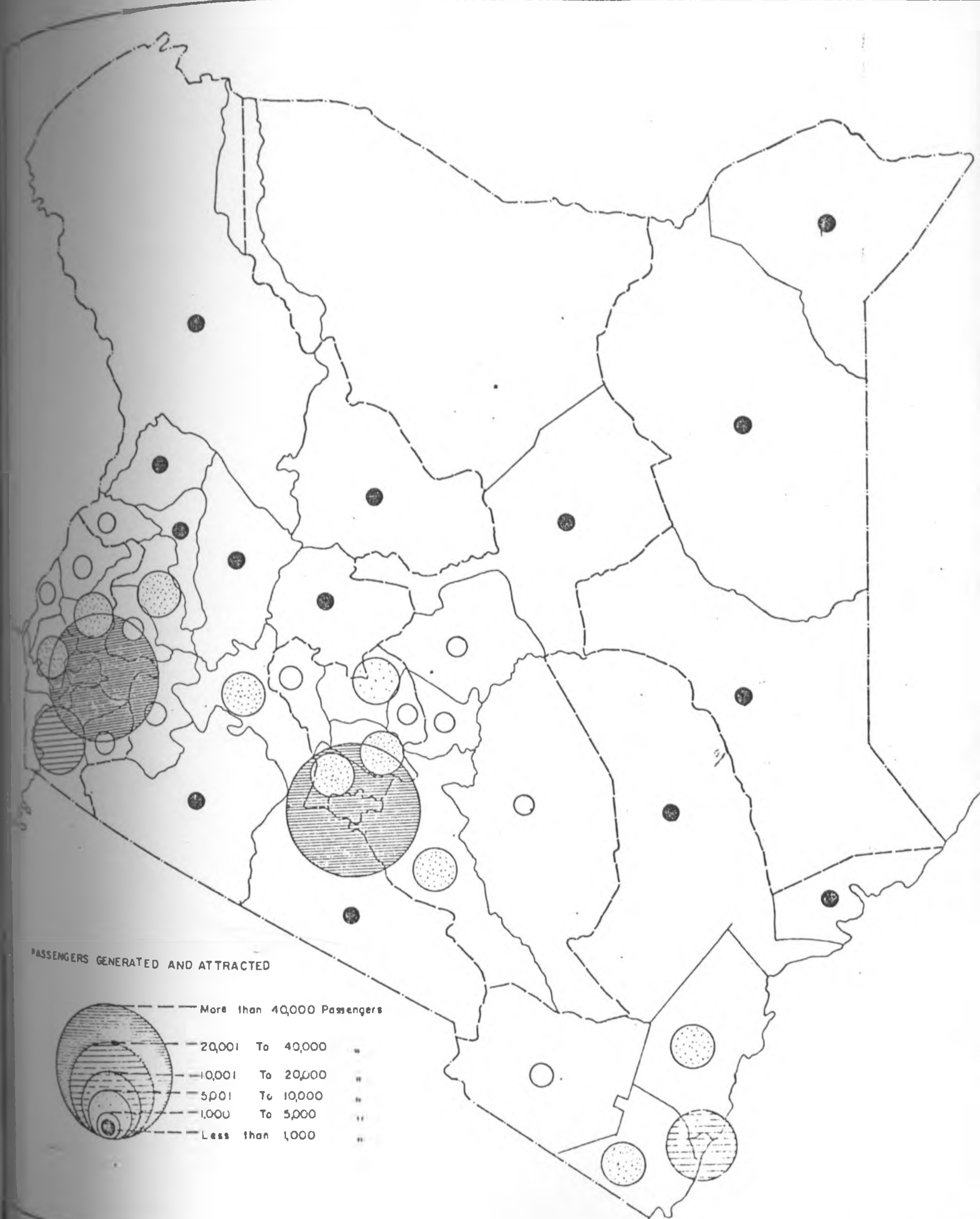


POPULATION POTENTIAL MAP OF KENYA

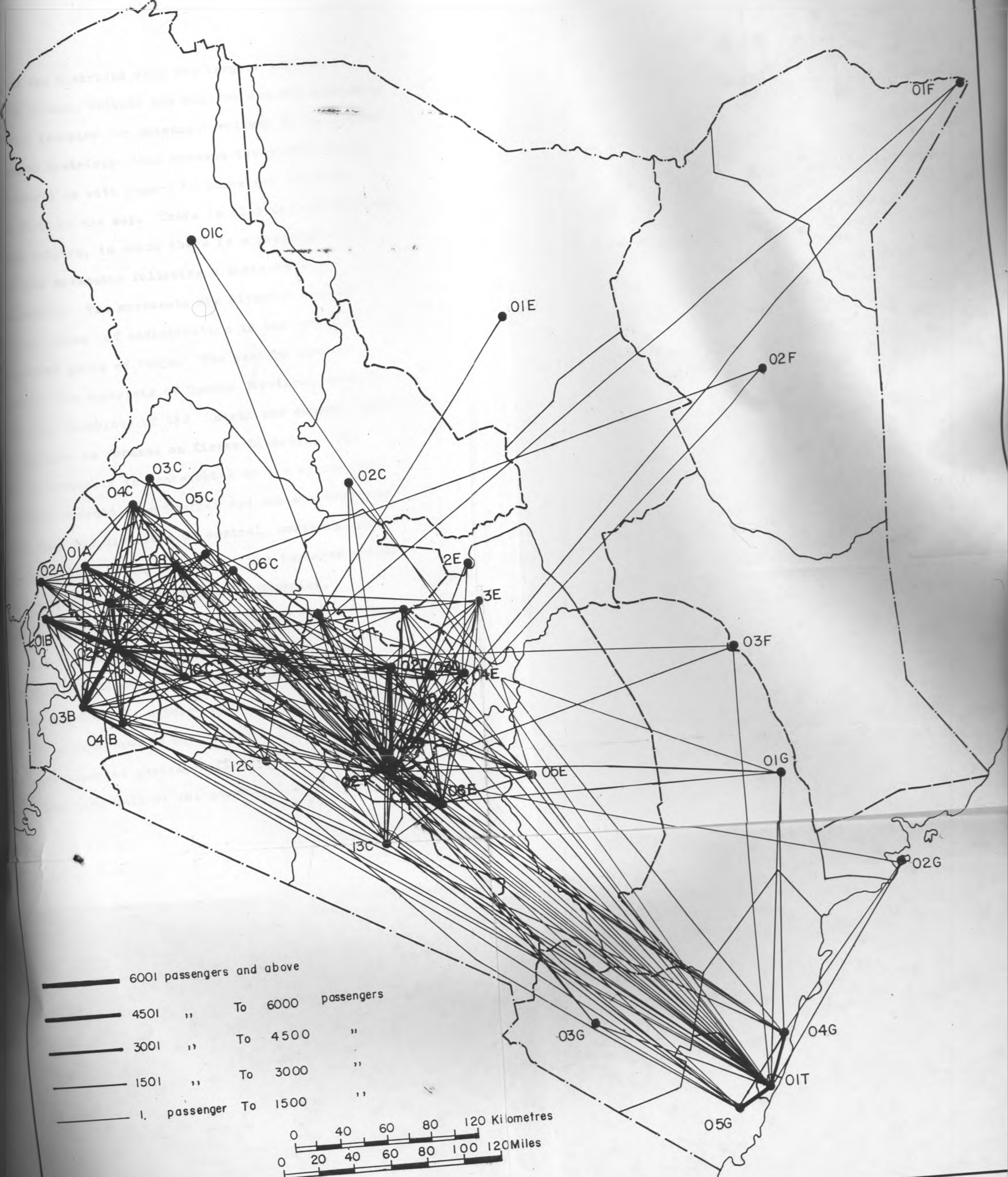
2. THE ANALYSIS OF THE INTER-DISTRICT PASSENGER FLOWS

The 41 origin and destination district zones of passenger traffic generation and attraction have been arrayed in a 41 by 41 flow matrix (Table 5.10 Appendix3)in which cells represent district to district passenger flow values. An analysis of the matrix of flow table shows that Kisumu District was clearly the most important district in terms of the number of passengers, generated and attracted in the aggregate, accounting for 18.46 per cent of all the inter-district passenger traffic followed by Nairobi (18.40%), Mombasa (6.22%), South Nyanza 4.67%), Kakamega (4.52%), Kwale (4.43%), Machakos (4.34%), Uasin Gishu (4.29%), Kilifi (4.28%), Kiambu (3.22%) and Siaya District (3.17%) in that order. These eleven districts accounted for 76. per cent of the observed passenger flows. The remaining 30 districts generated and attracted the remaining 24 per cent of the national traffic. In every case, the percentage recorded was less than 3. The districts such as Turkana, Samburu, Baringo, Marsabit, Isiolo, Mandera and Wajir generated and attracted so negligible passenger traffic that the figures yielded insignificant or no percentage points.

Figures 5.2 and 5.3 show the volume of passengers generate and attracted and the patterns of flow respectively. The graphic representation as shown in Figure 5.3 appears rather noisy and no clear patterns are readily discernible; however, two major patterns can be distilled from the map. The map shows that there is a general distance - biased movement



TOTAL NUMBER OF PASSENGERS GENERATED AND ATTRACTED IN THE FLOW SYSTEM



THE INTER-DISTRICT PASSENGERS FLOW MAP

pattern between the districts with the largest volumes of movement such as Kisumu, Nairobi and Mombasa and the adjoining districts, with a tendency for passenger volumes to be greater between the nearby districts than between the distant ones. This is particularly so with regard to passenger flows of over 6,000 as shown on the map. There is also the directional-biased movement pattern, in which there is a geographical configuration with movements following a north-west to south-east direction. The movements are directed towards three centripetal zones of concentration in the western, central and coastal parts of Kenya. The western zone of movements between the districts of Nyanza Province, Western Province, and some districts of the north and central parts of Rift Valley Province is focused on Kisumu District. The central zone of movements is represented by the orientation of movements towards Nairobi from Central and Eastern Province Districts and from the districts of central, northern and southern parts of Rift Valley Province. The isolated coastal zone has its movements focused on Mombasa District.

As can be seen from Table 5.2 over 50 per cent of the passengers travelled over distances ranging from 0 - 100 kilometres. The 100 kilometre - limit may be said, on average, to be the maximum distance between most of the neighbouring district headquarters, and as such defines a zone within which the inter-district passenger flows are of highest intensity. Less than half of the passengers travelled over distances of more than 100 kilometres. Table 5.3 also shows

TABLE 5.2 DISTANCES TRAVELLED, BY PASSENGERS

DISTANCE BAND IN KM	PERCENTAGE TRAVELLING
0 - 100	55.1
101 - 200	32.8
201 - 300	3.3
301 - 400	4.8
401 - 500	3.0
501 - 600	0.4
601 - 700	0.1
701 - 800	0.0
801 - 900	0.4
OVER 900	0.1

Source: Summary from Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

some correspondence between the population sizes of the districts and the number of passengers generated and attracted, although the correspondence does not appear to be as close as that for distance and the number of passengers that travelled within the specified distance bands. However, the table demonstrates that there is some association between the population sizes of the districts and the volume of passengers that were generated and attracted. Districts with more than 400,000 people accounted for about three quarters of the total volume of the inter-district passenger flows, and these were 16 out of the 41 districts.

TABLE 5.3: DISTRICT POPULATION BANDS AND PERCENTAGE OF PASSENGERS GENERATED AND ATTRACTED

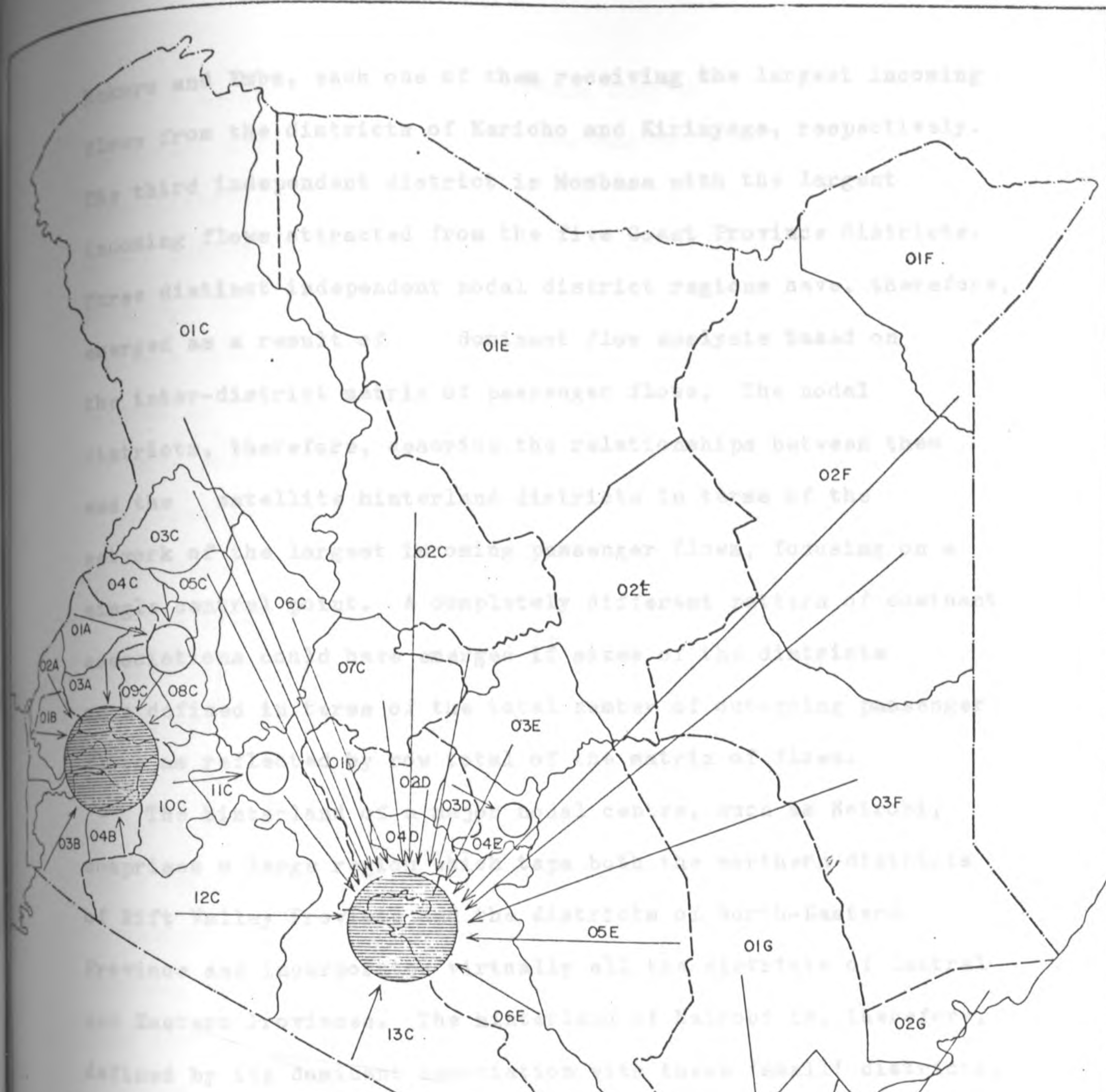
DISTRICTS WITH POPULATIONS OF	PERCENTAGE PASSENGERS GENERATED AND ATTRACTED	NUMBER OF DISTRICTS
MORE THAN 700,000	33.6	6
600,000 - 700,000	6.8	3
500,000 - 600,000	5.6	2
400,000 - 500,000	28.3	5
300,000 - 400,000	10.5	2
200,000 - 300,000	12.9	9
100,000 - 200,000	1.9	9
LESS THAN 100,000	0.4	5
TOTAL	100.0	41

Source: Summary from the Kenya National O/D Traffic Survey File, March, 1983.

If the two maps Figures 5.2 and 5.3 are superimposed upon each other and compared to the movement potential map,(Figure 5.1), the fit is reasonably close in every respect. The only slight difference occurs in the coastal zone of traffic movement. The potential map does not show the coastal zone as one of the areas with high potential for movement, although it forms an isolated zone of a weak potential surface. This is in contrast to the actual high movements as revealed by the two maps.

In order to extract a more revealing pattern of dominant and subordinate flows within the framework of the matrix of flows we turn to dominant flow analysis (Nystuen and Dacey, 1961). The dominant flow analysis is used as a basis for deriving and isolating nodal regions. While this method was used by Nystuen and Dacey to identify nodal city regions using inter-city telephone calls, the technique is quite general and may be adapted to many types of phenomena. The inter-district flows of passenger is suitable for this type of analysis when the flows are viewed as relationships that link the districts as objects that can be mapped using the district headquarters as the nodal centres from where flows converge or diverge. In the case of our analysis the districts are conceptualised as functional regions in the network of passenger flows, giving rise to multi-dimensional associations among them.

The results of the dominant flow analysis have been mapped (Figure 5.4) and the dominant nodal districts have been identified. Kisumu and Nairobi Districts stand out clearly as the most dominant nodal regions as identified by the largest incoming passenger flows, followed by Mombasa as an independent nodal district. Kisumu has one satellite nodal district based on Uasin Gishu, which in turn dominates the districts of Bungoma and Trans - Nzoia. Nairobi has two satellite nodal districts based on



MAP OF DOMINANT PASSENGER FLOWS

Nakuru and Embu, each one of them receiving the largest incoming flows from the districts of Kerioho and Kirinyaga, respectively. The third independent district is Mombasa with the largest incoming flows attracted from the five Coast Province districts. Three distinct independent nodal district regions have, therefore, emerged as a result of dominant flow analysis based on the inter-district matrix of passenger flows. The nodal districts, therefore, describe the relationships between them and the satellite hinterland districts in terms of the network of the largest incoming passenger flows, focusing on a single central point. A completely different pattern of dominant associations could have emerged if sizes of the districts were defined in terms of the total number of out-going passenger flows as reflected by row total of the matrix of flows.

The hinterland of a major nodal centre, such as Nairobi, comprises a large region which taps both the northern districts of Rift Valley Province and the districts of North-Eastern Province and incorporates virtually all the districts of Central and Eastern Provinces. The hinterland of Nairobi is, therefore, defined by its dominant association with these 'small' districts, where small is defined in terms of the sizes of the totals of their incoming flows. Some of these districts, in turn, are the focus of association from other smaller districts within their vicinity, for example, Kericho and Kirinyaga Districts may be said are connected to Nairobi via the intermediate districts of Nakuru and Embu respectively. In this way, the regions are nested together in a hierarchical order with large centres having a larger number of connections than do small ones. Both the direct and indirect associations can be important in these inter-district passenger flow networks. In terms of the direct connections such as between Nairobi and Nakuru, for example, a bus at Nakuru may receive passengers directly from a matatu from Kericho bound for Nakuru and carry them to Nairobi as their final destination. In the same way, the outbound passengers from Nairobi may proceed down the ranks to intermediary levels rather than directly to every point in the region.

The identification of the three nodal districts also corresponds reasonably well with the locations of the high peaks in the movement potential map (Figure 5.1). Some interesting patterns emerge, particularly in the orientation of some of the districts' largest out-going flows. These patterns call for a further examination of some nodal associations, with respect to unexpected orientations of the largest out-going flows. Bungoma, Uasin Gishu and Kirinyaga Districts are cases which need examination, though briefly.

One would expected Bungoma District on the grounds of physical proximity and ethnicity, to send its largest flow of passengers to Kakamega District. Kakamega District, with Kakamega town as the administrative headquarters of Western Province, should have attracted the largest number of passengers from Bungoma instead of Uasin Gishu District in Rift Valley Province. This anomaly could be explained in terms of the much more direct and convenient link afforded by the Eldoret - Bungoma - Malaba Road with Uasin Gishu District than the Kisumu - Kakamega - Webuye Road provides. But a much more logical explanation seems to be the new industrial and commercial developments taking place in Uasin Gishu District, particularly in Eldoret. These industrial and commercial outlets apparently offer alternative sources of goods and services for the people of Bungoma District in preference to those sources based in Kisumu or Kakamega town. Kakamega town, to a large extent, is basically an administrative headquarters for Western Province, and as far as the commercial life in the Province is concerned, offers a range of goods and services which are in no way superior to those that should be found in Bungoma or Webuye town. Moreover, the establishment of Luhya settlement schemes close to Uasin Gishu District may have brought the people of Bungoma and Uasin Gishu Districts much closer to one another than they feel they are to their ethnic brothers to the south. The conterminous districts have, historically, had common borders for many years during colonial administration in Kenya, and for that reason the people of Bungoma District may find Uasin Gishu District the most convenient gateway to the districts in the Central Rift Valley and beyond.

Analysis of the data also shows that the interaction between Kakamega and Busia Districts is also very weak as compared to the two districts' connections with Kisumu District. Kisumu town has been the main commercial outlet for Western Kenya and a long standing administrative headquarters until fairly recently. To date, some provincial administrations in Western Province are still commanded from Kisumu. The orientation of the movement of people from Busia to Kisumu has historical connections. Much of the district's population in the south has had cultural and administrative connections with the people of Kisumu District and town during the colonial days. It was not until the 1961 district boundary changes that the southern parts of the present Busia District became part of the administration of the present Western Province. Perhaps historical events of the past which have shaped intra-ethnic relationships among the Baluhya people could be looked into to give further insights into the comparatively low levels of interaction between the districts of Western Province. This could be an area for historical research.

Another interesting case is the orientation of Uasin Gishu District, movement-wise, to Kisumu. We would expect Uasin Gishu District to send its largest out-going passengers to Nákuru as the headquarters of Rift Valley Province. Nakuru town in the heart of Rift Valley Province seems to be more of a transit town than a meeting point of several tribal groups from Nyanza Province in the west, Central Province in the east and for the people of southern and northern districts of Rift Valley Province as claimed by Hickman and Dickens (1960) twenty five years ago. Moreover, according to the movement data, the district appears to be more of a Central Province district than a district that houses the headquarters of Rift Valley

Province. Rather than being a satellite of Nairobi in common with the Central Province districts, one would expect Nakuru town to create a centripetal force for movements within the Province. The reasons for lack of such a force cannot be far fetched. With the industrial, commercial and social developments in Rift Valley Province shifting towards Eldoret in Uasin Gishu District, it is not surprising to note that the focus of movements and activities has swung towards Eldoret. This may well sound economic, social and political death knell for Nakuru.

The orientation of all the districts in Central Province and most of the districts in Eastern Province, except Kirinyaga District towards Nairobi is something to be expected. The deviant case of Kirinyaga District can be explained, if not fully, by its administrative connections with Embu District. Much of the eastern parts of Kirinyaga District was part of Embu District until the district boundary changes in 1961. It is not surprising, therefore, that the people in Kirinyaga District should still nurture sentimental attachments to their brothers in Embu District, may be for social, economic or political reasons. The District of Kirinyaga sent its largest flow of passengers to Embu District, contrary to our logical expectations of closer contacts with any of the Central Province districts or Nairobi. Experience seems to suggest that the two largest clans of Kirinyaga District, the Ndia and Gichugu get along better with the people of Embu District than they do with the more politically and commercially aggressive Kikuyus of the nearby Muranga and Nyeri Districts.

C. THE INTER-PROVINCIAL PASSENGER MOVEMENT PATTERNS

The dominant flow analysis of the inter-district passenger flow data identified two types of district nodal regions, the independent and satellite nodal regions (Figure 5.4). In this section our analysis is going to be focused on the O/D data aggregated at the provincial level of observation. This analysis will attempt to assess and evaluate the volume and directions of the flows with reference to provincial origins and destinations. The relative contribution of the districts as sources of the provincial streams of out-going passengers will be examined in perspective and dominant flow associations at the provincial level will also be identified, but not mapped.

Table 5.4 is a matrix of the inter-provincial flows of passengers. The significance and predominance of three of the eight provinces in terms of the volume of passengers attracted is clearly shown in the table. There is a major contrast between the Provinces of Nyanza, Nairobi, Coast and the remaining five provinces. The largest share of the attracted passenger flows went to Nyanza (27.57%), followed by Nairobi (18.11%) and Coast (16.17%) Provinces in that order. The remaining 38.15 per cent were attracted to Rift Valley (11.34%), Central (10.27%) Eastern (8.44%), Western 8.00%) and North - Eastern Province a mere 0.06 per cent. This contrast

DESTINATION / ORIGIN	WESTERN	NYANZA	RIFT VALLEY	CENTRAL	EASTERN	NORTH EASTERN	COAST	NAIROBI	TOTAL ORIGIN	PERCENT ORIGIN
WESTERN	2166	3983	1488	9	-	7	-	222	7875	7.16
NYANZA	3583	20,785	3557	139	3	-	276	1839	30,182	27.46
RIFT VALLEY	2208	4341	4214	88	58	1	74	3407	14,391	13.09
CENTRAL	22	11	82	2063	1646	-	149	6433	10,406	9.46
EASTERN	15	9	24	1686	107	-	62	7043	8,946	8.14
NORTH EASTERN	-	-	2	-	-	-	92	125	219	0.20
COAST	5	164	92	17	154	58	16,159	678	17,327	15.76
NAIROBI	797	1009	3008	7289	7315	2	964	154	20,538	18.69
TOTAL DESTINATION	8796	30,302	12,467	11,291	9,283	68	17,776	19,901	109,884	100
PERCENTAGE DESTINATION	8.00	27.57	11.34	10.27	8.44	0.06	16.17	18.11	100	

The Underlined figures show the largest out-going flows from each Province

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

emphasises the relative importance of the locations of the independent district nodal regions identified by dominant flow analysis. The cell values in Table 5.4 show the number of passengers attracted to each province including the number of passengers generated and attracted to itself and Table 5.5 shows the percentage shares.

1 PASSENGERS ATTRACTED TO NYANZA PROVINCE

Nyanza Province clearly emerged as the leading destination for the provincial streams of passengers. Some detailed analysis of the sources of these streams of passengers should be of some considerable assistance to the understanding of the patterns of flow and the underlying relevant factors.

The provincial sources of the Nyanza incoming passengers were dominated by Nyanza itself accounting for 68.59%, followed by Rift Valley (14.32%), Western Province (13.14%), and Nairobi (3.33%). The rest of the provinces contributed negligible numbers and in all cases less than one per cent. From Rift Valley, the majority of the passengers came from Uasin Gishu District (36.94%), followed by Trans - Nzoia (22.59%), Nandi (21.39%), Kericho (10.56%) and Nakuru (3.59%). The rest of the districts sent less than 2 per cent each to Nyanza Province. From Western Province, the majority of the passengers came from Kakamega District (66.85%), followed by Busia (25.94%) and Bungoma (7.21%). Passengers from Nairobi Province showed preference for Kisumu District (54.90%), South Nyanza (40.14%), Kisii (3.57%) and Siaya District (1.39%). The distribution of

TABLE 5.5 PERCENTAGE OF PASSENGERS ATTRACTED TO EACH PROVINCE, MARCH, 1983

DESTINATION / ORIGIN	WESTERN	NYANZA	RIFT VALLEY	CENTRAL	EASTERN	NORTH EASTERN	COAST	NAIROBI
WESTERN	24.62	13.14	11.94	0.08	-	10.29	-	1.12
NYANZA	40.73	68.59	28.53	1.23	0.03	-	1.55	9.24
RIFT VALLEY	25.10	14.32	33.80	0.78	0.62	1.47	0.42	17.12
CENTRAL	0.25	0.04	0.66	18.27	17.73	-	0.84	32.33
EASTERN	0.17	0.03	0.19	14.93	1.15	-	0.35	35.39
NORTH-EASTERN	-	-	0.02	-	-	-	0.52	0.63
COAST	0.06	0.54	0.74	0.15	1.66	85.29	90.90	3.41
NAIROBI	9.06	3.33	24.13	64.55	78.80	2.94	5.42	0.77
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

passengers generated within the province emphasises the importance of Kisumu District (56.40%), followed by South Nyanza (19.7%), Siaya (18.5%) and Kisii District (5.4%). Nyanza Province attracted passenger mainly within the province itself, the balance came from the populated districs of the adjoining provinces and from Nairobi Province.

2 PASSENGERS ATTRACTED TO NAIROBI PROVINCE

Nairobi is the second most important province in terms of passengers attracted from provincial sources. Of a total of 19,901 passengers that were destined for Nairobi, 35.39 per cent came from Eastern Province, 32.33 per cent from Central, 17.12 per cent from Rift Valley, 9.24 per cent from Nyanza, 3.41 per cent from Coast and 1.12 per cent from Western Province. Nairobi itself generated and attracted only 0.77 per cent of its own passengers. This is understandable, given the fact that Nairobi has its own internal passenger transport service. From the Eastern Province source, Machakos District had the largest share (54.08%), followed by Embu (20.66%), Kitui (17.62%) and Meru District (7.26%). Marsabit and Isiolo contributed very little to the Eastern Province stream of passengers to Nairobi. The Central Province source was dominated by Nyeri (33.69%) and Muranga (32.63%), followed by Kiambu (18.11%), Nyandarua (8.75%) and Kirinyaga (6.82%). Nakuru District was clearly the most important source of passengers from Rift Valley Province, contributing 47.29 per cent of the Rift Valley Stream.

The other important contributors were the Districts of Trans-Nzoia (9.48%), Elgeyo Marakwet (8.51%), Narok (8.04), Kajiado (6.84%), Laikipia (5.96%), and West Pokot, 5.11 per cent. The remaining districts contributed less than 5 per cent each to Nairobi. From the Provinces of Nyanza, Coast and Western the main sources of passengers to Nairobi were, Kisumu District (71.13%), South Nyanza (21.20%), Mombasa(86.14%), Busia (56.8%) and Kakamega District 43.2 per cent from their respective provinces. Once again, proximity to the source provinces, jointly with population sizes of the provincial districts seem to be the most important variables determining the volume of passenger flows from the provincial source districts to the destinations.

3. PASSENGERS ATTRACTED TO COAST PROVINCE

Coast Province itself was by far the most important generator and attractor of its own passengers accounting for 90.90 per cent of the national stream of passengers destined for the province. This emphasises the isolated position of the province in relation to other provinces and the importance of the frictional effect of distance on the propensity for interaction with distant Provinces. The second most important source was Nairobi Province (5.42%), followed by Nyanza Province (1.55%). Contributions from the rest of the provinces were very insignificant and in each case, less than 1 per cent. Of the Nairobi's 964 passengers to the Coast Province, 79.88 per cent went to Mombasa District, 14.42 per cent to Taita/Taveta and 2.90, 2.18 per cent were destined for Kwale and

Kilifi Districts, respectively. Tana River and Lamu Districts attracted negligible numbers of passengers from Nairobi. From Nyanza Province to the Coast only South Nyanza and Siaya Districts had sizeable contributions to the provincial stream to Coast Province. Within Coast Province, Kwale District was evidently the most important generator of the internal passenger traffic accounting for 36.22 per cent. Kilifi generated 31.36 and Mombasa 26.85 per cent. Taita/Taveta, Lamu and Tana River Districts generated 3.54, 1.16 and 0.88 per cent, respectively.

4. PASSENGERS ATTRACTED TO RIFT VALLEY PROVINCE

The major provincial sources of passengers attracted to Rift Valley Province were Rift Valley itself (33.80%), followed by Nyanza (28.53%), Nairobi (24.13%) and Western Province (11.94%). Central, Eastern, Coast and North-Eastern Provinces sent less than 1 per cent each to Rift Valley. The major district sources of the Nyanza out-going passengers to Rift Valley were Kisumu (91.14%), followed by South Nyanza (6.52%), Kisii (1.72%) and Siaya District sent only 0.62 per cent. The Nairobi stream went mainly to Nakuru (52.69%), Trans - Nzoia (15.93%), Kajiado (14.35%), Uasin Gishu (5.16%), Narok (4.05%) and to West Pokot (2.65%). The other districts attracted insignificant numbers of passengers from Nairobi. Bungoma District (49.7%), dominated the Western Province source of passengers to Rift Valley, followed by Kakamega (40.6%) and Busia District (9.7%). Within the province, Uasin Gishu District generated 36.37 per cent, followed by Trans Nzoia (25.98%), Nakuru (21.46%), Kericho (13.23%), Narok (1.28%) and Baringo District (1.05%). Each of the remaining districts generated less than 1 per cent of the internal traffic. Moreover, the Districts of Turkana and Samburu interacted with none of the thirteen districts of the province, not even between themselves.

5. PASSENGERS ATTRACTED TO CENTRAL PROVINCE

Nairobi Province (64.55%), Central Province itself (18.27%) and Eastern Province (14.93%) were the chief generators of passenger traffic to the Province. Apparently because of the overwhelming forces of the nearby Nairobi Province, the Province attracted very little passenger traffic from the other five provinces. Nyanza Province sent only 1.23 per cent, while Rift Valley sent 0.78, Coast 0.15, Western 0.08 per cent and North-Eastern Province sent practically no passengers. The major destination districts for the Nairobi stream of passengers were the districts of Nyeri (32.16%) and Muranga (31.40%); Kiambu, Nyandarua and Kirinyaga Districts attracted 16.63, 15.74 and 4.07 per cent, respectively. In Eastern Province, the greatest contributions came from the districts of Embu (49.70%) and Machakos (47.33%). The districts of Marsabit, Meru and Kitui were least attracted to Central Province, while Isiolo District generated no traffic at all. With regard to the internal generation of passengers, Kiambu District took the lead

(74.12%), while the districts of Muranga, Kirinyaga, Nyeri and Nyandarua accounted for 18.66, 4.17, 2.81 and 0.24 per cent, respectively.

6. PASSENGERS ATTRACTED TO EASTERN PROVINCE

Eastern Province drew the majority of its incoming passengers mainly from Nairobi (78.80%) and Central Province (17.73%). The contributions from the Province itself and from the rest of the provinces were insignificant. Moreover, Western and North-Eastern Provinces sent no passengers to the Province. Much of the Nairobi traffic went to Machakos District (56.12%). The rest went to Embu (18.99%), Kitui (17.39%), Meru (6.54%) and Isiolo (0.96%), while Marsabit District attracted no passengers from Nairobi. From the Central Province source, Kiambu District sent 53.40 per cent, Kirinyaga 38.88, Nyeri 5.89 and Muranga District 1.83 per cent, while Nyandarua District was not attracted to the Province. Movements of passengers within the Province was dominated by Embu District (74.77%), followed by Machakos (13.08%) and Kitui (12.15%). Meru, Isiolo and Marsabit Districts did not generate any internal passenger traffic.

7. PASSENGERS ATTRACTED TO WESTERN PROVINCE

Western Province was one of the least attractive provinces in terms of passenger movements throughout the country. As would be expected, the nearby Nyanza Province was the greatest contributor (40.73%), followed by Rift Valley Province (25.10%).

The Province itself generated and attracted 24.62 per cent of its own traffic and Nairobi sent to the Province 9.06 per cent of the passengers. Contributions from the rest of the provinces were insignificantly small, with North-Eastern Province not attracted at all to the Province. The Nyanza source was dominated by Kisumu District (91.4%), a reflection of the powerful role Kisumu town has played in the economic, social and political life of the people in Western Province. South Nyanza District sent 8.28 per cent to the Province, but the contributions from Kisii and Siaya Districts were insignificant. From the Rift Valley source, Uasin Gishu District contributed most of the traffic (89.72%), followed by Nandi (4.26%), Trans-Nzoia (3.80%), Nakuru (1.77%) and Kericho (0.45%). Other districts of the Province sent no passengers to Western Province, a reflection of the attenuating effects of distance. The Nairobi stream of traffic was attracted mainly to Kakamega (41.53%) and to Busia (41.41%), while Bungoma District attracted 17.06 per cent of the passenger from Nairobi. Within the Province, Kakamega District generated 66.4 per cent of the internal provincial traffic, Bungoma 32.7 and Busia District only 0.9 per cent.

8. PASSENGERS ATTRACTED TO NORTH-EASTERN PROVINCE

As would be expected, North-Eastern Province was the least attractive from the stand point of passenger movements. Coast Province was the only major generator of the incoming passengers to the Province, accounting for 85.29 per cent. There seems to be some kind of a symbiotic relationship - a give and take relationship as it were, between North-Eastern and Coast Provinces. North-Eastern Province was number four in rank among the Provinces which sent passengers to Coast Province. A closer tie can be forged between the two Provinces in view of the fact that most of the people in the two provinces are Moslems. The other provinces which had some connections with North-Eastern Province were Western (10.29%), Nairobi (2.94%) and Rift Valley Province (1.47%). The rest of the provinces did not generate any passenger movements to North-Eastern Province. The Coast Province stream went mainly to Garissa District, and all the passengers were from Mombasa District. Similarly all passengers from Nairobi went to Garissa, and they were only 2 passengers. The 7 passengers from Western Province came from Kakamega District and they all went to Wajir. North-Eastern Province did not generate its own internal passenger traffic.

The volume and directions of the inter-provincial passenger flow, is shown in Figure 5.5. Subjecting the aggregated provincial data to dominant flow analysis, three major provincial nodes emerge. These are not shown graphically, but can be easily identified in the matrix of flow Table 5.4 by the underlined figures. Nyanza Province clearly stands out as the most dominant provincial node in the system with the largest number of passengers generated and attracted to it. Rift Valley and Western Provinces are its satellites. Nairobi Province is the second node with Central, Eastern and North-Eastern Provinces as its satellites. Its largest out-going flow of passengers was to Eastern Province. Coast Province forms an

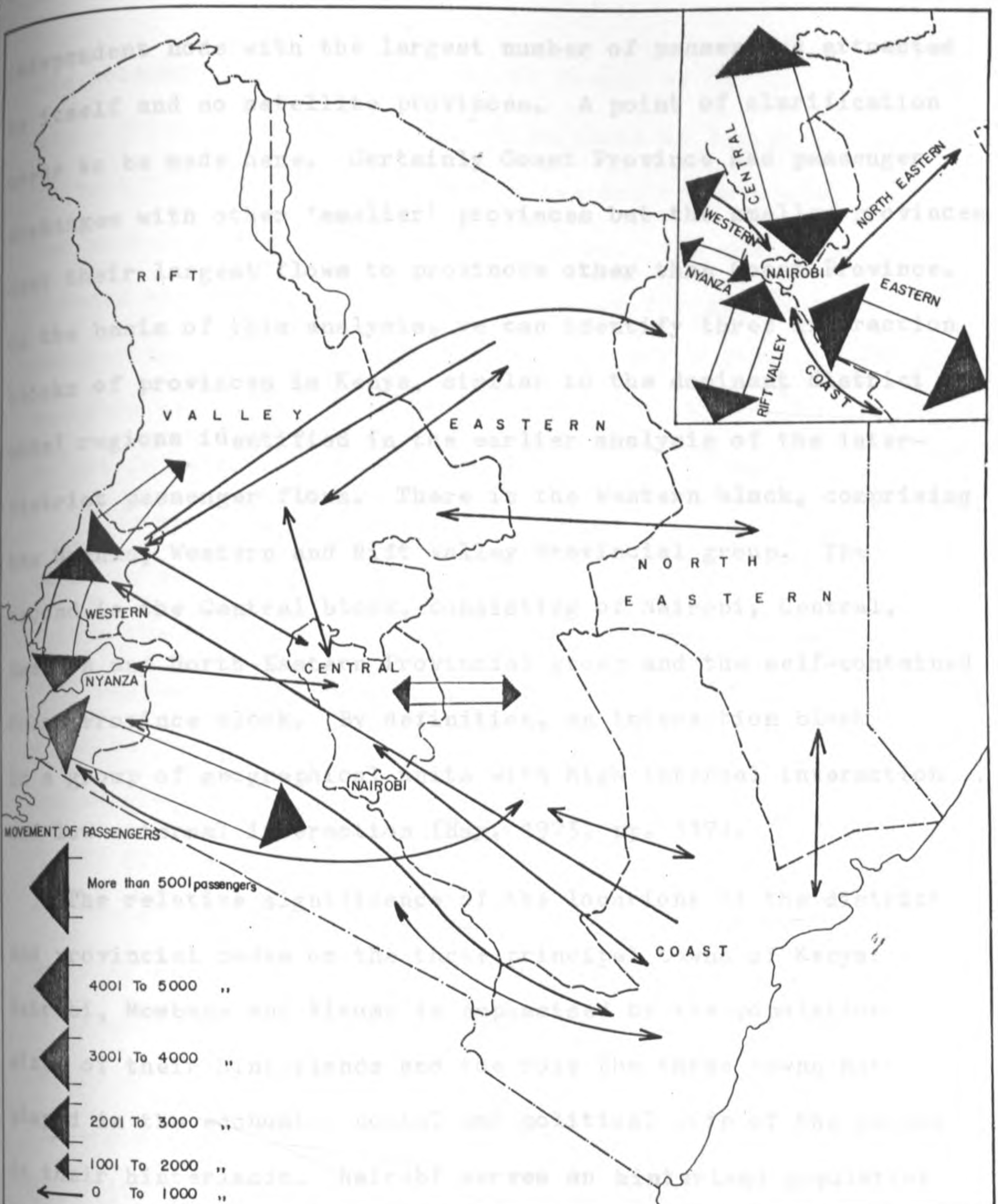


FIGURE 5.5 INTER-PROVINCIAL MOVEMENT OF PASSENGERS, MARCH, 1983

independent node with the largest number of passengers attracted to itself and no satellite provinces. A point of clarification needs to be made here. Certainly Coast Province had passenger exchanges with other 'smaller' provinces but the smaller provinces sent their largest flows to provinces other than Coast Province. On the basis of this analysis, we can identify three interaction blocks of provinces in Kenya, similar to the dominant district nodal regions identified in the earlier analysis of the inter-district passenger flows. There is the Western block, comprising the Nyanza, Western and Rift Valley Provincial group. The second is the Central block, consisting of Nairobi, Central, Eastern and North-Eastern Provincial group and the self-contained Coast Province block. By definition, an interaction block is a group of geographical units with high internal interaction and low external interaction (Hay, 1973, pp. 117).

The relative significance of the locations of the district and provincial nodes on the three principal towns of Kenya: Nairobi, Mombasa and Kisumu is emphasised by the population sizes of their hinterlands and the role the three towns have played in the economic, social and political life of the people in their hinterlands. Nairobi serves an hinterland population of about 8.4 million, Kisumu 5.6 million and Mombas 1.4 million. These hinterland populations are based on dominant flow associations in terms of passenger flows. Other analyses may identify the hinterland populations differently. Basing the argument on the population sizes of the hinterlands and the nodal linkage relationships between the hinterland districts, the economic, social and political forces of Nairobi appear to tap a fairly wider area compared to those of Kisumu and Mombasa. Nairobi, therefore, still remains the hub of economic, social and political activities in the country. The positions of Mombasa and Kisumu leave a lot of ground for speculative arguments. It is tempting to suggest, on the strength of the analysis of traffic data, that Kisumu has a more promising future in terms of growth compared to Mombasa town.

The significance of Mombasa as the chief port of Kenya seems to depend mainly on its extensive hinterland which goes beyond the boundary of Kenya and on its tourist attraction. With respect to its relations with the rest of the country, which is rather tenuous according to the passenger traffic data, the future of Mombasa and its growth seems to depend mainly on the growth and development of the five coastal satellite districts, at least at the national level. Kisumu seems to be enjoying a unique position both in Western Kenya and in relation to Uganda and Tanzania which can be reached from Kisumu by land and by water, thus making it an important commercial outlet for Western Kenya to these two neighbouring countries. The hinterland districts of Kisumu include some of the districts with the most dynamic population concentration in Kenya but also those with the highest potential for agricultural, industrial and commercial development. Kisumu only needs a simple dose of the right development capital. Other developments will automatically follow as it has the dynamism.

D MODELLING PASSENGER MOVEMENTS

The origin-destination data have been aggregated for the purpose of modelling the flows on a comprehensive basis for all the three modes of passenger movement between Nairobi and the forty districts. The purpose of modelling the flows is to establish statistically, the nature and magnitudes of the relationships between the volume of passenger flows, population and distance factors. These variables have been mentioned fairly frequently in the earlier analyses as the most important and likely determinants of the magnitude and patterns of the observed inter-district passenger movements. A third factor, vehicles generated has been incorporated into the model as a transport supply factor on the conceptual ground that the total number of vehicles generated from a given area is an indication of the volumes of passenger movement that can be generated.

The gravity model has been used as a modelling device in studies involving trip distribution (Fouracre and Sayer), 1977, pp.5-12). It has been employed in its extended form to test the hypothesis that the volume of passenger flows between Nairobi and the forty administrative district units of Kenya is directly proportional to the products of their populations and the population of Nairobi, the total number of vehicles generated from the districts and from Nairobi, and inversely proportional to the distances separating Nairobi from them. In symbolic form, the function can be represented thus:

(1) $T_{ij} = k.(P_i P_j).(V_i V_j) .d_{ij}^{-b}$, with i=1 for Nairobi

where T_{ij} = the volume of passenger flow between i and j,

P_i and P_j = the population sizes of i and j,

V_i and V_j = the total number of vehicles generated from i and j to all the districts.

d_{ij} = the intervening distance between i and j, and k and b are constants to be estimated.

The major operational problem in the formulation and testing of the gravity model lies in the empirical estimation of the two parameters, namely, k and b. In this linear form, the exponent of distance becomes a negative one. Since the purpose is to estimate the role of each independent variable in generating the volumes of passenger flow, the exponents of $(P_i P_j)$ and $(V_i V_j)$ do not have to be forced or constrained to equal 1.0. Instead, they should be left as parameters to be estimated. The exponents of the masses are, therefore, assigned letter symbols of unknown size. Thus, the general operational version of the gravity model becomes:

(2) $T_{ij} = k.(P_i P_j)^{b_1} . (V_i V_j)^{b_2} . d_{ij}^{-b_3}$, with i = 1 for Nairobi,

where k, b_1, b_2 and b_3, as explained above, are parameters to be estimated.

This extended version of the gravity model was used by Fouracre and Sayer (1977) in a study of travel characteristics of road users in Malawi. The interested reader should consult the work of Isard (1960) and Taylor (1976) to get an insight into the significance of the gravity model and to trace its historical development and its variant formulations.

There are some issues which arise in the application of the gravity model. The first issue concerns the measurements of the two independent variables: mass and distance. In empirical studies, mass has been measured in a number of ways. Since population totals can be regarded as surrogates for demand, numbers of people have been a standard measure of mass. However, depending on the exact nature of the problem under investigation, other measures such as job opportunities, per capita income, hospital beds and other alternative measures of the size of a place can also be more appropriate (Isard, 1960, pp.504-505). The second issue concerns the operational definitions and measurements of distance. In some studies of movement, a simple airline measure of distance has proved to be quite adequate. However, travel time and transport costs are at times more relevant measures than the physical distance. Other alternative measures include fuel consumption in transport, number of gear shifts, stop signs and traffic lights (Isard, 1960, pp.506).

Another basic issue relates to weights to be applied to the masses. It is reasonable to expect that, other things being equal, an area with higher per capita income will generate a larger volume of movement than an area of equal population but lower per capita income. One way to correct for such a factor is to multiply the population of each area by its average per capita income or any other possible weights (Isard, 1960, pp.507-508). The weighted modified version of the gravity model used in this chapter is of the form:

(3) $T_{ij} = k.(w_i P_i w_j P_j)^{b_1} . (V_i V_j)^{b_2} . d_{ij}^{-b_3}$,

with i = 1 for Nairobi,

where w_i and w_j are weighting parameters for the i and j districts, which are their levels of educational development as measured by the composite index. **The weight, w_i, is multiplied by P_i before working out the logarithms, and the same for district j.**

The logarithmic version of the multiple regression equation can be written as:

(4) $\log T_{ij} = a + b_1 \log (w_i P_i w_j P_j) + b_2 \log(V_i V_j) - b_3 \log d_{ij}$,

with i=1 for Nairobi, where a=log k.

The use of logarithmic transformation is a frequently applied strategy, especially in linear regression analysis in which the gravity model formulation is applied. This is because distance decay functions of human interaction are generally highly skewed, with a very large number of contacts at shorter distances. Furthermore, since interaction is the function of the product of two masses, a plot of interaction intensity with values of the product of the masses is also likely to be skewed. The resulting curves would show curvilinear relationships. If the original data are transformed to their logarithms, the relationships between the variables become linear or nearly so. For this latter reason, all the variable values used in regression analyses applying the gravity model formulations in chapters 5 and 6 of this work, have been transformed to their common logarithms. For a similar reason, the districts' areal values used in regression analysis in Chapter 4 were transformed to their common logarithms.

1. THE VARIABLES

The dependent variable, the volume of passenger flows is a combined data representing movements in both directions. The distances were measured off along the shortest routes between the districts' headquarters and Nairobi using the Kenya Route Map, Scale 1:1,000,000. The populations of the districts were taken from the recent 1979 Kenya Population Census, Volume 1, while the total number of vehicles generated from i and j to all the districts was calculated from the Kenya National 1983 Traffic Survey matrix of flow table. In the simple gravity model formulation, total population is regarded as the mass, but it is common knowledge that individuals who compose the mass make varying contributions to the interaction potential of any given area. In the light of this consideration, it was decided to assign weights to the populations of the districts. The weights assigned to the populations of the districts were the indices of levels of educational development of the districts. These indices seem to be more reflective of the average interaction propensities of the districts' populations, as a population tends to be more mobile, the more educated the members of the population are. In fact, assigning the indices of educational level as weights to the population mass has considerably improved the performance of the gravity model used in this study from R^2=0.58 with unweighted populations to R^2=0.65 with weighted popultions (Table 5.8).

2. STATISTICAL ANALYSIS AND INTERPRETATION

To establish the functional form of T_{ij}, $(w_iP_i w_jP_j)$, (V_iV_j), d_{ij} and the values of a,b_1,b_2 and b_3, multiple regression analysis was used after the data had been transformed to common logarithms (Table 5.6). But before multiple regression and correlation analyses were performed, an analysis of simple correlations among the variables was carried out to shed light on the magnitudes of the intercorrelations among the variables. The coefficients of their intercorrelation and significance levels are shown in Table 5.7. The correlation coefficients between the dependent and independent variables are in accord with the hypothesised relationships. Except for the simple correlation coefficient between population and vehicles generated, the other simple correlation coefficients between the remaining variables are not significantly very high.

In order to examine the relative contribution of each of the three independent variables to the variations in volume of passenger movements, the variables were subjected to multiple correlation and regression analyses. The multiple correlation and regression analyses yielded the values in Tables 5.8 and 5.9. The multiple regression and correlation analyses show that distance was the most important factor accounting for about 49 per cent of the explained total variance in the volume of passenger flows, while population accounted for 16 per cent

TABLE 5.6 THE RELATIONSHIPS BETWEEN VOLUME OF PASSENGERS AND POPULATION, DISTANCE AND VEHICLES GENERATED

STRICT	LOG PASSENGER VOLUME	LOG POPULATION $(W_iP_iW_jP_j)$	LOG DISTANCE (d_{ij})	LOG VEHICLES GENERATED (V_iV_j)
NGOMA	2.133	5.528	2.608	6.257
SIA	2.658	5.312	2.683	5.959
KAMEGA	2.630	5.933	2.592	6.659
AYA	1.431	5.476	2.622	6.256
SUMU	3.269	5.498	2.528	7.219
TH NYANZA	2.900	5.779	2.617	6.573
SII	2.214	5.828	2.570	6.544
RKANA	1.000	4.714	2.860	5.195
MBURU	1.342	4.477	2.562	4.581
T POKOT	2.394	4.796	2.614	4.906
ANS NZOIA	2.884	5.164	2.579	6.193
GEYO MARAKWET	2.474	4.951	2.551	4.472
RINGO	1.892	5.112	2.475	5.440
KIPIA	2.654	4.903	2.301	5.713
SIN GISHU	2.474	5.231	2.489	6.593
NDI	1.322	5.241	2.555	5.906
RICHO	2.086	5.600	2.418	6.245
KURU	3.419	5.498	2.193	6.567
OK	2.587	5.000	2.190	5.676
JIADO	2.801	4.861	1.875	5.668

BLE 5.6

THE RELATIONSHIPS BETWEEN VOLUME OF PASSENGERS AND POPULATION, DISTANCE AND VEHICLES GENERATED. (CONT'D)

ISTRICT	LOG PASSENGER VOLUME	LOG POPULATION $(w_iP_iw_jP_j)$	LOG DISTANCE (d_{ij})	LOG VEHICLES GENERATED (V_iV_j)
ANDARUA	3.232	5.146	2.292	5.664
RI	3.654	5.522	2.187	6.168
IRINYAGA	2.866	5.235	2.103	5.826
ANGA	3.642	5.676	1.924	6.493
IAMBU	3.376	5.672	1.255	6.685
ARSABIT	0.000	4.574	2.749	4.882
ISIOLO	1.986	4.264	2.454	5.025
U	2.995	5.768	2.462	5.664
BU	3.453	5.174	2.152	6.283
ITUI	3.400.	5.530	2.276	5.791
AKOS	3.898	5.873	1.806	6.743
DERA	0.477	4.555	3.001	4.741
IR	0.477	4.685	2.808	4.405
ARISSA	2.082	4.662	2.583	4.857
A RIVER	0.301	4.692	2.708	4.949
	0.602	4.336	2.923	4.906
A/TAVETA	2.301	4.903	2.580	5.727
LIFI	1.623	5.437	2.740	6.401
ALE	1.602	5.273	2.714	6.309
BASA	3.131	5.455	2.693	6.955

es: Logs passengers and vehicles generated calculated from the O/D Traffic Survey Data File, March, 1983, MOTCO.

Log population calculated from figures of Kenya population Census, 1979, Vol 1, C.B.S.

Log distance calculated from distances measured off Kenya Route Map, 1978, Survey of Kenya.

TABLE 5.7 MATRIX OF CORRELATION COEFFICIENTS BETWEEN THE FOUR VARIABLES

VARIABLE	1	2	3	4
1. PASSENGERS	1.000			
2. POPULATION	0.643	1.000		
3. DISTANCE	-0.698	-0.397	1.000	
4. VEHICLES GENERATED	0.639	0.836	-0.391	1.000

All the coefficients of correlation are significant at 5 per cent level.

TABLE 5.8 MULTIPLE COEFFICIENTS OF CORRELATION

VARIABLE	R	R^2	R^2 CHANGE
DISTANCE	0.698	0.488	0.488
POPULATION	0.804	0.647	0.159

TABLE 5.9 STEPWISE REGRESSION COEFFICIENTS

VARIABLE	b[1]	b	STANDARD ERRORS (b)	F
DISTANCE	-1.539	-0.509	0.321	23.043**
POPULATION	0.547	0.243	0.402	1.859
(CONSTANT) a	1.359		0.633	0.267

[1] Unstandardised regression coefficients used for prediction purposes.

** Significant at the 1 per cent level.

Vehicles generated did not reach a satisfactory F-ratio and tolerance level. The two independents, together accounted for 65 per cent of the total variation in the volume of passenger movements between Nairobi and the forty administrative district units.

The extended version of the gravity model has performed reasonably well, though less satisfactorily as a substantial amount of variance remains to be explained. The hypothesised relationship is confirmed partly in the case of the inverse relationship between passenger volume and distance, but for population and vehicles generated, the relationships did not reach reasonable levels of significance. The results, however, support previous findings that distance is the most important variable accounting for much of the variations in the movement of passengers between urban centres and rural zones of traffic generation (Fouracre and Sayer, 1977). In the cited study, about eight variables were used as independents, but only four explained 90 and 79 per cent of the variations for the towns of Blantyre and Lilongwe, respectively. The districts' nodal linkage associations as identified by the map of dominant passenger flows (Figure 5.4) suggest that the dominant districts such as Kisumu, Mombasa, Eldoret, Nakuru and Embu had some effects on the movements of passengers between their hinterland districts and Nairobi. Moreover, the tendency of the dominant nodal districts to handle their own passenger traffic in addition to passengers from the hinterland districts (traffic shadow effect) seems to account for some of the unexplained variance in the model. Since these factors cannot be quantified and incorporate into the gravity model, and because of lack of other relevant data, no further analysis was attempted.

E. SUMMARY

In this chapter, an attempt has been made to describe, analyse and explain the spatial patterns of the inter-district and provincial aggregate movement of passengers by buses, matatus and private cars throughout the country. One of the major results of the analysis is that matatus led the other modes of public transport in terms of the number of people carried. The reasons for this trend have been suggested as free entry into the operation of matatu business made possible by the Presidential Decree of 1973, comparatively low costs of buying and operating matatus, and the flexibility in the movement of matatus compared to buses both in urban areas and on the gravel and earth roads of the rural areas. A comparison of the population potential map of Kenya with the maps of actual passenger movements showed that they correspond very closely; the fit being more exact with respect to the high potentials located in western and central Kenya. This correspondence suggests that population and distance are significant factors influencing the inter-district volumes of passenger flow (Tables 5.2 and 5.3).

The inter-district dominant flow analysis identified three main dominant nodal regions based on the districts of Kisumu, Nairobi and Mombasa, with a nested hierarchical system of flow, for the Kisumu node, established around Uasin Gishu District and that for the Nairobi node, established around Nakuru and Embu Districts. The relative significance of the locations of the three nodes on the principal towns of Kenya: Nairobi, Kisumu and Mombasa is emphasised by their functions as the major economic, social and political centres and the respective populations of 8.4, 5.6 and 1.4 million of the hinterlands they serve.

The application of the stepwise multiple regression analysis to the passenger flow data using an extended version of the gravity model formulation with population, distance and the number of vehicles generated as independent variables showed that distance was the most important factor explaining 49 per cent of the variation in the volume of passenger movement between Nairobi and the district zones of passenger generation and attraction. The addition of population to the equation increased the level of explanation to 65 per cent. There was very insignificant change in the level of explanation when the number of vehicles generated was added to the equation. The resulting finding, though less satisfactory in view of the substantial proportion of unexplained variance, is in agreement with other findings that distance (friction) population (mass) are the only two variables with any general applicability in the gravity-potential methods of predicting volumes of flows (Smith, 1970; Fouracre and Sayer, 1977). However, in the case of the data used in this study, the location of the dominant district nodes with respect to their hinterland districts and the effects of their traffic-shadow seem to account for some of the unexplained variance.

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CHAPTER SIX

MOVEMENT OF COMMODITIES

A. INTRODUCTION

Although some work has been done at the inter-district level on rural passenger traffic generation and distribution in Kenya (Howe, 1966), so far, no work has been done and published dealing with commodity flows by road or rail at the inter-district level of analysis. Clearly, therefore, there is a great need for such a study, particularly work dealing with the modelling of inter-district or regional freight flows applying the simple gravity model and its various formulations or other general equilibrium models (Chisholm and O'Sullivan, 1973, pp. 11 - 19). The overall purpose of such models is to relate freight flows to one or more other variables so that it may be possible to make forecasts of freight flows given forecasts or assumptions regarding the other variables in the system. This can be helpful in assessing investments requirements and long-term operating costs for future possible spatial distributions of activities. Moreover, the use of such models might throw some light on the factors that influence the spatial distribution of commodity flows and the associated answers to the question of regional comparative advantages.

Commodity flow studies can play an important part in the analysis of market structure and investigations of spatial economics (Gould and Smith, 1961). By mapping and describing the pattern of commodity flows one can get an insight into the pattern of population and resource distribution and other factors determining the flow of commodities in a given region. Furthermore, it is also useful to know how much more or how much less of a given commodity is demanded in a system of commodity flows, because such knowledge may give more pertinent explanations of the underlying regional pattern.

In this chapter, an attempt will be made to describe, analyse and explain the spatial patterns of the inter-district and provincial commodity flows by road using the Kenya National Origin-Destination Traffic Survey data for March, 1983. First, the proportional share of the eight commodities that were enumerated, in terms of total tonnage moved, will be examined. Second, the relative shares of the districts in terms of receipts (imports) and shipments (exports) of individual commodities are presented and discussed. Finally, the implications of these both for the spatial structure of the inter-district flows and for provincial trade balances are considered.

The technique of dominant flow analysis has been employed to identify dominant-dependent associations between the districts and patterns of hierarchical flows, and the technique of transaction flow analysis has been used to calculate the expected levels of districts' shipment of commodities to Nairobi so that the concept of complementarity can be expressed quantitatively. An extended version of the gravity model formulation has been employed to relate commodity flows to socio-economic variables that are thought to be important generators of commodity flows.

B. THE INTER-DISTRICT COMMODITY MOVEMENT PATTERNS

1. THE ANALYSIS

The eight commodities that were selected for enumeration in the National Origin-Destination Traffic Survey and subjected to this analysis were maize, wheat, coffee, tea, refined sugar, cement, soda-ash and soda products and petroleum fuels and products (Table 6.1). These products represent the most important commodities in the country's internal and external trade. As can be seen from the table, maize had the largest share (27.26%) in the inter-district road commodity flows, followed by petroleum fuels and petroleum products (24.44%), cement (14.21%) and tea (11.07%). The remaining four commodities accounted for less than one-quarter of the inter-district road trade in the selected commodities. The significance of the two agricultural products, maize and tea, and the two industrial products; petroleum fuels and petroleum products and cement in the domestic consumption pattern can readily be assessed from the table. Of particular note, is the leading position and the relative significance of maize as the chief staple food for the majority of Kenyans.

The relative positions of districts in terms of receipts (imports) and shipments (exports) from and to other districts of the country are shown in Tables 6.2 - 6.9. With respect to the receipts of maize, Kisumu District (31.27%), Nakuru (28.23%),

TABLE 6.1 TONNAGE OF COMMODITY GROUPS AS A PROPORTION OF TOTAL INTER-DISTRICT COMMODITY RECEIPTS AND SHIPMENTS

COMMODITY	TOTAL RECEIPTS AND SHIPMENTS (TONS)	PERCENTAGE OF TOTAL
1. MAIZE	747,325	27.26
2. WHEAT	227,599	8.30
3. COFFEE	100,123	3.65
4. TEA	303,456	11.07
5. REFINED SUGAR	252,477	9.21
6. CEMENT	389,573	14.21
7. SODA ASH AND SODA PRODUCTS	50,388	1.86
8. PETROLEUM FUELS AND PETROLEUM PRODUCTS	669,727	24.44
TOTAL	2,740,668	100.00

Source: Summary from the Kenya National Origin-Destination (O/D) Traffic Survey Data File, March, 1983, Ministry of Transport and Communications (MOTCO).

Nairobi (12.88%), Uasin Gishu (6.88%) and Mombasa (5.48%) accounted for about 85 per cent. This is a reflection of the demand for this staple food by the preponderance of urban populations in the five districts. On the shipment side of the scale, South Nyanza District (20.29%), the districts of Trans Nzoia (13.51%), Nairobi (12.28%), Kericho (11.53%), Kisii (11.43%), Kisumu (5.59%), Nandi (5.46%) and Machakos (5.31%) accounted for 85 per cent. All these districts, except Nairobi, are important producers of maize. The relatively low shipments of maize by road from important maize growing districts such as Uasin Gishu (4.07%) and Nakuru (0.81%) seem to be explained by the small number of districts to which they shipped maize. The inter-district commodity shipment data show that Uasin Gishu District shipped maize to Nairobi and Nakuru Districts and to itself, while the shipments from Nakuru District were to Kisumu, Kericho and Trans Nzoia Districts. Moreover, since major areas of maize production within the districts are well served by rail lines, it would appear that much of the shipment of maize from the two districts goes by rail as an alternative means of transport. However, it is not possible to say with certainty what tonnage of maize is shipped by rail due to lack of comparable data. Such a close-up type of comparative study should be pursued in future as a possible line of study if the relative significance of road and rail transport in the movement of commodities has to be established.

The inter-district movement of wheat is rather revealing. Nairobi dominated the trade in wheat, accounting for 87.26 per cent of all the tonnage received, followed by Kisumu District (5.83%). Clearly, this is an indication of the urban dominance in the consumption of wheat and its products. Narok District (77.64%) was by far the leading exporter of wheat and virtually all of it went to Nairobi. The shipments from major wheat growing districts such as Nakuru (3.43%) and Uasin Gishu (0.47%) were very insignificant, apparently because of rail-road competition. However, because there is no comparable data, not much can be read into these figures. The second position was held by Mombasa (7.80%). This is, clearly, imported wheat that comes through the Port of Mombasa for transshipment to up-country districts since none of the coastal districts is a producer of wheat. This demonstrates that Kenya does not produce enough wheat to satisfy her domestic demand.

The movement of coffee was dominated by Mombasa (33.01%), Nairobi (26.16%), Kisumu (15.02%), Kirinyaga (12.61%) and Kericho (8.36%) as receivers. The role of the Mombasa Port as an export outlet for this leading Kenya's export crop stands out even more clearly. The importance of Nairobi is emphasised by its being the headquarters of the Kenya Planters' Co-operative Union, a body responsible for roasting, preliminary processing and packing of coffee before export. Important shippers of coffee were Nairobi (38.44%), Machakos (14.03%), Kisumu (10.70%), Embu (7.08%), Kisii (5.38%), Muranga (5.05%) and Mombasa (5.10%). It should be noted that while districts such as Kisumu and Mombasa are not important as producers of coffee, the considerably large quantities from the districts can only be explained in terms of transshipments. For Mombasa, this quantity seems to represent the re-export of fully processed coffee into the country, as Kenya coffee is exported as roasted beans. The comparatively very small quantity of coffee shipped from Kiambu District (0.25%), yet it is one of the leading producers, appears to be attributable to the fact that the district lies in Nairobi's traffic-shadow. This is the tendency of a large centre in a region to act as the traffic-receiving and shipping point, not only for its own traffic, but also for the traffic of the surrounding districts (Taaffe, 1956; Gould and Smith, 1961). This tendency is, seemingly, true in the case of shipments of export commodities, such as coffee and tea from the districts near Nairobi.

The movement of tea was dominated by Mombasa District (82.69%) as the principal receiver of this export production orientated commodity, emphasising significance of the port of Mombasa as the export outlet. The only district which received a sizeable traffic of this commodity was Nairobi (9.12%). The receipts of the rest of the districts were very insignificant. Nairobi (29.64%) was the leading shipper of tea, followed by

Kericho District (20.29%) as would be expected. Nyeri District shipped 6.59 per cent, Muranga (6.45%), Nakuru (6.15%), Nandi (5.54%), Meru (5.33%) and Kiambu District (5.16%), all of which, except Nakuru District, are principal growers of tea.

Kisumu District was the leading receiver of refined sugar, accounting for 33.68 per cent of the total tonnage of the inter-district receipts. The district of Uasin Gishu received 15.88 per cent, followed by Embu (9.56%), Garissa (6.05%), Mombasa (5.34%) and South Nyanza (5.09%). It would seem that Kisumu District as the leading producer of refined sugar is also the largest receiver from the nearby producing districts of South Nyanza and Kakamega for trans-shipment by rail to other parts of the country. Kisumu still commanded the first position as the largest shipper of the commodity, accounting for 20.41 per cent, closely followed by Kakamega District (20.01%), Bungoma (13.87%), Nairobi (12.59%), South Nyanza (7.34%) Kirinyaga (6.95%) and Kwale (5.34%). Except for Nairobi and Kirinyaga, the rank order positions of the districts is in accord with what should have been expected with respect to largest shipments from these predominantly sugar cane growing districts. The positions of Nairobi and Kirinyaga can be explained in terms of larger stock holdings for distribution to the nearby districts.

The movement of cement shows a fair distribution in terms of the districts' receipts, with most of the districts receiving

TABLE 6.2 MOVEMENT OF MAIZE BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	0.63	-
KAKAMEGA	0.28	2.85
SIAYA	0.07	0.23
KISUMU	31.27	5.59
SOUTH NYANZA	3.21	20.29
KISII	3.40	11.43
TRANS NZOIA	0.23	13.51
BARINGO	0.08	-
UASIN GISHU	6.88	4.07
NANDI	0.23	5.46
KERICHO	0.46	11.53
NAKURU	28.23	0.81
KAJIADO	-	1.06
NYANDARUA	0.11	0.96
KIRINYAGA	0.95	1.81
MURANGA	-	0.54
KIAMBU	2.58	-
EMBU	0.47	1.01
KITUI	0.37	-

TABLE 6.2 **MOVEMENT OF MAIZE BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983**(CONT'D)

DISTRICT	RECEIPTS %	SHIPMENTS %
MACHAKOS	1.23	5.31
KILIFI	0.76	0.17
KWALE	0.20	-
MOMBASA	5.48	1.09
NAIROBI	12.88	12.28
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO

TABLE 6.3 MOVEMENT OF WHEAT BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
KAKAMEGA	0.93	-
SIAYA	-	0.10
KISUMU	5.83	0.93
UASIN GISHU	0.47	0.47
KERICHO	0.86	-
NAKURU	-	3.43
NAROK	0.77	77.64
NYERI	-	0.95
MURANGA	0.95	-
KIAMBU	1.16	2.82
KITUI	-	0.97
MACHAKOS	1.67	-
TAITA TAVETA	0.10	-
MOMBASA	-	7.80
NAIROBI	87.26	4.89
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

TABLE 6.4 MOVEMENT OF COFFEE BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
KISUMU	15.02	10.70
KISII	0.33	5.38
UASIN GISHU	1.19	-
KERICHO	8.36	0.37
KAJIADO	0.08	-
NYERI	0.75	2.53
KIRINYAGA	12.61	1.80
MURANGA	0.25	5.05
KIAMBU	-	0.25
MERU	-	3.98
EMBU	-	7.08
KITUI	-	2.30
MACHAKOS	-	14.03
TANA RIVER	-	1.49
KILIFI	0.34	-
KWALE	1.90	1.50
MOMBASA	33.01	5.10
NAIROBI	26.16	38.44
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

TABLE 6.5 MOVEMENT OF TEA BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
KAKAMEGA	1.20	2.43
KISUMU	-	1.05
SOUTH NYANZA	0.41	-
KISII	0.09	0.79
TRANS NZOIA	-	0.06
LAIKIPIA	1.04	-
UASIN GISHU	0.06	-
NANDI	-	5.54
KERICHO	0.45	20.29
NAKURU	-	6.15
KAJIADO	-	1.55
NYANDARUA	-	1.93
NYERI	0.51	6.59
KIRINYAGA	-	0.75
MURANGA	-	6.46
KIAMBU	1.99	5.16
MARSABIT	0.30	-
MERU	-	5.33
EMBU	0.82	2.29
MACHAKOS	0.41	-

TABLE 6.5 **MOVEMENT OF TEA BY ROAD, RECEIPTS AND SHIPMENT, MARCH, 1983.**(CONT'D)

DISTRICT	RECEIPTS %	SHIPMENTS %
WAJIR	0.42	-
TAITA TAVETA	-	1.19
KILIFI	0.49	-
MOMBASA	82.69	2.80
NAIROBI	9.12	29.64
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic survey Data File, March, 1983, MOTCO.

TABLE 6.6 MOVEMENT OF REFINED SUGAR BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	-	13.87
BUSIA	0.91	-
KAKAMEGA	1.00	20.01
SIAYA	5.50	0.68
KISUMU	33.68	20.41
SOUTH NYANZA	5.09	7.34
KISII	0.86	2.09
LAIKIPIA	-	0.16
UASIN GISHU	15.88	-
KAJIADO	0.94	-
NYERI	-	1.53
KIRINYAGA	-	6.95
MURANGA	1.42	1.10
KIAMBU	1.51	4.20
EMBU	9.56	-
KITUI	3.54	0.94
MACHAKOS	2.34	-
WAJIR	0.81	-
GARISSA	6.05	-
LAMU	0.93	-
KILIFI	0.49	-
KWALE	1.37	5.34
MOMBASA	5.34	2.79
NAIROBI	2.78	12.59
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

TABLE 6.7 MOVEMENT OF CEMENT BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	3.22	-
BUSIA	0.78	-
KAKAMEGA	4.17	0.41
SIAYA	2.30	-
KISUMU	4.83	22.10
SOUTH NYANZA	3.41	1.17
KISII	2.32	-
TURKANA	2.42	0.49
TRANS NZOIA	1.16	-
UASIN GISHU	5.42	6.23
KERICHO	3.86	-
NAKURU	5.68	0.62
NAROK	1.52	-
NYERI	1.68	1.16
KIRINYAGA	0.09	1.18
MURANGA	0.19	0.86
KIAMBU	6.68	0.62
MERU	1.35	-
EMBU	2.07	0.18
KITUI	0.98	-
MACHAKOS	3.51	23.42

TABLE 6.7 MOVEMENT OF CEMENT BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983.(CONT'D)

DISTRICT	RECEIPTS %	SHIPMENTS %
MANDERA	0.38	-
GARISSA	2.44	-
TANA RIVER	0.47	0.27
LAMU	-	0.31
TAITA TAVETA	4.10	-
KILIFI	2.69	1.32
KWALE	2.47	1.31
MOMBASA	1.65	24.56
NAIROBI	28.16	13.79
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

TABLE 6.8 MOVEMENT OF SODA ASH AND SODA PRODUCTS BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	10.55	-
BUSIA	3.82	-
KAKAMEGA	6.07	1.18
SIAYA	2.54	-
KISUMU	25.55	19.48
SOUTH NYANZA	2.59	-
TRANS NZOIA	2.60	-
UASIN GISHU	1.06	25.81
KERICHO	-	0.19
NAKURU	10.88	0.63
KIAMBU	10.72	-
MACHAKOS	14.95	5.67
KWALE	-	2.99
MOMBASA	2.99	-
NAIROBI	5.68	44.05
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

TABLE 6.9 MOVEMENT OF PETROLEUM FUELS AND PETROLEUM PRODUCTS BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	0.30	-
KAKAMEGA	4.67	-
SIAYA	1.28	-
KISUMU	6.19	16.10
SOUTH NYANZA	8.62	0.36
KISII	5.05	2.23
WEST POKOT	0.81	-
TRANS NZOIA	7.88	0.06
LAIKIPIA	1.73	-
UASIN GISHU	1.91	9.22
NANDI	0.26	-
KERICHO	4.54	0.74
NAKURU	10.39	4.21
NAROK	2.96	-
KAJIADO	1.21	0.53
NYANDARUA	0.21	-
NYERI	1.33	-
KIRINYAGA	0.24	0.42
MURANGA	2.65	0.19
KIAMBU	0.21	1.62
MARSABIT	0.23	-

TABLE 6.9 MOVEMENT OF PETROLEUM AND PETROLEUM PRODUCTS BY ROAD, RECEIPTS AND SHIPMENT, MARCH, 1983. (CONT'D)

DISTRICT	RECEIPTS %	SHIPMENTS %
ISIOLO	-	0.07
MERU	0.86	-
EMBU	6.00	-
KITUI	1.02	-
MACHAKOS	9.31	0.17
GARISSA	0.85	-
TANA RIVER	0.45	-
LAMU	0.19	0.31
TAITA TAVETA	2.52	-
KILIFI	2.82	1.05
KWALE	1.35	-
MOMBASA	1.71	29.48
NAIROBI	10.25	33.22
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

between 1 and 6 per cent, except for the larger proportional share of 28.16 per cent for Nairobi. This reflects on the widespread demand for this commodity in the building and construction industry, and emphasises the importance of Nairobi as a leading market. The leading shippers were Mombasa (24.56%) and Machakos (23.42%) as would be expected. Kisumu (22.10%) was third, followed by Nairobi (13.79%) and Uasin Gishu District (6.23%). Although, Nairobi, Kisumu and Uasin Gishu Districts are not producers of this commodity, their importance as shippers can be attributed to the positions of Nairobi, Kisumu and Eldoret towns on the railheads from where cement is transferred to road trucks for distribution to the neighbouring districts.

Kisumu District was clearly the leading receiver of soda-ash and soda products, accounting for 25.55 per cent of total receipts. Other major receivers of the commodity were Machakos (14.95%), Nakuru (10.88%), Kiambu (10.72%), Bungoma (10.55%), Kakamega (6.07%) and Nairobi (5.68%). The relatively insignificant share of Mombasa District (2.99%) in road transportation of this commodity, with the Port of Mombasa as the chief exporter, shows that soda-ash is transported by rail to Mombasa for export. Soda-ash is basically an industrial raw material and the fact that the five districts were the principal receivers of the commodity, shows their importance as industrial district units. The major shippers of the commodity were Nairobi (44.05%), Uasin Gishu (25.81%), Kisumu (19.48%) and Machakos (5.67%). The absence of Kajiado District from the list of shippers shows that Soda-ash is transported from Lake Magadi soda works exclusively by rail.

All the districts, except Busia, Turkana, Samburu, Elgeyo Marakwet, Baringo, Isiolo, Mandera and Wajir, received petroleum fuel and petroleum products by road and the proportional shares were fairly uniform, a reflection of equal demand for this commodity in all the districts. However, larger receipts by road were for Nakuru (10.39%), Nairobi (10.25%), Machakos (9.31%), South Nyanza (8.62%), Trans - Nzoia (7.88%) Kisumu (6.19%), Embu (6.00%) and Kisii (5.05%). As would be expected, Nairobi (33.22%) and Mombasa (29.48%) sent the largest shipments by road, followed by Kisumu (16.10%), Uasin Gishu (9.22%) and Nakuru (4.21%), all on the railheads.

The Government owned Kenya Pipeline Company started operating the 449 kilometres Mombasa - Nairobi oil pipeline in February, 1978 (Republic of Kenya 1979). White oil is transported from the Mombasa oil refinery to the company's depot in Nairobi for subsequent transfer to oil companies for local distribution and for re-export to neighbouring countries. After up-grading the Mombasa - Nairobi Road to bitumen standard the white oil products were conveyed to Nairobi from Mombasa Refinery, approximately one half by rail and one half by road tankers. With the opening of the pipeline, it was expected that the proportions transported by road and rail from Mombasa to Nairobi should fall considerably. According to data in Table 6.1, petroleum fuels and product was the second most important commodity in terms of the tonnage carried by road. In view of the limitations of the data used in this study to road haulage, it is difficult to assess the proportional share of rail transport in the internal movement of the commodity or the share of the oil pipeline between Mombasa and Nairobi. However, it appears from the available road data that a considerable quantity is shipped from Mombasa (29.48%) to Nairobi and other districts, and similarly this can be said in the case of rail transport, particularly to districts with access to railheads.

The overall movement of all the commodities by road is shown in Table 6.10. Nairobi, Kisumu, Mombasa and Nakuru in that order were the leading receivers of all the commodities combined. On the shipment side, Nairobi, Mombasa and South Nyanza led the list, each one of them sending out to the other districts over 10 per cent of the total shipment.

2. ROAD TRADE BALANCES

Table 6.11, (Appendix 4) is a summary of all the inter-district commodity trade transactions aggregated at the provincial levels of receipts and shipments. The complex spatial relationships identified above find their economic expression in the inter-provincial trade balances which for any province, reflect

TABLE 6.10 MOVEMENT OF ALL COMMODITIES BY ROAD RECEIPTS AND SHIPMENTS, MARCH, 1983

DISTRICT	RECEIPTS %	SHIPMENTS %
BUNGOMA	0.59	1.27
BUSIA	0.32	-
KAKAMEGA	2.62	3.10
SIAYA	1.10	0.13
KISUMU	15.73	8.55
SOUTH NYANZA	4.16	10.20
KISII	2.87	4.29
TURKANA	0.42	0.08
WEST POKOT	0.23	-
TRANS NZOIA	2.48	3.66
BARINGO	0.02	-
LAIKIPIA	0.65	-
UASIN GISHU	4.71	5.33
NANDI	0.14	2.36
KERICHO	2.54	6.56
NAKURU	10.25	2.76
NAROK	1.16	6.33
KAJIADO	0.43	0.44
NYANDARUA	0.09	1.77
NYERI	0.78	0.53

TABLE 6.10 MOVEMENT OF ALL COMMODITIES BY ROAD, RECEIPTS AND SHIPMENTS, MARCH, 1983 (CONT'D)

DISTRICT	RECEIPTS %	SHIPMENTS %
KIRINYAGA	0.83	2.53
MURANGA	1.23	1.45
KIAMBU	2.73	1.99
MARSABIT	0.11	0.76
ISIOLO	-	0.13
MERU	0.48	0.22
EMBU	3.17	0.83
KITUI	0.88	0.18
MACHAKOS	4.33	2.77
MANDERA	0.07	-
WAJIR	0.07	-
GARISSA	0.74	-
TANA RIVER	0.21	0.11
LAMU	0.14	0.15
TAITA TAVETA	1.43	0.20
KILIFI	1.61	0.57
KWALE	1.06	0.85
MOMBASA	12.10	13.97
NAIROBI	17.56	15.93
TOTAL	100.00	100.00

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

conditions of surpluses and deficits in the movement of each of the eight commodities separately and in aggregate. All the provinces, except Coast and Nairobi Provinces, and North Eastern Province, which neither received nor shipped maize, had favourable trade balances in maize. The excess receipts over shipments of wheat for Western, Nyanza, Eastern and Nairobi Provinces resulted in correspondingly unfavourable trade balances. This should be expected as the four provinces do not produce wheat. The favourable trade balance in wheat for Coast Province, as was pointed out, was due to the transshipment of imported wheat from the Port of Mombasa to up-country Provinces, as none of the districts in Coast Province produces wheat.

The Provinces of Rift Valley, Central and Coast received more tonnage of coffee than they shipped, resulting in unfavourable trade balances. The effects of rail-road competition and the traffic-shadow of Nairobi, with surplus balance in the movement of coffee, could be the explanation for the unfavourable trade balances for Rift Valley and Central Provinces. The other provinces, except North Eastern and Western Provinces which, apparently, did not record any movements in coffee, had surplus balances, which for Nairobi should be explained in terms of transshipment. Virtually all the provinces, except North Eastern and Coast Provinces had very favourable balances of trade in tea. The apparently very large receipt of tea for Coast Province is attributable to the use of Mombasa Port as the export outlet for tea.

Trade balances for refined sugar were in favour of Western, Central and Nairobi Provinces, while Nyanza, Rift Valley, Eastern and North Eastern Provinces recorded deficits in their trade balances. Coast Province had a balanced trade transaction in the commodity. For Nyanza Province, the unfavourable trade balance in refined sugar seems to be reflected in the large receipts of refined sugar recorded from the nearby Western Province as noted earlier for Kisumu District, apparently, for onward transshipment by rail to other destination districts. Western Province, Rift Valley, Central, North Eastern and Nairobi Province recorded deficits in the trade balance for cement, whereas Nyanza Province, Eastern and Coast Province recorded surpluses in their trade balances for the commodity. The balances of trade were in favour of Western Province and Nairobi Province for the inter-provincial transaction in soda-ash and soda products. Coast Province again had a balanced trade in the commodity. The rest of the provinces recorded deficits in soda-ash and soda products trade. The only provinces that had favourable balances of trade in petroleum fuels and petroleum products were Coast Province and Nairobi Province. This was to be expected given the locations of oil refinery at Mombasa and the oil pipeline terminal at Nairobi. The rest of the provinces had deficits with Rift Valley Province and Eastern Province recording the largest tonnages in the commodity.

Taking all the commodities in aggregate, the inter-provincial trade balances were in favour of Western Province, Rift Valley and Central Province. The overall trade balance positions for the remaining provinces were unfavourable. Nyanza Province was particularly affected by the large trade balance deficit recorded for petroleum fuels and petroleum product, while the major cause of the overall unfavourable trade position for Eastern Province were the large deficits recorded for their trade in petroleum fuels and petroleum products and in refined sugar. Coast Province and Nairobi had their largest deficit records in tea and wheat trade, respectively. North Eastern Province was a receiver in all the commodity transactions hence its overall unfavourable trade balance position.

The graphic representation of the patterns of the inter-district commodity flows is shown in Figure 6.1, exhibiting two major patterns similar to those for the inter-district passenger flows. These are distance and direction oriented flow patterns. The exception to the short-distance-large-volume flows is the long-distance-large-volume commodity movement between Nairobi and Mombasa. The overall direction of movements is a long north-west to south-east axis. The relative contributions of each province in terms of volume and directions of the flows are illustrated in Figure 6.2.

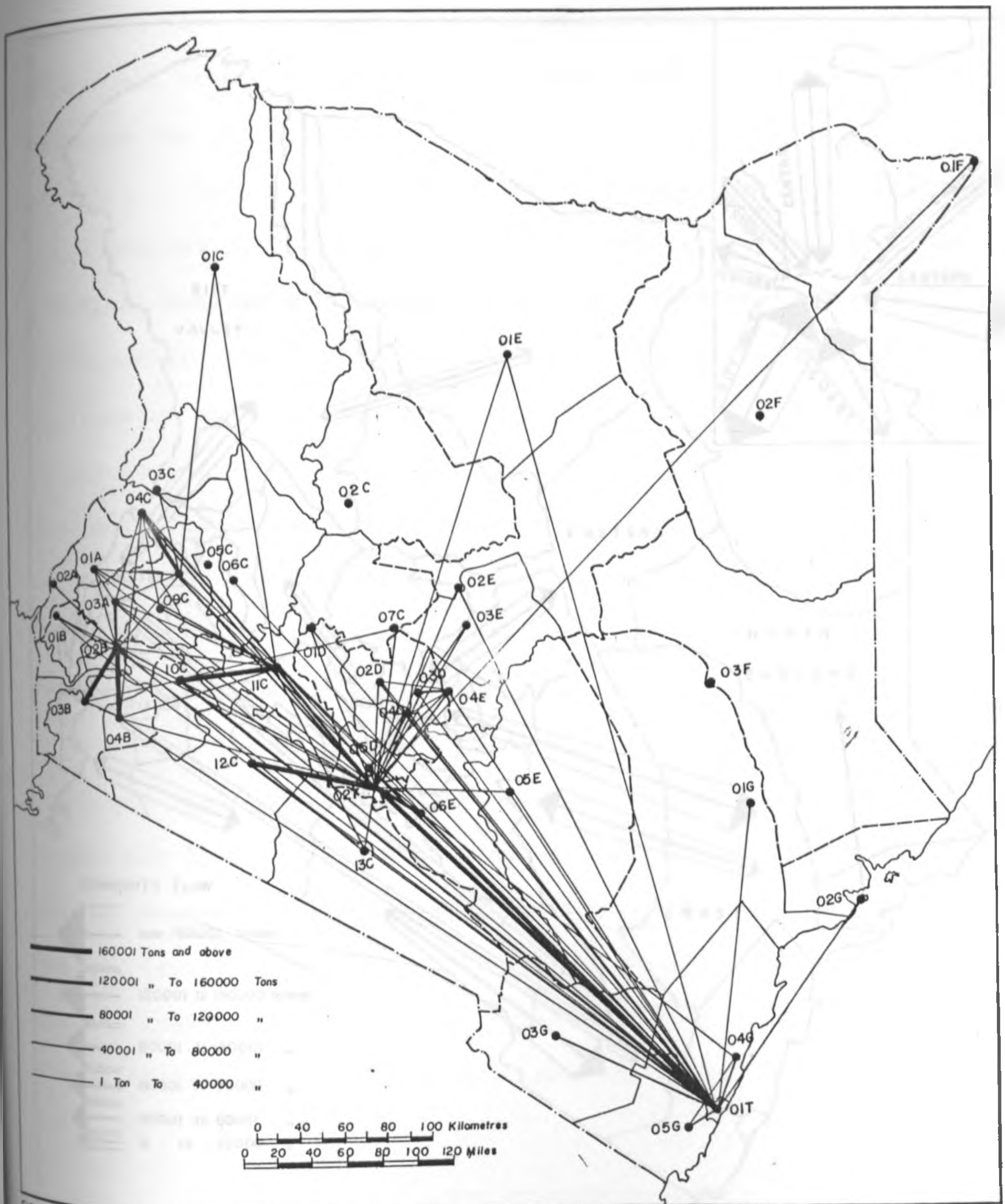


FIG. 6.1 INTER-DISTRICT MOVEMENT OF COMMODITIES

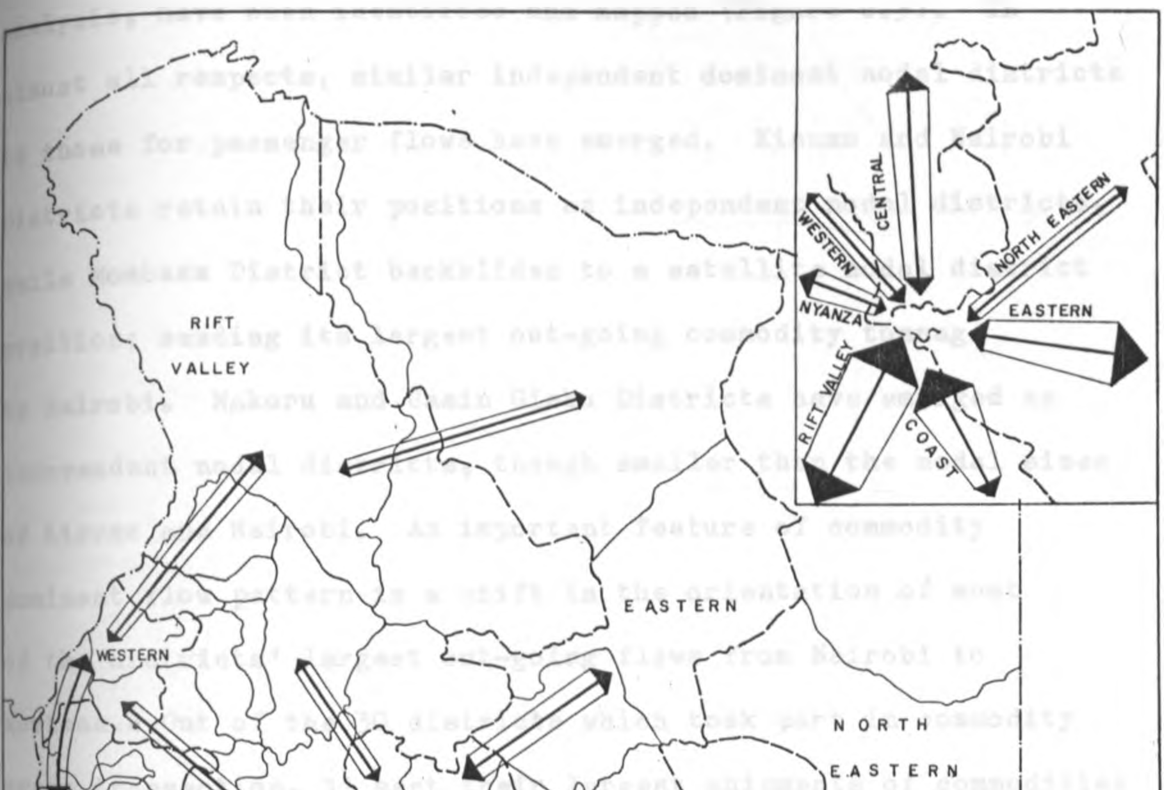


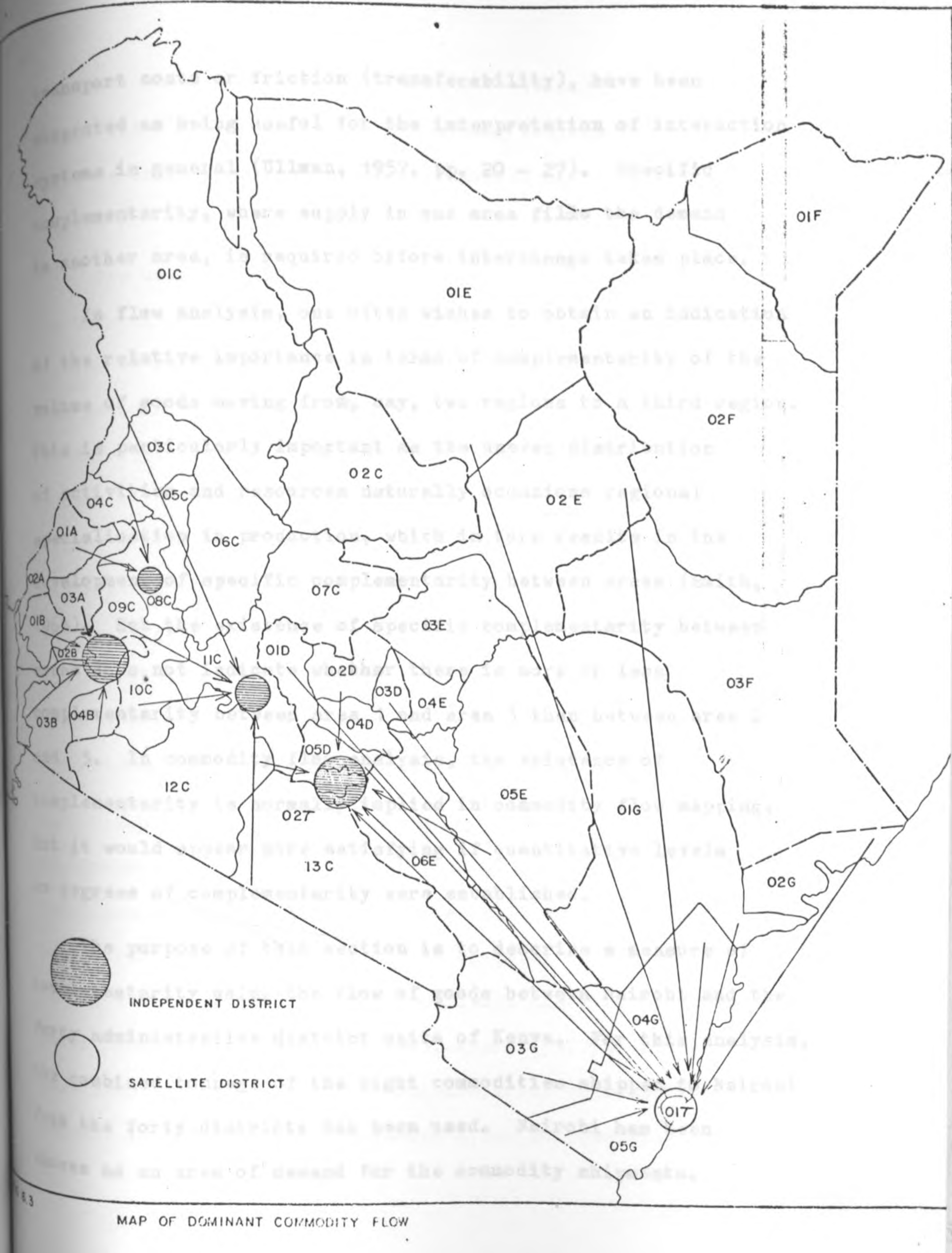
FIG 6.2 INTER-PROVINCIAL COMMODITY FLOW MAP

3. DOMINANT FLOW ANALYSIS

Dominant nodal districts, in terms of commodity flow analysis, have been identified and mapped (Figure 6.3). In almost all respects, similar independent dominant nodal districts to those for passenger flows have emerged. Kisumu and Nairobi Districts retain their positions as independent nodal districts, while Mombasa District backslides to a satellite nodal district position; sending its largest out-going commodity tonnage to Nairobi. Nakuru and Uasin Gishu Districts have emerged as independent nodal districts, though smaller than the nodal sizes of Kisumu and Nairobi. An important feature of commodity dominant flow pattern is a shift in the orientation of most of the districts' largest out-going flows from Nairobi to Mombasa. Out of the 30 districts which took part in commodity trade transaction, 11 sent their largest shipments of commodities to Mombasa. Kisumu District had four, Nairobi four, Nakuru four, and Uasin Gishu two. The dominant position of Mombasa, though not in terms of total tonnage, emphasises the role of the port of Mombasa in the export shipments of commodities such as coffee, tea and soda-ash. With respect to this analysis, Mombasa District captured the largest out-going commodity flows from districts which, in essence, are the major hinterlands of Nairobi.

C. MEASURES OF RELATIVE COMPLEMENTARITY

The notions emphasising supply and demand (complementarity), alternative sources of supply (intervening opportunity), and



MAP OF DOMINANT COMMODITY FLOW

transport costs or friction (transferability), have been suggested as being useful for the interpretation of interaction systems in general (Ullman, 1957, pp. 20 - 27). Specific complementarity, where supply in one area fills the demand in another area, is required before interchange takes place.

In flow analysis, one often wishes to obtain an indication of the relative importance in terms of complementarity of the volume of goods moving from, say, two regions to a third region. This is particularly important as the uneven distribution of activities and resources naturally occasions regional specialisation in production, which in turn results in the development of specific complementarity between areas (Smith, 1964). But the existence of specific complementarity between areas does not indicate whether there is more or less complementarity between area 1 and area 3 than between area 2 and 3. In commodity flow analysis, the existence of complementarity is normally implied in commodity flow mapping, but it would appear more satisfying if quantitative levels or degrees of complementarity were established.

The purpose of this section is to describe a measure of complementarity using the flow of goods between Nairobi and the forty administrative district units of Kenya. For this analysis, the combined tonnage of the eight commodities shipped to Nairobi from the forty districts has been used. Nairobi has been chosen as an area of demand for the commodity shipments.

In fact, Nairobi is a deficit area for virtually all the commodities enumerated. It, therefore, follows that there must be trade connections between Nairobi and the districts, the degree and magnitude of which should be quantitatively evaluated.

The volume of commodites that moved from each district to Nairobi is shown by graduated circles in Figure 6.4. As can be seen from the figure and Table 6.12, Narok (34.76%) and Mombasa District (26.63%) dominated commodity shipments to Nairobi. The other districts such as Trans Nzoia (8.21%), Machakos (8.20%) and Nyandarua (4.21%) are no where near the volume of shipments from the two districts. In this way, it may rightly be concluded that the districts of Narok and Mombasa have more complementary trade relationships with Nairobi than the other districts. However, it would be wrong to deduce conclusive comparative statements about specific complementarity from this map and the section of the table alone.

There is a column in Table 6.12 (Appendix 5) which shows the proportion of each district's total shipment (surplus) which was sent to Nairobi, and this tells a completely different story from that of the map and the shipment to Nairobi column of the table. Kitui (100.00%) now leads the list, followed by Narok (96.18%), Machakos (51.79%), Nyeri (51.77%) and so on. Does this mean that the level of complementarity between Kitui and Nairobi is the higher, even though Kitui shipped only 4821 tonnes to Nairobi compared to Narok's shipment of 166,816 tonnes? Clearly, a better assessment of complementarity is needed.

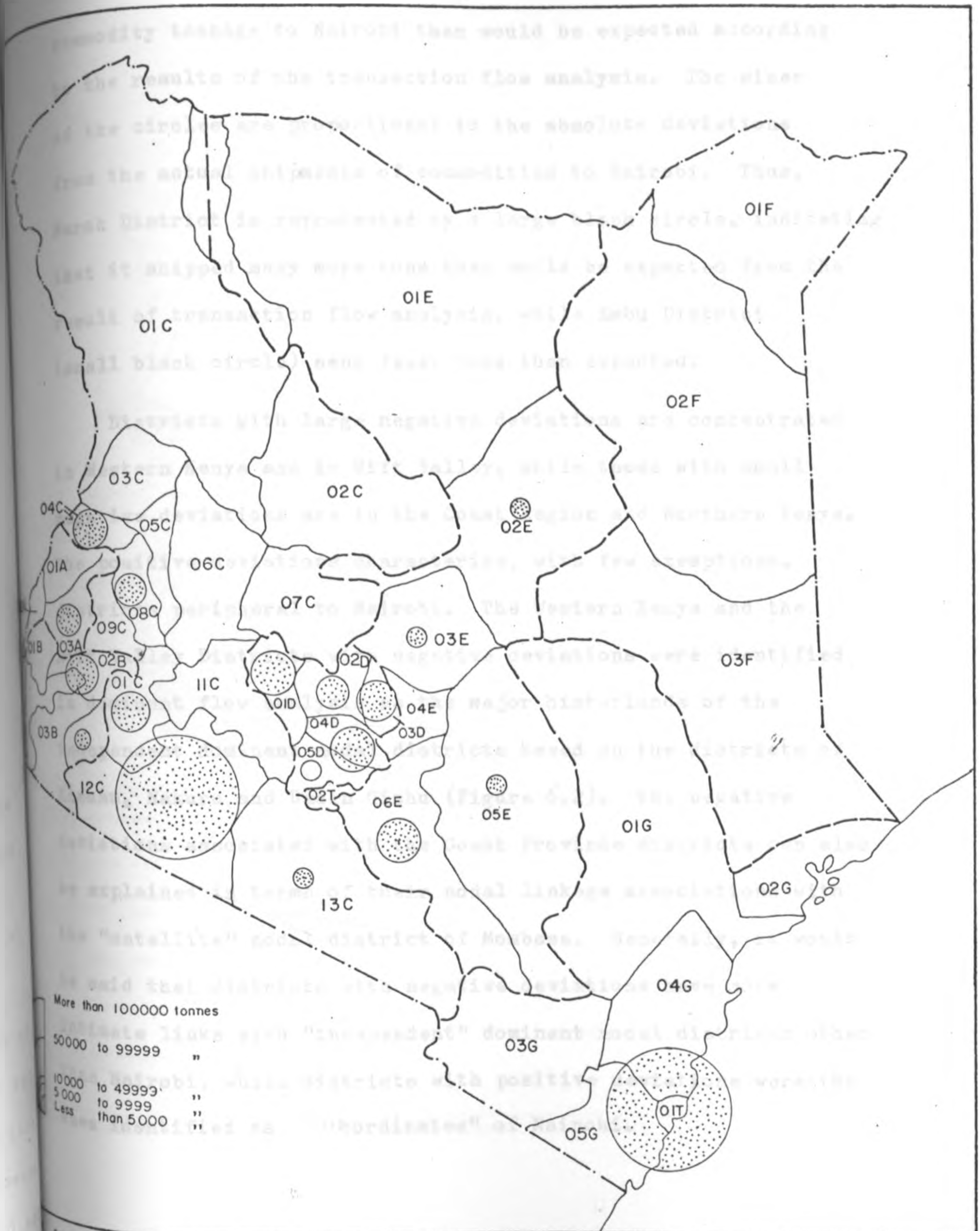
1. EXPECTED SHIPMENTS OF COMMODITIES GENERATED BY TRANSACTION FLOW ANALYSIS

The simplest way to express relative complementarity is to establish expected levels of commodity flow and then compare these with the actual volumes. The transaction flow model enables one to estimate the proportion of flows between regions under certain assumptions (See Chapter 3, section C(2)). The model identifies those pairs of areas which are interacting at higher or less than expected on the basis of their relative sizes and challenges the investigator to discover the relevant variables most closely associated with the observed deviations. In transaction flow analysis, the product of the out-going flow from (i) to all the regions and the total incoming flow to (j) from all regions representing the attractive force, divided by the total flow in the system yields the "expected" level of commodity flow for a given area. The computational results of transaction flow analysis are given in Table 6.13(Appendix 6) and the ratios of actual to expected commodity flow have been used in Table 6.12 (Appendix 5) as measures of the relative importance, in terms of complementarity, of the volume of commodities moved from the forty districts to Nairobi. It is, therefore, possible to evaluate quantitatively the strength of their complementary trade relationships with Nairobi (Table 6.12). Those districts with complementarity indices below 1.00, can be interpreted as low and those with values of 1.00 and above as high.

A comparison of Figures 6.4 and 6.5 indicates some striking differences between size of shipment to Nairobi and the degree of complementarity. While Narok District accounts for the largest percentage of commodities shipped by road to Nairobi, followed by Mombasa District, these shipments are smaller than might be expected, thereby indicating relatively lower levels of complementarity compared to that of Kitui District. Narok District now ranks second, while the rank position of Mombasa District, although its complementarity level is reasonably high, is below several other districts, which in terms of size of shipments to Nairobi hold very low positions. The ratios of actual to expected flows have, therefore, yielded indices of complementarity, and these figures can be used to assess and evaluate the relative significance of the inter-district trade relationships.

2. ABSOLUTE DEVIATIONS OF COMMODITY SHIPMENTS TO NAIROBI

The absolute deviations from actual commodity shipments to Nairobi are shown in Table 6.13 and mapped in Figure 6.6. The blank circles in Figure 6.6 show that the districts shipped more commodity tonnage to Nairobi than would be expected on the basis of transaction flow model formulation. The black circles indicate that the districts sent fewer



COMMODITY SHIPMENTS BY ROAD TO NAIROBI, MARCH 1983 commodity tonnage to Nairobi than would be expected according to the results of the transaction flow analysis. The sizes of the circles are proportional to the absolute deviations from the actual shipments of commodities to Nairobi. Thus, Narok District is represented by a large blank circle, indicating that it shipped many more tons than would be expected from the result of transaction flow analysis, while Embu District (small black circle) sent fewer tons than expected.

Districts with large negative deviations are concentrated in Western Kenya and in Rift Valley, while those with small negative deviations are in the Coast Region and Northern Kenya. The positive deviations characterise, with few exemptions, districts peripheral to Nairobi. The Western Kenya and the Rift Valley Districts with negative deviations were identified in dominant flow analysis as the major hinterlands of the independent dominant nodal districts based on the districts of Kisumu, Nakuru and Uasin Gishu (Figure 6.2). The negative deviations associated with the Coast Province districts can also be explained in terms of their nodal linkage associations with the "satellite" nodal district of Mombasa. Generally, it would be said that districts with negative deviations have more intimate links with "independent" dominant nodal districts other than Nairobi, while districts with positive deviations were the ones identified as "subordinates" of Nairobi.

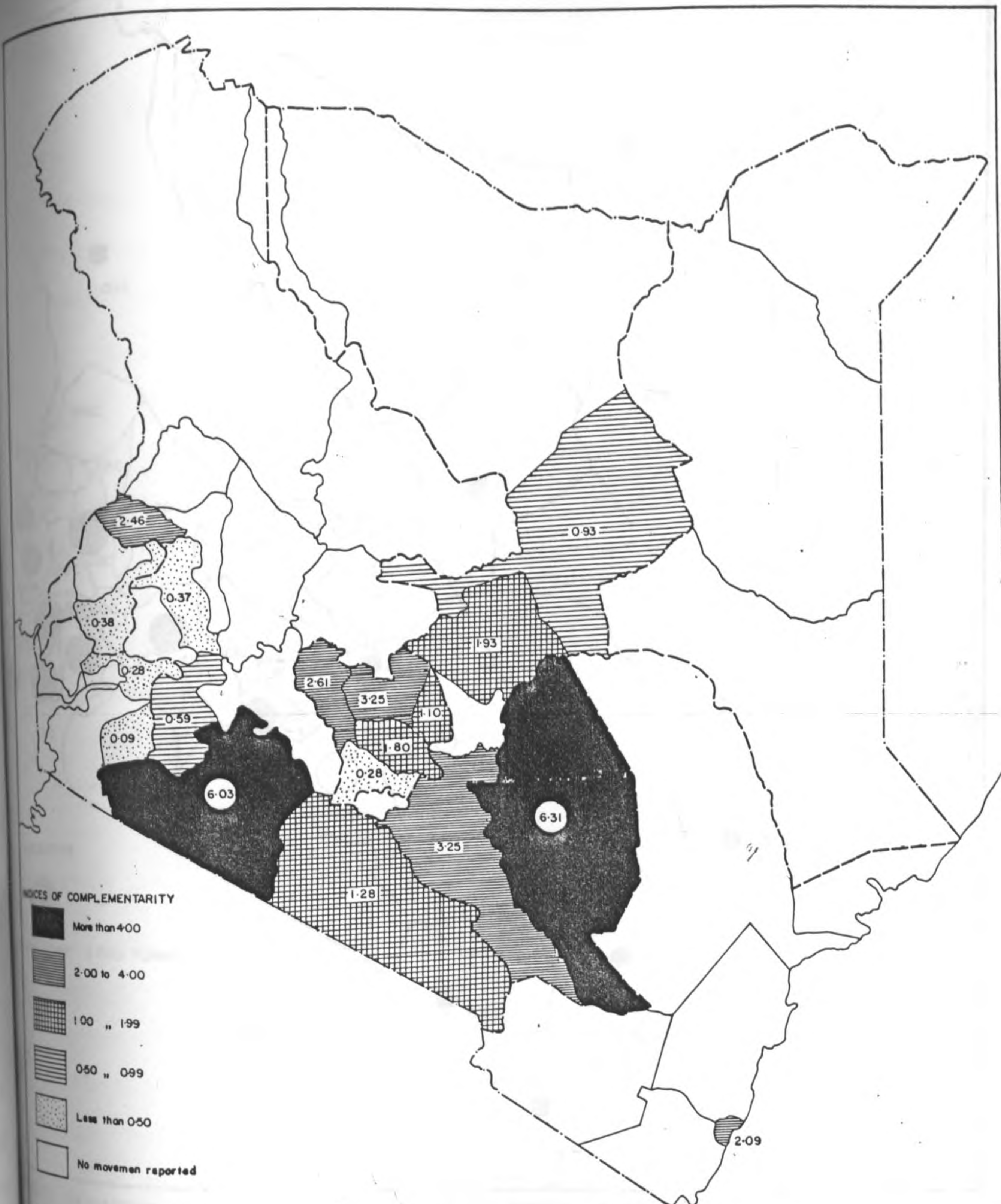
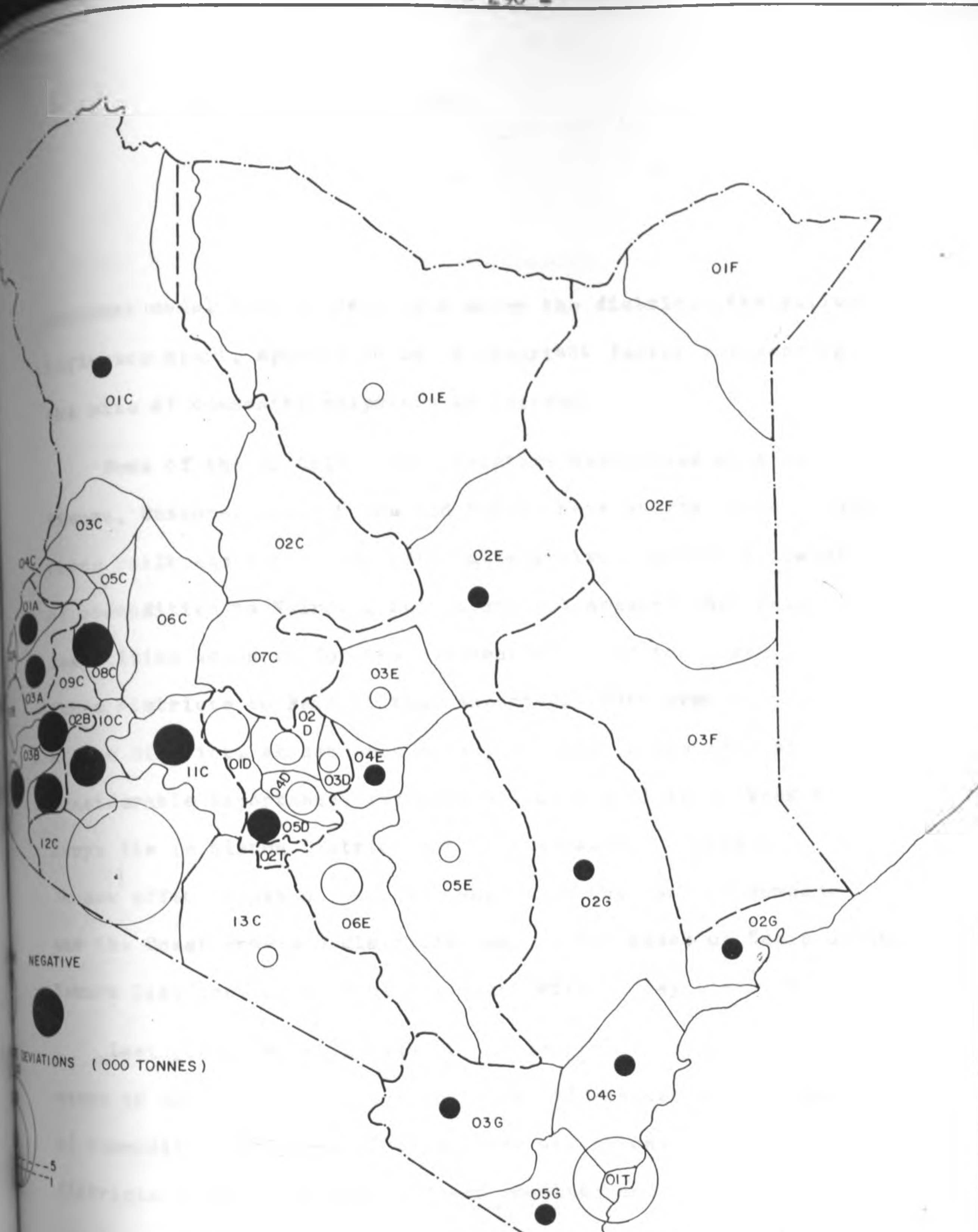


FIG 6·5 COMPLEMENTARITY INDICES FOR SHIPMENT OF COMMODITIES TO NAIROBI, MARCH 1983



ABSOLUTE DEVIATIONS OF SHIPMENT OF COMMODITIES TO NAIROBI MARCH, 1983

Dominant nodal link associations among the districts, the railway influence apart, appears to be an important factor influencing the size of commodity shipments to Nairobi.

Some of the districts with negative deviations such as Kisumu, Bungoma, Uasin Gishu and Nakuru have access to railheads. These railheads definitely offer alternative means of shipment of commodities to Nairobi, and as such it appears that rail competition accounts for the shipment of fewer tons from these districts to Nairobi than expected. Furthermore, Kisumu District, as has been noted, occupies a position of considerable importance, and many of the districts in Western Kenya lie in Kisumu District's traffic-shadow. Traffic shadow effect argument can be advanced in the case of Mombasa and the Coast Province districts, and in the cases of Uasin Gishu, Nakuru District and some of the other Rift Valley Districts.

Lastly, and more important, the length of haul or distance seems to account for the considerable differences in the quantity of commodities shipped. The negative deviations associated with the districts of Northern Kenya, Coast Province and Western Kenya may be explained partly by the frictional effects of distance. This is partly emphasised by the fact that the peripheral districts to Nairobi sent more tons of commodities than would be expected on the basis of transaction flow estimations. Thus, four factors are evident in the differences in the commodity tonnage shipped: the effects of independent dominant nodes in the inter-district commodity flow, rail-road competition, traffic-shadow effect and length of haul or the attenuating effect of distance.

D. MODELLING COMMODITY SHIPMENTS

Transaction flow model, as has been pointed out, is indifferent to all other influences within the interaction system except the relative attractive power of its component parts. Thus, the attractive power of the interacting area is measured in terms of the product of the total out-going flow from an area to all the areas and the total incoming flow to another area from all areas. In reality, such forces as the friction of distance, cultural and economic influences can affect considerably the pattern of trade transactions between areas. The model identifies those areas which interact at higher or less than expected, and challenges the investigator to discover, by residual mapping, the relevant factors most closely associated with the deviations. This has been done and four factors have been suggested as the most likely to be associated with the observed deviations. It is now then necessary to proceed to assess quantitatively, the spatial associations by the use of the gravity model formulation.

Although the gravity model depends on the veracity of a very limiting set of assumptions, it is, nevertheless, one of the best approaches for modelling commodity flows given the kind of data actually available (Shisholm and O'Sullivan, 1973, pp.18). Since most of the factors identified as being closely associated with the commodity shipment deviations in residual mapping are not easily quantifiable, it was decided to use other relevant factors as masses in the gravity model formulation. These are: employment earnings, and the total number of vehicles generated from i and j to all the district units of observation. The gravity model formulation is represented thus:

$$T_{ij}=k.\ (E_i E_j)^{b_1}\cdot(V_i V_j)^{b_2}\cdot d_{ij}^{-b_3}$$, with i=1 for Nairobi

where T_{ij}= the tonnage of commodity shipped and received between i and j,

E_i and E_j= the employment earnings in i and j,

V_i and V_j = the total number of vehicles generated from i and j to all the districts,

d_{ij}= the intervening distance between i and j, and k, b_1, b_2 and b_3 are constants to be estimated.

By taking the logarithms of each side of the equation, a multiple regression equation is produced thus:

$$\log T_{ij}= a+b_1 \log (E_i E_j)+b_2 \log (V_i V_j)-b_3 \log d_{ij},$$

with i=1 for Nairobi and

a=log k.

1. THE VARIABLES

The dependent variable, the tonnage of commodity shipped and received is a combined data representing movements in both directions. The distances are the same as the ones used in the modelling of passenger flows. Employment earnings were taken from Employment and Earnings in the Modern Sector, published in 1979 by Central Bureau of Statistics, Ministry of Economic Planning and Development, Kenya. The number of vehicles generated came from the same source as for the modelling of passenger flows.

2. STATISTICAL ANALYSIS AND INTERPRETATION

All the variables were transformed to logarithms in an effort to approximate normal distribution before performing multiple correlation and regression analyses (Table 6.14, Appendix 7). The results of simple inter-correlations among the four variables are shown in Table 6.15. As expected, distance is significantly (at 5 per cent level) and negatively correlated with goods shipped and received. Employment earnings and vehicles generated are also significant at 5 per cent level and positively correlated with goods shipped and received. The high correlation between employment earnings and vehicles generated seems to suggest that the two variable measure the same thing.

In order to establish the relative contribution of each of the independent variables to the variations in the tonnage shipments, the variables were subjected to multiple correlation and regression analyses. The multiple correlation and regression analyses results in Tables 6.16 and 6.17 show that employment earnings and distance were the only significant variables, explaining about 38 per cent of the variations in the shipment of commodities. The variable, vehicles generated, was not included for further analysis on grounds of insufficient F-ratio level or Tolerance-level. The performance of the gravity model as an approach to the modelling of commodity shipments

TABLE 6.15 MATRIX OF CORRELATION COEFFICIENTS BETWEEN THE FOUR VARIABLES

VARIABLE	1	2	3	4
1. GOODS SHIPPED AND RECEIVED	1.000			
2. EMPLOYMENT EARNINGS	0.526	1.000		
3. DISTANCE	-0.526	-0.462	1.000	
4. VEHICLES GENERATED	0.441	0.862	-0.369	1.000

All the correlation coefficients are significant at 5 per cent level.

TABLE 6.16 MULTIPLE COEFFICIENTS OF CORRELATION

VARIABLE	R	R^2	R^2 CHANGE
EMPLOYMENT EARNINGS	0.526	0.276	0.276
DISTANCE	0.615	0.378	0.102

TABLE 6.17 STEPWISE REGRESSION COEFFICIENTS

VARIABLE	b[1]	b	STANDARD ERRORS (b)	F
EMPLOYMENT EARNINGS	1.420	0.359	0.578	6.044*
DISTANCE	-2.115	-0.359	0.861	6.042*
(CONSTANT) a	0.942		3.589	0.069

[1] Unstandardised regression coefficients used for prediction purposes.

* Significant at 5 per cent level.

clearly leaves much to be desired, because of the enormous amount of residual variance (62 per cent) unaccounted for by the two independent variables. It would seem that the relatively low value for R^2 for the combined commodity shipments indicates that the gravity model is not very suitable for examining flows aggregated by the type of commodities used in this study. Another reason for the poor performance of the gravity model in this analysis is that there were a number of districts which did not exchange commodities at all with Nairobi. Notwithstanding the conclusions, it is suggested that a serious consideration should be given to the effects on commodity shipments of the dominant nodal districts, their traffic-shadow and rail-road competition as identified by the analysis of residuals. A follow-up study is clearly called for to establish the relative significance of these factors on commodity flows in Kenya.

A complementary analysis of commodity shipment by rail would have been preferred using all the forty districts as units of observation, but this aspect of analysis could not be attempted because the available data relate only to the nineteen districts in Kenya with railhead facilities. This would, therefore, mean that such an analysis would be restricted only to the nineteen districts with railhead facilities. Moreover, the available rail shipment data only show station to station and not district to district movements which were the basis of analysis in this study.

E. SUMMARY

The analysis of the inter-district flows for the eight commodities that were enumerated in the National Origin - Destination Traffic Survey shows that maize, petroleum fuels and products, cement and tea accounted for over three quarters of the total tonnage that moved between the forty one districts. The districts of Nairobi, Kisumu, Mombasa and Nakuru in that order, emerged as the leading receivers of all the commodities combined, while Nairobi, Mombasa and South Nyanza Districts dominated the shipment side, thus concentrating the inter-district commodity flow on a relatively small number of districts. At the provincial level of aggregation, the road trade balances, which for any province reflect conditions of surpluses and deficits for the combined tonnage received and shipped, Western Province, Rift Valley Province and Central Province had favourable trade balances, while the remaining provinces had deficits.

The application of dominant flow analysis to the matrix of commodity flow identified Kisumu and Nairobi Districts as the most dominant independent nodes, while Nakuru and Uasin Gishu Districts emerged as smaller independent nodal districts. Mombasa District, though a satellite of the Nairobi node, captured the largest number of out-going flows in the entire system including those from the districts which are essentially the major hinterlands of Nairobi. This, obviously, emphasises the importance of Mombasa Port in the export shipment of commodities such as coffee, tea, cement and soda ash.

The existence of complementary interchange of commodities between the districts can easily be seen in the matrix of flow table and in the inter-district commodity map. But this alone is not enough. To indicate, quantitatively, the levels or degrees of complementarity expressed in commodity flows between the forty districts and Nairobi, transaction flow analysis was used to establish the expected levels of flows which were then compared with actual flow levels. The ratios of actual to expected flows yielded a measure of the quantitative degrees of complementarity between Nairobi and each of the districts. It was then possible to establish the relative strength of interaction between the districts and to identify those districts which had higher or lower levels of complementarity with Nairobi. The districts of Kitui and Narok had the highest levels of complementarity, while the districts of Kisii, Kiambu and Kisumu had the lowest levels.

Transaction flow analysis identified districts which interchanged commodities with Nairobi at higher or lower levels than expected. By mapping the residuals, four relevant factors most closely associated with the observed deviations were suggested. These are the influence of the locations of the independent dominant nodes in the inter-district commodity flow, rail-road competition, traffic-shadow effect and the frictional effects of distance. The use of the gravity model formulation in a multiple regression analysis showed that employment earning and distance explained only 38 per cent of the variation in the volume of commodities that moved between the districts and Nairobi, the regression coefficients of both variables being significant at

5 per cent level. The three factors suggested by the examination of the map of residuals, but not included in the regression analysis, seem to account for much of the unexplained variance. Since these factors are not easy to quantify and cannot be incorporated in an extended version of the gravity model formulation, further analysis was not attempted. It may be concluded that the gravity model was not the most suitable tool for analysing the commodity flow or a better level of explanation could have been achieved if there were no sizeable number of districts with missing data on commodity flows.

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CHAPTER SEVEN

PATTERNS OF DEVELOPMENT AND THEIR RELATIONSHIPS TO THE DEVELOPMENT OF ROAD TRANSPORTATION IN KENYA

A. INTRODUCTION

Development is a relative concept and a multidimensional phenomenon, the spatial variations of which change with time depending on the nature and quality of the data used for measuring it. Some people measure it in terms of per capita income or Gross Domestic Product, while others use a variety of other measures such as the most important dimension in principal components analysis (Soja, 1968; Nyangira, 1972),"a system of correspondence points"(McGranahan et al., 1972) and other techniques of data amalgamation. Some scholars such as Soja and Nyangira prefer the use of the concept of"relative modernisation" instead of development, which to them means the process of change that constitutes progress toward a developed stage like the Western World is experiencing; something more than just economic development or political independence (Nyangira, 1972, pp. 6). The concept of development is as defined in Chapter 1 of this study, which see (pp. 6).

The model of transport development (Figure 2.1) postulates that the development of transportation is a function of social, cultural, economic and political forces and conditions of the societal system. However, the model also indicates by feedback reaction that transport/development relationship is a two-way interaction process, in that development or its components are also determined by the pattern of transport development. Development is, therefore, a system of interrelated variables or indicators which change together in a systematic manner. This means that indicators that distinguish between the relatively more developed from the relatively less developed countries or regions along a development scale should be considered part of the measurement of that development. It, therefore, follows that factors whose change constitute development must of necessity be correlated with each other and the development of which they are part, regardless of direct causal linkages between them. The selection of the original 25 indicators of development which were reduced to a group of 18 high - correlate core indicators, was based on this premise (Tables 3.1 and 3.2). This group of 18 indicators is the subject of the analytical treatment in this chapter. They were combined to generate a single measure of development and other component indices using the multivariate taxonomy technique (Harbison, et al., 1970; Sorguc et al., 1976).

In this chapter, the patterns of development including that of the development of road transport, in the 39 rural districts of Kenya are examined using composite scores. First, the composite indices of development are used as a basis for rank ordering, comparing and classifying the districts according to their levels of development. Second, the conceptual model is going to be sketched to establish the theoretical relationships among the concepts of road transport and socio - economic development represented in the model. The purpose is not just to show relationships as proposed but also to identify, statistically, the important linkages among the relationships, demarcate the problem of investigation and simplify the complex interrelationships, using a series of stepwise multiple regression analyses. Particular interest is focused on the relative influence of road transport on general development vis-a-vis, the influence of other socio - economic parameters of development, and vice versa. By assuming that road transport development is the most powerful determinant of the spatial variations in the pattern of general development, an attempt will be made to validate or otherwise the unsettled debate on the "cause-effect relationships" between transport and development (Storey, 1970; Wilson, 1966). The objectives are to generalise the findings to the situation in Kenya, discuss their implications for development planning in Kenya and to make inferences to the developing and developed World.

B. THE PATTERNS OF DEVELOPMENT: RESULTS AND INTERPRETATION

1. PATTERNS OF DEVELOPMENT

Table 7.1 (Appendix 9) shows the scores and rank positions of the districts on the levels of development measured in terms of the composite indices of development and Figure 7.1 maps the spatial variations in the overall composite index of development. The

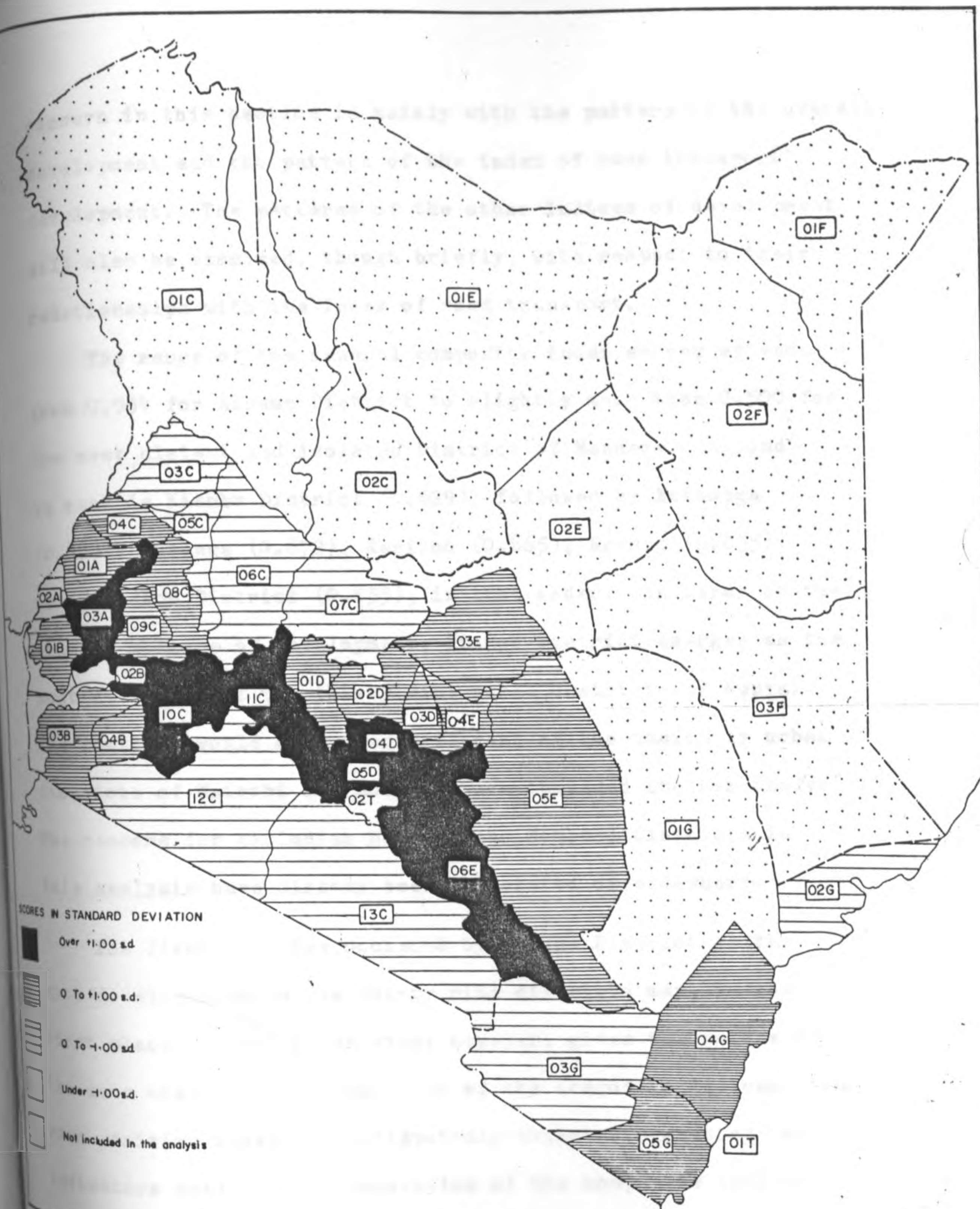


FIGURE 7·1 DISTRICT SCORES ON THE COMPOSITE INDEX OF DEVELOPMENT concern in this section is mainly with the pattern of the overall development and the pattern of the index of road transport development. The patterns of the other indices of development will also be examined, though briefly, with respect to their relationships with the index of road transport.

The range of the general composite index scores extends from 0.954 for Kisumu District to slightly more than 0.500 for the most distant and isolated District of Mandera. Second in rank is Kiambu District (0.929), followed by Kakamega (0.888), Muranga (0.872), Kericho (0.865), Nakuru (0.855) and Machakos District (0.855), in that order. In terms of the general measure of development, Kisumu District emerges as the most developed of the thirty nine rural districts of Kenya. The position would have been different if the basically urban districts of Nairobi and Mombasa were included in this analysis. The reasons for excluding Nairobi and Mombasa districts in this analysis have already been elaborated on elsewhere.

The first position occupied by Kisumu District as the most developed among the thirty nine districts may, in the first place, appear surprising; however, given the nature of the data used in the computation of the composite indices, its rank position should be undisputedly expected. Most of the indicators used in the computation of the composite indices of development had values that were inherently "quantitative" rather than "qualitative". Not qualitative in the sense that, for example, the data for indicators of agricultural development or education development did not represent the actual monetary values in agricultural production or the quality of the type of educational achievements. This position applies to a number of indicators used in this analysis. Notwithstanding this reservation, this section examines in a little more details, the rank positions of the districts in the general development score in perspective, and suggest some possible explanations.

Kisumu District, with Kisumu town as its core, has occupied an important strategic position in terms of economic, social and political development since the beginning of colonial days in this country. It was the original terminus of the Uganda Railway. Kisumu town was the administrative headquarters for all the present districts of Nyanza Province, Western Province and some districts of the present Rift Valley Province. The first roads to be built in western Kenya started from or reached Kisumu District (then Central Nyanza) then connected it with the neighbouring districts. Parts of Kisumu District were designated as buffer zones and attracted European and Indian farmers for settlement in the early stages of the development of this country. Moreover, Kisumu town (in Kisumu District) is the third largest town in Kenya (1979 Population Census, 152,643) after Nairobi and Mombasa. So one would expect, in the absence of Nairobi and Mombasa District in the analysis, Kisumu to occupy the rightful position according to the data used in this study.

It was also observed in the analyses of the inter-district passenger and commodity flows that Kisumu District was one of the leading and sometimes the leading dominant nodal district. The only districts that competed with Kisumu as independent nodal districts were either Nairobi or Mombasa. Given all these considerations, Kisumu District, clearly, must be one of the districts which attracted the colonial government development efforts and these marks of development are still manifest. Some of the earliest schools, and hospitals in this country, such as Maseno and St. Mary's Yala and the Old Nyanza General Hospital, for example, were established in Kisumu District. It is, therefore, not surprising that Kisumu District scored highly on the composite index of development as the most developed. It should, however, be noted that the high performance of the district is mainly attributable to the inclusion of data for the considerably more developed Kisumu Town.

Kisii and South Nyanza Districts (in Nyanza Province) occupy the 8th and 9th positions respectively, while the young Siaya District is in the 20th position. Siaya District was part of the old Central Nyanza District with Kisumu town as the administrative headquarters, until the mid-1960's when the new district was created. Much of the area in which development was concentrated in the old district remained within the administrative boundary of Kisumu District. South Nyanza was ranked as one of the least developed districts occupying the

25th position out of 41 districts by Soja (1968) using factor scores on Development Dimension extracted through the principal components method. It is almost twenty years ago since Soja's study was conducted, and it is true that a number of developments have taken place in South Nyanza since then, for example, the Awendo Sugar Factory. He pointed out, however, that the rank position of South Nyanza District was anamolous, as it is a fairly well densely populated district with high potential for agricultural production and commercial possibilities. It is no wonder, therefore, that South Nyanza now occupies a position among the first ten well developed districts in the country. South Nyanza ranks fourth, fifth, eighth, third and tenth on transport, population, health, education and communication indices, respectively. When the scores are aggregated at the provincial level, Nyanza Province takes the leading position as the most developed out of the seven provinces (Table 7.2).

In Central Province, Kiambu District, Muranga, and Nyeri District rank among the first top ten districts as highly developed. Kiambu District as was pointed out ranks second after Kisumu District. This is, however, consistent with general expectation. In fact, the district has kept unbeaten record in standing in the second and third positions in all the indices of development, except in education and agriculture where the district ranked ninth and eleventh, respectively. Its ninth position in education seems to betray general expectation, but as was pointed out

TABLE 7.2 THE RANKING OF PROVINCES ON THE COMPOSITE INDEX OF DEVELOPMENT

PROVINCE	SCORE ON COMPOSITE INDEX	RANK
NYANZA	0.840	1
CENTRAL	0.824	2
WESTERN	0.797	3
EASTERN	0.705	4
RIFT VALLEY	0.702	5
COAST	0.693	6
NORTH EASTERN	0.544	7

Source: Author's own calculations from Table 7.1 (Appendix 9) earlier, the data on education does not reflect educational quality i.e. levels of achievement, the status of the schools etc. Kiambu District has been described as one of the most favoured districts outside the formerly settled districts because of its close proximity to Nairobi (Soja, 1968). It was one of the first districts in Kenya to be settled by the white farmers, to respond favourably to the British administration and to receive a fairly close network of roads. Today the district can boast as one with the closest network of bitumen surfaced roads in the country and the leading, mainly rural, district industrial unit in the country. The list can be endless. All these achievements can be attributed to the physical and economic potential (possibilities) and predisposition of the district. A number of development projects have been channelled into the district both in pre-and post-independence periods. That Kiambu should rank second, as the most developed as gauged by the index of general development, should have been expected. More or less similar reasoning could be preferred in the cases of Muranga and Nyeri Districts, but there is no need to elaborate any further.

The only districts in the province that rank low in the general index are Kirinyaga and Nyandarua, but in each case not below the mean score (0.726). Both districts are new and young and should not be expected to have reached the development standards that have been achieved in the districts of Kiambu, Muranga and Nyeri. Central Province, as expected, ranked second after Nyanza Province in the overall development.

Only Kakamega District in Western Province ranks among the first top ten as one of the highly developed districts. Bungoma and Busia Districts occupy the thirteenth and twenty second positions, respectively: Bungoma with the overall development score above the mean and Busia below. Kakamega District stands in the third position in the overall index of development and in the first position in population and education indices. The district is the second highly densely populated district in the country after Kisii District. To a large extent, high population density can be associated with development. A district unit with a large number of people needs more roads, more educational facilities and more health care centres. No wonder Kakamega District ranks among the first top ten in education, health, agricultural, transport and communication indices, all of which are fairly well correlated with population density. In aggregate, Western Province occupies the third position among the highly developed provinces.

From Eastern Province, only Machakos ranks among the first top ten highly developed districts. Meru, Kitui and Embu Districts rank as eleventh, twenty first and twenty third in the general development index. As would be expected, Marsabit and Isiolo Districts are among the least developed districts in the country and stand in the thirty-fourth and thirty-seventh positions, respectively. The Province occupies the fourth position, with a below mean score in the general index, and ranks among the less developed provinces.

Generally, Rift Valley Province ranks as one of the less developed provinces and occupies the fifth position with an overall score of 0.702. Ranking among the highly developed top ten districts are the districts of Kericho (fifth) and Nakuru (sixth). Kericho and Nakuru have been and are still districts of considerable agricultural potential and development. Kericho ranks first and Nakuru tenth in agricultural index and Nakuru first in industrial and commercial, and in communication indices. Nakuru seems to have backslid fairly quickly from the high ranking position (third) the district occupied in Soja's factors scores in Development Dimension. Some of the reasons why the district's social and economic positions seem to be weakening have been discussed in Chapter 5, and there is no need to elaborate on them any further. The glowing account of the district, in praise of its development achievements, given by Soja are, if anything, the achievements of colonial settlers.

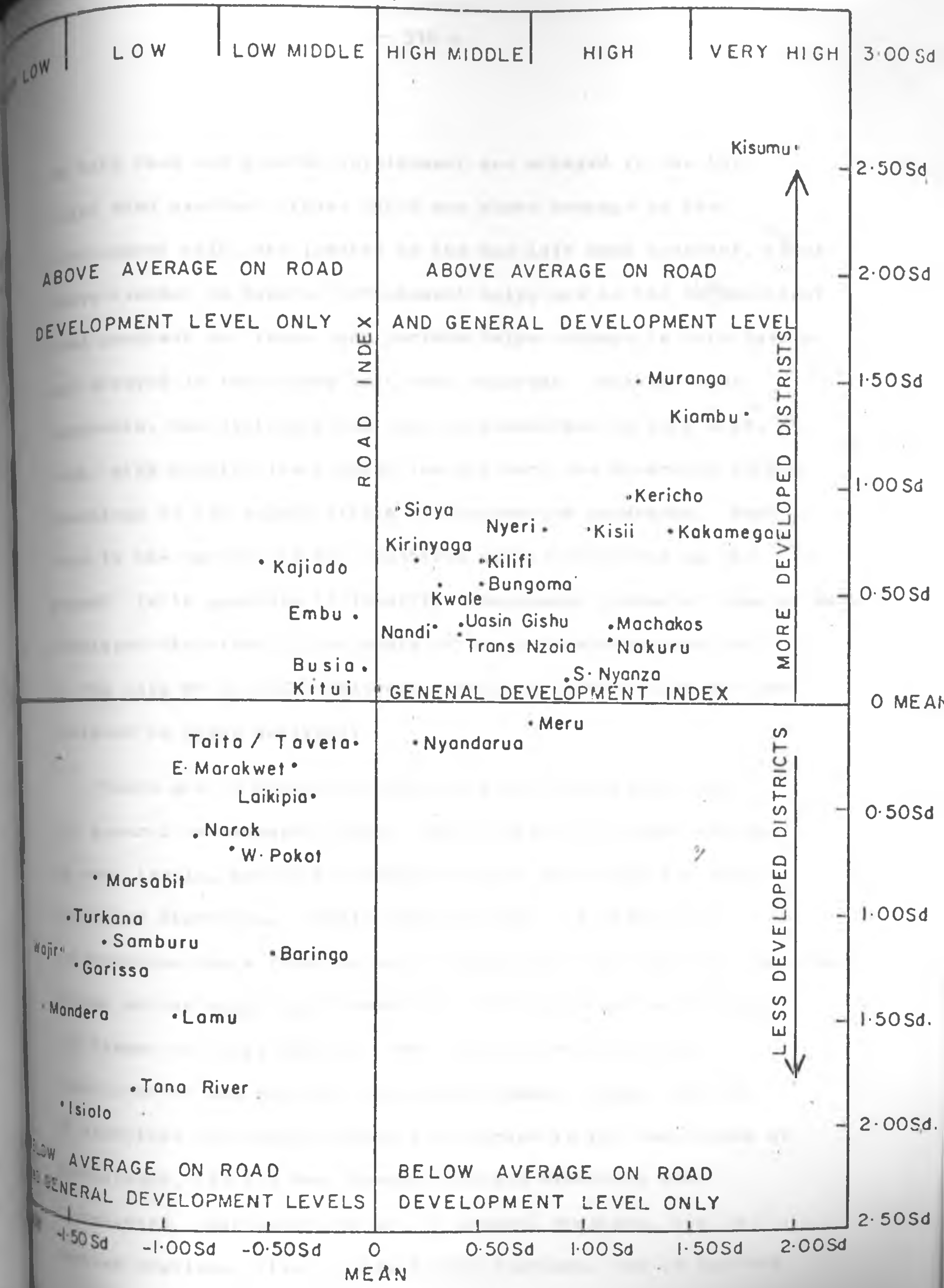
The other districts in Rift Valley Province with development scores above the average and, as such, rank as more developed are Trans Nzoia (fourteenth), Uasin Gishu (fifteenth) and Nandi (seventeenth). The remaining basically pastoral districts of the Province rank among the least developed. Laikipia, once a European settled district in Rift Valley, does not seem to have achieved much in terms of development. Its twenty fifth position in the general development index contrasts sharply with Soja's placing in the sixteenth position in his development dimension.

The second last, and last positions in the provincial rankings on the overall index of development are occupied by Coast (sixth) and North Eastern (seventh) Provinces. The two provinces rank together with Eastern and Rift Valley Provinces as less developed compared to Nyanza, Central and Western Provinces. However, the districts of Kilifi and Kwale in Coast Province have relatively high scores in the general development that place them among the districts that can be described as high-medium-developed. The isolated positions of the Coast Province districts seem to reduce the spread-effects of development which should reach them from the upcountry districts and from Mombasa. But it appears that such effects are already being felt in the districts adjoining Mombasa, such as Kilifi and Kwale, given their relatively higher-scores on the general development index compared to the other Coast Province districts.

2. THE RELATIONSHIPS BETWEEN THE LEVEL OF ROAD TRANSPORT DEVELOPMENT AND OTHER LEVELS OF DEVELOPMENT

When the joint distribution of the districts on the index of road transport development and other development indices are graphed, as in Figures 7.2 - 7.8, several scales are created, i.e. the scale of transport-general development (Figure 7.2), the scale of transport-population development (Figure 7.3), etc. An examination of the configuration of points on these scales points out more clearly the continuous and linear nature of most of the distributions, suggesting strongly the existence of significant relationships between the level of road transport development and other levels of development. Districts range from lower rankings at the bottom of the graphs to higher rankings at the top. It is not, however, very easy to identify homogeneous groups of less developed or more developed districts, given the evidence provided by the pattern of the distributions. Such allocation of districts to groups can only come from arbitrary segmentation of the continuous array or on the basis of information provided by the data and beyond that which has gone into this analysis. An attempt has been made to do that at the end of this section. Nevertheless, the graphs provide an impressive visual picture from which one can conveniently classify the districts on the basis of their performances on the scales of transport-development. Some in-depth analysis of transport-general development scale will be attempted here. The distributions of districts on the other scales can be readily analysed by the reader from relevant graphs and inferences and interpretations made accordingly. At the end of this analysis a comprehensive synthesis of the relationships between the scale of road transport development and other levels of development will be made.

Figure 7.2 is the graph of the relationship between the road transport and the general development levels. The graph is divided into four quadrants, which categorise the districts on the basis of their performance on the scale of transport-development. The districts with the above average performance



THE RELATIONSHIP BETWEEN ROAD TRANSPORT AND GENERAL DEVELOPMENT LEVEL on both road and general development are arrayed in the top right hand quadrant, those which are above average on road development only, are located on the top left hand quadrant, those above average on general development only, are in the bottom right hand quadrant and those that perform below average in both levels are arrayed in the bottom left hand quadrant. Within these quadrants, the districts can also be classified as very high, high, high middle, low middle, low and very low according to the locations of the points within the respective quadrants. What then is the pattern of the locations of the districts on the graph? Is it possible to identify homogeneous groups of less or more developed districts on the basis of the information provided by the data or on other relevant exogenous factors that are not included in these analyses?

There are 19 districts that are above average on road and general development levels, and 15 which are below average on both levels, giving two groups of more developed and less developed districts. Within these groups, the districts' performances range from the very highly developed districts such as Kisumu at the top, highly developed districts such as Muranga and Kiambu to those that are very low such as Isiolo and Tana River at the bottom in both development levels. Of the 19 districts with scores above the average in the two levels of development, all the four Nyanza Province districts are represented, four districts are in Central Province, two in Western Province, five in Rift Valley Province, two in Eastern

Province and two in Coast Province. There is therefore, a fair provincial representation in the pattern of districts distribution, except for North-Eastern Province from where there was no representation at this level. On the other hand, districts categorised as below average on both levels are predominantly in North-Eastern and Rift Valley Provinces with three in Coast Province and two in Eastern Province. The patterns in the top left hand and bottom right hand quadrants are less clearly marked. Meru and Nyandarua Districts perform reasonably well in general development and only low middle in transport development, while Kajiado, Busia and Embu Districts are only high middle in road development. The question to be posed is, what are the major characteristic features underlying these patterns of distribution? The key elements or typologies differentiating these distributions can be many and complex, but some important elements can be identified and examined.

The first can be identified as population density and sizes of the districts. All the 19 districts with above average performance on road and general development have population densities of over 100 persons per square kilometre of land, except Uasin Gishu, Nakuru, Kitui, Machakos, Kilifi and Kwale districts with below this number, which can be explained by their relatively larger sizes compared to the sizes of the majority of the other districts. Moreover, all the 19 districts have populations of over 250,000. The districts categorised as below average on road and general development have population densities below 100 and population sizes of less than 250,000

(Table 7.11, Appendix 12). Population concentration is a critical factor determining road network development as well as development in general. High population densities or large population sizes, thus appear to be both stimulus and response to development process. One should, therefore, expect to a large extent, districts with high population densities or simply with large populations to be more developed than those sparsely populated.

A second significant factor is the differentiation between those districts which are basically sedentary crop and livestock farming and those that are basically pastoral and nomadic. The characteristic feature of the districts which perform above average in both transport and general development levels is the former, while those that are below average in both levels is the latter case. Sedentary and, primarily, agricultural people are readily responsive to development forces than the mobile pastoralists. So it is evidently no coincidence that this group of districts should be strung at the top right hand corner of the graph as the more developed in both levels.

The third related variable is the influence of the railroad axis. This axis runs from Mombasa through the districts of Kilifi and Kwale to Kisumu and Kakamega Districts in Western Kenya, with a branch northwards through the Central Province districts of Kiambu, Muranga, Kirinyaga and Nyeri. Another branch runs through the districts of Uasin Gishu, Trans Nzoia and Bungoma. The only districts with above average performance outside this axis are Kisii, South Nyanza, Kitui and Nandi.

Out of the 19 districts classified as above average in both levels, 15 have road densities above 0.20 kilometres per square kilometre of land (Table 7.11, Appendix 12). Theoretically, these are the districts in which a person demanding transport by road to a service centre must travel on average less than 5 Kilometres and less than 10 Kilometres at the maximum to reach a classified road (Republic of Kenya, 1978). The close relationship between transport and development is well documented, and need no discussion. It is, therefore, not a surprise that this group of districts should form a cluster as the more developed than the 15 districts at the bottom left hand corner of the graph.

These three factors are not the only possibilities that can be used as a basis of segmenting the districts into less and more developed groups. In fact, the forces operating are not only economic, but can have equally important political, socio-cultural and psychological overtones. Others, such as the districts' areal sizes and climatic conditions, must be taken into consideration.

Table 7.3 summarises and synthesises the relationships between the scale of road transport development and other levels of development, with regard to the classificatory nomenclature adopted on the graphs. From the table, we can summarise in conclusion that 42.49 per cent of the districts emerge as above average on road and on the seven levels of development, 34.07 per cent below, 13.92 per cent above average on road level only and 9.52 per cent below average on road level only. Are these

DEVELOPMENT LEVEL	BELOW AVERAGE ON ROAD AND LEVELS 1-7	BELOW AVERAGE ON ROAD ONLY	ABOVE AVERAGE ON ROAD ONLY	ABOVE AVERAGE ON ROAD AND LEVELS 1-7	TOTAL
1. GENERAL DEVELOPMENT LEVEL	15	2	3	19	39
2. POPULATION LEVEL	16	1	3	19	39
3. AGRICULTURAL DEVELOPMENT LEVEL	9	8	8	14	39
4. INDUSTRIAL AND COMMERCIAL DEVELOPMENT LEVEL	13	4	7	15	39
5. COMMUNICATION DEVELOPMENT LEVEL	14	3	6	16	39
6. EDUCATION DEVELOPMENT LEVEL	14	3	3	19	39
7. HEALTH DEVELOPMENT LEVEL	12	5	8	14	39
TOTAL	93	26	38	116	273
PERCENTAGE	34.07	9.52	13.92	42.49	100.00

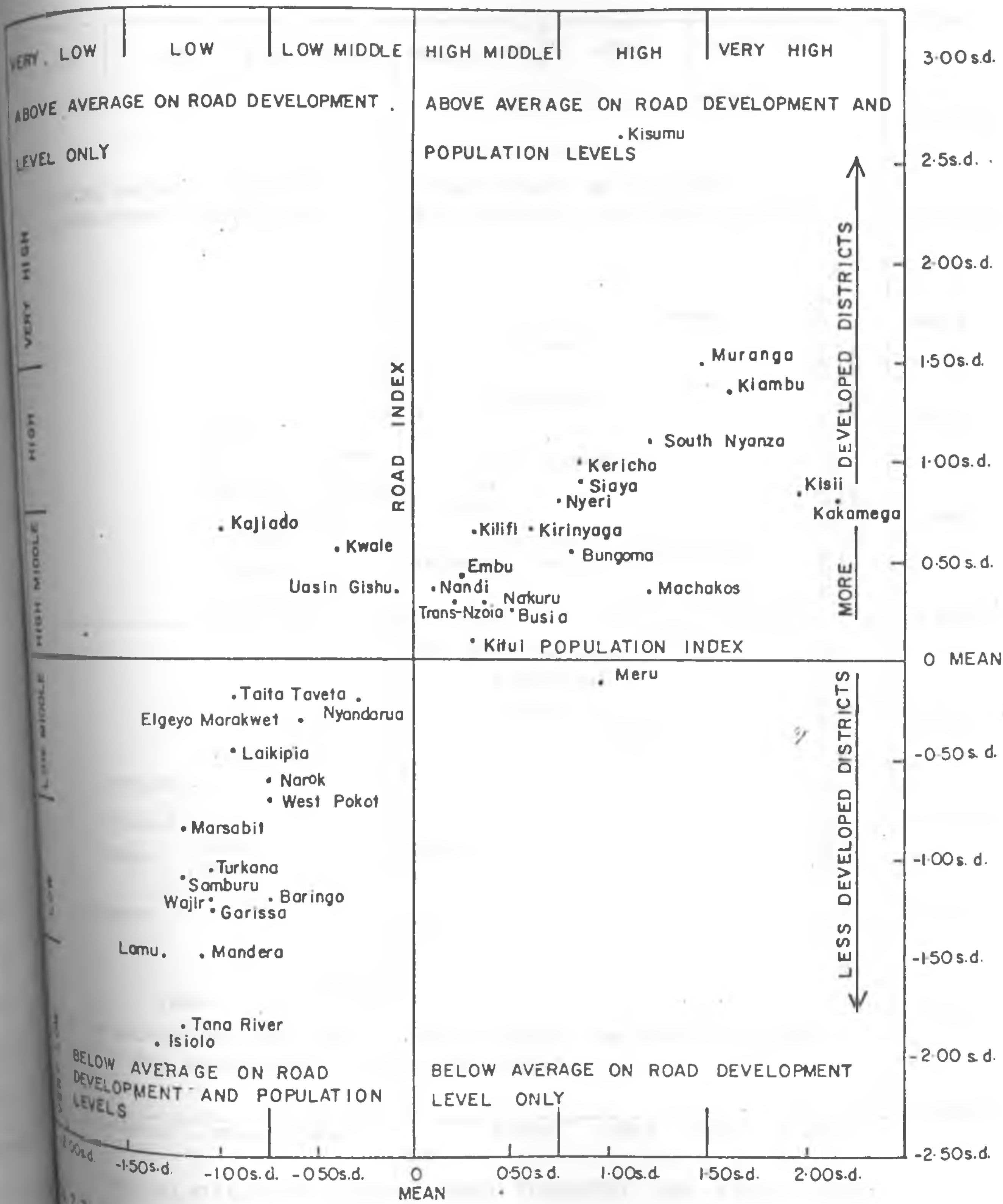
Source: Calculation's based on Figures 7.2 - 7.8.

relationships significant ? and if so, how strong are they ? To answer these questions, correlation and regression analyses were used to shed light on the form and strength of the relationships.

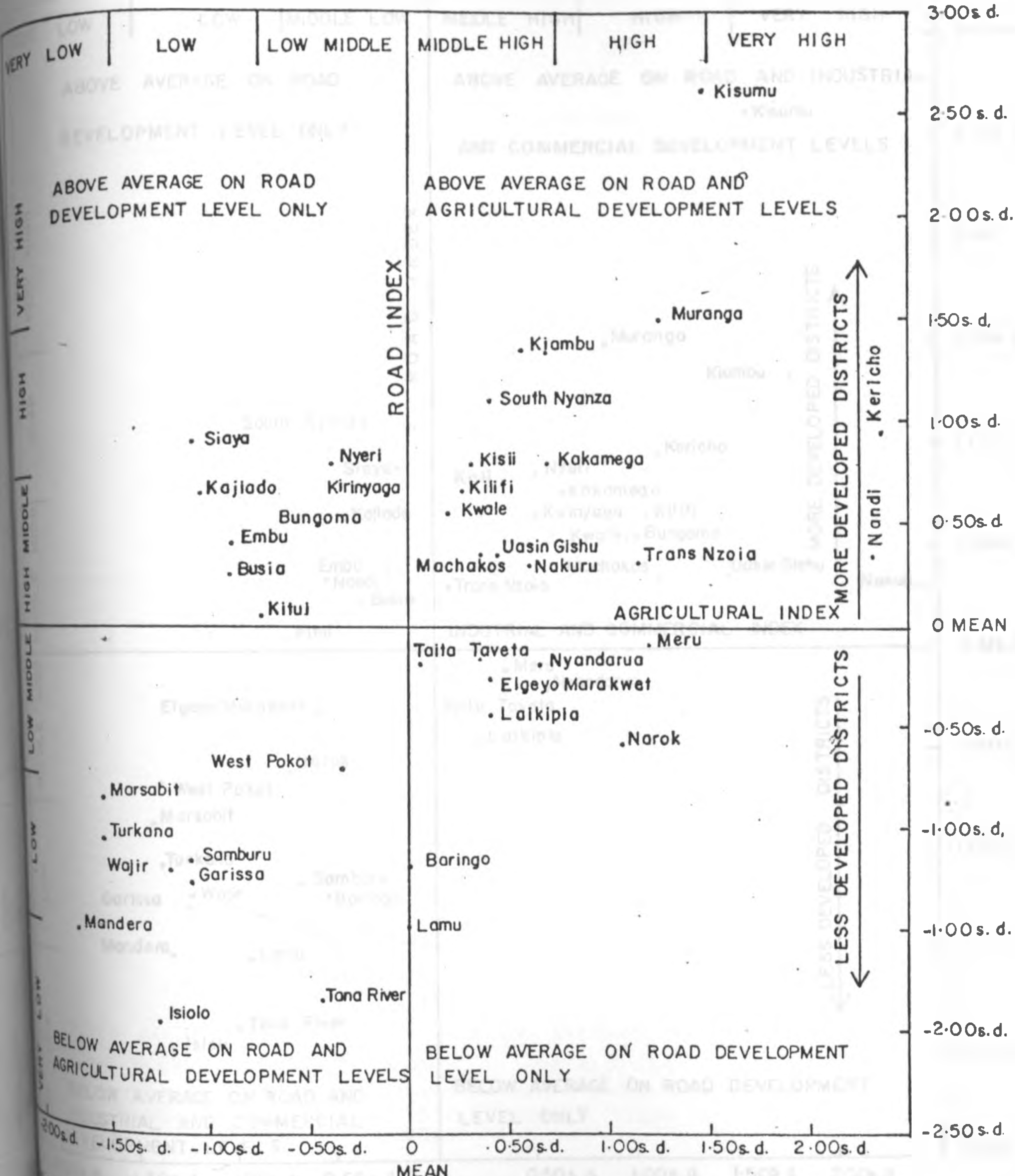
3. STATISTICAL ANALYSES AND INTERPRETATION

The graphs (Figures 7.2 - 7.8) show that the index of road transport development is closely related to the other indices of development, given the linear pattern of the arrangement of the points. However, it is difficult to tell from the linear pattern of the points how strong the relationships are from the graphical visual observation alone. Moreover, the strength of the intercorrelations among the other development variables, in addition to the strength of their relationships with the road transport development variable, needs to be known. To find out all these, bivariate and multiple correlation, and regression analyses were performed to determine how strong the relationships are.

The data on development indices in Table 7.4 (Appendix 10) were subjected to bivariate and multiple correlation and regression analyses. First , the strength of the bivariate correlation between dependent (composite index) and the seven independent variables was examined. The purpose was to discuss briefly the nature and strength of the correlations between the dependent variable and the independent variables and to decide on which independent variable to be entered in the first equation of the stepwise multiple regression analysis. Second, a stepwise multiple regression analysis was performed in order to examine the relative contribution of each of the independent variables to the total variance, with particular keen interest in the contribution of the level of road transport development.



7.3 THE RELATION BETWEEN ROAD TRANSPORT AND POPULATION LEVEL



7.4 THE RELATIONSHIP BETWEEN ROAD TRANSPORT AND AGRICULTURAL DEVELOPMENT LEVEL

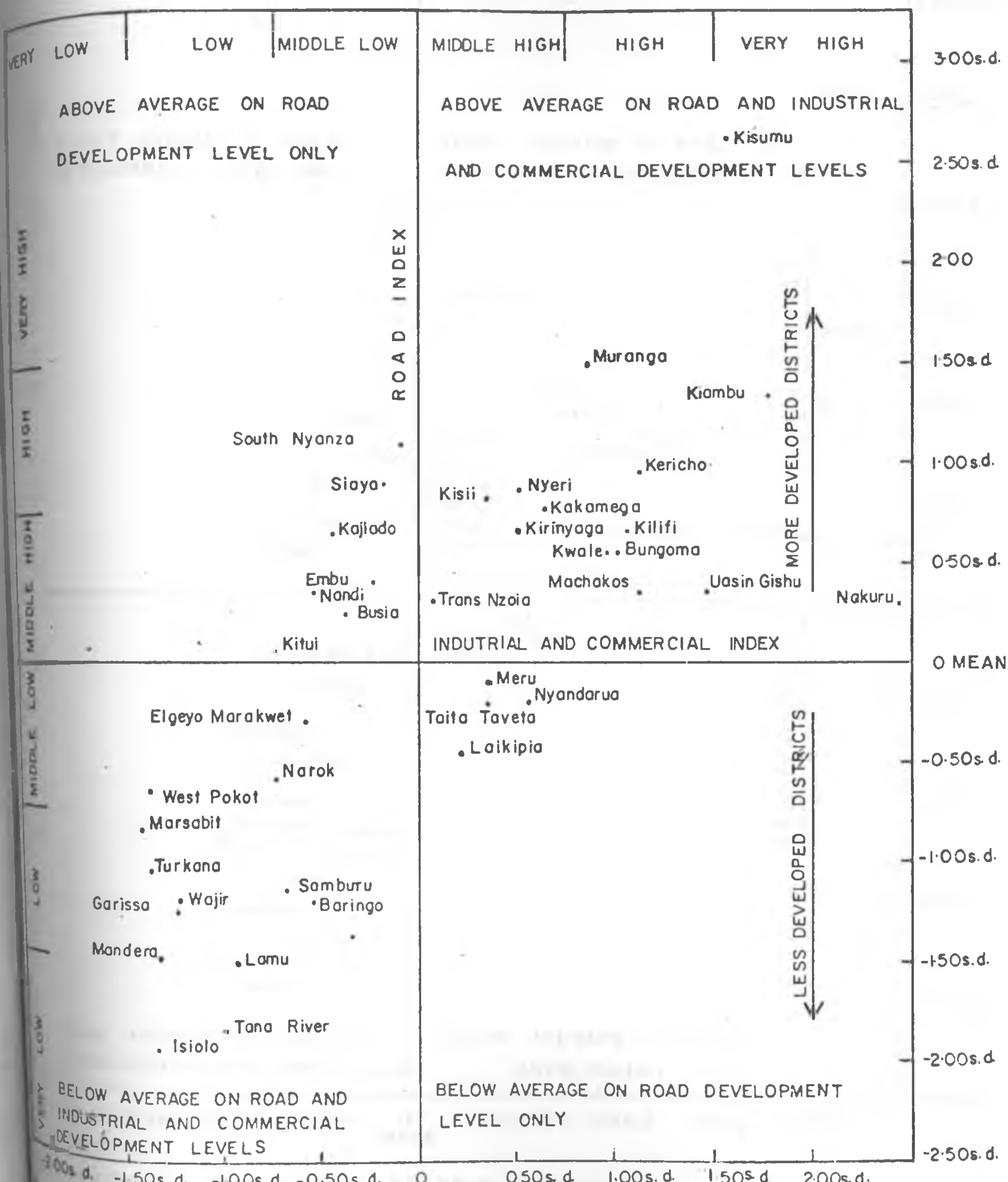
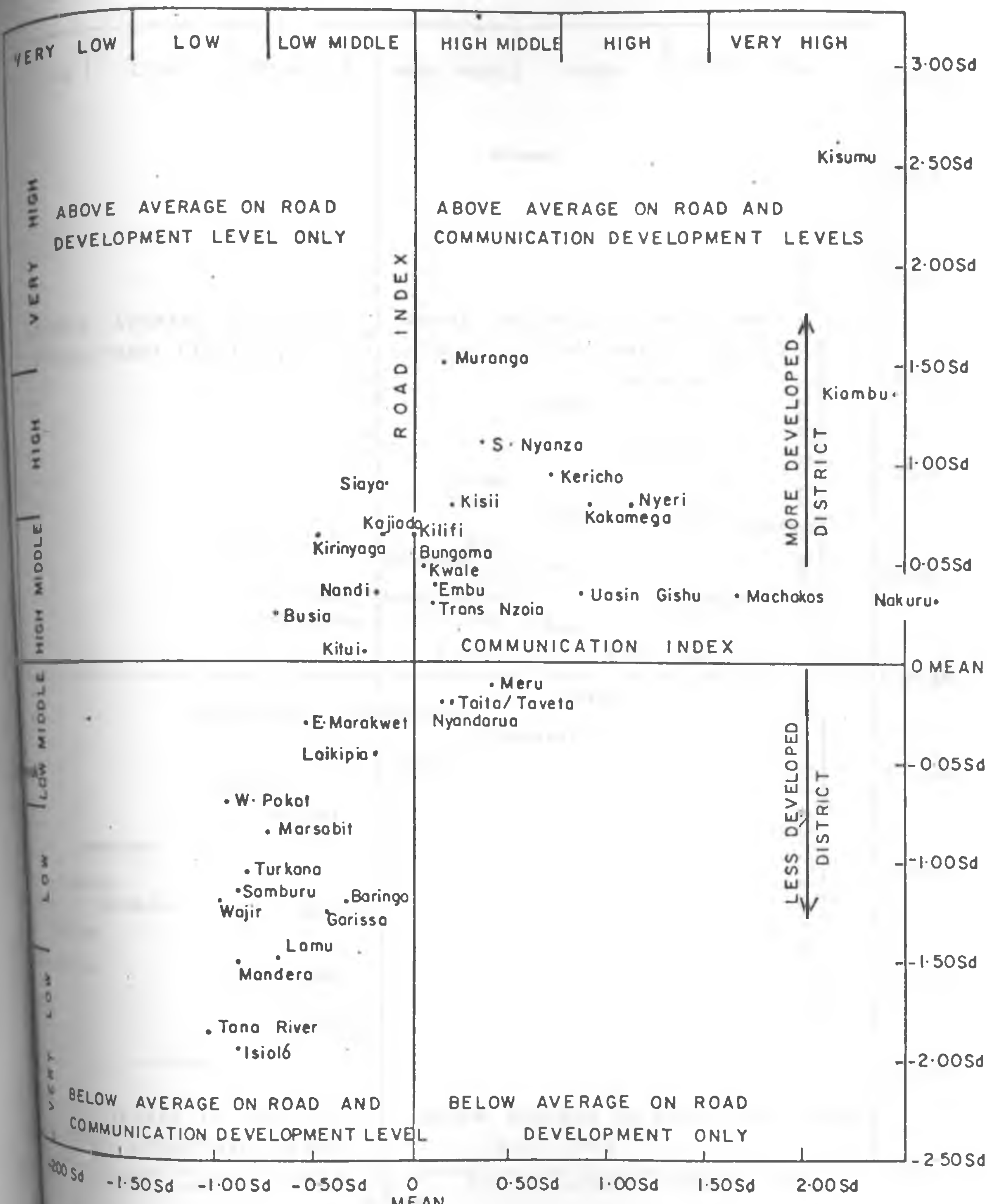
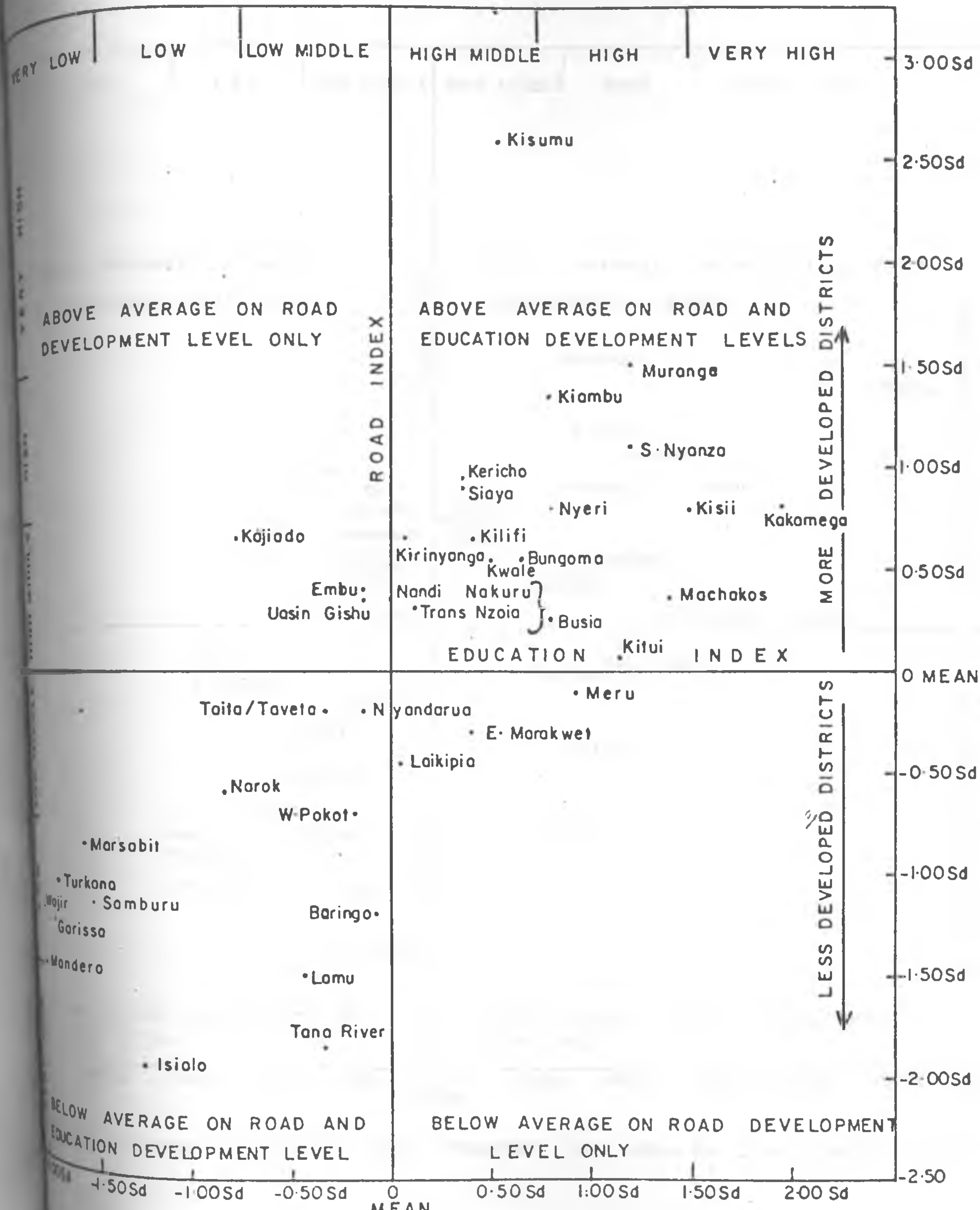


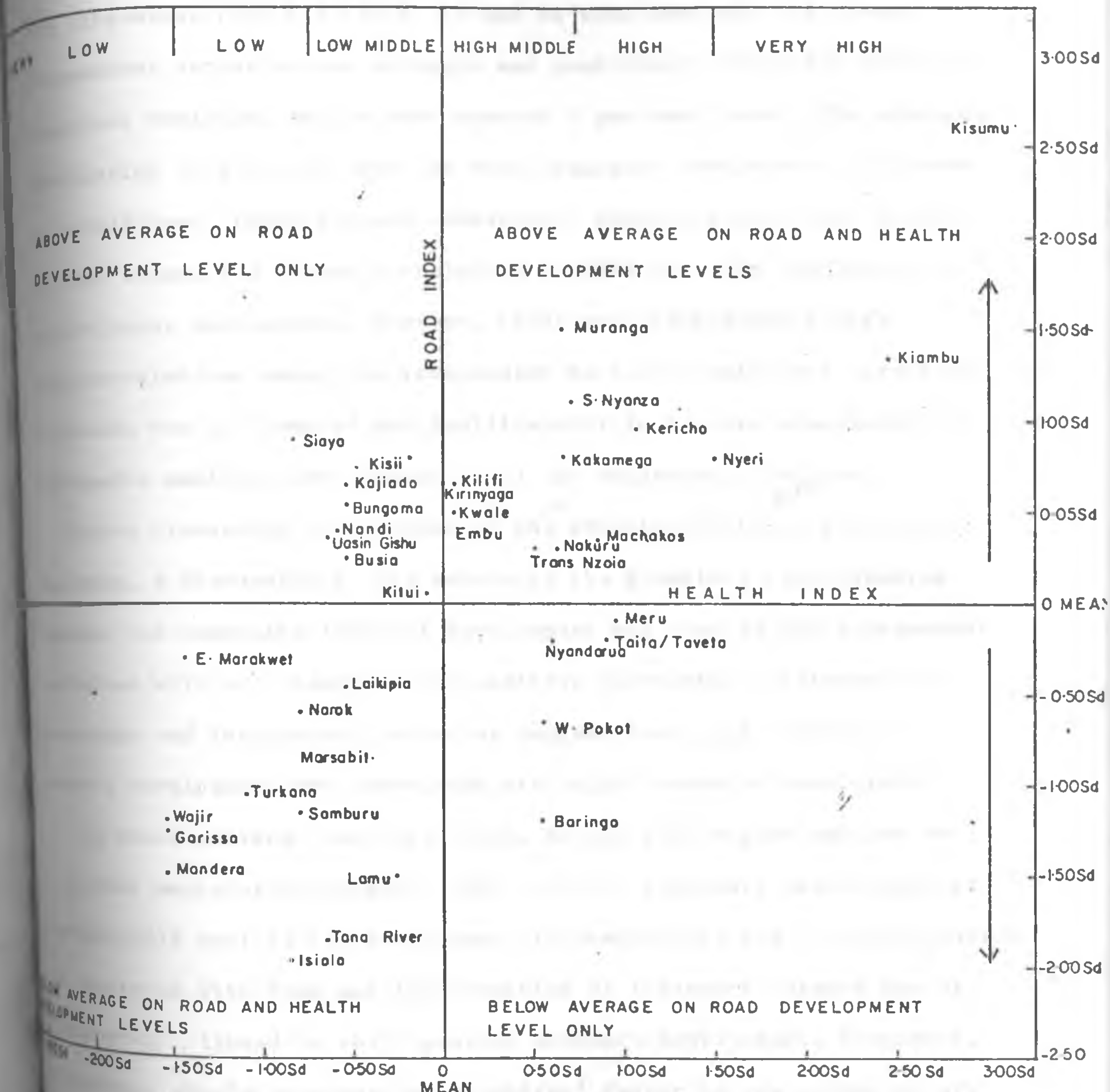
Fig 7.5 THE RELATIONSHIP BETWEEN ROAD TRANSPORT AND INDUSTRIAL AND COMMERCIAL DEVELOPMENT LEVEL



.7.6. THE RELATIONSHIP BETWEEN ROAD TRANSPORT AND COMMUNICATION DEVELOPMENT LEVEL.



THE RELATIONSHIP BETWEEN ROAD TRANSPORT AND EDUCATION DEVELOPMENT LEVEL



THE RELATIONSHIP BETWEEN ROAD TRANPORT AND HEALTH DEVELOPMENT LEVEL

Table 7.5 presents the bivariate correlation coefficients between the variables. From the table, it can be seen that all the seven independent variables are strongly and positively correlated with the dependent variable, and in each case at 1 per cent level. The strongest correlation is with the level of road transport development, followed by population, industrial and commercial, education and other levels in that order. The lowest correlation (0.694) was with the level of agricultural development. However, there are significantly high intercorrelations among the independent variables which are likely to introduce the problems of multicollinearity in the stepwise multiple regression analysis(see Chapter 3 (c) for suggested solutions).

Before discussing the results of the stepwise multiple regression analysis, a discussion of the nature of the bivariate relationships between the composite index of development and some of the independent variables will be attempted. The positive correlations between the dependent and independent variables suggest that high levels of general development are associated with high levels of development in the other sectors, and vice versa. As has been argued earlier and supported empirically(Haggett, 1969, pp.76), transport development is demonstrably part of the development infrastructure and the distribution of countries with high and low densities of transport network may be reasonably linked to their general economic development. Transport, therefore, should be viewed as a critical factor in the promotion of, not only, the general development, but also the development of other sectors of the economy. An area can have a high potential for development, but its resources can only be fully exploited if there is an efficient means of transporting the essential inputs and for marketing the products.

TABLE 7.5 MATRIX OF CORRELATION COEFFICIENTS BETWEEN THE EIGHT VARIABLES

VARIABLE	1	2	3	4	5	6	7	8
1. COMPOSITE INDEX	1.000							
2. TRANSPORT INDEX	0.895	1.000						
3. POPULATION INDEX	0.893	0.823	1.000					
4. AGRICULTURAL INDEX	0.694	0.522	0.494	1.000				
5. INDUSTRIAL AND COMMERCIAL INDEX	0.873	0.748	0.669	0.591	1.000			
6. COMMUNICATION INDEX	0.811	0.666	0.635	0.425	0.838	1.000		
7. EDUCATION INDEX	0.857	0.713	0.849	0.565	0.631	0.538	1.000	
8. HEALTH INDEX	0.784	0.657	0.582	0.529	0.651	0.737	0.583	1.000

All the coefficients of correlation are significant at 5 per cent and 1 per cent level.

without the means of transport, very little specialisation in production can take place. That the index of road transport development should correlate highly with the index of general development in the bivariate analysis lends support to these arguments.

The relationship between population and development can also be justified. The higher the population of a given area, the greater the demand for the other components of development. Other things being equal, it can be argued that the higher the level of development in a given unit area, the more concentrated the population. Similar lines of reasoning can be extended in the case of the relationships between general development and the other independent variables used in this analysis, but these need not be pursued further.

The findings as revealed in Table 7.5 cannot be used as a basis for establishing and identifying which of the independent variables is the most important contributor to the total variation in the composite index of development, leave alone the best predictor of the dependent variable. In order to see the relative contribution of the seven sectoral indices of development to the total variation in the composite index of development, a stepwise multiple regression analysis has been carried out.

Multiple regression is a general statistical technique through which one can analyse the relationship between a dependent or criterion variable and a set of independent or predictor variables. It may be viewed either as a descriptive tool or as an inferential tool. As a descriptive tool, multiple regression procedure can be used to summarise and decompose the linear dependence of one variable on others. As an inferential tool, it can be used to evaluate the relationships between the dependent and the independent variables from the examination of sample data(Nie, et al., pp. 321). One of the most important uses of the technique as a descriptive tool is to control for other confounding factors in order to evaluate the contribution of a specific independent variable or a set of independent variables to the variation in the dependent variable by stepwise multiple regression procedures. This is specifically the purpose for which the stepwise multiple regression procedure has been used in this chapter, and not as an inferential tool for hypothesis testing.

Stepwise multiple regression may be regarded as essentially a search or screening procedure. The procedure isolates, in particular , those independent variables which have critical causal effects(in a statistical sense) and as such should be retained in an equation to describe the variance or to predict other values of the dependent variable(Johnston, 1980,pp. 84). It is for descriptive purpose that the stepwise multiple regression procedures have been used in this chapter as opposed to the predictive and inferential purposes adopted in the preceding chapters. The reason for this is that the composite index of development(the dependent variable) is a weighted average of the other seven sectoral indices of development(the independent variables).

Tables 7.6 and 7.7 present the results of the stepwise multiple regression analysis. Population and industrial and commercial indices do not appear in the final stepwise regression equation because they were highly correlated(0.8 and above) with the indices of transport, education and communication, and because they reached insufficient F-ratio and tolerance levels(see Chapter 3 (c) for cut-off levels). From Table 7.6, it can be noted that the five independent variables took virtually all the variance of the general level of development, with the transport index explaining 80 per cent of the total variance.

TABLE 7.6 MULTIPLE COEFFICIENTS OF CORRELATION

VARIABLE	R	R^2	R^2 CHANGE
TRANSPORT INDEX	0.895	0.801	0.801
EDUCATION INDEX	0.948	0.898	0.097
COMMUNICATION INDEX	0.981	0.962	0.064
AGRICULTURAL INDEX	0.993	0.987	0.025
HEALTH INDEX	0.996	0.992	0.005

TABLE 7.7 STEPWISE REGRESSION COEFFICIENTS

VARIABLE	b[1]	b	STANDARD ERROR (b)
TRANSPORT INDEX	0.143	0.203	0.0009
EDUCATION INDEX	0.142	0.184	0.0010
COMMUNICATION INDEX	0.143	0.137	0.0015
AGRICULTURAL INDEX	0.144	0.151	0.0008
HEALTH INDEX	0.141	0.119	0.0013
(CONSTANT) a	0.001		0.0002

[1] Unstandardised regression coefficients used for prediction purposes

The addition of the other four variables into the regression equation resulted in the explanation of almost all the remaining 20 per cent of the variance. That the five variables should explain 99 per cent of the variation in the general level of development, with the two duplicate variables excluded, should have been expected since the scores on the general index of development are essentially the weighted sums of the component indices. However, the relatively higher contributions of the indices of transport, education and communication to the total variance are clearly shown in Table 7.6.

These findings lend support to the findings of Sorguc and his associates(1976). Their research, done in Turkey found a multiple correlation coefficient of 0.996 between the general index and sectoral indices similar to the ones used in this study. The transport index was the most important variable, followed by the indices of education and agriculture.

Another stepwise multiple regression analysis was carried out, this time with the index of road transport as the dependent variable and the other sectoral indices as independents The purpose of the analysis was to see the relative contribution of the chosen sectoral indices to the variation in the index of road transport development. An examination of the matrix of correlation coefficients, Table 7.5, shows that all the six sectoral indices of development are positively correlated with the road transport index, the highest correlation being with the population index and the lowest with the agricultural index. Rather than use all the six sectoral indices of development in the stepwise multiple regression analysis, a selection of four sectoral indices of development was made. These are population , agriculture, industrial and commercial and communication indices (Table 7.8, Appendix 11).These four variables seem, on a priori grounds, to be the most important determinants of the development of road transport. The education and health indices, though highly correlated with the index of road transport development, were excluded from the analysis.

Tables 7.9 and 7.10 show the results of the stepwise multiple regression analysis, indicating that only three independent variables have been retained in the final equation. The communication variable had low F-ratio and tolerance levels. Moreover, it was highly correlated with the industrial and commercial variable. The three remaining variables, together, explained about 75 per cent of the total variance, with population explaining 68 per cent of the variance. This finding reinforces and confirms the findings in Chapter 4, that population is the most important factor influencing the development of road transport.

These analyses show that according to the Kenyan experience, there are very close relationships between the development of road transport and general development on the one hand, and its components on the other. These relationships have been established graphically and by bivariate and multiple correlation, and regression analyses applied to development data through the taxonomy technique.

TABLE 7.9 MULTIPLE COEFFICIENTS OF CORRELATION

VARIABLE	R	R^2	R^2 CHANGE
POPULATION INDEX	0.823	0.677	0.677
INDUSTRIAL AND COMMERCIAL INDEX	0.864	0.748	0.070
AGRICULTURAL INDEX	0.865	0.748	0.000

TABLBE 7.10 STEPWISE REGRESSION COEFFICIENTS

VARIABLE	b[1]	b	STANDARD ERROR (b)
POPULATION INDEX	0.538	0.580	0.108
INDUSTRIAL AND COMMERCIAL INDEX	0.400	0.347	0.142
AGRICULTURAL INDEX	0.026	0.019	0.144
(CONSTANT) a	0.016		0.165

1 Unstandardised regression coefficients used for prediction purposes.

C. SUMMARY

In this chapter, a set of 18 intercorrelated indicators of socio-economic development were combined to generate a composite index of general development and seven sectoral indices of development using the multivariate taxonomy technique. The indices have been used to rank, compare and classify the 39 administrative districts of Kenya according to their levels of development. The patterns of development have been mapped and illustrated graphically. It was found that, in each of the eight indices of development, the districts with higher scores are located in Nyanza, Central and Western Provinces. That the developed districts should be found concentrated in relatively few areas is not a case unique to Kenya alone. As Ullman(1958) puts it, development concentration is not only characteristic of developing countries, but is a dominant feature of the more advanced countries as well.

The graphs showing the joint distributions of the districts on transport-general development scale and other indices of development suggest that there are some underlying elements differentiating the more developed districts from the less developed ones. The analysis of the graphs suggested three major factors that can be used as a basis for categorising the districts as more or less developed. These are population densities and sizes of the districts, the predominant type of agricultural practices and the ease of access to road and rail transport.

Districts with larger populations and higher densities , those in which sedentary farming practices are predominant and those with high road network densities and access to rail heads rank higher in development scores than those without. These three elements are not the only possibilities, however, because the forces operating can be many and complex. Others, which may be of physical, socio-cultural and political nature , can equally be important.

Significant relationships between the general level of development and the other levels of socio-economic development have been established statistically by the use of bivariate correlation analysis. The highest correlation was with the index of road transport development . A further analysis applying stepwise multiple regression analysis to the data showed that the indices of transport, education, communication, agriculture and health explained 99 per cent of the variance of the index of general development , with the index of road transport development emerging as the most important contributor. The simple correlation coefficients between the level of road transport and other sectoral levels of development show that they are positively correlated, the highest correlation being with the population level. The second stepwise multiple regression analysis applied to four sectoral indices of development as independents, with the road transport index as the dependent variable, showed that the indices of population, industrial and commercial levels were the most important contributors to its total variance. The index of agricultural development contributed very little to its total variance. From these findings, it can be concluded that transport/development relationship is a two-way one. Transport and development or its component elements are mutually dependent. Both are functionally related.

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CHAPTER EIGHT

CONCLUSIONS

A. INTRODUCTION

This study examined the development of road transport system of Kenya and its interactions with the socio-economic components of development. Five lines of investigation were pursued. First, a historical survey of the origins, growth and development of the road network system was presented, with major stages in its evolution and underlying causes identified. Second, the identified stages in its growth and development were compared with the ideal-typical sequence model proposed by Taaffe and his associates (Taaffe, et al., 1963). Third, an assessment and evaluation was made, with respect to the nature, form and degree of the network's relationships with selected indices of socio-economic development and land areas of the administrative districts. The fourth line of investigation involved the analysis of the patterns of passenger and commodity flows. Lastly, composite indices of socio-economic development were calculated with a view to ranking comparing and classifying the districts according to their levels of development, and to establishing the levels of their interaction with the index of road transport development.

In order to determine the significance of the findings of the five lines of investigation, the following hypotheses were formulated and tested. The first hypothesis tested was that the development of the road network system is determined to a large extent by population, levels of agricultural development and the areas of the district units of observation. Second, that there is a significant difference between the stages of growth of the Kenya road network system and those of the ideal-typical sequence of network growth model. Third, that the spatial variations in the volume of passenger flows can be explained in terms of socio-economic characteristics of the districts and the distances separating them. Fourth, that the spatial variations in the volume of commodity flows can be explained in terms of socio-economic characteristics of the districts and the distances separating them. All these hypotheses, except the second hypothesis, were formulated within the framework of the conceptual model of transport development (Figure 2.1) and tested statistically by stepwise multiple regression procedures.

In this concluding chapter, a synthesis will be made of the major strands of the materials in the preceding chapters. First, a summary of the major findings as revealed by the tested hypotheses will be presented. This will be followed by a summary of other findings not hypothesised, but revealed by other ways in which the data were analysed and presented. Major contributions made by the study to the broad field of transport geography, to transport geography of Kenya and to the geography of the country's development will be outlined. The chapter closes by concluding remarks, recommendations and suggested future lines of investigation.

B. MAJOR FINDINGS AND CONTRIBUTIONS

1. MAJOR FINDINGS AS REVEALED BY TESTED HYPOTHESES AND THE RESULTS OF CORRELATION AND REGRESSION ANALYSES

The simple correlation analysis applied to the road network development data to establish the nature and degree of its relationships with the index of population, level of agricultural development and land area showed that the highest correlations were with population (0.85) and with land area (-0.75), and the lowest (0.56) was with the level of agricultural development. The negative correlation with land area indicates that higher densities of road networks are characteristic of districts with smaller areas, while larger districts tend to have low densities of networks. This should generally be expected, as a large sparsely populated unit will require a large per capita road investment to be served compared to a small densely populated unit. When the data were subjected to the stepwise multiple regression procedure, the first equation showed that population alone explained 73 per cent of the variation in the distribution of road network. The additions of land area and the level of agricultural development into the second and third equations increased the level of explanation by 6 and 1 per cent, respectively. Tests for the significance of these relationships showed that population and land area were the only significant explanatory factors. The failure of the level of agricultural development as an independent variable to reach a sufficient level of explanation is surprisingly unexpected, given the amount of effort the colonial government and the present government of the Republic of Kenya have devoted to the construction and improvement of rural access roads and roads in the districts of high agricultural potential. However, other factors, such as the establishment of colonial administration and the spread of white settlements in the early years of this century seem to have had considerable influence on the present pattern of road network distribution. This is particularly reflected in the formerly white settled districts such as Nakuru and Trans Nzoia for example, and in the districts such as Kisumu and Kiambu in which local governments were strongly established and colonial administration closely monitored. These districts have closer networks of roads compared to the formerly "closed districts" such as Samburu, Isiolo, Baringo etc.

With respect to the comparison of the stages of the evolution of the network with those of the ideal-typical sequence model, it was found that the Kenya road network system has developed through three main stages comparable to the second, third and fourth phases of the Taaffe model. The first stage, can be said, began with the construction of Mackinnon and Sclater Roads towards the end of the nineteenth century and continued upto about 1920. This period witnessed the construction of one penetration line of connection (the Mackinnon-Sclater Road) from the coast and several others in the interior parts of the country to link established centres of British administration and areas of white settlement during the first and second phases of settlement in the highlands. The second stage ran from 1920 to 1940 when several lines of inter-connection tied together newly white settled districts of Trans Nzoia, Laikipia and Nanyuki with the old ones, and the already established centres of administration in the African and white settled districts. The third stage, which is not yet completed, began after 1940 and represents a continuation of the construction and the intensification of inter-connecting lines reinforced by the emergence of high priority linkages represented by major bitumenisation programmes such as those of Nairobi-Nakuru-Kisumu, Nairobi-Thika-Nyeri and Nairobi-Mombasa Roads and other smaller programmes completed and still in progress. According to this study, the first phase in Taaffe model, "scattered ports," is relevant to the development of ports, and as such cannot be considered as the first stage in the development of the modern Kenya road network system. The Taaffe model seems to have considered the growth and development of ports, railways and roads simultaneously, while this study considers only the sequence of road network development.

The application of the stepwise multiple regression analysis to the movement of passengers using the gravity model formulation showed that distance was the most important factor explaining

49 per cent of the variation in the volumes of passenger movement between Nairobi and the 40 district zones of passenger generation. The addition of population to the equation increased the level of explanation by about 16 per cent. But when the number of vehicles generated was included, there was no significant increase in the level of explanation. Moreover, population and the number of vehicles generated were highly correlated indicating that its influence had already been absorbed by the influence of population as a measure of mass. An examination of the map of dominant flows (Figure 5.4) suggested that the locations of the dominant nodal districts in relation to their hinterland districts and the impact of their traffic-shadow had considerable effects on the volume of passenger movements between the respective satellite districts and Nairobi. For example, Kakamega District sent 2636 passengers to the nodal district of Kisumu, but only 96 passengers to Nairobi, while Kisumu District sent 1308 passengers to Nairobi.

The performance of the gravity model when applied to commodity flow data was even much less encouraging. Employment earnings and distance as independent variables explained only 38 per cent of the variation in the volume of commodity tonnage shipped to Nairobi. Moreover, the explanatory power of distance turned out to be much weaker than it was the case in the movement of passengers. It would, therefore, appear that distance, as an impedence force, has more significant effect on the movement of people but less effect on the movement of commodities. This is reflected by its regression coefficients of -0.509 and -0.359 for passengers and commodity movements, respectively. Additional factors such as the locations of the nodal districts and their traffic-shadow effects and rail-road competition, as revealed by the analysis of the map of residuals (Figure 6.6) from transaction flow model, seemed to be closely associated with the unexplained variance. But Smith (1970) has one important observation which should be borne in mind in connection with regression analysis applying the gravity model as a tool for the explanation of the intensity and volumes of movement. He noted that in correlation-regression and gravity-potential methods of predicting volumes of flows, population (attractive mass) and distance (friction) appear to be the only two variables with any general applicability. Most other variables seem to be peculiar to a given situation. This may well be true with the suggested factors as revealed by the analysis of residuals from the transaction flow model.

The application of bivariate correlation analysis to composite indices of development demonstrated that they are significantly and strongly correlated with the index of overall development. In each case, the coefficient of correlation was not less than 0.60. The highest correlation was with the index of road transport development. The results of stepwise multiple regression analysis showed that the indices of road transport, education, communication, agriculture and health together explained 99 per cent of the variation in the level of general development. The index of road transport development was the most important explanatory variable. A further analysis using the stepwise multiple regression procedures to demonstrate that the relationship between transport and development is a two-way interaction process, showed that the indices of population, industrial and commercial and the index of agricultural development explained 75 per cent of the variation in the level of road transport development. The results of the correlation and regression analyses show clearly that transport and development and/or components of development are mutually dependent as cause-and -effect of each other.

2. MAJOR FINDINGS NOT HYPOTHESISED, BUT REVEALED BY OTHER TECHNIQUES OF DATA ANALYSIS AND PRESENTATION

A historical survey of the development of roads in Kenya shows that before 1890, the major commercial routes of communication between the coastal ports and interior centres such as Machakos, Eldama Ravine and Mumias were the caravan routes used by the Arab dealers in ivory and slaves. Except for footpaths and animal trails, there were no clearly defined routes of commercial significance in the interior parts of the country. The first modern roads to convey wheeled vehicles in Kenya were the Mackinnon and Sclater Roads. The former road, constructed in 1890 by a Mr. Wilson of the Imperial British East Africa Company, ran from Mombasa to Kibwezi and the latter constructed in 1894 by Captain Sclater, a leader of a team of Uganda Railway surveyors, ran from Kibwezi through Mumias to Busia on the Uganda border. From the year 1900 onwards, road construction works were carried out under the supervision of British administration. Major road construction works were concentrated in the white settled districts and in the African districts of western, and central Kenya and in those at the coast. Except for a few administrative roads, the districts in the northern and southern parts of the Rift Valley and those in the north-eastern parts were virtually roadless.

Closer road network densities are concentrated in western Kenya, central and at the coast. This is clearly illustrated by the road density surface map(Figure 4.4) which shows the concentric pattern of the density surfaces round the three core areas. Thus, one-quarter of the total area of the country is favourably predisposed, with high and medium levels of road density. The larger part of the country mainly to the north and east is characterised by low levels of network density. The pattern exhibited by the road density surface clearly shows the co-variant nature of the distribution of road network and the distributions of other aspects of socio-economic development of the country. From the analysis of the road network density surface map (Figure 4.4) and the maps showing the pattern of distribution of road networks (Figures 4.3 and 4.5) three broad zones of development in Kenya can be delineated. These are: (1) core areas of high network connectivity and development, (2) areas of emerging and positive road network development and, (3) the depressed areas of low network development.

The analysis of the inter-district movement of passengers by buses, matatus and private cars revealed that 42.6, 40.6 and 16.8 per cent of the passengers travelled by matatus, buses and private cars respectively. This finding contrasts sharply with the results of the 1976 National Origin-Destination Traffic Survey which showed that only 6.6 per cent of passenger trips were accounted for by matatus compared to 45 per cent of the trips accounted for by commercial buses (Republic of Kenya, 1978). Perhaps of special interest to businessmen in road transport industry, was the finding that areas of high movement potential correspond very closely with areas in which actual movements of passengers and commodities were more intensified (Figure 5.1, 5.2, and 5.3). The three areas, with their bases in western Kenya and central Kenya and a third one at the coast, attracted and generated the largest volumes of movement in the inter-district passenger flows. Particularly important were the districts of Kisumu (18.46%), Nairobi (18.40%) and Mombasa (6.22%). Distance and population sizes of the districts appeared to be closely associated with the inter-district volumes of passenger flows. Generally, the volumes of movement tended to fall between districts whose headquarters are more than 100 kilometres apart; and out of the 41 districts, 16 with more than 400,000 people accounted for over 75 per cent of the inter-district movements of passengers.

Kenya can be divided into three major dominant nodal regions with their bases on Kisumu, Nairobi and Mombasa Districts. These have been identified by the technique of dominant flow analysis applied to the matrix of passenger and commodity flows. Kisumu District dominated the western Kenya passenger flow system with a nested hierarchy established around Uasin Gishu District, while the central Kenya system was dominated by Nairobi with nested hierarchies defined around Nakuru and Embu. A similar pattern of dominance-dependence associations emerged when commodity data was subjected to the analysis. The major difference was that Nakuru and Uasin Gishu Districts established their own independent systems of dominant-dependent associations. Except for a few anomalous associations, these findings seem to be in agreement with general expectation. There are six designated development centres in Kenya: Nairobi, Mombasa, Kisumu, Eldoret, Nakuru and Thika (Ogendo, 1984). The fact that five of these towns were the convergent points in the dominant nodal districts, clearly is a reflection of the importance of these urban centres in the economic, social and political organisation of the Kenya space and of interactions around their respective hinterlands. In an attempt to describe communication structure and nodality in Kenya, Soja (1968, pp. 46 - 47) identified almost a similar pattern. However, any further interpretation of the significance of these dominance-dependence associations can only be meaningful after comparing and evaluating the results of other analyses with similar patterns of associations.

One of the major attempts made to analyse the pattern of the inter-district commodity flows was to express quantitatively the concept of complementarity. To do this the technique of transaction flow analysis was used to calculate the expected levels of the districts' shipment of commodities to Nairobi. The ratios of actual to expected quantities shipped yielded indices of complementarity, which were then compared with the districts' percentage of actual shipments. It was found that, in terms of actual quantities shipped, the districts of Narok (34.75%), Mombasa (26.63%), Trans Nzoia (8.21%) and Machakos (8.20%) were the leading shippers, but when these were compared with the indices of complementarity, the districts of Kitui (6.31), Narok (6.03), Nyeri (3.25) and Machakos (3.25) had the highest levels of complementary trade relationships with Nairobi. These findings clearly demonstrate that, in a system of commodity trade transactions, unless indices of complementarity are known, it can always be misleading to evaluate the strength of trade connections between places using the sizes of their shipment as a yardstick.

The taxonomy methodology generated indices of socio-economic development. The computed indices of general development, transport, population, agriculture, industrial and commercial, communication, education and health were used as a basis for ranking, comparing and classifying the 39 districts of Kenya with respect to their levels of development. Taking the first top three districts in each level, the rank positions of the districts were as follows: Kisumu, Kiambu and Kakamega Districts ranked highest in the overall development; Kisumu, Muranga and Kiambu in transport; Kakamega, Kisii and Kiambu in population; Kericho, Nandi and Muranga in agriculture; Nakuru, Kiambu and Kisumu in industrial and commercial; Nakuru, Kiambu and Kisumu in communication; Kakamega, Kisii and South Nyanza in education; and Kisumu, Kiambu and Nyeri in health. Thus the most developed districts on the basis of this rank ordering, are in Western, Nyanza, Rift Valley and Central Province. The rank positions of the districts in the general level of development (composite index) showed that 22 districts had above average scores. Among these are Kakamega and Bungoma in Western Province; all the Nyanza and Central Province districts; Meru, Embu, Kitui and Machakos in Eastern Province; Trans Nzoia, Uasin Gishu, Nandi, Kericho and Nakuru in Rift Valley and Kilifi and Kwale Districts in Coast Province. Clearly, the ranking of the districts on the composite index of overall development appears to be reasonable and consistent with general knowledge, thus giving credibility to the taxonomy method.

When the joint distributions of the districts on the graphs of transport-development scales were scrutinised, it was found that factors such as differences in population sizes and densities, predominant type of agricultural practices and ease of access to road and rail transport are major elements differentiating the more developed from the less developed districts. Most of the 22 districts with above average scores in overall development have larger population sizes and higher densities, are districts in which sedentary agriculture is predominant, have access to rail transport and higher densities of road network. The opposite is the case with the remaining less developed 17 districts. However, other typological differences such as the districts areal sizes, climatic characteristics, culture and other factors also appear as differentiating elements.

3. CONTRIBUTIONS MADE BY THE STUDY

The findings highlighted in the preceding two sections should be considered in total as major contributions the study has made to work in the general field of transport geography and specifically to the understanding and knowledge of transport geography of Kenya. While no absolute originality is claimed in the techniques of analysing the data presented in this study, the resulting findings, their interpretation and the conclusions arrived at, should be regarded as the products of this work. Among the scholars whose ideas and methodological approaches to the analysis of transport networks and patterns of flows were indispensable in this work are: Kansky (1963), Nystuen and Dacey (1961), Smith (1964) and Savage and Deutsch (1960). To all these scholars and others cited in the various chapters, the author is greatly indebted.

The application of the method of dominant flow analysis to the passenger and commodity flow data in order to identify dominance-dependence nodal regions of traffic movement in Kenya is an important contribution to the methodology in flow analysis. This method, originally suggested by Nystuen and Dacey is becoming increasingly popular in the analysis of inter-regional flows of phenomena such as telephone calls, money flows, passenger and commodity movements. Instead of subjecting the matrices of flows to matrix-powering procedures, which is the procedure followed by Nystuen and Dacey, this study considered only the raw data of direct flows between district pairs. The resulting groupings of the districts into dominance-dependence associations produced a flow structure which corresponds fairly closely with the expected nodal organisation of Kenya.

The application of the technique of transaction flow analysis to the inter-district commodity flow data, is yet another contribution this study has made to demonstrate its potential use in the analysis of movement data and to suggest an additional tool to the quantitative kit of transport geography. The technique identified districts interacting with Nairobi at higher or less than expected on the basis of the relative sizes of their shipments. The deviations from actual flows were mapped and relevant factors most closely associated with the observed deviations were discovered. Some of the factors were later used in the regression analysis using the gravity model formulation. The approach adopted in this study is similar to mapping residuals from a regression equation. The difference is that in transaction flow analysis, the mapping of residuals is a preliminary exercise aimed at identifying the relevant factors to be included in the regression analysis proper. The ratios of actual to expected flows yielded indices of complementarity. This method has been used by Smith (1964) in a study of agricultural commodity flow by rail to New England. The major difference is that in Smith's study, the expected volumes of shipment were obtained by regression analysis.

Politicians, economists, planners and geographers may want to compare their countries or regions with others in a geographical area or at similar levels of development for planning purposes. The taxonomy technique, used in this study, is an excellent methodology for making such comparisons, particularly when large numbers of indicators are used to measure various aspects of development. The methodology is an internationally recognised statistical tool for making comparisons of international development (Harbison et al. 1970, pp. 15). The major contribution this study made in its application, is the introduction of modifications in the procedures of calculating composite indices of development. The procedures have been outlined and described in detail in Chapter 3 of this work. These modifications should be considered as additional contributions to the original methodology. So far, the technique has not been widely used in the analysis of geographical problems. There is a greater scope for geographers to apply it in the various analyses of geographical problems, particularly where the analysis of large quantities of data on indicators of development is involved.

The conceptualised model of transport/development relationship illustrated in Figure 2.1 is an important contribution the study has made to the general field of transport geography. The model was based on Cooley's theoretical postulate that the character of a transport system, as a whole and in detail, is determined by its interrelations with the economic, social, political and physical forces and conditions of a given area (Hurst, 1974, pp. 15). This observation was made by Cooley about a hundred years ago. Since that time, a number of attempts have been made by transport geographers to design conceptual schemes to establish broader theoretical bases for transport studies (Ullman, 1956; Hurst, 1974; Hay, 1973). To all these efforts, the conceptual model proposed in this study must be considered as a significant additional contribution. An attempt was made within the context of the model to describe the operational concepts and to specify the nature of their interrelationships. A number of hypotheses were formulated to tie these relationships into testable forms. Not all the relationships specified in the model were tested. It is hoped, other scholars working at the same or different levels of analysis will test the validity of the untested but specified relationships in the model. Moreover, in its simplified form, the model can be expanded and/or modified to incorporate more complex relationships, including the relationships with the elements of the physical environment.

The graphic method showing the joint distributions of the districts on the index of road transport development and other indices of development demonstrated the linear nature of their relationships. The arrangements of points on the graphs arrayed the districts linearly from the more developed at the top to the less developed at the bottom of the scales. This is a useful method for classifying the districts into groups of very high-above average, medium high-above average, medium low-below average and very low-below average, in terms of their standard deviation scores in each of the indices represented. Moreover, the method was of considerable assistance in the identification of major characteristics differentiating the more developed from the less developed groups of districts and for generating further hypotheses before analysing the form and nature of the relationships by correlation and regression procedures.

Perhaps the most important contribution made by the study may be considered in terms of the materials assembled and presented to illustrate the various aspects examined in the study. The most important is the material relating to the history of road development in Kenya. The fragmentary bits of information were pieced together from diverse sources, ranging from annual reports of the Colonial Government, tables, maps and other archival sources. From these sources, it was possible to trace the history of the construction of major roads in this country. An attempt was made in the majority of cases to give the names of the roads, the years in which they were opened for public use, their length and the years in which the major towns they connected were established. A significant contribution on this line are the two maps designed specifically to show how the Kenya road network has evolved from 1890 and immediately after 1940 (Figures 4.1, 4.2). These new materials on road network development have considerably bridged the information gap that has persisted for many years in this country.

Most of the maps used to illustrate various aspects of this study, have been prepared for the first time and derive their origin from this study. Particularly new are the population potential map (Figure 5.2), maps (Figures 4.1 and 4.2) showing the evolution of Kenya road network system as examined in the preceding paragraph, the inter-district and provincial passenger and commodity flow maps, the maps of dominant passenger and commodity flows (Figure 5.2 - 5.5 and 6.1 - 6.6) and several others. All these maps and tables. accompanying the material covered in the thesis, must be considered important contributions the work has made not only to the knowledge of transport geography, but also to the knowledge and understanding of the geography of the country's development. The maps and tables should provide useful sources of information and can be used as source materials for further analysis and general reference.

C. CONCLUDING REMARKS AND RECOMMENDATIONS

1. CONCLUDING REMARKS

It has been established by the results of the analyses performed in this study that the most important socio-economic variable closely related to the development of road networks and patterns of movement is population or any socio-economic variable highly correlated with it. This was clearly demonstrated by its high correlations with the index of network development (0.85), vehicle generated (0.84), the index of road transport (0.82) and the composite index of development (0.89). These findings seem to agree with the conclusion of Taaffe and his associates, that much of the impact of other factors on transport system is expressed through their relationships to the population pattern (Taaffe et al., 1963). The negative correlations between land area and the index of road network development, population and with the level of agricultural development are worth noting. Clearly, this is an indication that large areal sizes of districts are a retardation to development in the various sectors of the economy. The negative area/development relationship deserves serious consideration with regard to the current policy in Kenya of "District Focus for Rural Development" (Republic of Kenya, 1983). Some of the provinces and districts in Kenya are too large for effective execution of development plans and administration.

The analysis of the inter-district spatial interaction patterns has revealed the dynamic structure of the spatial organisation of Kenya. The existence and strength of linkages between the districts, the hierarchy of nodal dominant districts and the extent of their hinterlands emerged most clearly from the comprehensive analysis and synthesis of the information provided by road network, passenger and commodity flow data. Some major conclusions which can be drawn from the analysis of these data include:

(a) Nairobi, Kisumu and Mombasa Districts are the most dominant in road communication network of Kenya, and this dominance is reflected in their hinterland population sizes of 8.4, 5.6, and 1.4 million, respectively. The districts of Uasin Gishu, Nakuru and to a lesser extent, Embu are emerging as potential competing nodes for the Kisumu and Nairobi spheres of influence.

(b) The coast and northern Kenya are major regions suffering from serious isolation from the rest of the country. Lack of interregional link with most parts of these two regions is strongly evident in the road network, passenger and commodity flow data analysed. For the coastal region, this lack of integration with the rest of the country is reinforced by the sparsity of road network linkages inland across a vast, nearly uninhabited area which lies interior to the coastal region. The only major link with the interior is by the international Mombasa-Nairobi trunk road. For northern Kenya, the hot and harsh climatic conditions and sparse population are major deterrent factors. Another deterrent factor is rugged topography.

(c) The relative positions of the independent dominant nodal districts in the interaction hierarchy of the secondary nodal districts such as Uasin Gishu, Nakuru and Embu and their hinterlands indicate the existence of macro-functional regions which may be useful for planning purposes in Kenya (Figures 5.4 and 6.3).

The above are among the most important aspects of the spatial organisation of Kenya which have become apparent through the analysis of the road network and spatial interaction data of passenger and commodity flows.

Although the regression analyses of the volumes of passenger and commodity flows using the gravity model formulations left considerable amounts of variance unexplained, the results show that population (mass) and distance (frictional force) are the only two important independent variables that explain, to some significant levels, the variations in the pattern of interactions. The effects of other additional socio-economic and/or transport generating factors seem to be subsumed, mainly, by the effect of population as a mass variable.

The taxonomy technique seems to be a reasonable tool of combining development data measured in different units. The major limitation of its use is lack of reliable data and clear definition of conceptually good indicators to be used as proxy measures of development. Clearly, there is a serious need for the collection of such data at the district and lower levels of aggregation, particularly time-series data. These should provide useful sources of information for researchers and development planners for constructing composite indices of development to compare the performance of units of development and as additional data to the armoury of information on indicators of development.

Much more revealing has been the ranking, and classification of the districts on the indices of road and composite development, and the identification of elements differentiating the more developed from the less developed districts. This should present a useful guide to policy makers and development planners of this country who are charged with the responsibility of designing and implementing programmes for the "District Focus for Rural Development". This is a new policy in Kenya that has made the districts the operational centres for rural development planning and implementation. From the analysis of data on indices of development, it appears that the more developed districts in Nyanza and Central Province, for example, have had disproportionately larger shares in the allocation of national resources for development compared to the less developed districts, mostly in Rift Valley, Coast and Eastern Provinces. This is, apparently, true in the case of the basically pastoral and nomadic districts of Kenya. One fundamental question to be asked is, are development planners and dispensers of resources for development going to continue to allocate more development funds to the districts that are already comparatively more developed or cut back the allocations in favour of the less developed ones? This is not an easy question to grapple with, in view of the differences in levels of development so far achieved, reflected by the ease or difficulty with which each district can be developed. Perhaps a policy of equitable allocation of funds for development that balances off the demands of the more developed against those of the less developed districts might be a reasonable panacea. But more importantly, the extent to which districts can be said to differ not only in their development pattern, but also in the kinds of pattern that are natural or normal for them because of typological differences must be taken into consideration.

2. RECOMMENDATIONS

(a) The difficulty of interaction between the coast and the interior parts of the country, especially between the isolated districts of Lamu and Tana River and the highland districts and beyond, could be reduced by developing an alternative all-weather road through Machakos and Kitui towns. This is likely to generate more interchange of people and goods between the coast and the rest of the country and to stimulate more economic development along the route and at the coastal end of the road. This is not currently the case when the only major access by road to the coast is via the Mombasa-Nairobi Road. Thus, the coast could be integrated with the rest of the country much more closely than is the case at present. Moreover, increasing interregional trade link with the northern coastal districts would be encouraged, particularly along the potential irrigable agricultural land in the lower Tana River Valley. This recommendation is based on data in Figures 4.3, 5.4 and 5.5.

(b) The present road transport system in Kenya is weighted heavily in favour of the better-watered districts. It is important that the growing contribution of the dryland districts in the north, north eastern parts and the Masai districts of Kajiado and Narok should be re-examined in view of the districts potential for intensive irrigated agriculture, general development of livestock economy and tourism. Most of the roads in the dryland districts are basically for local administration and are unusable in wet weather, except by four-wheel drive motor vehicles. In this respect, the pattern of roads, when considered in terms of quality and geographical distribution, is far less below that found in the better watered and agriculturally more productive districts of the country. This presents one of the main bottle-necks in the economic development and integration of the dryland districts with the major centres of economic development. The better roads in the northern districts of Kenya link them with the more developed districts in the south and not west-east with each other. There is, therefore, a serious need for the construction and improvement of all-weather west-east roads to tie the dryland districts together, in addition to the north-south roads, if the livestock products of the districts are to be accessible to the potential markets in the south. This recommendation is based on the information provided in Chapter 4 and in Figure 4.3.

3. SUGGESTED FUTURE RESEARCH AREAS

It is always not possible in a study as wide and complex, such as this, to cover all aspects of any transport system. It was, therefore, expected that the study of the development of road transport system of Kenya would point out several important sidelines which could provide research topics suitable for future investigation. To a limited extent, some of these sidelines were examined, though briefly, to provide answers which were crucial to the satisfactory completion of the current study. To list all the sidelines deserving investigation would be too long for the space available, hence a special selection of what appear to be the major topics directly relevant to the current study has been made. The suggested sidelines are as follows:

(a) A detailed study of the influence of physical characteristics of Kenya on the spatial pattern of road network distribution.

(b) A historical survey of the politics of road network development in Kenya, including the role of local governments and private organisations in the development of roads in the country.

(c) An evaluative study of the inter-district nodal accessibility and connectivity of the road network system.

(d) The quantitative and qualitative study of the growth of motor vehicle populations and their distribution with particular reference to the determining factors.

(e) A study of the relationship between the volume of traffic on the major road segments and the sizes of the connecting urban nodes.

(f) The detailed comparative study of the role of road and rail transportation in the movement of people and goods including the relative shares of road, rail and oil pipeline in the shipment of white oil from Mombasa to Nairobi.

(h) A study of cost-distance and time-distance relationships as reflected in the movement of people and goods between the major urban centres of the country.

(i) The influence of dominant nodes and their traffic-shadow effects on the movement of people and goods between districts.

The above suggested topics for future research relate mainly to aspects of the road transport and other modes of transport including the rail and oil pipeline. There are, however, two other sidelines which the analysis and closer examination of the district and provincial data used in this study suggest as areas meriting further research.

(a) A study of functional regions and central place hierarchies and their hinterlands with a view to establishing their suitability for use as a basis for development planning in Kenya as opposed to development plans that are based on district and provincial boundaries. It would appear that plans based on such regions as revealed by the inter-district flow data(Figures 5.4 and 6.3) would be invaluable for detailed location decisions in the country's planning process. Such a study should inevitably incorporate the analysis of more interaction data than the ones used in this study. Such additional interaction data should include telephone flows, newspaper and money circulation if more clearly defined functional regions and central place hierarchies and their hinterlands are to be delineated.

(b) A study to be carried out to identify the problems of administration, implementation and of monitoring development programmes in larger districts and provinces with a view to dividing them into smaller and manageable units. Rift Valley Province is a special case in this respect, but Eastern, Coast and North Eastern Provinces also fall in this category. The interaction data on passenger and commodity flows(Figures 5.4 and 6.3) suggest that Nakuru and Eldoret as central places can organise systems of viable economic districts around them if Rift Valley Province were to be divided into two. Furthermore, this study has demonstrated clearly that one of the major factors differentiating the more developed from the less developed districts is the differences in their areal sizes. Larger districts tend to exhibit lower levels of development compared to districts with smaller sizes (Tables 4.2 and 4.4; Figures 7.2 - 7.8). However, other typological differences such as population sizes and densities, climatic conditions and cultural practices should be taken into consideration.

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A P P E N D I C E S

TABLE 3.4 MATRIX OF CORRELATION COEFFICIENTS BETWEEN INDICATORS OF DEVELOPMENT

INDICATOR	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1														
2	-.14	1													
3	.16	.68	1												
4	.06	.74	.72	1											
5	-.14	.55	.51	.64	1										
6	-.16	.50	.42	.57	.96	1									
7	.08	.76	.74	.75	.58	.53	1								
8	-.21	.15	.28	.42	.28	.26	.24	1							
9	-.05	.30	.50	.53	.54	.52	.47	.84	1						
10	.17	.76	.67	.75	.52	.35	.82	.08	.26	1					
11	.28	.55	.44	.52	.39	.37	.55	.24	.13	.53	1				
12	.11	.82	.70	.74	.53	.46	.88	.13	.32	.38	.59	1			
13	.04	.82	.73	.75	.58	.54	.90	.13	.36	.12	.62	.99	1		
14	.32	.63	.75	.70	.56	.52	.80	.27	.46	.83	.35	.82	.81	1	
15	.03	.04	.21	.02	.02	.10	.06	.27	.30	.15	.02	.07	.07	.34	1

INDICATOR	1	2	3	4	5	6	7	8	9	10	11	
16	-.35	.20	.18	.27	.26	.24	.21	.55	.40	.04	.42	[illegible]
17	.09	.62	.47	.61	.40	.45	.74	.11	.30	.77	.42	[illegible]
18	.27	.40	.19	.32	.54	.62	.56	.21	.43	.25	.40	[illegible]
19	.18	.42	.34	.32	.42	.41	.46	.29	.41	.34	.31	[illegible]
20	.27	.79	.75	.80	.52	.46	.87	.09	.24	.94	.52	[illegible]
21	-.16	.98	.70	.75	.56	.49	.75	.14	.30	.80	.60	[illegible]
22	-.09	.18	-.22	-.02	.00	.63	.22	.12	.06	-.36	.23	-[illegible]
23	.29	.73	.75	.73	.48	.46	.83	.06	.27	.92	.43	[illegible]
24	.18	.64	.63	.76	.69	.63	.81	.31	.53	.77	.44	[illegible]
25	.06	.60	.67	.81	.72	.69	.86	.46	.66	.72	.58	[illegible]

Indicators Identification

1. Total Kilometrage of classified roads
2. Road density km/sq. km
3. Connectivity index
4. Number of passengers generated
5. Percentage wage employment in industry

...FOR INDICATORS OF DEVELOPMENT (CONT'D)

12	13	14	15	16	17	18	19	20	21	22	23	24	25
.21	.26	.20	.39	1									
69	.66	.85	.06	.11	1								
.40	.44	.42	.05	.28	.49	1							
29	.31	.36	.12	.34	.41	.79	1						
94	.85	.80	.03	.15	.77	.34	.24	1					
88	.88	.67	.02	.20	.66	.40	.31	.84	1				
24	-.33	.34	.06	.21	-.06	.03	-.15	.24	.25	1			
94	.91	.87	.02	.03	.66	.25	.21	.94	.78	.36	1		
80	.80	.83	.12	.35	.59	.50	.44	.81	.66	.24	.79	1	
76	.80	.78	.13	.46	.59	.57	.49	.64	.70	.05	.70	.87	1

6. Percentage earnings in industry
7. Wholesale and retail trade licences issued
8. Percentage employment in wholesale and retail trade
9. Percentage earnings in wholesale and retail trade
10. Total number of primary Schools

11. Primary School enrolment ratio

12. Number of Secondary Schools

13. Secondary School enrolment

14. Health facilities

15. Hospital beds per 1000 population

16. Health personnel per 1000 population

17. Potential agricultural production

18. Percentage wage employment in agriculture

19. Percentage earnings in agriculture

20. Total population

21. Population density per sq. km.

22. Population rate of growth

23. Service Centre Units

24. Post Office facilities

25. Telecommunication line Capacity

APPENDIX 2

TABLE 4.5 STAGES IN THE DEVELOPMENT OF ROAD NETWORK

1890 - 1900

	ROAD NAME		ROAD LENGTH (KM)
1.	Mackinnon Road from Mazeras to Kibwezi		296
2.	Sclater Road from Kibwezi to Busia		648

1900 - 1920

	ROAD NAME		ROAD LENGTH (KM)
1.	Voi - Taveta Road	(1902)*	120
2.	Mkonumbi - Witu Road	(1902)	35
3.	Malindi - Mambrui Road	(1902)	16
4.	Machakos Road Station - Machakos	(1902)	35
5.	Nairobi - Dagoretti Road	(1902)	13
6.	Nairobi - Ngong Road	(1902)	16
7.	Machakos - Kitui Road	(1902)	72
8.	Nairobi - Fort Hall (Muranga) Road	(1902)	96
9.	Londiani - Eldama Ravine Road	(1902)	35
10.	Kericho - Muhoroni Road	(1902)	42
11.	Mombasa - Vanga Road	(1902)	80
12.	Mombasa - Malindi Road	(1902)	96
13.	Kisumu - Mumias Road	(1902)	77
14.	Lumbwa - Kericho Road	(1906)	30
15.	Naivasha - Nyeri Road	(1906)	72
16.	Fort Hall (Muranga) - Nyeri Road	(1906)	42
17.	Nairobi Township Roads	(1906)	35
18.	Nakuru - Baringo Road	(1907)	144
19.	Nakuru - Rumuruti Road	(1907)	107

TABLE 4.5 STAGES IN THE DEVELOPMENT OF ROAD NETWORK (CONT'D)

	ROAD NAME		ROAD LENGTH (KM)
20.	Gilgil - Rumuruti Road	(1907)	104
21.	Rumuruti - Baringo	(1908)	67
22.	Naivasha Station West of Lake	(1908)	27
23.	Kiambu - Limuru Road	(1908)	30
24.	Fort Hall (Muranga) - Embu Road	(1908)	48
25.	Fort Hall (Muranga) - Kabarabaras Road	(1908)	26
26.	Fort Hall (Muranga) - Karuri's Road	(1908)	48
27.	Nyeri - Rumuruti Road	(1908)	72
28.	Nyeri - Karuri's Road	(1908)	64
29.	Nairobi - Limuru Road	(1909)	30
30.	Nairobi - Kiambu Road	(1909)	30
31.	Mazeras - Rabai	(1909)	5
32.	Kibwezi - Kitui Road	(1910)	130
33.	Nairobi - Fort Smith (Kabete) Road	(1910)	13
34.	Kisumu - Kaimosi Road	(1910)	42
35.	Kibigori - Nandi Hills Road	(1910)	35
36.	Nandi Hills - Kaimosi Road	(1910)	37
37.	Kendu Bay - Kisii Road	(1910)	45
38.	Homa Bay - Kisii Road	(1910)	61
39.	Kisii - Karungu Road	(1910)	74
40.	Kericho - Sotik Road	(1910)	56
41.	Sotik - Kisii Road	(1910)	64
42.	Homa Bay - Karungu Road	(1910)	72
43.	Kisumu - Kibos Road	(1910)	10
44.	Kisumu Township Roads	(1910)	8
45.	Naivasha Township Roads	(1910)	5
46.	Nakuru - Molo Road	(1910)	54

TABLE 4.5 STAGES IN THE DEVELOPMENT OF ROAD NETWORK (CONT'D)

ROAD NAME		ROAD LENGTH (KM)
47. Nakuru - Ngusur	(1910)	10
48. Nakuru - Solai Road	(1910)	48
49. Nakuru - Meroroni	(1910)	11
50. Uasin Gishu Road	(1910)	107
51. Kedong Valley Road	(1910)	22
52. Molo East Road	(1910)	26
53. Molo West Road	(1910)	26
54. Naivasha - Kinangop Road	(1910)	8
55. Ogada - Kaimosi Road	(1911)	29
56. Mombasa Island Roads	(1911)	13
57. Kapsabet - Kapiet Road	(1912)	22
58. Kisii Township Roads	(1912)	2
59. Muhoroni - Tuideret Road	(1913)	34
60. Nyeri - Western Kenya Farms	(1914)	35
61. Sotik - Amala River Road	(1914)	19
62. Ngong - Namanga Road	(1914)	163
63. Nyeri - Township Roads	(1915)	3
64. Kijabe - Mara Station Road	(1916)	160
65. Nyeri - Nanyuki Road	(1920)	59
66. Nanyuki - Meru Road	(1920)	82
1921 - 1940		
67. Mombasa - Gazi Road	(1921 - 1926)	45
68. Mombasa - Kwale - Vanga Road	"	134
69. Kinango - Samburu - Voi Road	"	144
70. Thika - Kitui Road	"	144
71. Embu - Meru Road	"	150

TABLE 4.5 STAGES IN THE DEVELOPMENT OF ROAD NETWORK (CONT'D)

	ROAD NAME		ROAD LENGTH (KM)
72.	Gilgil - T. Falls (Route E)	(1921 - 1926)	67
73.	Gilgil - " (Route W)	"	107
74.	Nakuru - Njoro - Londiani Road	"	74
75.	Eldama Ravine - Timboroa Road	"	29
76.	Kisumu - Kisii Road	"	125
77.	Campi Nyasa - Kapsabet Road	"	53
78.	Eldoret - Kapsabet Road	"	48
79.	Eldoret - Kitale Road	"	74
80.	Eldoret - Sergoit - Marakwet Road	"	70
81.	Eldoret - Cherangani Road	"	51
82.	Eldoret - Turbo Road	"	18
83.	Soy - Turbo - Murogosi Road	"	26
84.	Turbo - West Trans - Nzoia	"	35
85.	Kitale - Kacheliba Road	"	80
86.	Kitale - Malakisi Road	"	86
87.	Malakisi - Uganda Border (Mbale) Road	"	14
88.	Malakisi - Uganda Border (Tororo) Road	"	18
89.	Kitale - Kakamega Road	"	102
90.	Kakamega - Kisumu Road	"	53
91.	Kakamega - Mumias Road	"	38
92.	Mumias - Busia Road	"	50
93.	Mumias - Malakisi Road	"	45
94.	Kaimosi - Kakamega Road	"	29
95.	Kisumu - Londiani Road	"	115
96.	Londiani - Kedowa - Lumbwa	"	19
97.	Kericho - Jamji - Litein - Sotik Road	"	82

TABLE 4.5 STAGES IN DEVELOPMENT OF ROAD NETWORK (CONT'D)

	ROAD NAME		ROAD LENGTH (KM)
98.	Jamji - Sondu Road	(1921 - 1926)	19
99.	Liteni - Monire Road	"	24
100.	Kacheliba - Lodwar Road	(1930)	264
101.	Karungu - Lolgorien Road	(1930)	-
102.	Eldama Ravine - Marigat - Kabarnet Road	(1930)	-
103.	Lodwar - Lokitaung Road	(1931)	219
104.	Nyeri - T. Falls	(1932)	123
105.	Nanyuki - Isiolo Road	(1932)	98
106.	Nanyuki - Rumuruti Road	(1932)	78
107.	Rumuruti - T. Falls Road	(1932)	35
108.	Kisumu - Butere - Kakamega	(1932)	107
109.	Kitale - Kapenguria	(1932)	42
110.	Turbo - Webuye	(1932)	34
111.	Webuye - Malakisi	(1932)	66
112.	Kisumu - Asembo Bay Road	(1936)	32
113.	Homa Bay - Suna Road	(1936)	83
114.	Athi River - Namanga Road	(1937)	150
115.	Jamji - Chemegel - Lolgorien Road	(1937)	-
116.	Rumuruti - Maralal Road	(1937)	125
117.	Thika - Kitui - Garissa Road	(1938)	-
118.	Nakuru - Mau Summit Road	(1938)	64
119.	Mau Summit - Timboroa Road	(1938)	48
120.	Mau Summit - Londiani Road	(1938)	11
121.	Litein - Kivunga Road	(1938)	18
122.	Kisii - Isebania Road	(1938)	98
123.	Soy - Turbo - Kipkarren Road	(1938)	26
124.	Eldoret - Tambach - Kabarnet Road	(1938)	88

TABLE 4.5 STAGES IN DEVELOPMENT OF ROAD NETWORK (CONT'D)

ROAD NAME	ROADS BUILT AFTER 1940	ROAD LENGTH (KM)	
125.	Meru Isiolo Road	(1943)	80
126.	Turbo - Kyebaiwa Road	(1943)	34
127.	Kyebaiwa - Malakisi Road	(1943)	75
128.	Sotik - Tenwick Road	(1945)	-
129.	Nyangusu - Kilgoris - Lolgorien-Mara Road	(1945)	-
130.	Kisumu - Busia Road	(1947)	-
131.	Njoro - Mau Narok Road	(1952)	37
132.	Webuye - Bungoma Road	(1953)	24
133.	Bungoma - Uganda Border Road	(1953)	35
134.	Mombasa - Tanga (Lunga Lunga) Road	(1953)	74

Source: Blue Books, 1901 - 1946, East Africa Protectorate and Colony and Protectorate of Kenya.

Annual Reports, 1897 - 1920, East Africa Protectorate.

Annual Reports, 1920 - 1950, Colony and Protectorate of Kenya.

(1902)* Year in which the road was open for public use.

APPENDIX 4

TABLE 6.11 INTER-PROVINCIAL ROAD TRADE BALANCES, MARCH, 1983

(TONNES)

COMMODITY	TRADE BALANCE	WESTERN	NYANZA	RIFT VALLEY	CENTRAL	EASTERN	NORTH EASTERN	COAST	NAIROBI
MAIZE	RECEIPTS	12,876	283,724	247,293	27,345	15,599	-	48,467	81,985
	SHIPMENTS	21,479	334,615	267,267	49,973	32,024	-	9,582	62,421
	BALANCE	+8,603	+50,891	+19,974	+22,628	+16,425	-	-38,885	-19,564
WHEAT	RECEIPTS	41,350	12,525	4,520	5,523	3,582	-	216	157,493
	SHIPMENTS	-	2,223	180,863	20,228	2,089	-	16,759	7,826
	BALANCE	-41,350	-10,302	+176,343	+14,705	-1,493	-	+16,543	-149,667
COFFEE	RECEIPTS	-	16,327	10,239	15,475	-	-	37,474	22,810
	SHIPMENTS	-	17,101	522	12,230	23,588	-	8,613	35,867
	BALANCE	-	+ 774	-9,717	-3,245	+23,588	-	-28,861	+13,057
TEA	RECEIPTS	529	2,160	6,560	10,723	6,528	1,789	220,999	33,455
	SHIPMENTS	10,376	7,865	144,371	63,316	9,600	-	17,080	71,562
	BALANCE	+9,847	+5,705	+137,811	+52,593	+3,072	-1,789	-203,919	+38,107

TABLE 6.11 INTER-PROVINCIAL ROAD TRADE BALANCES, MARCH, 1983 (CONT'D)

COMMODITY	TRADE BALANCE	WESTERN	NYANZA	RIFT VALLEY	CENTRAL	EASTERN	NORTH EASTERN	COAST	NAIROBI
REFINED SUGAR	RECEIPTS	8,639	106,023	40,519	8,378	39,212	9,222	20,446	5,438
	SHIPMENTS	85,242	94,754	-	39,668	283	-	20,446	26,685
	BALANCE	+76,603	-11,269	-40,519	+31,290	-38,929	-9,222	-	+21,247
CEMENT	RECEIPTS	9,571	58,924	89,916	41,984	37,515	8,373	53,931	108,476
	SHIPMENTS	1,945	70,281	37,801	20,625	57,789	-	126,645	55,370
	BALANCE	-7,626	+11,357	-52,115	-21,360	+20,274	-8,373	+72,714	-53,106
SODA-ASH AND SODA PRODUCTS	RECEIPTS	-	20,675	9,796	7,222	10,075	-	2,015	2,818
	SHIPMENTS	794	10,124	6.746	-	3,818	-	2,015	24,678
	BALANCE	+794	-10,551	-3,050	-7,222	-6,257	-	-	+21,860
PETROLEUM FUELS AND PETROLEUM PRODUCTS	RECEIPTS	23,666	153,800	222,499	38,299	134,058	4,387	69,899	67,326
	SHIPMENTS	-	98,097	116,892	20,732	4,944	-	232,674	152,180
	BALANCE	-23,666	-55,703	-105,607	-17,567	-129,114	-4,387	+162,775	+84,854

TABLE 6.11 INTER-PROVINCIAL ROAD TRADE BALANCES, MARCH, 1983 (CONT'D)

COMMODITY	TRADE BALANCE	WESTERN	NYANZA	RIFT VALLEY	CENTRAL	EASTERN	NORTH EASTERN	COAST	NAIROBI
	RECEIPTS	96,631	654,158	631,342	154,949	246,569	23,771	453,447	479,801
TOTAL	SHIPMENTS	119,836	635,060	754,462	226,772	134,135	-	433,814	436,589
	BALANCE	23,205	-19,098	+123,120	+71,823	-112,434	-23,771	-19,633	-43,212

Source: Summary from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO.

Note: '+' indicates a net inflow of funds, '-' signifies a net outflow from a Province, given the assumption that the price of one unit tonne is the same for all the commodities. By subtracting receipts from shipments the result is trade balance.

TABLE 6.12 COMMODITY SHIPMENTS TO NAIROBI BY ROAD, MARCH, 1983

DISTRICT	SHIPMENT TO NAIROBI		TOTAL ROAD SURPLUS (TONNES)	SHIPMENT TO NAIROBI AS % OF TOTAL ROAD SURPLUS	COMPLEMENTARITY INDICES F_{ij}/Fe_{ij}	
	TONNES	PER CENT			LOW	HIGH
BUNGOMA	-	-	34890	-	-	-
BUSIA	-	-	-	-	-	-
KAKAMEGA	5243	1.09	84946	6.17	0.38	-
SIAYA	-	-	3637	-	-	-
KISUMU	10581	2.20	234197	4.51	0.28	-
SOUTH NYANZA	-	-	279552	-	-	-
KISII	1866	0.38	117674	1.58	0.09	-
TURKANA	-	-	2324	-	-	-
SAMBURU	-	-	-	-	-	-
WEST POKOT	-	-	-	-	-	-
TRANS NZOIA	39405	8.21	100,385	39.25	-	2.46
ELGEYO MARAKWET	-	-	-	-	-	-

DISTRICT	SHIPMENT TO NAIROBI		TOTAL ROAD SURPLUS (TONNES)
	TONNES	PER CENT	
BARINGO	-	-	-
LAIKIPIA	-	-	-
UASIN GISHU	8738	1.82	146129
NANDI	-	-	64741
KERICHO	17052	3.55	179674
NAKURU	-	-	75738
NAROK	166816	34.76	173433
KAJIADO	2457	0.51	12038
NYANDARUA	20204	4.21	48600
NYERI	7564	1.57	14608
KIRINYAGA	11768	2.45	69422
MURANGA	11372	2.37	39667
KIAMBU	2449	0.51	54475
MARSABIT	-	-	20955
ISIOLO	535	0.11	3602
MERU	1789	0.37	6023
EMBU	-	-	22741

SHIPMENT TO NAIROBI AS % OF TOTAL ROAD SURPLUS	COMPLEMENTARITY INDICES F_{ij}/Fe_{ij}	
	LOW	HIGH
-	-	-
-	-	-
5.97	0.37	-
-	-	-
9.49	0.59	-
-	-	-
96.18	-	6.03
20.41	-	1.28
41.57	-	2.61
51.77	-	3.25
16.95	-	1.10
28.66	-	1.80
4.49	0.28	-
-	-	-
14.85	0.93	-
29.70	-	1.93
-	-	-

DISTRICT	SHIPMENT TO NAIROBI		TOTAL ROAD SURPLUS (TONNES)	SHIPMENT TO NAIROBI AS % OF TOTAL ROAD SURPLUS	COMPLEMENTARITY INDICES F_{ij}/Fe_{ij}	
	TONNES	PER CENT			LOW	HIGH
KITUI	4821	1.00	4821	100.00	-	6.31
MACHAKOS	39363	8.20	75993	51.79	-	3.25
MANDERA	-	-	-	-	-	-
WAJIR	-	-	-	-	-	-
GARISSA	-	-	-	-	-	-
TANA RIVER	-	-	2859	-	-	-
LAMU	-	-	3900	-	-	-
TAITA TAVETA	-	-	5140	-	-	-
KILIFI	-	-	15695	-	-	-
KWALE	-	-	23237	-	-	-
MOMBASA	127778	26.63	382983	33.36	-	2.09
TOTAL	479,801		2,740,668			

Source: Author's own calculations from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO. Chapter 3 of this work give the description of how to calculate Fe_{ij} by the technique of transaction flow analysis.

APPENDIX 6

TABLE 6.13 ABSOLUTE DEVIATIONS OF SHIPMENTS OF COMMODITIES TO NAIROBI

DISTRICT	ACTUAL SHIPMENT (TONNES)	EXPECTED SHIPMENT (TONNES)	DEVIATION
BUNGOMA	-	5557	-5557
BUSIA	-	-	-
KAKAMEGA	5243	13,529	-8286
SIAYA	-	-	-
KISUMU	10581	37,306	-26,725
SOUTH NYANZA	-	44,532	-44,532
KISII	1866	18,742	-16,876
TURKANA	-	366	-366
SAMBURU	-	-	-
WEST POKOT	-	-	-
TRANS NZOIA	39405	15,987	+23,418
ELGEYO MARAKWET	-	-	-
BARINGO	-	-	-
LAIKIPIA	-	-	-
UASIN GISHU	8738	23,274	-14,536
NANDI	-	-	-
KERICHO	17052	28,618	-11,566
NAKURU	-	12,062	-12,062
NAROK	166816	27,627	+139,189
KAJIADO	2457	1916	+541
NYANDARUA	20204	7740	+12,464

TABLE 6.13 **ABSOLUTE DEVIATIONS OF SHIPMENTS OF COMMODITIES TO NAIROBI**(CONT'D)

DISTRICT	ACTUAL SHIPMENT (TONNES)	EXPECTED SHIPMENT (TONNES)	DEVIATION
NYERI	7564	2327	+5,237
KIRINYAGA	11768	10,665	+1,103
MURANGA	11372	6317	+5,055
KIAMBU	2449	8675	-6,226
MARSABIT	-	3335	-3335
ISIOLO	535	571	-36
MERU	1789	925	+864
EMBU	-	3619	-3619
KITUI	4821	764	+4,057
MACHAKOS	39363	12,102	+27,261
MANDERA	-	-	-
WAJIR	-	-	-
GARISSA	-	-	-
TANA RIVER	-	454	-454
LAMU	-	619	-619
TAITA TAVETA	-	816	-816
KILIFI	-	2497	-2497
KWALE	-	3697	-3697
MOMBASA	127778	69,548	+58,230

Source: Calculated from the Kenya National O/D Traffic Survey Data File, March, 1983, MOTCO. The technique of transaction flow analysis (Chapter 3) generated the expected tonnage shipped.

APPENDIX 7

TABLE 6.14 THE RELATIONSHIP BETWEEN VOLUME OF COMMODITY FLOWS TO NAIROBI AND EMPLOYMENT EARNINGS, DISTANCE, AND VEHICLES GENERATED

DISTRICT	LOG FOODS SHIPPED AND RECEIVED	LOG EMPLOYMENT EARNINGS $(E_i E_j)$	LOG DISTANCE (d_{ij})	LOG VEHICLES GENERATED $(V_i V_j)$
BUNGOMA	3.37	5.16	2.61	6.26
BUSIA	0.00	4.67	2.68	5.96
KAKAMEGA	3.72	5.53	2.59	6.66
SIAYA	3.57	4.79	2.62	6.26
KISUMU	4.65	5.68	2.53	7.22
SOUTH NYANZA	0.00	5.40	2.61	6.57
KISII	3.27	5.40	2.57	6.54
TURKANA	0.00	4.29	2.86	5.20
SAMBURU	0.00	4.34	2.56	4.58
WEST POKOT	0.00	4.39	2.61	4.91
TRANS NZOIA	4.59	5.15	2.58	6.19
ELGEYO M.	0.00	4.50	2.55	4.47
BARINGO	2.79	4.73	2.48	5.44
LAIKIPIA	4.19	5.07	2.30	5.71
UASIN GISHU	4.00	5.37	2.49	6.59
NANDI	0.00	5.15	2.56	5.91
KERICHO	4.33	5.53	2.42	6.25
NAKURU	4.94	5.78	2.19	6.57
NAROK	5.29	4.50	2.19	5.68
KAJIADO	4.16	4.82	1.88	5.67
NYANDARUA	4.36	5.05	2.29	5.66
NYERI	4.46	5.58	2.18	6.17
KIRINYAGA	4.14	4.97	2.10	5.83
MURANGA	4.59	5.38	1.92	6.49
KIAMBU	4.14	5.80	1.26	6.69

TABLE 6.14

THE RELATIONSHIP BETWEEN VOLUME OF COMMODITY FLOW TO NAIROBI AND EMPLOYMENT EARNINGS, DISTANCE AND VEHICLE GENERATED (CONT'D)

DISTRICT	LOG FOODS SHIPPED AND RECEIVED	LOG EMPLOYMENT EARNINGS $(E_i E_j)$	LOG DISTANCE (d_{ij})	LOG VEHICLES GENERATED $(V_i V_j)$
MARSABIT	3.49	4.50	2.75	5.88
ISIOLO	2.73	4.56	2.45	5.03
MERU	4.17	5.41	2.46	5.66
EMBU	4.71	5.13	2.15	6.28
KITUI	4.34	4.89	2.28	5.79
MACHAKOS	4.99	5.56	1.81	6.74
MANDERA	3.25	4.29	3.00	4.74
WAJIR	3.25	4.23	2.81	4.41
GARISSA	3.31	4.69	2.58	4.86
TANA RIVER	0.00	4.39	2.71	4.95
LAMU	0.00	4.39	2.92	4.91
TAITA TAVETA	0.00	4.88	2.58	5.73
KILIFI	0.00	5.07	2.74	6.41
KWALE	0.00	4.88	2.71	6.31
MOMBASA	5.20	6.22	2.69	6.96

Sources: Logs goods shipped and received and of vehicles generated calculated from the O/D Traffic Survey Data File, March, 1983, MOTCO.

Log employment earnings calculated from figures in Employment and Earnings in the Modern Sectors, 1979 C B S.

Log distance calculated from the Kenya Route map, 1978, Survey of Kenya.

APPENDIX 8

TABLE 6·18 INTER-DISTRICT MOVEMENT – COMMODITIES

UNGOMA	BUSIA	KAKAMEGA	SIAYA	KISUMU	S NYANZA	KISII	TURKANA	SAMBURU	W POKOT	T NZOIA	E MARAKWET	BARINGO	LAIKIPIA	UASIN GISHU	NANDI	KERICHO	NAKURU	NAROK	KAJIADO	NYANDARUA	NYERI	KIRINYAGA	MURANGA	KIAMBU	MARSABIT	ISIOLO	MERU	EMBU	KITUI	MACHAKOS	MANDERA	WAJIR	GARISSA	T RIVER	LAMU	TAITA	KILIFI	KWALE	MOMBASA	NAIROBI	TOTAL	% ORIG
–	–	–	–	14578	–	–	–	–	–	–	–	–	–	20312	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	34890	1·27
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4740	–	8136	–	34880	–	–	–	–	–	–	–	–	–	19635	–	–	12242	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5243	84946	3·10
–	–	–	–	3637	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3637	0·13
–	8639	41350	26285	53657	–	53106	–	–	–	–	–	–	–	8983	–	19899	7630	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4067	10581	234197	8·55
–	–	–	–	164466	107368	2172	–	–	–	–	–	–	–	–	–	5547	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	279552	10·20
–	–	–	–	98515	5254	8650	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3389	1866	17674	4·29
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2324	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2324	0·08
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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–	–	529	–	–	–	1468	–	–	–	–	–	–	–	47230	1753	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	39405	100385	3·66
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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7109	–	–	–	5774	–	–	11468	–	6261	63377	–	–	–	24508	–	–	16894	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	8738	146129	5·33
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	41098	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	23643	–	64741	2·36
–	–	–	–	393	1751	–	–	–	–	–	–	–	2399	–	–	–	92645	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	65434	17052	179674	6·56
2040	–	422	–	6438	–	3267	–	–	–	1753	–	–	–	–	2040	33508	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	26270	–	75738	2·76
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	6617	166816	173433	6·33
–	–	–	–	1711	–	–	–	–	–	–	–	–	–	–	–	–	7870	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2457	12038	0·44
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	28396	20204	48600	1·77
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3842	–	–	–	–	–	–	–	–	–	–	3202	7564	14608	0·53
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3722	–	–	–	–	–	26360	–	–	–	–	–	–	–	–	–	–	27572	11768	69422	2·53
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4089	–	–	–	2149	–	–	–	–	–	–	–	–	–	–	22057	11372	39667	*1·45
–	–	–	–	–	–	–	–	–	–	874	–	–	–	–	–	–	–	–	–	–	–	–	6302	10729	–	–	–	134	–	9219	–	–	–	–	–	–	–	–	24768	2449	54475	1·99
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	20955	–	20955	0·76
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3067	535	3602	0·13
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4234	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1789	6023	0·22
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	13006	–	9735	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	22741	0·83
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4821	4821	0·18
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	7282	–	–	–	–	–	–	29348	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	39363	75993	2·77
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3900	–	3900	0·15
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5140	–	5140	0·20
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3304	–	–	–	–	–	–	3413	865	8113	–	15695	0·57
–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2879	20358	–	23237	0·85
–	–	21336	–	13364	–	–	–	–	–	–	–	–	–	7282	–	5989	6819	–	–	–	–	–	–	9374	–	–	–	3237	7238	47846	–	–	18148	5727	3814	39068	40591	25372	–	127778	382983	13·97
330	–	–	3730	33625	–	–	–	–	–	–	–	620	15448	1265	–	4558	86211	31779	11839	2478	21283	1882	27307	11460	3067	–	13085	51252	16952	58884	1789	1789	2045	–	–	–	–	–	31911	–	436589	15·93
219	8639	71773	30015	431107	114373	78663	11468	–	6261	68004	–	620	17847	129215	3793	69501	281015	31779	11839	2478	21283	22844	33609	74735	3067	–	13085	86974	24190	119253	1789	1789	20193	5727	3814	39068	44004	29116	331718	479801	2740668	100
0·59	0·32	2·62	1·10	15·73	4·16	2·88	0·42	0·00	0·23	2·48	0·00	0·02	0·65	4·71	0·14	2·54	10·25	1·16	0·43	0·09	0·78	0·83	1·23	2·73	0·11	0·00	0·48	3·17	0·88	4·35	0·07	0·07	0·74	0·21	0·14	1·43	1·61	1·06	12·10	17·50	100	

Source: Summary from the Kenya National Origin–Destination Traffic Survey Data File, March, 1983, Ministry of Transport and Communications (M.O.T.C.).

APPENDIX 9

TABLE 7.1 THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT.

DISTRICT	COMPOSITE INDEX	RANK	DISTRICT	TRANSPORT INDEX	RANK
KISUMU	0.954	1	KISUMU	1.095	1
KIAMBU	0.929	2	MURANGA	0.915	2
KAKAMEGA	0.888	3	KIAMBU	0.896	3
MURANGA	0.872	4	SOUTH NYANZA	0.851	4
KERICHO	0.865	5	KERICHO	0.827	5
NAKURU	0.855	6	SIAYA	0.821	6
MACHAKOS	0.855	6	KISII	0.808	7
KISII	0.840	8	NYERI	0.804	8
SOUTH NYANZA	0.828	9	KAKAMEGA	0.801	9
NYERI	0.818	10	KILIFI	0.782	10
MERU	0.815	11	KIRINYAGA	0.778	11
KILIFI	0.784	12	KAJIADO	0.776	12
BUNGOMA	0.783	13	BUNGOMA	0.765	13
TRANS-NZOIA	0.771	14	KWALE	0.760	14
UASIN GISHU	0.770	15	EMBU	0.735	15
KWALE	0.763	16	UASIN GISHU	0.729	16
NANDI	0.754	17	NANDI	0.727	17
KIRINYAGA	0.752	18	MACHAKOS	0.727	17
NYANDARUA	0.747	19	TRANS-NZOIA	0.725	19
SIAYA	0.738	20	NAKURU	0.724	20
KITUI	0.727	21	BUSIA	0.718	21

TABLE 7.1 **THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	COMPOSITE INDEX	RANK	DISTRICT	TRANSPORT INDEX	RANK
BUSIA	0.720	22	KITUI	0.686	22
EMBU	0.715	23	MERU	0.654	23
TAITA/TAVETA	0.714	24	TAITA/TAVETA	0.642	24
LAIKIPIA	0.693	25	NYANDARUA	0.641	25
ELGEYO M.	0.677	26	ELGEYO M.	0.620	26
BARINGO	0.668	27	LAIKIPIA	0.599	27
KAJIADO	0.662	28	NAROK	0.573	28
WEST POKOT	0.646	29	WEST POKOT	0.562	29
NAROK	0.630	30	MARSABIT	0.535	30
LAMU	0.614	31	TURKANA	0.501	31
TANA RIVER	0.592	32	SAMBURU	0.485	32
SAMBURU	0.577	33	BARINGO	0.475	33
MARSABIT	0.569	34	WAJIR	0.473	34
GARISSA	0.558	35	GARISSA	0.467	35
TURKANA	0.553	36	MANDERA	0.430	36
WAJIR	0.546	37	LAMU	0.428	37
ISIOLO	0.546	37	TANA RIVER	0.371	38
MANDERA	0.529	39	ISIOLO	0.353	39
MEAN	0.726		MEAN	0.673	
STANDARD DEVIATION	0.116		STANDARD DEVIATION	0.165	

TABLE 7.1 **THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	DEMOGRAPHIC/ POPULATION INDEX	RANK	DISTRICT	AGRICULTURAL INDEX	RANK
KAKAMEGA	1.024	1	KERICHO	1.045	1
KISII	0.987	2	NANDI	1.0.38	2
KIAMBU	0.930	3	MURANGA	0.908	3
MURANGA	0.906	4	MERU	0.903	4
SOUTH NYANZA	0.858	5	KISUMU	0.901	5
MACHAKOS	0.858	5	TRANS-NZOIA	0.900	6
KISUMU	0.835	7	NAROK	0.886	7
MERU	0.813	8	KAKAMEGA	0.844	8
SIAYA	0.797	9	NYANDARUA	0.836	9
KERICHO	0.794	10	NAKURU	0.833	10
BUNGOMA	0.785	11	KIAMBU	0.828	11
NYERI	0.765	12	UASIN GISHU	0.816	12
KIRINYAGA	0.754	13	SOUTH NYANZA	0.810	13
BUSIA	0.739	14	LAIKIPIA	0.807	14
NAKURU	0.706	15	E. MARAKWET	0.805	15
KITUI	0.705	16	MACHAKOS	0.803	16
KILIFI	0.697	17	KISII	0.794	17
EMBU	0.693	18	KILIFI	0.788	18
TRANS-NZOIA	0.685	19	KWALE	0.780	19
NANDI	0.667	20	TAITA/TAVETA	0.767	20
UASIN GISHU	0.633	21	BARINGO	0.760	21
NYANDARUA	0.591	22	LAMU	0.755	22

TABLE 7.1 **THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	DEMOGRAPHIC/ POPULATION INDEX	RANK	DISTRICT	AGRICULTURAL INDEX	RANK
KWALE	0.576	23	BUNGOMA	0.737	23
E. MARAKWET	0.542	24	WEST POKOT	0.716	24
BARINGO	0.519	25	NYERI	0.709	25
WEST POKOT	0.515	26	KIRINYAGA	0.704	26
NAROK	0.512	27	TANA RIVER	0.704	26
LAIKIPIA	0.479	28	KITUI	0.669	28
TAITA/TAVETA	0.479	28	BUSIA	0.649	29
KAJIADO	0.476	30	EMBU	0.647	30
TURKANA	0.465	31	KAJIADO	0.631	31
WAJIR	0.463	32	SAMBURU	0.626	32
GARISSA	0.460	33	SIAYA	0.624	33
MANDERA	0.449	34	GARISSA	0.624	33
MARSABIT	0.439	35	WAJIR	0.611	35
TANA RIVER	0.439	35	ISIOLO	0.608	36
SAMBURU	0.434	37	TURKANA	0.572	37
LAMU	0.419	38	MARSABIT	0.567	38
ISIOLO	0.411	39	MANDERA	0.553	39
MEAN	0.648		MEAN	0.757	
STANDARD DEVIATION	0.178		STANDARD DEVIATION	0.122	

TABLE 7.1 THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT (CONT'D)

DISTRICT	INDUSTRIAL COMMERCIAL INDEX	RANK	DISTRICT	COMMUNICATION INDEX	RANK
NAKURU	1.059	1	NAKURU	1.083	1
KIAMBU	0.965	2	KIAMBU	1.048	2
KISUMU	0.938	3	KISUMU	1.018	3
UASIN GISHU	0.922	4	MACHAKOS	0.964	4
MACHAKOS	0.875	5	NYERI	0.899	5
KERICHO	0.872	6	KAKAMEGA	0.879	6
KILIFI	0.868	7	UASIN GISHU	0.872	7
BUNGOMA	0.862	8	KERICHO	0.859	8
KWALE	0.850	9	MERU	0.823	9
MURANGA	0.835	10	SOUTH NYANZA	0.822	10
KAKAMEGA	0.802	11	TAITA/TAVETA	0.803	11
NYANDARUA	0.793	12	KISII	0.803	11
KIRINYAGA	0.787	13	MURANGA	0.800	13
NYERI	0.782	14	NYANDARUA	0.797	14
KISII	0.780	15	TRANS-NZOIA	0.792	15
TAITA/TAVETA	0.767	16	KWALE	0.787	16
MERU	0.766	17	BUNGOMA	0.780	17
LAIKIPIA	0.748	18	KILIFI	0.780	17
TRANS-NZOIA	0.725	19	EMBU	0.770	19
SOUTH NYANZA	0.701	20	KAJIADO	0.763	20
SIAYA	0.687	21		0.762	21

TABLE 7.1 THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT (CONT'D)

DISTRICT	INDUSTRIAL COMMERCIAL INDEX	RANK	DISTRICT	COMMUNICATION INDEX	RANK
EMBU	0.679	22	LIKIPIA	0.756	22
BUSIA	0.659	23	NANDI	0.753	23
KAJIADO	0.655	24	KITUI	0.741	24
NANDI	0.642	25	BARINGO	0.740	25
BARINGO	0.640	26	GARISSA	0.730	26
E. MARAKWET	0.626	27	KIRINYAGA	0.726	27
SAMBURU	0.617	28	E. MARAKWET	0.721	28
NAROK	0.614	29	LAMU	0.705	29
KITUI	0.614	29	BUSIA	0.702	30
LAMU	0.581	31	MARSABIT	0.700	31
TANA RIVER	0.577	32	TURKANA	0.686	32
GARISSA	0.541	33	ISIOLO	0.685	33
WAJIR	0.537	34	SAMBURU	0.682	34
MANDERA	0.529	35	MANDERA	0.682	34
ISIOLO	0.525	36	WEST POKOT	0.679	36
WEST POKOT	0.521	37	WAJIR	0.671	37
TURKANA	0.518	38	TANA RIVER	0.668	38
MARSABIT	0.512	39	NAROK	0.523	39
MEAN	0.717		MEAN	0.780	
STANDARD DEVIATION	0.143		STANDARD DEVIATION	0.111	

TABLE 7.1 **THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	EDUCATION INDEX	RANK	DISTRICT	HEALTH INDEX	RANK
KAKAMEGA	0.997	1	KISUMU	1.109	1
KISII	0.927	2	KIAMBU	1.020	2
SOUTH NYANZA	0.882	3	NYERI	0.949	3
MURANGA	0.878	4	KERICHO	0.907	4
KITUI	0.876	5	MERU	0.897	5
MACHAKOS	0.874	6	TAITA TAVETA	0.895	6
MERU	0.846	7	MACHAKOS	0.888	7
BUSIA	0.825	8	SOUTH NYANZA	0.873	8
NYERI	0.821	9	KAKAMEGA	0.870	9
KIAMBU	0.821	9	MURANGA	0.868	10
BUNGOMA	0.801	11	NYANDARUA	0.866	11
KISUMU	0.783	12	NAKURU	0.862	12
KWALE	0.780	13	WEST POKOT	0.859	13
E. MARAKWET	0.763	14	BARINGO	0.858	14
KILIFI	0.762	15	TRANS NZOIA	0.853	15
SIAYA	0.756	16	KILIFI	0.813	16
KERICHO	0.753	17	KWALE	0.813	16
NYANDARUA	0.723	18	KIRINYAGA	0.807	18
NAKURU	0.721	19	EMBU	0.806	19
TRANS NZOIA	0.719	20	KITUI	0.798	20
LAIKIPIA	0.711	21	KISII	0.785	21
KIRINYAGA	0.708	22	LAMU	0.780	22

TABLE 7.1 **THE RANKING OF DISTRICTS ON COMPOSITE AND SECTORAL INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	EDUCATION INDEX	RANK	DISTRICT	HEALTH INDEX	RANK
NANDI	0.701	23	MARSABIT	0.768	23
BARINGO	0.687	24	BUNGOMA	0.754	24
EMBU	0.681	25	KAJIADO	0.754	24
UASIN GISHU	0.677	26	KAIKIPIA	0.754	24
WEST POKOT	0.674	27	BUSIA	0.752	27
TAITA TAVETA	0.650	28	NANDI	0.750	28
TANA RIVER	0.647	29	UASIN GISHU	0.745	29
LAMU	0.634	30	TANA RIVER	0.742	30
KAJIADO	0.582	31	SAMBURU	0.728	31
NAROK	0.575	32	NAROK	0.727	32
ISIOLO	0.517	33	ISIOLO	0.725	33
SAMBURU	0.473	34	SIAYA	0.722	34
MARSABIT	0.466	35	TURKANA	0.698	35
TURKANA	0.435	36	E.MARAKWET	0.664	36
GARISSA	0.425	37	GARISSA	0.659	37
WAJIR	0.414	38	MANDERA	0.658	38
MANDERA	0.408	39	WAJIR	0.655	39
MEAN	0.701		MEAN	0.805	
STANDARD DEVIATION	0.150		STANDARD DEVIATION	0.098	

Sources: see Appendix 13 Table 7.12 for sources and explanation of variables, and chapter 3 for procedures of calculating composite indices of development.

APPENDIX 10.

TABLE 7.4 THE RELATIONSHIPS BETWEEN COMPOSITE INDEX AND OTHER INDICES OF DEVELOPMENT

DISTRICT	COMPOSITE INDEX	TRANSPORT INDEX	POPULATION INDEX	AGRICULTURAL INDEX
BUNGOMA	0.783	0.765	0.785	0.737
BUSIA	0.720	0.718	0.739	0.649
KAKAMEGA	0.888	0.801	1.024	0.844
SIAYA	0.738	0.821	0.797	0.624
KISUMU	0.954	1.095	0.835	0.901
SOUTH NYANZA	0.828	0.851	0.858	0.810
KISII	0.840	0.808	0.987	0.794
TURKANA	0.553	0.501	0.465	0.572
SAMBURU	0.577	0.485	0.434	0.626
WEST POKOT	0.646	0.562	0.515	0.716
TRANS NZOIA	0.771	0.725	0.685	0.900
E. MARAKWET	0.677	0.620	0.542	0.805
BARINGO	0.668	0.475	0.519	0.760
LAIKIPIA	0.693	0.599	0.479	0.807
UASIN GISHU	0.770	0.729	0.633	0.816
NANDI	0.754	0.727	0.667	1.038
KERICHO	0.865	0.827	0.794	1.045
NAKURU	0.855	0.724	0.706	0.833
NAROK	0.630	0.573	0.512	0.886
KAJIADO	0.662	0.776	0.476	0.631

TABLE 7.4 **THE RELATIONSHIPS BETWEEN COMPOSITE INDEX AND OTHER INDICES OF DEVELOPMENT** (CONT'D)

DISTRICT	COMPOSITE INDEX	TRANSPORT INDEX	POPULATION INDEX	AGRICULTURAL INDEX
NYANDARUA	0.747	0.641	0.591	0.836
NYERI	0.818	0.804	0.765	0.709
KIRINYAGA	0.752	0.778	0.754	0.704
MURANGA	0.872	0.915	0.906	0.908
KIAMBU	0.929	0.896	0.930	0.828
MARSABIT	0.569	0.535	0.439	0.567
ISIOLO	0.546	0.353	0.411	0.608
MERU	0.815	0.654	0.813	0.903
EMBU	0.715	0.735	0.693	0.647
KITUI	0.727	0.686	0.705	0.669
MACHAKOS	0.855	0.727	0.858	0.803
MANDERA	0.529	0.430	0.449	0.553
WAJIR	0.546	0.473	0.463	0.611
GARISSA	0.558	0.467	0.460	0.624
TANA RIVER	0.592	0.371	0.439	0.704
LAMU	0.614	0.428	0.419	0.755
TAITA TAVETA	0.714	0.642	0.479	0.767
KILIFI	0.784	0.782	0.697	0.788
KWALE	0.763	0.760	0.576	0.780
MEAN	0.726	0.673	0.648	0.757
STANDARD DEVIATION	0.116	0.165	0.178	0.122

TABLE 7.4 THE RELATIONSHIPS BETWEEN COMPOSITE INDEX AND OTHER INDICES OF DEVELOPMENT (CONT'D)

DISTRICT	INDUSTRIAL/ COMMERCIAL INDEX	COMMUNICATION INDEX	EDUCATION INDEX	HEALTH INDEX
BUNGOMA	0.862	0.780	0.801	0.754
BUSIA	0.659	0.702	0.825	0.752
KAKAMEGA	0.802	0.879	0.997	0.870
SIAYA	0.687	0.762	0.756	0.722
KISUMU	0.938	1.018	0.783	1.109
SOUTH NYANZA	0.701	0.822	0.882	0.873
KISII	0.780	0.803	0.927	0.785
TURKANA	0.518	0.686	0.435	0.698
SAMBURU	0.617	0.682	0.473	0.728
WEST POKOT	0.521	0.679	0.674	0.859
TRANS NZOIA	0.725	0.792	0.719	0.853
E. MARAKWET	0.626	0.721	0.763	0.664
BARINGO	0.640	0.740	0.687	0.858
LAIKIPIA	0.748	0.756	0.711	0.754
UASIN GISHU	0.922	0.872	0.677	0.745
NANDI	0.642	0.753	0.701	0.750
KERICHO	0.872	0.859	0.753	0.907
NAKURU	1.059	1.083	0.721	0.862
NAROK	0.614	0.523	0.575	0.727
KAJIADO	0.655	0.763	0.582	0.754

TABLE 7.4 THE RELATIONSHIPS BETWEEN COMPOSITE INDEX AND OTHER INDICES OF DEVELOPMENT (CONT'D)

DISTRICT	INDUSTRIAL/ COMMERCIAL INDEX	COMMUNICATION INDEX	EDUCATION INDEX	HEALTH INDEX
NYANDARUA	0.793	0.797	0.723	0.866
NYERI	0.782	0.899	0.821	0.949
KIRINYAGA	0.787	0.726	0.708	0.807
MURANGA	0.835	0.800	0.878	0.868
KIAMBU	0.965	1.048	0.821	1.020
MARSABIT	0.512	0.700	0.466	0.768
ISIOLO	0.525	0.685	0.517	0.725
MERU	0.766	0.823	0.846	0.897
EMBU	0.679	0.770	0.681	0.806
KITUI	0.614	0.741	0.876	0.798
MACHAKOS	0.875	0.964	0.874	0.888
MANDERA	0.529	0.682	0.408	0.658
WAJIR	0.537	0.671	0.414	0.655
GARISSA	0.541	0.730	0.425	0.659
TANA RIVER	0.577	0.668	0.647	0.742
LAMU	0.581	0.705	0.634	0.780
TAITA TAVETA	0.767	0.803	0.650	0.895
KILIFI	0.868	0.780	0.762	0.813
KWALE	0.850	0.787	0.780	0.813
MEAN	0.717	0.780	0.701	0.805
STANDARD DEVIATION	0.143	0.111	0.150	0.098

Source: See Appendix 13 Table 7.12 for sources and explanation of of variables and chapter 3 for procedures of calculating composite indices of development.

[illegible] ROAD TRANSPORT INDEX AND INDICES OF POPULATION,
AGRICULTURAL, INDUSTRIAL, COMMERCIAL AND COMMUNICATION

DISTRICT	TRANSPORT INDEX	POPULATION -DEMOGRAPHIC INDEX	AGRICULTURAL INDEX	INDUSTRIAL COMMERCIAL	COMMUNICATION INDEX
BUNGOMA	0.765	0.785	0.737	0.862	0.780
BUSIA	0.718	0.739	0.649	0.659	0.702
KAKAMEGA	0.801	1.024	0.844	0.802	0.879
SIAYA	0.821	0.797	0.624	0.687	0.762
KISUMU	1.095	0.835	0.901	0.938	1.018
SOUTH NYANZA	0.851	0.858	0.810	0.701	0.828
KISII	0.808	0.987	0.794	0.780	0.803
TURKANA	0.501	0.465	0.572	0.518	0.686
SAMBURU	0.485	0.434	0.626	0.617	0.682
WEST POKOT	0.562	0.515	0.716	0.521	0.679
TRANS NZOIA	0.725	0.685	0.900	0.725	0.792
E. MARAKWET	0.620	0.542	0.805	0.626	0.721
BARINGO	0.475	0.519	0.760	0.640	0.740

DISTRICT	TRANSPORT INDEX	POPULATION -DEMOGRAPHIC INDEX	AGRICULTURAL INDEX	INDUSTRIAL COMMERCIAL	COMMUNICATION INDEX
LAIKIPIA	0.599	0.479	0.707	0.748	0.756
UASIN GISHU	0.729	0.633	0.816	0.922	0.872
NANDI	0.727	0.667	1.038	0.642	0.753
KERICHO	0.827	0.794	1.045	0.872	0.859
NAKURU	0.724	0.706	0.833	1.059	1.083
NAROK	0.573	0.512	0.886	0.614	0.523
KAJIADO	0.776	0.476	0.631	0.655	0.763
NYANDARUA	0.641	0.591	0.836	0.793	0.797
NYERI	0.804	0.765	0.709	0.782	0.899
KIRINYAGA	0.778	0.754	0.704	0.787	0.726
MURANGA	0.915	0.906	0.908	0.835	0.800
KIAMBU	0.896	0.930	0.828	0.965	1.048
MARSABIT	0.535	0.439	0.567	0.512	0.700
ISIOLO	0.353	0.411	0.608	0.525	0.685
MERU	0.654	0.813	0.903	0.766	0.823

TABLE 7.8 THE RELATIONSHIPS BETWEEN ROAD TRANSPORT INDEX AND INDICES OF POPULATION, INDUSTRIAL, COMMERCIAL AND COMMUNICATION (CONT'D)

DISTRICT	TRANSPORT INDEX	POPULATION -DEMOGRAPHIC INDEX	AGRICULTURAL INDEX	INDUSTRIAL COMMERCIAL	COMMUNICATION INDEX
EMBU	0.735	0.693	0.647	0.679	0.770
KITUI	0.686	0.705	0.669	0.614	0.741
MACHAKOS	0.727	0.858	0.803	0.875	0.964
MANDERA	0.430	0.449	0.553	0.529	0.682
WAJIR	0.473	0.463	0.611	0.537	0.671
GARISSA	0.467	0.460	0.624	0.541	0.730
TANA RIVER	0.371	0.439	0.704	0.577	0.668
LAMU	0.428	0.419	0.755	0.581	0.705
TAITA TAVETA	0.642	0.479	0.767	0.767	0.803
KILIFI	0.782	0.697	0.788	0.868	0.780
KWALE	0.760	0.576	0.780	0.850	0.787

Sources: Same as for Table 7.4 Appendix 10.

APPENDIX 12

TABLE 7.11 ORIGINAL DATA MATRIX

1. ROAD TRANSPORT INDICATORS

DISTRICT	TOTAL KILOMETRAGE CLASSIFIED ROADS	ROAD DENSITY KM/SQ KM CLASSIFIED ROADS	CONNECTIVITY INDEX BETA INDEX	NUMBER OF PASSENGERS GENERATED
BUNGOMA	1044	0.34	1.11	1774
BUSIA	545	0.33	1.06	1329
KAKAMEGA	1255	0.36	1.09	4772
SIAYA	1134	0.45	1.14	3324
KISUMU	1357	0.65	1.12	18982
SOUTH NYANZA	1969	0.34	1.18	6273
KISII	1112	0.51	1.12	1704
TURKANA	2465	0.04	0.92	138
SAMBURU	1258	0.06	0.88	6
WEST POKOT	789	0.16	0.92	257
TRANS NZOIA	670	0.27	1.08	2481
E. MARAKWET	531	0.20	1.00	293
BARINGO	1436	0.14	0.86	138
LAIKIPIA	974	0.10	1.05	266
UASIN GISHU	832	0.22	1.00	5274
NANDI	838	0.31	1.11	1046
KERICHO	1718	0.35	1.35	1094
NAKURU	1358	0.19	1.14	2750

1. ROAD TRANSPORT INDICATORS (CONT'D).

DISTRICT	TOTAL KILOMET-LAGE CLASSIFIED ROADS	ROAD SENSITY KQ/SQKM CLASSIFIED ROADS	CONNECTI-VITY INDEX BETA INDEX	NUMBER OF PASSENGERS GENERATED
NAROK	1647	0.09	1.00	383
KAJIADO	1587	0.08	1.04	391
NYANDARUA	652	0.18	1.05	613
NYERI	1310	0.40	1.18	2373
KIRINYAGA	590	o.41	1.15	1193
MURANGA	1589	0.64	1.29	2519
KIAMBU	1379	0.56	1.24	3708
MARSABIT	2139	0.03	1.00	1
ISIOLO	992	0.04	0.70	27
MERU	1688	0.17	1.09	543
EMBU	707	0.26	1.12	2378
KITUI	2349	0.08	1.21	1363
MACHAKOS	2430	0.17	1.07	4634
MANDERA	1331	0.05	0.80	3
WAJIR	1613	0.03	0.82	3
GARISSA	1631	0.04	0.86	213
TANA RIVER	971	0.03	0.73	143
LAMU	387	0.06	0.78	187
TAITA TAVETA	858	0.05	1.17	635
KILIFI	1460	0.12	1.24	5119
KWALE	1041	0.13	1.14	5891

2. DEMOGRAPHIC/POPULATION INDICATORS

DISTRICT	TOTAL POPULATION '000' (1979)	POPULATION DENSITY PER SQ KM	POPULATION RATE OF GROWTH (1969-1979) %	SERVICE CENTRE UNITS
BUNGOMA	504	164	3.85	22
BUSIA	298	183	4.04	14
KAKAMEGA	1031	293	2.79	40
SIAYA	475	188	2.16	21
KISUMU	482	230	1.87	22
SOUTH NYANZA	818	143	2.12	32
KISII	870	296	2.56	28
TURKANA	143	2	-1.29	9
SAMBURU	77	4	1.02	7
WEST POKOT	159	31	5.11	9
TRANS NZOIA	260	105	7.63	7
E. MARAKWET	149	55	-0.63	10
BARINGO	204	19	2.34	13
LAIKIPIA	135	14	7.30	6
UASIN GISHU	301	79	4.64	11
NANDI	299	109	3.65	15
KERICHO	633	130	2.83	23
NAKURU	523	74	6.04	20
NAROK	210	11	5.38	8
KAJIADO	149	7	5.66	12

2. DEMOGRAPHIC/POPULATION INDICATORS (CONT'D)

DISTRICT	TOTAL POPULA-TION '000' 1979	POPULATION DENSITY PER SQ KM	POPULATION RATE OF GROWTH (1969-1979) %	SERVICE CENTRE UNITS
NYANDARUA	233	66	2.80	15
NYERI	486	148	3.03	22
KIRINYAGA	291	203	2.99	18
MURANGA	648	262	3.83	33
KIAMBU	686	280	3.74	36
MARSABIT	96	1	6.43	6
ISIOLO	43	2	3.73	6
MERU	830	84	3.36	34
EMBU	263	97	3.93	18
KITUI	464	16	3.08	23
MACHAKOS	1023	72	3.76	48
MANDERA	106	4	1.06	7
WAJIR	139	2	4.91	7
GARISSA	129	3	7.16	8
TANA RIVER	92	2	6.19	7
LAMU	42	7	6.56	7
TAITA TAVETA	148	9	2.91	12
KILIFI	431	35	3.43	19
KWALE	288	35	3.44	12

3. AGRICULTURAL INDICATORS

DISTRICT	POTENTIAL AGRICULTURAL PRODUCTION £ '00000'	PERCENTAGE WAGE EMPLOYMENT	PERCENTAGE EMPLOYMENT EARNINGS
BUNGOMA	190	23.1	5.5
BUSIA	114	8.4	7.5
KAKAMEGA	270	32.2	19.2
SIAYA	156	-	-
KISUMU	150	22.9	77.6
SOUTH NYANZA	336	12.5	41.5
KISII	210	29.5	15.1
TURKANA	33	5.5	4.7
SAMBURU	16	12.1	17.4
WEST POKOT	122	18.4	16.6
TRANS NZOIA	152	59.5	38.3
E. MARAKWET	154	35.7	22.7
BARINGO	100	32.9	24.6
LAIKIPIA	56	39.9	41.1
UASIN GISHU	229	33.2	15.8
NANDI	228	78.9	66.0
KERICHO	326	72.0	55.8
NAKURU	162	42.4	26.9
NAROK	515	8.7	9.6

3. AGRICULTURAL INDICATORS (CONT'D)

DISTRICT	POTENTIAL AGRICULTURAL PRODUCTION, £'00000'	PERCENTAGE WAGE EMPLO-MENT	PERCENTAGE EMPLOYMENT EARNINGS
KAJIADO	32	17.1	10.1
NYANDARUA	139	44.0	30.2
NYERI	108	20.6	15.1
KIRINYAGA	71	29.1	12.5
MURANGA	183	58.6	36.5
KIAMBU	135	48.3	22.8
MARSABIT	16	6.7	5.8
ISIOLO	11	13.1	11.5
MERU	393	32.3	7.7
EMBU	76	13.1	9.7
KITUI	95	9.1	7.4
MACHAKOS	247	28.4	12.1
MANDERA	7	5.3	5.6
WAJIR	14	0.8	0.4
GARISSA	27	16.3	9.8
TANA RIVER	81	23.7	15.8
LAMU	119	24.0	25.2
TAITA TAVETA	52	41.8	25.2
KILIFI	163	28.8	18.5
KWALE	130	32.4	18.4

4. INDUSTRIAL AND COMMERCIAL INDICATORS

DISTRICT	PERCENTAGE WAGE EMPLOY-MENT IN INDUSTRY	PERCENTAGE EARNINGS IN INDUSTRY	WHOLESALE & RETAIL TRADE LICENCES ISSUED	PERCENTAGE WAGE EMPLOY-MENT IN WHOLESALE & RETAIL TRADE	PERCENTAGE EARNINGS IN WHOLESALE & RETAIL TRADE
BUNGOMA	20.4	19.9	2118	4.0	6.4
BUSIA	6.2	1.6	1289	4.0	0.9
KAKAMEGA	5.0	5.7	3880	2.1	2.2
SIAYA	7.5	2.2	1500	1.9	1.3
KISUMU	22.1	16.4	2713	5.5	12.9
SOUTH NYANZA	3.2	0.1	2296	3.7	2.2
KISII	3.6	0.8	3576	2.0	3.2
TURKANA	-	-	247	0.0	0.0
SAMBURU	-	-	460	7.3	7.4
WEST POKOT	-	-	294	-	-
TRANS NZOIA	2.0	2.3	1372	6.5	11.4

4. *INDUSTRIAL AND COMMERCIAL INDICATORS (CONT'D)*

DISTRICT	PERCENTAGE WAGE EMPLOYMENT IN INDUSTRY	PERCENTAGE EARNINGS IN INDUSTRY	WHOLE SALE & RETAIL TRADE LICENCES ISSUED	PERCENTAGE WAGE EMPLOYMENT IN WHOLE SALE & RETAIL TRADE	PERCENTAGE EARNINGS IN WHOLE SALE & RETAIL TRADE
E. MARAKWET	7.9	26.6	620	0.2	0.0
BARINGO	9.4	8.9	413	1.3	1.1
LAIKIPIA	13.8	9.9	1061	5.1	5.7
UASIN GISHU	27.6	32.6	2182	4.7	7.5
NANDI	2.6	1.6	1669	0.6	0.3
KERICHO	7.8	6.4	3570	2.1	11.0
NAKURU	14.2	16.1	4771	6.1	25.9
NAROK	-	-	736	6.5	5.6
KAJIADO	4.0	6.4	320	9.8	8.3
NYANDARUA	5.4	5.5	3096	5.3	5.9
NYERI	6.4	2.4	2953	6.4	4.5
KIRINYAGA	10.5	6.5	2345	3.7	4.9
MURANGA	2.0	1.0	4848	4.2	4.2
KIAMBU	24.1	32.7	4607	2.9	2.7
MARSABIT	-	-	161	-	-
ISIOLO	-	-	333	4.7	0.0

DISTRIC	PERCENTAGE WAGE EMPLO- YMENT IN INDUSTRY	PERCENTAGE EARNINGS IN INDUSTRY	WHOLE SALE & RETAIL TRADE LICENCES ISSUED	PERCENTAGE WAGE EMPLOMENT IN WHOLE SALE & RETAIL TRADE	PERCENTAGE EARN- INGS IN WHOLE SALE & RETAIL TRADE
MERU	2.1	1.6	3142	4.2	5.4
EMBU	0.9	0.1	1052	12.2	9.4.
KITUI	-	-	1511	0.8	0.9
MACHAKOS	10.3	15.9	4455	3.2	3.8
MANDERA	-	-	350	0.5	0.2
WAJIR	-	-	440	0.4	0.4
GARISSA	1.0	0.5	398	0.2	0.1
TANA RIVER	0.9	1.0	377	0.7	0.9
LAMU	-	-	619	5.3	3.1
TAITA TAVETA	7.2	6.1	1307	6.0	11.9
KILIFI	13.9	12.1	1950	7.2	14.5
KWALE	13.3	8.7	1055	10.4	18.0

5. COMMUNICATION INDICATORS

DISTRICT	POST OFFICE FACILITIES	TELECOMMUNICATION LINE CAPACITY
BUNGOMA	22	590
BUSIA	9	170
KAKAMEGA	44	880
SIAYA	21	330
KISUMU	42	4020
SOUTH NYANZA	33	540
KISII	29	500
TURKANA	8	0
SAMBURU	5	100
WEST POKOT	5	70
TRANS NZOIA	12	588
E. MARAKWET	14	130
BARINGO	18	161
LAIKIPIA	15	650
UASIN GISHU	37	1240
NANDI	18	380
KERICHO	38	870
NAKURU	69	3661
NAROK	7	140
KAJIADO	23	200
NYANDARUA	22	880
NYERI	41	1890

5. COMMUNICATION INDICATORS (CONT'D)

DISTRICT	POST OFFICE FACILITIES	TELECOMMUNICATION LINE CAPACITY
KIRINYAGA	14	210
MURANGA	27	580
KIAMBU	40	4850
MARSABIT	10	70
ISIOLO	7	50
MERU	29	870
EMBU	17	850
KITUI	16	320
MACHAKOS	63	1327
MANDERA	7	0
WAJIR	5	0
GARISSA	6	140
TANA RIVER	3	72
LAMU	10	152
TAITA TAVETA	30	415
KILIFI	20	770
KWALE	25	490

6. EDUCATIONAL INDICATORS

DISTRICT	TOTAL NO. OF PRIMARY SCHOOLS	PRIMARY SCHOOLS ENROLMENT RATIO	NUMBER OF SECONDARY SCHOOLS	SECONDARY SCHOOL ENROLMENT
BUNGOMA	349	120	79	13563
BUSIA	254	106	31	5188
KAKAMEGA	689	104	154	28290
SIAYA	313	106	38	6650
KISUMU	317	92	34	8009
SOUTH NYANZA	604	90	64	8009
KISII	707	82	114	23337
TURKANA	32	19	1	154
SAMBURU	49	30	3	391
WEST POKOT	69	98	3	451
TRANS NZOIA	103	147	14	3660
E. MARAKWET	148	84	12	2110
BARINGO	135	93	18	2771
LAIKIPIA	89	155	4	1458
UASIN GISHU	186	93	23	4551
NANDI	257	95	23	4059
KERICHO	360	89	43	8829
NAKURU	210	124	34	8966
NAROK	112	67	5	920
KAJIADO	74	78	5	1025

6. EDUCATIONAL INDICATORS (CONT'D)

DISTRICT	TOTAL NO. OF PRIMARY SCHOOLS	PRIMARY SCHOOLS ENROLMENT RATIO	NUMBER OF SECONDARY SCHOOLS	SECONDARY SCHOOL ENROLMENT
NYANDARUA	134	93	23	4693
NYERI	267	101	105	19605
KIRINYAGA	155	99	41	10503
MURANGA	311	110	119	18386
KIAMBU	306	101	86	24455
MARSABIT	22	33	2	227
ISIOLO	23	57	2	328
MERU	674	94	89	17229
EMBU	164	103	19	4641
KITUI	371	110	38	5598
MACHAKOS	924	123	120	26451
MANDERA	13	12	1	155
WAJIR	18	12	1	280
GARISSA	19	16	2	301
TANA RIVER	60	56	2	456
LAMU	43	117	2	305
TAITA TAVETA	124	91	20	3064
KILIFI	229	68	15	2291
KWALE	176	71	9	1972

7. HEALTH INDICATORS

DISTRICT	HEALTH FACILITIES	HOSPITAL BEDS/ 1000 POPULATION	HEALTH PERSONNEL PER 1000 POPULATION
BUNGOMA	26	1.18	0.17
BUSIA	23	1.65	0.20
KAKAMEGA	54	1.50	0.21
SIAYA	32	1.06	-
KISUMU	98	3.89	0.60
SOUTH NYANZA	63	1.00	0.12
KISII	36	0.95	0.15
TURKANA	18	1.72	0.11
SAMBURU	16	2.52	0.21
WEST POKOT	11	1.17	0.13
TRANS NZOIA	18	1.14	0.17
E. MARAKWET	20	1.99	-
BARINGO	41	1.25	0.11
LAIKIPIA	19	1.03	0.25
UASIN GISHU	22	1.14	0.19
NANDI	26	1.02	0.16
KERICHO	73	1.89	0.12
NAKURU	41	1.50	0.33
NAROK	24	2.26	0.12
KAJIADO	27	2.63	0.16
NYANDARUA	44	1.55	0.31
NYERI	59	2.54	0.42

7. HEALTH INDICATORS (CONT'D).

DISTRICT	HEALTH FACILITES	HOSPITAL BEDS/ 100 POPULATION	HEALTH PERSONNEL PER 1000 POPULATION
KIRINYAGA	31	1.15	0.27
MURANGA	56	1.60	0.18
KIAMBU	86	2.77	0.38
MARSABIT	18	3.41	0.30
ISIOLO	9	0.32	0.28
MERU	70	1.72	0.12
EMBU	28	2.80	0.30
KITUI	42	1.86	0.12
MACHAKOS	61	0.88	0.19
MANDERA	8	0.45	0.12
WAJIR	10	0.85	0.09
GARISSA	10	0.37	0.10
TANA RIVER	24	2.63	0.16
LAMU	12	1.68	0.40
TAITA TAVETA	39	2.33	0.46
KILIFI	45	1.23	0.13
KWALE	36	1.40	0.16

Source: See Appendix 13 Table 7.12 for sources and explanation of variables.

APPENDIX 13

TABLE 7.12 SOURCES AND EXPLANATION OF VARIABLES

INDICATORS OF ROAD TRANSPORT DEVELOPMENT

1. Total kilometrage of classified roads - This is the sum of kilometres of road length of classified roads A,B,C,D,E and X in the district, based on data from Road Maintenance Schedule, 1980 - 81, Ministry of Transport and communication, July 1980.

2. Road density, kilometres per square kilometre of land. This is the number of kilometres or fraction of a kilometre per square kilometre of land area, from the author's calculations based on classified roads and the districts' land areas.

3. Connectivity index. The better index measures the connectivity of transport network by dividing the number of vertices (V) into the number of edges (E), giving a range of values between 0.5 at the lowest and 3.0 at the maximum for a planar graph. Our values were for a planar graph, calculated from maps drawn from Kenya Route Map, 1978, Survey of Kenya.

4. The number of passengers generated was calculated from the combined passengers that were generated from each district to all the other districts travelling by cars, matatus and buses. Source: the Kenya National Traffic Survey, March 1983.

TABLE 7.12 SOURCES AND EXPLANATION OF VARIABLES (CONT'D)

POPULATION/DEMOGRAPHIC INDICATORS OF DEVELOPMENT

5. Total population. This was taken from Kenya Population Census, 1979, Volume 1, Ministry of Economic Planning and Development, CBS.

6. Population density per square kilometre of land. Author's calculation based on population figures for 1979.

7. Population rate of growth. Same source as above.

8. Service Centre Units. A service centre policy in Kenya designates urban, rural, market and local centres as centres serving hinterland populations of 150,000; 50,000; 15,000; and 5,000 respectively. In this study, the number of urban, rural, market and local centres in each district were assigned weights of 3, 1, 0.3 and 0.1; the weights being based on the ratios of the hinterland populations and 50,000. Source: Republic of Kenya, - Development Plan, 1979 - 1983.

INDICATORS OF AGRICULTURAL DEVELOPMENT

9. Potential agricultural production. This is an estimate based on the productivity of a combination of soils and rainfall conditions in a district converted into monetary value. The values represent the potential production under good land use. The estimates have been made by the physical Planning Office in the Department of Lands and Settlement.

TABLE 7.12 SOURCES AND EXPLANATION OF VARIABLES (CONT'D)

Source: Kenya Highway Transport Study, Vol. 1, 1978.

10. Percentage wage employment. This is the proportional share in wage employment in the district, excluding self - employed and family workers. Source: Employment and Earnings in the Modern Sector, C.B.S.

11. Percentage employment earnings. This is the proportional share of the agricultural sector in the total cash payment to salaried workers in the district. Source, same as for 11 above.

INDICATORS OF INDUSTRIAL AND COMMERCIAL DEVELOPMENT

12. Percentage wage employment in industry. The explanation for this indicator and source is the same as for agriculture (11).

13. Percentage earnings in industry - Same as for agriculture 12.

14. Wholesale and retail trade licences issued. This is simply the number of operating business units in the district in terms of the trade licences applied for and issued in a particular year. Source: Provincial Annual Reports, 1979 - 80.

15. Percentage wage employment in wholesale and retail trade. Explanation and source same as for agriculture.

16. Percentage earnings in wholesale and retail trade. Same as for agriculture.

TABLE 7.12 SOURCES AND EXPLANATION OF VARIABLES (CONT'D)

INDICATORS OF COMMUNICATION DEVELOPMENT

17. Post Office facilities. The indicator measures the level of postal service provided in the district. For the purpose of comparability head post office is assigned a score of 5 assuming that each one provides services to an average of 5 departmental post offices in the district. Departmental post office is given a score of 1 and postal agencies a score of ½ each. Source: District Development Plans, 1979 - 83.

18. Telecommunication line Capacity. This is the number of automatic and mannual telephone exchange units of lines so far installed and in operation. Source: Development Plan, 1978 - 83, Volume II.

INDICATORS OF EDUCATIONAL DEVELOPMENT

19. Total number of primary schools. These are primary schools with classes from 1 -- 7. No account was taken of the number of streams in each class. Source: Ministry of Education Annual Report, 1978.

20. Primary school enrolment ratio. This is the number of pupils enrolled in primary schools per 100 children of primary school age which is between 6 and 12 years. The enrolment ratio is estimated from the number of children of the above ages enrolled in primary schools in a particular year divided by the projected population of the same age group for the same year. Source: Kenya Report of the Pilot Study on the Socio - Economic Indicators, 1981, CBS.

TABLE 7.12 SOURCES AND EXPLANATION OF VARIABLES (CONT'D)

21. Number of Secondary Schools. These include Government maintained, assisted, private and Harambee Secondary schools in the district. No account was taken of the number of streams, or whether the school runs upto Form 4 or Form 6. Source: Educational Trends, 1973 - 1977.

22. Secondary school enrolment. This is the number of pupils enrolled in secondary schools in the district. Source: Same as for 22.

INDICATORS OF HEALTH DEVELOPMENT

23. Health facilities. This is the number of health units in the district including Government, Missionary and private hospitals, health centres, and dispensaries. Source: District Development Plans, 1979 - 83.

24. Hospital beds per 1,000 population. Sources: Author's own calculations based on data from Districts Development Plans, 1979 - 83.

25. Health Personnel per 1,000 population. Health personnel include, doctors, clinical officers, nurses and midwives. Source: Same as in 24 above.