Road Infrastructure Investment and its Impact on Agricultural Productivity and Equity in Tanzania

Damian Mulokozi Gabagambi

VERLAG GRAUER · Beuren · Stuttgart · 2003

Gabagambi, Damian Mulokozi:
Road Infrastructure Investment and its Impact on Agricultural Productivity and Equity in Tanzania.
VERLAG GRAUER, Beuren und Stuttgart, 2003.

ISBN 3-86186-430-4

D 100
Dissertation Universität Hohenheim, Institut für Agrar- und Sozialökonomie in den Tropen und Subtropen, 2003.

Von der Fakultät II - Agrarwissenschaften - der Universität Hohenheim zur Erlangung des Grades eines Doktors der Agrarwissenschaften (Dr. sc. agr.) genehmigte Dissertation.
Berichterstatter, 1. Prüfer: Prof. Dr. M. von Oppen
Mitberichterstatter, 2. Prüfer: Prof. Dr. T. Becker
3. Prüfer: Prof. Dr. F. Heidhues
Prodekan: Prof. Dr. K. Stahr
Tag der mündlichen Prüfung: 29.04.2003

Gedruckt mit Unterstützung des Ökumenischen Studentenwerkes e.V.

Printed in Germany.
Druck: F. u. T. Müllerbader GmbH
Forststr. 18, 70794 Filderstadt, Germany

VERLAG ULRICH E. GRAUER
Linsenhofer Str. 44, 72660 Beuren, Germany
Tel. +49 (0)7025 842140, Fax +49 (0)7025 842499
Internet: http://www.grauer.de/, E-Mail: grauer@grauer.de

To the memory of
Leonard M. Gabagambi,
my father

ACKNOWLEDGEMENTS

At the outset, I express my gratitude to Prof. Dr. M. von Oppen of Institute 490B at the University of Hohenheim, for supervising this work. I was very much inspired by his integrity and personal organization that were strongest stimuli in completing this dissertation. Equally, I express my sincere thanks to Mrs. B. von Oppen for the generosity and educative discussions held during my two visits to her farm enterprise in Uckermark, Brandenburg.

I am deeply indebted to Ökumenisches Studienwerk e. V. of Bochum for financial support, without which this work would have remained a daydream. I am also grateful to those who were involved in one way or another in a successful completion of this dissertation. In the list are Prof. Dr. T. Becker, Prof. Dr. F. Heidhues, Prof. Dr. K. Stahr, Prof. Dr. D. Werner, Prof. Dr. V. Hoffmann of the University of Hohenheim, Professor Dr. G. Lorenz of Humboldt University of Berlin, Prof. G. Nzalayaimisi, Prof. F. Bahendwa, Dr. A. Blomquist, Dr. M. Blomquist, Mr. S. Kilimuhana, Mrs L. Akijar, of Tumaini University and Mrs. S. Werner of ÖSW. Others include Miss T. Hirsch, Mrs S. Johnson, Mrs. M. Karras, Mr. A. Khachatryan, Dr. N. Khachatryan, Miss R. Hirsch, Miss A. Hau, Dr. F. Hartwich, Dr. K. Issaka, Dr. N. Mungkung, Miss P. Suebpongsang, Miss A. Jimenez, Mr. D. Djadjaglo, Mr. M. D. Reys, Mr. M. Majdalawi, Miss K. Jiriwan, Mr. T. Hijawi, Mr. D. A. Kilasi, Mr. F. Lihida, Mr. Kishimbo, Mr. Kinyero, Mr. N. Y. Machengo, Mr. H. A. Nelson, Mr. A. Kahawi, Mr. B. Chando and Mr. S. Mlongo.

Without mentioning Dr. med. G. Hirsch and his family for a loving heart and unconditional support to my family during our stay in Stuttgart, would be a serious omission. I find it hard to get appropriate phraseology to express my gratitude to this family, probably this will do: *"Vielen Dank für alles was ihr für uns gemacht habt. Wir glauben, der Allmächtige Gott wird euch für alles entschädigen"*.

Last but not least, heartfelt gratitude goes to my family, especially my wife Esther Ashery, who endured, mostly with good humour, the painful process involved in a partner writing a scientific work. She, together with our children, Judith and Jerry, kept our home homely. Anyone not mentioned should consider himself/herself implicitly implied in this acknowledgements. Although this work involved many people, I remain solely responsible for any mistakes and views expressed in this book.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

At the outset, I express my gratitude to Prof. Dr. M. von Oppen of Institute 490B at the University of Hohenheim, for supervising this work. I was very much inspired by his integrity and personal organization that were strongest stimuli in completing this dissertation. Equally, I express my sincere thanks to Mrs. B. von Oppen for the generosity and educative discussions held during my two visits to her farm enterprise in Uckermark, Brandenburg.

I am deeply indebted to Ökumenisches Studienwerk e. V. of Bochum for financial support, without which this work would have remained a daydream. I am also grateful to those who were involved in one way or another in a successful completion of this dissertation. In the list are Prof. Dr. T. Becker, Prof. Dr. F. Heidhues, Prof. Dr. K. Stahr, Prof. Dr. D. Werner, Prof. Dr. V. Hoffmann of the University of Hohenheim, Professor Dr. G. Lorenz of Humboldt University of Berlin, Prof. G. Nzalayaimisi, Prof. F. Bahendwa, Dr. A. Blomquist, Dr. M. Blomquist, Mr. S. Kilimuhana, Mrs L. Akijar, of Tumaini University and Mrs. S. Werner of ÖSW. Others include Miss T. Hirsch, Mrs S. Johnson, Mrs. M. Karras, Mr. A. Khachatryan, Dr. N. Khachatryan, Miss R. Hirsch, Miss A. Hau, Dr. F. Hartwich, Dr. K. Issaka, Dr. N. Mungkung, Miss P. Suebpongsang, Miss A. Jimenez, Mr. D. Djadjaglo, Mr. M. D. Reys, Mr. M. Majdalawi, Miss K. Jiriwan, Mr. T. Hijawi, Mr. D. A. Kilasi, Mr. F. Lihida, Mr. Kishimbo, Mr. Kinyero, Mr. N. Y. Machengo, Mr. H. A. Nelson, Mr. A. Kahawi, Mr. B. Chando and Mr. S. Mlongo.

Without mentioning Dr. med. G. Hirsch and his family for a loving heart and unconditional support to my family during our stay in Stuttgart, would be a serious omission. I find it hard to get appropriate phraseology to express my gratitude to this family, probably this will do: *"Vielen Dank für alles was ihr für uns gemacht habt. Wir glauben, der Allmächtige Gott wird euch für alles entschädigen"*.

Last but not least, heartfelt gratitude goes to my family, especially my wife Esther Ashery, who endured, mostly with good humour, the painful process involved in a partner writing a scientific work. She, together with our children, Judith and Jerry, kept our home homely. Anyone not mentioned should consider himself/herself implicitly implied in this acknowledgements. Although this work involved many people, I remain solely responsible for any mistakes and views expressed in this book.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDICES

ABBREVIATIONS

Abbreviation	Interpretation
a.s.l.	Above Sea Level
AGSAC	Agricultural Sample Census
AGSASU	Agricultural Sample Survey
ASDS	Agricultural Sector Development Strategy
ASU	Agricultural Statistics Unit
BBT	Brooke Bond Tanzania Limited
BOT	Bank of Tanzania
CDP	Cooperative Development Policy
CIDF	Cashew Input Development Fund
CRDB	Cooperative and Rural Development Bank
CSB	Central Statistical Bureau
DRC	Democratic Republic of Congo
DRT	Department of Research and Training
ERP.	Economic Recovery Program
EU	European Union
FAO	Food and Agriculture Organization
FHWA	Federal Highway Administration
FRG	Federal Republic of Germany
GDP	Gross Domestic Product
GNP	Gross national product
HDI	Human Development Index
IARC	International Agricultural Research Centres
ICRISAT	International Crop Research Institute for the Semi-Arid Tropics
IDA	International Development Agent
IITA	International Institute of Tropical Agriculture
IDWK	Institut der Deutschen Wirtschaft, Köln
IRP	Integrated Roads Program
IRRI	International Rice Research Institute
MAC	Ministry of Agriculture and Cooperatives
MADIA	Managing Agricultural Development in Africa
MAFS	Ministry of Agriculture and Food Security
MCM	Ministry of Co-operatives and Marketing
MCT	Ministry of Communication and Transport
MDB	Marketing Development Bureau
MOW	Ministry of Works
MRALG	Ministry of Regional Administration and Local governments
MTC	Mufindi Tea Company
MWCT	Ministry of Work, Communication and Transport
MWLD	Ministry of Water and Livestock Development
NAFCO	National Food Corporation, and Tanzania
NALRP	National Agricultural and Livestock Research Project

NAMP	National Agricultural Master Plan
NAP	National Agricultural Policy
NARM	National Agricultural Research Master Plan
NARS	National Agricultural Research System
NBC	National Bureau of Statistics
NGO	Non-governmental organisations
NMS	National Master Sample
NPV	Net present value
PO-RALG	President Office Regional Administration and Local Governments
PVB	Present value of benefit
PVC	Present value of Cost
RETCO	Regional Transport Companies
RFB	Road Fund Board
SSA	Sub-Saharan Africa
SUDECO	Sugar Development Corporation
T&V	Training and Visit
TAFORI	Tanzania Forestry Research Institute
TANESCO	Tanzania Electricity Supply Company
TANROAD	Tanzania National Roads Agency
TANWART	Tanzania Wattle Company
TAZARA	Tanzania and Zambia Railway
TNAAP	Tanzania National Agricultural Adjustment Programme
TPRI	Tropical Pesticides Research Institute
RFB	Road Fund Board
TZS	Tanzanian Shilling
URT	United Republic of Tanzania
v.p.d	Vehicles per day
WB	World Bank

Chapter One

1 Introduction

Tanzania has substantial potentials to achieve faster and diversified economic growth necessary to raise welfare of her people. But the country is experiencing development problems. The economy is characterised by a large share of agricultural goods, predominance of primary exports, low degree of industrialisation and of economic diversification, high population growth rate, and high level of indebtedness. These problems are manifested in poverty as indicated by low income per capita, hunger, diseases, and low life expectancy. Escaping from these economic hooks, and creating sustainable development has been a dream of the government since independence. However, so far little has been achieved towards this goal.

Sustainable economic development of a country is a long-term process that occurs over decades and generations. Although increased industrialisation, and urbanisation are all important in the growth and development process, there is explicit consensus among economists that development of agriculture is a necessary starting point (Johnston and Mellor, 1961; Kuznets, 1964; Nicholls, 1964). To this, Todaro (1989) adds that without agricultural development, industrial growth either would be stultified, or if it succeeded, would create such severe internal imbalances in the economy that the problems of widespread poverty, and unemployment would become even more pronounced.

To have a significant contribution to economic development, agriculture should be modernised by being transformed from predominantly home-consumption oriented farm units to more specialised, productive and market oriented enterprises. The modernisation process requires substantially increasing the total output and productivity in a manner that will directly benefit the average small producers while providing

sufficient food surplus to support a growing urban industrial sector (Farris, 1983).

In Tanzania, the agricultural sector is far from being modernised. Most of agricultural output is produced using rudimentary technology, mainly by smallholder farmers scattered in rural communities. On the other hand, the major markets and processing facilities for crops as well as input sources are located in urban centres usually at a considerable distance from each other and from the major seaports. Because of this structure of human settlement and of production, access to market in terms of transport system assumes an extraordinarily important role in the country's economic development. Well-developed road infrastructure benefits the farmers in many ways. It opens villages to other villages and to market centres, reduces transport costs and improves competitiveness in the marketing system. This, increases producer prices, and raises the income of the poor, whose expenditures stimulate demand of industrial goods.

The views presented above concede with those of the World Bank, which underscore the gravity of rural transport bottlenecks in Sub-Saharan Africa (SSA). The bank observes that improving rural infrastructure is an essential requirement for the modernisation and growth of agriculture. It further cautions that although better market incentives (especially related to prices and inputs) to farmers remain important factors in agriculture, their impact would be blunted if the physical barrier and economic cost of transporting goods to and from local markets remains high. The alleviation of these barriers and easing socio-economic intercourse essential for development would require improvement in access between villages and markets, schools, medical, economic, administrative and social services, which affect the day to day lives of rural people (World Bank, 1991).

Furthermore, Mellor and Pandya (1990) in their research project "Managing Agricultural Development in Africa" (MADIA) estimated that the present rural road network of SSA needs to be substantially increased if the full agricultural potentials of the region necessary to support the population are to be realized. They argue that even if only a

part of the extra rural road network required to increase densities were to be built, the annual outlay could double to US$ 2 billion a year, or about 1.4% of SSA Gross national product (GNP). These figures are relevant given the 4.0% per annum target for agricultural growth in the region forecast, which translates to about a 1.5% increase in GNP. This target for extra agricultural production is unlikely to be achieved if there is no improvement in rural roads and other market infrastructure.

There are vivid evidences to show that road infrastructure rehabilitation exerts significant impacts on the life of the people in the area influenced by a particular road project. For example, an economic and social impact assessment study, which was carried out by the Ministry of Works, Communication and Transport (MWCT) on Kwa Sadara-Mbweera road in 1992, showed that in two years since the road was rehabilitated, annual daily traffic flows had increased from about 59 to 274 vehicles per day, passenger traffic had increased from 66 to 1,300 per day, vehicle operating costs declined by 31%, agricultural input supply and other social amenities improved substantially. With this background, this study asserts that if profitability of inputs remains a problem due to high marketing and transportation cost in Tanzania, strategies to improve agricultural production and fight poverty will not be successful.

1.1 Problem Statement

Tanzania's economy is facing a challenge. The World Bank (1996) asserts that even if the economy of Tanzania grew by 8% from the current 4%, with the population growing at 2.8% per annum, by year 2010 about one third of the population would still be living in poverty. Today, over 60% of the population in Tanzania is estimated to be living below the international poverty line of $2 per day (World Bank, 2000). This underlines the magnitude of the challenge facing the country in implementing her National Development Vision 2025. However, tremendous achievements could be realised if the government addressing the problems facing the farm sector and allied industries, which support over 70% of the population.

The major agricultural concerns have been stipulated in the National Agricultural and Livestock Policy (NALP) of 1997, and its implementation strategies (ASDS) of 2001. They include low productivity, poor coordination and limited capacity, underdeveloped supporting facilities, erosion of the natural resource base, inappropriate technology, drought, lack of access to financial services and markets, and lack of secure and timely supply of inputs. Many strategies aimed at improving the agricultural sector have focused on direct intervention for example provision of inputs such as fertilisers and other chemicals at subsidised prices, establishing of cheap financial institutions for farmers, provision of modern farm equipment, and marketing agricultural produces through single channel marketing system.

These policies have not produced desired fruits; there are still numerous constraints. Exports are lower than they were in the late 1960s and 1970s and agricultural productivity is unreliable and lower than world average. By way of comparison, while one farmer in Tanzania produces enough food to feeds 3 people per year, in a developed country like Germany, one farmer feeds 104 people (MAC and NBS, 1999; FRG, 1998). In recent years food shortage has been extensive and the government declared 1997/98 as a famine year. Food shortage forces the country to import thousands of tons of foodstuffs especially cereals. In this way, the country loses not only foreign exchange that could be used to import industrial inputs but also revenue when the importation is accompanied by tax exemption. A common feature is that while people in one part of the country are starving, in other parts they are complaining of lack of market for their produce. This indicates bottlenecks in the procurement and distribution process, that is, market infrastructure.

Indeed market infrastructure, especially road network has not been given due attention as a catalyst for stimulating agricultural productivity. The supply of roads in Tanzania, just like in other developing countries is highly insufficient. In many food-growing areas, crops are carried many kilometers by head porterage to the assembly markets or roadsides (Riverson and Carapetis, 1991). Barwell and Calvo (1989) found that activities involving transport consume inordinate amounts of household time and energy in rural areas. The average total time spent by village

households on transport is estimated at 1,875 hours a year in Tanzania (for about 80 ton-kilometres, with an average household size of 4.5). Problems in the transport sector affect agricultural production in two ways: firstly, the time and energy spent on transport related activities reduce labour productivity. Secondly, increased marketing costs as a result of inadequate and poorly maintained roads are passed on to the farmers in terms of low farm-gate prices.

Policy-makers in Tanzania acknowledge the positive contribution of good road to economic efficiency and well being of the society. However, many of them lack an understanding of empirical relationships between road infrastructure and other facets of the economy. This study provides empirical evidence how roads contribute to economic development, and also examine the profitability of road investment in Tanzania. Quantitative measurements of this type would enable policy-makers have an idea about the explicit impact of their decisions to improve or neglect market infrastructure. The main objective of this study is to examine the linkage between road and agricultural productivity in Tanzania, using Tanzania-Zambia road (TANZAM) as a case study. Apart from examining the role of the agricultural sector and the spatial distribution of road network in Tanzania, this study seeks to answer the following relevant questions:

(i) Roads are important for agricultural development, but how can road infrastructure contribution to aggregate agricultural productivity be quantified?
(ii) Road improvement generates gains to the society, are the gains accrued equitably distributed between strong and weak participants in the system?
(iii) What are the sources of productivity gain from improved access to road infrastructure?
(iv) Is investing in road construction in the study area an economically profitable venture?

In answering these questions, the study is guided by four basic hypotheses:

(i) Access to road has a significant positive impact on aggregate agricultural productivity.
(ii) Gains from improved market access are not equally distributed among strong and weak producers because of the difference in endowments and in the ability to take advantage of improved economic conditions.
(iii) Productivity gains from improved roads are due to specialisation and intensification effects.
(iv) It is economically profitable to invest in road infrastructure in the study area.

1.2 Scope and Limitation of the Study

The impact of road infrastructure is a very wide subject. Following the powerful impact of roads on human life there are various perspectives from which road influence could be studied. Historians interested in the dynamic aspect of trade opportunities brought about by road accessibility, may focus their study on cultural exchange, stimulation for innovations and progress, as well as exploitation and suppression. Sociologists, also interested in human development point out the social implications of increased mobility of people in the trading process (for example marginalisation of the ethnic minorities in rural areas, cultural contamination and spread of diseases). Geographers' interest is at the spatial distribution of production and concentration of human settlements, especially marketplaces and urban centres, and also spatial and temporal patterns associated with periodic markets in the area influenced by a road project. For economists, the centre of interest in improved road access is increase in efficiency that translates into economic gains to the actors in the system, the view that is followed by this study. The main emphasis is on the relationship between road access and aggregate agricultural productivity and distribution of gains among producers.

In the real world, everything is related to everything else. It would be virtually impossible to cover the whole aspects related to the fields of road infrastructure and agriculture, and this study does not pretend to do this. Agricultural sector means different things to different economists and nations. For Tanzania it encompasses activities such as crop production, livestock keeping, forestry, hunting and fishing. Each of these would require a considerable volume, time and resources for a comprehensive coverage. The coverage of this study is limited to crop production. However other aspects of agriculture are mentioned in appropriate sections to underline points under consideration.

The system of production and marketing of crops is wide, taking into consideration the wide range of actors along the agricultural value-chain. These include producers, traders or middlemen, consumers, state and non-governmental organisations (NGOs). All these respond to road development in different and sometimes complex ways. The limitation of this study is on the influence of roads on the decision-making behaviour of farm households in allocating resources in the area affected by a road. It is appropriate to target the producer because he/she is an entity that triggers all the activities in the system by creating products and offering them for sale. Due to their specific nature, aspects of road engineering, transport in its broad context, urban roads, industrial location, trading in manufactured good, sociological and environmental issues of road infrastructure are not covered in this text, although they seemingly relate to the topic. However, in some parts they are mentioned in passing.

By examining only the relationship between road infrastructure and agricultural productivity, the assumption was that other factors likely to exert influence on agricultural production are constant. That is, they are not interfering with the analysis, which may not be the case. For example, if farmers do not have access to basic social amenities such as water and health services, their productivity would definitely decrease. Apart from removing labour from the production process sickness drains resources in terms of cash from production. Lack of domestic water supply in the vicinity of households may severely reduce the productivity of female farmers and children as they spend most of the time searching for water.

Probably the most important assumption was that institutions that govern the behaviour of actors in the production and marketing system are conducive for a free market economy. But if the policy framework does not provide equal opportunities for all participants in the agrichain, the results of a study like this may be adversely affected. For example if farmers are not free to choose what, where and when to sell their products in response to price incentives offered by the marketing system, and if traders are not permitted to buy certain kinds of produces, or are not allowed to buy crops from certain areas, the impact of access to road infrastructure may not be realised. The same is true if there are bottlenecks in laws regulating ownership and importation of vehicles, spare parts and other intermediate means of transport.

Furthermore, the data used in the technical analysis are cross-sectional in nature, that is, they were collected on the individual farmers at a given point of time. In this way, there is a possibility that the underlying trend of events determining observed output could not be considered in the analysis. Similarly, by dealing with farm-level data some variables such as rainfall, temperature and policy decisions, all being important factors influencing agricultural output were omitted in the analysis. In Tanzania rainfall and temperatures are not measured at individual farm-level.

In addition, this study belongs to the social science domain. The shortcomings in this field have been long documented. Like any other social study, this study deals with human beings whose behaviour cannot be predicted in any precise way. The theory that governed this study was based on an economic man, who is absolutely rational all the time. But in real life the decision-making behaviour of a human being is very circumstantial. Thus, the responses given by the farmers during the survey cannot be guaranteed, because the responses were definitely based on certain speculations. However, all possible precautions were taken to avoid misunderstandings during the survey process. Lastly, it is worth mentioning here that the coverage of the study was limited to the mainland part of Tanzania. This was partly to limit the size of the study and partly because road and agricultural sectors are not Union matters. Zanzibar has its own ministries of transport and agriculture.

1.3 Organisation of the Book

This book is organised into seven chapters presented sequentially to give the reader a smooth navigation through the text. The book has been prepared with both, professional and non-professional readers in mind. Because of that a balanced presentation has been made between technical and non-technical materials. The first chapter introduces the subject of the study and presents the main questions, which this study seeks to answer and the hypotheses upon which it is hinged. In Chapter Two, the physical and economic overview of Tanzania and the study area in particular is presented.

This study touches directly two sectors namely agriculture and road infrastructure. Therefore, Chapter Three and Four are devoted to comprehensive coverage of these sectors at national level. Issues pertaining to the nature, performance and potentials of the agricultural sector are discussed in Chapter Three, whereas the nature and development of road network in the country is discussed in Chapter Four. Apart from discussing the conceptual framework on which this study is based, Chapter Five reviews literature on previous empirical works related to the main theme of this study. In addition, the methodological aspects including formulation and estimation of the model are given in details in the same chapter. Chapter Six deals with analysis and interpretation of the results. The presentation is basically divided into three parts. In part one, detailed results of descriptive analysis are presented. Part two deals with the results of econometric analysis, and the last part concentrates on profitability analysis of road investment. The last chapter presents summary, conclusion and recommendations for policy purposes. At the end of the book, appendices are present to supplement some concepts in the main text.

Chapter Two

2 Physical and Economic Overview

In Chapter One, the main objectives of this study were outlined. This Chapter presents the physical and economic features of Tanzania and the study area in particular. This will prepare grounds for discussing specific issues relevant to agricultural and road sectors in Tanzania. However, aspects related to agricultural policies and road infrastructure in the country are skipped here. They are given special coverage in separate chapters because they are the focus of this study.

2.1 Physical Features of Tanzania

Tanzania is located in the tropics south of the equator between latitude 1^0 0'S and 11^0 45'E and between longitude 29^0 13'E and 40^0 78'E. Her area is nearly 945,087 km^2 of which 885,987 km^2 is landmass. The southern highlands form a major connected mountainous area (Figure 2.1). In the northeast is a mountainous region that includes Mount Meru (4,566 m) and Mount Kilimanjaro (5,895 m). To the west of Kilimanjaro is Serengeti National Park, which contains the Olduvai Gorge and Ngorongoro Volcanic Crater. West of Serengeti, are the shores of Lake Victoria. Southwest of Lake Victoria lies Lake Tanganyika, which forms Tanzania's border with Democratic Republic of Congo (DRC). In the southeastern part is a mountainous region that includes Lake Nyasa. East of Lake Nyasa is the Selous game reserve. Northeast of Selous is Tanzania's coastal strip of about 800 km, crossed by some permanent rivers.

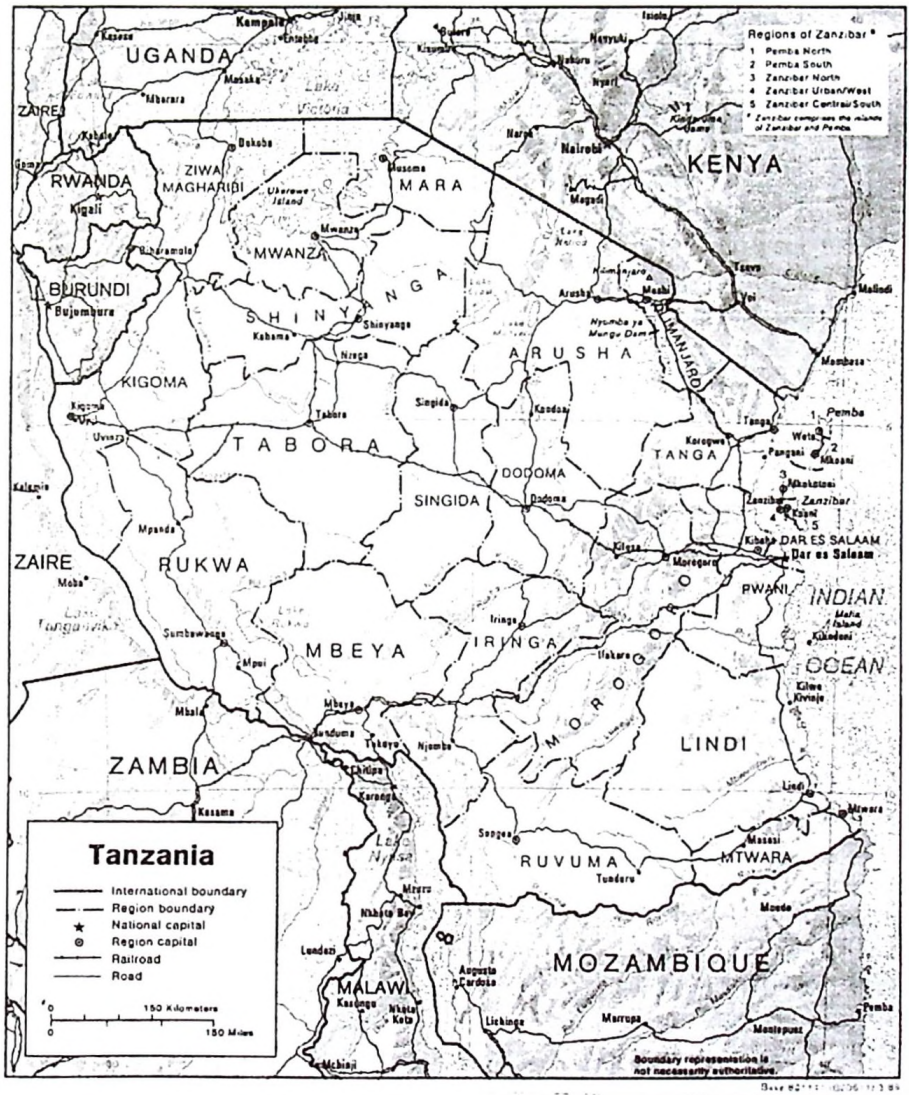


Figure 2.1: Tanzania location, administrative regions and transport network

Source: http://www.inweh.unu.edu/lvfo/images/tz.gif

Tanzania climate displays great range of regional differences. In most areas there are two very distinct rainy seasons: the long rains roughly from March to May and the short rains from October to December. Rainfall in large parts of the country is relatively low and there is considerable uncertainty about the average amount of rain with strong annual fluctuations. A large part of central regions is semi-arid, receiving less than 500 mm of rain annually. In contrast, the mountainous area of northeast and southwest receive over 2,000 mm of rain annually. Along the cost, rainfall ranges between 1,000 and 1,900 mm. Rain often falls in a very concentrated way and then leads to temporary flooding, but it usually also ends very rapidly. During the dry season it hardly rains at all; particularly in the central parts of the country there is effectively no drop of rain, often for several months (Hofmeier 1973).

In terms of temperature, the narrow lowland coastal region is consistently hot and humid (27-29 ^{o}C), while in the central, northern and western parts, highland plateaus modify climate. These areas have low humidity with temperatures ranging between 20 and 27 ^{o}C during the summer season. The temperature can be as high as 30 ^{o}C or higher during winter season. In the sufficiently elevated areas of the northeast and southwest, the temperature occasionally drops below 15 ^{o}C at night in summer. On the mountains the temperature can be as low as 6 – 8 ^{o}C (Hofmeier, 1973).

Detailed surveys of quality and fertility of soils are only available for fairly small areas of the country. But it is clear that large parts of the total land area do have soils of only minor quality for agricultural usage. Particularly fertile are the volcanic soils in Arusha and Kilimanjaro regions in the north and those in the Southern Highlands. In addition there are smaller areas with very fertile black cotton soil scattered all over the country. Laterite and murram, which are mainly used for the construction of earth and gravel roads, are, largely available in the whole country, but their distribution is uneven at local level (Hofmeier, 1973).

2.2 Economic Features

2.2.1 The Structure of the Economy

The structure of Tanzania's economy is categorised into nine major sectors of which agriculture is a leading sector. Other sectors include trade, public administration, utilities, construction, manufacturing, transport and communication, finance and insurance, and mining (Figure 2.2).

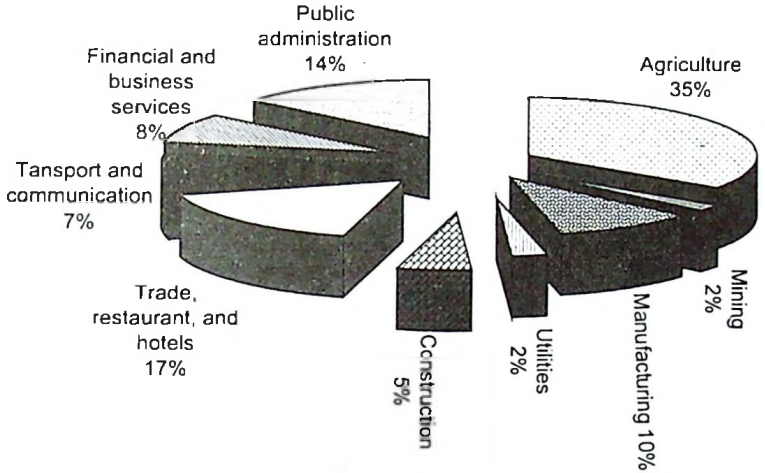


Figure 2.2: Tanzania GDP by kind of economic activity, 1999

Source: Compiled from BOT Economic Bulletin, December 31, 2001

The industrial sector contributed about 10% to GDP in 1999, but it is increasing at a fairly high average annual growth rate (BOT, 2001). This sector together with the construction and the public utilities sector contributed more than 15% of GDP. This indicates clearly the relatively unimportant role that industry still has at the moment for the total economy. One characteristic of industrial production in Tanzania is concentration of industrial activities on just a few locations, predominantly Dar es Salaam. Other growing industrial locations include Mwanza, Arusha, Moshi and Mbeya. Growth activities include food processing, beverages, tobacco, pharmaceuticals, footwear, electric

equipment, chemicals, batteries, steel, saw milling, cement, textiles, and paper.

The country is rich in mineral resources and its mining industry is becoming an important sector in the economy. In 1999 its contribution to GDP was estimated at 2.0% (BOT, 2001). Good progress has been made in gold mining in Mwanza and Tabora. On the other hand, Tanzanite at Merelani, Arusha, is emerging as one of the most important minerals in Tanzania. In addition, Tanzania has a potential for minerals such as natural gas & oil, iron, salt, phosphates, coal, gypsum, kaolin and tin (World Bank, 1996).

Tourism is an important activity on which considerable expectations for the future are based. Exact figures in respect to its contribution to GDP and its influence on the balance of payments do not exist, but it is clear that there is a large potential for the development of tourism and that this sector could possibly reach a similar importance as in Kenya, where the receipts from tourism figure are prominent in the balance of payments. However, its contribution to the economy can be implicitly implied in the trade, restaurants and hotels sector, which contributed 17% to GDP in 1999. At present the "northern circuit", which comprises Mount Kilimanjaro, the town of Arusha and Moshi, and the parks of Lake Manyara, Ngorongoro Crater and Serengeti is the most important tourist area. (BOT, 2001). The agricultural sector and the transport and communication sector will be given special coverage in Chapter Three and Four because they form the central point of this study.

2.2.2 Population

Government statistics put the population figure at 33.7 million in 1999. The entire population of the classified urban area accounts for only 33% of total population. The growth rate of the urban population quadruples that of the population at large, and the degree of urbanisation is increasing at a tremendous rate. There are 20 towns with a population of more than 100,000 inhabitants. The distribution of population within Tanzania is extremely uneven. There are tremendous differences in respect to population density and also growth rates show marked

differences between various regions. Figure 2.3 shows clearly that the areas of main population concentration are very scattered and are in most cases found on the periphery of the country. The largest highly populated areas are found around Lake Victoria, at the foot of Mount Meru and Mount Kilimanjaro, Tanga, Mbeya and Mtwara regions. With the exception of some concentration around Tabora, Kigoma, Singida, Dodoma, Morogoro and Arusha regions, the centre of the country is almost empty.

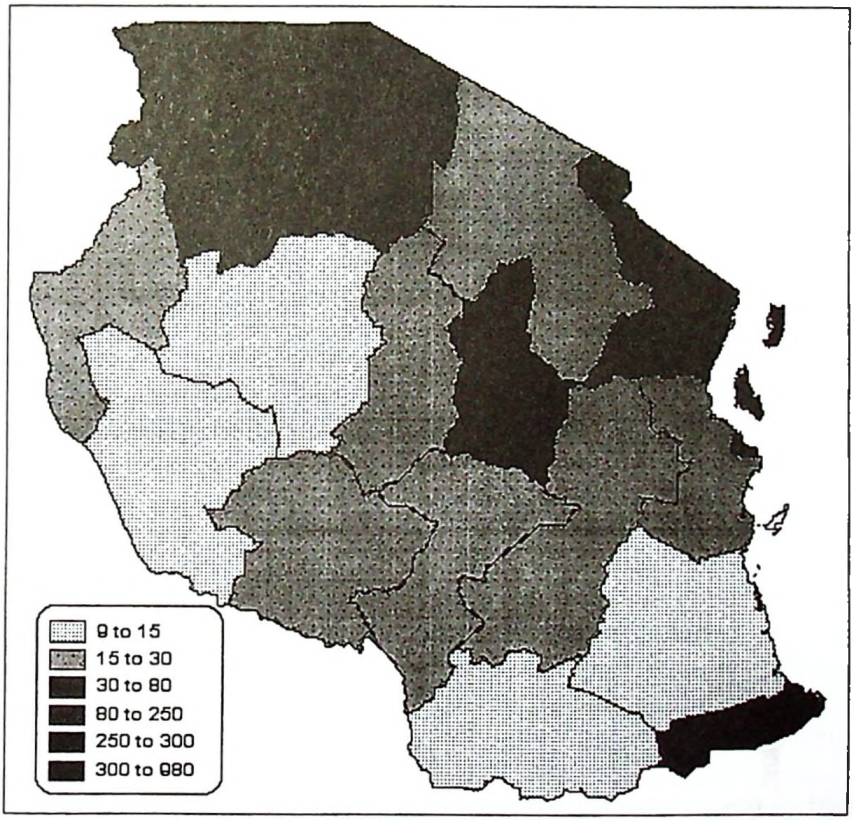


Figure 2.3: Population density of Tanzania (inhabitants/km²)

Source: http://www.fao.org

The whole situation is characterised by several population concentrations that are geographically far apart from each other and only in a few cases linked by populated corridors. This very uneven population distribution with vast, almost unpopulated stretches of land was certainly significantly influenced by prevailing conditions of climate and soil quality, but also because of historical developments. So far the only dynamic urban growth centres apart from Dar es Salaam are the Arusha-Moshi complex and Mwanza, all three along the northern boundary of the country and Mbeya in the southern highlands.

2.2.3 Macroeconomic Context

Since independence in 1961 Tanzania has changed the country's development strategy and economic management system from market-oriented to socialist-oriented and back to market-oriented economic system. This had serious consequences to the spatial production and distribution of the social and economic infrastructure as well as to economic progress and poverty alleviation objectives. In the first phase of market-led economic development (1961-66), the economy grew rapidly. The international and domestic trade that emerged determined the direction and pattern of transport infrastructure, the relative growth of urban centres and the regional specialization of food and cash crop production. A small urban economy based on manufacturing, handicraft and services emerged leading to urban-rural exchanges. The transport sector fostered the spatial division of labour and the progressive integration of the domestic market (NBS, 1997). The Arusha Declaration of 1967, in which large manufacturing, financial, commercial, construction, mining and export and import businesses were nationalized, altered the pattern of inter-rural, urban-rural, intra-urban as well as linkages of domestic to international markets.

With most of the economy under state control, public expenditures were seen as the vehicle for developing the economy. Initially, the economy performed well with both agriculture and industry growing at moderate rates between 1966 and 1975. Impressive gains were recorded in education, health and rural development. In transportation, pan-

territorial prices were introduced and this encouraged production in some isolated parts of the country.

However, by the early 1980s the gap between public expenditure and aggregate supply had widened, the current account deficit was about 15% of GDP, inflation was about 30% and the exchange rate was substantially overvalued. These economic imbalances were caused primarily by the high level of government expenditure and were exacerbated by the decline in the country's terms of trade due to the collapse of the coffee boom, decline in donor aid and the war with Uganda in 1979-80. With these difficulties, the level of public expenditures allocated for construction and maintenance started to decline resulting in severe deterioration of road infrastructure. The government supported a highly overvalued currency by means of rationing and price controls, which created an acute shortage of basic consumer goods. In the manufacturing sector the shortage of foreign exchange for importation of intermediate goods led to under utilisation of capacity and the parallel market began to flourish (URT, 2000).

Having exhausted the various direct means of stimulating the economy and restoring growth to pre-1975 levels, in the mid-1980s, the government attempted a number of changes in economic incentives; but these were not comprehensive enough to address the high level of distortion in the economy. Finally, in 1986, the government launched its first Economic Recovery Program (ERP). The objectives of ERP were to achieve a positive growth rate in per capita income, lower the inflation rate and restore a sustainable balance of payment position. These objectives were to be achieved through policy and institutional reforms, market liberalization and enhancing the role of the private sector. Further, measures towards exchange rate equilibrium, positive interest rates and export promotion were to be implemented through a gradual dismantling of the administrative controls over prices and marketing and distribution arrangements. The introduction of these measures stimulated production, integration of domestic markets and changes in production patterns.

With the agricultural sector responding favourably to the ERP, it soon became apparent that the deteriorated road infrastructure, high

transport costs and lack of reliable means of transport had become serious constraints to expansion of production and integration of markets. In 1990, the Integrated Roads Program (IRP) was launched as a ten-year program aimed at stabilisation and restoration of the road network (World Bank, 1996).

2.3 Physical and Economic Features in the Study Area

As it will be made clear later, this study was conducted along the Tanzania and Zambia highway (TANZAM) on the Tanzania section. This road passes through five administrative regions namely Dar es Salaam, Coast, Morogoro, Iringa and Mbeya. In this section physical and economic characteristics of the regions covered in this study are examined. Dar es Salaam is excluded because of the reason to be explained later. The agricultual activities and transport network for these regions will be discussed uder respective chapters later. The studied regions present a fairly good picture of Tanzania, considering the fact that they lie between 0 and 3000 m a.s.l.

2.3.1 Coast Region

Coast region is situated on the Eastern part of Tanzania mainland along the Indian Ocean coastal belt. The region covers a total area of 3.4 million ha, which is equivalent to 3.8% of the total area of Tanzania. Out of this, 0.3 million ha are under cultivation of different cash and food crops. Administratively, the region is divided into six districts namely Bagamoyo, Kibaha, Kisarawe, Mkuranga, Rufiji and Mafia. Of these, Kibaha, Kisarawe and Bagamoyo are dissected by TANZAM.

Topography of Coast region is characterised by three main features; the coastal belt zone, the river basins and lowland zone, and the highland plateau zone. The coastal belt zone extends from the northern border of Bagamoyo district with Tanga region to the southern border of Rufiji district with Lind region. The zone rises from 0 m to 100 m above sea level. The zone is dominated by sandy loam soils except lower lands with heavy clay water logged soils suitable for paddy production (NBS, 1997).

The river basins and lowland zone comprises four big rivers (Rufiji, Wami, Ruvu and Pangani), traversing the region from west to east to discharge waters into the Indian Ocean. Rufiji River crosses the region in the southern parts passing through Rufiji district in a west-east direction. Wami River crosses the region in the northern parts passing through Bagamoyo district in a west-east direction. Ruvu River crosses the region through different parts passing Kibaha and Bagamoyo districts in a southern west-north east direction. The Highland plateau Zone is the coastal hills and highland areas, which rise from 100 m to 480 m above sea level, mainly dominated by loam, and sandy clay soils.

The weather is generally hot due to the influence of the ocean. The region experiences a tropical climate with an average temperature of 28 °C. There are two rain seasons, the main and the short rain seasons, with average rain of 1000 mm per year. The main rain season lasts for roughly 120 days between March and June. The rains are usually heavy and spread throughout the region. This is also the main crop planting season for all crops, but especially so for the seasonal crops such as maize, paddy and cotton. The short rain season lasts for about 60 days between October and December. The rains are not evenly distributed and they are not very much reliable. They are suitable for short-term crops such as pulses (NBS, 1997).

Economically, Coast region has a typical agricultural economy with more than 90% of its population depending on agriculture. In the year 1996 Gross regional income was estimated at TZS 20.8 billion, the contribution of agriculture being 17.3 billion, equivalent to 83.3 per cent of regional income. The region has the lowest GDP per capita (TZS 28,149). It ranks last in the contribution to the National GDP, in which it contributes only 1%. According to NBS (1997), this is attributed to numerous constraints in the farming sector. In terms of population, Coast is the least populated region in Tanzania mainland, with only 2.8% of the total population of the country according to 1988 Population Census. Population is not evenly distributed among districts. Mafia district has the highest population density of 63.8 people per square kilometre while Rufiji has the lowest population density of 11.4 people per square kilometre. Average household size differs from one district to another, but the household size for the region is 4.9, which is a bit lower

than the national average of 5.2. In general, the average household size is higher in the urban areas than in the rural areas possibly because of region's proximity to Dar es Salaam, which attracts immigrants from rural upcountry.

2.3.2 Morogoro Region

Morogoro region occupies a total of 7.3 million ha, approximately 8.2% of the total area of Tanzania mainland. It is the third largest region in the country after Arusha and Tabora regions. Administratively the region is divided into five districts namely Morogoro urban, Morogoro rural, Kilosa, Kilombero and Ulanga district. Three distinct agro-ecological zones are identified in Morogoro region. These include highlands (600 m a.s.l), plateau (300-600 m a.s.l), and lowland and river valleys (blow 300 m a.s.l).

The annual rainfall ranges from 600 mm in lowlands to 1,200 mm in the highland plateau. However, some areas of Kilosa district and Morogoro rural experience very low rainfalls. The mean annual temperatures vary with altitudes. The average annual temperatures vary between 18 ^{0}C on the mountains and 3 ^{0}C in river valleys. In general the hot wet season runs from July to September. The region's contribution to national economic growth stands at an average of 4.7% and the region ranks 8 out of 20 regions in the country. In 1994, the GDP per capita was estimated at TZS 59,370 well above 13 other regions in the country. Population-wise the region had a population of 1.2 million in the 1988 national population census, growing at 2.6% per year. Like in the Coast region, the population is unevenly distributed, Morogoro rural being the most populated district accounting for 35.2% of the regional population total. About 78% of the residents of Morogoro region live in rural area.

2.3.3 Iringa Region

Iringa Region lies in the southern highlands of Tanzania mainland. It stretches from the semi-arid central Tanzania in the north to the shores of Lake Nyasa in the south. The region has an area of 5.9 million ha, 73%

of which is arable land. The area under cultivation makes 6.8% of the total region's area. Iringa is composed of six administrative districts: Mufindi, Iringa rural, Iringa urban, Njombe, Ludewa and Makete. The region is further subdivided into 31 divisions, 113 wards and 628 villages.

Iringa Region is divided into three agro-ecological zones namely the highland zone, midlands zone and lowlands zone. The highlands zone lies at an altitude of 1,600 to 2,700 m above seal level and covers an area of about 2.3 million ha. The midlands zone lies at an altitude of 1,200 to 1,600 m above sea level and covers an area of 1.8 million ha. The lowlands zone lies at an altitude of 900 to 1,200 m sea level and covers an area of 0.6 million ha. The areas falling within the lowlands zone include mainly the low-lying north of the Iringa region along the Ruaha River.

Iringa region is dominated by the Kipengele and Livingston mountain ranges in the south and Udzungwa Mountains separating Iringa and Morogoro region. Northern Iringa is relatively flat, high plain cut by the eastern rift valley in which the great Ruaha River runs. As far as drainage is concerned Iringa region forms part of the Indian Ocean drainage zone. The great and little Ruaha Rivers join the Rufiji River outside the region to form part of the Rufiji River basin. In terms of climate, the region is characterised by a wide range of climatic conditions. Annual rainfall ranges between 500 and 1,600 mm depending on the agro- ecologic zone. The highland zone has in most cases temperatures below 15 ^{0}C and receives plenty of rainfall ranging between 1,000 mm and 1,600 mm per year. In the midlands zone temperatures range between 15 ^{0}C and 20 ^{0}C with average rainfall varying between 600 and 1,000 mm. The areas falling within the lowland zone are normally dry with temperatures ranging between 20 – 25 ^{0}C. They also receive little rainfall of 500 to 600 mm.

Iringa region is one of the 10 regions in Tanzania, which have large population. In the 1988 population census, the region had 5.3% of the total population in the country, growing at 2.7% annually. However, the population density is relatively low compared to densely populated regions like Kilimanjaro, Mwanza, Mtwara, Tanga or Kagera. Iringa's

population density of 21.3 persons per km² is below the national average of 26 persons per km².

2.3.4 Mbeya Region

Mbeya Region is located in the southwestern corner of the Southern Highlands of Tanzania. It lies at an altitude of 475 m a.s.l. with high peaks of 2,981 m a.s.l. at Rungwe. Mbeya shares borders with countries of Zambia and Malawi. The region covers 6.3 million ha, which is 6.4% of the total area of Tanzania. Out of this, 1% is water and 47% is arable land. Administratively, Mbeya region is divided into Chunya, Ileje, Mbeya, Mbozi, Rungwe and Mbalali Districts. The districts are further subdivided into 25 divisions, which are subdivided into 135 wards and 577 villages.

In most arable areas, soils are of moderate fertility. Although a large area of the region is cultivated, large tracks of land are still covered with natural vegetation. Three types of agro-ecological zones are found in Mbeya Region. These include the high potential zones, the medium potential zone and the low potential zone. The highlands zone lies at an altitude of 1,500 to 2,400 m a.s.l. The midlands zone lies at an altitude of 800 to 1,500 m a.s.l., whereas the lowlands lie at an altitude of 800 to 1,400 m a.s.l. There are three main drainage basins within the region. These include Ruaha-Rufiji basin extending towards the east, the inland Lake Rukwa basin in the northwest, and the Lake Nyasa basin in the south.

Mbeya region, like that of other regions in the country depends on subsistence agriculture. About 80% of population dwell on crop production, and the rest live on livestock keeping, fishing, small-scale industrial activities, minor mining and other petty business. It is also reported that over 90% of the regional GDP), is derived from agriculture. The Gross domestic product was estimated at TZS 84.9 billion in 1994, making a contribution of 5.7% to the national GDP. The five-year average per capita income of the region is about TZS 33,375, being the lowest in the "big four" namely Iringa, Mbeya Ruvuma and Rukwa (Table 2).

Table 2: Regional GDP and GDP per capita, at current prices for the four maize surplus regions (millions TZS)

Year	Region							
	Iringa		Mbeya		Ruvuma		Rukwa	
	GDP	GDP per capita	GDP	GDP per capita	GDP	GDP per capita	GDP	GDP per capita
1990	35,897	28,144	32,978	21,174	18,063	21,856	24,346	33,203
1991	45,663	34,812	42,243	26,374	22,909	26,954	31,721	42,067
1992	56,694	42,028	52,191	31,685	29,567	33,828	39,933	51,495
1993	71,664	51,659	65,901	38,904	38,638	42,985	51,631	64,742
1994	92,021	64502	84,903	48,737	48,565	52,537	66,160	80,669
5-year average	60,388	44,229	55,643	33,375	31,548	35,632	42,758	54,435

Source: NBS, 1997

In the 1988 population census Mbeya region had 1,476,199 people, about 6% of total Tanzania population. This makes Mbeya region one of the most populated regions in Tanzania after Shinyanga and Mwanza. The population growth rate of 3.3% per annum is one of the highest rates in the country. However the population density of 25 people per km^2 is lower that the national average. The density is generally lower in the rural areas than in urban areas. The household size is 4.9, which is lower than the national average of 5.2.

Table 2: Regional GDP and GDP per capita, at current prices for the four maize surplus regions (millions TZS)

Year	Region							
	Iringa		Mbeya		Ruvuma		Rukwa	
	GDP	GDP per capita	GDP	GDP per capita	GDP	GDP per capita	GDP	GDP per capita
1990	35,897	28,144	32,978	21,174	18,063	21,856	24,346	33,203
1991	45,663	34,812	42,243	26,374	22,909	26,954	31,721	42,067
1992	56,694	42,028	52,191	31,685	29,567	33,828	39,933	51,495
1993	71,664	51,659	65,901	38,904	38,638	42,985	51,631	64,742
1994	92,021	64502	84,903	48,737	48,565	52,537	66,160	80,669
5-year average	60,388	44,229	55,643	33,375	31,548	35,632	42,758	54,435

Source: NBS, 1997

In the 1988 population census Mbeya region had 1,476,199 people, about 6% of total Tanzania population. This makes Mbeya region one of the most populated regions in Tanzania after Shinyanga and Mwanza. The population growth rate of 3.3% per annum is one of the highest rates in the country. However the population density of 25 people per km^2 is lower that the national average. The density is generally lower in the rural areas than in urban areas. The household size is 4.9, which is lower than the national average of 5.2.

Chapter Three

3 Agricultural Sector Development in Tanzania

As already noted this study focuses on the sectors of agriculture and road infrastructure. While road infrastructure will be delt with in the following chapter, in this chapter, salient feature of the agricultural sector in Tanzania are explored. Specifically, the chapter discusses issues related to management, nature and performance of the agricultural sector, with the aim of portraying the potentials for increased output. The chapter also examines briefly crop production in the study areas.

3.1 Management of Agricultural sector in Tanzania

Management of agricultural sector in Tanzania is under the Ministry of Agriculture (MAC). The functions of the ministry revolves around achieving the objectives of the agricultural sector in the country, which include to: sustain food self-sufficiency, increase production and product quality for both domestic consumption and export, diversify production to widen commodity market through product development, raise farm income and expand employment opportunities, increase integration within the agricultural sector and between agriculture and industries, and preserve and protect the nation's natural resource base to achieve sustainable agricultural development (Shao, 1993). Consequently, MAC is responsible for developing agriculture that is substantially commercial, competitive and highly diversified through formulation of appropriate policies, provide sound regulatory frameworks and support services as technical advice to farmers and private sector for a sustainable growth and poverty reduction. In addition the ministry ensures food security, improves rural livelihood, expands rural employment and acts as an effective basis for economic growth and inter-sectoral linkages, while utilising natural resources in an overall sustainable manner.

However, when this study was carried out, the government had split MAC into three ministries to increase effectiveness in rendering services. The ministries include the Ministry of Agriculture and Food Security (MAFS), the Ministry of Co-operatives and Marketing (MCM) and the Ministry of Water and Livestock Development (MWLD). The operations of these ministries are still intermingled, but it suffices to say that they are responsible for formulating the sector development strategy and facilitating its implementation at national level. With the cooperation and support of the President's Office-regional Administration and Local Governments (PO-RALG), which has jurisdiction over the local authorities, they are supposed to supervise and monitor implementation at district or local authority level. The ministries facilitate, co-ordinate and monitor implementation by private sector stakeholders and Non-Governmental Organizations (NGOs).

3.2 Contribution of Agriculture to the Economy

The importance of the agricultural sector in Tanzania's economy can be perceived through its contribution to the economy. If agriculture were dropped in the equation, Tanzania's $8.8 billion of GDP in 1999 (World Bank, 2000) would drop to $4.6 billion with consequent drop in GDP per capita from $293 to $153. On the other hand, export earnings would drop by 60% with severe impact on the balance of payment. While precise estimates of real growth of the sector are difficult, evidence on improved performance sector is extensive, and it confirms official findings which puts real growth in the range of about 5% during the post socialist policy period (1986-1994), compared to about 2% during the socialist era (1966-1985). According to WB (1994) cited by Mlambiti and Isinika (1997), real growth in agricultural GDP paralleled total GDP growth from 1966 through 1992 with agriculture averaging 2.8 and GDP 2.7% per annum. However, when analysed on yearly or specific short periods, there emerges marked divergence between the two indicators (Figure 3.1).

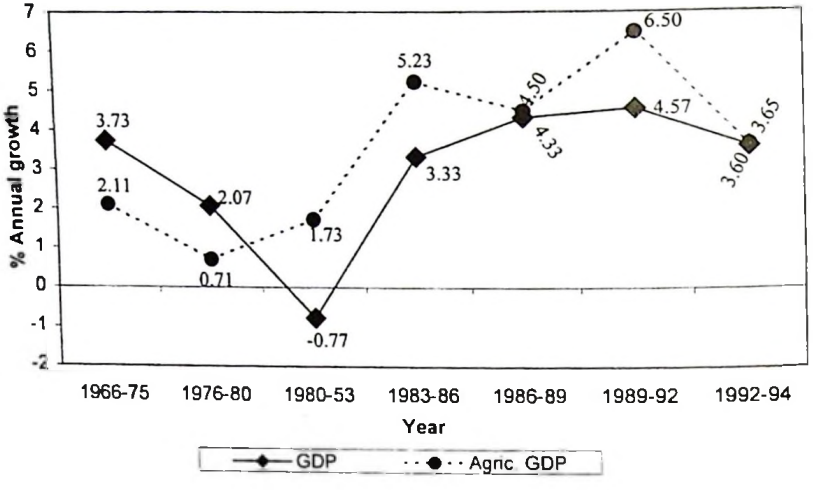


Figure 3.1: Percentage annual growth of GDP and agriculture GDP at 1976 prices for the period 1966-1994

Source: WB country study (1996)

From Figure 3.1, it could be noted that generally, growth in agriculture lagged behind GDP during the initial period of the socialist economy. Agricultural growth was 45% lower than the GDP rate in 1966-75, and 65% lower in 1976-80. Agriculture started to recover in the early 1980s while GDP growth was negative. From 1983/84, period, agricultural growth increased relatively faster enhancing the overall growth of GDP. On the other hand, as argued by Mlambiti and Isinika (1997), there is no consistent relationship between agricultural performance and balance of payments. For example in the period 1980-1983, agricultural contribution to GDP was increasing while the balance of payments deficit was decreasing. However, in the period 1990-1994, both agricultural contribution and the balance of payments deficit increased except in 1994 when balance of payments was half of the previous year.

Table 3.1: Real budget Allocations to agriculture

Budget item	1990-1991[a]	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999
	Million TZS								
Total vote[b]	57,293	64,432	71,001	62,696	63,252	40,161	26,420	21,829	37,047
	Percent of total agricultural budget								
Distribution by sector									
Administration[c]	33	10	10	10	5	4	9	13	29
Crop development[d]	4	47	39	44	47	55	49	48	34
Research and development	29	25	34	22	30	18	10	15	15
Cooperative development	0	6	5	6	3	4	5	9	4
Food security and strategic grain reserve	0	0	0	7	5	6	12	11	3
Livestock development	33	12	12	12	9	13	16	4	15
Total	100	100	100	100	100	100	100	100	100

Note: a=1990/91 distribution by sector includes only recurrent expenditure because development expenditure figures are not allocated by sector.
b=Total vote includes only recurrent and development expenditure.
c=Administration includes policy and planning
d=Crop development includes input trust fund

Source: WB Country study for Tanzania, 2000

Despite its role in the economy the agricultural sector seems to attract less attention in the national budget. Examination of government expenditure on agriculture shows fluctuations, with overall sharp decline in budgetary support for the ministry (Table 3.1). For example, the real allocation in 1997-98 is about one third the average annual value in the 1991/92 – 1993/94 period. There was some recovery in the agricultural budget in the 1998-99 and 1999-2000 budgets. Even so, the 1999-2000 estimates is almost one third lower, in real terms, than the average of the allocations in the first three years of the period. The table also presents the allocation of the agriculture budget among different spending categories. Crop and livestock development is the largest item, showing a declining share after 1991-92, the first year in the table to include development budget expenditures along with recurrent expenditures. The declining share of research and development is especially worrisome for future productivity growth in agriculture, falling from 25-30% in the early years of liberalisation to an estimated 12% in the 1999 -2000 budget[1].

Records show a striking drop in the development budget as a share of total budgetary spending on agriculture over the 1990s (World Bank, 2000). The local development budget went down from an average of 17% of Ministry expenditures in 1990/92 to 2% in 1996/98. Foreign support for the Ministry is all counted in the development budget, and has also fallen significantly since 1994-95 (World Bank, 2000). The share of MAC's budget coming from foreign sources declines from 60 to 10-20%, implying an even larger drop in absolute funding since the total ministry's budget is declining in absolute terms. A falling share of government spending devoted to MAC, although there are some recoveries in the recent budgets, exacerbates this trend.

[1] As compared to the European Union (EU), this level of expenditure is extremely low. The EU spends about 50% of its annual budget on agriculture, despite the fact that agriculture contributes less than 2% of the EU GDP.

3.3 Agriculture, Rural Poverty and Food Security

Poverty is generally understood to be a state of not being able to obtain the goods or services necessary to meet some minimum standard of living (World Bank, 2000). Tanzania places a high priority on reducing poverty and food insecurity. Achieving these objectives is closely linked to the performance of the agricultural sector for two reasons: One, literature shows that poverty is primarily a rural phenomenon in Tanzania. The incidence of poverty is twice as great in rural areas as in urban area, while the severity of poverty is three times greater. Two, urban incomes are 2-3 times greater than rural incomes. Rural households lag behind urban households in almost every physical indicator of living standard: housing type, electrification, access to clean water, ownership of consumer durables, and incidence of child malnutrition. If one controls for education, farm size, place of residence, and other household characteristics, farmers that grow cash crops have higher incomes than those that do not.

Regarding food security, the concept is generally defined as the condition in which all people at all times have enough food for a healthy and productive life. Food security involves three components: food availability, food access, and food utilization. Food security does not necessarily imply food self-sufficiency, since a household can be food secure if its income is high and stable enough to purchase its food requirements. In remote areas with poor transportation infrastructure, households may be forced, however, to produce most or all of their food requirements (Lipton 1983; Haddad 1997).

While agricultural development is essential for increasing food production, it also has an important role in creating effective demand, that is, the capacity of people to purchase food. According to the WB (1994), average caloric intake per capita in Tanzania is estimated at 206 Kcal/capita in 1989, above the 1831 estimated in 1965. A survey by MAC in 1994 indicates that the availability of food varies by farming systems and regions, but the main source of calories for Tanzanians is maize, which provides 62% of total calories, and rice, the other preferred staple, contributes 8%. The rest of

caloric intake comes from cassava (13%), sorghum (8%) roots and bananas. The incidence of malnutrition in rural areas among children under 5, with below 80% of the standard weight for age is between 40 and 60% (Sarris and van den Brink (1994).

3.4 Agricultural Practice in Tanzania

3.4.1 Land Base and Use

Tanzania mainland covers about 94.3 million has of which 88.4 ha is landmass. The country has allocated 22 million ha, that is, 23% of its surface area to reserves of different kinds. The area actually cropped, about 3.4 million ha, is only 3% of the surface area of Mainland Tanzania. Another 6.5 million ha, outside of the reserves, is considered arable and suitable for cereals such as maize and rice, bringing the total area of good agricultural potential up to about 10 million ha, much of which is already used as fallow or pastureland. Within the various reserves, there is an additional 3 to 4 million ha which, has been assessed as suitable for cereal cultivation (URT, 1998). Some facts about the agricultural sector in Tanzania are presented in Table 3.2.

Approximately, 27% of the land area is estimated to be tsetse-infested and thus unusable for agricultural production. Extinction of the fly is only possible when the bush is permanently cleared from the land just like in the case of large-scale farming. It can, therefore, be predicted that without opening up large farms in the future considerable landmasses will still remain in this unproductive condition (Hofmeier, 1973). Most agricultural production is carried out by small-scale farmers, numbering 4.2 million, with landholding of less than 0.2 ha per farmer. Land under medium and large-scale farming is estimated at 1.5 million has. Livestock keeping is mainly under traditional pastoralists who keep an average of 50 head of cattle. It is estimated that land under livestock in Tanzania is 24.0 million ha largely comprising of 15.6 million cattle, 10.7 million goats, 3.5 million sheep and 27.0 poultry (URT, 2001; NBS, 1999).

Table 3.2: Selected main features of the agricultural sector in Tanzania

Features	Quantity	% of total land
Total land resource (million ha)	95.5	100.0
Arable land (million ha)	44.0	46.1
Rangeland (million ha)	50.0	52.4
Land under livestock (million ha)	24.0	25.1
Tsetse infested area (million ha)	26.0	59.1[a]
Area under cultivation (million ha)	10.1	23.0[a]
Area suitable for irrigation (million ha)	1.0	2.3[a]
Area under irrigation (million ha)	0.2	0.5[a]
Area under medium and large-scale farming (million ha)	1.5	3.4[a]
Per capita farm land holding (ha per head)	0.1	
Livestock population (million):		
Cattle	15.6	
Goats	10.7	
Sheep	3.5	
Poultry (Chicken)	27.0	
Other features:		
Agricultural households (million)	4.2	
Population in agriculture (million)	22	
Agricultural households size	5.2	
Agricultural productivity in terms of number of people fed by one farmer in the country	3	
Fertiliser use (kg per ha)	21	
Contribution of agriculture to GDP (%)	27	
Contribution of agriculture to export earnings (%)	65	
Agricultural budget as % of total budget[b]	5.2	

Note: a = percentage of arable land, b =Ten year average (1990/91- 1999/2000 budget

Source: Compiled from various statistical records in MAC

3.4.2 Distribution of Crop Production

The distribution of cash crop production for the internal or export market has developed very unevenly. In many parts of the country subsistence agriculture is still prevalent, while in some areas a strong specialisation on market products has already been attained. Food crop production dominates the economy contributing some 55% of agricultural GDP, with the livestock sub-sector accounting for another 30%, while additional cash crops (coffee, cotton, cashewnuts, sugar, pyrethrum, tea, tobacco, sisal, oil seeds) for 8%, fishing and hunting 6%, and forestry 1% (World Bank, 1994). Tanzania is not a country with a typical monoculture. But the three main products coffee, cotton and sisal contributed 36 per cent to all Tanzania's exports in 1997 (Bank of Tanzania, 1998). Production of exports crops is concentrated in a few areas within the country, since natural conditions and requirements for each crop differ widely (Figure 3.2).

From this point of view, there exists a very distinct regional differentiation. Coffee is concentrated in three areas around Arusha/Kilimanjaro, Kagera, and Mbeya. Cotton is almost exclusively grown in the areas south of Lake Victoria around Mwanza, while sisal is cultivated only in proximity to railways and ports mainly in Tanga and in the vicinity of Morogoro. Cashewnuts come mainly from Mtwara and from areas around Dar es Salaam. The production of various oilseeds like groundnuts, sesame and sunflower are mainly grown in the dry centre of the country in Dodoma and in the south. Tea is concentrated in five production areas around Bukoba, Tukuyu, Mufindi, Njombe and Usambara Mountains. Tobacco is grown mainly in Tabora, Iringa and Songea and pyrethrum exclusively in Iringa, Mbeya and Arusha. Of late non-traditional crops such as chillies, hot pepper and ornamental flowers are being introduced, and there is a great potential for export markets.

Figure 3.2: Spatial distribution of cash crops in Tanzania

Source: MOW

3.4.3 Irrigation

The area suitable for irrigation in Tanzania is estimated at 2.3% of total arable land, but only half of this is under irrigation. Irrigation is practiced by 6% of the total number of households in the country. The main source of irrigation water is river (59%) followed by wells (25%), dams (13%), taps and lakes accounts for 2% each. The total area under irrigation in Tanzania is about 0.2 million ha, about 0.5% of arable land resource. However, it is estimated that 2.3% of arable land is suitable for irrigation. Irrigation is practiced mainly in Kilimanjaro, Arusha, Mbeya and Tanga. The crops grown under small-scale irrigation include paddy, maize, tomatoes, banana, coffee, beans, cabbage and onions (MAC and NBS, 1999). A small proportion of irrigation on large scale is owned by the state (for example the National food corporation (NAFCO) and Sugar development corporation (SUDECO), and private tea plantation companies such as Brooke bond (T) limited (BBT), Mufindi tea company (MTC) and Tanzania wattle company (TANWART).

3.4.4 Use of Modern Inputs in Agriculture

While the evidence of adoption and use of potentially profitable new technology, especially by the smallest farmers is encouraging, the level of use at 21 kg per ha is far lower as compared to a country like Germany where an average fertiliser use is about 250 kg per ha (IDWK, 2001). The World Bank (1994) asserts that the use of improved seeds, normally associated with fertilizer adoption has been increasing in the country. About 27% of farmers use high yielding variety seeds. With regard to the use of implements, WB points out that in areas where ox farming is practiced, ownership of oxen had doubled in the last 5 years. Ox ownership also increased overall from 4 to 7.8%. On the part of tractors, the use is declining for smallholders probably due to increased costs of hiring tractors. Pesticides are also used, mostly among cash crop farmers in the cotton, coffee and cashewnuts zones. About 12% of the farming population uses pesticides. The bank concludes that the adoption of innovation is

encouraging despite the difficulties agriculture encountered over the past two decades. Nevertheless, the adoption of all agricultural technologies was hampered by several factors including low import capacity which led to high dependence on grants and credit for input supply resulting in high annual fluctuations in supply areas. Poor transport and communication infrastructure impeded input distribution and marketing of farm products (Mlambiti and Isinika 1997). In 1994/95 an Input Fund was established using a levy of TZS 10 per kg of exported crop. However, the Fund is being criticised for mismanaging the revenue (Misanga, 1998).

3.4.5 Agricultural Financing

Credit is an important ingredient in agricultural production as it enables farm producers whose incomes are low to acquire agricultural inputs such as tractor services, fertiliser, high yielding varieties, herbicides and other pesticides, which are essential for increasing productivity. In early days of independence, credit systems was developed, which target the specific needs of producers in the farm sector based on a single marketing system (Mbilinyi and Nyoni, 1997). This arrangement was possible because the credit institutions monopolised the marketing of agricultural commodities. In practice the credit was not always repaid, either because of weather-related crop failure, corruption or political pressure. The mounting debts of the cooperatives and the crop authorities stemmed in part from the problems of recovering credit from farmers. The task of recovering credit has, if anything, become more difficult with output marketing liberalisation (Poulton et al, 1998).

On the other hand the Cooperative and Rural Development Bank (CRDB) shifted priorities away from the smallholder sector immediately after its privatisation. Studies show that the use of formal credit is rare at peasant farm level (Kashuliza, 1994; Mlambiti et al, 1990). Mbiha et al (1997) found that credit was one of the major obstacles in expanding the operations of grain traders in Ulanga District of Tanzania. Mlambiti et al (1990) made similar observations in Kilombero district. Most small-scale farmers and

traders raise capital from their personal savings and borrowing from friends and relatives. The World Bank (2000) observed that on average less than 5% of the total credit from formal institutions in Tanzania went to peasant farmers in 1994-95. This is exemplified by a persistent declining trend of borrowing from commercial banks for agricultural purposes (Figure 3.3).

In the early 1990, during the early days of liberalisation, agriculture was the leading borrower from the commercial banks, commanding 41.1% of total domestic lending. The situation has changed since then, borrowing for agriculture has drastically diminished to only 8.0% of the total loan bill. This can be explained by the fact that the cooperatives, which used to be main borrowers, have failed to compete in the free market economy, and have lost creditworthiness. However, in the tobacco sector, the credit system continues to function. Private buyers provide inputs on credit and recover the money from crop payment at harvesting time. This arrangement has not been without problems. There is conflict between buyers and growers concerning estimate of the debt size.

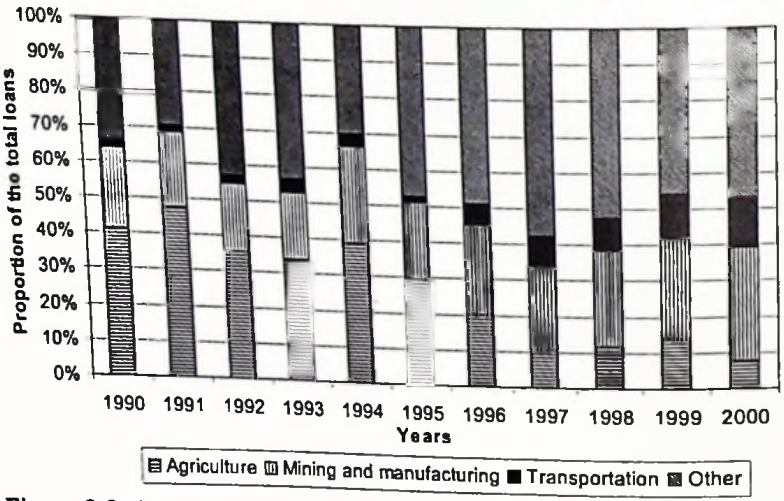


Figure 3.3: Commercial bank domestic lending by borrowing sector

Source: Compiled from Bank of Tanzania Economic Bulletin, 1998 and 2001

In the case of coffee buyers are experimenting with the system in which part of the harvest payment is given in the form of a voucher, worth 4% of the farm gate value of the coffee sold that can be used to purchase inputs for the next following year (Ngondo, 1999). In the case of cashew nuts, credit is highly needed for purchasing sulphur dust to fight powdery mildew disease. Private firms began to import sulphur in 1991/92, and sold it to the stockists on credit, allowing them to extend credit to the farmers.

With all these problems the stockists have been selective in issuing credit. However, the Cashew Input Development Fund (CIDF), an NGO established in 1996 with traders' participation is credited for boosting cashew production in Ruvuma region. The NGO is allowed to levy from traders 2% on the value of cashew nuts exported and provides credit for sulphur imports and use (World Bank, 1999). Kilimanjaro Cooperative Bank was started in 1995 using levy fund from coffee sales, and has rapidly expanded its loan clientele among primary cooperative societies in arabica coffee producing region. Initial results from a wide spread arabica coffee producer input financing in 1999 through primary cooperative societies seem quite promising (World Bank, 2000).

3.4.6 Agricultural Research

Smallholder sub-sector can become more productive, if improved technological package can be infused, taking into consideration the agro-ecological and social economic environment of the various farming communities. These institutions involved in agricultural researches constitute the National Agricultural Research System (NARS), with the Department of Research and Training (DRT) playing a leading role. Other institutions include (i) Tropical Pesticides Research Institute (TPRI), which is a semiautonomous parastatal organisation MAC. It conducts its own research on pesticides and provides a number of technical services, which include registration of pesticides and supervision of quarantine services (ii) the universities especially the Sokoine University of Agriculture (SUA) and to

a lesser extent the University of Dar es Salaam carry out agricultural related research works. Similarly, some faculty staff conducts agricultural related research on their own interests, and (iii) some private and public sector bodies also carry out research work in relation to their respective crops such as tea, wattle, barley and maize. Some estates such as those of the sugarcane also conduct research work, mainly adaptive trials, in collaboration with DRT institutes.

Coordination and collaboration of the activities of these institutions is important to ensure that research is seeking solutions to the agricultural problems facing different actors and, in a way, avoiding duplication of reaserch work. After the preparation of the National Agricultural Research Master plan (NARM) efforts have been made to improve its linkages with other components of the Tanzanian NARS. For instance, memoranda of understanding have been signed between DRT and the universities together with other institutions such as Tanzania Forestry Research Institute (TAFORI) to foster collaborative research activities within the established priorities, which could be supported by a research fund obtained nationally or through external donors. The DRT has a network of 22 major research stations and substations in seven zones, defined by agro-ecological criteria, each with a lead station and substation. Despite this large research network, the research services have not been able to fulfil their role in developing appropriate technological packages for farmers. This is attributed to a combination of factors such as inadequate funding, lack of clear research priorities, poor physical research infrastructure, low research staff morale, and poor research-extension farmer linkages (URT, 1996). To address these problems the government formulated the National Agricultural and Livestock Research Project (NALRP), which was in progress when this study was prepared.

However, studies on the productivity of research show that there is little impact of research at farm level. Isinika (1995) found that productivity of agriculture in the last two decades has been on the decline. Hartwich (2000) observed that inputs and outputs of agricultural research operations in Tanzania are low. However, given the nature and complexity

of measuring research productivity it is difficult to make unequivocal conclusion about research impact.

Tanzania, like other developing countries, cannot rely exclusively on her own in agricultural research efforts. There is a strong cooperation and support from International Agricultural Research Centres (IARC). While the IARCs generally are not donors in the strict sense, they do nevertheless contribute to research in the country in terms of training, germ plasm, networking, literature, and, in some cases small amounts of operational funds. Much of the technological information NARS needs can be obtained from, the IARCs, developed countries, regional centres, and also from neighbouring countries facing similar problems By adapting research results from the IARCs to local conditions the NARS can make rapid progress, at a relatively low cost. The IARCs have contributed substantially to the improvement of global agriculture for the benefit of developing countries. Consequently, there is no need for the NARS of this country to develop similar research programmes. Rather, it must adopt and adapt what technologies it can from the IARCs and neighbouring countries' NARS.

3.4.7 Agricultural Extension

Extension service is one of the important public services offered to the sector. Since 1988 the National Agriculture and Livestock Extension Rehabilitation Project (NALERP), supported the extension service in select region, funded by International Development Agency (IDA) and other donors. The project had established the Training and Visit (T&V) method in 13 of the 20 regions and trained some 4,400 village extension workers in the new methods. One of the strengths of NALERP is unification of crop and livestock extension efforts to a single, broad-based approach, thus enabling Village Extension Officers (VEO) to respond to all farmers' enquiries. However, effectiveness of the general extension service is said to have diminished due to the inability of the more specialized departments to respond to requests for technical advice in specialized areas such as irrigation, veterinary services, mechanized agriculture and plant protection

because of inadequate funding and bureaucracy. An evaluation of the T&V system established that it was not possible to conclude that the introduction of T&V extension in Kenya increased the impact of extension on production (Virsha and Evenson, 1993 cited by Mlambiti and Isinika, 1997). Tanzania ought think of privatising extension services by encouraging knowledge-brokers, who may charge fee from their clients.

3.4.8 Farmers Cooperatives

The Cooperative movement in Tanzania has a long history. Between 1932 and 1967 cooperative were owned and controlled by the members on democratic principles. After 1967, cooperatives were perceived as vehicles for furtherance of socialistic policies. Since then cooperatives have been characetrised by excessive political interference. The worst scenerio was in 1976 when cooperative unions and agricultural marketing societies were dissolved to give way to parastatal crop authorities to handle all agriculture-related functions. This had a disastrous impact on the sector. By 1980 the problems related to the new set up had become so alarming that the government decided to re-establish the cooperative movement in 1982 (World Bank, 1994). However, primary societies and unions were hastily formed, without regard for economic viability or managerial capacity while crop marketing and processing system collapsed. This chaos, coupled with external pressure from financial supporters, led to the establishment of the 1991 Cooperative Act, which provided for the formation of an independent, member-controlled, cooperative movement based on cooperative principles.

The process of restructuring the movement is being carried out but at a slow pace. The recently formed Ministry of Cooperatives and Marketing guided by the Cooperative Development Policy (CDP) of 1997 will probably transform cooperative movement into independent, voluntary and economically viable institutions for providing and dissemination of agricultural inputs for the betterment of small-scale farmers.

3.4.9 Marketing of Agricultural Products in Tanzania

Strict government control in agricultural marketing was the system in operation since Tanzania attained its independence. The establishment of one channel marketing system excluded the participation of the private sector. Basically that was a reflection of the government desire to ensure that all segments of the farming population had access to product market and also got more equitable prices. The Tanzania National Agricultural Adjustment Programme (TNAAP), agreed between the WB and the government in 1990 recognised the role of the private sector in crop marketing.

Consequently the food crop marketing system is characterised by numerous small traders operating with no stable government policy to support them (Putterman, 1995; Santorum and Tibaijuka, 1992; Limbu, 1993; Marketing Development Bureau (MDB), 1994; Ashimogo 1996; and Gabagambi, 1998). Urban wholesalers purchase grain from regional assembly markets in places where they exist or sale to urban retailers in main towns. However, selling food crops across the national boarders is virtually prohibited by local government authorities on the guise of food security enhancement. In terms of transport, most food crop traders depend on unreliable transport. Once they have assembled the consignment they wait at roadsides for any truck that might have come in the area for a different purpose. Occasionally a group of traders collectively hire a truck. But there are no economies of scale in it because the charge is based on a bag. However, the average cost of transport is lower with railway where it exists because charge is based on the capacity of the carriage.

Most flows of food crops within Tanzania are toward Dar es Salaam because of growth in population relative to the rest of the country. However a large proportion of food crops is still consumed within the household or locality where they were produced. It is estimated that only 26% of maize and 50% of rice produced between 1992/93 and 1997/98 were sold within Tanzania (Maro, 1999). The MAC estimates that 13% of the maize marketed surplus, 70% of marketed domestic rice, and 95% of marketed beans had a

destination in Dar es Salaam city. Four regions are earmarked for supplying 90% of maize to Dar es Salaam. These include Dodoma (46%), Iringa (19%), Mbeya (16%) and Ruvuma (10%). Dar es Salaam's rice supply came from Mbeya (43%), Morogoro (29%), Shinyanga (19%) and Tanga (8%). On the other hand, 95% of beans supplied in Dar es Salaam originated in Mbeya, Arusha, Tanga, Morogoro and Ruvuma (World Bank, 2000).

The measure taken to liberalise traditional export crops went slowly and were more difficult than those of food crops because of reluctance of the government to lose hand on export crops. With the reforms crop marketing boards altered the business relationship between the boards and the cooperative unions. Under this new arrangement, the cooperatives retain the crop ownership from the point of production up to the final sale. In 1993, crop boards (Miscellaneous Amendment Act) introduced a multi-channel marketing system for important cash crops such as coffee, cotton, cashewnuts and tobacco. For the first time in history since independence in 1961, the private firms were allowed to purchase the traditional export crops directly from the producers and handle them throughout the marketing chain.

3.5 Agricultural Production in the Study Area

3.5.1 Coast Region

The economy of the region is dominated by agricultural activities comprising of small-scale farming for food and cash crops, livestock keeping and plantations for sisal and sugar. The main food crops produced include paddy, maize, cassava and millet (sorghum) and are grown almost in all six districts. The main cash crops include cashewnuts, coconut, cotton and sesame. There are other crops of minor importance such as oranges, pineapples, mangoes and tomatoes. Livestock involves cattle, goats, sheep and poultry. In 1995 there were a total of 116,752 cattle out of which 5,212 were dairy cattle and 111,540 were indigenous cattle. More than 70% of all cattle in the region are found in Bagamoyo district. Rufiji, Kisarawe and

Mkuranga districts all together account for only 1.7% of the total livestock population in the region. Dairy cattle are kept around the city of Dar es Salaam and along TANZAM for easy transport of equipment and dairy products. Major crop output is presented in Table 3.3 below.

Table 3.3: Major food crop production (Tons) by district, 1990-1994 averages

Crop type	District					Total production
	Bagamoyo	Kibaha	Kisarawe	Rufiji	Mafia	
Paddy	4488	3,980	8,051	15,231	1,526	33,276
Maize	4,007	1,756	6,052	14,523	458	26,682
Cassava	63,272	52,791	182,127	65,023	11,079	371,522
Sorghum	4,882	599	994	1,832	26	7,106
Cowpea	600	724	235	931	0	2,431
Total	77,249	59,850	197,459	97,540	13,089	441,017

Source: NBS, 1997

3.5.2 Morogoro Region

Agriculture is the major economic occupation for the majority of residents in Morogoro region. It engages about 80- 90% of labour force. Maize and paddy are the major staple food crops. Other food crops in the region include sorghum, sweet toes, beans, cassava, millet, groundnuts, tomatoes, fruits and vegetables (Table 3.4). The main cash crops are cotton, coffee, sisal, onions and oil seeds (sesame, sunflower and some cocoa along the mountain slopes). Other productive sectors include livestock keeping, fisheries, and beekeeping. The region's arable land totals 5.9 million ha with only 1.2 million ha (about 20%) cultivated. With exception for plantations, agriculture is characterised by relatively small farms of an average size of 1.2 has. Morogoro region traditionally is not a livestock region. Pastoral tribes practicing nomadic lifestyle keep large number of cattle, sheep and goats. Commercial livestock production is relatively new in the region and normally limited to national ranches.

Table 3.4: Major food crop production (Tons) by district, 1994

Crop	Year					5-year average
	1990/ 1991	1991/ 1992	1992/ 1993	1993/ 1994	1994/ 1995	
Maize	214585	240,959	319,385	200,462	221,986	239,475
Paddy	129,329	110,820	109,273	97,800	139,290	117,302
Sorghum	23,164	57,135	53,280	35,655	31,500	40,147
Beans	21,890	9,332	75,177	12,278	12,300	26,195
Cassava	120,528	140,405	67,850	50,400	63,500	88,537
Cowpea	424	1,565	7,130	3,927	5,880	3,785
Banana	64,900	96,800	13,180	24,400	41,000	48,056
Sweet potatoes	9,240	39,020	25,000	20,992	31,800	25,210
Sunflower	715	507	269	357	366	443
Sesame	545	370	97	261	455	346
Groundnuts	1,009	346	155	164	299	395
Total	586,352	697,281	670817.42	446,717	5,483,977	589,891

Source: NBS, 1997

3.5.3 Iringa

The region's main agricultural activities include crop production, livestock rearing, and fishing. Maize is the major staple food crop. Other food crops in the region include wheat, sorghum, Irish and sweet potatoes, cassava, millets, paddy, groundnuts, peanuts, tomatoes, fruits and vegetable. The main cash crops are tobacco, pyrethrum, tea, sunflower, coffee and onions. Land is the major potential resource in the region. About 11% of the total arable land is currently under cultivation. For instance, Mufindi District is able to utilize only 19.6% of its arable land, while Njombe and Iringa Districts are capable of exploiting 14.8 and 7.2% respectively. This implies that the vast agricultural potential land in the region is yet to be exploited. Crop production levels are still very low attributed to the use of inferior agricultural practices. Maize is both a major food staple and the most marketed crop in the region (Table 3.5). Maize production is of vital importance not only to the region but also for the nation as a whole. Iringa

belongs to the group of four regions known as the "Big Four" credited for surplus maize production in Tanzania.

Table 3.5: Major food crop production (Tons) by district, 1994

Crop type	District					Total production
	Iringa	Mufindi	Njombe	Ludewa	Makete	
Maize	159,823	74,482	159,352	43,220	24,516	461,394
Sorghum	35,23	74	1,899	219	571	38,086
Wheat	5,898	1,01	3,494	254	3,476	14,223
Paddy	9,147	-	-	144	506	9,797
Beans	9,21	12,543	15,910	1,630	1,814	41,018
Cassava	1,521	5,214	-	12,514	-	19,249
Irish potatoes	37,674	18,702	89,402	640	23,985	170,903
Sweet potatoes	11,050	13,041	19,045	120	697	43,959
Groundnuts	440	309	390	-	-	1,139
Total	269,997	125,466	289,492	58,741	55,565	799,768

Source: NBS, 1997

3.5.4 Mbeya

Mbeya region is one of the main food surplus regions. The region has an area of 6.4 million ha of which 4.0 million ha are suitable for agriculture and livestock keeping. However, only an average of 1.3 million ha are cultivated annually for cash crops. About 80% of the population depend on agriculture for their livelihood. The region also produces surplus food (maize, paddy, potatoes, pulses and green vegetables) to the tune of 350,000 tons a year, which in most cases the region exports to other regions especially Dar es Salaam, Dodoma, Singida and the Lake regions. Maize is the major staple food in the region. Table 3.6 summarises major food crops in the region. Mbeya is one of the most important cash crops producers in Tanzania. The region produces over 12,000 tons of coffee, about 21% of total National coffee production. It produces 1,800 tons of pyrethrum, equivalent to 48% of the national production. Similarly Mbeya region

produces 35% of tea produced in the whole country. Tobacco and cotton are also on the tune of 1,000 and 6,000 tons respectively annually.

Table 3.6: Production (tons) of major food crops in Mbeya region (1990/91-94)

Year/crop	1990/91	1991/92	1992/93	1993/94	1994/95
Maize	434,111	451,290	436,000	517,623	572,630
Paddy	105,330	120,945	108,000	113,430	139,185
Sorghum/millet	37,969	28,404	32,474	10,350	17,300
Wheat	146	330	269	485	570
Beans	13,667	18,432	35,136	30,725	30,909
Peas	445	486	533	315	450
Irish potatoes	65,374	83,700	89,322	77,711	54,580
Sweet potatoes	45,445	61,340	100,434	111,736	107,380
Cassava	27,866	55,500	48,977	83,802	61,602
Bananas	181,798	166,435	197,217	213,617	171,678
Groundnuts	9,779	5,655	13,600	14,422	13,604
Fruits	16,828	9,275	76,542	83,560	78,650
Sesame	230	350	898	923	440
Vegetables	29,000	18,640	25,437	83,560	10,685
Total	950,312	1,033,819	1,160,842	1,210,889	1,259,6603

Source: NBS, 1997

Chapter Four

4 Road Infrastructure Development in Tanzania

After exploring the position of agriculture in Tanzania's economy in the previous chapter, this chapter discusses the development in the road infrastructure sector, as a prime mover of economic transformation in the country. Particularly, discussion of distribution and management of the road network in Tanzania is made. The overall structure of the transport sector in Tanzania consists of four main sub-systems, which include (a) a road network criss-crossing the country (b) two railway systems - the Tanzania-Zambia Railway Authority (TAZARA), which links Dar es salaam with Zambia, and the Tanzania Railways Corporation (TRC) which serves the central, northern and lake regions (c) the four main seaports of Dar es Salaam, Zanzibar, Tanga and Mtwara and (d) a civil aviation sub sector consisting of Air Tanzania Corporation (ATC), several small airlines, two international airports of Dar es Salaam (DIA) and Kilimanjaro (KIA), and more than 60 smaller domestic airports and air strips. Road transport is by far the most dominant mode of transport accounting for more than 70% of the total internal traffic flows (MCT, 1999). Because of that, this chapter concentrates on issues related to road network.

4.1 The Role of Roads in Tanzanian Economy

As pointed out previously, transport in general and more specifically road transport plays an important part of the daily activities of the people and the entire economy of the country. The contribution of the roads sector to the Tanzanian economy may not be easily separated out from that of the whole transport sector in general. Its dominance, however, is well documented, mainly in the areas of contribution to GDP, employment,

capital formation, provision of intermediate inputs to all the other sectors of the economy, and poverty reduction in the sense of unlocking areas offering economic opportunities (Likwelile, 2000). An in-depth separate account of the road sector's contribution in the Tanzanian economy is hampered by data inadequacy. Estimates show that road transport handles about 70% of freight traffic in the country. Road transport is also the dominant mode for passenger transport and it handles about two thirds of international traffic, which accounts for about one third of the cargo handled in the country (Maro et al. 1993). Road transport contributes about 4.6% to GDP and about 73.2% to transport GDP (Table 4.1). Road transport's share of transport equipment is at an average of 18.8%, with investments in vehicles comprising nearly one fifth of total transport equipment.

Compared to other modes, road transport is dominant in terms of cargo volume transported. There are limited available data on the size and characteristics of the vehicle population in Tanzania. However, the best estimate by MCT puts the figure at around 360,000 vehicles (in 1998) of which about 75% are private cars, 20% are commercial vehicles including tracks, buses and taxis, and the balance are special purpose vehicles. The distribution of tracks and buses is shown in Appendix 1. According to MCT, the number of vehicles in the country is growing at 5% per year, although in the recent past car imports has boomed at the rate of 20,000 vehicles per month (personal conversation with MCT and TRA official).

Table 4.1: Key indicators relating transport and the Tanzanian Economy

Indicator	1966/70	1971/75	1976/80	1981/85	1986/95
Real GDP Growth (%)	3.9	3.8	2.8	0.7	4.1
Sectoral Real GDP Growth Rates (%)					
(i) Agriculture	2.1	2.5	1.8	3.0	4.9
(ii) Manufacturing	8.1	4.8	2.7	-4.9	3.8
(iii) Economic Services	5.9	3.7	2.6	0.4	4.2
(iv) Public services	6.0	12.9	9.1	2.6	0.4
Transport GDP		10.3	10.5	7.3	6.8
Land Transport /GDP		4.3	3.0	4.3	4.4
Land Transport/Transport GDP		68.2	71.2	73.3	73.0
Fixed Capital Formation (%GDP)	16.5	20.5	22.2	15.7	31.7
Sectoral shares of Fixed Capital Formation (%)					
(i) Agriculture	9.0	6.3	8.1	10.7	34.5
(ii) Manufacturing	15.4	14.0	25.3	24.0	13.0
(iii) Economic Services	43.1	54.6	34.9	31.7	27.7
(iv) Public Services	5.8	2.9	16.1	15.7	5.7
Total Equipment				32.0	30.0
Transport Equipment/Total equipment				46.0	42.0
Road /transport equipment				13.7	23.1
Share of Fixed Capital Formation (%)					
(i) Private Sector	47.0	32.0	44.0	55.0	60.7
(ii) Public Sector	53.0	68.0	56.0	45.0	39.3

Note: Economic services include electricity and water, financial, trade and hotels, transport and storage. Land transport includes road and rail transport

Source: Likwelile, 2000

The vehicle fleet of 360,000 in Tanzania translates into 12 cars per 1000 people. As compared to many other countries this ratio is far small. Appendix 2 presents some key indicators of road transport sector performance in selected countries. As can be noted, Tanzania compares well with Uganda in terms of car density (number per km of road), number of cars per 1000 people and paved road percentage of total road length. However, when road density is considered, Tanzania ranks last in the list.

4.2 The Historical Perspective of Road Transport in Tanzania

Road transport in Tanzania goes a long way in history before the emergence of Tanzania as a country. An idea about the historical development of roads is important for understanding the current spatial distribution of roads in Tanzania. Until the beginning of 19th century there were hardly any connections between the coast and the interior. The period from 1820 to 1880 at the peak of the slave and ivory trade, the first important caravan routes came into existence, which traversed long distances and in some case crossed the whole present Tanzanian territory. By 1840 the main caravan route had reached its final point at Ujiji. From there other branches from the main route extended from Tabora northwards to lake Victoria, and southwards to the southern corner of lake Tanganyika and the northern end of Lake Nyasa (Ogot and Kieran, 1968). The opening up of the interior by means of constructing relatively wide cleared roads from Dar es Salaam started in 1876. Along many miles the natives began to form extensive fields in the adjacent lands and had commenced to settle in open and cleared spaces (Owen 1964).

Germany is credited for laying down the foundation of road network in Tanzania. In 1884 when Germany occupied Tanganyika, there was no any real economic and political cohesion of the vast area (Owen, 1964). The 30 years of the German colonial period were characterized by a dramatic change in the economic and social structure of the country. The basic change in transport conditions made a significant contribution, through the construction of the railways. All measures in the field of transport that were carried out and those that were planned, but could not be executed any more, were principally based on strategic considerations about the exploitation of the economic potential of the country which was thought to be very large. Short-run considerations of profitability were never applied to any of the transport projects. These projects laid the foundation for all subsequent developments in the sector. If the existing plans had also been carried out and had not been stopped by the war, then the present regional structure of the country would look quite differently today and the necessary transport infrastructure on which an accelerated economic

growth could have been based would have already been provided at that time (Hofmeier, 1973).

The British Mandate was characterised by stagnation in the area of transport in Tanganyika. This was probably due to the worldwide depression, the increasing uncertainty about the political future of the mandate territory and the effects of World War II (IBRD, 1961). During the entire inter-war period almost no systematic road planning was being done at a national scale. Existing roads developed from original caravan routes and simple footpaths; others had been cut through the bush for troop movements during the war. Generally they had not been built from the point of view of a road engineering or taking into consideration the economic needs of opening up productive areas (Moffett, 1955). The obvious backwardness of the road system was still typical until World War II. Because of the unsatisfactory use of the existing railway facilities during this period, it was always a generally prevailing opinion that no roads should be built over large distances parallel to any railway. It was believed at that time that the railway was the decisive instrument for the development of the country and that road transport had to play only a subsidiary role as a feeder (Obst, 1943).

The most important trunk road that was systematically constructed and improved between the wars was the "Great North Road" from the Kenyan border near Namanga via Arusha, Dodoma, Iringa and Mbeya to the Zambian border at Tunduma. This road was seen as part of the famous dream concept of a road connection from the Cape to Cairo (Hofmeier, 1973).

4.3 Current Road Network in Tanzania

Before the nature of road network in Tanzania is discussed, it is imperative to comment on the classification of roads in general. Roads are usually classified into three levels: (i) national or primary roads connecting capital cities, which serve as the main linkages to other countries, the sea, and

other strategic points; (ii) departmental, provincial, regional or secondary roads connecting regions within the country; and (iii) municipal, local and tertiary roads connecting towns within one province. Tertiary roads are further divided in rural and urban roads. Practically all countries have this typical classification system (Wasike, 2001), Tanzania being not an exception in this respect.

Total road network in Tanzania is estimated at 85,000 km of which 60,000 km forms the classified network. Within the classified network 13,067 km are trunk roads, 17,730 are regional roads and the rest are district roads. About 3,800 km of trunk roads (4% of total road network) are paved. In addition there are about 30,000 km of unclassified roads, which are managed by parastatals, national parks and village councils. Trunk roads constitute the primary road network, and their distribution is presented in Figure 4.1. Regional roads are the second layer which links up the trunk roads with the regional and main district centres (MOW, 1993). The road system is divided into 9 main traffic corridors, namely TANZAM, Northeast, Southern coastal, Central, Lake circuit, Southern, Great north, Western and Midwest corridor (Table 4.2). In the subsequent sections these corridors are discussed to see their economic importance. Their important features are summarised in Appendix 3.

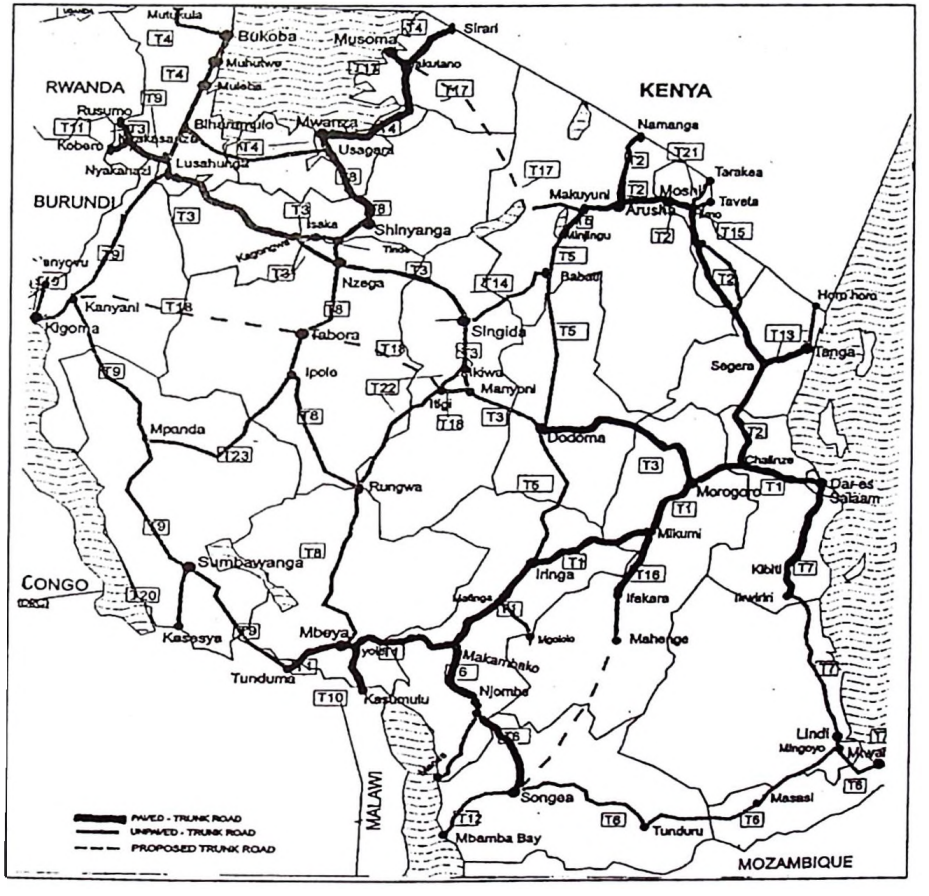


Figure 4.1: Trunk road network in Tanzania

Source: MOW

Table 4.2: The nine trunk road corridors in Tanzania[2]

Corridor	Links	Length (km)
1. TANZAM corridor	Dar es Salaam–Morogoro–Mikumi (link to Ifakara and Mahenge)– Iringa–Mafinga (link to Mgololo)–Makambako–Mbeya (with link to Itungi Port and Malawi) –Tunduma	1,324
2. North-eastern corridor	Dar es Salaam–Tanga–Arusha–Namanga	950
3. Southern coastal corridor	Dar es Salaam–Lindi–Mtwara	506
4. Central corridor	Morogoro–Dodoma–Mwanza–Rusumo (on Rwanda border)–Kobero (Burundi border)	1,584
5. Lake circuit	Sirari (Kenya border)–Musoma–Mwanza–Bukoba–Mutukula (Uganda border)	1,019
6. Southern corridor	Lindi–Mtwara–Songea (linking to Makambako on TANZAM route and to Mbamba Bay on Lake Nyasa	1,326
7. Great north corridor	Iringa (on TANZAM)–Arusha–Namanga	1,024
8. Western corridor	Tunduma (on TANZAM)–Sumbawanga–Mpanda–Uvinza–Kigoma–Nyakaza and Nyakahura (on Lake Circuit)	1,286
9. Midwest corridor	From Central corridor in the east to the TANZAM corridor in the Southwest	1,381
Total trunk road length		13,067

Source: The Louis Berger Group, Inc, 2000

[2] All the nine corridors are scheduled to be paved by 2025 according to the National Transport Policy, 2000

These roads differ in terms of traffic density. The highest traffic levels occur on three main corridors, that is, the TANZAM, the Northeastern corridor and the Central corridor (Figure 4.2).

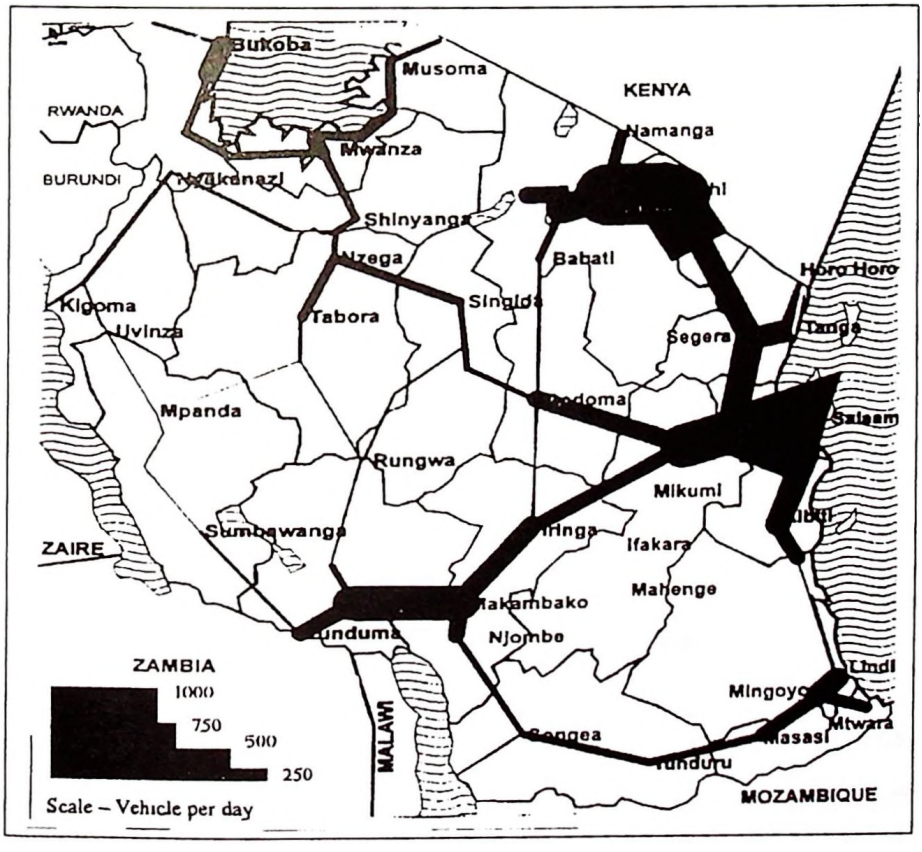


Figure 4.2: Traffic flows on the trunk road network

Source: MOW

4.3.1 TANZAM Highway

The TANZAM corridor has a route length of some 1,324 km connecting Tanzania's major port, Dar es Salaam with Zambia, Malawi and Zaire. In addition to the main route the corridor includes two branches, these being to Itungi Port and to Mahenge. With the exception of the branch roads, the road has a bitumen surface throughout its entire length. Traffic volumes range from 250 v.p.d between Mbeya and Tunduma to about 1, 500 v.p.d near Dar es Salaam. A large proportion of traffic on this road is heavy vehicles carrying imports and exports for the neighbouring regional economies and central Tanzania in competition with the Railways. Excluding Dar es Salaam the TANZAM passes through four regions, which in total contain about 4.5 millions people, or about 20% of total national population. About 3.8 millions of this regional total is located within the immediate catchments of the TANZAM corridor.

Of the ten largest urban areas in Tanzania, three are located on the TANZAM corridor, these being Dar es Salaam, Mbeya and Morogoro. Total tonnage of agricultural production from regions served by the TANZAM amounts to about 1.3 millions tons including cash crops and food crops. This amounts to about 21% of national production, which is about 6.2 millions tons. Of the total national output about 459,000 tons or 8% are cash crops. The four regions served by the TANZAM corridor produce 75,000 tons or 16% of the total national cash crop production.

4.3.2 Northeastern Corridor

The Northeastern corridor has a route length of some 950 kilometres connecting Tanzania's major port, Dar es Salaam with Tanga, Arusha and Moshi. North of Tanga the corridor connects with the Kenyan road network at Horohoro. Of all total route length, 700 km are of bitumen construction and are generally in good condition. Excluding Dar es Salaam the corridor passes through four regions, which in total contain about 4.4 millions

people, or about 19% of total national population. About 3.8 millions of this regional total is located within the immediate catchments of the Northeastern corridor. The corridor starts from Chalinze about 80 km west of Dar es Salaam on the TANZAM highway and links up Dar es Salaam with the towns of Moshi, Arusha and Tanga and the Kenyan border in the north. The highest traffic volumes occur between Moshi and Arusha (about 1,500 v.p.d) and between Segera and Chalinze (about 600 v.p.d).

Total tonnage of agricultural production from regions served by Northeastern corridor amounts to about 1.0 millions tons including cash crops and food crops. This amounts to about 16% of national production. The four regions served by the Northeastern corridor produce 183,400 tons or 40% of the total national cash crop production. There is little statistical data regarding industrial and commercial development in Tanzania and the most recent comprehensive data appears to be the 1989 National economic report. This report gives detailed regional data for value of output for 3 broad sub-sectors; mining and quarrying, manufacturing and electricity. The four regions served by the Northeastern corridor generate about 25% of the total national output in the three sub-sectors.

4.3.3 Central Corridor

The central corridor rivals the Northeastern and TANZAM corridors in economic importance. It is the longest corridor (1,076 km) connecting most of central Tanzania with Dar es Salaam and providing an important transport corridor for the landlocked countries of Burundi and Rwanda. Two sections of the road between Morogoro and Dodoma (about 256 km) and between Isaka and the Burundi and Rwanda borders are bituminised. The Morogoro-Dodoma section has deteriorated substantially and is scheduled for resealing under IRP-I. The highest traffic volumes occur between Morogoro and Dodoma (about 400 v.p.d). On the rest of the corridor traffic levels approximate about 200 v.p.d.

The Central corridor links Dar es Salaam with Morogoro, Mwanza and Musoma and has a total route length of about 1584 kilometres. The route has a bituminous surface between Morogoro and Dodoma (261 km) and also between Isaka and the Burundi and Rwanda border. The route between Dodoma and Nzega (455 km) is gravel/earth construction and is generally in poor condition. There are also very steep sections such as Sekenke Escarpment where gradients reach 14%, making the route very difficult for heavy vehicles. The road improvement strategy for IRP II is to bring the entire route up to bitumen standard. The regions served by the Central corridor contain a total population of 9.2 millions (1988) people or about 39% of the total national population. About 6.3 millions of this regional total is located within the immediate catchments of the Central corridor.

4.3.4 Lake Circuit Corridor

The Lake circuit corridor has a route length of some 1,019 kilometres connecting the towns of Musoma, Mwanza and Bukoba. To the north east the route connects with the Kenyan road network and in the west with Uganda. The section from Mwanza -Musoma (221 km) is of bitumen construction. West of Mwanza the surface is gravel extending to Bukoba and the Ugandan border. Upgrading of 148 km from gravel to surface dressing is currently underway between the Ugandan border and Muleba, which is 80 km south of Bukoba. Under IRP II rehabilitation to bitumen standard of 80 km between Bukoba and Muleba will be carried out. The Lake circuit corridor passes through three regions, which in total contain about 4.1 millions people, or about 18% of total national population. About 2.4 millions of this regional total is located within the catchments of the Lake corridor. The second highest populated urban area in Tanzania, this being Mwanza, with a population of 223,000 (in 1988), is located on the Lake circuit corridor.

4.3.5 Southern Coastal Corridor

The Southern coastal corridor has a route length of some 508 kilometres connecting Dar es Salaam with Mingoyo in the south, where the route connects with the Southern corridor. The road has bitumen surface on its first 153 km and between Lindi and Mingoyo. The remaining 330 km are of earth/gravel construction. Excluding Dar es Salaam, the Southern coastal route passes through two regions, which in total contain about 1.2 millions people, or about 5% of total national population. About 1.0 million of this regional total are located within the immediate catchments of the southern Coastal corridor. Total tonnage of agricultural production from regions served by the Southern coastal corridor amounts to about 0.3 millions tons including cash and food crops. The two regions served by the southern coastal corridor produce 19,000 tons or 5% of the total national cash crop production.

4.3.6 Southern Corridor

The Southern corridor has a route length of about 1,326 km connecting Lindi and Mtwara on the east coast to Songea and Makambako in the west where the route connects with the TANZAM corridor. About 491 km are of bitumen construction. Under IRP II, it is proposed to carry out spot improvements over the 459 km gravel section between Masasi and Songea. Excluding Dar es Salaam, the Southern corridor passes through four regions, which in total contain about 3.5 millions people, or about 15% of total national population. About 1.4 millions of this regional total is located within the immediate catchments of the Southern corridor. Total tonnage of agricultural production from regions served by the Southern corridor amounts to about 1.2 millions tons including cash crops and food crops amounting to about 19% of national production. The four regions served by the Southern corridor produce 19,300 tons or 4.2% of the total national cash crop production.

As noted earlier, the Southern corridor has bitumen pavement for a total distance of 491 km. Traffic volumes over the gravel sections are generally less than 200 v.p.d and improvement to bitumen standard is not of high priority. However while Ruvumu and Mtwara have relatively low population regions with total population amounting to 1.7 millions, food crop production in the two regions amounts to 668,000 tons or 13% of total food crop production in Tanzania. There are therefore substantial food surpluses to transport through the corridor. Maintenance of the surface to an acceptable standard is therefore essential to the local economy.

4.3.7 Western Corridor

The western corridor has a route length of about 1,286 kilometres connecting Nyakanazi in the north to the TANZAM Highway and Tunduma in the south. The road has an earth/gravel surface over its entire route. The corridor passes through three regions, which in total contains about 3.1 millions people, or about 13% of total national population. About 2.4 millions of this regional total is located within the immediate catchment of the Western corridor. Total tonnage of agricultural production from regions served by the Western corridor amounts to about 1.0 millions tons including cash crops and food crops. This amounts to about 17% of national production. The three regions served by the Western corridor produce 25,300 tons or 6% of total national cash crop production. While the regions served by the Western corridor are of relatively low population, amounting to 13% of the national total, food crop output is about 1.0 millions tons or 19% of the total national output. All three regions are therefore food surplus areas and must transport food crops to the deficit regions in the north and east. While traffic volumes are relatively low, it is essential to maintain the road surface in an acceptable condition.

4.3.8 Great North Corridor

The Great north corridor has a route length of about 1,024 km connecting the TANZAM corridor with Arusha in the north and the Kenyan border at Namanga. It includes a branch route from Makuyuni to Oldeani. Of the total alignment only 214 km are bitumen. Under IRP II, it is proposed to upgrade the 99 km section of gravel road to Ngorongoro Crater to surface dressing. The Great north corridor Route passes through three regions, which in total contain about 3.8 millions people, or about 17% of total national population. About 2.6 millions of this regional total is located within the immediate catchments of the Great north corridor. Of the ten largest urban areas in Tanzania, two are located on the Great north corridor, these being Dodoma and Arusha.

4.3.9 Midwest Corridor

The Midwest corridor has a route length of about 1,201 km connecting the Central corridor in the east with the Western and TANZAM corridors in the southwest. Traffic volumes on the corridor are generally low ranging from 50 to 100 vehicles per day. The entire route is of earth or gravel construction. In view of the low traffic volumes improvement to bitumen standard is not required. However, spot improvements and rehabilitation is necessary for over about 473 km of the route. The Midwest corridor passes through three regions, which in total contain about 3.2 millions people, or about 13% of total national population. About 1.8 millions of this regional total is located within the immediate catchments of the Midwest corridor. Total tonnage of agricultural production from regions served by the Midwest corridor amounts to about 1.2 millions tons, which is equivalent to about 20% of national production.

4.4 Road Infrastructure in the Study Area

The previous sections have discussed the distribution of road network in general for the country. In order not to lose some specific details regarding the study area, this section examines road connections in regions studied.

4.4.1 Coast Region

The road network in the Coast region forms an important link in the national road system linking Dar es Salaam with other regions of Tanzania Mainland. All road communications between Dar es Salaam and other regions of the country pass through the Coast region as follows:

- Dar es Salaam - Chalinze -Tanga and Arusha road links Dar es Salaam with the northern parts of the country.
- Dar es Salaam - Morogoro - Dodoma road links Dar es Salaam with the Central and Western parts of the country.
- The Dar es Salaam - Tunduma road links Dar es Salaam with the South -Western parts of the country.
- The Dar es Salaam - Kibiti - Lindi road links Dar-es- Salaam with the Southern parts of the country.

There are a total of 3,713 km of roadways in Coast region comprising of 349 km paved, 173 km gravel and 3,191 km unpaved roads. The distribution of road network by district and nature of road is given in Table 4.3.

Table 4.3: Distribution and nature of roads (km) by district in Coast region, 1997

District	Area (km^2)	Type of road				Total	Road density (km/100 km^2)
		Trunk roads	Regional roads	District roads	Feeder roads		
Bagamoyo	9867	154	316	51	382	903	9.2
Kibaha	1,812	45	53	132	140	370	20.4
Kisarawe	6,896	-	151	153	596	900	20.2
Mkuranga	2,430	90	45	166	151	452	18.6
Rufiji	13,339	118	122	215	424	879	6.6
Mafia	518	-	68	36	105	209	40.3
Total	32,407	407	755	753	1,798	3,713	11.5

Source: NBS, 1997.

Road network distribution in Coast region shows that Bagamoyo and Kisarawe districts have the longest road network while Mafia district has the least road length. However, in terms of road density, Mafia district has the best road coverage of 40 km of road for each 100 km2, whereas Rufiji has the lowest road density of about 5 km for each 100 km. Figure 4.3 shows the general distribution of road network in the region.

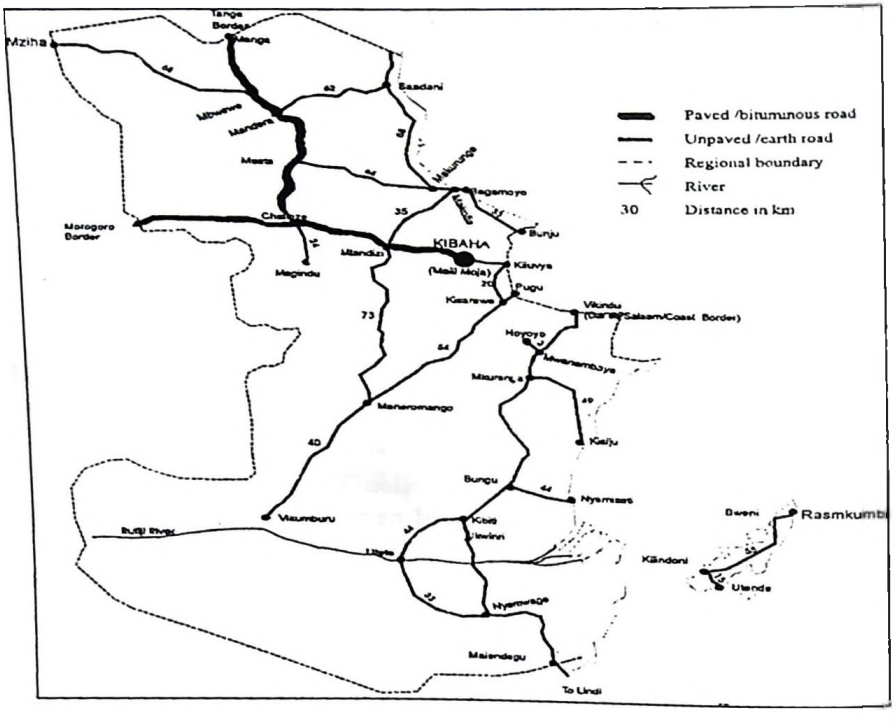


Figure 4.3: Coast region road network

Source: MOW

4.4.2 Morogoro Region

Morogoro region has a total road network of 3,742 km. Out of this a total of 55 km are trunk roads, 961 km regional roads, 1,043 km district roads and 1,179 km feeder roads (Table 4.4).

Table 4.4: Distribution and nature of roads (km) by district in Morogoro region, 1997

District	Area (km²)	Type of road				Total	Road density (Km/100 km²)
		Trunk roads	Regional roads	District roads	Feeder roads		
Kilombero	14,246	74	271	188	67	600	4.2
Kilosa	14,918	230	215	397	666	1,508	10.1
Morogoro rural and urban	19,316	187	331	335	310	1,163	6.0
Ulanga	24,460	68	144	123	136	471	1.2
Total	72,939	559	961	1,043	1,179	3,742	5.1

Source: NBS, 1997

The trunk and regional roads are in good shape, though they require maintenance. District and feeder roads are in a poor state. Speaking in general terms all trunk roads are paved, whereas regional and district roads are of gravel standard, and feeders road are made of earth material. With respect to road density, Table 4.5 shows that Kilosa district is more served with road than any other district in the region. For every 100 km2 the district has 10.1 km of road. Morogoro follows with 6 km of road per 100 km2. However, this may be misleading because this figure combines Morogoro rural and urban road statistics. The distribution of road network in Morogoro is shown in Figure 4.4 below.

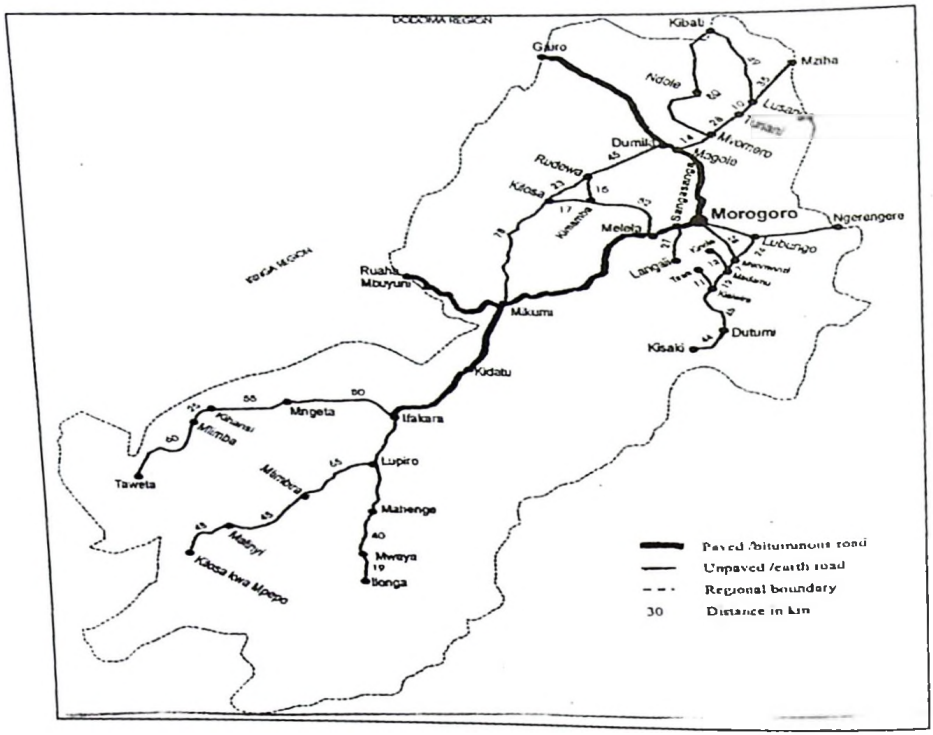


Figure 4.4: Morogoro region road network

Source: MOW

4.4.3 Iringa Region

There is a total of 4,867 km of road network in Iringa region, which includes trunk, regional, district and feeder roads. Out of this 477 km are paved. The region possesses a big portion of TANZAM running from Mbuyuni in Iringa District to Iyayi in Njombe district. Another paved road runs from

Makambako Township to Lukumbulu Mountains (Iringa region) and continues to Songea town in Ruvuma region. Another trunk road runs to Dodoma region via Mtera Dam. In general transport system in Iringa region is relatively better than in many regions in Tanzania mainland. However, feeder roads are not very good, especially during rain season. Table 4.5 shows the distribution of roads by district in the region.

Table 4.5: Distribution and nature of roads (km) by district in Iringa region, 1997

District	Area (km^2)	Type of road				Total	Road density (km/100 km^2)
		Trunk roads	Regional roads	District roads	Feeder roads		
Iringa	28,620	278	416	532	834	2060	7.2
Mufindi	7,123	178	210	360	475	1224	17.2
Njombe	10,668	140	276	430	656	1502	14.1
Ludewa	8,397	180	80	565	320	1145	13.6
Makete	4,128	12	230	188	314	744	18.0
Total	58,936	788	1,213	2,075	2,599	6,675	11.3

Source: NBS, 1997

From the table it is noted that Iringa district has the poorest road network. It has a road density of only 7 km of road per 100 km2 of land area. On the other hand Makete seems to have a better road network compared to other districts in the region. The physical distribution of road network in the region is presented in Figure 4.5.

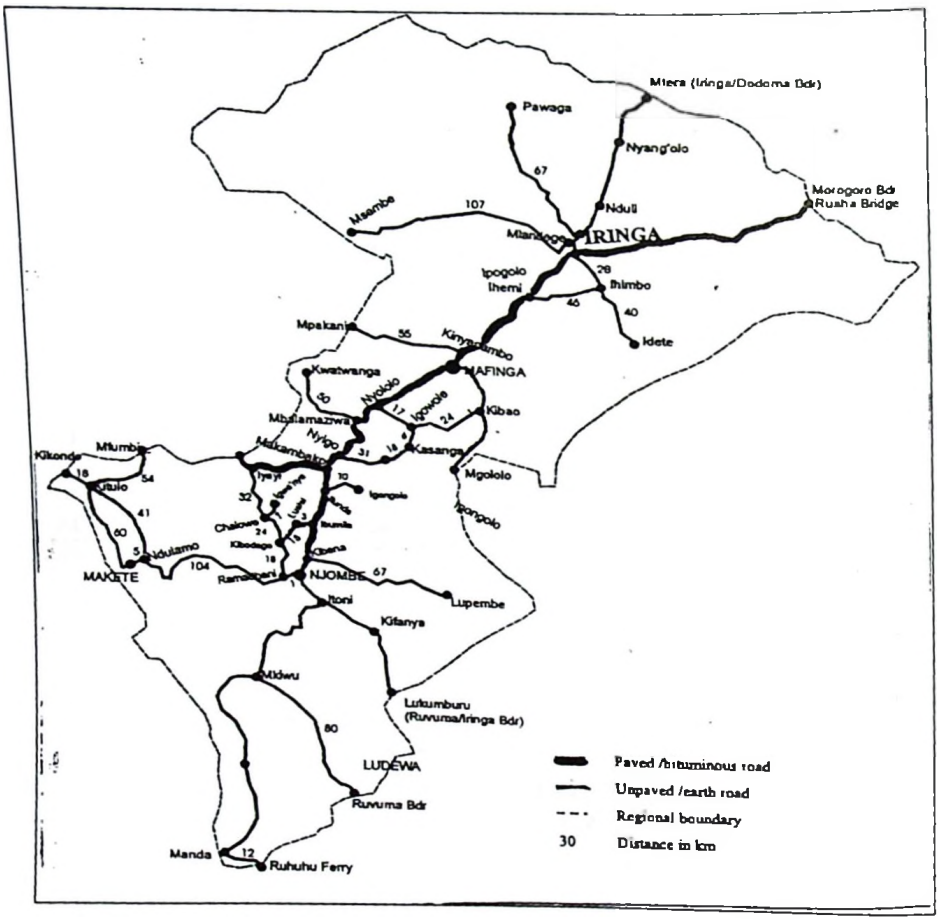


Figure 4.5: Iringa region road network

Source: MOW

4.4.4 Mbeya Region

Mbeya region generally boasts of good transport and communication system. From Dar es Salaam, Mbeya Region can be reached by road and/or railway (TAZARA). There are about 717 km trunk roads, 1,276.7 km of regional roads, 1,420.2 of district roads and 1463.2 of feeder roads. Paved road accounts for 9% of total road length whereas gravel and earth (unpaved) surfaced roads account for 26 and 65% respectively. Apart from Dar es Salaam, Mbeya is well connected by roads to other neighbouring regions. From Tunduma Mbeya is connected to Sumbawanga in Rukwa region. Other connections include Mbeya to Itigi in Singida region, Kambikatoto to Tabora region, Mbeya to Iringa town, and from Uyole to Kasumulu the border with Zambia. Distribution of road by district and nature of surface is shown in Table 4.6. The physical distribution of road network is shown in Figure 4.6.

Table 4.6: Distribution and nature of roads (km) by district in Mbeya region, 1997

District	Type of road					Total	Road density (km/100 km²)
	Area (km²)	Trunk roads	Regional roads	District roads	Feeder roads		
Chunya	29,219	250	65.5	322.4	68	705.9	2.4
Kyela	1,908	45	104.0	134.0	165	448	23.5
Ileje	1,322	-	175.0	223.0	185	583	44.1
Municipal	185	27	14.0	-	129	170	91.9
Mbeya rural	19,093	188	351.2	392.4	271.6	1,203	6.3
Mbalali	16,000	-	-	-		-	-
Mbozi	9,679	140	254.0	62.4	314.6	771	8.0
Rungwe	2,211	67	313.0	286.0	330.0	996	45.1
Total	63,622	717	127.7	1420.2	1463.2	4831.1	7.6

Source: NBS, 1997

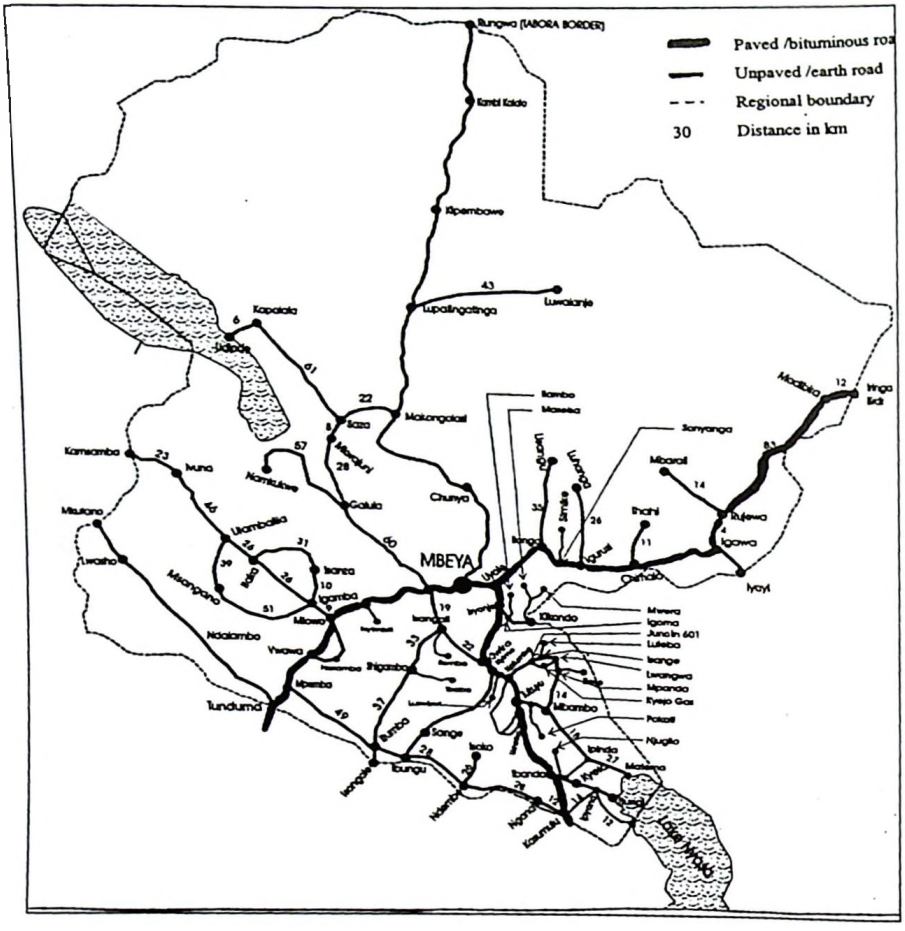


Figure 4.6: Mbeya region road network

Source: MOW

4.5 Road Network Management in Tanzania

Road management involves three main components namely operation, maintenance and development (Table 4.7)

Table 4.7: Road management categories

Management category	Activity
Operation	Traffic management (guidance, control, etc)
	Facilities management
	Administration
	Policing
	Incident management (accidents, hazards, etc)
Maintenance	Routine maintenance
	Pavement and shoulder (localized repairs including patching, crack sealing, etc)
	Reserve and drainage (vegetation control, drainage cleaning and repair, etc)
	Appurtenances (signs, lighting, pavement, markings, barriers, etc)
	Structures (minor repairs to bridges, tunnels, etc)
	Snow and hazard control (removal of snow, ice, debris and hazardous materials)
	Emergency work (landslides, washouts, catastrophic damage, etc)
	Periodic maintenance:
	Restoration
	Resurfacing (surface treatment, thin asphalt overlays)
	Rehabilitation (shape correction and/or strengthening by overlay, etc.)
	Reconstruction (replacement, recycling)
	Structures maintenance
Development	Improvement
	Incremental capacity increases (alignment, widening, additional lanes, etc.)
	Facility upgrading (dualization, paving)
	Safety enhancement (barriers, intersection improvement, etc.)
	Expansion
	New construction
	Facility construction
	Land acquisition

Source: Modified from Paterson and Archondo-Callao, (1991)[3]

[3] Quoted by Roth, (1996)

Operation implies control related activities including traffic management and administration in general. On the other hand maintenance implies keeping the road in its usable state, whereas development deals with construction of new roadways. There are two types of road maintenance activities. The first type is routine maintenance, which is basically small-scale activities involving simple equipment like hoes and spades; and is done once or more than once in a year. The nature of work performed includes cleaning the road lane, draining ditches, patching potholes, grading, vegetation control and emergency repair, which involves works that are a result of unforeseen conditions like floods, fallen trees and earth slips. The second type of maintenance is called periodic maintenance, which is done in periods of 3 to 5 years intervals and its activities are relatively larger in scale. This is done to strengthen a weakened road and is machine intensive involving equipment like bulldozers, rollers, and large lorries. The kind of works done include putting a new layer of asphalt or putting gravel material on a road (Roth, 1996)

For many years the government of Tanzania did not given roads the attention they deserved. However, in recent years, the government has recognised transport as one of the major priority areas for its socio-economic development. Formation of two ministries and two semi-autonomous bodies, and implementation of road improvement programmes are all indications that the government is committed to evolve the transport sector to make it meet the needs and expectations of the people within the constraints of the country's resources. To this effect, a road transport sub-sector policy was underway when this study was carried out. In terms of central government recurrent and development expenditure allocation on road infrastructure, Tanzania now appears to compare favourably to other African countries. In 1994 expenditure on roads and bridges accounted for 6.4% of total public expenditure, and over the 1990's the figure has ranged between 4 and 7%, an improvement compared to earlier years (Batalia and Kachenje, 1998).

4.5.1 Institutions Responsible for Road Management in Tanzania

The management and development of road network in Tanzania falls under five institutions namely the Ministry of Works (MOW), the Ministry of Communication and Transport (MCT), the Ministry of Regional Administration and Local Governments (MRALG), and two semi-autonomous bodies; the Tanzania National Roads Agency (TANROAD) and the Tanzania Road Fund Board (RFB).

4.5.1.1 The Ministry of Works

The Ministry of Works is responsible for all construction activities in the country. In the transport sector the ministry is charged with strategic planning, donor coordination, performance monitoring and setting standards. The functions of the ministry as stipulated in the budget speech of 2001/02 include to: (i) manage, control access and usage of the road network (ii) carry out design and overall supervision of roads, bridges and ferry crossing using consultants and in-house capacity (iii) carry out inspection of roads and bridge works to ensure adherence to quality standards and cost effectiveness (iv) provide professional and administrative support in contract management (v) coordinate donor assisted projects and (vi) control road safety and vehicle axle load.

4.5.1.2 The Ministry of Communication and Transport

The Ministry of Communication and Transport is responsible for providing balanced, effective and efficient domestic and international transport and communications infrastructure, and services. In the transport sector the functions of the ministry include: (i) overseeing the communication and transport policies and their implementation (ii) transport licensing for road, marine, railway and air transportation (iii) overseeing projects under the ministry and (iv) coordinating government Agencies falling under this ministry.

4.5.1.3 The Road Fund Board

The Board was established following the Road Toll (Amendment) (No2) Act of 1998. The Board was officially inaugurated in August 1999 with the following function as given by the Act: (i) advise the minister on new sources of road tolls, adjustment of rates of existing tolls and on regulations for the collection of road tolls for the purpose of ensuring an adequate and stable flow of funds to road operations. At the moment the Fund collects fund from four main sources namely fuel levies, heavy vehicle licences, transit fees and vehicle overload fees (RFB, 2000) (ii) Apply the money deposited into the fund for the purpose approved by the parliament (iii) ensure full collection and transfer of collected road tolls to the fund accounts (iv) develop and review periodically the formulae for the allocation and disbursement from the fund to TANROAD, local authorities and other road agencies and advise the roads Minister accordingly (v) Recommend to the roads Minister an allocation of funds for TANROAD, local authorities and other road agencies to undertake road management at a level that is sustainable and affordable (vi) disburse funds from the fund to TANROAD, local authorises and other road agencies (vii) ensure that the operations of TANROAD, local authorises and other road agencies and the Fund are technically and financially sound and (viii) monitor the use of the fund disbursed to TANROAD, local authorises and other road agencies for the purpose of the objectives of the fund.

4.5.1.4 Tanzania National Road Agency (TANROAD)

The Agency was established under the Executive Agencies Act of 1997 as a semi-autonomous government Executive agency of the Ministry of Works responsible for the management of the mainland trunk and regional road network in an efficient and cost effective manner adopting commercial - style principle. The core task of the Agency is managing the national road network. The activities of TANROAD among other things include: (i) carry out detailed road network and bridge inventory (ii) carry out maintenance and development of the trunk and regional road network to the extent

prescribed in the performance agreement with the RFB (iii) encouraging development of an efficient and appropriate private sector implementation capacity principally through the provision of regular and sustained workload and (iv) adequate supervision of consultants and contractors, including appropriate quality assurance and quality control procedures

4.5.1.5 Ministry of Regional Administration and Local Governments

The MRALG has responsibility for the maintenance of district roads, village roads and some urban road network (MCT, 1998). These responsibilities were formerly under the Prime Minister's Office and later under the President's Office-Regional Administration and Local Government.

4.5.2 The Integrated Roads Project (IRP)

In the late 1980's, Tanzania's road infrastructure had sharply deteriorated, constraining economic growth, especially in the agricultural sector. The country urgently needed to improve its road network. The government, together with the Donors, implemented a major road rehabilitation program as a key part in the Tanzania the ERP, launched in 1986. In 1990, the government of Tanzania launched, a 10 year project, IRP, as a component of the ERP. The IRP aims to stabilize and restore the road network to enable it to provide its basic services of accessibility and loading capacity. The IRP provides the framework for MOW investments in road improvements. It focuses, not only on physical improvements to roads, but also on institutional improvements, greater resource mobilization and commercialisation of road management.

The IRP had two phases. Phase one, IRP-I, covered the period 1990-1996 and had as its interim physical targets of bringing 60% of trunk roads and 50% of regional roads in good condition. The second phase, IRP-II, covered the period 1996-2000. The cost of implementing IRP has been estimated at US$ 1,633 millions, 8.5% of which is to be financed by government, the rest

prescribed in the performance agreement with the RFB (iii) encouraging development of an efficient and appropriate private sector implementation capacity principally through the provision of regular and sustained workload and (iv) adequate supervision of consultants and contractors, including appropriate quality assurance and quality control procedures

4.5.1.5 Ministry of Regional Administration and Local Governments

The MRALG has responsibility for the maintenance of district roads, village roads and some urban road network (MCT, 1998). These responsibilities were formerly under the Prime Minister's Office and later under the President's Office-Regional Administration and Local Government.

4.5.2 The Integrated Roads Project (IRP)

In the late 1980's, Tanzania's road infrastructure had sharply deteriorated, constraining economic growth, especially in the agricultural sector. The country urgently needed to improve its road network. The government, together with the Donors, implemented a major road rehabilitation program as a key part in the Tanzania the ERP, launched in 1986. In 1990, the government of Tanzania launched, a 10 year project, IRP, as a component of the ERP. The IRP aims to stabilize and restore the road network to enable it to provide its basic services of accessibility and loading capacity. The IRP provides the framework for MOW investments in road improvements. It focuses, not only on physical improvements to roads, but also on institutional improvements, greater resource mobilization and commercialisation of road management.

The IRP had two phases. Phase one, IRP-I, covered the period 1990-1996 and had as its interim physical targets of bringing 60% of trunk roads and 50% of regional roads in good condition. The second phase, IRP-II, covered the period 1996-2000. The cost of implementing IRP has been estimated at US$ 1,633 millions, 8.5% of which is to be financed by government, the rest

(91.5%) from donor support in the form of loans and grants. The IRP has recorded some success in terms of road rehabilitation, upgrading and construction. Records show that about 2,583 km of trunk and 3,753 km of regional roads have been rehabilitated. Those upgraded are 333 km, while about 100 km have been constructed. Another notable achievement of the IRP relates to the strengthening of road management capacity of the Ministry of Works, both at the headquarters and regional engineers' offices. These achievements notwithstanding, more needs to be done to ensure sustainability of the road network. Substantial investments are required to bring the entire network to maintainable status and ensure the improved network is kept in good condition through regular maintenance (MOW).

Chapter Five

5 Theoretical Perspective, Literature and Methodology

This study was carried out in the framework of market access impact on economic development. The main focus was market access in terms of road infrastructure. This chapter reviews previous empirical works that have been used to measure the contribution of roads and infrastructure in general on economic development. The chapter also presents detailed account of methodological issues including the survey design, data collection procedure, specification, identification, and estimation process of the simultaneous equation model. Later, a presentation is made about how the total market effect derived from the coefficients is used to analyse economic return on road investment. The chapter begins by examining the transition process from subsistence market oriented agriculture to commercialised agricultural production.

5.1 Market Induced Development Hypothesis

The market induced development hypothesis explains the transition process from subsistence to commercial form of production in the farming sector. Its basic paradigm holds that efficient marketing system generates prices that induce economic development through influencing resource allocation. For this to happen a farm household should be integrated into the main stream of the economy. That means the farm household should stop being a self-sufficient, home–consumption oriented production unit, which internally decides on production and consumption without relating to any external market. That is demand and supply forces are adjusted internally. All needs of the family are satisfied out of own production; whatever is needed may be produced even though at high costs because the farm may be having a comparative disadvantage in producing it. Figure 5.1 shows a transition

process when a self-sufficient family is integrating into the commercial marketing system. The inner ring shows the self-sufficient household, which is composed of family, farm, resources and consumption goods.

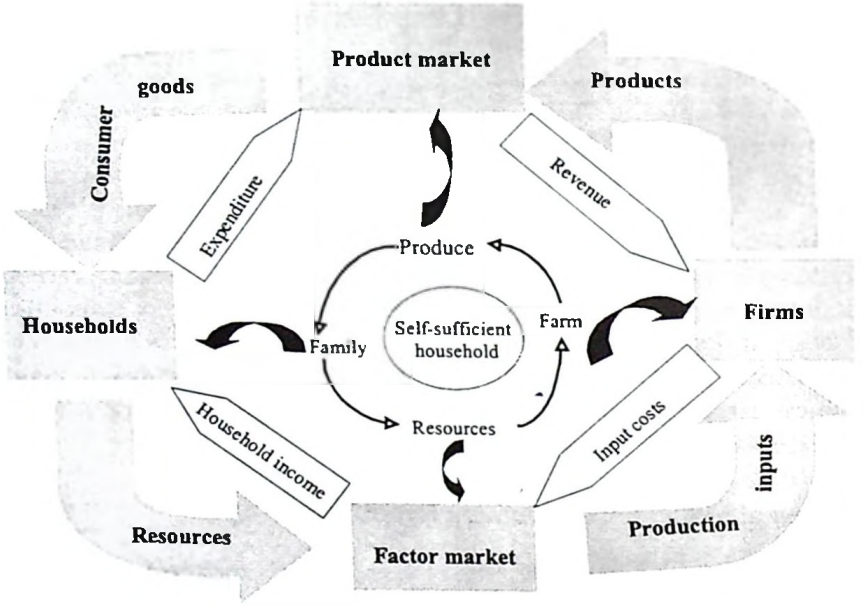


Figure 5.1: A self-sufficient household integrating into the marketing system

Source: Institute 490B

The family uses resources at its disposal, for example labour and land, to work on the farm and produce goods, which are in turn consumed by the

family. Outside the household there is the main stream of the economy, comprised of households, firms, factor market and consumer goods market. When the household is exposed to the external world, it starts producing not only to its local consumption but also to the needs of the others. The self-sufficient household disintegrates and its components become absolved in respective components of the economic system. The household joins other households, resources join the factor market, consumption goods find their way to the consumer goods market and farm joins firms. The household becomes part of the national marketing system.

5.2 Agricultural Markets and Marketing

Markets exist, wherever a supply of goods or services is meeting the corresponding demand, and a price is being determined. Several markets form a marketing system. The first seller of agricultural commodities is the farmer, who offers his produce to a trader or directly to a consumer; the trader assembles larger quantities of the same commodities for further handling and for selling it to another trader or to the consumers. At each trade level, where the good is exchanged against money and the ownership changes, a transaction is taking place and a price is being determined. The commodity on its way from the producer to the consumer follows what is known as a commodity chain, which adds value (utility) to the product.

Commodity chains for different products may have different lengths; depending upon how much utility a consumer wants to have added before he consumes the product. Generally, the more utility added when transforming the raw material into a final consumer good, the larger the cost margin and consequently the lower the farmer's share in the consumer price (von Oppen, 1999). Under the condition of effective competition among traders, the margins of traders cannot exceed the actual costs involved in the transformation process plus a normal profit margin[4]. Competition

[4] Normal profit margin in this case is the profit equivalent to the interest a trader would get if he/she invested his/her capital in the financial market.

among traders is a necessary condition for an efficient functioning of the commodity chain.

The agricultural marketing system constitutes the entire set of agricultural markets, that is, input markets as well as product markets. Since in all of these markets prices are determined, and these prices affect the decisions of individual farmers as well as consumers and all of the traders, the agricultural marketing system is highly interactive. The communication among the individual elements (decision-makers) and components (markets) in the system is essentially based upon price signals. The dynamics of an agricultural marketing system depend upon the clarity and speed in which price signals are transmitted. Development overtime and markets therefore are closely related. Markets also determine spatial structure of countryside and they affect the social fabric of the society.

There seems to be a growing consensus among economists that aligns with the broader, more dynamic views of marketing as a major element in development in other sectors. Hence production, processing and distribution activities are seen as a closely interrelated set of activities that operate in a system context. The system includes the familiar components of farm production, rural assembly, processing, distribution (both rural and urban), and flow of industrially produced agricultural inputs and consumer goods to rural markets (Riley and Weber, 1978). Rural markets emerge as local trading centres hierarchically interconnected within a large regional and national market network. In most developing countries there is a steady and sometimes relatively rapid build-up of urban population, and rising levels of consumer income place great pressures on the marketing system to expand and undertake an increasingly complex set of activities that link the rural and urban sectors of the economy (Mittendorf, 1978).

5.3 Functions of Agricultural Marketing

According to a simplified conceptual framework of agricultural marketing functions developed at the Department of Marketing of Institute 490B[5] at the University of Hohenheim, the system of production and marketing in agriculture can be described as the interaction and outcome of decisions by various actors in pursuit of a number of specific activities, each following certain economic principles. In this setting, the system of production and marketing fulfils three basic functions; utility generation, resource allocation and welfare generation. This is shown as an interplay of actors and their activities in Table 5.1. The actors are farmers, traders, consumers and public decision makers.

5.3.1 Utility Generation Function

The activities involved in utility generation are transportation, storage, processing and transaction or price finding. Transportation generates utility in space. If a trader finds that a commodity in location A is more valuable in location B, he will buy and transport it from A to B, thus increasing its utility. However, if the cost of transporting the good exceeds the perceived gain in utility, it will not be transported. Transportation involves variable costs of moving the goods. This activity is carried out primarily by private decision makers at all levels (farmers, traders and consumers). However, the fixed costs of transportation in providing infrastructure such as roads and communication systems are generally borne by the public decision maker (who may, of course, specifically charge user fees for example, levying toll fees or market fees for the sake of sustainability of the infrastructure).

[5] Institute of Agricultural Economics and Social Sciences in the Tropics and Sub-tropics

Table 5.1: Functions of Agricultural Markets: Actors and Activities

Function	Activity (Economic principle)	Actors				
		Private decision makers				Public decision makers
		Farmers		Traders/Middlemen	Consumer	
Utility generation	Transportation (Profit maximisation)	From farm to assembly markets		From assembly markets to wholesale/retail markets	From retailer to home	Public investments into roads, and communication systems
	Storag: (Profit maximisation)	In small stores/bags for own consumption or sale		Limited storage because turnover is more important	Hardly any storage	Public storage
	Processing (Profit maximisation)	For own consumption		Industrial milling and processing	Partial processing and cooking	Rare or no processing
	Transaction and price finding (Marginal cost=Price=Marginal utility (MC=P=MU)	Opportunity value of produce consumed at home or not sold	First transaction in assembly markets: producer price	Intermediate transaction in trade sector: various market prices	Transaction at retail markets: consumer price Opportunity value of money not spent	Market organisation, price policies, price reporting
Resource allocation	Direction (Comparative advantage)	High farm prices		Low costs	Lower consumer prices	Priority setting
	Intensity (Maximising returns)	Specialisation or diversification		Specialisation or diversification	Increase in quality of consumption	Physical infrastructure
	Extent (economies of scale)	Intensification, innovation		Improved capacity utilisation	Increase in quantity of consumption	Institutional infrastructure
		Increased production, increased marketed surplus		Expansion of enterprise		Support system
Welfare generation	Market intervention (Efficiency maximisation subject to acceptable equity level	Increase in producer surplus vs. taxation/redistribution		Increase in efficiency gains vs. taxation, fees, increasing competition	Increase in consumer surplus Vs taxation, support schemes	Policy formulation; trade off between efficiency and equity

Source: Institute 490B, University of Hohenheim

Storage generates utility in time. If to a farmer a product available at harvest is more valuable at a later point in time, he will store it for later use or sale, thus increasing its utility in time. However, if the cost of storing the product exceeds the expected gain in utility, it will not be stored but used or sold immediately. Storage is often done in privately owned warehouses on account of private owners. Storage in privately or publicly owned warehouses on behalf of the public is found where the public has been given a responsibility for stabilizing supplies and prices through public intervention and stocking of reserves. Processing generates utility in form. Normally, to a consumer a raw material, (for example cereal grains), will be useful in a different form (for example flour). Therefore, some middlemen submit the product to a process of transformation, thus increasing its utility by processing it. However if the cost of transforming the product exceeds the perceived gain in utility, it will not be processed. Processing of goods is generally left to the private sector where industrial processing by middlemen and food preparation at the household level are the major transformation activities. Here the public sector generally sees very little scope of intervening.

Transactions generate utility in ownership. If a good is more useful to a buyer than to the seller, then both will agree to exchange ownership at a price, which makes both participants in the transaction better off. The seller receives money and the buyer receives the good. However if the transaction costs of bringing buyer and seller together exceed the mutually perceived advantage, the transaction will not take place. This price finding effect of an ownership change contains valuable information, which should be treated as a public good. The prices provide information on the marginal utility and marginal cost of production, therefore it is of common interest that prices agreed upon between two negotiating partners on most products be made publicly available and reported in such way that other decision makers have access to and can make use of this information.

Transactions and price finding is clearly the domain of the private sector. At the level of transactions between producers and traders prices are determined in assembly markets. But farmers also take into account the

opportunity value of grain not sold but kept for home consumption. Thus farmers are aware that also for grain not sold, there is a price, which they have to account for, thus consuming it so that marginal utility equals price. Similarly, consumers who are purchasing food for consumption do so by keeping in mind the marginal utility of money, which is not spent on food but on other items. However, support of price finding and price reporting are major investments for the public policy makers, to provide transparency and competition in the marketing system. This implies organizing markets in a way that competitive price finding can take place at minimum costs and that price reporting is done correctly and effectively.

5.3.2 Resource Allocation Function

The process of agricultural transformation consists of change in the cropping pattern. Cropping pattern means the proportion of area under different crops. Allocation of area to different crops (resource allocation) undergoes a change as a result of changes in relative profitability of various crops, which is an outcome of improvements in productivity and changes in relative price structure (Kaushik, 1993). Price signals indicate the direction into which a farm enterprise should change its activities. This implies specialization or diversification as the comparative advantage may indicate. Further, the intensity by which an activity is pursued is decided such as to maximize returns. The extent, to which an activity is followed, depends on the economies of scale inherent in an operation. Thus decisions about direction, intensity, and extent of activities are implicitly reflecting decisions on resource allocation. Causal relationships exist between these decisions so that some of these decisions reinforce one another and generate self-accelerating virtuous circular effects involving decision makers at all levels along the agrichain (Figure 5.2).

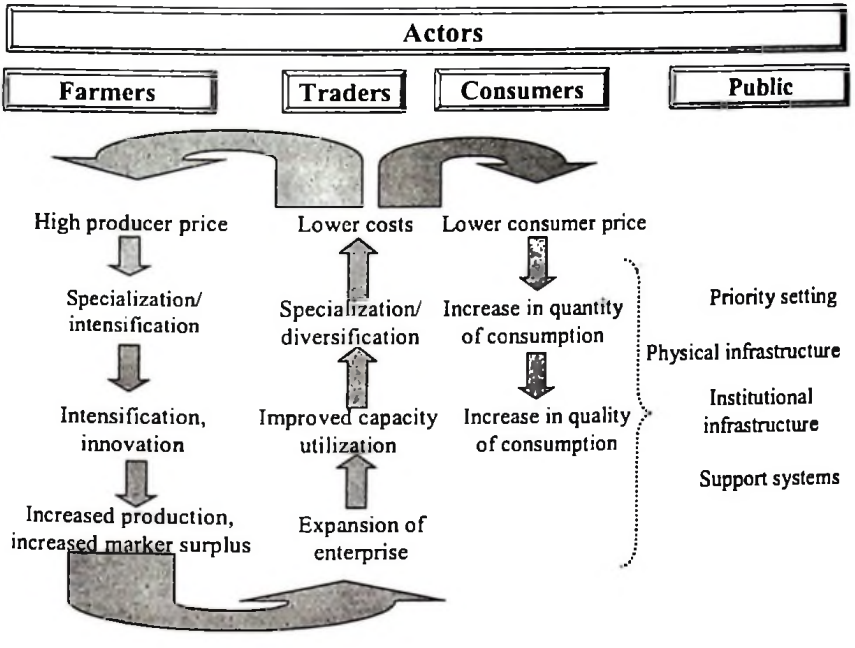


Figure 5.2: Virtuous circular effects of a marketing system

Source: Von Oppen and Gabagambi (2002)

On the part of a farmer, if he receives a clear price signal, about a price of a product, which he could sell in a market within his reach, he will immediately calculate and compare the price with his own costs of production. If he finds, that the price is and will stay high enough to promise him a profit, he will decide to redirect his production system by specializing (or possibly diversifying) into the direction of this comparative advantage. Once having decided to specialize or diversify he is likely to increase the intensity of land use, by utilizing the proceeds from the market

sales for purchasing inputs and for adoption of improved technologies. Since farmers in the same village or region operate under similar agro-climatic conditions, it is quite likely that the majority will choose to follow similar directions of specialization and intensification of production with the results that at aggregate level in the region the density of marketed surplus will increase. The increase in marketed surplus is likely to be very large since a constant quantity is normally used for own consumption; it is only the residual, which is being marketed. Any slight increase in productivity will dramatically increase this residual.

On the part of traders, if they are faced with dramatically growing densities of production and market arrivals they will expand their operation, because their utility generating activities are all subject to considerable economies of scale, and of capacity utilization. Likewise, traders will specialize or diversify according to comparative advantage. Increased density of market surplus implies lower costs of processing and handling. Under the pressure of competition, these cost savings are passed on to producers in the form of higher farm-gate prices and to consumers in the form of lower consumer prices. Higher farm-gate price implies more income to the producer, which permits further intensification. Lower consumer price implies increased disposable income to the consumers, especially in urban areas. Marketing services become a large portion of the consumer food bill and the composition of the market basket shifts from low-cost, starchy foods toward higher cost livestock products, fruits and vegetables.

At this point, the public intervention is necessary to reinforce the virtuous circle described earlier. Major investments are required for transportation equipment, highways, and other physical facilities. Governments usually assume leadership in planning and financing much of the market infrastructure and frequently perform major roles in facilitating and regulating development of marketing institutions and in some instances actually organising and managing marketing enterprises (Farris, 1983). In addition, the government is supposed to create institutional framework conducive to promote the marketing system.

5.3.3 Welfare Generation Function

It has been shown previously that an efficient marketing system generates welfare. But welfare gains are not necessarily distributed among key actors in the system. The gains may be enjoyed by producers, consumers or traders. But a general observation is that markets tend to accentuate the gap between the rich and the poor. Resource endowment is different among farmers and traders, and still differs from one region to another. Regions with more resources will become rich and richer whereas those with less resource will become poor and poorer. In this case the public, through appropriate policies, should intervene in the production and marketing process to bring equity. If consumers are enjoying the welfare gains, redistribution should take place in favour of producers, and the same applies if the farmers reap the lion's share in the welfare gains. There are two ways by which the public may intervene at policy level. First, it may identify the factors that impede smooth running of the system and formulates policies that remove the bottlenecks, for example through improving market infrastructure. Second, it may carry out redistribution of gains in an endeavour to bring equity. However, the forms of intervention in the redistribution process should be chosen carefully in order not to frustrate the self-accelerating chain of market effects discussed earlier.

In the foregoing presentation it has been indicated that, when the farm is connected to the marketing system it becomes transformed from subsistence to market oriented production unit. By this, it implicitly implies improvement or provision of infrastructure that facilitates farmers' access to the market. As noted by Kessides (1996), inadequate transport and communication impede the efficient functioning of markets, and thus has highly unfavourable impacts on prices faced by the poor either as producers or consumers. Later, this chapter looks in details at the issue of infrastructure and its influences on economic performance. Consideration is particularly on road transport infrastructure. However, it is imperative to begin by presenting definitions of main concepts that will be used frequently in the foregoing discussion.

5.4 Definition of Concepts

5.4.1 Market Access

Market access is part of accessibility concept, which is a very wide concept. Barwell (1999) whose work on transport in rural areas of developing countries is appreciated by many scholars defines accessibility as the ability or ease of reaching various destinations or places offering opportunities for a desired activity. He identifies three levels of accessibility, namely (i) of basic needs such as food, education, health services, (ii) of wider needs through access to major centres of activity, for example towns and markets, (iii) of personal movement or travel for non-essential purposes. This study deals with accessibility level (iii) in which physical access to agricultural markets is embedded. Agricultural market access is the ease or difficulty of producers to reach markets for inputs and outputs. The level of market accessibility is facilitated, together with other things, by the social institutional framework, purchasing power of the farmers, availability of marketplaces, roadways and the rolling stock - vehicular capacity in this case (Likwelile, 2000). Problems in any of these will hinder farmers from reaching the market.

5.4.2 Infrastructure

The term 'infrastructure' is derived from the military language of World War II where it meant the permanent installations required for military operations (Gove, 1993). Since then the term has evolved to mean the underlying framework of the socio-economic system. As such infrastructure is a part of capital stock of an economy, which literature refers to as social overhead capital. According to its function, infrastructure is an investment of investments that carries the superstructure of the directly productive capital stock (Hofmeier, 1973). In its widest sense, infrastructure includes all public services from law and order through education and public health to transportation, communications, power and water supply as well as such agricultural overhead capital as irrigation and drainage system (Button, 1996).

An explicit definition of infrastructure proves to be very difficult. Jochimsen (1966) gives the widest concept of infrastructure. He distinguishes between three main groups of material, institutional and personal infrastructure. Material infrastructure includes the totality of all installations and equipment of an economy that are used in the fields of energy provision, transport and telecommunications, conservation of natural resources, buildings and equipment of the public administration and of all education, research, health and social services. Institutional infrastructure includes all naturally grown and set norms, institutions and procedures in their "constitutional reality" in as far as they concern degree of actual equal treatment of equal economic phenomena. Institutional infrastructure provides the framework within which economic subjects formulate their own economic plans and carry them out in cooperation with others.

Finally, personal infrastructure includes, the number and qualities of people within the scope of the economy in respect to their abilities to contribute to the raising level and the degree of integration of economic activities. This includes general education, specialisation and qualification of people in various functions in an economy with a division of labour and also their distribution according to sectors, regions and sizes of enterprises. With this definition Jochimsen considerably widens the normal understood concept of infrastructure as mainly basic material investments. Jochimsen includes two aspects in his considerations that had always been treated as given data within the context of economic theory. These data were not considered to be variables, which could be influenced by economic decisions. They are definitely only to a minor extent subject to direct economic influences. Despite their eminent importance for the process of economic development both institutional and personal infrastructure will not be further considered in this study.

5.4.3 Area of Influence of a Road

The area of influence of a rural road is defined as the area served, impacted or modified by a road in its immediate geographical environs. Within this

area the implementation of a road project is likely to alter the land use pattern, production costs and revenues, and marketing and distribution systems. Rural roads providing access from farms to the local markets may serve as catalysts in the monetisation of the local economy. In quantifying the benefits of a road investment, a critical input is an estimate of the area influenced by the road.

There is a wide divergence in the estimates of area of influence. One recurrent theme in delineating the area of influence is the use of the maximum distance from the road in any direction that a person can travel during one day using any available method of transportation (Carnemark, 1976). However, conventionally the zone of influence is defined as the area within a one-day walk of the site of a proposed road - approximately 48 km in either direction of the road (Steiner, 1965). In this particular study the service area of a road was taken as the entire area within 20 km radius of the road.

5.4.4 Aggregate Agricultural Productivity

Productivity is the ratio of the output(s) produced to the input(s) that are used (Wong, 1986). When the production process involves a single input and a single output, this calculation is a trivial matter. However, when there is more than one input (which is often the case) then calculation of productivity becomes complex (Coelli et al, 1999). Diewert (1992) suggests a method for aggregating these inputs into a single index of inputs referred to as Total Factor Productivity (TFP) calculated using either Fisher or Tornqvist indices given by Equation 5.1.

$$TFP = \frac{Output\ Index}{Input\ Index} = \ln Output\ Index - \ln Input\ Index \qquad (5.1)$$

However, this approach does not give contribution of individual factor of production. In addition, success in the use of TFP method depends very much on the availability of data for all components of the index namely labour, land and capital. When it is not possible to obtain meaningful data, other traditional measures of productivity, such as labour productivity in a factory and land productivity (yield) in farming could be used, though they leave out important information about the production process because they are partial measures of productivity (Coelli et al, 1999).

In recent years, scholars in the field of agricultural economics have used aggregate partial productivity in terms of output per unit of a particular input or a group of factors that are lumped into a single category. As argued by Odhiambo (1998), while it is possible to quantify the productivity of most of the resources used in farm production, it is productivity of land that is usually given prominence, because land is the most limiting factor at peasant farm level. This study followed this trend by adopting per unit of land productivity measurement approach. Productivity as measured in this study represents aggregate partial productivity, that is, overall productivity of a farm per acre in the reference period in monetary terms. It was computed at average market prices (1999/2000) for each crop in the study area. As will be seen later, multiplying the quantity of each product by its average price, adding up over all products and dividing the total by the area under respective crops gave aggregate productivity as shown in equation 5.2 below:

$$AAP = \frac{\sum_{i=1}^{N} (Q_i * P_i)}{\sum_{i=1}^{N} \frac{A_i}{N}} \qquad (5.2)$$

where, *AAP* stands for aggregate agricultural productivity in monetary value, *Q* for quantity of *i*th crop in its selling units, *P* for average price of *i*th crop, *A* for area under *i*th crop, *i* is a subscript denoting output and price for a particular crop and *N* represents total number of crops under consideration

5.5 The Role of Road Infrastructure on Economic Development

There is a strong theoretical justification that infrastructure is a sine-qua-non for economic development. Bajpai (1993) points out that, if economic development of any region is termed as the development of its agriculture, manufacturing and services sectors, then the infrastructure may be considered as those basic facilities which are required to sustain the development of these sectors in a long run. The role of roads in the society dates back to the immergence of humanity. From the earliest days men realised that different men could make different products, and that trade could make products available in different places. Trade started from person to person, but grew to involve different towns and different land. Transport emerged as an important activity in the trade process (Jaffe and Hilbert, 1998). History shows that a well-designed system of roadways played a vital role in the growth and maintenance of the Roman Empire (O'Flaherty, 1983).

The importance of road infrastructure is also acknowledged by Likwelile (2000), who argues that the prosperity of a nation is bound up with the state of its roads. Throughout the world roads carry the bulk of goods being traded and people being transported, even where sophisticated alternatives have been created. Thus suitable road networks provide an essential foundation for economic growth and prosperity, and are indeed critical for the sustainability of a country's economic development. To this, Binder and Smith (1996) add that road network has also important non- economic components such as political, social and military cohesion of a country.

The positive contribution of road infrastructure on economic productivity emanates from its impact on the cost structure of an industries, and thus influences production decisions of economic agents. This happens via two channels. First is through shifting the cost per unit of output in an industry downward. Second relates to the factor adjustment effect whereby firms tend to adjust their production decisions with respect to input hiring (own labour, intermediaries and capital stock) if services they receive from infrastructure are substitutes or complements of their own factors of

production (Anas et al, 1996). Road infrastructure does also play an important role in ensuring timely communication, reasonable utilization of installed capacities and provides access to sources of supplies and marketing outlets (Ndulu and Wangwe, 1997).

In this way, roads strongly influence spatial allocation of processing plants for agricultural produces. Inadequate road network leads to development of numerous small-scale processing plants, whereas good road system makes it possible for processors to construct large plants and enjoy economies of scale. Infrastructure and transport deficiencies add to input costs, which in turn raise production costs as manufacturing firms and farmers are forced to pay more for inputs. In addition, inadequacy in infrastructure and transport hampers labour mobility, resulting into wasting time. Infrastructure deficiencies constrain the carrying out of a wide range of income generating activities. All these constraints, translate into substantial production and distribution/marketing costs, which force economic agents to face narrow windows of opportunity and they earn less in terms of incomes.

In a way, this culminates into reduced personal welfare and thus increased incidences of poverty. A good example is given by Potkanski (1997) quoted by Mbilinyi and Nyoni (1997), who argues that economic reforms in Tanzania have benefited smallholder-farming communities, especially those near urban centres and along trunk roads, who have access to markets for their crops. For those situated in remote areas the situation has become even worse. The state owned Regional Transport Companies (RETCOs), which used to provide transport services in rural areas regardless of road conditions have either collapsed or have been privatised in the market economy.

Another front relates to the welfare effects, the consumption dimension of the equation, the relevant case in this case is accessibility to social amenities. Improved infrastructural development facilitates participation in social events, accessibility to social services like education, health care, sources of clean and safe water, etc. Ability to access these services

enhances the quality of human capital and positively impacts on labour productivity. Human capital development is a critical input for the country's sustainable development (Likwelile, 2000).

The most extensive coverage of the role of infrastructure on economic development is given by Kessides (1996), who summarizes some of the economic benefits of infrastructure in the context of developing countries. Her main argument is that, infrastructure contributes to economic development both by increasing productivity and by providing amenities that enhance the quality of life. This is achieved in a complex relationship. Infrastructure services are intermediate inputs to production, and any reduction in theses input costs raises the profitability of production, permitting higher levels of output, income, and/or employment. Furthermore, infrastructure services raise the productivity of other factors of production since its availability leads to higher returns obtainable from land, labour, and capital. The existence of infrastructure in a given location may attract flows of additional resources, leading to reduced factor costs and transaction costs at that site. She continues with her analysis by exploring various areas and ways in which infrastructure contributes to economic growth, ranging from production, international competitiveness, domestic market development, economic diversification, technological innovations and personal wealth.

In connection with this, research studies for example those of Lanjouw and Stern (1993) and Epstein (1973) cited by Evans (1990) indicate that infrastructure has direct effects on production costs and profitability of agriculture, which are similar to those observed in the manufacturing sector. Rural roads (farm to market), for example, have a major effect in improving marketing opportunities and reducing transaction costs. The marketing of agricultural commodities, excluding the stage of processing, can account for 25-60% of final prices for foodstuffs in developing countries, with about half of the marketing costs attributable to transport. Adequate road infrastructure in rural areas could both raise farmers' income and lower the prices of food to urban consumers. This outcome would be more likely to occur as improved transport facilitates the adoption of productivity

enhancing technology (such as fertiliser) on the farms (Ahmed and Hosain, 1990), reduce transport costs, and makes markets more competitive by increasing access to market information (Beenhakker, 1987). The benefits of improved transport facilities on personal mobility and the access it provides to other goods and services, such as education and health care cannot be overemphasised. Recent research in Sub-Saharan Africa by Barwell (1996), documents practice of 'head loading' of firewood, water and crops due to absence of road infrastructure for motor vehicles and of intermediate means of transport such as carts and bicycle. Thus, where the poor have little access to modes of transport other than walking, they have to forego time, which could be spent on activities with higher utility to them.

An earlier work by Voigt (1955) clearly indicates the reciprocal relationships between transport expansion and general economic development and particularly emphasises the long-run effects of the transport system on the whole structure of a national economy. He demonstrates how different modes of transport can have very different effects in different stages of economic development. He argues that development processes originally initiated by a road network system, in some cases show a distinct dynamism of their own, which influences various areas quite differently. As a result of the influencing forces of the road network system, distinct development in evacuation zones come into existence. Development, therefore, not only depends upon a certain given structure of the economy, but rather there are clear reciprocal effects between economic development factors that cannot always clearly be isolated from each other. Resulting from this analysis Voigt pleads that developing countries should increase the quality of their road network system beyond the apparent present needs. Only this would provide the base for the initiation of the balanced market oriented development of all other economic sectors in the future. He concludes by stressing that road network system should not be regarded as the sole strategic variable in the development process.

Similarly, scholars like Wilson et al. (1982) challenge a strong emphasis on the special role of the transport infrastructure as prerequisite for economic development. Wilson distinguishes three different possible effects of

improvements of a road transport system: one, a positive stimulation of economic development through improvement of the quality of the transport system. This is accomplished by a reduction in the amount of resources that have to be spent for the distribution of given amount of goods and people. Two, a slow-down of otherwise possible economic growth because of unduly large use of scarce resources in the transport sector instead of other more economic alternatives. This concerns the problem of comparison of the overall productivity of all theoretically feasible investment possibilities. It is often argued that this type of misallocation of fund is particularly relevant in cases of transport projects. It is said, in this connection, that because of indivisibility, long life and eternal effects of transport projects, conventional criteria of productivity lead to less exact results that transport investment can be regarded as 'safe' politically; therefore there do not exist any strong sanctions in case of all obvious misallocations. Three, an absolute reduction of income in region or country in which a road network investment has been carried out. This is based on the possibility that products from more advanced areas are flooding the market that had been protected by high transport costs and are consequently destroying the exiting structure. This situation results in preponderance of negative polarisation effects against positive trickling-down effects.

He concludes that it is not justified to regard the road transport sector as something basically different from all other sectors of the economy. It is necessary to underline clearly that transport contributes to economic growth only in connection with many other sectors. In case of positive effects of the transport investments certain preconditions in regard to the general dynamism of the economy and the existence of certain institutions must already have been met beforehand. Wilson concludes by suggesting an integrated planning approach of the public sector to ensure the desired reactions to transport investments, but he considers these investments to be successful particularly in areas where there is already a certain economic dynamism.

In this respect, Bergman and Sun (1996) support Wilson when they conclude that the complexity of how and where infrastructure stimulates productivity reveals more than typical conclusions about justifiable volumes of additional public investment in general infrastructure. In their study about the impact of infrastructure on manufacturing they found that infrastructure has a consequence of reducing rather than stimulating manufacturing productivity in certain counties of the United States of America. They advise that provision of infrastructure should be undertaken with its spatial consequences in mind.

The discussion above gleans a disturbingly shallow degree of consensus about the influence of road transport network on economic development. That is why institutions such as the Federal Highway Administration (FHWA) of the United States of America began to re-examine this hypothesis and its implication for national investment through a research agenda on the interrelationship between road transport infrastructure investment and productivity (Binder and Smith, 1996). Kessides (1996), in supporting the idea of inconsistence in the results of infrastructure impact research studies she points out that these studies have demonstrated correlation, but the range of results is large and thus, conclusions are far from robust. She classifies the main shortcomings of much of these researches into four main categories: simultaneity of effects is not accounted for adequately, and therefore cannot be inferred from time series correlations; even where efforts are made to identify the direction of causality, the results are still often inconclusive because of other econometric issues such as omission of variables that might explain both output and infrastructure growth, and poor model specification; the variables used are often too aggregated to be meaningful for policy conclusions.

Most of the studies do not differentiate among quality composition of infrastructure, or among levels of the stock; finally, most of the available research does not examine the efficiency of utilisation of the infrastructure, that is, the flow of services actually generated from the investment expenditure. She concludes her observation by emphasising the need for a refined theoretical understanding of the mechanisms of the linkages

between infrastructure and economic growth and productivity, and for empirical studies, which capture the effects of particular kinds of infrastructure services on various activities of firms and households.

Recently a more revealing line of research led by a pioneering works of von Oppen on the impact of market on agricultural development has examined the effects of market access on productivity of agriculture in developing countries in Africa and Asia. These include, for example studies of von Oppen (1984) in Mahbubnagar and Nagpur regions of India, Ijaimi (1994) in Sudan, Njehia (1994) in Kenya, Odhiambo (1998) in Machakos and Meru provinces of Kenya, Hau (1999) in Thailand, Munyemana and von Oppen (1999) in Benin and Malawi, Kyi (2000) in Phyapone and Yemethin regions of Myanmar (Burma), and Abele (2001) in Niger. Specifically, these studies have examined the market infrastructure impact on agricultural productivity, using distance and/or time as proxy variables for market access. Though the approaches have been different depending on the main objectives of individual studies the results bring to surface an underlying trend as shown in Figure 5.3.

The V represent value of average aggregate productivity, and the DT represent market access in terms of distance or time from the homestead to the market infrastructure. It can be noted that there is an inverse relationship between market access and aggregate productivity. As distance or time increases aggregate productivity decreases. For example, at DT_0, the aggregate productivity is V_3. An increase in distance or time from DT_0 to DT_1 results into a decrease in productivity from V_3 to V_2. Similarly, an increase in distance or time from DT_1 to DT_2 results into a decrease in productivity from V_2 to V_1. An extreme case is at DT_3 where aggregate productivity drops to V_0. More about this will be discussed in chapter six, which presents results of this study.

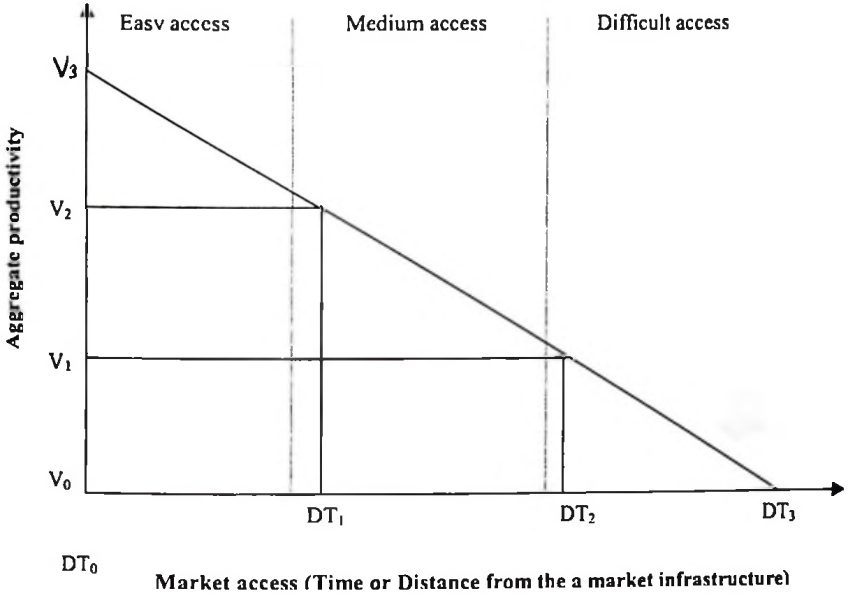


Figure 5.3: The relationship between market access and productivity

Such studies have separated total effect of influence of market infrastructure access into two components (i) specialisation, which implies reallocation or diversification of resources as determined by comparative advantage and economies of scale inherent in a particular production process, and (ii) intensification, which means use of productivity enhancing input such as fertiliser and high yielding variety seeds. As has been the case with industrial scenario the results are diverse and no general conclusion can be made about market infrastructure influence on farm productivity. But there is a general hypothesis, subject for further studies, which suggests two behaviours of productivity response to market infrastructure access (Figure 5.4).

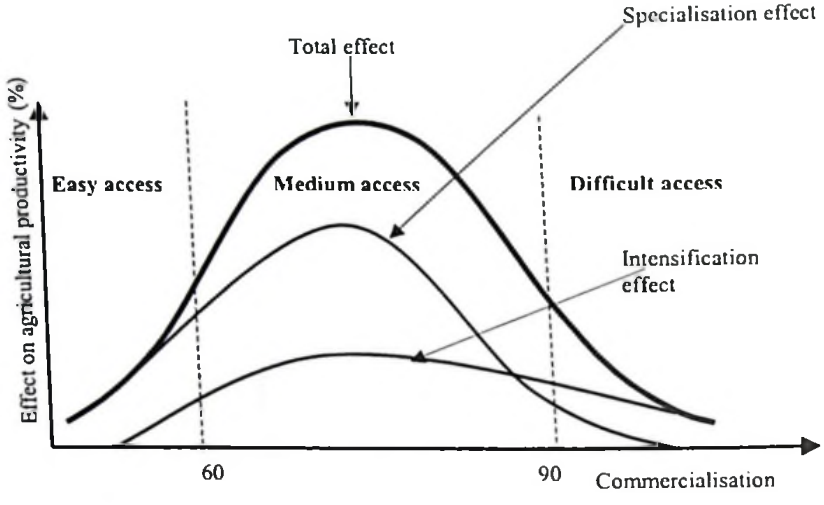


Figure 5.4: Total effect, specialisation and intensification effect of market access

Source: Von Oppen and Gabagambi (2002)

First, the total effect of market infrastructure increases at an increasing rate with the level of commercialisation up to a certain point (say 60%), and starts to increase at a decreasing rate and drops at a decreasing rate up to insignificant values beyond, say 90% of commercialisation. Second, at lower levels of commercialisation, a greater portion of the total effect is due to specialisation effect, whereas, at higher levels much of the total effects is due to intensification effects.

5.6 Public-Private-Partnership in Road Investment

Ownership, investment and pricing of road infrastructure have been a mounting concern in many countries. A limitation of much of the literature on road network infrastructure is that it assumes, almost automatically, that public provision is a necessary prerequisite for efficient investment and utilisation to be attained (Button 1996). Andersson (1991) advances two main reasons for this propensity among-policy makers. First, transport infrastructure is characterised by 'public good' attributes and, therefore will tend to be under-supplied if left to market forces. Second, infrastructure contains negative externalities, which are often found either implicitly or explicitly in policy statements, but the overriding economic rationale for intervention is generally the public good one. While important in quantitative terms, these externalities represent significant economic costs estimated at 20% of the GDP of high-income countries (Quinet, 1990).

However, the longstanding notion of public provision of road infrastructure is challenged by Button (1996) who asserts that a rather more limited role for government in infrastructure provision might reduce some of the problems uncounted in running the system, and lead to a more substantive provision of the infrastructure. For those who cannot accept the intuitive line of reasoning that transport infrastructure is much nearer to the economic private good than that of public good, he gives empirical evidence from countries such as the United Kingdom and United States. In these countries the large part of investment in transport infrastructure has in the past come from private rather than public sources, and there appears little empirical evidence of relative under investment when markets where allowed to operate compared to countries where national ownership prevailed, and supposedly, the public good problem of under investment would have been avoided.

In a way of summing up the problems surrounding road management, Roth (1996) seems to pinpoint the real source of failure in the public supply of roads from a market economy point of view. He argues that the essence of the market system is not, as is widely believed, price incentives, but

ownership. A key element in property ownership is the existence of a clearly defined entity or individuals who stand to become worse off if their property loses value and to gain if it gains value. Those individuals have strong personal incentives to maintain the value of their assets. In the case of publicly provided roads, although one should not underestimate the power of conscientious, well-trained well-equipped officials, most of those concerned do not become worse off when the roads in their care deteriorate. Ridiculously, Roth points out that in some countries where road deterioration brings about new contracts for rehabilitation, the handling of big new contracts can actually make officials better off.

Roth's observations are not difficult to see from practical point of view. In many developing countries including Tanzania, roads in private plantations, estates and mines are adequately maintained by their private owners. In contrast, the neighbouring roads that are the responsibility of governments are in a poor state. Against this background public-private-partnership in the provision of roads becomes eminent.

There are three forms by which private sector can participate in road provision, namely unencumbered ownership, franchise (Build-Operate-Transfer, B-O-T), and management. In the unencumbered form, the private sector takes full responsibility for the project and all financial risks, and is entitled to all rewards. While common in the competitive sectors of the economy, unencumbered ownership is rare in the provision of roads because of the public sector insistence on regulating tolls and other aspects of highway projects. In the franchises case the public sector contracts with a private entity to provide and operate a highway for a limited period. Under B-O-T agreements, private investors finance and build roads at their own risk, operate them for an agreed period, and then transfer ownership to the public sector. In the management contracts, the public sector undertakes the initial investment and contracts for the private sector to manage the operation of its roads. Management contracts are common in the United States of America for the maintenance of local authority roads. Unencumbered ownership is much less common. Most privately provided roads, bridges and tunnels are operated under franchise, reflecting the

unwillingness of governments to allow private interests to own roads for indefinite periods (Roth, 1996). In Africa and Latin America, governments are, increasingly adopting the franchise agreement under the B-O-T system, though the main problem is low traffic density in these continents. The World Bank estimates that for a franchise to be economical the traffic volume should be over 3,500 per day (Hamilton, 1996).

5.7 Empirical Measurement of Road Infrastructure Impact

Evaluating public investments in road infrastructure involves quantification of the impact of the improvement. This is important to be able to perform a rational allocation of scarce resources. A sufficiently long-term view has to be taken in order to include all possible effects on the entire national economy. As a practical instrument for the quantitative evaluation of productivity of transport investments and other not directly productive infrastructural projects, cost-benefit-analysis has been developed which is generally used in the evaluation of infrastructure projects (Hofmeier, 1973). In this analysis it is attempted to quantify as far as possible all conceivable socio-economic costs and benefits that are related to a particular road project and to compare them. In this study, the approaches used in the analysis of road infrastructure impact have been divided into two groups based on whether benefits are direct or indirect. Each group is discussed in the following sections.

5.7.1 Quantification of Direct Benefits Approach

By far the most important direct benefits result from the reduction of operating costs of vehicles using a particular road. Of special importance for vehicle operating cost savings is the improvement of the road surface as in the case of upgrading an earth road to gravel or bitumen standard. Other savings result from horizontal and vertical realignment of roads and from shortened travelling distances between the end points of voyages as a result of the construction of shortcuts and new cross-connections. Other direct

benefits of road investments result from lower road maintenance costs of improved roads, from reduced losses due to road accidents and from timesavings for passengers and freight. Also a reduction of damage to freight is expected from improved roads. The quantification of costs normally does not create any special problems. The calculation is based on the estimates of road engineering concerning required physical units of various types of work to be performed (Hofmeier, 1973).

In essence, in the direct benefit approach, analysis of road impact is limited to quantification of road user savings. This methodology is well suited for cases where normal traffic is substantial and transport cost savings are a reliable measure of road benefits. The World Bank paper by Carnemark et al (1976) criticises this approach on grounds that it usually neglects to consider the mechanisms through which road user savings are translated into new output and income. It also frequently ignores the existence of other constraints in the area of influence of the road investments, which limit its developmental impact. The Bank emphasises that the interdependence of transport and agricultural production system in the rural environment be taken into account in road analysis, especially in agrarian economies. The analysis should focus on the mechanisms by which road user savings are translated into increased agricultural production and income, with a view of answering the critical question, "how will producers respond to transport costs savings"?

5.7.2 Quantification of Indirect Benefits Approach

Considerably more difficult is an evaluation of the different indirect benefits connected with the improvement of the road system. Hofmeier (1973) gives an extensive coverage of the aspects involved in the measurement. Indirect benefits of improvements in the road sector include increased wage employment, certain multiplier effects of other direct benefits, improved chances for mass production of certain products due to the enlargement of the market, increased social security, increased efficiency of public administration and better chances for a sensible decentralisation. Most of

these potential benefits cannot normally be accurately described in qualitative terms for specific transport investments nor can they be quantified. For practical reasons only the most important benefit categories are normally included in the analysis. Under this category of approaches, several attempts have been used to quantify the benefits of increased economic activities induced by the road investment. In the following sections, discussion of some empirical methods, which have been used by different researchers in analysing the impact of road network, is given. Later, the method adopted in this study is presented and discussed in details.

5.7.2.1 The Traffic Density Method

Traffic density as used in this context is the number of vehicles passing at a certain road point per time. This method was used by Bonney and Hide (1968) to examine the impact of road network infrastructure on economic development in Tanzania. Specifically, they used traffic density in terms of vehicle per day (v.p.d.) to measure the contribution of road transport to cash crop production and GDP in districts and regions of Tanzania. To do this they first distinguished three different types of traffic movements: intra-district traffic over relatively short distances and directly connected with the relationships between rural areas and the respective market centres of districts, inter-district traffic over long distances across district boundaries and mainly resulting from the relationships between district centres and regional centres, centre-traffic between the local and regional areas on the one hand and biggest centre of the country on the other hand.

They found certain relations to best express regular patterns of relationships between traffic movements and certain other indicators considered to be relevant in this context. In the case of intra-district traffic they postulated equation 5.3 below:

$$D = \frac{V}{2.16} - 10 \qquad (5.3)$$

where, D = intra-district traffic in v.p.d, and V = value of annual production of cash crops in a district in £1,000. The movements of inter-district traffic were most closely connected with the spatial distribution (expressed in terms of travelling time) of small market centres in comparison with the respective regional centres and with the size of GDP of the various Districts. The travelling time between various centres depended both upon distance and condition of roads, in this case the equation for the postulated relationship was:

$$Di = \left[\frac{H}{t^s_m} \times 0.105\right] + 3 \qquad (5.4)$$

where, Di denotes inter-district traffic in v.p.d, H denotes GDP per District in £1,000 and t^s_m symplises travelling time between subsidiary and main market centres in hours. In the case of centre-traffic the movements to and from the big city originated mainly from the regional centres. These traffic movements depended upon the same influencing factors as in the case of inter-district traffic. The respective equation is as follows:

$$Dc = \left[\frac{\Sigma H_i}{t^m_n} \times 0.156\right] + 4 \qquad (5.5)$$

where, Dc stands for centre traffic of each region in v.p.d., ΣHi indicates total regional GDP in £1,000, and t^m_n is travelling time between regional centre and big city in hours.

These formulae are easy to use if data on the variables are available, and they are useful in obtaining rough estimates. However, they seem to be over-simplified to present a complex ill-defined system such as road

transport and the economy. In addition, no details are given about the way the relationships were established and their limitations so that a knowledge of their universality could be gained. They are of little practical use for the case in point.

5.7.2.2 Producer Surplus Approach

In practice, this is a comprehensive method focusing directly on the basic economic changes in the area of influence due to road improvements. Either marginal cost and or average cost are used for computing producer surplus. This measure of project benefits combines four distinct effects: (i) The incremental surplus (incremental revenues minus incremental costs) realized by various producers because of higher producer prices, lower production costs, and improved market access. Costs are measured in economic terms, so the surplus does not necessarily correspond to incremental financial profits (ii) benefits to users of the products transported, if market prices decline as a result of the road improvement (iii) losses that may accrue to users of the products in other markets who may face higher prices (iv) changes in profits realized by middlemen and suppliers of transport services throughout the distribution system.

The producer surplus approach begins by focusing on a given sector, such as agriculture, and a given product (Carnemark et al, 1976). For this crop, conditions (costs, prices and quantities) are projected year-by-year over the project lifetime both with and without the road investment. The incremental producer surplus is calculated as the difference between producer surplus before the investment and the producer surplus after the investment as shown in equation 5.6 below.

$$(R_2 - VC_2) - (R_1 - VC_1) = IPS \qquad (5.6)$$

Where, R_1 and R_2 represent revenue before and after the project respectively, VC_1 and VC_2 stand for variable cost before and after the

investment respectively, and IPS represents incremental producer surplus. Figure 5.5 presents the same concept using sketch illustrations.

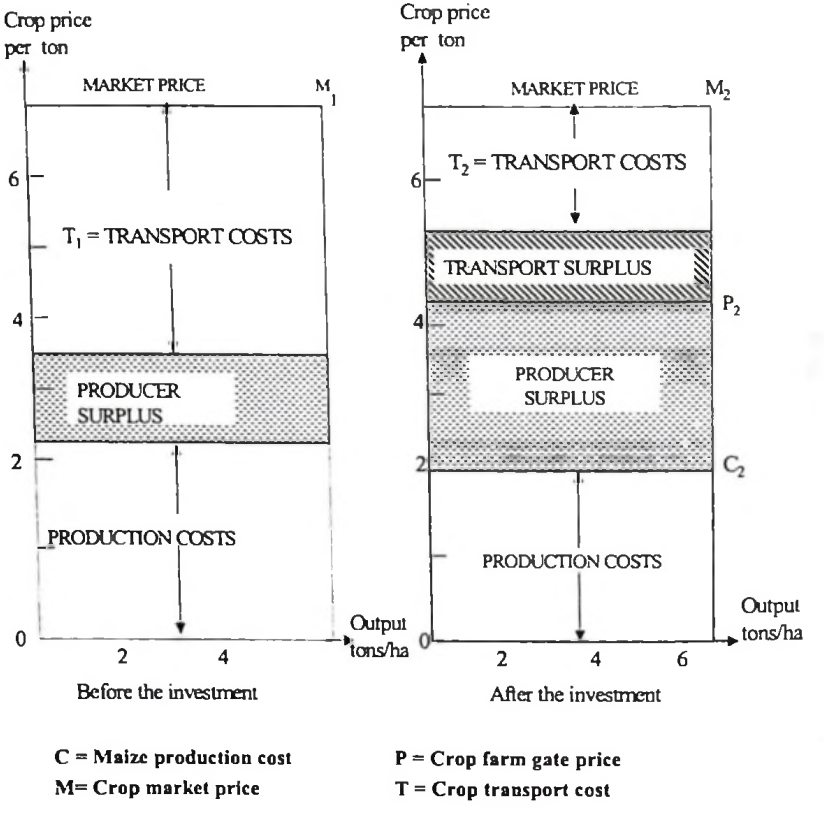


Figure 5.5: Producer surplus for a particular crop

Source: Modified from Carnemark et al, (1976)

In the before "investment case" case, the transport sector is zero since it is assumed, for simplicity, that transport costs plus normal profit make up the entire difference between farm-gate price and market price. This method requires enormous data from the past, present and the future. Its coverage is very prolific in nature encompassing production marketing and consumption. A number of experts from engineering, agronomy and economics are required to correctly estimate the future trend in production quantities, costs and prices. Thus it was not suitable for the purpose of this study, since data used were cross-sectional.

5.7.2.3 Regression Analysis Approach

5.7.2.3.1 Single Equation models

In a single equation model one dependent variable is assumed to be influenced by one or more independent variables. The general form of the model takes the following form:

$$Y_i = A + \beta_1 X_{1i} + \beta_2 X_{2i} + \beta_3 X_{3i} + \ldots + \beta_n X_{ni} + u_i \qquad (5.7)$$

Where Y is the dependent variable, X_1, X_2 ... X_n independent variables, u stochastic disturbance term, and i the i^{th} observation, in case the data are time series, the subscript t would denote the i^{th} observation. In the case under consideration one or more of the Xs represent infrastructural component, that is, proxy variable(s) used in measuring infrastructure access. This kind of approach was used by von Oppen et al (1984) to measure the contribution of market infrastructure to development. Although their results were appealing, the work was criticised for being essentially a single equation, and thus, a reduced form of a much more complex system of various interdependent relationships. The most frequently used form of single equation models in empirically based research of infrastructure impact is the Cobb-Douglas production function. The general equation for this function, in the case of two variable inputs takes the form shown in Eq 5.8 below.

$$Y = AX_1^{b1}X_2^{b2}e \qquad (5.8)$$

The A and b_i coefficients are estimated by converting all the variables measured, both inputs and outputs into their logarithms and then using ordinary least squares (OLS) multiple regression on these logarithms. Thus obtaining;

$$Log\ Y = a + b_1 logX_1 + b_2 logX_2 + u \qquad (5.9)$$

Where, Y stands for output, a is a multiplicative contant, X_1 stands for labour input, X_2 for capital input, b_1 and b_2 for elasticities of variables, u for disturbance term and e for base of natural logarithm. Equation 5.8 is simply the antilog of equation 5.9. The equation is easily extended to include more variable inputs, infrastructural component for example. Cobb-Douglas production function models permit analysts to account for the partial contribution to output made by the paid, internally supplied factors of production, and to attribute some of the residual productivity to externally sourced infrastructure and other inputs (Bergman and Sun, 1996). These models are sufficiently flexible to allow testing whether the independent presence of specific, measurable forms of infrastructure improve productivity. But since this relationship has been shown to differ by industry sector in the work of Johansson and Wigren (1993) and Mera (1973), it is considered important to control for the mix of sectors when estimating regional production functions. On the other hand, such models should permit one to test whether a particular type of infrastructure interacts with and qualitatively improves the productivity of conventional factors such as labour and capital. However, Costa et al (1987) argue that in application, Cobb-Douglas production function may yield statistical estimates that are more difficult to interpret. This is particularly the case when the function is applied to the noisy spatial data that are used to estimate regional production functions. The choice of functional form should depend on its appropriateness in relation to the question of concern, and also quite often, on the limitations imposed by data and other analytical features of the research design.

As pointed out previously, estimation of Cobb-Douglas production functions involves OLS, which is criticised by econometricians (for example Hoch, 1958), for producing biased parameters. This is due to dual directional causation, which leads to violation of an importsnt assumption of the classical linear regression model, namely, the assumption of no correlation between the explanatory variable(s) and the disturbance term. However, the OLS technique is useful if the analysis is limited to examining the presence and direction of technical relations between factor productivity and infrastructure. Were one directly concerned with causal relations, for example, estimating unbiased inputs proportioned correctly to produce a certain output, simultaneous equation bias would become an important issue (Bergman and Sun, 1996).

5.7.2.3.2 *Simultaneous Equation Models*

Although single-equation models like the Cobb-Douglas production function expressed above, are often used to examine relations between economic variables, the relationship may be so complex that a system of simultaneous equations may be required. This is particularly so if there is a two-way relationship between dependent and independent variables as is the case in farm production. The solution to this problem is to apply other methods of estimation, which give better estimates. There are several methods for that purpose. The most common are: (1) the reduced form method or indirect least squares (ILS), (2) The method of instrumental variables (IV), (3) Two-stage least squares (2SLS), (4) Limited information maximum likelihood (LIML), (5) the mixed estimation method, (6) The three-stage least squares (3SLS), and (7) full information maximum likelihood (FIML). The 3SLS and FIML methods, are the most efficient of all the others (Koutsoyiannis, 1987). Because the 3SLS is less tedious than FIML, it was used in this study.

The 3SLS estimates all the parameters of the structural equation simultaneously. It is a logical extension of 2SLS, the first two stages of 3SLS being those of 2SLS. In the first stage, all reduced form coefficients are estimated using OLS. In the second stage, all structural coefficients are

estimated by applying 2SLS to each of the structural equations. The third stage applies generalised least squares estimation of all the structural coefficients of the system using a covariance matrix for the stochastic disturbance terms of the structural equations that are estimated from the second stage residues (Intriligator, 1994).

The general presentation of the simultaneous model may be summarised as in equations 5.10 -5.12 bellow.

$$Y = f_1(K, L, W, F) \quad (5.10)$$

$$K = f_2(Y, L, W, F) \quad (5.11)$$

$$W = f_3(Y, K, F) \quad (5.12)$$

Where Y stands for output or productivity, L for inputs under land category, which include all natural factors of production, K for inputs under capital category implying all man-made production factors such as fertiliser, pesticides, modern seeds etc except road infrastructure. W stands for inputs grouped under labour category, which include inputs related to direct human effort in the production process, and F for infrastructure component.

Before a model is estimated it should be identified. Identification means, it is possible to obtain numerical estimates of the parameters of a structural equation from the estimated reduced form coefficients. The identification problem arises because different sets of structural coefficients may be compatible with the same set of data. In other words, a given reduced form equation may be compatible with different structural equations or different hypotheses (model), and it may be difficult to tell which particular hypothesis (model) is being investigated (Gujarati, 1995). If it is possible to obtain numerical estimates the parameters of a structural equation from the estimated reduced form coefficients, a particular equation is identified. If this cannot be done, the equation under consideration is unidentified or underidentified. An identified equation may be either exactly identified or overidentified. It is said to be exactly identified if unique numerical values of

the structural parameters can be obtained. It is said to be overidentified if more than one numerical values can be obtained. To know whether a model is identified, two conditions namely order and rank condition must be fulfilled. The order condition simply states that 'in a system of G equations and K variables, an equation containing M variables is identified if the number of excluded variables (K-M) in that particular equation (but included in other equations of the model) is at least equal to the total number of equations in the model less one (G-1). According to this rule, a model is identified if each equation is identified.

But the order condition is not a sufficient condition for identifiability of the model, that is, even if it is satisfied, it may happen that an equation is not identified (Gujarati, 1995). Therefore, a necessary and sufficient condition for identification is needed. This is provided by the rank condition of identification. According to the rank condition a model is identified if and only if it is possible to form at least one non-zero determinant of order G-1 from the matrix of the coefficients of the excluded variables from a particular equation but contained in other equations of the model. If the rank condition is satisfied the order condition is automatically satisfied but not vice versa (Koutsoyiannis, 1987). It is cumbersome to calculate determinants of order G-1 for all equations in a bid to identify a non-zero determinant, especially when the model contains a larger number of equations.

However, the saving grace is that, by examining certain properties of matrices, it is possible to deduce the possibility of forming a non-zero determinant of the order G-1 for each equation without embarking on detailed calculations of the actual value of the determinants. According to Koutsoyiannis (1987), examining the following conditions will reveal absence or presence of a non-zero determinant: (i) if all the elements in a row or column are zero, the value of the determinant is zero (ii) if any two rows or columns are identical the value of the determinant is zero and (iii) if a row is a multiple of another row the value of the determinant is zero. After the model is estimated, computation of elasticity of variables is carried out from the variable coefficients as shown in equation 5.13.

$$\eta = \beta i \left[\frac{Xi}{Yi} \right] \qquad (5.13)$$

where η denotes elasticity at the variables means, βi stands for the coefficient of ith explanatory variable, Xi stands for the mean value of ith explanatory variable, and Yi is the mean value for the ith dependent variable. From the Elasticities, specialisation and intensification effects are derived. Because this study adopts the simultaneous equation model, detailed aspects of specification, identification, estimation, and derivation of total market effect are covered in details in the following sections. But before then, it is imperative to present how the data used in this study were collected.

5.8 Data Type and Collection

The reliability and validity of any research results ultimately depend on the availability of the appropriate data. It is therefore essential to explain how the survey was designed and the way primary and secondary data were collected. The survey was conducted along TANZAM. This road was chosen not only because it is the most important road in the country in terms of number of traffic per day and annual volume of cargo, but also because it passes through most important agricultural regions in the country, and has been there for a considerable length of time to have influenced socio-economic activities along it. The four regions fairly represent typical climatic condition in the country, ranging from 0 m a.s.l. to as high as 3000 m a.s.l.

5.8.1 Survey Design and Primary Data Collection

To ensure that the data collected were the ones that were sought, and also to help the survey run smoothly, a pilot testing was carried out to. In this way the clarity of questionnaire language, shedding light on the time required for real data collection, and identification of redundant and/or

omitted items in the questionnaire were check. By omitting irrelevant questions in the questionnaire after the pilot testing, average time for interviewing one respondent was cut by half from approximately 40 minutes. For the structure of the questionnaire used in the survey see Appendix 4. In addition, during the preliminary survey, formal discussions were held with leaders in each of the villages visited. Apart from explaining the purpose of the study, appointments were made for actual interviews. Village leaders agreed to call village meetings from which a sample of farmers would be selected. The pilot testing was carried out in March/April 2000. The actual survey was conducted between May and August/September 2000. During the survey, in each village, a meeting was held on the interview date as scheduled.

In each region crossed by TANZAM, except Dar es Salaam one station was selected for survey. Dar es Salaam was not considered in the analysis because the all area is almost urban with insignificant food crop production. Collecting data from such a place would introduce biasness in the results. The stations were Chalinze for Coast, Mikumi for Morogoro, Ilula for Iringa and Chimala for Mbeya regions (Figure 5.6). Choosing of the stations, among other things, was based on the presence of a feeder road. A feeder road in the context of this study is defined as a road link "feeding" into a main road at any point along the main road. At each station three villages based on the relative proximity to tpaved road were selected. The villages were categorised as easy access (closest to the paved road), medium access (middle) and difficult access (furthest from the paved road). From each village 10 men and 10 women were interviewed, making a sample size 240 respondents. In choosing women care was taken not to include widows who had lost husbands in the last two yeas, because the assumption was that in this period the influence of the husband would still be prevailing.

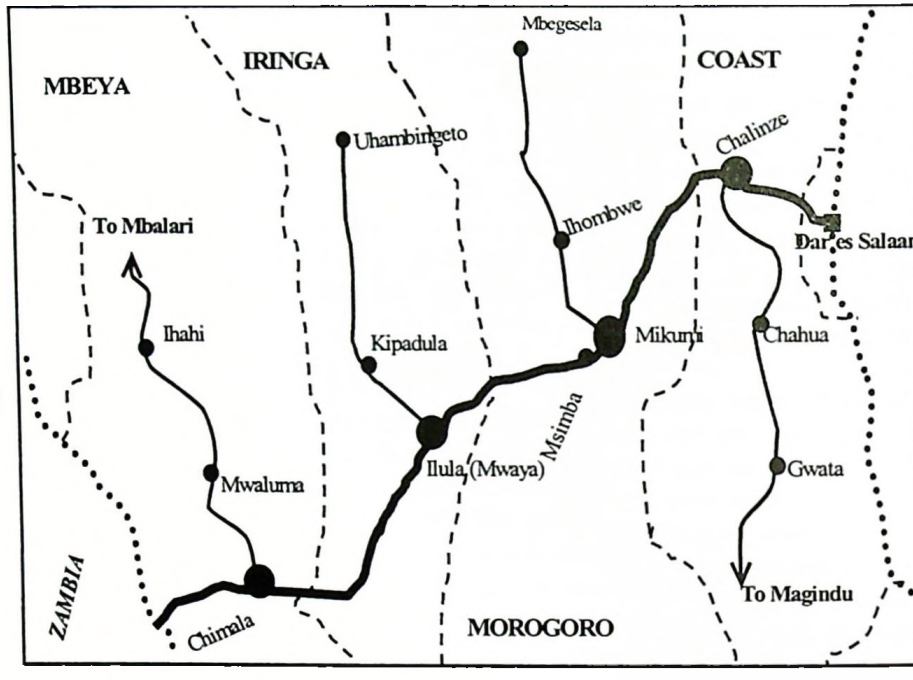


Figure 5.6: Location of the survey area

The stratification of respondents into men and women was important because they belong to two distinct social groups. For socio-cultural reasons men dominance and marginalisation of women has been practiced for centuries in Tanzania. This coupled with extra social functions of women such as reproduction and childcare has translated into difference in power, resource ownership and levels of income (Mbilinyi, 1996). For example, it is argued by (Omari (1993) that when extension workers introduce new technology, normally women are not the target groups though they play great role in production. Many extension workers aim at reaching male peasants who dominate cash crop production. Another confirmation is given

by the World Bank (2000), which asserts that there is gender bias in credit access in Tanzania. The number of male-headed households that received credit in 1994/95 in Tanzania was 50% higher than that of female-headed households Table 5.2 summarises the basic information about the survey and the sampling process.

Table 5.2: Summary of survey design

Station	Distance from Dar es Salaam (km)	Village	Distance from TANZAM (km)	No. of respondents	
				Men	Women
		Chalinze	0	10	10
Chalinze	103	Chahua	5	10	10
		Gwata	15	10	10
		Msimba	0	10	10
Mikumi	303	Ihombwe	11	10	10
		Mbegesela	18	10	10
		Mwaya	0	10	10
Ilula	445	Kipaduka	8	10	10
		Uhambingeto	16	10	10
		Chimala	0	10	10
Chimala	748	Mwaluma	6	10	10
		Ihahi	14	10	10
Total				120	120

Source: Survey, 2000

From the sample, cross-sectional data on production and marketing of major crops were collected. The crops included maize, paddy, sunflower, tomatoes, groundnuts, beans, sorghum/millet, sesame, cassava, and onions for the period 1998/1999-production season and 1999/2000 marketing season.

5.8.2 Secondary Data Collection

Secondary data were obtained from various sources such as Bureau of statistics, Bank of Tanzania, Ministry of Agriculture, Ministry of Works, Ministry of Communication and Transport, National Transport Company, National Institute of Transport, libraries of Sokoine University of Agriculture, and the University of Dar es Salaam. Secondary data are ready made data available for analysis to the researcher. It is therefore important to have an insight about the statistical system in Tanzania. Over the period, 1949-1961, collection and compilation of statistics was the responsibility of a Unit of the East Africa statistical department located in Dar es Salaam. In 1961 just before independence this unit was reconstituted as the Statistics division of the Ministry of finance. Its name was subsequently changed to Central Statistical Bureau (CSB). In 1964 CSB was transferred as a division to the directorate of planning in the President's office, which later became the Ministry of Economic Affairs and Development Planning. It has since then remained under this Ministry.

In Tanzania, statistical production is to a large extent centralised under the Bureau of Statistics. There are only a few statistical units outside the bureau, which are attached to government ministries e.g. labour, agriculture, finance (Customs Department), education and health. Most of these units compile some statistics in their own areas through the processing of the relevant administrative records. For example in agriculture, the statistics are obtained mainly through administrative records, survey of large farming, Agricultural Sample Surveys (AGSASU) and the Agricultural Sample Census (AGSAC), conducted within the framework of the National master sample (NMS). The data collection method employed is the personal interview, through interviewers permanently stationed in the selected villages (NBS, 1994).

The use of area measurements and crop cutting provide objective estimates yield and production at national level. Farmers with large farming establishments are covered in the large scale farming survey. The survey covers all farmers with more than 20 ha of total farming land and farmers

with a herd of 50 or more animals. There are about 1,000 such farms in Mainland Tanzania. The data covered in the agricultural census are all statistics, which deal with the enduring characteristics of agricultural production, and some statistics concerning characteristics related to agricultural activities, covering items such as location, number of fields land tenure, household members classified by age, sex, occupation and educational level, equipment and other inputs. The quality of data obtained through these methods is considered to be good because the law of the land guides the collection process. Statistical data collection in the country is done under the authority of the statistics ordinance 1961. Like most statistical Acts, it compels those requested to supply data to supply accurate data within a specified time and provides for confidentiality of such data.

5.8.3 Data Processing

From the questionnaire data were entered into, where they were validated and edited. This involved identification of missing data and outliers and making decisions on how to handle them. In most cases missing values and outliers were replaced by average values. In secondary data, outliers and gaps were filled by a five-year moving average. In rare cases missing price data of certain crops were filled by price values in an adjacent town, assuming that markets were fairly interconnected. In the case the price figures were not available, national average prices were used. Data entry was done in Excel 5.0 spreadsheet, later exported to other software packages, SPSS 9.0 and LIMDEP 7.0 for further analysis.

5.8.3.1 Descriptive Analysis

In descriptive analysis the concentration was on descriptive statistics to describe the basic features of the data. According to any standard statistics book, descriptive statistics describe a large set of observations with a single indicator, for example mode, median, means, central tendency, variation,

range, variance and standard deviation. In other words descriptive statistics provide simple summaries about the sample and the variables. Together with simple graphics analysis, they form the basis of quantitative analysis of data. However, descriptive statistics pose a risk of distorting the original data or losing important detail. Even given these limitations, descriptive statistics provide a powerful summary that may enable comparisons across sampling units based upon a reference variable. In the case in point, road access was used as a reference variable, which determines all other households' characteristics. Based on this, analysis of other variables such as age distribution, use of modern inputs, household income and productivity was performed.

5.8.3.2 Econometric Analysis

It may have been noted that in the descriptive analysis described earlier, not much attention was paid to the causal relationship between variables. The analysis was confined to detecting the relationship without concerned about which variable(s) influence the others in a comprehensive manner. In econometric analysis variables were categorised as endogenous (those which the model seeks to estimate) and exogenous (those influencing the endogenous variables). They were postulated to relate in a simultaneous manner as explained in Section 5.7.2.1.2. Then, a three-stage least squares technique (3SLS) was applied. The principles of this technique have already been discussed in section 5.7.2.3.2. In the following sections, the process of specification, identification and subsequent estimation of the simultaneous model used in this study is discussed.

5.8.3.2.1 Model Specification

Agricultural production is determined by many factors ranging from physical and measurable inputs through climatic to the difficult-to-measure social institutional factors. Mukhopadhyay (1989), lists some of the factors as (i) land area; (ii) quality of land - forest or hill areas, desert or river basin,

humus content, organic composition, salinity, alkalinity, etc.; (iii) Irrigation and extent of control over water supply; (iv) type of irrigation-canal or sprinkler or traditional methods; (v) Fertiliser quantity and its nutrient content; and (vi) Pesticides. Others factors include (vii) labour hours; (viii) quality attributes of labour, such as age and gender composition of the labour force, general education and skill, social and professional background; (ix) mechanical power - number and type of tractors and other equipment used; (x) oxen-number and condition of oxen used; (xi) seed type and quality - traditional or high yielding varieties; (xii) rainfall-amount and distribution; (xiii) managerial and supervisory services; and (xiv) socio - economic institutional factors, such as land tenure, co-operatives, credit, marketing facilities, farm sizes and land fragmentation, and so on. Variation in agricultural production may be due to any or all of these factors, which might vary from place to place and time to time.

A simultaneous equation system seems to be an appropriate method of handling such complex economic reality. A simultaneous equation model determines the values of one set of variables, the endogenous variables, in terms of another set of variables, the exogenous variables. Simultaneous equation models may include only a few equations or hundreds of them (Salvatore, 1996). Indeed, the number of mathematical relationships that would be required for exhaustive description of agricultural production phenomenon would be large. But as recommended argued by Koutsoyiannis (1987), systems with large numbers of equations are difficult to handle. He recommends that models should be as simple as possible but as complex as necessary. Base on this principle, the model used in this study, extended from the general form presented in equation 5.10-12 was formulated. Table 5.3 presents a summary of the variables used in each equation of the model.

Table 5.3: Summary of variables used in the 3SLS analysis

Equation	Variables	Variable code	Units	Expected sign
Equation 5.4	Aggregate agricultural productivity	AAP	TZS/acre	Dependent variable
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Positive/Neutral
	Distance to Dar es Salaam	DDS	km	Negative
	Fertiliser quantity	FER	kg/acre	Positive
	Pesticide quantity	PES	% of land	Positive
	High yielding variety seeds area	HYV	% of land	Positive
	Labour input	LAB	man-days/acre	Positive/Neutral
Equation 5.5	Distance to Dar es Salaam	DDS	kg/acre	Dependent variable
	Annual household income	TZS	dummy	Positive
	Education of household head	EDU	years	Positive
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Positive/Neutral
	Distance to Dar es Salaam	DDS	km	Negative
	Annual household income	INC	TZS	Positive
Equation 5.6	Pesticide Value	PES	TZS/acre	Dependent variable
	Credit	CRE	dummy	Positive
	Age of household head	AGE	years	Positive/Neutral
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Negative
	Distance to Dar es Salaam	DDS	km	Negative
	Annual household income	INC	TZS	Positive

Table 5.3: continued

Equation 5.7	HYV area	HYV	% of land	Dependent variable
	Education of household head	EDU	years	Positive
	Fertiliser quantity	FER	kg/acre	Positive
	Education of household head	EDU	years	Positive
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Negative
	Distance to Dar es Salaam	DDS	Km	Negative
	Annual household income	INC	TZS	Positive
Equation 5.8	Labour quantity	LAB	Man-days/acre	Dependent variable
	Household size	HHS	No of people	Positive
	Area cultivated by tractor or oxen	TOX	acres	Negative
	Hired labour value	HLV	TZS/man-day	Negative
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Positive
	Distance to Dar es Salaam	DDS	km	Negative
Equation 5.9	Annual household income	INC	TZS	Dependent variable
	Market orientation	MKO	% of crop sold	Positive
	Age of household head	AGE	years	Positive/Neutral
	Education of household head	EDU	years	Positive
	Time to the nearest dust road	TFR	minutes	Negative
	Distance to the paved road (TANZAM)	DTZ	km	Negative
	Distance to Dar es Salaam	DDS	km	Negative

Source: Own compilation

The mathematical presentation of the model takes the form in equation 5.14 to 5.19 below.

$$AAP = f_1 (FER, PES, HYV, LAB, TFR, DTZ, DDS) \quad (5.14)$$

$$FER = f_2 (INC, MAN, EDU, TFR, DTZ, DDS) \quad (5.15)$$

$$PES = f_3 (INC, CRE, AGE, TFR, DTZ, DDS) \quad (5.16)$$

$$HYV = f_4 (EDU, FER, INC, TFR, DTZ, DDS) \quad (5.17)$$

$$LAB = f_5 (HHS, TOX, HLV, TFR, {}_5DTZ, {}_6DDS) \quad (5.18)$$

$$INC = f_6 (MKO, AGE, EDU, TFR, DTZ, DDS) \quad (5.19)$$

Note that road access variables (*TFR, DTZ* and *DDS*) appear on every equation. This is because they are variables of interest, which the study is set to examine. The *FER, PES, HYV, LAB* and *INC* variables appear on both sides of the equal signs, this means that they both affect and are in turn affected by the other variables in the model, that is, they are simultaneously determined. The construction of the model was on experimental approach, where acceptance of the variable was based on its positive contribution to the model improvement. Introducing coefficients and their expected signs in mathematical notations in equations 5.14-5.19 yielded the structural equations 5.20 to 5.25 below.

$$AAP = \beta_{10} + \beta_{11}FER + \beta_{12}PES + \beta_{13}HYV + \beta_{14}LAB - \gamma_{11}TFR - \gamma_{12}DTZ - \gamma_{13}DDS + \mu_1 \quad (5.20)$$

$$FER = \beta_{20} + \beta_{21}INC - \gamma_{21}MAN + \gamma_{22}EDU - \gamma_{23}TFR - \gamma_{24}DTZ - \gamma_{25}DDS + \mu_2 \quad (5.21)$$

$$PES = \beta_{30} + \beta_{31}INC + \gamma_{31}CRE + \gamma_{32}AGE - \gamma_{33}TFR - \gamma_{34}DTZ - \gamma_{35}DDS + \mu_3 \quad (5.22)$$

$$HYV = \beta_{40} + \beta_{41}EDU + \beta_{42}FER + \beta_{43}INC - \gamma_{41}TFR - \gamma_{42}DTZ - \gamma_{43}DDS + \mu_4 \quad (5.23)$$

$$LAB = \beta_{50} + \gamma_{51}HHS - \gamma_{52}TOX - \gamma_{53}HLV + \gamma_{54}TFR + \gamma_{55}DTZ + \gamma_{56}DDS + \mu_5 \quad (5.24)$$

$$INC = \beta_{60} + \gamma_{61}MKO + \gamma_{62}AGE + \gamma_{63}EDU - \gamma_{64}TFR - \gamma_{65}DTZ - \gamma_{66}DDS + \mu_6 \quad (5.25)$$

Symbols β and γ denote coefficients of endogenous and exogenous variables respectively. The μs are stochastic disturbance terms. The negative signs on the road access proxy variables (*TFR, DTZ* and *DDS*) in equation 5.20, 5.21, 5.22, 5.23 and 5.25 indicate the anticipated inverse relationship between distance or time and the endogenous variable in a particular question. The

signs of these variables are postulated to be positive in equation 5.24 because it is assumed that there is a positive relationship between road access proxy variables (distance and time) and farm labour supply. As the distance from the road to the household homestead increases labour supply to farm activities increase because of lack of opportunities in non-farm activities. Furthermore, the sign for use of manure in equation 5.21 is negative because, logically manure and inorganic fertilisers are substitute products. A similar argument could be given for the negative sign of *TOX* and *HLV* in equation 5.24.

5.8.3.2.2 Model Identification

The theoretical perspective of the identification process was explained in details in Section 5.7.2.3.2. To examine the identification conditions for the model, the system is rewritten to include excluded variables for each equation (Eq (i)-(vi) of Appendix 5a). Then a summary of the model coefficients is given in a matrix table (Appendix 5b). The zero coefficients indicate that the variable is excluded in that particular equation. At this stage, examination of the order and rank conditions could be made. The identification procedure for equation 5.20 only is explained, for other equations the procedure is similar. With reference to Section 5.7.2.3.2, the total number of equations in the model (G) is 6. The total number of variables in the model (K) is 17. Total number of variables included (M) in equation 5.20 is 8. That implies that the number of variables excluded in this particular equation (K-M) is 17 minus 8. This should be at least equal to the number of equations in the model (G) less one, that is, 6 minus 1, which equals 5. Presented in a different way $K\text{-}M \geq G\text{-}1 \sim 17\text{-}8 \geq 6\text{-}1 \rightarrow 9 \geq 5$. By this result, equation 5.20 is overidentified. From Table 5.4 it can be seen that each equation in the model is overidentified, and hence the model is overidentified, and thus estimation would be possible.

Table 5.4: Order Condition of The Model

Equation	No. of variables in the model (K)	No. of variables in the equation (M)	No. of excluded variables in the equation (K-M)	No. of equations in the model (G)	G-1	Identification status of the equation (K-M >G-1)
5.20	17	8	9	6	5	Overidentified
5.21	17	7	10	6	5	Overidentified
5.22	17	7	10	6	5	Overidentified
5.23	17	7	10	6	5	Overidentified
5.24	17	7	10	6	5	Overidentified
5.25	17	7	10	6	5	Overidentified

Source: Own model formulation

But as pointed out previously the order condition is not a sufficient condition for identifiability of the model, therefore examination of the rank condition of the model is necessary. Once more explanation of the rank condition for equation 5.20 is presented, for other equations the process is similar. The steps involve striking off from the system the equation under consideration, and also all the variables included in that particular equation. That is rewriting the system without the equation and its variables. This creates a matrix of excluded variables in the equation (Table 5.5(a)). It is easy to follow this discussion if this explanation is read complementarily with Appendix 5. From the matrix of excluded variables examination of the possibility to form at least one non-zero determinant matrix is carried out. One of those non-zero determinants is presented in Table 5(b). From Appendix 6, which presents identification of all equations in the system, it is realised that the model was over identified, and thus could be estimated.

Table 5.5 (a): Matrix of excluded variables from equation 5.20

Equation	Variables							
	INC	EDU	AGE	MAN	HHS	TOX	HLV	MKO
5.21	1	1	0	1	0	0	0	0
5.22	1	0	1	0	0	0	0	0
5.23	1	0	0	0	0	0	0	0
5.24	0	0	0	0	1	1	1	0
5.25	0	1	1	0	0	0	0	1

Table 5.5 (b): Non-zero Determinant Matrix for equation 5.20

Equation	INC	EDU	HHS	TOX	HLV
5.21	1	1	0	0	0
5.22	1	0	0	0	0
5.23	1	0	0	0	0
5.24	0	0	1	1	1
5.25	0	1	0	0	0

5.8.3.2.3 Model Estimation

As pointed out previously the model was estimated using a three stage least squares technique (3SLS). The 3SLS is a systems method, that is, it is applied to all the equations of the model at the same time and gives estimates of all the parameters simultaneously. This method was developed by A. Zeller and H. Theil in 1962 as a logical extension of Theil's two stage least squares (2SLS) (Koutsoyiannis, 1987). It involves the application of the method of least squares in three successive stages. It utilises more information than the single-equation techniques, that is, it takes into account the entire structure of the model with all the restrictions that this structure imposes on the values of the parameters. The computations of the 3SLS are complicated and tedious; the saving grace is that there are computer software that can carry out all the computations of a complex model in a fraction of a second. The software used in this study is

LIMDEP 7.0. The computer output basically gives the coefficients, standard errors, and t-values of the model equation by equation (Appendix 7).

5.9 Analysis of Road Investment Returns

In many developing countries including Tanzania, roads belong to the public domain. The system is not normally operated on commercial basis. Construction and maintenance of the system relies on the mechanisms of the government to identify and expand road network in the light of advice from its experts. Road construction requires enormous amount of investment. Governments often face a large number of priorities in spending its meagre resources. Because contribution of road infrastructure on economic development is apparently not visible, there is a propensity among policymakers to neglect investment in road infrastructure. There is a need to demonstrate that the benefits gained from investing in roads sufficiently justify the costs of implementing road projects. To evaluate road investment return, a net benefit flow in the study area was established. Then payback period and internal rate of return (IRR) analysis were performed.

5.9.1 Payback Period Technique

The payback period is the length of time from the beginning of the project until the net value of the incremental production stream reaches the total amount of the capital investment (Heidhues and Erhardt, 2001). The formula for computing a payback period when the annual net incremental benefit is constant is:

$$\textit{Payback Period} = \frac{\textit{Capital Investment}}{\textit{Annual net Increment Benefit}} \qquad (5.26)$$

If the returns from the investment are expected to vary from year to year, the computation simply involves adding up the expected returns for each succeeding year, until the total cost of the project is arrived at. To get an exact time period, it is assumed that the benefit flows are evenly distributed in any particular year. Thus, monthly flows could be added arithmetically until the investment cost is reached or approximated. This concept is summarised in the following formula:

$$P = A + \frac{B - C}{D - C} \qquad (5.27)$$

Where, P represents payback period, A year before final payback year, B total to be paid back, C total paid back at start of final payback year, C total paid back at the end of final payback year, and D total paid back at the end of final payback year. However, the payback period method has some drawbacks. Apart from ignoring any benefits that occur after the payback period, it ignores the time value of money. Thus, the method is usually complemented by other methods, usually internal rate of return.

5.9.2 Internal Rate of Return Method

The internal rate of return (IRR) is essentially the interest rate that is equivalent to rate of return expected from the investment. Knowing this rate makes it possible to compare the rate that could be earned by investing the capital in other alternative investments. If IRR is less than the cost of borrowing used to fund the investment, the investment will clearly be a money loser. As a rule of thumb, the IRR should exceed the opportunity cost of capital by a sufficient margin to take account of any additional risk associated with the investment. The IRR is identified under the condition that the net present value (NPV) is zero (Gittinger, 1982), that is,

$$NPV = 0 = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+i)^t} \qquad (5.28)$$

where, B_t is incremental benefit in period t, C_t incremental cost in period t, n number of periods t and i internal rate of return.

Exact computation of IRR is tedious, for that reason approximation is often favoured. The approximation procedure is based on the principle that an interpolation between a positive and a negative net present value approximately comes close to the condition of NPV value of zero. The process involves two steps. One, choosing two different discount rates one leading to a positive NPV, the other to a negative NPV. The second step is interpolation between these two NPVs. This can be done geometrically or mathematically using the formula:

$$IRR = r_l \frac{(r_h - r_l) \times NPV(r_l)}{|NPV(r_l)| + |NPV(r_h)|} \qquad (5.29)$$

where, n symbolises lower discount rate and r_h higher discount rate. However, in real life experience, computation of IRR is easily performed by computer software. In this study MS Excel 5.0, was used in calculating IRR. After the calculation of the IRR, the sensitivity analysis to examine the consequences of unexpected events on the net benefit flow is normally carried out. In this analysis, first, benefits were undervalued while holding costs constant. Secondly, costs were escalated while holding benefits constant. In each case, recalculation was made to determine whether the investment was still viable.

Chapter Six

6 Analysis, Results and Discussion

The previous five chapters explored, in general terms different aspects pertaining to agriculture and roads in Tanzania. Particularly in Chapter Five, conceptual aspects of infrastructure impact on economic development, and the methodological issues were clearly discussed. In doing so, the foundation for discussing specific issues regarding the influence of road infrastructure on agricultural productivity was laid down. This chapter presents analysis and discussion of the results of this particular study. The chapter starts with descriptive analysis, presents econometric analysis and finish with profitability analysis of road investment.

6.1 Descriptive Analysis

Using descriptive statistics, various household characteristics in relation to household road accessibility were examined. The characteristics examined include family attributes, such as age, family size, education and income, and farming practices for example land ownership, farm size, cropping pattern, market orientation and crop production.

6.1.1 Age Distribution

Analysis of age distribution revealed an inverse relationship between age and distance from the highway (Table 6.1). As the distance increased the age decreased. With the exception of Chimala station, this trend was observed at all other stations. No specific trend was observed between men

and women, though the age of women tended to be higher than that of men, but the difference was not statistically significant (Table 6.1).

Table 6.1: Average Age Distribution

Centre	Village	Distance from highway (km)	Nature of market access	Men	Women	Overall
Chalinze	Chalinze	0.1 - 4.9	Easy access	47	58	52
	Chahua	5.0 - 9.0	Medium access	46	46	46
	Gwata	13.0 - 17.0	Difficult access	44	40	42
Mikumi	Msimba	0.1 - 2.5	Easy access	49	51	50
	Ihombwe	10.0 - 12.5	Medium access	44	45	44
	Mbegesela	17.0 - 19.8	Difficult access	43	45	44
Ilula	Mwaya	0.1 - 0.8	Easy access	51	51	51
	Kipaduka	7.0 - 9.5	Medium access	41	45	44
	Uhambingeto	15.8 - 17.5	Difficult access	42	45	43
Chimala	Chimala	0.0 - 0.8	Easy access	50	49	49
	Mwaluma	5.0 - 8.0	Medium access	48	46	47
	Ihahi	13.0 - 16.0	Difficult access	53	46	50

Source: Own survey, 2000

More information was revealed when farmers in each category (regardless of village and gender) were combined and analysed as one sample. Two important features surfaced. First, the percentage of young farmers aged below 36 years increased as accessibility to the road became difficult. It was 18% in easy access, 29% in medium access and 34% in difficult access villages (Figure 6.1). Second, the percentage of older farmers over 55 years of age decreased with road access problems. In easy access villages they accounted for 44%, whereas in medium and difficult access 26 and 21% respectively. By way of contrast, young farmers below 36 years of age accounted for 20% in easy access, 26% in medium access and 35% in difficult access villages.

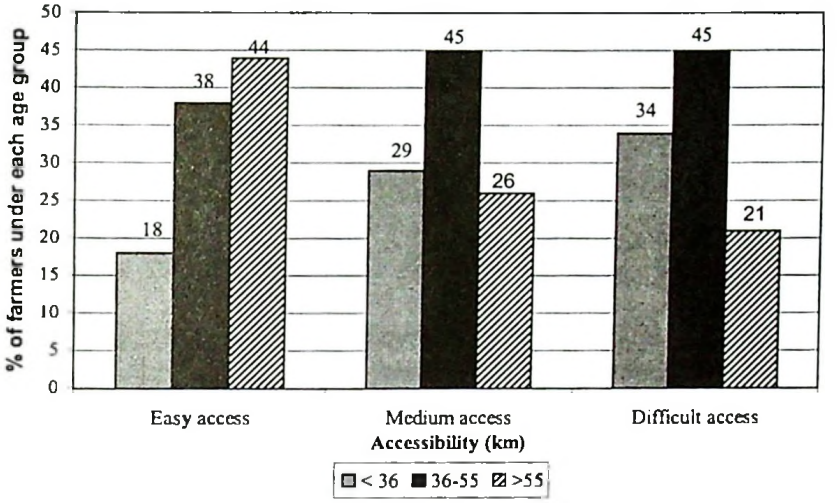


Figure 6.1: Percentage of farmers by age groups and accessibility

Source: Own survey, 2000

The interpretation of this observation may be that near the highway youths are caught up in petty trading activities, mainly selling souvenir and foodstuffs to passengers travelling up-country and/or to Dar es Salaam. On the other hand girls are employed in house keeping jobs. It can as well be argued that near the highway there is high tendency for youth to migrate to urban areas in search of more paying job opportunities in manufacturing and service industries. As a result farming activities remain in the hands of older members of the farming communities.

On the contrary, in villages with poor access most youths remain in the villages engaged in farming activities. Although migration of youths to urban areas reduces labour in the farming process, it has a long run positive

impact on the whole process of agricultural transformation in two ways. Firstly, by moving out of agriculture (assuming they secured relatively better income sources in urban areas) they would not only escape from rural hidden unemployment but also enlarge the market base for agricultural products to the benefit of the producers. Secondly, as labour force decreases labour becomes expensive in the rural area and this will create a potential for capital intensive and more modern farming.

6.1.2 Land Acquisition

Examination of land acquisition was important in deducing information about how the scarcity of this resource limited the production process. In Tanzania, matters related to land use are guided by two important pieces of legislation; the Land Act and the Village Act passed by the parliament in April 1999. In principle the Land Law provides that land ownership is public and vested under the custody of the President of the United Republic of Tanzania. In a way people working on land, for example farmers, are tenants of the state. Through state agents such as village councils, land is relocated to people for farming and other purposes. However most farmers consider land to be a freehold property. A common practice in the farming communities in Tanzania is to acquire land through allocation from the village government, inheritance, or through buying from other members of the society. These were examined during the survey in which farmers were asked to identify the means through which they acquired land. The responses are presented in Table 6.2.

Table 6.2: Source of land in the surveyed villages

Centre	Village	Method of acquisition							
		Inherited		Bought		Hired		Village council	
		No.	%	No.	%	No.	%	No	%
Chalinze	Chalinze	7	35	5	25	0	0	8	40
	Chahua	4	20	3	15	3	15	10	50
	Gwata	4	20	3	15	7	35	6	30
	Msimba	9	45	0	0	0	0	11	55
Mikumi	Ihombwe	8	40	2	10	0	0	10	50
	Mbegesela	5	25	5	25	1	5	9	45
	Mwaya	8	40	8	40	4	20	0	0
Ilula	Kipaduka	9	45	7	35	1	5	3	15
	Uhambingeto	10	50	4	20	4	20	2	10
	Chimala	7	35	3	15	7	35	3	15
Chimala	Mwaluma	6	30	3	15	4	20	7	35
	Ihahi	6	30	4	20	0	0	10	50

Source: Own Survey, 2000

It can be noted that the dominant method for obtaining farming land in the study area was through village governments. The only exception was at Ilula where inheritance and buying of land were common. The extreme case was at Mwaya village where the number of farmers who obtained land through the village council was zero. This may be attributed to the booming tomato production around Ilula area, which has attracted many people from other parts of the country, whose quick means of obtaining land is through buying and hiring. Land for redistribution by the village council is no longer available.

6.1.3 Land Use and Cropping Pattern

As pointed out earlier this study covers areas along a 1000 km highway, thus encompassing a wide variation in climatic conditions. The first two regions included in the study, that is, Coast and Morogoro lie on the lowland not more than 200m a.s.l. whereas Iringa and Mbeya are located on a plateau of over 2,500m a.s.l. That being the case the study area supports production of a wide variety of crops. The survey shows that the main crops grown by the majority of farmers include maize, paddy, sunflower, beans, sorghum, sesame, cassava, onions, groundnuts and tomatoes. Normally a farmer grows a number of crops in his farm in intercropping or relay-cropping, rarely on a pure stand. Maize was grown in all 12 villages surveyed. However, the number of crops differs depending on the nature of accessibility of households (Table 6.3).

A number of observations could be made from Table 6.3. The number of farmers growing less than 4 crops decreased with distance from the highway. In easy access villages 45 farmers grew 1 to 3 crops in any particular season. For medium and difficult access villages the number of farmers was 34 and 28 respectively. But a different picture was cast for farmers growing 4 or more crops. The number of farmers who grew 4-6 crops was 33 in easy access, 41 in medium access and 43 in difficult access villages. On the other hand the number of farmers who grew more than 6 crops was 2 in easy access, 5 in medium access and 9 in difficult access villages. A closer examination of the trend in villages at each centre, suggested that as the distance from the highway to the household increased, the number of crops grown increased. In a way the observation above shed light on the specialisation behaviour of farmers with improved access to market.

Table 6.3:Number of crops by farmers in different villages

Nature of accessibility	Centre along TANZAM	Village	Number of crop classes			
			< 4	4 - 6	> 6	Total
	Chalinze	Chalinze	17	3	0	20
	Mikumi	Msimba	9	11	0	20
Easy access	Ilula	Mwaya	11	8	1	20
	Chimala	Chimala	8	11	1	20
		Total	45	33	2	80
	Chalinze	Chahua	20	0	0	20
	Mikumi	Ihombwe	3	15	2	20
Medium access	Ilula	Kipaduka	5	13	2	20
	Chimala	Mwaluma	6	13	1	20
		Total	34	41	5	80
	Chalinze	Gwata	19	1	0	20
	Mikumi	Mbegesela	1	15	4	20
Difficult access	Ilula	Uhambingeto	4	14	2	20
	Chimala	Ihahi	4	13	3	20
		Total	28	43	9	80

Source: Own Survey data, 2000

In terms of size, farm holdings ranged between less than 1 to over 30 acres split into several plots. The mean values were 5.7 acres in easy access households, 6.2 and 6.7 acres in medium and difficult access households respectively. This may suggest that as farmers become isolated from the marketing system, they become poorly served with inputs and thus to increase production to meet family requirement more land is tilled. Relaying on the mean value for examining farm size distribution may conceal some useful information, especially when the standard deviation is large like in this case. Therefore, the analysis is continued by classifying land under cultivation into 3 categories namely less than 5 acres, 5 – 9 acres and over 9

acres. Then the distribution of cultivated land between men and women at different levels of accessibility were examined (Figure 6.2).

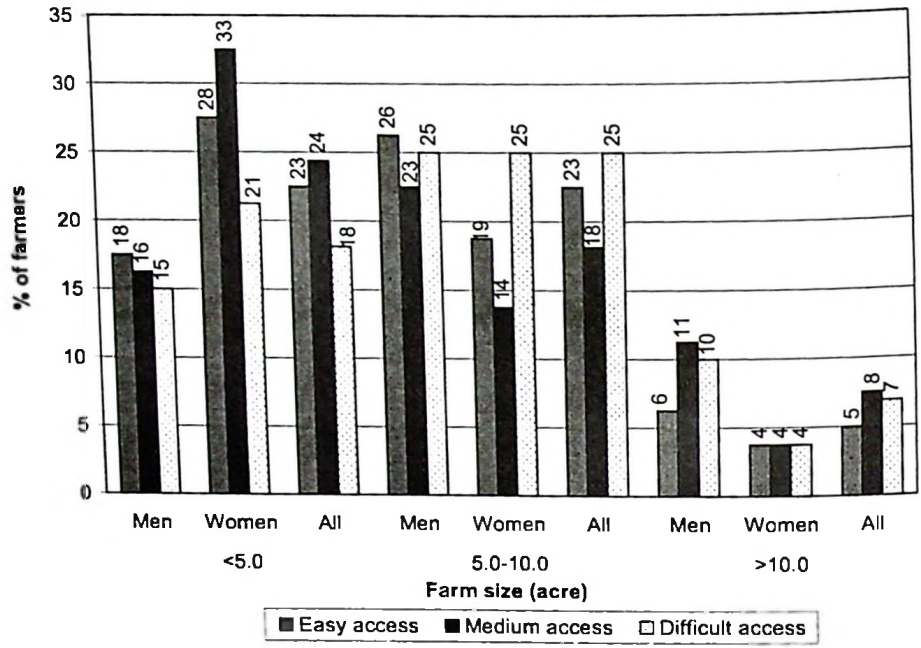


Figure 6.2: The relationship between farm size and road accessibility

Source: Own survey data, 2000

There was no specific trend, which was observed in farm sizes. However, it was observed that the number of farmers cultivating more than 9 acres was very small. Another observation was that for farm size "less than 5" the farm sizes were smallest in easy access village for men, women and for the overall sample. The situation was different for farmers cultivating over 9 acres,

where farm sizes are small for easy access households and larger for medium access households.

6.1.4 Use of Fertiliser

Fertiliser is one of the most important factors influencing production in agriculture. However, its level of use in some areas of the study was still insignificant. Only 66 farmers, that is 27% of all farmers interviewed used fertiliser during 1999/2000 season. Of the farmers who used fertiliser, 62% were men and 38% were women. The mean value was 25.0 kg/acre (standard error 2.9) for men and 30.8 kg/acre (standard error 5.3) for women. Fertiliser was mainly used in maize, paddy and tomato farming (Table 6.4).

Table 6.4: Frequency distribution for fertilizer use in the study area

Nature of accessibility	Village	Use of fertiliser				Total number of farmers
		Yes	%	No	%	No
Easy access	Chalinze	9	45	11	55	20
	Msimba	4	20	16	80	20
	Mwaya	10	50	10	50	20
	Chimala	13	60	8	40	20
	Total	36	45	44	55	80
Medium access	Chahua	6	30	14	70	20
	Ihombwe	0	0	20	100	20
	Kipaduka	5	25	15	75	20
	Mwaluma	7	35	13	65	20
	Total	18	23	62	78	80
Difficult access	Gwata	4	20	16	80	20
	Mbegesela	0	0	20	100	20
	Uhambingeto	3	15	17	85	20
	Ihahi	5	25	15	75	20
	Total	12	15	68	85	80
Total		66	28	174	72	240

Source: Own survey data, 2000

Examination of fertiliser use at individual village level revealed a similar trend in which fertiliser use decreased as the distance from the highway increased (Figure 6.3). The extreme scenario was at Mikumi where fertiliser was used only at the easy access village, Msimba. No fertiliser use was reported in Ihombwe and Mbegesela. At Ilula and Chimala the number of farmers who used fertiliser was higher than at other centres because they are located in the highland zone, famous for agricultural production in Tanzania. Specifically, at Ilula the high level of fertiliser use was associated with intensive tomato farming while at Chimala for paddy production.

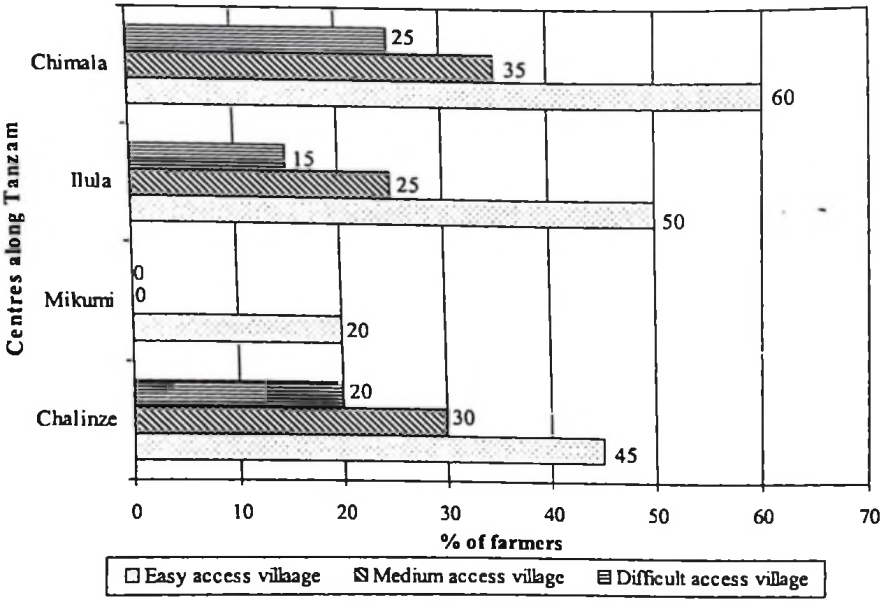


Figure 6.3: Percentage of farmers using fertiliser in the survey area

The influence of Dar es Salaam was not detected at all. The number of people using fertiliser at Chalinze and Mikumi, the centres relatively closer to Dar es Salaam was lower than at the other two centres. In terms of quantity, the fertiliser use was generally low in the survey area. The average quantity ranged between 4 and 100 kg per acre, with mean value of 27.2 kg per acre (22.0 standard deviation). This was three times as much as the national average of 21 kg/hectare (9.5 kg/acre).

There is limited knowledge about optimal use of fertiliser in the study area. A common practice is application of fertiliser, mostly urea, on parches of poor soil on the farm. In actual fact this violates the rationale of fertiliser use. Scientifically, fertiliser application aim at replacing nutrients extracted by crops in the growth process. Thus calculation of fertiliser quantity to be added to the soil should base on the yield. Researches show that 7 tons of grain output extract about 45 kg of phosphorus (P_2O_5), 30 kg of potash (K_2O) and 160 kg of nitrogen (N). If more quality is desired more N should be added, taking into consideration that 40 kg of N increases protein content by 2% (Prof. Dr. Kühn of Zentrum für Agrarlandschafts-und Landnutzungsforschung (ZALF) e.V, in Uckermark, Brandenburg - Germany). Of course farmers in Tanzania are not to be blamed for misuse of fertiliser. It is upon the public and private institutions, individually or in partnership to educate them.

The importance of fertiliser in increasing agricultural productivity is not a new concept in Tanzania. The question is, why is the use of fertiliser so dwindling among farming communities in Tanzania? To gain some insights about this issue, the study examined the attitude of farmers towards fertiliser use, the responses are summarised in Table 6.5.

Table 6.5: Reason for not using fertiliser by gender of household head and accessibility

Nature of accessibility	Reason	Gender of household head				Total	
		Men		Women			
		No	%	No	%	No	%
Easy access	Very expensive	8	44	14	54	22	50
	Destroys soil	3	17	2	8	5	11
	Not available	2	11	6	23	8	18
	Soil is fertile enough	5	28	4	15	9	21
	Total	18	100	26	100	44	100
Medium Access	Very expensive	7	24	10	30	17	27
	Destroys soil	7	24	6	18	13	21
	Not available	9	31	12	36	21	34
	Soil is fertile enough	6	21	5	15	11	18
	Total	29	100	33	100	62	100
Difficult Access	Very expensive	11	34	8	22	19	28
	Destroys soil	7	22	4	11	11	16
	Not available	11	34	13	36	24	35
	Soil is fertile enough	3	9	11	31	14	21
	Total	32	100	36	100	68	100
Overall total		79	45	95	55	174	100

Source: Own survey data, 2000

The reasons vary across accessibility levels. In easy access villages the main reason for not using fertiliser was its expensiveness, the factor reported by 44% of men and 54% of women. In medium and difficult access areas the main reason for not using fertiliser was its unavailability. This reason accounted for over 30% for both men and women. However, when men and women were combined and analysed as one sample in each accessibility category, the "very expensive" reason for not using fertiliser dominated by accounting for 50% in easy access villages, 27% in medium access villages and 28% in difficult access villages.

Two things may be inferred from these results. One, since the agricultural reforms started, the price of fertiliser has skyrocketed beyond the reach of the majority of farmers. Two, it may indicate reluctance of traders to penetrate remote areas; they serve farmers along the road. Potkanski (1997), made a similar observation who found that und that economic reforms in Tanzania have benefited smallholder-farming communities, especially those near urban centres and along trunk roads, who have access to markets for their crops. For those situated in remote areas the situation has become even worse. The state owned Regional Transport Companies (RETCOs), which used to provide transport services in rural areas regardless of road conditions have either collapsed or have been privatised in the market economy.

On the other hand these results indicate that there was a high level of awareness among farmers on the use of fertiliser even in areas with problems of accessibility. The problem was that the fertiliser was not available. Other reasons "destroy soil" and "soil is fertile enough", which are associated with ignorance, accounted for a significant proportion as well. These together accounted for 33%, 39% and 36% in easy, medium and difficult access villages respectively.

With regard to the use of manure, 33% of all the farmers interviewed used manure. Of this, 54% were men and 46% were women. The main type of manure used was cow-dung. Analysis of manure use across accessibility levels did not reveal much information. The number of farmers who used manure expressed as proportion of all farmers who used fertiliser in a particular accessibility category was 32.5% for easy access, 30% for medium access and 37.5% in difficult access villages. Of course the high percentage of people using manure in difficult access villages may be associated with unavailability of fertiliser in those areas.

6.1.5 Use of Pesticides

It was found that the use of herbicide was not common among farming communities in the study area. However, at Ilula there was a significant use of fungicides, especially Copper (II) Sulphate (blue copper) to control fungal diseases in tomato. At Chimala, there was extensive use of herbicides to control weeds in rice farms. At other centres, Mikumi and Chalinze pesticides were minimally used (Table 6.6).

Table 6.6: Cross-tabulation of pesticide use along TANZAM

Nature of accessibility	Gender of household head			
	Pesticide use	Man	Women	Total
Easy access	Yes	12	9	21
	No	28	31	59
	Total	40	40	80
Medium access	Yes	8	5	13
	No	32	35	67
	Total	40	40	80
Difficult access	Yes	9	5	14
	No	31	35	66
	Total	40	40	80
Total 'Yes' counts		29	19	48

Source: Own survey data, 2000

The Table shows that 48 farmers, of which 29 where men and 19 were women, used pesticides worth TZS 636,532. The distribution of pesticides among farmers in different levels of accessibility is shown in Figure 6.4. It can be noted that TZS 318,482, about 50% of the total money spent on pesticides in the study area was along the highway. The amount declined with distance from the highway. It was 26% and 24% in medium and difficult access areas respectively. In terms of pesticide use per land unit, the trend was not revealed clearly, but the difference between easy access

and difficult access villages was quite significant. Farmers in easy access villages used TZS 2,682 per acre, whereas in medium and difficult access they used TZS 3,118 and TZS 1,465 respectively. The value of pesticide per acre in easy access villages was almost two times more than the value of pesticide per acre in difficult access villages.

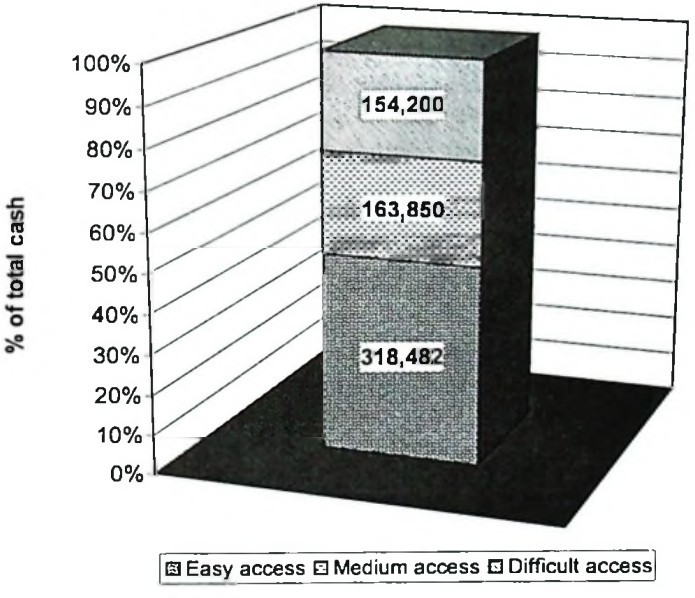


Figure 6.4: Proportion of pesticide use based on the nature of accessibility

6.1.6 Household Income

6.1.6.1 Off-farm-Income Generating Activities

The majority of people in the study area derive their income from agricultural related activities. It was observed that farming occupies 90% of the people interviewed. The remaining 10% were traders and government employees, especially primary school teachers. It was as well noted that farmers were engaged in various off-farm income generation activities (Table 6.7).

The main off-farm income-generating activity in all access levels was handcraft. It accounted for 44% in easy access, 56% in medium access and 53% in difficult access villages. Handcraft activities entailed weaving of baskets and containers for collection and storage of harvests, marts, carpentry, and preparation of ornamental stuffs especially for selling as souvenir to visitors and passengers. Handcraft is followed by petty trade, which was reported by 43% of farmers in easy access villages, 34% in medium access and 39% in difficult access villages. Near the highway, trading involved such activities as kiosks, milling machines and food vendoring. However, kiosks were found in every village, but they varied in the quality and size. In most cases these kiosks sell only basics like salt, bicycle spares, pens, sweets, clothes, plastic dishes and some plastic jewellery. The most income generating activity occupied by women is brewing of local liquor "pombe", which they normally sell on Sundays. Nevertheless, they don't make much out of it because the price is too low – a plastic mug, "kopo" costed TZS 100 (about 13 US cents). Although this seems small amount of money, it is enough to siphon off the extra income of many families.

Table 6.7: Off-farm activities by gender of household head and accessibility

Access Level	Off-farm activity	Gender of household head							
		Men	% of men	% of total in access category	Women	% of women	% of total in access category	Total	% of total in access category
	Employment	7	18	9	4	10	5	11	14
	Handcraft	15	38	19	20	50	25	35	44
Easy	Petty trade	18	45	23	16	40	20	34	43
access	Total	40	100	50	40	100	50	80	100
	Employment	4	13	6	3	8	4	8	10
	Handcraft	40	58	29	22	55	28	45	56
Medium	Petty trade	12	30	15	15	38	19	27	34
access	Total	40	100	50	40	100	50	80	100
	Employment	5	13	6	2	5	3	7	9
	Handcraft	18	45	23	24	60	30	42	53
Difficult	Petty trade	17	43	21	14	35	18	31	39
access	Total	40	100	50	40	100	50	80	100

Source: Own survey data, 2000

6.1.6.2 Breakdown of Income by Source

Farmers derived income from four major sources, namely agriculture, salary/wage, trading and miscellaneous sources. Like in Table 6.7, the difference in income between farmers in different access levels came out clearly, but the source seemed to differ (Figure 6.5).

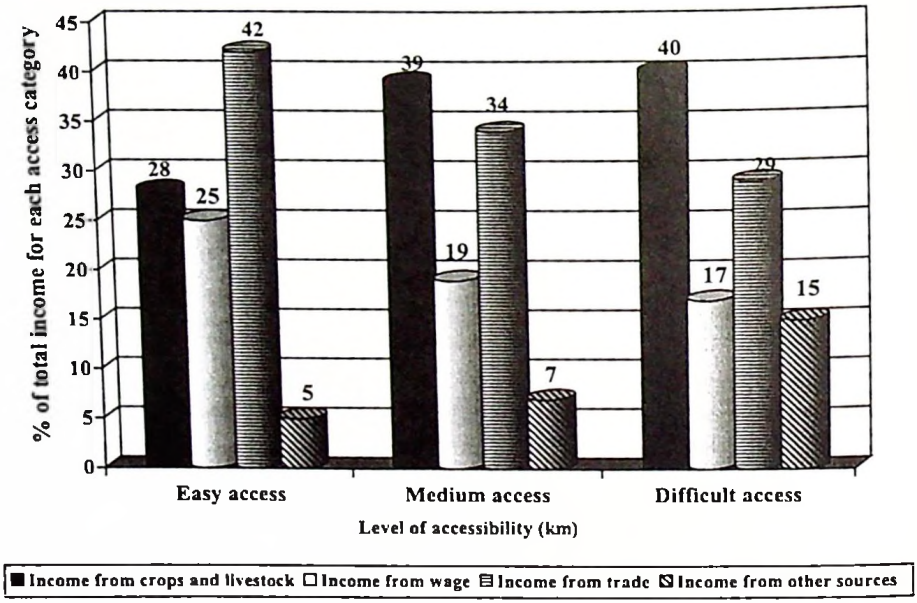


Figure 6.5: Variation of income across access levels

Source: Own survey data, 2000

The main source of income was trading, which contributed 42% of total income in easy access villages in 1990/2000 season. Agriculture ranked second, contributing 28% of total income. On the contrary, in the medium and difficult access villages, the main source of income was agriculture,

which accounted for 39% and 40% of total income respectively. From the foregoing discussion it can be concluded that the main source of income to the majority of people in the study area and the countryside in general is agriculture. However, many people occupied in agriculture do so because they do not have any better alternatives occupation. As soon as the situation improves they shift to other more paying occupations, as seen to people near the roadway.

6.1.6.3 Income Distribution among Men and Women

To extract more information from income data, household income classes were arbitrarily created and cross-tabulation analysis carried out. The classes were low income (less than TZS 200,000), medium income (TZS 200,000 - 500,000) and high income (over TZS 500,000). Table 6.8 summarises the results in the three access levels.

Table 6.8: Income levels by gender and accessibility

Gender	Income classes (TZS)	Easy access			Medium access			Difficult access			
		No	% of gender	% of easy access total	No	% of gender	% of easy access total	No	% of gender	% of easy access total	Total % of gender total
		(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)
Men	< 200,000	13	33	16	17	43	21	23	58	29	44
	200,000 - 500,000	10	25	13	19	48	24	16	40	20	38
	> 500,000	17	43	21	4	10	5	1	3	1	18
	Total	40	100	50	40	100	50	40	100	50	100
Women	< 200,000	16	40	20	24	60	30	31	78	39	59
	200,000 - 500,000	17	43	21	13	33	16	7	18	9	31
	Over 500,000	7	18	9	3	8	4	2	5	3	10
	Total	40	100	50	40	100	50	40	100	50	100

Source: Own survey data, 2000

Overall, 44% of men and 59% of women in the study area had annual household income below TZS 200,000. Closer examination of the data from accessibility and gender perspective (Column (b), (e) and (h)) revealed that in easy access area 43% of men and 18% of women had income higher than TZS 500,000. In medium access villages, the percentage of people with income over TZS 500,000 dropped to 10% for men and 8% for women. In difficult access villages, the percentage of people with income higher than TZS 500,000 was only 3% for men and 5% for women. On the other hand, a reverse trend emerged when the analysis was performed without taking gender into consideration (Column (c), (f), and (i)). The percentage of farmers below TZS 200,000 is 36% in easy access, 51% in medium access and 68% in difficult access villages. Furthermore, analysis at individual village level in relation to other villages at a given station along the highway was carried out, the results of which are summarised in Figure 6.6.

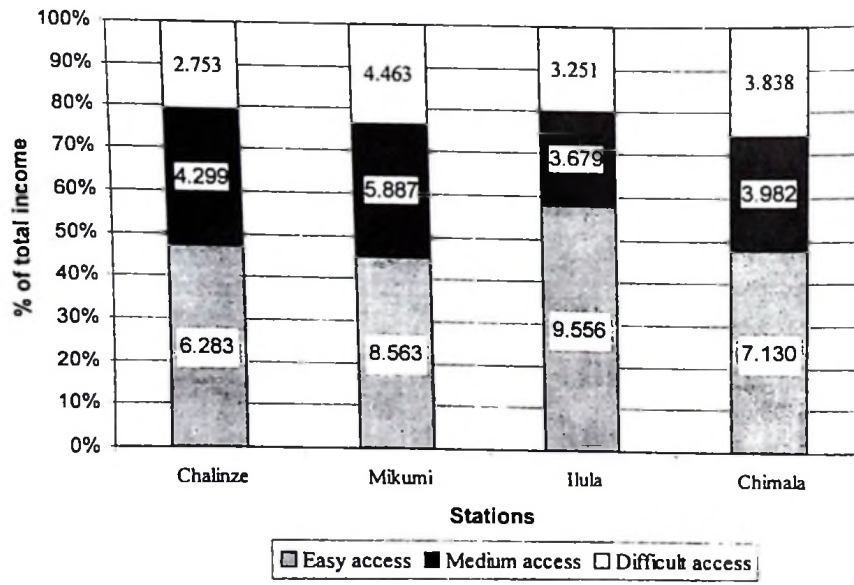


Figure 6.6: Income distribution at different stations along TANZAM

Source: Own survey data, 2000

It can be noted that at each station the villages located near the highway accounted for largest share of total income. At Chalinze station, the easy access village, Chalinze, accounted for 47% of total income. The medium access village, Gwata, accounted for 31% and the difficult access village accounted for only 22%. At Mikumi, the village nearest to the highway (Msimba) accounted for 45% of total income, whereas the medium access village (Ihombwe) and the difficulty access village (Mbegesela) accounted for 31 and 24% respectively. Similar observations were made at Ilula and Chimala. When household income was condensed to a daily income, a picture, which is easy to comprehend, came to surface (Table 6.9).

Table 6.9: Household income expressed in US $6 per day

Village	Nature of market access	Men	Women	Overall	t-value between men and women	t-value between easy and difficult access village
	(a)	(b)	(c)	(d)	(e)	(f)
Chalinze	Easy access	1.3	0.9	1.0758	1.066	
Chahua	Medium access	0.8	0.6	0.7361	0.786	2.771***
Gwata	Difficult access	0.5	0.4	0.4714	1.199	
Msimba	Easy access	1.7	1.2	1.4662	1.395	
Ihombwe	Medium access	1.2	0.8	1.0081	2.393***	3.463***
Mbegesela	Difficult access	0.9	0.7	0.7641	1.406	
Mwaya	Easy access	1.8	1.4	1.6363	0.853	
Kipaduka	Medium access	0.7	0.6	0.6299	0.543	4.023***
Uhambingeto	Difficult access	0.6	0.5	0.5566	0.211	
Chimala	Easy access	1.6	0.9	1.2208	1.614*	
Mwaluma	Medium access	0.7	0.6	0.6819	0.392	2.270***
Ihahi	Difficult access	0.7	0.6	0.6573	0.309	

*Significant at 10%, *** Significant at 1%

Source: Own survey data, 2000

[6] Conversion made at USD 1 equivalent to TZS 800, exchange rate during the survey time (BOT, 2001)

The household income per day in the survey area was found to be very low and compared well with World Bank's observation that the majority of Tanzanians are living under US $ 2 per day (World Bank, 2000). As observed previously, household income was highest for village with easy access and lowest for villages with difficult access. The difference between easy access and difficult access was quite significant (Column (f). There was a clear difference between men and women in all villages. Men had higher daily income than women, but the difference was not significant with exception of Ihombwe village, where the difference was significant at 5% level. The difference in income was exemplified in the standard of living among households in different access levels. Actually, the analysis of the relationship between road access and other variables could be continued indefinitely. Some relationships between road accessibility and many other household features are summarised in Appendix 8.

6.1.7 Marketing Practices

6.1.7.1 Market Orientation

Market orientation was measured in terms of the proportion of household produce that was sold to the market. Emphasis was placed on crops that were sold in cash or in exchange for inputs from traders. Local exchanges among farmers were ignored because they were classified as consumption - indeed they do not reflect a farmer's orientation to the commercial marketing system. It was observed that 81% of all farmers in the study area sold some of their produces to traders. In total the farmers in the surveyed village produced crops valued at TZS 55,392,400 in the 1999/2000 season. Out of this they sold the crops valued at TZS 28,738,121, equivalent to 51% of total value of crops. This means, farmers consumed 49% of the crops they produced. When farmers were arbitrary classified into two groups "not market oriented" for farmers who sold 50% or less of crops, and "market oriented" for farmers who sold more than 50% of crops it was found that only 32% of all farmers interviewed were market oriented. The proportion of market oriented

farmers decreased as access to road became difficult. It was 48% in easy access, 26% in medium access and 23% in difficult access villages (Figure 6.7).

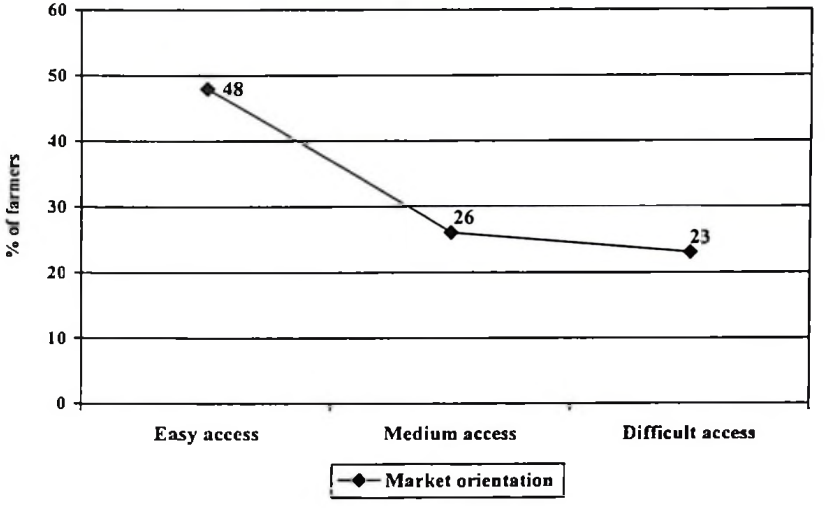


Figure 6.7: Proportion of farmers who are market oriented

Analysis on gender basis revealed that, at every station along the highway, men were more market oriented than women. Only 33% of 77 market-oriented farmers in the survey area were women. This may be attributed to the fact that women attach more importance on household food security. This increases their tendency to stock crops more than men. This is supported by the fact that fewer women than men bought extra food to supplement their own production (Table 6.10). From the table it could be noted that in easy access villages, 20 men-headed households bought extra food, whereas the number of women-headed households, which bought extra food, is only 16. A similar observation was made in medium access villages. However, in difficult access villages 14 men-headed households bought extra food as compared to 18 women-headed households in the 1999/2000 season.

Table 6.10: Buying of extra food to supplement own production in 1999/2000 season

Accessibility classes	Gender	If household bought extra food		Total
		Yes	No	
Easy access	Men	20	20	40
	Women	16	24	40
	Total	36	44	80
Medium access	Men	20	20	40
	Women	12	28	40
	Total	32	48	80
Difficult access	Men	14	26	40
	Women	18	22	40
	Total	32	48	80

Source: Own survey data, 2000

6.1.7.2 Transport modes and marketing arrangement

As pointed out previously in section 6.1.3 farmers owned several plots of land scattered in different locations in a village or surrounding areas. In general, the farms were located at an average distance of 3.5 km from a household home. Farmers spent an average of 1 hour and 13 minutes to move to the furthest plot. This wasted time has an impact on agricultural productivity. The mode of transport used by 60% of the farmers interviewed was head-loading. Bicycle transport was reported by 36% of farmers, while cars by only 14% of interviewed farmers. Storage of harvests is normally in traditional structures called "vihenge", mud-walled and grass-thatched structures. Occasionally storage is done in homes. No farmer reported selling crop right away in the farm after harvesting or having contractual arrangement with traders. Harvests are normally and sold in small lots depending on the household cash need - for example paying for medication, school fees, development levy and meeting other social obligations. In this way, crops stored serve as food and savings for the farmers.

In all the villages surveyed, except Chimala there had never been a cooperative association for farmers. At Chimala there used to be one but it no longer functions, the building structure is decaying. Worse still no village had an assembly market. Traders move from house-to-house and village-to-village collecting crops in small lots. About 60% of farmers sold their crops at home, 24% at the paved road and 17% at the feeder road. Because of limited movement and lack of assembly markets where exchange of information about the market condition could take place among farmers and traders, farmers rely on traders for price information. This was reported by 50.5% of the farmers who sold crops. Other sources include neighbours or friends (34.2%) and travelling (15.3%). There is a possibility that price information circulated by traders' is unrealistic and may likely hinder farmers' market intelligence. Determination of price is by negotiation. But the farmers are in most cases at a loser end. Compared to the farmers, traders are few and more organised, thus, the possibility of colluding and manipulating the price cannot be ruled out. Apart from that, selling of crops is based on the household needs that cannot be deferred. In terms of reasons for selling crops, "cash need" ranked first by being reported by 65% of all the farmers who sold crops. Other reasons include price incentive reported by 23%, and creation of space for next harvest, 12% (Figure 6.8).

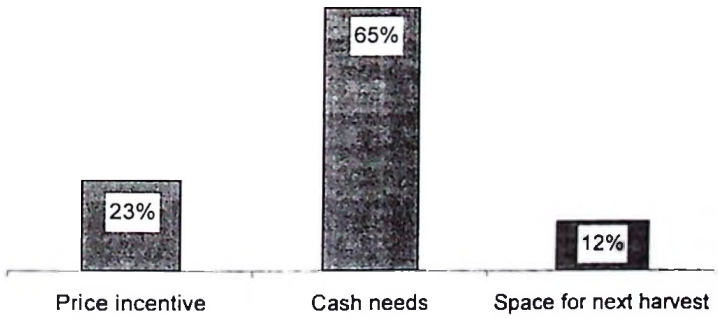
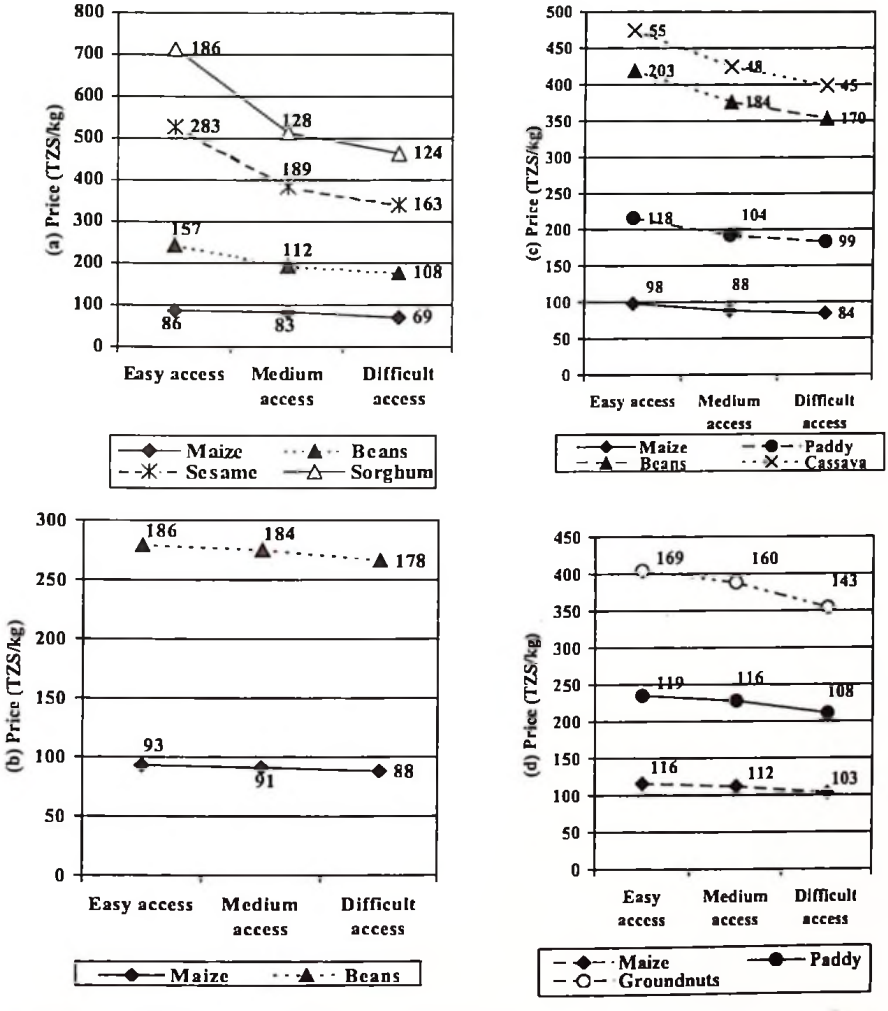


Figure 6.8: Reasons for selling harvests (% of farmers who sold crops)

In this kind of marketing arrangement, farmers located near the roadway were likely to be more accessed by traders than their counterparts located in relatively far points off the roadway. This was exemplified by the number of traders who contacted a particular farmer searching for crops to purchase in the 1999/2000 season. While farmers in easy access villages contacted an average of 6 traders, farmers in medium and difficult access contacted 3 traders each respectively. When asked about the major obstacles they face in the farming process, 32% of farmers interviewed ranked "lack of inputs" as the major problem. Other problems mentioned include "lack of market for produce" (29%), pests (27%) and drought (12%). Lack of market is mentioned by 22% in easy access villages and 38% in medium access villages.

On the other hand, 36% of farmers in easy access villages and 28% of farmers in medium access villages respectively mentioned lack of inputs as the major obstacle in farming. This may be giving a hint about intensification and specialisation aspects of farmers. Near the highway where market is readily available, increasing output through expansion of land (specialisation) is no longer possible; the only possibility is to use more fertiliser (intensification). On the part of medium access villages, farmers mentioned fertiliser was a secondary need; they still had a possibility to increase output by expanding area. All these problems translate into poor productivity of the farm sector. The process of collecting crops in small lots is cumbersome and costly to traders. Of course traders recover collection costs by offering low producer prices depending on the accessibility level of the farmers. Prices of crops decreased with distance from the highway (Figure 6.9.). For example, at Chalinze station the price of maize was TZS 86 per kg for Chalinze village, which is nearest to the highway, TZS 83 for Chahua and TZS 69 for Gwata, the furthest village from the roadway. A similar price trend for maize and other crops was observed for other villages at other stations.



(a) Chalinze (b) Mikumi (c) Ilula (d) Chimala

Figure 6.9: Price trends for selected crops at the four centres along TANZAM

An alternative outlet for farm output was for farmers to transport crops to the highway, where they sold crops to travellers, mostly truck drivers returning to their bases from business trips. The drivers, acting as middlemen, haul the products mainly to Dar es Salaam, Iringa and Mbeya, (depending on their bases), where they sell to wholesalers at organised marketplaces in urban and semi-urban towns for example Makambako. The process of transporting farm products to the selling points is not easy. In most surveyed areas, motor vehicle transport service was precarious. Farmers used public transport, normally pickups, Land-rovers and minibuses operated by individual entrepreneurs. There was no specific schedule, the vehicle left after it had attained a full load. A small one-ton pickup could carry up to 20 passengers together with several bags of crops and baskets hanging on the sides to or from selling points. But the fare, which ranged between TZS 100 and 1,500 (about 13 US cents and $ 1.88) for 5 to 20 km trip to TANZAM seemed high to some passengers, and they normally try to negotiate it down. Those who couldn't afford walked all the way or use borrowed bicycles for some hours to reach TANZAM.

6.1.8 Aggregate Agricultural Productivity

The trend of aggregate agricultural productivity was not in any case different from other variables. Farmers located near the highway had higher productivity than those located far away from the highway. The value of total crops produced by the interviewed farmers is TZS 63,190,511 distributed as shown in
Figure 6.10.

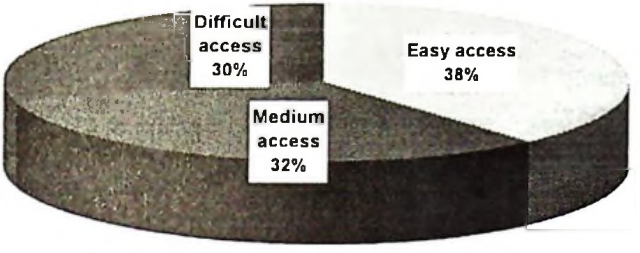


Figure 6.10: Share of total output value in different access levels

The easy access villages, accounts for 38% of the whole value of crops, whereas medium and difficult access villages accounted for 30% and 32% respectively. Similarly, productivity computed by dividing aggregate value of output by total area under cultivation was found to be TZS 51,087 for easy access, TZS 41,704 for medium access and TZS 38,175 for difficult access. In all access levels, the productivity of men was higher than the productivity of women (Table 6.11). It was higher by 22% in easy access, by about 13% in medium access and 7% in difficult access villages. Similarly, the productivity of men decreased consistently with distance from the highway. The productivity of men in easy access villages was 26% higher than the productivity of men in difficult access villages. On the other hand, the productivity of women in the easy access areas was 38% higher than the productivity of women in the medium access villages. However, in difficult access villages, the productivity of women was higher than the productivity of men by 7%. The overall difference

between productivity of men and women was 4,837. The independent samples t-test revealed that the difference was not statistically significant.

Table 6.11: Comparison between productivity of men and women

Nature of access	Men	Women	Difference between men and women	Difference between successive access level		% difference between men and women	% difference between access level	
				Men	Women		Men	Women
Easy acces	57,589	44,584	12,705	11,612	4,853	22		
Medium access	45,677	39,731	5,946	8,723	334	13	26.1	38.2
Difficult access	36,954	39,397	-2,443			-7	22.0	5.6
Average	46,074	41,237	4,837					

Source: Own data

6.2 Econometric Analysis

The descriptive analysis discussed in the last section assumed that access to the paved road was the only determinant of all other household characteristics, especially agricultural productivity in the study area. Consequently, the analysis was centred on variation of variables in relation to access to the roadway. In this way, the complex interrelationships between multitudes of factors that influence productivity were ignored. The following section embarks on a multivariate analysis, with the view of sorting out the most important factors that influence productivity. The way the model was constructed has already been explained in details in Chapter Five. For easy comparison, and indeed for model verification, the analysis was performed on three sub-samples, that is, men, women and the whole sample. The mean values of the variables used in the model are presented in Table 6.12.

Table 6.12: Mean values of variables used in the simultaneous regression model

Variable	Variable code (Abbreviations)	Units	Men		Women		All	
			Mean	Std err	Mean	Std err	Mean	Std err
Aggregate agricultural productivity	AAP	TZS/acre	44,898	2,294	36,563	2,499	40,730	1,714
Fertiliser use	FER	Kg/acre	36.5	3.4	25.0	3.9	32.2	2.7
Pesticide use	PES	% of land	50.1	4.6	38.0	5.0	45.3	3.5
Area under HYV	HYV	% of land	32.7	3.1	43.0	5.3	37.2	2.9
Labour use	LAB	Man-days/acre	73.3	5.0	124.0	16.3	98.6	8.7
Time to the nearest unpaved road	TFR	Minutes	13.2	0.9	13.7	1.0	13.5	0.7
Distance to Tanzania-Zambia road	DTZ	km	8.3	0.6	8.3	0.6	8.3	0.4
Distance to Dar es Salaam	DDS	km	404.1	21.7	409.7	21.7	406.9	15.0
Annual household income	INC	TZS	255,130	21,936	176,942	15,950	216,036	13,767
Use of manure	MAN	Dummy	...	...	...	...	...	...
Education level of the household head	EDU	Years	3.4	0.3	2.1	0.3	2.8	0.2
Use of credit	CRE	Dummy	...	...	...	...	...	...
Age of household head	AGE	Years	46.4	1.2	47.1	1.3	46.8	0.9
Household size	HHS	Number	7.0	0.3	5.8	0.2	6.4	0.2
Area cultivated by tractor or oxen	TOX	% of land	56.2	4.4	60.1	5.4	57.6	3.3
Hired labour price	HLV	TZS/man-day	382	66.7	374.5	56.3	378.8	44.5
Household market orientation	MKO	% of crop sold	42	3.1	28.2	1.8	34.1	1.8

Source: Own survey data, 2000

6.2.1 Model Results

The results of the simultaneous regression model are presented in Table 6.13a-c. The variables on the third rows of the tables are the five dependent (endogenous) variables of the model, whereas the variables on the first columns are the explanatory (exogenous) variables. The numbers in the tables are the coefficients of the exogenous variables with their t-values in brackets. A coefficient indicates the magnitude of change in an endogenous variable when an exogenous variable in a particular equation changes by one unit. The signs indicate the direction of change, in which a positive sign indicates an increase while a negative sign indicates a decrease. As could be noted, most coefficients were significant and their magnitudes plausible. There is enormous amount of information on these coefficients that cannot be extracted due to time and resource limitations. Therefore interpretation of only a few variables relevant to the study is given.

From the tables it could be noted that an increase in distance by 1 km from the paved road to the household homestead is associated with a decrease in aggregate agricultural productivity, equivalent to TZS 4,755 for men, TZS 650 for women and TZS 2,682 for the whole sample. This is understandable because such increase in distance, results in a decrease in fertiliser use by 0.4 kg per acre, a decrease in the area under pesticide and high yielding variety seed by 0.2% and 2.1% respectively, and a decrease in annual household income by TZS 114 for the whole sample. A similar interpretation could be given for other variables in the men and women's samples. For example, if the area under high yielding variety seeds were increased by 1%, productivity would increase by TZS 153 for men and TZS 46 for women.

Table 6.13a: Variable coefficients from 3SLS analysis for the men sample

Variable	N=120					
	Endogenous variables					
	AAP (Eq. 5.20)	FER (Eq. 5.20)	PES (Eq. 5.20)	HYV (Eq. 5.20)	LAB (Eq. 5.20)	INC (Eq. 5.20)
AAP	DEP					
FER	989.373***	DEP		0.642*		
	(36.825)			*(0.633)*		
PES	29.756		DEP			
	(0.370)					
HYV	153.421**			DEP		
	(1.883)					
LAB	15.358				DEP	
	(0.808)					
INC		0.0001***	0.0001***	-0.000002		DEP
		(4.162)	*(3.867)*	*(-1.209)*		
MAN		-0.192				
		(-0.015)				
EDU		0.156		0.0001*		2287.978**
		(0.308)		*(1.685)*		*(1.792)*
CRE			244.139**			
			(2.048)			
AGE			-0.968***			3694.728*
			(-4.496)			*(1.669)*
HHS					2.555***	
					(2.459)	
TOX					-0.0166	
					(-1.505)	
HLV					-0.014**	
					(-1.908)	
TFR	-2799.842***	-0.289*	-0.154	-1.817*	0.230**	-190.047***
	(-2.483)	*(-1.559)*	*(-1.023)*	*(-1.549)*	*(1.901)*	*(-3.578)*
DTZ	-4754.980***	-0.489*	-2.493**	-3.086*	3.541*	-4629.049*
	(-8.171)	*(-1.616)*	*(-1.908)*	*(-1.747)*	*(1.560)*	*(-1.535)*
DDS	-27.714	0.0290	-0.066	0.180*	0.108	-44.908
	(-0.444)	*(2.026)*	*(0.400)*	*(1.545)*	*(1.209)*	*(-0.577)*
MKO						2015.784*
						(1.550)

Note: *** = Significant at 1%, ** = Significant at 5%, * = Significant at 10%
Figures in brackets indicate t-values

Table 6.13b: Variable coefficients from 3SLS analysis for the women sample

Variable	n=120					
	Endogenous variables					
	AAP (Eq. 5.20)	FER (Eq. 5.20)	PES (Eq. 5.20)	HYV (Eq. 5.20)	LAB (Eq. 5.20)	INC (Eq. 5.20)
AAP	DEP					
FER	134.916***	DEP		0.316*		
	(11.367)			*(1.545)*		
PES	55.548		DEP			
	(0.444)					
HYV	45.785***			DEP		
	(6.010)					
LAB	-46.382				DEP	
	(-0.156)					
INC		0.0001***	0.0002***	-0.0002***		DEP
		(4.498)	*(4.539)*	*(-3.555)*		
MAN		-0.013				
		(-0.006)				
EDU		0.387		0.002***		1092.96***
		(0.183)		*(12.006)*		*(2.281)*
CRE			446.99**			
			(1.823)			
AGE			-0.981*			1804.21
			(-1.647)			*(1.200)*
HHS					4.030	
					(0.772)	
TOX					-0.051	
					(-0.169)	
HLV					-0.041**	
					(-1.938)	
TFR	-620.556*	-0.490**	-0.279*	-1.461*	0.276	-388.56
	(-1.669)	*(-2.087)*	*(-1.560)*	*(-1.617)*	*(0.604)*	*(-0.905)*
DTZ	-650.077**	-0.506**	-2.788*	-1.529*	6.526**	-5077.45**
	(-1.880)	*(-1.810)*	*(-1.682)*	*(-1.494)*	*(1.613)*	*(-1.938)*
DDS	6.216	-0.048***	-0.020*	0.146	0.066	-69.676
	(3.752)	*(-3.865)*	*(-1.550)*	*(3.761)*	*(1.089)*	*(-1.203)*
MKO						4378.42*
						(1.665)

Note: ***=Significant at 1%, **=Significant at 5%, *=Significant at 10%,
Figures in brackets indicate t-values

Table 6.13c: Variable coefficients from 3SLS analysis for the whole sample

Variable	n=240					
	Endogenous variables					
	AAP (Eq. 5.20)	FER (Eq. 5.20)	PES (Eq. 5.20)	HYV (Eq. 5.20)	LAB (Eq. 5.20)	INC (Eq. 5.20)
AAP	DEP					
FER	549.32**	DEP		0.567***		
	(1.810)			(42.257)		
PES	9.366*		DEP			
	(1.550)					
HYV	97.109***			DEP		
	(15.58)					
LAB	-0.193				DEP	
	(-0.913)					
INC		0.00002***	0.0001***	0.000001*		DEP
		(3.910)	(5.731)	(1.714)		
MAN		-0.172				
		(-0.267)				
EDU		0.274*		0.001*		2006.28***
		(1.559)		(1.603)		(1.851)
CRE			303.41*			
			(1.627)			
AGE			-1.068*			-2711.40**
			(-1.627)			(-1.785)
HHS					1.2224	
					(0.530)	
TOX					-0.021	
					(-1.274)	
HLV					-0.0279***	
					(-2.605)	
TFR	-2043.89**	-0.3814*	-0.223*	2.099	-0.024	-113.46*
	(-1.938)	(-1.540)	(-1.638)	(4.690)	(-1.035)	(-1.576)
DTZ	-2681.86***	-0.499*	-2.569*	-2.754**	4.867**	-4547.15*
	(-12.136)	(-1.617)	(-1.576)	(-1.810)	(1.986)	(-1.702)
DDS	21.113	0.0396	-0.0112	-0.217***	-0.101*	-0.342
	(4.052)	(4.105)	(-1.068)	(-4.052)	(-1.576)	(-0.007)
MKO						3008.17**
						(1.832)

Note: ***=Significant at 1%, **=Significant at 5%, *=Significant at 10%
Figures in brackets indicate t-values

Rationally, a change in an exogenous variable affects a number of other variables in the system. For example an increase in distance from the paved road affects productivity variable, fertiliser use, area under high yielding variety seeds, labour and income. These linkages will be used later to derive specialisation and intensification effects of road infrastructure improvement. Handling the model results in coefficient forms poses a problem of interpretation because of the influence of the units in which the variables were measured. To illustrate this point consider the impact of a kilometre increase in distance from the household home to the paved road for the whole sample (Table 13c). This would result in a decrease of aggregate agricultural productivity by TZS 2,682. To Tanzanians, this information makes sense because Tanzanians are familiar with a shilling. For people not used to the Tanzanian shilling, such change in productivity may not present a clear picture.

To carry the above argument further, the values of some coefficients are infinitesimal. For example, from the coefficients tables, the influence of income on other variables is quite small. If the income of a man-headed household increased by TZS 1, fertiliser use would increase by 0.00007 kg per acre, area under pesticides and high yielding variety seeds would increase by 0.0001% and 0.000002%. These results are plausible given the value of a shilling, which is negligible. Of course magnifying these numbers to read "An increase in annual household income by TZS 10,000, would lead to an increase in fertiliser use by 0.7 kg per acre, area under pesticide by 1% and area under high yielding variety seeds by 0.002%" could mitigate the problem of interpretation. But this does not seem to offer a convenient way out of this trap. To solve these problems, elasticities of variables at their mean values were computed (Table 6.14).

Table 6.14: Variable Elasticities

Variable	Men n=120						Women n=120						Whole sample n=240					
(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)	(ix)	(x)	(xi)	(xii)	(xiii)	(xiv)	(xv)	(xvi)	(xvii)	xviii	xix
	AAP	FER	PES	HYV	LAB	INC	AAP	FER	PES	HYV	LAB	INC	AAP	FER	PES	HYV	LAB	INC
AAP																		
FER	0.80***			0.72*			0.10***			0.18*			0.43**			0.49***		
PES	0.03						0.06						0.01*					
HYV	0.11**						0.05***						0.09***					
LAB	0.03						0.16						0.51					
INC		0.49***	0.62***	0.016				0.71***	0.93**	0.82***				0.134***	0.48***	0.006*		
MAN		Na						Na						Na				
EDU		0.02		0.14*		0.03**		0.03		1.70***		0.02***		0.02*		1.10*		0.03***
CRE			Na						Na						Na			
AGE			0.90**			0.67*			1.22*			0.29			-1.10*			-0.59**
HHS					0.24***						0.19						0.08	
TOX					-0.01						-0.03						-0.01	
HLV					-0.07**						-0.12**						-0.11***	
TFR	-0.82***	-0.11*	-0.04	-0.73*	0.04**	-0.001***	-0.23*	-0.27**	-0.10*	-0.47*	0.03	-0.03	-0.68**	-0.16*	-0.07*	0.76	-0.003	-0.01*
DTZ	-0.88***	-0.11*	-0.41**	-0.78*	0.40*	-0.15*	-0.15**	-0.17**	-0.61*	-0.30*	0.43**	-0.24**	-0.54***	-0.13*	-0.47*	-0.61**	0.41*	-0.17*
DDS	-0.25	0.32	5.4	2.22*	0.6	-0.07	-0.07	-0.79***	-0.21*	1.4	0.22	-0.16	-0.21	-0.5	-0.1	-2.37***	-0.42*	-0.001
MKO						0.33*						0.70*						0.47**

Note: Na = Not applicable because the variable was a dummy
*** = Significant at 1%, ** = Significant at 5%, * = Significant at 10%

Source: Own data

In essence, elasticity calculation reduces coefficients into pure numbers free of measurement units. This gives an interpreter freedom to choose units of interest. For the purpose of this study, percentage units were chosen. The interpretation could be summarised as follows: "a W% increase or decrease of variable X results into a Z% increase or decrease in variable Y". Following this, three types of effects exerted by a change in a given exogenous variable on a corresponding endogenous variable were deduced. These include direct (specialisation), indirect (intensification) and total effects.

6.2.2 Specialisation Effects of Road Accessibility

Specialisation is a production decision that involves reallocating resource (land) to different crops in order to increase output. That is, if for example a farmer is growing coffee and vanilla on the farm, and the price signals sent by the market indicate that vanilla is more paying than coffee, *ceteris paribus*, in order to maximise returns a rational farmer could decide to increase the area under vanilla by reducing the area under coffee. If the price is persistently high enough and agro-climatic factors allow, the farmer could put the whole farm under vanilla. In this way, the farmer is specialising in the production process. Specialisation is sometimes referred to as direct effect for two reasons: first, it involves exogenous variables appearing in the productivity equation (first equation) of the model. Second, from theoretical point of view the first reaction from the producer in response to price incentive is resource reallocation, before contemplating expensive output enhancing inputs such as fertiliser, high yielding seed and so on.

The specialisation effect of a marketing system is represented by elacitisties in column (ii), (viii) and (xiv) of Table 6.14 for the three sub samples. It is shown that if access to paved road were improved by 1%, the direct effect on productivity would be 0.88% for men, 0.15% for women and 0.54% for the whole sample. Similarly, if time spent by farmers to move from their homesteads to the nearest feeder road was reduced by 1%, a direct effect on

productivity would be an increase of 0.82% for men, 0.23% for women and 0.68% for the whole sample.

6.2.3 Intensification Effect of Road Accessibility

It could be noted that when an exogenous variable changes it affects not only the target endogenous variable but also other variables to which it is related as specified in the model. If one excludes the influence on a target variable, the remaining influences are regarded as intensification or indirect effects. According to the model for example, when household income increases, the use of fertiliser and pesticides increases. But these two have also an impact on aggregate agricultural productivity. Understanding this concept is crucial because it will help in understand the derivation of total effects of road infrastructure improvement on productivity. For that matter, one more example is explained. When the level of education increases, the use of fertiliser and income levels of households increase. But at the same time increased fertiliser use affects aggregate agricultural productivity, while income affects the use of fertiliser, pesticides and high yielding variety seeds, which in turn affects aggregate agricultural productivity.

The indirect impact of road infrastructure can be examined in a similar manner by tracing the influence of road access proxy variables, TFR and DTZ. To limit the discussion to a manageable level, concentration is devoted to examination of the whole sample results given previously in Table 6.13c. If time to reach the unpaved road were reduced by 1%, it would increase aggregate productivity by 0.68%, fertiliser use by 0.16%, pesticide use by 0.07%, use of high yielding variety seeds by 0.76% and household income by 0.01%. Similarly, reduction of distance from homestead to the paved road by 1%, results into 0.54% increase in aggregate agricultural productivity, 0.13% increase in fertiliser use, 0.47% increase in pesticide use, 0.61% increase in use of high yielding variety seeds, and 0.17% increase in household income.

From the AAP equation it can be noted that fertiliser, pesticides and high yielding variety seeds influence aggregate agricultural productivity. It follows then that aggregate agricultural productivity would increase by 0.06% from the 0.13% increase in fertiliser use, by 0.01% from the 0.47% increase in pesticides, and by 0.06% from the 0.61% increase in the use of high yielding variety seeds. Note that according to the formulation, household income does not have any direct impact on aggregate agricultural productivity, but it directly affects the use of fertiliser, pesticides and high yielding variety seeds. Therefore the 0.17% increase in household income would increase fertiliser use by 0.004%, pesticide use by 0.04% and use of high yielding variety by 0.001. It can be shown that these increases together would increase aggregate agricultural productivity by 0.002%. And this is essentially the idea behind indirect or intensification effects.

6.2.4 Total Effects of Road Access on Agricultural Productivity

The total effect of road impact on productivity is an arithmetic summation of both specialisation and intensification effects explained in section 6.3.2 and 6.3.3 above. To be able to demonstrate the impact of a change in road access variables on aggregate agricultural productivity, the results are magnified by considering a 10% improvement in accessibility. Road improvement in this case may take two forms: one, construction of new feeder roads or upgrading existing ones to paved level, two, improving access of household access to intermediate means of transport (IMT)[7]. Then the impact throughout the system was traced out to ascertain the total effect. It was shown previously in Table 6.14 that a 1% decrease in the distance to the paved road would directly increase aggregate agricultural productivity by 0.88% for men, 0.15% for women and 0.54% for the whole sample. When a 10% improvement is considered, this translates to 8.8% for men, 1.5% for women and 5.4% for the whole sample (first numbers in column (c), (e) and (g) of Table 6.15).

[7] Intermediate means of transport (IMT) imply any means of transport between headloading and vehicles (Barwell, 1999)

Table 6.15: The Impact of a 10% Improvement in Road Accessibility on Aggregate Agricultural Productivity

Effect	Men		Women		Whole sample	
	Time to unpaved road (TFR)	Distance to paved road (DTZ)	Time to Unpaved road (TFR)	Distance to paved road (DTZ)	Time to unpaved road (TFR)	Distance to paved road (DTZ)
(a)	(b)	(c)	(d)	(e)	(f)	(g)
Specialisation effect (%):	8.2	8.8	2.3	1.5	6.8	5.4
Intensification effect (%):	1.7	2.6	0.4	1.6	1.5	1.6
Fertiliser	0.9	0.9	0.0	0.2	0.7	0.6
Pesticides	Ns	0.1	0.1	0.4	0.0	0.1
HYV seeds	0.8	0.9	0.2	0.2	0.8	0.6
Labour	0.0	0.1	0.1	0.7	NS	0.2
Income	0.0	0.6	NS	0.1	0.0	0.1
Total Effect (%)	9.9	11.4	2.7	3.1	8.3	7.0

Note: NS = Not significant

Source: Own study

When the effect is traced of 10% improvement in market access on other variables that in turn affect aggregate agricultural productivity, it is found that it is 2.6% for men, 1.6% each for women and the whole sample (second numbers in column (c), (e) and (g) of Table 6.15). Adding the first and second numbers in respective columns yields 11.4% for men, 2.7% for women and 7.0% for the whole sample as total effect of the improvement in road infrastructure for each sample. With the results in Table 6.15, other factors remaining constant, a variety of questions regarding improved road access in the study area could be answered. For example, if the existing road network in the study area were improved by 10% what would be the impact on total agricultural output? How could improved access to roads widen the gap between the rich and the poor? Knowing the cost of road

development, how could the indirect return of road investment be estimated? These issues are dealt with in subsequent sections.

6.2.5 Distribution of Gains From Improved Road Access

In the foregoing discussion it has been demonstrated clearly that improving accessibility of households to the road infrastructure generates gains as shown in Table 6.15. Critical examination reveals that these gains are not distributed equally between men and women. Men gain more than women. For example, whereas improvement in access to unpaved road by 10% would increase aggregate agricultural productivity by 9.89% (almost 10%) for men, the improvement for women is only 2.7%. The same is true for improved access to paved road, where gain for men is 11.4% as compared to only 3.1% for women.

The observations above amplify the theoretical perspective that improvement in the marketing system, if unchecked is likely to benefit the strong more than the weak participants in the system, something that is understandable. In a poor and traditional society such as Tanzania, women are marginalized in the process of decision-making and information sharing. This has translated into differences in ownership of resources and income. When the market condition improves men very likely acquire more resources than women and this accentuates the difference between the two genders.

6.3 Estimation of Road Investment Return in the Study Area

In this section the analysis of the relationship between road investment and the value of induced agricultural output is carried out. The aim is to see whether the returns in terms of induced output are sufficiently high to cover the investment cost in a relatively short time. To do this, information on the construction and maintenance cost, value of induced increments in agricultural output and incremental cost in terms of key inputs were

required. Data on construction and maintenance costs were collected from MOW. The value of agricultural output in the study area was computed from the time-series data provided by the ministry of Agriculture in its publication "Basic Data for Agriculture and Livestock Sector 1991/1992 - 1997/98". Fertiliser and pesticide requirements were extracted from Social Economic Profiles published jointly by the Planning Commission and Regional Commissioner's Office for respective regions. In the following sections induced cost and benefit from road improvement in Tanzania are discussed to set grounds for analysing road investment return.

6.3.1 Road Operation and Management Costs in Tanzania

Road operation and management costs depend decisively upon many factors. They include terrain, cost of land, pavement thickness, number of lanes, number and nature of bridges, availability of resources in the site proximity and quality of soil on the site. It is beyond the scope of this study to plumb the depths of road operation and management costs. However, examination of construction costs of some road projects in Tanzania (in 1999/2000), presented in Table 6.16[8] gives an idea on the magnitude of road management cost in the country.

[8] Most activities on roads in Tanzania are emergence works. This may indicate, together with other things, an underlying problem of lack of maintenance culture in the Tanzania society

Table 6.16: Construction costs of some selected road projects in Tanzania, 1999/2000 – 2000/2001

Project	Length (in km)	Surface type	Cost (TZS Millions)	Cost per km (TZS Millions)	Remarks
Dodoma – Manyoni	135	Unpaved	1,533.5	11	Emergency repair
Babati – Singida	162	Unpaved	1,855.0	11	Emergency repair
Sumabwanga – Mpanda	240	Unpaved	2,753.1	11	Emergency repair
Shelui – Nzega	132	Unpaved	1,911.3	14	Emergency repair
Lindi – Nangurukuru	165	Unpaved	1,544.8	9	Emergency repair
Muhutwe – Biharamulo	128	Unpaved	1,471.5	11	Emergency repair
Tunduma - Sumbawanga	230	Unpaved	4,725.0	21	Emergency repair
Mto Magogo-Shinyanga/Mwanza boarder	110	Paved	35,000.0	318	Improvement from unpaved
Arusha – Namanga	102	Paved	512.4	5	Emergency repair
Morogoro – Dodoma	264	Paved	1,872.1	7	Emergency repair
Kigoma – Nyakanazi	325	Unpaved	5,473.8	17	Emergency repair
Mutukula – Muhutwe	112	Paved	20,183.0	180	Improvement from unpaved
Shelui – Nzega	108	Paved	25,078.1	232	Improvement from unpaved
Dar es Salaaam – Mlandizi	54	Paved	39,760.0	736	Replacement of old paved layer
Iringa-Dodoma-Babati-Minjingu-Arusha	556	Unpaved	4,645.9	8	Emergency repair
Mtwara and Lindi rural roads	3,975	Unpaved	3,730.0	1	Routine/Recurrent maintenance
Ruvuma and Southern Iringa rural roads	2,700	Unpaved	25,285.0	9	Routine/ Recurrent maintenance

Source: Compiled from MOW records

The cost figures presented in Table 6.16 concur with estimates from MOW. Table 6.17 below indicates the construction and maintenance costs for roads in Tanzania as estimated by the Ministry of Works. Routine maintenance[9] is normally carried out once or more times a year. Periodic maintenance is carried out in a period of 4 to 5 years for unpaved road, and 5 to 7 years for paved roads. The cost of constructing bridges is estimated at TZS 13.5 millions per m^2.

Table 6.17: Construction and maintenance costs for roads in Tanzania

Management category	Paved road cost (TZS Millions)	Paved road maintenance cost as % of construction cost	Unpaved road cost (TZS Millions)	Unpaved road maintenance cost as % of construction cost
Construction	300		48.8	
Routine maintenance	0.6	0.2	0.5	1.0
Periodic maintenance	29.9	10.0	1.8	44.7

Source: MOW

6.3.2 Current Agricultural Productivity in the Study Area

Only important food crops, whose wholesale and retail prices are recorded on weekly basis by MDB, were considered in the analysis. The crops include maize, sorghum, millet, banana, wheat, paddy, beans, cassava and sweet potatoes. The quantities (tons) of crop were transformed into monetary values as detailed in Appendix 9. In this process, an eight-year average quantity, area and prices were calculated for each crop in each of the four regions crossed by the paved road under consideration (TANZAM). The value of each crop was computed by multiplying its quantity by its average price. Then productivity was computed by dividing the overall crop value (TZS by the overall area under considered crops. As will be seen clearly later, the total agricultural output value in the study area was computed at TZS

[9] In this particular presentation, routine maintenance comprises also emergency maintenance

296,454.3 millions from 1,005.3 ha of land. This means the agricultural productivity value in the study area is about TZS 294,904 per acre.

6.3.3 Current Input Usage in the Study Area

The most important farm input used in the study area is fertiliser. However other inputs such insecticides, modern seeds, fungicides and herbicides are also in use. Total requirements for fertiliser for Coast, Morogoro, Iringa and Mbeya is estimated at 94,260.7 tons per year. This is about 75% of the national total fertiliser consumption of 125,913 tons per year (Table 6.18).

Table 6.18: Current input usage in the study area

Region	Annual fertiliser consumption (tons)	% of total fertiliser consumption in the four regions	% of total fertiliser consumption at national level
Coast	378.5	0.4	0.3
Morogoro	3,247.2	3.4	2.6
Iringa	63,206.0	67.1	50.2
Mbeya	27,429.3	29.1	21.7
Total	94,261.0	100.0	74.9

The price of fertiliser depends on the fertiliser type. During the survey, it was found that the price of fertiliser during the period under review ranged between TZS 8500 and TZS 14,000 per 50-kg bag with an average of TZS 11,278), which was used in estimating value of incremental fertiliser in the surveyed regions.

6.3.4 Analysis of a 10% Improvement in Access to Road

In the previous sections, the costs and benefits of road management in Tanzania have been established. In this and subsequent sections, the value

of costs and benefits discussed earlier, are used to estimate returns on a 10% road improvement in the study area. By road improvement it implies two aspects. One, decrease in the distance from household homestead to a paved road, which is possible through construction of more paved roads to connect the study area with other regional Headquarters and neighbouring countries. Two, reducing time spent by rural households to move to the nearest unpaved road. This can be achieved through increased access to IMT. Because of time and resource constraints, the analysis is confined to paved roads.

6.3.4.1 Investment Cost for a 10% Improvement in Road Network

Earlier in Chapter Four, the total length of paved road networks in Coast, Morogoro, Iringa and Mbeya regions were presented. For the sake of clarity and relevance to the foregoing discussion similar information is presented and simulation of the incremental road length as a result of a 10% improvement in the road network is carried out (Table 6.19).

Table 6.19: Paved roads in the study area

Region	Paved road	10% increase in road asset
Coast	351.5	35.2
Morogoro	441.0	44.1
Iringa	335.9	33.6
Mbeya	365.4	36.5
Overall total	1493.8	149.4

Source: NBS, 1997

From the table it can be noted that 10% improvement in paved road network would mean an increment of 149.4 km of paved roads. From the previous discussion, it can be shown that this increment would cost TZS 44,820 millions as investment cost, 89.6 million as routine maintenance cost and 4,467.1 million as periodic maintenance cost.

6.3.4.2 Induced Agricultural Production From a 10% Road Improvement

As discussed in section 6.3.2, the current agricultural productivity in the study area is estimated at TZS 296,454.3 million. From the previous discussion on total effects of road access, it was established that a 10% improvement in road access, would increase overall aggregate agricultural productivity in the study area by 7.0%. This implies an increase of TZS 20,752 millions in aggregate agricultural output in the study area (Table 6.20).

6.3.4.3 Induced Fertiliser Use From a 10% Road improvement

It was pointed out earlier in Table 6.14 that a 1% increase in pave roads (DTZ) would increase fertiliser use (FER) by 0.13% for the whole sample. It follows then that a 10% improvement in paved road would increase fertiliser use by 1.3%, which is equivalent to 1,225.4 tons. At the price of TZS 11,278 per 50-kg bag the cost of such an increase represents TZS 276.4 millions.

6.3.4.4 Flow of Benefits and Cost from a 10% Road Improvement

From the foregoing discussion, it has been realised that the investment outlay for 149.4 km of paved road is TZS 44,820 millions. To maintain this road on routine basis would require TZS 89.6 millions annually. It is assumed that periodic maintenance is carried out after every six years, and that in year 1 and 2 there is no effect on the production level. In year three, 50% of induced output is realised, and in year four, 75%. Further assumption is that road construction is completed in year 0 of the project, and there is no salvage value of road construction equipment. Similarly, the rate of fertiliser use follows a similar trend, that is, in year 1 and 2 there is no significant increase in fertiliser use. In year three, fertiliser use increases -by 50% and in year four by 75%. A full increase is attained in year five. On this background a benefit and cost flow is construct (Table 6.21).

Table 6.20: Agricultural productivity and summary of other basic information

Overall	Crops									Total
	Maize	Sorghum	Miliet	Bananas	Wheat	Paddy equivalent[10]	Beans	Cassava	Sweet potatoes	
TOTAL OUTPUT VALUE (Million TZS)	69,651.5	16,170.3	1,757.9	51,615.8	4,074.2	59,500.2	49,069.1	26,171.9	18,443.5	29645
TOTAL AREA (x 1000 ha)	429.5	79.8	11.2	95.0	19.1	129.7	109.0	89.1	42.9	1,00
PRODUCTIVITY (TZS/ha)										294,90

SUMMARY	
Current Total Output (Million TZS)	296,454.0
Total Area (x 1000 ha)	1,005.3
Productivity (TZS/ha)	294,904.0
Incremental Productivity (TZS/ha)	20,643.3
New Productivity Level (TZS/ha)	315,547.1
New Production Level (Million TZS)	317,206.0
Incremental Production (Million TZS)	20,752.0
Current Total Paved Road (km)	1,494.0
Incremental Paved Road (km)	149.4
Construction cost for paved road (Million TZS)	300.0
Incremental construction cost for paved road (Million TZS	44,820.0
Routine maintenance cost (per km) for paved road (TZS)	600,000.0
Routine maintenance cost for incremental paved road (Million TZS)	89.6
Periodic maintenance cost (per km) for paved road (Million TZS)	29.9
Periodic maintenance cost for 149.4 km of paved road (Million TZS	4,467.1
Cost of incremental fertiliser use (Million TZS)	276.4

[10] Prices available were for rice while quantities for paddy, thus paddy quantities were converted into rice equivalence at the ratio of 1 kg of paddy = 0.67 kg of rice

6.3.5 Payback Period of the Road Infrastructure

It may be recalled that the total investment cost to increase road infrastructure by 10% is TZS 44,820 millions. Inspection of cumulative net benefit flow in Table 6.21 reveals that this investment cost would be recovered between year 7 and year 8. Assuming that the returns are evenly distributed among months in any given year, it is possible to compute the exact time length at which the investment cost would be recouped. This idea has already been summarised in equation 5.27 in Chapter Five. Making substitutions in this equation, gives the time frame required for the investment to be paid back. That is,

$$A7 + (B44{,}820 - C37{,}196.5)/(57{,}582.5 - C37{,}196.5) = 7.4$$

This shows that, if the state invested TZS 44,820 million to construct 149.4 km of paved road in the study area, the number of years for this economic venture to payback would be 7 years and about 5months.

Table 6.21: Benefit and cost flow for a 10% improvement in paved roads in the study area

Cash flow items	Project years										
	0	1	2	3	4	5	6	7	8	9	10
Inflows (millions)				10,375.9	15,564.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0
Farm Output											
Outflows (millions)											
Road construction cost	44,820.0										
Routine maintenance costs		89.6	89.6	89.6	89.6	89.6		89.6	89.6	89.6	89.6
Periodic maintenance cost							4,467.1				
Fertiliser cost				138.2	207.3	276.4	276.4	276.4	276.4	276.4	276.4
Net benefit flow (millions)	-44,820.0	-89.6	-89.6	10,148.1	15,267.1	20,386.0	16,008.5	20,386.0	20,386.0	20,386.0	20,386.0
Cumulative net benefit flow (millions)	-44,820.0	-44,909.6	-44,999.2	-34,851.1	-19,584.0	802.0	16,810.5	37,196.5	57,582.5	77,968.5	98,354.5

Cash flow items	Project years									
	11	12	13	14	15	16	17	18	19	20
Inflows (millions)	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0	20,752.0
Farm Output										
Outflows (millions)										
Road construction cost										
Routine maintenance costs	89.6		89.6	89.6	89.6	89.6	89.6		89.6	89.6
Periodic maintenance cost		4,467.1						4,467.1		
Fertiliser cost	276.4	276.4	276.4	276.4	276.4	276.4	276.4	276.4	276.4	276.4
Net benefit flow (millions)	20,386.0	16,008.5	20,386.0	20,386.0	20,386.0	20,386.0	20,386.0	16,008.5	20,386.0	20,386.0
Cumulative net benefit flow (millions)	118,740.5	134,749.0	155,135.0	175,521.0	196,907.0	216,293.0	236,679.0	252,687.5	273,073.5	293,459.5

Source: Own compilation

6.3.6 Internal Rate of Return of Road Investment

From the net benefit flow in Table 6.20, IRR for the road investment was computed at different time intervals. It was found that the IRR was 19.8% after 10 years of the investment, 23.1% after 15 years and 24.0% after 20 years (Table 6.22).

Table 6.22: Internal rate of return of road investment in the study area

Project year	Benefit flow	Project year	Benefit flow
0	-44,820	11	20,386
1	-90	12	16,285
2	-90	13	20,386
3	10,148	14	20,386
4	15,267	15	20,386
5	20,386	16	20,386
6	16,009	17	20,386
7	20,386	18	16,285
8	20,386	19	20,386
10	20,386		
IRR after 10 years = 19.8			
IRR after 15 years = 23.1			
IRR after 20 years = 24.0			

Source: Own compilation

The levels of IRR were almost three times higher than the deposit nominal interest rates in the financial market in Tanzanian. At the time of this study, the interest rate was 7-10% per annum (BOT 2000). This indicates that investing in road infrastructure has significant economic returns. However, the calculated IRR was equivalent to the cost of borrowing money from Tanzanian financial market to finance the road project, which stood at 20-22% during this study. This indicates that if the fund to carryout the investment was borrowed from the bank in Tanzania, the investment would still break-even. But a grate part of road improvement and expansion fund in Tanzania is sourced in the international capital market whose borrowing

rates may be quite than domestic rates. Going into details of this matter is outside the scope of this study.

6.3.7 Sensitivity analysis of Road Investment

After computing IRR, sensitivity analysis was performed to examine its stability, just in case the situation under which it was established changed. Sensitivity analysis was carried out on four scenarios:

Scenario 1: benefit assumed to be overestimated by 10%
Scenario 2: benefit assumed to be overestimated by 20%.
Scenario 3: costs assumed to be underestimated by 10%, and
Scenario 4: costs assumed to be underestimated by 20%

In all four simulations, the values of IRR remained stable with little change from the calculated IRR, showing that the investment was still viable. As shown in Table 6.23, the difference between the simulated and calculated IRR ranged between 6.7% and 21.7%. Detailed IRR computations are presented in Appendix 10. The results show tremendous return from road investment, taking into consideration that gains considered in this analysis were from one sub-sector only - food crops. There is a clear possibility that, if all possible gains were taken into consideration the results could be great. These results should sufficiently convince policy makers to give priority to construction and maintenance of paved roads.

Table 6.23: Summary of sensitivity analysis results

	IRR after 10 years	IRR after 15 years	IRR after 20 years
Calculated IRR (Reference)	19.8	23.1	24.0
Benefits overestimated by 10%	17.7	21.3	22.3
Difference from calculated IRR	2.1	1.8	1.7
% difference	10.6	7.8	7.1
Benefits overestimated by 20%	15.5	19.3	20.4
Difference from calculated IRR	4.3	3.8	3.6
% difference	21.7	16.5	15.0
Costs underestimated by 10%	17.9	21.5	22.4
Difference from calculated IRR	1.9	1.6	1.6
% difference	9.6	6.9	6.7
Costs underestimated by 20%	16.2	20.0	21.0
Difference from calculated IRR	3.6	3.1	3.0
% difference	18.2	13.4	12.5

Chapter Seven

7 Summary, Conclusion and Policy Recommendations

7.1 Summary

7.1.1 Background

Tanzania is one of the poorest countries of the world. The government recognises that improving productivity of the agricultural sector is a solution to the economic ailment. That is why since independence in 1961, the government has been implementing various programs to boost agricultural production. However not much has been realised in this respect. About 18 millions people are still living in abject poverty and food scarcity has become a chronic problem. A common feature is that while people in one part of the country are starving, in other parts they are complaining of lack of market for their produce. This indicates bottlenecks in the procurement and distribution process in the marketing system, especially efficient transport mechanism.

Indeed market infrastructure in terms of road network has not been given due attention as a stimulant of agricultural productivity in Tanzania. Theoretically, access to road infrastructure could positively influence agricultural productivity through enhancing efficient allocation of resources among producers (specialisation) and encourage them to use modern inputs (intensification). In Tanzania the road transport system is highly inadequate. In many areas crops have to be carried many kilometres by head loading to village markets or roadsides. This consumes exorbitant household time and energy that could be used in production and other income-generating activities.

Whether or not good road network contributes to economic development is not an issue for discussion, it certainly does. That is why topics on improving road communication dominate casual and political discussions between professional and members of the lay community. However, participants in these discussions lack an understanding of empirical relationships between road infrastructure and other elements of economic development. Because building roads is an expensive venture, and at the same time, most economic gains from roads are intangible, road investment tends to receive less priority among competing ends of public resources. This study is designed to provide evidence that roads contribute to economic development by using agricultural sector as an example. Quantitative measurement of this type could help policy-makers have an insight about the impact of their decision to neglect or improve road infrastructure.

Apart from explaining the role of the agricultural sector and the spatial distribution of road network in Tanzania, this study seeks to answer the following relevant questions:

(i) Roads are important for agricultural development, but how can road infrastructure contribution to aggregate agricultural productivity be quantified?

(ii) Road improvement generates gains to the community, are the gains accrued equitably distributed between strong and weak participants in the system?

(iii) Market access effect is divided into specialisation and intensification, which one is greater than the other in the study area?

(iv) Is investing in road construction in the study area an economically profitable venture?

(v) What can be done to improve road infrastructure and agricultural productivity in Tanzania?

In answering these questions, four hypotheses guide the study:

(i) Access to road has a significant positive impact on aggregate agricultural productivity.

(ii) Gains from improved market access are not equally distributed among strong and weak producers because of the difference in endowments and in the ability to taking advantage of improved economic condition.

(iii) Specialisation is higher than intensification effect of market access in the study area.

(iv) It is economically profitable to invest in road infrastructure in the study area.

7.1.2 Methodology and Data Analysis

The empirical analysis in this study is based upon primary and secondary data collected in Tanzania along the Tanzania-Zambia highway. In each region traversed by this road, except Dar es Salaam one station was selected for the survey. Dar es Salaam was not considered in the analysis because its urban nature would introduce unnecessary biasness in the results. The stations were Chalinze for Coast Region, Mikumi for Morogoro Region, Ilula for Iringa Region and Chimala for Mbeya Region. At each station three villages at different relative distance from the highway were selected. The villages were categorised as easy access (closest to the paved road), medium access (middle) and difficult access (furthest from the paved road). The population was stratified into men and women. From each stratum, 120 respondents were randomly interviewed, 10 from each village. This made a sample size of 240 respondents. Cross-sectional data, mainly for production and marketing of major crops were collected for the 1998/1999 season. The crops involved include maize, paddy, sunflower, tomatoes, groundnuts, beans, sorghum/millet, sesame, cassava, and onions. Secondary data were obtained from various institutions.

Descriptive, econometric and profitability analyses were carried out. In **descriptive analysis**, it was assumed that all observed differences among respondents were due to market access. Using SPSS 9.0 software, the relationships between market access and other variables were examined. In **econometric analysis**, as many confounding factors as possible were modelled into a six-equation simulataneous system with 17 variables. A three-stage-least squares econometric technique (3SLS) was carried out using LIMDEP 7.0 software. **Financial analysis**, which entailed computation of a payback period and internal rate of return, was carried out in Excel 5.0.

7.1.3 Results

7.1.3.1 Descriptive Analysis

Descriptive analysis showed a significant inverse relationship between most variables and distance from the roadway. As the distance from the household to the paved road decreases productivity increases. For example, while the overall productivity for easy access villages was TZS 49,269 for medium and difficult access it was TZS 39,883 and 33,040 respectively. Similarly, a significant difference between variables for men and women headed households was apparent. Men were better than women at all levels of road access. For instance, in the easy access villages the productivity for men was 26% higher than for women. In medium and difficult access the difference in productivity between men and women were 12% and 16% respectively.

A similar observation was made for household income. While households near the roadway made $ 1.10 to 1.60 per day, those located in difficult access villages made only $ 0.50 to 0.80 per day. Other variables such as market orientation, household income, use of modern inputs (such as fertilisers, pesticides and high yielding variety seeds), age and producer prices manifested similar trends as productivity and household income. The only exception was labour, which had a positive relationship with distance,

possibly because of youths migrating to urban areas and/or getting involved in non-farm activities near the road.

As far as transport is concerned, the mode of transporting crops from the field to the storage or selling point, which was used by 60% of the farmers interviewed, was head loading. The remaining 40% was shared between bicycle and car at 26% and 14% respectively. On the other hand no single village surveyed had an assembly market. Traders moved from household to household to collect crops.

7.1.3.2 Econometric Analysis

Most variable coefficients carried expected signs and were statistically significant. Elasticity of road access variables indicated that a 10% decrease in the distance from the household to the highway (for example by building more paved roads), would increase aggregate agricultural productivity by 11.4% for men (8.8% from specialisation and 2.6% from intensification) and 3.1% for women (1.5% from specialisation and 1.6 from intensification). By a similar line of reasoning, if the time from the household to the feeder road was reduced by 10% total effect on aggregate agricultural productivity for men would be an increase of 9.9% for men and 2.7% for women. These results indicate a clear differential impact roads have on different groups of producers, the better-off getting even better.

7.1.3.3 Profitability Analysis

Computation of a payback period showed that, if TZS 44,820 million were invested in expanding paved road network in the study area, it would take about 7 years to recover the investment outlay. The internal rate of return (IRR) of such investment after 10 years was found to be 20%. Sensitivity analysis indicated that the investment was economically viable.

7.2 Conclusion and Policy Recommendations

The findings presented in this study bring to surface a number of issues that are important for policy. It has been shown implicitly that one of the major causes of poverty is isolation. Improving the access and mobility of the isolated poor pave the way for access to market, services and other opportunities. In this way, road access is critical for economic activities, and improvement of the standard of living of the people. The impact of improved market access in terms of road infrastructure can be seen in among other things, increased aggregate agricultural productivity, agricultural commercialisation, increased household income, and improved well being of the rural people. The impact can also be seen in the stronger social and economic linkages between rural and urban areas and in opening up opportunities for the rural people to engage in non-farm activities. It was also clearly shown that in the study area, specialisation effect of road improvement is higher than intensification effect. It can undoubtedly be concluded that road infrastructure is a powerful tool to commercialise agriculture in a developing country such as Tanzania.

It was also discovered that improved road access does not necessarily improve the well being of everyone in the rural area. The ability of an individual to take advantage of improved market access depends on the economic power or social function of an individual. The rich or the stronger are likely to benefit more than the poor or the weak. This has been confirmed by the results that household characteristics were better for men than for women. Furthermore, it was found that investment in paved roads in the study area is a viable economic venture. From these observations the following recommendations for consideration by policy-makers are made:

(i) Since it has been empirically shown that agricultural productivity is linked to physical market access in terms of good road network, the issue of investment priorities in road network is of paramount importance for transforming the agricultural sector in Tanzania. In this respect road network improvement could be used to address the challenges of poverty reduction and rural

development in general. However, in improving road network it should always be remembered that building roads is one thing and maintaining them is another. If the rate of road construction is equivalent to the rate of road deterioration, the anticipated positive impact on agricultural productivity may not be realised. In addition, because the ability of the government to shoulder all the costs of building roads is limited, there is a need to involve a wider public in the provision of road infrastructure. The idea of privatising road infrastructure, which is currently under debate by the general public is a good example of public-private-partnership. Better a road or bridge with a fee than no road or bridge at all.

(ii) Road network is just one among a variety of factors that enhance market access. As such, the mere presence of road network may not bring desired change in productivity. Other factors such as vehicular capacity, markets and institutional set-up of the marketing system play a significant role. Because of that it is important to review the entire system and resolve the bottlenecks. For example, taxation policy on vehicles and spare parts, establishment of assembly markets and avoidance of distortive regulatory activities that impede the development of competition in the production and marketing system ought to be examined. In addition, because it is not possible to supply roadways close to each and every small farm, enhanced access to intermediate means of transport (IMT) such as bicycles, ox-carts, donkey, wheel-burrows, is necessary to reduce time and energy wasted in moving crops from the fields to the assembly points and roadsides.

(iii) It has been shown that the gains from market access are not necessarily equitably shared between men and women, or the strong and the poor. The gap between them tends to widen with market access improvement. Therefore, strategies to improve market access should be gender sensitive. Programmes to boost

the income of women should therefore accompany road improvement strategies. For example, special credit could be given to enable them to access modern inputs.

(iv) The analysis showed that specialisation effect of market access in terms of road improvement is higher than intensification effect in the study area. This implies that there is a tremendous opportunity for improving agricultural productivity in the area by just creating policy environment that will enable farmers to specialise. That is, relocating land resource without necessarily, embarking on expensive inputs such as fertiliser and pesticides.

Zusammenfassung, Schlussfolgerungen und Empfehlungen

Zusammenfassung

Hintergrund

Tansania ist eins der ärmsten Länder der Welt. Die derzeitige Tansanische Regierung hat erkannt, dass eine Verbesserung der Produktivität im Agrarsektor das Patentrezept gegen wirtschaftliches Elend ist.

Deshalb hat sie seit Beginn der Unabhängigkeit 1961 verschiedene Programme eingeführt, um die landwirtschaftliche Produktion anzukurbeln. Jedoch ist nicht viel in dieser Hinsicht verwirklicht worden. Ungefähr 18 Millionen Menschen leben noch immer in bitterer Armut und Nahrungsmittelknappheit ist zu einem chronischen Problem geworden. Ein gängiges Bild ist, dass die Bevölkerung in einem Teil des Landes verhungert, während sie in anderen Teilen über fehlende Absatzmöglichkeiten für ihre Erzeugnisse klagt. Dies macht Engpässe im Beschaffungs- und Verteilungsprozess des Marketingsystems deutlich, vor allem sichtbar an mangelnden leistungsfähigen Transportmöglichkeiten. In der Tat ist der Infrastruktur des Marktes im Sinne eines adäquaten Straßennetzes, als Stimulus für die landwirtschaftliche Produktivität, nicht die gebührende Aufmerksamkeit gewidmet worden. Theoretisch könnte der Zugang zu einer Straßeninfrastruktur die landwirtschaftliche Produktivität durch eine sinnvollere Zuteilung von Geldmitteln unter den Produzenten (Spezialisierung) positiv beeinflussen und diese dazu ermutigen, moderne Produktionsmittel einzusetzen (Intensivierung).

In Tansania ist das Straßen – Transportsystem in höchstem Maße unzulänglich. In vielen Gegenden muss das Getreide auf dem Kopf viele Kilometer bis zu Dorfmärkten oder Straßenrändern getragen werden. Dies verschlingt Unmengen an Zeit und Energie, welche für die Produktion und andere sich auszahlende Tätigkeiten gebraucht werden könnte. Ob ein gut ausgebautes Straßennetz zur ökonomischen Entwicklung beiträgt oder nicht, steht außer Frage, jeder weiß dass das es das tut. Deshalb werden

sowohl informelle als auch politische Diskussionen unter Fachmännern und Laien von der Frage, wie man die Straßenverbindungen verbessern kann, dominiert. Jedoch fehlt ihnen das Verständnis für die umfassenden Beziehungen zwischen Straßeninfrastruktur und anderen Elementen der wirtschaftlichen Entwicklung. Da Straßenbau ein sehr kostspieliges Wagnis ist und zudem wirtschaftliche Gewinne hieraus nicht sichtbar sind, zieht bei der Verteilung der öffentlichen Mittel Investition in Straßenbau in Konkurrenz mit anderen den kürzeren. Diese Arbeit erbringt den Beweis, dass Straßen zur wirtschaftlichen Entwicklung beitragen indem sie sich den landwirtschaftlichen Sektor als Beispiel nimmt. Quantitative Messungen dieser Art könnte maßgeblichen Politikern verdeutlichen, welche Folgen ihre Entscheidung, die Straßeninfrastruktur zu verbessern oder zu vernachlässigen, nach sich zieht.

Abgesehen davon, dass sie die Bedeutung des Agrarsektors und die räumliche Verteilung des Straßennetzes in Tansania darstellt, versucht diese Arbeit eine Antwort auf folgende, damit verbundene Fragen zu geben:

(i) Straßen sind wichtig für die landwirtschaftliche Entwicklung, aber wie kann die Tatsache, dass Straßeninfrastruktur zur Steigerung der landwirtschaftlichen Produktivität führt, quantitativ bestimmt werden ?

(ii) Durch eine Verbesserung der Straßen fallen Gewinne für die Gemeinschaft an. Werden diese Gewinne gerecht zwischen den starken und schwachen Teilnehmern dieses Systems verteilt?

(iii) Market access effect is divided into specialisation and intensification, which one is greater than the other in the study area?

(iv) Sind Investition in den Straßenbau in der Studienregion eine wirtschaftlich durchführbare Unternehmung?

(v) Was kann getan werden um die Straßeninfrastruktur und die landwirtschaftliche Produktivität in Tansania zu verbessern?

In dieser Studie wird die Beantwortung jener Fragen von 4 grundlegenden Hypothesen begleitet. Diese beinhalten:

(i) Straßenzugang wirkt sich auf signifikante Weise positiv auf die gesamte landwirtschaftliche Produktivität aus.

(ii) Gewinne, welche bei verbessertem Marktzugang entstehen, werden nicht gleichmäßig auf starke und schwache Produzenten verteilt, da es Unterschiede gibt bei den jeweiligen Ausstattungen und in der Fähigkeit, Nutzen aus verbesserten wirtschaftlichen Bedingungen zu ziehen.

(iii) Spezialisierungseffekt ist höher als der Intensivierungseffekt in dem Untersuchungsgebiet.

(iv) Aus Ökonomischer Sicht ist eine Investition in die Straßeninfrastruktur der untersuchten Gebiete gewinn-bringend.

Methodik

Die empirische Analyse in dieser Studie basiert auf Primär- und Sekundärdaten, welche in Tansania entlang der Tansania – Zambia Autobahn gesammelt wurden. In jeder Region, abgesehen von Dar-es-Salaam, die von dieser Autobahn durchquert wird, wurde eine Station für die Umfrage ausgewählt. Dar-es-Salaam wurde in diese Analyse nicht mit einbezogen, da ihr städtischer Charakter unnötige subjektive Ergebnisse mit einfliessen lassen würde. Die Stationen waren Chalinze für die Küstenregion, Mikumi für die Region Morogoro, Ilule für die Region Iringa und Chimala für die Region Mbeya. An jeder Station wurden drei Dörfer mit verhältnismäßig unterschiedlichem Abstand zu der Autobahn ausgewählt. Die Dörfer wurden kategorisiert in einfacher Zugang (am nächsten zur Pflasterstraße gelegen), mittlerer Zugang (nahe zur Pflasterstraße gelegen) und schwieriger Zugang (am weitesten von der Pflasterstraße gelegen). Die Bevölkerung wurde eingeteilt in Männer und Frauen. Aus beiden Gruppen wurden 120 Umfrageteilnehmer stichprobenartig interviewt, jeweils 10 aus jedem Dorf. Dies ergab eine Mustergröße von 240 Teilnehmern.

Querschnittsdaten, hauptsächlich über die Produktion und Vermarktung der Hauptgetreidesorten wurden während der Saison 1998/99 gesammelt. Beteiligte Getreide waren Mais, Reis, Sonnenblume, Tomate, Erdnüsse, Bohnen, Sorghum, Hirse, Sesam,Maniok und Zwiebeln. Sekundärdaten wurden von unterschiedlichen Einrichtungen eingeholt.

Deskriptive, Ökonometrische und Profitabilitäts Analysen wurden durchgeführt. Bei der deskriptiven Analyse wurde vorausgesetzt, daß alle beobachteten Unterschiede zwischen den Umfrageteilnehmern auf den unterschiedlichen Zugang zum Markt zurückzuführen waren. Mit SPSS 9.0 Software wurden die Beziehungen zwischen Marktzugang und anderen Variablen untersucht. Bei der wirtschaftlichen Analyse wurden so viele widersprüchliche Faktoren wie möglich in einem System aus sechs Gleichungen mit 17 Variablen untergebracht. Eine 3 SLS wirtschaftliche Technik wurde mit LIMDEP 7,0 Software durchgeführt. Die Profitabilitäts Analyse, die eine Berechnung der Rückzahlungsfrist mit einschloss, wurde in Excel 5.0 durchgeführt.

Ergebnisse

Deskriptive Analyse

Die Deskriptive Analyse wies ein signifikant inverses Verhältnis zwischen den meisten der Variablen und der Distanz zur Straße auf. Sobald die Entfernung zwischen Wohnung und Asphaltstrasse abnimmt, nimmt die Produktivität zu. Während die gesamte Produktivität bei einfachem Zugang zur Straße bei 49,69 TZS lag, betrug sie bei mittlerem und schwierigem Zugang 39.883 TZS, beziehungsweise 33.040 TZS. Entsprechend war ein signifikanter Unterschied zwischen Variablen aus Haushalten unter männlicher, beziehungsweise weiblicher Führung zu verzeichnen, in allen Bereichen die im Verhältnis mit Zugang zur Straße zu sehen sind, schnitten Männer besser ab als Frauen. Zum Beispiel lag in den Dörfern mit einfachem Zugang zur Straße die Produktivität bei Männern um 26% höher als bei Frauen. In Dörfern mit mittlerem und schwierigem Zugang betrug

der Unterschied in der Produktivität bei Männern und Frauen 12%, beziehungsweise 16%. Etwas ähnliches war bei den Haushaltseinkommen zu beobachten. Während Haushalte nahe der Straße einen Umsatz von 1,10 bis zu 1,60 $ pro Tag machten, betrug er bei jenen mit schwierigem Zugang zur Straße nur 0,50 bis 0,80 $ pro Tag. Andere Variable, wie z.B. Marktlagebestimmung, Haushaltseinkommen, der Gebrauch moderner Produktionsmittel (Düngemittel, Schädlingsbekämpfungsmittel und sehr erträgliche Vielzahlsamen), Alter sowie Herstellerpreise wiesen ähnliche Trends wie bei Produktivität und Haushaltseinkommen auf. Die einzige Ausnahme machte die Variable Arbeit, auf welche Distanz eine positive Auswirkung hatte, möglicherweise wegen der Jugendlichen, die in die städtischen Regionen abwandern und, beziehungsweise oder Beschäftigungen nahe der Straße nachgehen, welche nichts mit Landwirtschaft zu tun haben.

Was den Transport betrifft, benutzten 60% der befragten Landwirte "headloading" um ihrGetreide vom Feld hin zum Speicherplatz oder Verkaufsort zu transportieren. Die verbliebenen 40% waren unterteilt in 26% Transport auf dem Fahrrad und 14% Transport mit dem Auto. Auf der anderen Seite hatte kein einziges der befragten Dörfer einen Marktplatz. Händler gingen von Haus zu Haus um das Getreide einzusammeln.

Ökonometrische Analyse

Die meisten der Koeffizienten der Variablen brachten erwartungsgemäße Ergebnisse und waren für die Statistik bedeutsam. Die Elastizität der Variablen bei Zugang zur Straße ließ erkennen, daß eine 10 prozentige Abnahme der Distanz zwischen Haushalt und Landstraße die gesamte landwirtschaftliche Produktivität um 11,4% bei Männern (8,8% hiervon durch Spezialisierung und 2,6% durch Intensivierung) erhöhen würde, sowie um 3,1% bei Frauen (1,5% hiervon durch Spezialisierung und 1,6% durch Intensivierung). Ein ähnlicher Argumentationsgang wäre, daß wenn man die Zeit die gebraucht wird um vom Haushalt zur Straße zur

Landstraße zu kommen, um 10% verringern könnte, würde das eine Zunahme der gesamten landwirtschaftlichen Produktivität bedeuten, für Männer eine Erhöhung von 9,9% TZS, beziehungsweise 2,7 TZS bei Frauen. Diese Resultate zeigen auf, daß Straßen deutlich unterschiedliche Auswirkungen haben auf die jeweils unterschiedlichen Gruppen von Produzenten; der wohlhabenden Schicht geht es immer besser.

Profitabilitäts Analyse

Die Berechnung einer Rückzahlungsperiode hat gezeigt, dass sich eine Investition von hat gezeigt, daß sich eine Investition von 44,820 Millionen TZS in den Ausbau eines gepflasterten Straßennetzes in genannten Regionen nach 7 Jahren amortisieren würde. Es zeigte sich, daß die Rendite (der interne Zinsfuss) einer solchen Investition nach 10 Jahren 20% betragen würde. Die Analyse der Sensitivität befand diese Investition als wirtschaftlich durchführbar.

Schlußfolgerungen und Empfehlungen

Die in dieser Studie präsentierten Ergebnisse bringen eine Anzahl von Diskussionspunkten mit sich, die für die Politik von Bedeutung sind. Es ist implizit gezeigt worden, daß einer der Hauptgründe für Armut die Isolation ist. Indem man die Zugangsmöglichkeiten und die Mobilität der isolierten, armen Bevölkerung verbessert, wird der Weg für Marktzugang, Dienstleistungen und andere Möglichkeiten bereitet. Insofern ist ein Zugang zur Straße entscheidend für wirtschaftliche Aktivität und die Verbesserung des Lebensstandards der Bevölkerung. Die Auswirkungen eines verbesserten Marktzugangs bezüglich der Straßeninfrastruktur zeigen sich unter anderem auch in gesteigerter landwirtschaftlicher Produktivität, landwirtschaftlicher Kommerzialisierung, steigendem Haushaltseinkommen und höherem Lebensstandard der ländlichen Bevölkerung. Sie zeigen sich auch in stärkeren sozialen und wirtschaftlichen Bindungen zwischen den ländlichen und städtischen Regionen, sowie in der sich neu erschließenden

Möglichkeit für die ländliche Bevölkerung in nicht landwirtschaftlichen Tätigkeitsbereichen unterzukommen. Auch zeigte sich deutlich, daß in den untersuchten Gebieten bei einer Verbesserung der Straßen der daraus resultierende Spezialisierungseffekt höher ist als der Intensivierungseffekt. Daraus kann zweifelsfrei gefolgert werden, daß eine Straßeninfrastruktur ein unverzichtbares Rüstzeug ist, um die Landwirtschaft in einem Entwicklungsland wie Tansania handelsfähig zu machen.

Es wurde auch demonstriert, daß verbesserter Zugang zur Straße nicht notwendigerweise das Wohl jedes einzelnen in den ländlichen Regionen verbessert. Die Fähigkeit eines Einzelnen, Nutzen aus einem verbesserten Marktzugang zu ziehen, ist von der wirtschaftlichen Kraft dieser Person abhängig. Der Reiche oder Starke wird eher davon profitieren wie der Arme beziehungsweise Schwache. Dies wurde bestätigt durch vorliegendes Ergebnis, welches zeigt, daß Männer bei allen für einen Haushalt charakteristischen Merkmalen besser abschneiden als Frauen. Ferner kam heraus, daß eine Investition in Pflasterstraßen in den untersuchten Gebieten ein wirtschaftlich durchführbares Unternehmen ist.

Ausgehend von diesen Beobachtungen ergeben sich folgende Empfehlungen, welche von maßgebenden Politikern berücksichtigt werden sollten:

(i) Da hier empirisch gezeigt wurde, daß landwirtschaftliche Produktivität mit physischem Marktzugang, d. h. mit einem gut ausgebauten Straßennetz in engem Zusammenhang steht, ist die Frage einer Bevorzugung des Ausbaus eines Straßennetzes bei der Verteilung des Investitionskapitals von größter Bedeutung. In dieser Hinsicht könnte eine Verbesserung des Straßennetzes dafür benutzt werden, es mit anstehenden Herausforderungen wie der Verringerung von Armut und ländlicher Entwicklung im allgemeinen aufzunehmen. Jedoch sollte man bei der Verbesserung eines Straßennetzes nie außer Acht lassen, daß es eine Sache ist, Straßen zu bauen, sie instand zu halten jedoch eine ganz andere. Wenn die Straßenbauquote äquivalent ist mit

der Straßenverschlechterungsquote, könnte der erhoffte positive Einfluß auf die Produktivität möglicherweise ausbleiben.

(ii) Das Straßennetz ist nur einer von vielen verschiedenen Faktoren, welche den Marktzugang fördern, demzufolge kann das bloße Vorhandensein eines Straßennetzes nicht den erwünschten Umschwung in der Produktivität bewirken. Andere Faktoren wie Fahrzeugkapazität, Absatzmärkte und ein einheitlicher Aufbau eines Absatzförderungssystems spielen ebenfalls eine bedeutende Rolle. Deshalb ist es wichtig, das gesamte System zu überprüfen und bestehende Engpässe zu beheben. Zum Beispiel das Besteuerungssystem für Autos und Ersatzteile, das Errichten von Verkaufsmärkten und die Vermeidung von störenden Regelungen, welche die Entwicklung eines Wettbewerbs in dem Produktions- und Vermarktungssystems erschweren. Zusätzlich dazu könnte ein erleichterter Zugriff auf Ersatztransportmittel (IMT) wie Fahrräder, Ochsenkarren, Esel usw. nötig sein, um die während dem Transport des Getreides von den Feldern zu den Sammelpunkten und Straßenrändern verschwendete Zeit und Energie zu verringern, da es nicht möglich ist jede einzelne kleine Farm mit einer Zufahrtsstraße zu versorgen.

(iii) Es wurde gezeigt, daß die aus dem Marktzugang resultierenden Gewinne nicht notwendigerweise gerecht zwischen Männern und Frauen bzw. den Starken und Schwachen aufgeteilt werden. Diese Kluft neigt dazu sich auszuweiten je besser der Marktzugang wird. Folglich sollten Programme zur Verbesserung des Marktzugangs auf die Geschlechterverteilung Rücksicht nehmen. Solche Programme sollten mit Maßnahmen ausgestattet sein das Einkommen von Frauen zu erhöhen. Zum Beispiel könnten spezifische Kredite zugeteilt werden um Ihnen einen Zugriff auf moderne Produktionsmittel zu ermöglichen.

(iv) Die Analyse zeigte, daß bei einer Verbesserung des Zugangs zum Markt in den untersuchten Regionen der Spezialisierungseffekt höher ausfällt als der Intensivierungseffekt. Dies legt nahe, daß hier noch reichlich Raum für eine Verbesserung der landwirtschaftlichen Produktivität in der Region besteht, indem man ein politisches Umfeld schafft, das es den Farmern ermöglichen wird, sich zu spezialisieren, d.h. schon vorhandene Ressourcen auszuschöpfen ohne notwendigerweise auf teuere Inputs wie z. B. Düngemittel und Pestizide zurückgreifen zu müssen.

References

Abele S. (2001), Bewertung von technischen Innovationen für kleinbäuerliche Betriebe in West-Niger unter Berücksichtigung von institutionellen Rahmenbedingungen. Stuttgart, Verlag Grauer.

Anas, A. S. K. Lee and M. Murray, (1996), Infrastructure Bottlenecks, Private Provision, and Industrial Productivity: A Study of Indonesian and Thai Cities. Policy Research Working Paper 1603, World Bank.

Andersson, A.E. (1991), Infrastructure and the formation of the society. In: *The future of transportation and communication.* Ed. R. Thord, Swedish national Road Administration, Borlänge.

Ashimogo, G. C. (1996), Agricultural Marketing Liberalisation in Tanzania: History and Prospects. Discussion paper presented at the workshop on community policy review, 1-9 April 1996, SUA. Morogoro, Tanzania.

Bajpai, N. D. A. (1993), Infrastructure for Agricultural Growth. Kitab Mahal, Allahabad.

Bank of Tanzania (BOT), (1998), Economic Bulletin for the quarter ended 31st December, 1998. Vol. XXVIII No. 4. Dar es Salaam.

Bank of Tanzania (BoT), (2001), Economic Bulletin for the Quarter Ended 30th June, 2001. Vol. XXX I No. 2 Dar es Salama.

Barwell, I. J. (1996), Transport and the villages: Findings from African Village-Level Travel and Transport Surveys and Related Studies. World Bank discussion paper No. 344, African series, Washington D.C.

Barwell, I. J. and C. Calvo, (1989), Makete integrated rural transport project: The transport demands of rural households: Findings from a village-level travel survey. ILO, Geneva.

Barwell, I. J. (1999), Rural Mobility in Developing Countries. World Bank Position Paper. Washington.

Batalia, C. J. and H. K. Kachenje, (1998), Draft paper on the road transport sub-sector policy. Ministry of Communications and Transport (MCT).

Bergman, E. M. and D. Sun, (1996), Infrastructure and manufacturing productivity: Regional accessibility and development level effects. In: *Infrastructure and the complexity of economic development.* Eds. D. F. Batten and C. Karlsson, Heidelberg. Springer-Verlag Berlin.

Binder, S. J. and T. M. Smith, (1996), The linkage between transportation infrastructure investment and productivity: A U.S. federal research perspective. In: *Infrastructure and the complexity of economic development.* Eds. D. F. Batten and C. Karlsson, Heidelberg. Springer-Verlag Berlin.

Button, K. (1996), Ownership, Investment and Pricing of Transport and Communications Infrastructure. In: *Infrastructure and the complexity of economic development.* Eds. D. F. Batten and C. Karlsson, Heidelberg. Springer-Verlag Berlin.

Carnemark, C. J. Biderman and D. Bovet, (1976), The Economic analysis of rural road projects. World Bank staff working paper No. 241. Washington, D.C, USA.

Coelli, T. D. S. P. Rao and G. E. Battese, (1999), An Introduction to Efficiency and Productivity Analysis. Kluwer Academic Publishers, London.

Costa, J. R. Ellson and R. Martin, (1987), Public Capital, Regional Output, and development: Some Empirical Evidence. Journal of Regional Science, Vol. 27, 3:419-343.

Diewert, W. E. (1992), Fisher Ideal Output, Input and Productivity Indexes Revisited. Journal of Productivity Analysis Vol. 3: 211-248.

Evans, H. E. (1990), Rural-Urban Linkages and Structural Transformation. Infrastructure and Urban Development Department, Discussion Paper No. INU 71, World Bank, Washington D.C.

Farris, P. L. (1983), Future frontiers in Agricultural Marketing Research, Iowa State University Press, U.S.A.

Federal Republic of Germany (FRG), (1998), Facts About Germany. Press and Information Office of the Federal Government. Societäts-Verlag, Frankfurt/Main.

Food and Agriculture Organization (FAO), (1999), Crop and food supply assessment mission to Tanzania. Special report: FAO/WFP.

Gabagambi, D. (1998), Evaluation of agricultural marketing efficiency in Tanzania: A case study of paddy and cotton in Ulanga district. MSc. Thesis, SUA, Morogoro, Tanzania.

Gittinger, P. J. (1982), Economic Analysis of Agricultural Projects. EDI Series in Economic Development. The John Hopkins University Press. Baltimore and London.

Gujarati, D. N. (1995), Basic Econometrics. New York. McGraw-Hill, Inc. Singapore.

Haddad, L. (1997), Overview of part I: Introduction. In: *Achieving Food Security in Southern Africa: New Challenges, New Opportunities.* Ed. L. Haddad, IFPRI, Washington, D.C.

Hamilton, M. J. (1996), Privately Financed Road Infrastructure: A Concession Company's Point of View. Sub-Saharan Africa Transport Policy Program. The World Bank, African Region. Working Paper No. 26.

Hartwich, F. (2001), Evaluating performance of agricultural research & development: an economic analysis of R&D in Universities and other Research Organizations in Cameroon and Tanzania. Stuttgart, Verlag Grauer.

Hau, A. M. (1999), Rural Market Structures and the Impact of Market Access on Agricultural Productivity– A Case Study in Doi Inthanon of Northern Thailand. Diplomarbeit, Institute 490B, University of Hohenheim.

Hofmeier, R. (1973), Transport and economic development in Tanzania. München. Weltforum-Verlag GmbH.

Ijaimi, A. A. (1994), Efficiency and equity Effects of market access on agricultural productivity in Sudan: A case study of smallholders along River Nile, north of Khartoum. Verlag Dr. Koster Berlin.

Institut der Deutschen Wirtschaft Köln (IDWK), (2001), Deutschland in Zahlen. Deutscher Instituts-Verlag GmbH.

Intriligator, M. D. (1978), Econometric Models, Techniques, and Applications. North Holland Publishing Co. Amsterdam. Oxford Prentice Hall, Inc. New Jersey.

Isinika, A. C. (1995), Assessing the Effect of Agricultural Research Expenditures on Agricultural Productivity in Tanzania. Unpublished PhD Thesis, The Graduate School, University of Kentucky.

Jaffe, E. D. and S. Hilbert, (2001), How to prepare for the Graduate management admission test. Barron's educational series, Inc. New York.

Jochimsen, R. (1966), Theorie der Infrastruktur: Grundlagen der Marktwirtschaftlichen Entwicklung, Tübingen.

Johansson, B. and R. Wigren, (1993), Production Milieu and Competitive Advantages. In: *Infrastructure and the complexity of economic development.* Eds. D. F. Batten and C. Karlsson, Heidelberg. Springer-Verlag Berlin.

Johnston, B.F. and J.W. Mellor (1961), The Role of agriculture in Economic development. American Economic Review, Vol. 51, 47: 566-93

Kashuliza, A. K. (1994), Rural Credit in Tanzania: An Analysis of Policy and Operational Problems in Financing Smallholder Agriculture. Unpublished PhD Thesis, Depertment of Agricultural Economics, Wye College- University of London.

Kaushik, K. K. (1993), Agricultural Transformation in Developing Economy. Kanishka Publishers.

Kessides, C. (1996), A Review of Infrastructure's Impact on Economic Development In: *Infrastructure and the complexity of economic development.* Eds. D. F. Batten and C. Karlsson, Heidelberg. Springer-Verlag Berlin.

Kormawa, P. M. (1996), Economic potential for production and marketing of soybeans n West Africa. Lt. Verlag Münster-Humberg.

Kuznets, S. (1964), Economic Growth and tzhe Contribution of Agriculture: Notes on Measurement. In: *Agriculture in Economic development.* Eds. C. Eicher and L. witt. McGraw Hill, New York.

Kyi, T. (2000), Market induced shifts in Agricultural Supply and Effects on Trade Patterns in Myanmar. Verlag Grauer, Stuttgart.

Lanjouw, P. and N. H. Stern, (1993), Agricultural Change and Inequality in Palanpur. In: *The Economics of Rural Organisation.* Eds. K. A.Hoff and J. Stiglitz. Oxford University Press.

Likwelile, B. S. (2000), The role of roads on the country's economy-Tanzania. Dar es Salaam. Research on poverty alleviation (REPOA). A paper prepared for road stakeholders meeting on public-private sector partnership in developing the road sector, RBF April 2000.

Limbu, F. (1993), Efficiency of the rice marketing system in Tanzania. Verlag Dr. Koster, Berlin.

Lipton, M. (1983), Variable access to food. In: *Integrating supply, distribution, and consumption.* Eds. J. P. Gittinger, J. Leslie and C. Hoisington. Published for the World Bank. The Johns Hopkins university press, London.

Maro, W. A. (1999), Agricultural marketing and transportation in Tanzania. Collaborator study prepared for the World Bank country study for Tanzania, 2000. IFPRI, Washington, D.C.

Mbiha, E. M. Mlambiti and G. C. Ashimogo, (1998), Evaluation of Agricultural Marketing and Rural Financing Constraints in Tanzania: The case of Ulanga District. Final Report submitted to DRPGS, SUA, August 1998.Rural financing in Ulanga district of Morogoro region in Tanzania. SUA.

Mbilinyi, M. and T. Nyoni, (1997), Rural Food Security Policy and Development Group. (RFS). Institute of Development Studies. Tanzania Episcopal Conference (TEC.

Mbilinyi, M. (1996), Big and Small: Changes in Tanzanian Agriculture. Paper presented at the Annual Gender Studies Conference (AGSC), IFM, Dar es Salaam.

Mellor J. and Pandya L. (1990), Food Aid and Development in the MADIA countries. International Food Policy Research Institute (IFPRI), Washington D.C.

Mera, K. (1973), Regional Production functions and Social Over head Capital : An analysis of the Japanese Case. Regional and Urban economics.

Ministry of Agriculture and Cooperatives (MAC) and National Bureau of statistics (NBS), (1999), Expanded Survey of Agriculture 1995/96, Tanzania Mainland. Main Report.

Ministry of Agriculture and Cooperatives (MAC), (1997), National Agricultural and Livestock Policy (NALP), Dar es Salaam.

Ministry of Communication and Transport (MCT), (1999), Integrated Road Project II Ministry of works. Dar es Salaam.

Mittendorf, H. J. (1978), The Challenge of Organising City Food Marketing Systems in Developing Countries. Landwirtschaft Vol. 17, pp. 323-41.

Mlambiti E. M. V. Rutachokozibwa and S. J. Lugore, (1993), Socio-Economic Survey of Kilombero Valley, Tanzania. Research Report, Sokoine University of Agriculture, Morogoro.

Mlambiti, E. M. and A. C. Isinika, (1997), Tanzania's Agricultural Development Towards the 21st Century. Paper presented at the Inaugural Ceremonies of Agricultural Economics Society of Tanzania (AGREST), Sokoine University of Agriculture (SUA), Morogoro, Tanzania.

Mukhopadhyay, N. A. (1989), Crops, costs, and variations: an investigation based on farm management studies.

Munyemana, A. and von Oppen M. 1999, Impact of agricultural market reforms on smallholder farmers in Benin and Malwai. Technical report submitted to IFPRI.

National Bureau of statistics (NBS), (1994), Collection of Official Statistics in Tanzania. President's Office Planning Commission, Dar es Salaam.

National Bureau of Statistics (NBS) (Tanzania), (1997), Mbeya region socio-economic profile. The planning commission, Dar es Salaam and Regional commissioner's Office, Mbeya.

National Bureau of Statistics (NBS) (Tanzania), (1997), Coast region socio-economic profile. The planning commission, Dar es Salaam and Regional commissioner's office, Coast, Kibaha.

National Bureau of Statistics (NBS) (Tanzania), (1997), Iringa region socio-economic profile. The planning commission, Dar es Salaam and Regional commissioner's office, Iringa.

National Bureau of Statistics (NBS) (Tanzania), (1997), Morogoro region socio-economic profile. The planning commission, Dar es Salaam and Regional commissioner's office, Morogoro.

National Bureau of Statistics (NBS) (Tanzania), (1999), Expanded Survey of Agriculture, 1995/96 – Tanzania Mainland. Statistical Unit of MAC, Dar es Salaam.

Ndulu,B.J. and S.M. Wangwe, (1997), Managing the Tanzanian Economy in Transition to Sustainable Development. In: *Economic Management in Tanzania*. Ed. D. Bol et al.

Ngondo, A. (1999), Profile of the agricultural sector. Collaborator study prepared for the World Bank country study for Tanzania, 2000. IFPRI, Washington, D.C.

Njehia, K.B. (1994), The impact of market access on agricultural productivity: A case study of Nakuru district, Kenya. Verlag Dr. Köster , Berlin, Germany.

Nicholls, W.H. (1964), The place of Agriculture in Economic Development. In: *Agriculture in Economic development*. Eds. C. Eicher and L. witt. McGraw Hill, New York.

O'Flaherty, C.A. (1983), Highways and Traffic. Vol. 1, Butler and Tanner Ltd.

Obst, E. (1943), Afrika: Handbuch der Praktischen Kolonialwissenschaft. Vol. XV, 1 (Transport), Berlin.

Odhiambo, W. (1998), Productivity, market orientation and agricultural intensification: A comparative analysis of smallholder farmers in Meru and Machakos district of Kenya. Verlag Ulrich E. Grauer, Stuttgart, Germany.

Ogot, B. and J. Kieran, (1968), Zamani: A Survey of East African History. Nairobi.

Omamo, S. W. (1998), Transport costs and smallholder cropping choices: An application to Siaya district, Kenya. American Journal of Agricultural Economics Vol. 80, pp 116-123.

Omari, C. K. (1993), Social structures and gender relation in Tanzania society. Paper presented at the workshop on women and mass media, held at Bwawani Hetel , Zanzibar, December 10-14 1993.

Owen, W. (1964), Strategy for mobility. Washington.

Planning Commission (Tanzania), (1999), Tanzania Development Vision 2025. Dar es Salaam.

Planning Commission, Dar es Salaam and Regional Commissioner's Office, Iringa, 1997), Iringa Region Socio-economic Profile.

Planning Commission, Dar es Salaam and Regional Commissioner's Office, Coast, (1997), Coast Region Socio-economic Profile.

Planning Commission, Dar es Salaam and Regional Commissioner's Office, Iringa, (1997), Morogoro Region Socio-economic Profile.

Planning Commission, Dar es Salaam and Regional Commissioner's Office, Iringa, (1997), Mbeya Region Socio-economic Profile.

Potkanski, T. (1997), Pastoral, Economy, Property rights and traditional Mutual Assistance mechanisms among the Ngorongoro and Salei Masaai of Tanzania. Pastoral Land Tenure Series Mono 2, London.

Poulton, C. A. Doward and J. Kydd, (1998), The Revival of Smallholder Cash Crops in Africa: Public and Private Roles in Provision of Finance. Journal of International Development. Vol. 10, (January-February): pp. 85-103

Putterman L. (1995), Economic reform and smallholder agriculture in Tanzania; A discussion of recent market liberalisation, road rehabilitation and technology dissemination effort. World Development Vol. 23 pp 311 - 326. Washington.

Quinet, E. (1990), The social cost of land transport. Environmental monograph 32. OECD, Paris.

Riley H.M. and T. M. Weber, (1983), Marketing in Developing Countries. In: *Future Frontiers in Agricultural Marketing Research*. Eds. P. L. Farris. The Iowa University Press, USA.

Riverson, N. D. J. and S. Carapetis, (1991), Intermediate Means of Transport in Sub-Saharan Africa: Its Potential for Improving Rural Travel and Transport. World Bank Technical Paper No. 161 Africa Technical Department Series, Washington D.C.

Road Fund Board (RFB), (2000), The Road Users. Quarterly Road Fund Board Magazine of the Ministry of Works in Tanzania (2000). Issue No. 1-November 2000.

Road Fund Board (RFB), (2002), Annual Report for Financial Year 2000/2001. Dar es Salaam, Tanzania.

Roth, G. (1996), Roads in a market economy. Ashgate publishing limited. England.

Salvatore, D. (1996), Managerial Economics in a Global Economy. McGraw Hill College Div

Santorum, A. and A. .Tibaijuka, (1992), Trading responses to food marketing liberalisation in Tanzania. Food Policy Volume 17 Number 6. pp 431-442.

Sarris, A. and R. van den Brink, (1994), From Forced Modernisation to Perestroika: Crisis and Adjustment in Tanzania. In: *Adjusting to Policy Failure in African Economies*. Ed. D. Sahn. Cornell University Press. Ithaca, New York.

Shao, M. F. (1993), Consolidated Funding Mechanisms for Agricultural Research in Tanzania. A paper prepared for the Joint FAO/SPAAR (Special Program for African Agricultural Research). Technical consultation on Funding of Agricultural Research in Sub-Saharan Africa. Held on 6-8 July 1993 Nairobi, Kenya.

Steiner, M. H. (1965), Criteria for planning rural roads in a developing country: The case of Mexico. Stanford, U.K.

The Louis Berger Group, Inc. M-Konsult Ltd, (2001), Phase I: The National Transport Sector Strategic Plan – Final Report. Ministry of Works, Dar es Salaam.

Todaro M. P. (1989). Economic Development in the Third World. Longman Inc. New York.

United Republic of Tanzania (URT), (2001), Agricultural Sector Development Strategy (ASDS), Dar es Salaam.

Voigt, F. (1955), Die Entwirkungen der Verkehrsmittel auf die wirtschafltlicher Structur eines Raumes, Dargestellt am Beispiel Nordbayerns. In: *Die Nürmberg Hochschule in Fränkischen Raum.* Nürmberg, Deutschland.

von Oppen, M. (1999), Theory and methods of empirical research on market – induced development of agriculture. Lecture notes. Institute of agricultural economics and social sciences in the tropics and sub-tropics.

von Oppen, M. and D. M. Gabagambi, (2002), Market access impact on agricultural productivity: Lessons from thirteen studies. Indian Journal of Commerce, Vol. 55 No. 1 & 2 pp 1-8, January-June 2002. New Delhi.

Von Oppen, M. P. P. Rao and S.V.K. Rao, (1984), The role of agricultural marketing for development. European congress of agricultural economists, Kiel, Germany.

von Oppen, M. K.B. Njehia and A.A. Ijaimi, (1997), Impact of Market Access on Agricultural Productivity: Lessons from India, Kenya and the Sudan. In: *Food Security and Innovations, Success and Lessons Learned at International Symposium 1996.* Eds. F. Heidhues and A. Fadani. Peter Land GmbH, Frankfurt.

von Oppen, M. P. P. Rao and S. K. V. Rao, (1983), Impact of Market Access on Agricultural Productivity in India. ICRASAT Economic Program. A paper presented at the International Workshop on Agricultural Markets in the Semi-Arid Tropics. Patancheru, Andhra Pradesh.

Wasike, W. S. (2001), Road Infrastructure Policies in Kenya: Historical Trends and Current Challenges. Infrastructure and Economic Services Division, Kenya Institute for Public Policy Research and Analysis (KIPPRA). Working Paper No. 1.

Webster's Third new international dictionary of English language unabridged. Merriam, (1993), Webster, Incorporated. Cologne.

Wilson, F.R. A. M. Stevens and R. T. Holyoke, (1982), Impact of Transportation on Regional Development. Transportation Research Record 851.

Wong, L. (1986), Agricultural Productivity in the Socialist Countries. Westview Special Studies on Agriculture Science and Policy. Westview Press Inc. USA.

World Bank, (1991), Intermediate means of transport in Sub-Saharan Africa: Its potential for improving rural travel and transport. Technical paper No. 161, Africa technical department series. Washington.

World Bank, (1994), Tanzania Agriculture. World bank Country study. Washington DC.

World Bank, (1996), Tanzania, The challenges of reforms: Growth, incomes and welfare. Report No. 14982-TA. Country operations division Eastern Africa department, Africa region.

World Bank, (1996), World Development Report. Washington D.C.

World Bank, (2000), Agriculture in Tanzania since 1986: Leader or follower of growth? IBRD, Washington, USA.

World bank, (2000), World development report 2000/2001: Attacking poverty. IBRD, Washington. Oxford University Press.

Appendices

Appendix 1: Distribution of licensed commercial vehicles by categories of carrying capacity, 1997

Region	Total Vehicle	Good vehicle (Tons)					Passenger vehicles (Seats)				
	fleet	0<T≤5	5<T≤10	10<T≤17	T>17	TOTAL	0<S≤15	16<S≤25	26<S≤65	S>65	Total
Arusha	1,610	450	185	21	22	618	138	55	90	0	283
Coast	1,185	477	130	9	55	671	28	118	369	0	515
D'Salaam	18,711	7,803	2,392	450	673	11,318	1,903	2,768	2,682	0	7353
Dodoma	755	473	119	6	6	604	35	63	49	0	147
Iringa	839	414	58	3	0	475	67	163	130	0	360
Kagera	1,373	681	314	15	4	1,014	136	85	128	3	352
Kigoma	215	86	49	5	0	140	24	35	15	0	74
Kilimanjaro	3,503	2,170	349	31	17	2,567	314	266	293	0	873
Mara	805	400	133	13	7	557	37	41	51	0	129
Mbeya	1,011	524	99	5	0	628	48	155	140	0	343
Morogoro	306	59	21	3	0	83	51	109	60	0	220
Mtwara	78	13	21	0	0	34	21	1	21	0	43
Manza	1,765	863	306	34	27	1,230	210	107	99	0	416
Rukwa	249	120	90	1	4	221	20	0	5	0	25
Ruvuma	1,135	502	224	24	5	1,055	181	84	107	0	372
Shinyanga	433	251	81	9	10	351	36	3	36	1	76
Singida	557	232	163	74	0	469	4	1	75	0	80
Tabora	173	68	64	2	1	135	13	1	18	1	33
Tanga	1,016	454	110	6	14	584	165	102	89	0	356
Total	35,718	16,040	4,908	711	845	22,754	3,431	4,157	4,457	5	12,050

Source: MCT

Appendix 2: Some key indicators of road transport sector in selected countries

Country	Indicator								
	Land area (km^2)[a]	Pop. (Mil.)[a]	Total road length (10^3 km)[a]	Total vehicle fleet (Mil.)[a]	Road density (km per 100 km^2)[a]	Car density (number per km of road)[a]	Number of cars per 1000 people[a]	Goods transported by road (Mil. ton-km)[b]	Pave road % of total road length[b]
Germany	356,959	82.0	231.0	48.3	65	209	589	301,800	99
United Kingdom (UK)	244,046	58.0	361.6	23.5	148	65	405	152,500	100
United States of America (USA)	9,372,614	262	6,240.0	195.0	67	31	744	1,534,430	59
South Africa	1,221,037	41.4		14.4	...	...	348	...	12
Tanzania	945,087	29.6	85.0	0.4	9	4	12	...	4
Kenya	582,646	27.5	150.0	0.6	26	4	20	...	14
Uganda	241,040	19.2	64.6.0	0.2	27	3	10	...	4

Note: a= collected from websites of respective governments b= collected from WB world report, 2000/2001Pop. = Population... = data not available Mil. = Million

Source: Compiled from WB report and websites

Appendix 3: Features of the main traffic corridors in Tanzania

Traffic Corridor	Feature							
	Area served		Length[a] (km)	Paved length (km)	Traffic volume (v.p.d)	Population[b] (million)	Agricultural output (thousand tons)	Manufacturing (thousand TZS)
	Region	District						
TANZAM	Coast, Morogoro, Iringa, Mbeya.	Bagamoyo, Kibaha, Kisarawe, Kilosa, Mororgoro, Iringa, Njombe, Makete, Mufindi, Mbeya, Mbozi, Ileje, Kyela, Rungwe	1,324	1,012	1,263	5.3	1,288	9,002
North Eastern	Dar es Salaam, Coast, Tanga, K'njaro, Arusha.	Bagamoyo, Kibaha, Kisarawe, Ilala, Temeke, Pangani, Handeni, Korogwe, Lushoto, Mwanga, Same, Moshi, Rombo, Hai, Arusha, Arumeru.	950	744	697	5.3	1,023	14,406
Central	Morogoro Dodoma Singida Tabora Shinyanga	Morogoro, Dodoma, Mpwapwa, Singida, Iramba, Manyoni, Nzega, Igunga, Shinyanga, Kahama, Meatu, Maswa.	1,584	614	151	8.8	2,763	14,316
Lake Circuit	Kagera Mwanza Mara	Bukoba, Muleba, Biharamulo, Ukelewe, Magu, Mwanza, Kwimba, Sengerema, Geita, Bunda, Musoma	1,019	226	205	3.3	986	3,496

Appendix 3: Continued

Traffic Corridor	Feature							
	Area served		Length[a] km	% road paved (of nationai total	Traffic Volume (v.p.d)	Population[b] (million)	Agricultural output (thousand tons)	Manufacturing (thousand TZS)
	Region	District						
Southern Coastal	Coast, Lindi	Kisarawe, Rufiji, Kilwa, Lindi.	508	178	2,417	0.8	302	773
Southern	Ruvuma, Mtwara, Iringa, Lindi.	Tunduru, Ruvuma, Mtwara, Masasi, Njombe, Lindi	1,326	493	190	2.0	1,239	1,942
Western	Kigoma, Rukwa, Mbeya.	Kigoma, Mpanda, Nkasi, Sumbawanga.	1,286	0	60	3.3	1,024	1,310
Great North	Arusha Dodoma Iringa	Monduri, Arumeru, Arusha, Babati, Hanang, Kondoa, Dodoma, Mpwapwa, Iringa.	1,024	269	464	3.6	1,211	7,485
Mid-west	Rukwa, Mbeya, Tabora.	Na	1,201	7	47	Na	1,208	1,449

Note: K'njaro =Kilimanjaro, Dar = Dar es Salaam a = excluding branches b = Population figure for 1988 extrapolated by 2.8% to year 2000 VPD = Vehicle per day Inter. = International Mill. = Millions Na = Not available TZS =Tanzanian shilling

Source: Compiled from various records in the Ministry of Works and Ministry of Communication and Transport in Tanzania

Appendix 4: Questionnaire - Farmers' Survey Along Tanzania-Zambia Highway (TANZAM) in Tanzania for the study

"Road Infrastructure Investment and Its Impact on Agricultural Productivity and Equity in Tanzania"

(Damian M. Gabagambi & Matthias v. Oppen)

1. Respondent Identification Variables:

1.1 Questionnaire No. _____
1.2 Date _____
1.3 Village_____
1.4 Ward _____
1.5 Division_____
1.6 District _____
1.7 Region_____
1.8 Name of Respondent _____

2. Family Information

2.1 Gender of respondent 1=Male 2=Female
2.2 Age_____ (years)
2.3 Education level _____ (Years in school)
2.4 Main occupation 1=Farming 2=Non Farming
2.5 What are your off-farm income generating activities 1=Employment 2=Handcraft 3=petty trade 4=Big Business 5=Other_____
2.6 Family size_____ (No. of people depending on you)
2.7 What is the number of family members under 10? _____
2.8 What is the number of family members between 10 and 17? _____
2.9 What is the number of family members between 18 and 65? _____
2.10 What is the number of family members over 65? _____
2.11 How many school children do you have in the family? _____

3. Farming Practice

3.1 What is the total size of your farmland? _____ (acres)
3.2 In how many plots is your land segmented? _____
3.3 How did you acquire most of your land? 1=Inherited 2=Bought 3= Hired 4 = Given by the village government
3.4 If you were to buy that land today how much would it cost? _____ (TZS)
3.5 How much of your land was irrigation in the 1999/2000 season? _____ (acres)
3.6 How much of major crops grown under irrigation was harvested?
3.7 Crop: _____ _____ _____ _____
3.8 Quantity: _____ _____ _____ _____
3.9 How far is the largest cultivated land plot from home? _____(km)
3.10 How long does it take to move from home to the largest land plot? _____ (Min.)
3.11 Which means of transport you and your family use to travel to the largest plot? 1=Foot 2=Bicycle 3=Car

3.12 How much of your land was cultivated under major crops during 1999/2000 farming season? _____ (ha)

3.13 How many types of crops did you grow in the 1999/2000 farming season? _____How much of each crop did you grow and harvest in the 1999/2000 farming season? (Fill the table below):

crops	Area (acre)	Quantity harvested (kg)	Quantity sold (kg)	Price per kg	Inter-cropped or relay cropping with

3.14 Did you buy staple food for family consumption in the 1999/2000 farming season? 1=Yes 2=No

3.15 If yes, how much food did you buy? _____ (kg)

3.16 Indicate in the table below the stock of livestock you had in the farming season 1999/2000

Livestock type	Livestock number at present	Livestock sold	Average Price

4. Farm Inputs

4.1 Labour Input

4.1.1 How many hours per day (on average) did your family spend on farming activities during 1999/2000 farming season in the following operations:

Operation	Number of hours worked per day	Total number of days worked	Comment
Land clearing			
Tillage & Levelling			
Sowing			
Weeding & Pest control			
Harvesting & storage			

4.1.2 How much hired labour did you use in your farm during 1999/2000 farming season? (fill the table as per 4.1.1 above)

Operation	Number of people	Number of Hours worked per day	Total Number of days worked
Land clearing			
Tillage			
Levelling			
Sowing			
Weeding & pesticide application			
Harvesting & storage			

4.1.3. How much of maize and/or paddy did you pay for labour in the 1999/2000 farming season? Maize_____ (kg) Paddy _____(kg)

4.1.4(a)Did you use tractor in tillage in the 1999/2000 farming season? 1=Yes 2=No

4.1.4(b)If you used a tractor, how much land was cultivated _____ (acres)

4.1.4(c)How much did you pay per acre _____ (TZS).

4.1.5(a)Did you use oxen in tillage in the 1999/2000 farming season? 1=Yes 2=No

4.1.5(b)If you used an oxen, how much land was cultivated _____ (acres)

4.1.5(c)How much did you pay per acre _____ (TZS).

4.2. Fertiliser Input

4.2.1. Indicate in the table below the amount and type of fertiliser you used in the 1999/2000 farming season:

Fertiliser type	Quantity	Price per unit	Crop fertilised	Area fertilised (Acre)

4.2.2. Did you use organic manure on your farm in the 1999/2000 farming season? 1=Yes 2=No

4.2.3 Indicate in the table below the amount and type of other chemicals you used in the 1999/2000 farming season:

Chemical type	Unit of measurement	Quantity	Price per unit	Crop applied

4.2.4 Indicate in the table below the amount and type of seed you used in the 1999/2000 farming season

Crop	Type of seed (Local/HYV)	Unit of measurement	Quantity	Price per unit	Crop	Area

5. Other Agricultural Services

5.1 Did you use credit (in cash or in kind) in farming activities in the 1999/2000 farming season? 1=Yes 2=No

5.2 How much credit did you use?

Credit nature	Amount	Purpose/crop(s)	Credit Terms	Comment
Cash				
Credit				

5.3 Did you consult an extension officer regarding farming activities in the 999/2000 farming season? 1=Yes 2=No

6. Household's Gross Income, Expenditure (in cash only) and Belongings During 1999/2000 Farming Season

6.1 Income breakdown:

Source	**Amount (TZS)**
Crops	
Livestock	
Salary or wage	
Credit	
Business/trade	
Other sources	
Total Income	

6.2 How much of your cash income went to the following categories of expenditure in 1999/2000 farming season?

Expenditure category	**Amount (TZS)**
Farm/Livestock inputs and other operations	
Business inputs and other operations	
Household supplies	
School fees and other contributions	
Medical care	
Other expenditures	

7. Marketing and Market Access Information

7.1 Did you sell some crops in the 1999/2000 season? 1=Yes 2= No

7.2 Did you know prices before selling most of your crops 1=Yes 2=No

7.3 What motivated you to sell crops? 1=Price 2=Cash problems 3=Space for the next harvest

7.4 Do you know where traders sold most of the crops they bought from this village in the 1999/2000 season? 1=Yes 2=No
7.5 If yes, do you know the market prices where traders sold crops? 1=Yes 2=No
7.6 If yes, what was the source of information 1=Traders 2=Friends 3=radio 4= Others (Specify)_____
7.7 Where did you contact trader(s) who bought your crops? 1=Home 2=nearby dust road 3=At the highway 4=(Specify)_____
7.8 What was the main transport mode used in transporting crops to the market? 1=Head-load 2=Bicycle 3=Car 4=Others _____
7.9 How many traders (on average) came to you before you decided to sell your consignment? _____
7.10 In how many lots of crops did you sell your crops? _____
7.11 Where did you buy most of your inputs (fertiliser & chemicals) in the 1999/2000 farming season? 1=Nearby shop 2=Marketplace 3=Other_____
7.12 7.8.2. How far is the place where you bought inputs? _____ (Km)
7.13 How far from home is the dusty road to the Tanzania-Zambia highway? ____ (Km)
7.14 How long does it take to move from your home to the road in 7.4 above? ___(Min.)
7.15 How much does it cost to travel from home to the Tanzania-Zambia Highway? ___ TZS
7.16 How long is it in terms of time from home to the Tanzania-Zambia highway _(minutes)
7.17 How far in terms of distance is the Tanzania-Zambia highway from home_____(Km)

8. Miscellaneous Information

8.1 Do you possess the following items? Tick (√) or cross (X) appropriately

Radio	Ox-plough	Car	Motor cycle	icycle	Iron sheet roofed House	Tractor	art

8.2 Are you a member of a co-operative union? 1=Yes 2=No
8.3 If No why 1=Expensive 2=Not important 3=Not available
8.4 Which problems do you consider to be pressing in carrying out farming activities? 1=Lack of market 2=Lack of inputs 3=Pests 4=Drought

THANK YOU

Appendix 5: Matrix of Coefficients of the Simultaneous System

(a) The model rewritten to include excluded variables for each equation

$AAP = \beta_{10} + \beta_{11}FER + \beta_{12}PES + \beta_{13}HYV + \beta_{14}LAB + 0MAN + 0EDU + 0INC + 0CRE \pm 0AGE + 0HHS + 0TOX + 0HLV + 0MKO - \gamma_{11}TFR - \gamma_{12}DTZ - \gamma_{13}DDS = \mu_1$ *(i)*

$FER = \beta_{20} + 0AAP + \beta_{21}INC - \gamma_{21}MAN - \gamma_{22}EDU + 0PES + 0\,HYV + 0LAB + 0CRE \pm 0AGE + 0HHS + 0TOX + 0HLV + 0MKO - \gamma_{23}TFR - \gamma_{24}DTZ - \gamma_{25}DDS = \mu_2$ *(ii)*

$PES = \beta_{30} + 0AAP + \beta_{31}INC - \gamma_{31}CRE + \gamma_{32}AGE + 0FER + 0HYV + 0LAB + 0MAN \pm 0AGE + 0HHS + 0TOX + 0HLV + 0MKO - \gamma_{33}TFR - \gamma_{34}DTZ - \gamma_{35}DDS = \mu_3$ *(iii)*

$HYV = \beta_{40} + \beta 41EDU - \beta_{42}FER + \beta_{43}INC + 0PES + 0LAB + 0MAN + 0EDU + 0CRE \pm 0AGE + 0HHS + 0TOX + 0HLV + 0MKO - \gamma_{41}TFR - \gamma_{42}DTZ - \gamma_{43}DDS = \mu_4$ *(iv)*

$LAB = \beta_{50} + 0AAP + \gamma_{51}HHS - \gamma_{52}TOX - \gamma_{53}HLV + 0FER + 0PES + 0HYV + 0MAN \pm 0AGE + 0INC + 0CRE + 0AGE + 0MKO - \gamma_{54}TFR - \gamma_{55}DTZ - \gamma_{56}DDS = \mu_5$ *(v)*

$INC = \beta_{60} + 0AAP + \gamma_{61}MKO - \gamma_{62}AGE + \gamma_{63}EDU + 0FER + 0PES + 0HYV + 0LAB \pm 0AGE + 0CRE + 0HHS + 0TOX + 0HLV - \gamma_{64}TFR - \gamma_{65}DTZ - \gamma_{67}DDS = \mu_6$ *(vi)*

(b) The model rewritten to include excluded variables for each equation

$0 = AAP - \beta_{10} - \beta_{11}FER - \beta_{12}PES - \beta_{13}HYV - \beta_{14}LAB + 0MAN + 0EDU + 0INC + 0CRE + 0AGE + 0HHS + 0TOX + 0HLV + 0MKO + \gamma_{11}TFR + \gamma_{12}DTZ + \gamma_{13}DDS = \mu_1$ *(vii)*

$0 = FER - \beta_{20} + 0AAP - \beta_{21}INC - \gamma_{21}MAN - \gamma_{22}EDU + 0PES + 0\,HYV + 0LAB + 0CRE + 0AGE + 0HHS + 0TOX + 0HLV + 0MKO + \gamma_{23}TFR + \gamma_{24}DTZ + \gamma_{25}DDS = \mu_2$ *(viii)*

$0 = PES - \beta_{30} + 0AAP - \beta_{31}INC - \gamma_{31}CRE - \gamma_{32}AGE + 0FER + 0HYV + 0LAB + 0MAN + 0EDU + 0HHS + 0TOX + 0HLV + 0MKO + \gamma_{33}TFR + \gamma_{34}DTZ + \gamma_{35}DDS = \mu_3$ *(ix)*

$0 = HYV - \beta_{40} - 0AAP - \beta_{41}FER - \beta_{42}INC + 0PES + 0LAB + 0MAN + \beta_{43}EDU + 0CRE + 0AGE + 0HHS + 0TOX + 0HLV + 0MKO + \gamma_{41}TFR + \gamma_{42}DTZ + \gamma_{43}DDS = \mu_4$ *(x)*

$0 = LAB - \beta_{50} + 0AAP - \gamma_{51}HHS + \gamma_{52}TOX - \gamma_{53}HLV + 0FER + 0PES + 0HYV + 0MAN + 0EDU + 0INC + 0CRE + 0AGE + 0MKO - \gamma_{54}TFR - \gamma_{55}DTZ - \gamma_{56}DDS = \mu_5$ *(xi)*

$0 = INC - \beta_{60} + 0AAP + \gamma_{61}MKO - \gamma_{62}AGE - \gamma_{63}EDU + 0FER + 0PES + 0HYV + 0LAB + 0MAN + 0CRE + 0HHS + 0TOX + 0HLV + \gamma_{64}TFR + \gamma_{65}DTZ + \gamma_{67}DDS = \mu_6$ *(xii)*

(c) Summary table for the model coefficients

Equation No.	Coefficients of the variables																	
	1	AAP	FER	PES	HYV	LAB	INC	TFR	DTZ	DDS	MAN	EDU	CRE	AGE	HHS	TOX	HLV	MKO
(vii)	$-\beta_{10}$	1	$-\beta_{11}$	$-\beta_{12}$	$-\beta_{13}$	$-\beta_{14}$	0	γ_{11}	γ_{12}	γ_{13}	0	0	0	0	0	0	0	0
(viii)	$-\beta_{20}$	0	1	0	0	0	$-\beta_{21}$	γ_{21}	γ_{22}	γ_{23}	γ_{24}	$-\gamma_{25}$	0	0	0	0	0	0
(ix)	$-\beta_{30}$	0	0	1	0	0	β_{31}	γ_{31}	γ_{32}	γ_{33}	0	0	$-\gamma_{31}$	$-\gamma_{32}$	0	0	0	0
(x)	$-\beta_{40}$	0	$-\beta_{42}$	0	1	0	$-\beta_{43}$	γ_{41}	γ_{42}	γ_{43}	0	β_{43}	0	0	0	0	0	0
(xi)	$-\beta_{50}$	0	0	0	0	1	0	$-\gamma_{51}$	$-\gamma_{52}$	$-\gamma_{53}$	0	0	0	0	$-\gamma_{54}$	γ_{55}	Γ_{56}	0
(xii)	$-\beta_{60}$	0	0	0	0	0	1	γ_{61}	γ_{62}	γ_{63}	0	$-\gamma_{64}$	0	$-\gamma_{65}$	0	0	0	$-\gamma_{66}$

Appendix 6: Examination of Identifiability conditions for the model

(A1) Matrix of excluded variables from equation vii:

Equation	INC	MAN	EDU	CRE	AGE	HHS	TOX	HLV	MKO
(viii)	1	1	1	0	0	0	0	0	0
(ix)	1	0	0	1	1	0	0	0	0
(x)	0	0	1	0	0	0	0	0	0
(xi)	0	0	0	0	0	1	1	1	0
(xii)	1	0	1	0	1	0	0	0	1

(A2) Non-zero Determinant Matrix for equation vii:

Equation	INC	EDU	HHS	TOX	HLV
(viii)	1	1	0	0	0
(ix)	1	0	0	0	0
(x)	0	1	0	0	0
(xi)	0	0	1	1	1
(xii)	0	1	0	0	0

(B1) Matrix of excluded variables from equation viii:

Equation	AAP	PES	HYV	LAB	AGE	CRE	HHS	TOX	HLV	MKO
(vii)	1	1	1	1	0	0	0	0	0	0
(ix)	0	1	0	0	1	1	0	0	0	0
(x)	0	0	1	0	0	0	0	0	0	0
(xi	0	0	0	1	0	0	1	1	1	0
(xii)	0	0	0	0	1	0	0	0	0	1

(B2) Non-zero Determinant Matrix for equation viii:

Equation	AAP	PES	HYV	LAB	AGE
(vii)	1	1	1	1	0
(ix)	0	1	0	0	1
(x)	0	0	1	0	0
(xi)	0	0	0	1	0
(xii)	0	0	0	0	1

(C1) Matrix of excluded variables from equation ix:

Equation	AAP	FER	HYV	LAB	EDU	MAN	HHS	TOX	HLV	MKO
(vii)	1	1	1	1	0	0	0	0	0	0
(viii)	0	1	0	0	1	1	0	0	0	0
(x)	0	1	1	0	1	0	0	0	0	0
(xi)	0	0	0	1	0	0	1	1	1	0
(xii)	0	0	0	0	1	0	0	0	0	1

(C2) Non-zero Determinant Matrix for equation ix:

Equation	AAP	FER	HYV	LAB	EDU
(vii)	1	1	1	1	0
(viii)	0	1	0	0	1
(x)	0	1	1	0	1
(xi)	0	0	0	1	0
(xii)	0	0	0	0	1

(D1) Matrix of excluded variables from equation x:

Equation	PES	LAB	MAN	EDU	CRE	AGE	HHS	TOX	HLV	MKO
(vii)	1	1	0	0	0	0	0	0	0	0
(viii)	0	0	1	1	0	0	0	0	0	0
(ix)	1	0	0	0	1	1	0	0	0	0
(xi)	0	1	0	0	0	0	1	1	1	0
(xii)	0	0	0	1	0	1	0	0	0	1

(D2) Non-zero Determinant Matrix for equation x:

Equation	CHE	LAB	EDU	AGE	MAN
(vii)	1	1	0	0	0
(viii)	0	0	1	0	1
(ix)	1	0	0	1	0
(xi)	0	1	0	0	0
(xii)	0	0	1	1	0

(E1) Matrix of excluded variables from equation xi:

Equation	AAP	FER	PES	HYV	INC	MAN	EDU	CRE	AGE	MKO
(vii)	1	1	1	1	0	0	0	0	0	0
(viii)	0	1	0	0	1	1	1	0	0	0
(ix)	0	0	1	0	1	0	0	1	1	0
(x)	0	1	0	1	1	0	0	0	0	0
(xii)	0	0	0	0	1	0	1	0	1	1

E2): Non-zero Determinant Matrix for equation xi:

Equation	INC	EDU	AGE	MAN	MKO
(vii)	0	0	0	0	0
(viii)	1	1	0	1	0
(ix)	1	0	1	0	0
(x)	1	0	0	0	0
(xii)	0	1	1	0	1

F1: Matrix of excluded variables from equation xii:

Equation	AAP	FER	PES	HYV	LAB	MAN	CRE	HHS	TOX	HLV
(vii)	1	1	1	1	1	0	0	0	0	0
(viii)	0	1	0	0	0	1	0	0	0	0
(ix)	0	0	1	0	0	0	0	0	0	0
(x)	0	1	0	1	0	0	1	0	0	0
(xi)	0	0	0	0	1	0	0	1	1	1

F2: Non-zero Determinant Matrix for equation xii:

Equation	AAP	FER	PES	HYV	LAB
(vii)	1	1	1	1	1
(viii)	0	1	0	0	0
(ix)	0	0	1	0	0
(x)	0	1	0	1	0
(xi)	0	0	0	0	1

Note: The number 1 and 0 indicates respectively the existence and absence of a coefficient in a particular equation

Source: Own compilation

Appendix 7(a): 3SLS Output for Men Sample

```
--> 3SLS;Lhs=AAP,FER,PES,HYV,LAB,INC;Eq1=TFR,DTZ,DDS,FER,PES,HYV,
      ,LAB;Eq2=MAN,EDU,TFR,DTZ,DDS,INC;Eq3=CRE,AGE,TFR,DTZ,DDS
      ,INC;Eq4=AAP,FER,INC,TFR,DTZ,DDS;Eq5=HHS,TOX,HLV,TFR,DTZ
      ,DDS;Eq6=MKO,AGE,EDU,TFR,DTZ,DDS;Inst=MAN,CRE,AGE,EDU,HHS
      ,TOX,HLV,TFR,DTZ,DDS$
+---------------------------------------------------------------------+
| Estimates for equation: AAP                                         |
| InstVar/GLS least squares regression    Weighting variable = none   |
| Dep. var. = AAP Mean=   374.1481944     , S.D.=   25130.51851       |
| Model size: Observations =     120, Parameters =   8, Deg.Fr.=  112 |
|  Residuals:  Sum of squares= .4998721552E+40, Std.Dev.=************ |
| Fit:       R-squared=*********, Adjusted R-squared = ************** |
|            (Note:  Not using OLS.  R-squared is not bounded in [0,1] |
| Diagnostic: Log-L = -5367.6232,Restricted(b=0) Log-L =   -1385.5911 |
|            LogAmemiyaPrCrt.=   86.756, Akaike Info. Crt.=     89.594 |
| Durbin-Watson Stat.=     1.8122      Autocorrelation   =      .0939 |
+---------+-------------+----------------+--------+---------+---------+
|Variable |Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+----------------+--------+---------+---------+
 TFR       -2799.842192      1127.4775       -2.483    .0130   -180.81667
 DTZ       -4754.980428      2942.4384       -8.171    .0000    8.2603750
 DDS       -27.71354091       62.417884       -.444    .6572    404.05621
 FER        989.3726460       26.866636      36.825    .0000   -636.58333
 PES        29.75661812       80.418207        .370    .7114   -745.46884
 HYV        153.4212293       81.477020       1.883    .0597   -723.88333
 LAB        15.35812768       19.014098        .808    .4192    73.266667
+---------------------------------------------------------------------+
| Estimates for equation: FER                                         |
| InstVar/GLS least squares regression  Weighting variable = none     |
| Dep. var. = FER   Mean=  -5.304861111  , S.D.=   496.1284325        |
| Model size: Observations =   120, Parameters =   6, Deg.Fr.=    114 |
| Residuals:  Sum of squares= 28021768.26  , Std.Dev.=      495.78724 |
| Fit:        R-squared= -.007017, Adjusted R-squared =       -.05118 |
|             (Note: Not using OLS. R-squared is not bounded in [0,1] |
| Diagnostic: Log-L = -911.9327, Restricted(b=0) Log-L =    -914.5907 |
|             LogAmemiyaPrCrt.= 12.461, Akaike Info. Crt.=     15.299 |
| Durbin-Watson Stat.=   1.7594        Autocorrelation   =      .1203 |
+---------+-------------+----------------+--------+---------+---------+
|Variable | Coefficient |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+-------------+----------------+--------+---------+---------+
 MAN      -.1921440790      .12822281       -.015    .9880    .35833333
 EDU       .1555654702      .50502774-01     .308    .7581    3.4000000
 TFR      -.2894286453      .18565019      -1.559    .1190   -180.81667
 DTZ      -.4889465574      5.9839926      -1.616    .1061    8.2603750
 DDS       .2898428640E-01  .14309025       2.026    .0428    404.05621
 INC       .7289293228E-04  .17513936E-06   4.162    .0000    255129.58
+---------------------------------------------------------------------+
```

```
+----------------------------------------------------------------------+
| Estimates for equation: PES                                          |
| InstVar/GLS least squares regression  Weighting variable = none      |
| Dep. var. = PES Mean= -6.212240294    , S.D.=  451.1535817           |
| Model size: Observations =     120, Parameters =   6, Deg.Fr.=  114  |
| Residuals:  Sum of squares= 25925513.64    , Std.Dev.=    476.88236  |
| Fit:        R-squared= -.126699, Adjusted R-squared =       -.17612  |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]  |
| Diagnostic: Log-L =   -907.2674, Restricted(b=0) Log-L =  -903.1875  |
|             LogAmemiyaPrCrt.= 12.383, Akaike Info. Crt.=     15.221  |
| Durbin-Watson Stat.=   2.1035        Autocorrelation  =      -.0518  |
+----------+-------------+----------------+--------+-------+----------+
|Variable  | Coefficient |Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+----------+-------------+----------------+--------+-------+----------+
 CRE        244.1386432      119.20832        2.048   .0406  .21666667
 AGE       -.9680810371      .21534045       -4.496   .0000  46.383333
 TFR       -.1543320156      .15091063       -1.023   .3065 -180.81667
 DTZ       -2.492630907      1.3064103       -1.908   .0564  8.2603750
 DDS       -.6626381432      .16568931       - .400   .6892  404.05621
 INC        .122281055E-03   .31621671E-06     .867   .0001  255129.58
+----------------------------------------------------------------------+
| Estimates for equation: HYV                                          |
| InstVar/GLS least squares regression    Weighting variable = none    |
| Dep. var. = HYV       Mean= -6.032361111    , S.D.=  458.2309642     |
| Model size: Observations =     120, Parameters =   6, Deg.Fr.=  114  |
| Residuals:  Sum of squares= .2750450407E+11, Std.Dev.=  15532.79046  |
| Fit:        R-squared=*********, Adjusted R-squared =  -1208.50174   |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]  |
| Diagnostic: Log-L = -1325.2801, Restricted(b=0) Log-L =   -905.0553  |
|             LogAmemiyaPrCrt.=  19.350, Akaike Info. Crt.=    22.188  |
| Durbin-Watson Stat.=   1.7566        Autocorrelation  =       .1217  |
+----------+-------------+----------------+--------+-------+----------+
|Variable  | Coefficient |Standard Error |b/St.Er.|P[|Z|>z]| Mean of X|
+----------+-------------+----------------+--------+-------+----------+
 TFR       -1.817078662      1.1735227       -1.549  .1214   -180.81667
 DTZ       -3.086028432      1.7664731       -1.747  .0807    8.2603750
 DDS         .1798496275      .11640750E-02   1.545  .1224    404.05621
 EDU         .6515635921E-02  .38783547E-03   1.685  .0919   44897.783
 FER         .6421624440      .33932409E-02   1.633  .1024   -636.58333
 INC       -.1681957557E-03   .13910112E-04  -1.209  .2266    255129.58
+----------------------------------------------------------------------+
| Estimates for equation: LAB                                          |
| InstVar/GLS least squares regression  Weighting variable = none      |
| Dep. var. = LAB     Mean=    .6105555556  , S.D.=   55.00507743      |
| Model size: Observations =   120, Parameters =   6, Deg.Fr.=    114  |
| Residuals:  Sum of squares= 248216.5726  , Std.Dev.=       46.66196  |
| Fit:        R-squared=  .274304, Adjusted R-squared =        .24248  |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]  |
| Model test: F[  5,  114] =    8.62,    Prob value =          .00000  |
| Diagnostic: Log-L = -628.3465, Restricted(b=0) Log-L =    -650.6616  |
|             LogAmemiyaPrCrt.=  7.735, Akaike Info. Crt.=     10.572  |
| Durbin-Watson Stat.=   1.3872        Autocorrelation  =       .3064  |
+----------+-------------+----------------+--------+-------+----------+
```

```
+---------------------------------------------------------------------+
|Variable | Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+--------------+---------------+--------+---------+---------+
 HHS        2.5554129955     1.0391526       2.459    .0139     7.0000000
 TOX       -.1658390687E-01  .11019207E-02 -1.505    .1322   -612.09295
 HLV       -.1405231441E-01  .51674212E-02 -1.908    .0564   -147.17500
 TFR        .2298435492      .12093183       1.901    .0574   -180.81667
 DTZ       3.5412251461     2.2700161       1.560    .1188     8.2603750
 DDS        .1082081094      .8950216E-02   1.209    .2266    404.05621
+---------------------------------------------------------------------+
| Estimates for equation: INC                                         |
| InstVar/GLS least squares regression  Weighting variable = none     |
| Dep. var. = INC   Mean=   2559.589792    , S.D.=   246692.4062      |
| Model size: Observations =     120, Parameters =   6, Deg.Fr.=  114 |
| Residuals: Sum of squares= .4529969011E+13, Std.Dev.=  199340.33780 |
| Fit:       R-squared=  .341565, Adjusted R-squared =          .31269 |
|            (Note:  Not using OLS.  R-squared is not bounded in [0,1] |
| Model test: F[  5,  114] =   11.83,     Prob value =          .00000 |
| Diagnostic: Log-L = -1631.5273, Restricted(b=0) Log-L =  -1659.6782 |
|             LogAmemiyaPrCrt.=  24.454, Akaike Info. Crt.=    27.292 |
| Durbin-Watson Stat.=     2.1484      Autocorrelation   =     -.0742 |
+---------------------------------------------------------------------+
|Variable |Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] | Mean of X|
+---------+-------------+---------------+--------+---------+---------+
 AGE       3667.170048     1143.9908       3.206    .0013     46.383333
 MKO       2015.783731     1300.5056       1.550    .1212     39.516667
 AGE       3694.728717     2213.7380       1.669    .0952     46.383333
 EDU       2287.978266     1276.7736       1.792    .0731      3.4000000
 TFR       -190.0466173     53.111427     -3.578    .0003   -180.81667
 DTZ       -4629.049429    3014.6674      -1.535    .1248     8.2603750
 DDS       -44.90767987     77.886139      -.577    .5642     404.05621
+---------+-------------+---------------+--------+---------+---------+
```

Appendix 7(b): 3SLS output for women sample

```
--> 3SLS;Lhs=AAP,FER,PES,HYV,LAB,INC;Eq1=TFR,DTZ,DDS,FER,PES,HYV,
        ,LAB;Eq2=MAN,EDU,TFR,DTZ,DDS,INC;Eq3=CRE,AGE,TFR,DTZ,DDS
        ,INC;Eq4=AAP,FER,INC,TFR,DTZ,DDS;Eq5=HHS,TOX,HLV,TFR,DTZ
        ,DDS;Eq6=MKO,AGE,EDU,TFR,DTZ,DDS;Inst=MAN,CRE,AGE,EDU,HHS
        ,TOX,HLV,TFR,DTZ,DDS$
+---------------------------------------------------------------------+
| Estimates for equation: AAP                                         |
| InstVar/GLS least squares regression  Weighting variable = none     |
| Dep. var. = AAP Mean=    304.6933333  , S.D.=   27378.69312         |
| Model size: Observations =    120, Parameters =   8, Deg.Fr.=   112 |
| Residuals:  Sum of squares= .7964735622E+48, Std.Dev.=************ |
| Fit:        R-squared=*********, Adjusted R-squared = ************ |
|             (Note: Not using OLS. R-squared is not bounded in [0,1] |
| Diagnostic: Log-L = -6500.8145, Restricted(b=0) Log-L =  -1395.8730 |
|             LogAmemiyaPrCrt.= 105.643, Akaike Info. Crt.=   108.480 |
| Durbin-Watson Stat.=     1.8771      Autocorrelation   =      .0615 |
+---------+-------------+---------------+--------+---------+---------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
TFR	-620.5557583	371.81292	-1.669	.0952	-155.06667
DTZ	-650.0776279	345.78597	-1.880	.0601	8.2385417
DDS	6.216300570	165.69445	3.752	.0002	409.73267
FER	134.9162245	11.869125	11.367	.0000	-785.67500
PES	55.54842844	1.2515253	.444	.6572	-834.81708
HYV	45.78474069	7.6176400	6.010	.0000	-781.93333
LAB	-46.38212046	297.17841	-.156	.8760	123.95833

Estimates for equation: FER
InstVar/GLS least squares regression Weighting variable = none
Dep. var. = FER Mean= -6.547291667 , S.D.= 417.6843157
Model size: Observations = 120, Parameters = 6, Deg.Fr.= 114
Residuals: Sum of squares= 25078755.49 , Std.Dev.= 469.02994
Fit: R-squared= -.271567, Adjusted R-squared = -.32734
(Note: Not using OLS. R-squared is not bounded in [0,1]
Diagnostic: Log-L = -905.2750, Restricted(b=0) Log-L = -893.9376
LogAmemiyaPrCrt.= 12.350, Akaike Info. Crt.= 15.188
Durbin-Watson Stat.= 1.6971 Autocorrelation = .1514

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
MAN	-.1344161043E-01	2.2505693	-.006	.9952	.30833333
EDU	.3874214394	2.1210292	.183	.8551	2.0916667
TFR	-.4902003519	.23488277	-2.087	.0369	-155.06667
DTZ	-.5063233050	.12797366E-02	-1.810	.0703	8.2385417
DDS	-.4839369106E-01	.12521187E-01	-3.865	.0001	409.73267
INC	.7561495461E-04	.16812036E-04	4.498	.0000	176942.06

Estimates for equation: PES
InstVar/GLS least squares regression Weighting variable = none
Dep. var. = PES Mean= -6.956809025 , S.D.= 380.2199048
Model size: Observations = 120, Parameters = 6, Deg.Fr.= 114
Residuals: Sum of squares= 15097476.03 , Std.Dev.= 363.91483
Fit: R-squared= .076230, Adjusted R-squared = .03571
(Note: Not using OLS. R-squared is not bounded in [0,1]
Model test: F[5, 114] = 1.88, Prob value = .10297
Diagnostic: Log-L = -874.8254, Restricted(b=0) Log-L = -882.6605
LogAmemiyaPrCrt.= 11.843, Akaike Info. Crt.= 14.680
Durbin-Watson Stat.= 1.7976 Autocorrelation = .1012

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
CRE	446.9923168	245.196005	1.823	.0682	.15000000
AGE	-.9809036017	.59556989	-1.647	.0995	47.133333
TFR	-.2784586536	.98679750E-01	-1.560	.1188	-155.06667
DTZ	-2.787589755	1.65730662	-1.682	.0926	8.2385417
DDS	-.1951862261E-01	.12593935E-01	-1.550	.1212	409.73267
INC	.1710986681E-03	.37695528E-05	4.539	.0000	176942.06

```
+----------------------------------------------------------------------+
| Estimates for equation: HYV                                          |
| InstVar/GLS least squares regression  Weighting variable = none      |
| Dep. var. = HYV      Mean=  -6.516111111  , S.D.=   425.0784749      |
| Model size: Observations =     120, Parameters =   6, Deg.Fr.=   114 |
| Residuals:  Sum of squares= .2932134983E+11, Std.Dev.=  16037.60653 |
| Fit:        R-squared=*********, Adjusted R-squared =   -1497.36381 |
|             (Note: Not using OLS. R-squared is not bounded in [0,1] |
| Diagnostic: Log-L = -1329.1180, Restricted(b=0) Log-L =   -896.0434 |
|             LogAmemiyaPrCrt.=   19.414, Akaike Info. Crt.=   22.252 |
| Durbin-Watson Stat.=   1.6998        Autocorrelation   =      .1501 |
+---------+-------------+----------------+--------+---------+---------+
|Variable | Coefficient |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+-------------+----------------+--------+---------+---------+
TFR        -1.460644801     .93631077       -1.617   .1059    -155.06667
DTZ        -1.528486696    1.0230835        -1.494   .1351     8.2385417
DDS         .1461649020     .38866927E-01    3.761   .0002     409.73267
EDU        -.2179333476E-01 .18152176E-03  -12.006   .0000     36563.200
FER         .3159940530     .15752445       -2.006   .0449    -785.67500
INC        -.1690741371E-03 .47556335E-04   -3.555   .0004     176942.06
+----------------------------------------------------------------------+
| Estimates for equation: LAB                                          |
| InstVar/GLS least squares regression  Weighting variable = none      |
| Dep. var. = LAB      Mean=   1.032986111  , S.D.=   178.7224220      |
| Model size: Observations =    120, Parameters =   6, Deg.Fr.=    114 |
| Residuals:  Sum of squares= 3304843.017    , Std.Dev.=    170.26406 |
| Fit:        R-squared=  .084787, Adjusted R-squared =        .04465 |
|             (Note: Not using OLS. R-squared is not bounded in [0,1] |
| Model test: F[  5,  114] =    2.11,    Prob value =          .06894 |
| Diagnostic: Log-L = -783.6771, Restricted(b=0) Log-L =    -792.0706 |
|             LogAmemiyaPrCrt.= 10.323, Akaike Info. Crt.=     13.161 |
| Durbin-Watson Stat.=     1.7041      Autocorrelation   =      .1479 |
+---------+-------------+----------------+--------+---------+---------+
|Variable |Coefficient  |Standard Error |b/St.Er.|P[|Z|>z]  |Mean of X|
+---------+-------------+----------------+--------+---------+---------+
HHS        4.0303332443     5.2180899         .772    .4399     5.8333333
TOX        -.5062422664E-01 .29894604       -.169    .8655    -795.99623
HLV        -.4094621932E-01 .21125094E-01  -1.938    .0526    -312.27500
TFR         .2754565061E-01 .45626633E-01    .604    .5460    -155.06667
DTZ        6.5255775887     4.0456154       -1.613    .1067     8.2385417
DDS         .6640151242E-01 .60950766E-01    1.089    .2760     409.73267
+----------------------------------------------------------------------+
| Estimates for equation: INC                                          |
| InstVar/GLS least squares regression  Weighting variable = none      |
| Dep. var. = INC    Mean=   1862.789861  , S.D.=   184951.5569        |
| Model size: Observations =    120, Parameters =   6, Deg.Fr.=    114 |
| Residuals:  Sum of squares= .2994059364E+13, Std.Dev.= 162060.72515 |
| Fit:        R-squared=  .225763, Adjusted R-squared =        .19181 |
|             (Note: Not using OLS. R-squared is not bounded in [0,1] |
| Model test: F[  5,  114] =    6.65,    Prob value =          .00002 |
| Diagnostic: Log-L = -1606.6822, Restricted(b=0) Log-L =  -1625.1124 |
|             LogAmemiyaPrCrt.= 24.040, Akaike Info. Crt.=     26.878 |
| Durbin-Watson Stat.=   2.1668        Autocorrelation   =     -.0834 |
+----------------------------------------------------------------------+
```

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
MKO	4378.421656	2629.68268	1.665	.0959	28.183333
AGE	1804.213069	1503.51089	1.200	.2301	47.133333
EDU	1092.967814	479.08764	2.281	.0225	2.0916667
TFR	-388.5570892	429.13990	-.905	.3652	-155.06667
DTZ	-5077.448783	2619.94262	-1.938	.0526	8.2385417
DDS	69.67599041	57.926756	1.203	.2290	409.73267

Appendix 7(c): 3SLS output for the whole sample

```
--> 3SLS;Lhs=AAP,FER,PES,HYV,LAB,INC;Eq1=TFR,DTZ,DDS,FER,PES,HYV,
      ,LAB;Eq2=MAN,EDU,TFR,DTZ,DDS,INC;Eq3=CRE,AGE,TFR,DTZ,DDS
      ,INC,Eq4=AAP,FER,INC,TFR,DTZ,DDS;Eq5=HHS,TOX,HLV,TFR,DTZ
      ,DDS;Eq6=MKO,AGE,EDU,TFR,DTZ,DDS;Inst=MAN,CRE,AGE,EDU,HHS
      ,TOX,HLV,TFR,DTZ,DDS$
```

Estimates for equation: AAP
InstVar/GLS least squares regression Weighting variable = none
Dep. var. = AAP Mean= 169.7103819 , S.D.= 26554.04819
Model size: Observations = 240, Parameters = 9, Deg.Fr.= 231
Residuals: Sum of squares=.2015104806E+19, Std.Dev.= 93399129.68971
Fit: R-squared=*********, Adjusted R-squared = -12853559.39233
(Note: Not using OLS. R-squared is not bounded in [0,1]
Diagnostic: Log-L = -4740.5329, Restricted(b=0) Log-L = -2784.9092
LogAmemiyaPrCrt.= 36.742, Akaike Info. Crt.= 39.579
Durbin-Watson Stat.= 1.6102 Autocorrelation = .1949

Variable	Coefficient	Standard Error	b/St.Er.	P[|Z|>z]	Mean of X
TFR	-2043.890448	1054.6390	-1.938	.0526	-167.94167
DTZ	-268186.5310	22097.666	-12.136	.0000	8.2494583
DDS	-2111.290841	520.99750	-4.052	.0001	406.89444
FER	549.3194612	303.49142	1.810	.0703	-711.12917
PES	9.365621694	6.0423366	1.550	.1212	-790.14296
HYV	97.10890630	6.2304453	15.586	.0000	-752.90833
LAB	-.1929433811	.21136400	-.913	.3613	98.612500

Estimates for equation: FER
InstVar/GLS least squares regression Weighting variable = none
Dep. var. = FER Mean= -2.963038194 , S.D.= 463.6833115
Model size: Observations = 240, Parameters = 7, Deg.Fr.= 233
Residuals: Sum of squares= 53274736.58 , Std.Dev.= 478.17041
Fit: R-squared= -.067913, Adjusted R-squared = -.09541
(Note: Not using OLS. R-squared is not bounded in [0,1]
Diagnostic: Log-L = -1817.7853, Restricted(b=0) Log-L = -1813.4526
LogAmemiyaPrCrt.= 12.369, Akaike Info. Crt.= 15.207
Durbin-Watson Stat.= 1.6476 Autocorrelation = .1762

```
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 MAN       -.1719986560       .64402323       -.267    .7894     .33333333
 EDU        .2742585397       .17593295       1.559    .1190    2.7458333
 TFR       -.3813717078       .19002078      -2.007    .0447   -167.94167
 DTZ       -.4987441017       .30843791E-01  -1.617    .1060    8.2494583
 DDS       -.3962632186E-01   .96534305E-01  -4.105    .0000   406.89444
 INC        .1753585794E-04   .44851032E-05   3.910    .0001   216035.82
+-------------------------------------------------------------------------+
| Estimates for equation: PES                                             |
| InstVar/GLS least squares regression  Weighting variable = none         |
| Dep. var. = PES Mean= -3.292262330  , S.D.=  418.7233409                |
| Model size: Observations =  240, Parameters =  7, Deg.Fr.=  233          |
| Residuals:  Sum of squares= 48808104.78  , Std.Dev.=  457.68640         |
| Fit:        R-squared= -.199762, Adjusted R-squared =  -.23066          |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]     |
| Diagnostic: Log-L =  -1807.2774, Restricted(b=0) Log-L = -1788.9747     |
|             LogAmemiyaPrCrt.=  12.281, Akaike Info. Crt.=  15.119       |
| Durbin-Watson Stat.=  1.6614       Autocorrelation  =  .1693            |
+---------+--------------+----------------+--------+---------+----------+
|Variable |Coefficient  |Standard Error |b/St.Er.|P[|Z|>z]  |Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 CRE       -303.4063954       63.902295      -2.069   .0386     .18333333
 AGE        1.068240763       .65657084       1.627   .1037    46.758333
 TFR       -.2230918546       .13619771      -1.638   .1015   -167.94167
 DTZ       -2.569535330       1.6304158      -1.576   .1152    8.2494583
 DDS       - 1119277269E-01   .10476553E-01  -1.068   .2854    406.89444
 INC        .5466823251E-05   .22745857E-06   5.731   .0000    216035.82
+-------------------------------------------------------------------------+
| Estimates for equation: HYV                                             |
| InstVar/GLS least squares regression  Weighting variable = none         |
| Dep. var. = HYV      Mean=  -3.137118056  , S.D.=  441.9981256          |
| Model size: Observations =  240, Parameters =  7, Deg.Fr.=  233          |
| Residuals:  Sum of squares= .9555086084E+11, Std.Dev.=  20250.66743      |
| Fit:        R-squared=*********, Adjusted R-squared =  -2161.18649      |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]     |
| Diagnostic: Log-L = -2716.8195, Restricted(b=0) Log-L =  -1801.9576     |
|             LogAmemiyaPrCrt.=  19.861, Akaike Info. Crt.=  22.698       |
| Durbin-Watson Stat.=  1.6526       Autocorrelation  =  .1737            |
+---------+--------------+----------------+--------+---------+----------+
|Variable | Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+--------------+----------------+--------+---------+----------+
 TFR       -2.099142741       .44725360      -4.693    .0000   -167.94167
 DTZ       -2.754391916       .65713234      -1.810    .0703    8.2494583
 DDS       -.2168371256       .53509183E-02  -4.052    .0001    406.89444
 EDU        .1028928264E-02   .64187648E-05   1.603    .1088    40730.492
 FER        .5641941411       .13351207E-01  42.258    .0000   -711.12917
 INC        .1236998636E-05   .72150004E-08   1.714    .0864    216035.82
+-------------------------------------------------------------------------+
```

```
+---------+--------------+----------------+--------+---------+----------+
| Estimates for equation: LAB                                            |
| InstVar/GLS least squares regression    Weighting variable = none      |
| Dep. var. = LAB     Mean=    .4108854167    , S.D.=   134.3710432      |
| Model size: Observations =   240, Parameters =   7, Deg.Fr.=    233     |
| Residuals:  Sum of squares= 3717183.251  , Std.Dev.=      126.30747     |
| Fit:        R-squared=    .112721, Adjusted R-squared =        .08987   |
|             (Note: Not using OLS. R-squared is not bounded in [0,1]    |
| Model test: F[  6,  233] =    4.93,     Prob value =          .00009     |
| Diagnostic: Log-L = -1498.2858, Restricted(b=0) Log-L =  -1516.1894     |
|             LogAmemiyaPrCrt.=  9.706, Akaike Info. Crt.=     12.544     |
| Durbin-Watson Stat.=     1.6876      Autocorrelation   =       .1562     |
+-------------------------------------------------------------------------+
|Variable | Coefficient  |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+--------------+---------------+--------+---------+---------+
 HHS        1.222443800      2.3079196        .530    .5963     6.4166667
 TOX       -.2047485736E-01  .16076821E-01  -1.274    .2028    -704.04459
 HLV       -.2790915378E-01  .10711876E-01  -2.605    .0092    -229.72500
 TFR       -.2431339837E-01  .23497741      -1.035    .3008    -167.94167
 DTZ        4.866641904      2.4504743       1.986    .0471     8.2494583
 DDS       -.1007443563      .63924083E-01  -1.576    .1152     406.89444
+-------------------------------------------------------------------------+
| Estimates for equation: INC                                             |
| InstVar/GLS least squares regression  Weighting variable = none         |
| Dep. var. = INC    Mean=    1105.594913   , S.D.=    221559.1425        |
| Model size: Observations =   240, Parameters =   7, Deg.Fr.=    233     |
| Residuals:  Sum of squares= .1030190850E+14, Std.Dev.= 210271.72792      |
| Fit:        R-squared=   .095527, Adjusted R-squared =        .07224    |
|          (Note: Not using OLS.  R-squared is not bounded in [0,1]       |
| Model test: F[6,    233] =    4.10,     Prob value =          .00062     |
| Diagnostic: Log-L = -3278.4706, Restricted(b=0) Log-L = -3294.0710       |
|             LogAmemiyaPrCrt.=   24.541, Akaike Info. Crt.=   27.379     |
| Durbin-Watson Stat.=     2.0619      Autocorrelation   =      -.0309     |
+---------+--------------+---------------+--------+---------+----------+
|Variable |Coefficient   |Standard Error |b/St.Er.|P[|Z|>z] |Mean of X|
+---------+--------------+---------------+--------+---------+----------+
 MKO        3008.172497     1642.0156        1.832    .0670     33.850000
 AGE        2711.399460     1518.9913        1.785    .0742     46.758333
 EDU        2006.278053     1083.8887        1.851    .0642     2.7458333
 TFR        -113.4621167    71.993729       -1.576    .1160    -167.94167
 DTZ        -4547.150398    2671.6512       -1.702    .0888     8.2494583
 DDS        -33.87795148    48.806533        -.007    .9945     406.89444
+---------+--------------+---------------+--------+---------+----------+
```

Appendix 8: The relationship between access to road and household characteristics

	Men			Women			Whole sample		
	Easy access (<5 km)	Medium access (5-13 km)	Difficult access (>13 km)	Easy access (<5 km)	Medium access (5-13 km)	Difficult access (>13 km)	Easy access (<5 km)	Medium access (5-13 km)	Difficult access (>13 km)
Variable									
Area under cultivation in acres	6.2	7.6	7.7	5.2	4.8	5.7	5.7	6.2	6.7
Total output in (x 1000 TZS)	369.3	334.3	294.5	235.2	171.4	175.1	302.2	252.8	234.8
Market orientation in %	47.0	37.4	28.1	32.8	28.6	23.2	39.9	33.0	25.6
Age of household head in years	49.0	44.7	45.5	52.3	45.9	43.3	50.6	45.3	44.4
Education level for household head in years	3.7	3.3	3.2	1.9	2.3	2.1	2.8	2.8	2.7
Household size	6.4	7.4	7.2	6.0	6.0	5.6	6.2	6.7	6.4
Area cultivated by tractor or oxen % of land	64.1	49.6	54.1	61.1	64.0	53.5	63.0	54.6	53.9
Hired labour price in TZS	446.5	467.2	227.0	363.7	483.2	278.2	407.8	474.1	249.6
Aggregate agricultural productivity (x1000 TZS)	56.5	42.4	35.8	42.1	37.4	30.2	49.3	39.9	33.0
Use of fertiliser in kg per acre	35.7	36.8	37.9	23.8	34.1	13.0	31.1	35.8	30.2
Area under pesticide in % of land	37.1	66.8	52.6	27.9	57.3	36.6	33.1	63.2	46.9
Area under high yielding variety	39.6	28.6	22.1	43.5	46.7	35.3	41.5	35.8	26.9
Use of labour in man-days	61.8	64.7	93.3	85.7	114.7	171.5	73.7	89.7	132.4
Household annual income (x 1000 TZS)	413.3	207.3	144.8	264.8	150.2	115.9	339.1	178.7	130.3

Source: Own survey, 1999/2000

Appendix 9: Major crop output in the study Area

(a) Coast Region

Year	Units	Crops								
		Maize	Sorghum	Millet	Bananas	Wheat	Paddy (Rice equivalent)	Beans	Cassava	Sweet potatoes
1991/92	Output (x1000 tons)	0.3	5.3		79.5		5.3	10.3	98.2	5.8
	Area (x1000 ha)	0.9	3.2		10.5		10.5	0.9	35.9	0.6
	Price (TZS/kg)	57.2	72.3		53.0		121.7	108.0	57.3	58.0
1992/93	Output (x1000 tons)	2.0	6.8		116.2		10.9	11.2	159.3	8.2
	Area (x1000 ha)	2.5	11.0		10.4		18.1	2.5	59.4	2.5
	Price (TZS/kg)	62.3	89.9		69.0		175.9	139.0	68.2	77.0
1993/94	Output (x1000 tons)	1.9	11.0		66.5		11.8	11.3	173.2	8.4
	Area (x1000 ha)	2.5	6.9		10.5		19.5	2.1	61.6	2.6
	Price (TZS/kg)	82.3	88.0		83.0		200.9	231.1	82.5	83.0
1994/95	Output (x1000 tons)	6.4	12.6		97.4		2.0	10.9	108.2	7.0
	Area (000 ha)	5.8	8.5		16.6		2.5	2.3	39.7	1.6
	Price (TZS/kg)	103.9	153.2		123.0		309.3	347.8	97.2	106.0
1995/96	Output (x1000 tons)	1.9	12.9		87.4		14.3	10.8	112.1	7.0
	Area (x1000 ha)	2.8	8.8		16.6		23.6	2.1	41.2	1.6
	Price (TZS/kg)	124.2	213.6		166.0		314.8	322.0	116.2	130.0
1996/97	Output (x1000 tons)	14.9	10.6		147.4		14.3	10.8	112.5	7.1
	Area (x1000 ha)	17.9	8.2		15.6		23.3	1.9	39.7	1.5
	Price (TZS/kg)	117.5	147.3		183.0		361.5	359.8	137.8	139.0
1997/98	Output (x1000 tons)	39.4	13.5		108.2		45.8	19.4	105.2	8.6
	Area (x1000 ha)	46.4	18.7		20.0		50.9	0.5	54.7	4.5
	Price (TZS/kg)	142.5	186.9		168.0		378.9	435.5	100.4	168.0
1998/99	Output (x1000 tons)	12.9	11.7		144.6		17.6	12.6	122.2	7.6
	Area (x1000 ha)	15.1	10.2		31.0		24.0	5.8	47.4	2.4
	Price (TZS/kg)	176.3	329.0		227.0		372.7	403.7	106.8	178.0
AVG OUTPUT (kg)		10.0	10.6		105.9		15.2	12.2	123.9	7.5
AVERAGE AREA (x1000 ha)		11.7	9.4		16.4		21.5	2.3	47.4	2.2
AVERAGE PRICE (TZS/kg)		108.3	160.0		134.0		279.5	293.4	95.8	117.4
OUTPUT VALUE (Million TZS)		1078.7	1,688.7		14,190.6		4,260.7	3,569.5	11,866.4	876.2

(b) Morogoro Region

Year	Units	Crop								
		Maize	Sorghum	Millet	Bananas	Wheat	Paddy (Rice equivalent)	Beans	Cassava	Sweet potatoes
1991/92	Output (x1000 tons)	99.4	36.0	0.1	107.2		66.9	33.6	92.9	18.0
	Area (x1000 ha)	113.7	21.0	0.1	25.0		49.1	22.5	33.8	2.3
	Price (TZS/kg)	50.4	74.3	67.3	53.0		120.7	79.8	57.3	58.0
1992/93	Output (x1000 tons)	60.2	47.8	0.1	51.3		109.2	37.3	87.5	18.0
	Area (x1000 ha)	73.3	36.8	0.1	25.3		54.6	20.1	31.7	2.3
	Price (TZS/kg)	54.9	101.6	110.0	69.0		171.3	115.6	68.2	77.0
1993/94	Output (x1000 tons)	120.4	36.8	0.1	95.3		118.5	37.3	90.0	18.0
	Area (x1000 ha)	76.9	37.3	0.1	25.3		59.2	20.3	32.7	2.3
	Price (TZS/kg)	69.2	82. 0	90.8	89.0		195.0	222.8	82.5	83.0
1994/95	Output (x1000 tons)	163.8	61.6	0.4	57.9		78.1	44.1	71.2	17.8
	Area (000 ha)	86.0	39.8	2.2	25.9		57.5	20.2	29..7	2.2
	Price (TZS/kg)	77.7	156.3	171.2	123.0		274.4	290.3	97.2	106.0
1995/96	Output (x1000 tons)	110.0	64.6	0.0	86.3		122.6	48.1	86.0	17.9
	Area (x1000 ha)	69.2	39.0	2.2	25.8		78.3	20.8	31.1	2.2
	Price (TZS/kg)	120.5	229.3	224.8	166.0		292.1	261.1	116.2	130.0
1996/97	Output (x1000 tons)	28.7	53.7	0.4	92.3		121.4	40.4	83.5	19.3
	Area (x1000 ha)	65.4	37.2	2.2	25.8		77.6	18.9	30.1	2.1
	Price (TZS/kg)	115.8	142.5	265.1	183.0		319.1	335.6	137.8	139.0
1997/98	Output (x1000 tons)	101.0	10.5	0.4	113.0		86.7	31.1	23.2	19.4
	Area (x1000 ha)	64.6	0.5	2.2	25.0		43.4	18.4	28.2	2.2
	Price (TZS/kg)	119.4	185.3	142.6	168.0		330.5	407.7	100.4	168.0
1998/99	Output (x1000 tons)	104.8	45.2	0.3	145.8		105.5	41.2	73.0	18.5
	Area (x1000 ha)	72.4	30.8	1.8	33.7		63.2	16.3	26.4	2.2
	Price (TZS/kg)	174.4	332.7		227.0		319.7	333.2	106.8	178.0
AVG OUTPUT (kg)			44.5	0,.2	93.6		101.1	39.1	75.9	18.4
AVERAGE AREA (x1000 ha)			30.3	1,.4	26.5		60.4	19.7	30.5	2.2
AVERAGE PRICE (TZS/kg)			163.0	134,.0	134.8		252.9	255.8	95.8	117.4
OUTPUT VALUE (Million TZS)			7,258.4	27.8	12,617.7		25,565.0	10,009.9	7,272.4	2,155.0

(c) Iringa Region

Year	Units	Crops								
		Maize	Sorghum	Millet	Bananas	Wheat	Paddy (Rice equivalent)	Beans	Cassava	Sweet potatoes
1991/92	Output (x1000 tons)	464.9	28.1	0.2	15.2	18.0	1.4	66.6	5.1	63.1
	Area (x1000 ha)	309.1	23.1	0.3	5.1	14.9	1.3	67.0	2.0	17.8
	Price (TZS/kg)	41.7	89.1	45.0	53.0	80.1	108.9	107.9	57.3	58.0
1992/93	Output (x1000 tons)	399.9	37.0	0.0	15.2	30.9	2.9	81.3	5.3	63.1
	Area (x1000 ha)	171.7	23.0	0.1	5.1	28.8	2.6	59.7	2.0	17.7
	Price (TZS/kg)	45.2	97.3	65.8	69.0	108.9	163.1	120.5	68.2	77.0
1993/94	Output (x1000 tons)	326.3	31.8	0.0	15.2	7.6	2.9	86.0	5.3	63.0
	Area (x1000 ha)	171.7	23.0	0.1	5.1	2.9	2.6	59.7	2.0	17.7
	Price (TZS/kg)	52.7	94.2	60.4	89.0	109.1	193.9	209.6	82.5	83.0
1994/95	Output (x1000 tons)	266.0	22.7	1.6	15.2	19.8	1.4	89.5	5.4	60.7
	Area (000 ha)	149.0	22.7	2.0	5.1	16.2	2.5	56.8	2.1	17.1
	Price (TZS/kg)	72.0	146.4	62.0	123.0	155.3	266.9	292.9	97.2	106.0
1995/96	Output (x1000 tons)	318.0	32.2	1.7	14.8	20.4	1.4	85.4	5.7	60.6
	Area (x1000 ha)	167.4	23.6	2.1	4.9	16.9	2.5	58.3	2.2	17.0
	Price (TZS/kg)	73.3	208.9	90.0	166.0	210.6	272.3	283.1	116.2	130.0
1996/97	Output (x1000 tons)	298.1	28.9	1.4	104.4	19.4	1.4	88.9	5.1	60.0
	Area (x1000 ha)	161.1	23.6	2.1	40.0	16.2	2.5	56.3	2.2	16.6
	Price (TZS/kg)	87.4	175.7	115.0	183.0	224.7	316.1	340.4	137.8	139.0
1997/98	Output (x1000 tons)	562.3	36.8	3.5	114.4	44.7	10.3	40.7	10.3	58.1
	Area (x1000 ha)	330.8	31.8	3.5	40.0	36.1	5.4	40.7	4.5	15.1
	Price (TZS/kg)	100.8	191.3	121.9	168.0	210.4	360.1	421.7	100.4	168.0
1998/99	Output (x1000 tons)	354.1	31.5	1.6	145.8	22.4	3.5	78.1	6.4	60.5
	Area (x1000 ha)	196.0	24.9	2.0	40.9	17.7	3.1	48.4	2.6	16.7
	Price (TZS/kg)	139.3	243.6	221.1	227.0	226.1	332.0	375.4	106.8	178.0
AVG OUTPUT (kg)			31.1	1.3	55.0	22.9	3.1	77.1	6.1	61.1
AVERAGE AREA (x1000 ha)			24.5	1.5	18.3	18.7	2.8	55.9	2.5	17.0
AVERAGE PRICE (TZS/kg)			155.8	97.7	134.8	165.7	251.7	268.9	95.8	117.4
OUTPUT VALUE (Million TZS)			4,849.3	122.6	7,414.6	3,793.0	792.1	20,725.0	581.5	7,175.7

(c) Iringa Region

Year	Units	Crops								
		Maize	Sorghum	Millet	Bananas	Wheat	Paddy (Rice equivalent)	Beans	Cassava	Sweet potatoes
1991/92	Output (x1000 tons)	464.9	28.1	0.2	15.2	18.0	1.4	66.6	5.1	63.1
	Area (x1000 ha)	309.1	23.1	0.3	5.1	14.9	1.3	67.0	2.0	17.8
	Price (TZS/kg)	41.7	89.1	45.0	53.0	80.1	108.9	107.9	57.3	58.0
1992/93	Output (x1000 tons)	399.9	37.0	0.0	15.2	30.9	2.9	81.3	5.3	63.1
	Area (x1000 ha)	171.7	23.0	0.1	5.1	28.8	2.6	59.7	2.0	17.7
	Price (TZS/kg)	45.2	97.3	65.8	69.0	108.9	163.1	120.5	68.2	77.0
1993/94	Output (x1000 tons)	326.3	31.8	0.0	15.2	7.6	2.9	86.0	5.3	63.0
	Area (x1000 ha)	171.7	23.0	0.1	5.1	2.9	2.6	59.7	2.0	17.7
	Price (TZS/kg)	52.7	94.2	60.4	89.0	109.1	193.9	209.6	82.5	83.0
1994/95	Output (x1000 tons)	266.0	22.7	1.6	15.2	19.8	1.4	89.5	5.4	60.7
	Area (000 ha)	149.0	22.7	2.0	5.1	16.2	2.5	56.8	2.1	17.1
	Price (TZS/kg)	72.0	146.4	62.0	123.0	155.3	266.9	292.9	97.2	106.0
1995/96	Output (x1000 tons)	318.0	32.2	1.7	14.8	20.4	1.4	85.4	5.7	60.6
	Area (x1000 ha)	167.4	23.6	2.1	4.9	16.9	2.5	58.3	2.2	17.0
	Price (TZS/kg)	73.3	208.9	90.0	166.0	210.6	272.3	283.1	116.2	130.0
1996/97	Output (x1000 tons)	298.1	28.9	1.4	104.4	19.4	1.4	88.9	5.1	60.0
	Area (x1000 ha)	161.1	23.6	2.1	40.0	16.2	2.5	56.3	2.2	16.6
	Price (TZS/kg)	87.4	175.7	115.0	183.0	224.7	316.1	340.4	137.8	139.0
1997/98	Output (x1000 tons)	562.3	36.8	3.5	114.4	44.7	10.3	40.7	10.3	58.1
	Area (x1000 ha)	330.8	31.8	3.5	40.0	36.1	5.4	40.7	4.5	15.1
	Price (TZS/kg)	100.8	191.3	121.9	168.0	210.4	360.1	421.7	100.4	168.0
1998/99	Output (x1000 tons)	354.1	31.5	1.6	145.8	22.4	3.5	78.1	6.4	60.5
	Area (x1000 ha)	196.0	24.9	2.0	40.9	17.7	3.1	48.4	2.6	16.7
	Price (TZS/kg)	139.3	243.6	221.1	227.0	226.1	332.0	375.4	106.8	178.0
AVG OUTPUT (kg)			31.1	1.3	55.0	22.9	3.1	77.1	6.1	61.1
AVERAGE AREA (x1000 ha)			24.5	1.5	18.3	18.7	2.8	55.9	2.5	17.0
AVERAGE PRICE (TZS/kg)			155.8	97.7	134.8	165.7	251.7	268.9	95.8	117.4
OUTPUT VALUE (Million TZS)			4,849.3	122.6	7,414.6	3,793.0	792.1	20,725.0	581.5	7,175.7

(d) Mbeya Region

Year	Units	Crops								
		Maize	Sorghum	Millet	Bananas	Wheat	Paddy paddy eq.	Beans	Cassava	Sweet potatoes
1991/92	Output (x1000 tons)	287.7	21.4	1.1	91.2	0.2	51.0	62.1	27.0	50.0
	Area (x1000 ha)	197.2	16.4	1.5	25.4	0.2	30.0	30.2	10.4	15.3
	Price (TZS/kg)	32.0	64.0	34.7	53.0	74.8	121.4	93.5	57.3	58.0
1992/93	Output (x1000 tons)	286.6	17.2	0.6	99.0	1.0	112.1	63.5	20.8	56.0
	Area (x1000 ha)	121.0	12.0	1.5	28.0	0.2	48.7	28.1	8.0	20.0
	Price (TZS/kg)	39.2	74.6	35.0	69.0	93.5	176.8	119.2	68.2	77.0
1993/94	Output (x1000 tons)	213.0	11.6	0.5	103.6	0.5	119.8	61.1	22.0	58.8
	Area (x1000 ha)	125.3	12.4	1.6	29.5	0.2	52.1	29.0	8.5	22.1
	Price (TZS/kg)	47.7	69.5	28.6	89.0	119.3	187.9	178.2	82.5	83.0
1994/95	Output (x1000 tons)	315.9	22.5	32.9	104.6	0.5	102.2	68.8	22.5	62.9
	Area (000 ha)	114.8	17.5	13.1	37.9	0.5	29.7	34.2	8.8	23.0
	Price (TZS/kg)	63.5	117.3	93.5	123.0	148.6	291.9	272.3	97.2	106.0
1995/96	Output (x1000 tons)	218.1	10.2	17.4	104.5	0.5	162.2	73.4	22.7	61.0
	Area (x1000 ha)	128.3	16.9	12.9	37.9	0.5	51.7	32.7	8.9	22.8
	Price (TZS/kg)	71.5	162.5	50.0	166.0	182.1	302.8	252.0	116.2	130.0
1996/97	Output (x1000 tons)	214.8	15.4	17.2	104.5	0.5	113.9	66.7	21.7	65.7
	Area (x1000 ha)	126.3	16.8	12.7	37.8	0.5	50.5	31.7	8.5	22.6
	Price (TZS/kg)	70.3	104.6	195.0	183.0	154.4	303.3	254.2	137.8	139.0
1997/98	Output (x1000 tons)	252.6	13.4	18.1	132.3	0.5	119.6	68.0	22.8	67.5
	Area (x1000 ha)	126.3	16.8	12.7	37.8	0.5	50.5	31.7	8.5	23.7
	Price (TZS/kg)	84.6	120.4	121.9	168.0	178.6	357.4	319.2	100.4	168.0
1998/99	Output (x1000 tons)	242.9	16.7	17.2	112.9	0.5	123.5	65.6	22.3	65.2
	Area (x1000 ha)	124.2	16.1	10.6	36.2	0.4	46.9	31.9	8.6	22.8
	Price (TZS/kg)	122.3	227.2	221.1	227.0	210.8	302.5	297.0	106.8	178.0
AVG OUTPUT (kg)			16.1	13.1	106.6	0.5	113.0	65.2	22.7	60.9
AVERAGE AREA (x1000 ha)			15.6	8.3	33.8	0.4	45.0	31.2	8.8	21.5
AVERAGE PRICE (TZS/kg)			117.5	97.5	134.8	145.3	255.5	223.2	95.8	117.4
OUTPUT VALUE (Million TZS)			1,892.0	1,279.6	14,361.0	76.3	28882.4	14,764.7	2,177.5	7146.4

Source: Agricultural and livestock basic statistics, 1998/1999

Appendix 10: Internal rate of return (IRR) and sensitivity analysis

Project year	Benefits flow	Benefits over estimated by 10%	Benefits over estimated by 20%	Cost under estimated 10%	Cost under estimated 20%
0	-44820	-44820	-44820	-49302	-53784
1	-90	-90	-90	-99	-108
2	-90	-90	-90	-99	-108
3	10148	9133	8118	10148	10148
4	15267	13740	12214	15267	15267
5	20386	18347	16309	20386	20386
6	16009	14408	12807	16009	16009
7	20386	18347	16309	20386	20386
8	20386	18347	16309	20386	20386
10	20386	18347	16309	20386	20386
11	20386	18347	16309	20386	20386
12	16285	14656	13028	16285	16285
13	20386	18347	16309	20386	20386
14	20386	18347	16309	20386	20386
15	20386	18347	16309	20386	20386
16	20386	18347	16309	20386	20386
17	20386	18347	16309	20386	20386
18	16285	14656	13028	16285	16285
19	20386	18347	16309	20386	20386
20	20386	18347	16309	20386	20386
IRR after 10 years	19.8	17.7	15.5	17.9	16.2
IRR after 15 years	23.1	21.3	19.3	21.5	20.0
IRR after 20 years	24.0	22.3	15.5	22.4	21.0