Dynamics of Poverty traps in Kenya: ***Modelling Food Security, Population Growth and the Poverty Trap***

By

Eric Omwanza Momanyi

2700278

Mini-Thesis submitted in Partial fulfilment of the Requirements for the Award of the Degree of Master of Arts in Development Studies at the University of the Western Cape.

Supervised by

Sharon Penderis

Institute of Social Development, University of the Western Cape

and

Birgit Kopainsky, PhD

University of Bergen

2010

Acknowledgement

This research work could not have been possible without support from numerous sources.

First I want to thank the Almighty God for the hitherto unimaginable opportunity to study in South Africa and Norway. For the provision, sustenance, protection and guidance, I am forever grateful.

Special appreciation goes to my two supervisors: Sharon for her prompt and tirelessly accurate feedback, encouragement and bearing with me during the numerous breaks. Birgit for believing in me, cheering me on and giving me technical support in developing the model and guidance on the thesis' technical aspects.

I want to thank my colleagues at the University of the Western Cape and the University of Bergen for their friendship and support. My friends Tony, Lydia, Ezra, Becky, Douglas, BT, Frode, Birgit, Alfred, Irem, Maria, Hassan and many more that I cannot name here for lack of space whose friendship brought the balance I so much needed. Technical feedback on presentation of this work to non-system dynamics audiences from Matteo Pedercini is recognized and appreciated.

I want to thank my brother Dan, for the financial support and understanding especially during the low times. Uncle Kimwomi, your constant messages of support are highly appreciated. Sammy and Margaret, thank you for having been there for me when I needed you.

Last but not least, I want to thank my fiancée Lusu for her support, encouragement and patience with me as I travelled the seemingly endless road in this research. Your support and smile gave me the strength to wake up each day and look forward to the end of it, especially during the tough times in 2009.

I however take responsibility for all the omissions, shortcomings and remaining errors.

List of Abbreviations

AFDB – African Development Bank

CASASP – Centre of Analysis for South African Social Policy

CMA – Chartered Management Accountants

DFID – Department of International Development

HDI – Human Development Index

HPI – Human Poverty Index

ICARRD – International Centre on Agrarian Reform and Rural Development

IFPRI – International Food Policy Research Institute

ILO – International Labour Organisation

KBNS – Kenya National Bureau of Statistics

KDNLP – Kenya Draft National Land Policy

MIT – Massachusetts Institute of Technology

ODC – Overseas Development Council

PQLI – Physical Quality of Life Index

SD – System Dynamics

UNSD – United Nations Statistics Division

UNDP – United Nations Development Programme

UNFPA – United Nations Family Planning Association

USAID – United States of America International Development

USDA – United States Department of Agriculture

Table of Contents

Table of Figures

Abstract

Rural poverty accounts for 63% of poverty worldwide. Land has been identified as a key productive asset in the hands of the rural poor. Through this land, the poor are able to produce food for their growing population numbers and sale of surplus to invest in more productive assets. This research project built a System Dynamics model to track the dynamic linkages between changes in the population, food available and land, and its impact on poverty traps in rural Kenya. The model was fitted with Kenyan population data from 1980 to 2005 and rural poverty headcount data for Kenya over the same period. Parameter values were estimated from several assorted publications. The model was used to test the policy implications of increase in land productivity and wage rates on poverty traps in rural settings. Preliminary results indicate that there is need to ensure the poor benefit from efforts of increasing land productivity for it to have a desirable poverty reduction impact. Furthermore, it emerged that demographic changes need to be monitored carefully to achieve a desirable and sustainable population-ecosystem equilibrium that enables the rural poor improve their livelihoods.

Key Words: Land, Peasant Land, Capitalist Land, Population, Food, Poverty Traps, System Dynamics, Model

1 INTRODUCTION

An enormous amount of money has been spent in the past couple of decades in efforts to improve the standards of living of people in developing countries (Baker, 2000). Loans from international lending institutions, development aid, bi-lateral assistance, amongst other channels, have been used extensively in the fight against poverty. Nevertheless, around one billion people still live below the poverty line and of these 800 million go hungry each day (Sachs, 2005). Furthermore, rural poverty accounts for nearly 63 per cent of poverty worldwide (Dao, 2004).

Over the years, different development theories have been the impetus behind public policies targeted at combating poverty and improving the standards of living of people in developing countries (Martinussen and Pedersen, 2003). These theories have constantly evolved as attempts are made to respond to their weaknesses and take into consideration emerging realities.

Evaluation reports on the progress of most development projects indicate mixed results. There is a general consensus that the objective of poverty reduction is not being achieved satisfactorily according to the expectations of all concerned. A report of the African Development Bank's development projects in Kenya relates the relative inability of these projects to achieve their intended objectives (AFDB, 2005). Whereas the bank set out to fund projects whose conception was based on felt needs of the Kenya government, the report acknowledges that there were inherent inadequacies in the strategies employed, amongst other weaknesses, leading to failure of these projects to achieve their objectives. The African Development Bank is not alone in this predicament; other evaluation reports of development projects share a similar story (USAID/Kenya, 2005; DFID, 2007). The Department for International Development's (DFID) evaluation report for 2007 indicates a 60 percent successful completion rate of its programs in Kenya. It also acknowledges that there is need to pay closer attention to pro-poor economic growth (DFID, 2007). Thus in spite of poverty reduction being a perpetual goal in almost all implemented development projects, failure of these projects to achieve targeted poverty reduction goals pose a unique challenge to most governments and other policy implementers.

Whereas lack of implementation capacity and poor governance in Kenya, amongst other reasons, have been proposed as possible causes of this failure (AFDB, 2005), reports emerging from other developing countries indicate a similar trend (Ferguson, 1990; AFDB, 2007). This recurrent trend has been attributed to limitations in the understanding of the underlying causes of poverty and food insecurity. The World Bank reports that there is a lack of proper articulation of poverty reduction strategies in projects implemented by the Kenya government between the 1998 – 2002 period under evaluation (World Bank, 2004).

With this in mind, it is therefore necessary to focus our efforts in understanding and articulating the complexity of poverty in order to design policies that respond appropriately to the problems so defined. Whereas the concept of poverty is a complex one with multidimensional causality, the focus of this research will be on the dynamic relationship between food security, population growth and their relationship to the poverty trap. For this purpose a computer simulation model will be developed that represents the relationship between these concepts and that allows for a formal analysis of their dynamic implications. Whereas the model envisaged in this research is a generic developing country context, the researcher shall use Kenyan data to estimate parameters used in the model.

1.1 Modelling Poverty in Existing Literature

Any scholar tackling the poverty phenomenon will acknowledge its complexity. There is a great deal of conceptual level understanding of poverty. In practice, the positive and negative factors that tend to increase or decrease poverty work simultaneously (Aziz, 2001). This makes it difficult to conclude whether a specific set of interventions can actually effectively reduce poverty.

Several attempts have been made in the past to develop models to measure poverty mainly using statistical and econometric tools. These measures, which include composite indices and regression analysis, attempt to map the complex relationship of the various factors contributing to the poverty trap. Composite indices so developed include the Physical Quality of Life Index (PQLI), developed by Morris (1979) for the Overseas Development Council (ODC), Index of Social Progress (Estes, 1997), the Human Development Index (HDI) and Human Poverty Index (HPI). Regression analysis on household data is also a common approach to understand the relationship between poverty and the independent variables collected at the household level.

1.2 Limitations of statistical and econometric analysis

The use of statistics and econometric analysis is a laudable attempt at demystifying the complex phenomenon of poverty. However, they have not remained without critique. These include but are not limited to:

- Usage of these indices is limited to data availability. For composite indices to be comparable across countries there is need for available uniform data (Haarmann, 1998:145). This is especially so when you consider that data collection in most developing countries is either developing, crude or non-existent altogether.
- Composite indices by their nature combine various indicators using different weights. This is meant to standardise the indices for purposes of comparability. However, as the UN acknowledges, different cultures place value on different aspects of human life (UNDP, 1994). Further, Deaton argues that whereas it may practically be useful to combine indicators into a single measure, there is no adequate underlying theory to determine the extent of weighting. This leaves weighting schemes to arbitrary value judgement. Deaton argues further that it is more informative as well as honest to keep the different indicators separate (Deaton, 1997).
- Particular indices have been accused of excluding one or more components of development (Booysen, 2002). Booysen argues that the HDI excludes other social achievements crucial to the quality of life of most notably political freedom and human rights which are considered critical for the enjoyment of freedom and capabilities.
- Composite indices have also been criticised for being unable to reveal anything more than a single variable can reveal. This argument is often employed by proponents of income based indicators (Booysen, 2002).
- The ad hoc selection of indicators in the computation of composite indices cannot be ignored. Elkan (1995) argues that the HDI has been made to be a politically motivated index intended to boost rankings of countries making concerted efforts at addressing health and education backlogs. Ad hoc selection may also be in the area of technical criteria where availability or accuracy of data alone drives the selection process of the indicators (Booysen, 2002).
- Accuracy and comparability of data used has faced sharp criticism. Lind (1992) and Ogwang (1994) consider the HDI as empirically unsound and conceptually weak given the measurement errors, bias and incompatibility inherent in the underlying data.

> For Booysen 'Some of the variables are on mathematical extrapolation rather than actual observation' (2002:140).

Regression analysis on the other hand, while a useful tool, often works on the assumption that the independent variable chosen is indeed exogenous (World Bank, 2001). However, owing to the existence of feedback, there is often a high possibility of endogenization of the so called 'exogenous' variables. Further, it is worthwhile to note that regression analysis might be useful in identifying the immediate causes of poverty, but becomes less successful in finding the deep underlying influences behind the immediate causes.

1.3 System Dynamics Modelling

Systems dynamics is a computer based tool for modelling and simulating complex problems that occur over time. Wolstenholme (1990:2) defined it as:

> 'A rigorous method for qualitative description, exploration and analysis of complex systems in terms of their processes, information, organisational boundaries and strategies; which facilitates quantitative simulation modelling and analysis for the design of system structure and behaviour.'

Sterman (2000), Coyle (1996) and Richardson and Pugh II (1981) warn that systems dynamics is not a tool to model systems per se, but to model problems. It is an iterative process that involves the reconstruction of the underlying system structures and uses computer simulation to generate the observed behaviour. The main point of departure from mainstream modelling tools is that it takes into consideration the effect of feedback, time delays and nonlinear relationships between cause and effect in the system. The aim of system dynamics is to recreate the problem-causing structure so that firstly, we can understand the problem and secondly, we can suggest policy options that can address the problem.

System dynamics is a computer based simulation approach. It is primarily used for policy design and analysis. As feedback loops, time delays and nonlinear relationships are explicitly considered in the models, the main purpose of a modelling effort is to analyse the behaviour patterns of a given system, the stability of the system and the mechanisms that promote or prevent the desired effects of policy interventions. The simulation models are, however, not suitable for precise predictions of system states for a specific point in time.

Systems Dynamics was developed by Jay Forrester at the Massachusetts Institute of Technology (MIT) in the 1950's. He developed it based on feedback systems in control theory. His intention was to find a tool that could be used to model complexities. Initial application of system dynamics was in complex management problems such as instabilities in production and employment, inconsistent corporate growth, and declining market share (Richardson and Pugh III, 1981). In latter years, system dynamics has been used in project management, environmental modelling, development planning among other complex problems (Sterman, 2000; Ford, 1999). Forrester contends that the growing field of systems dynamics is seen as the best tool for dealing with multiple-feedback-loops and nonlinear systems that extend across many different disciplines (Coyle, 1996: xii).

The focus of system dynamics, therefore, is to understand and analyse systems taking keen notice of feedback to analyse complexity in systems. There are numerous variables and feedback processes that must be mastered before anyone can assume to have understood dynamics within systems. Sterman (2000) argues, however, that the most complex behaviours within systems arise out of the interactions (feedbacks) among the components of a system and not necessarily from the complexity of the components themselves. Often it is these changing relationships between variables as a result of feedback that lead to policy resistance.

This research used the systems dynamics approach to investigate the interrelationships of issues such as food security, population growth and how these interactions dynamically affect those individuals caught in poverty traps. The focus was modelling the relationship between these variables and introducing feedback in order to develop some insights into the nature of policy resistance in poverty reduction programs. The researcher has taken courses in systems dynamics at the University of Bergen in Norway. He is currently involved in a project called the Bergen Learning Environment for Development Planning (BLEND) that aims to produce a holistic National Development model for developing countries using the system dynamics approach. The work produced in this thesis draws on the expertise achieved while working with BLEND but is the sole initiative of the author.

The system dynamics model developed in this research is implemented using the *Vensim* Simulation Software.

1.4 Introduction to Kenya

The Republic of Kenya has an area of approximately 582,646 square kilometres of land (KDNLP, 2005). This comprises 97.8% land, while the remainder is occupied by water masses. Of this land, only 20% can be classified as medium to high potential while the rest is either arid or semi arid. Population density varies from as low as two persons per square kilometre in the Arid and Semi Arid areas, to 2000 persons per square kilometre in the high potential areas.

The 1999 census places the Kenyan population at 30 million, while it is projected that this number will reach the 40 million mark in the 2009 census. A total of 20% of this population is urbanised, while 80% live in the rural areas and derive their livelihoods from agriculture (ICARRD, 2006).

The pattern of land ownership in Kenya is influenced by historical developments that date back to the colonial period. During this time, the British established a number of legislations that converted land that was initially communal land into state land and granted subsidiary rights to individuals (Syagga, 2007). Entrenchment of colonialism in Kenya brought about a number of issues including massive alienation of land from Africans and individualization of tenure. This led to inequality in land ownership and use, landlessness, squatting and the resultant poverty.

Independence in Kenya did not bring the anticipated land reforms that were the rallying cry of most independence activists. There is no doubt that the colonial legacy was upheld. Colonial themes and patterns of organisation in almost all aspects of the economy were maintained. In the early independence period, Kenya had two property regimes that have persisted to date. These included a land tenure system based on English law that applies to high potential-export-oriented areas and a largely neglected regime of customary law in the so called 'marginal areas'. This involves a land distribution structure characterised by large landholdings on high potential land and highly degraded and fragmented holdings in other areas (Syagga, 2007).

Rural farmers in Kenya cultivate both subsistence and cash crops. Food crops are planted both for domestic consumption and surplus sales among the small holders, while large scale farmers mainly produce for sale. Food crops cultivated in Kenya include maize, wheat, rice, potatoes, beans and bananas, amongst others. Cash crops include those crops cultivated mainly for sale and comprise raw material inputs in the manufacture of different products. These are both food and non-food crops including pyrethrum, coffee and tea.

Rural poverty in Kenya has demonstrated resilient behaviour over time. In spite of decades of poverty reduction efforts targeting the agricultural sector, the proportion of people living below the established poverty line[1] has not seen any remarkable change. If anything, there are times when this condition has worsened. Figure 1.1 below illustrates this pattern in the last three decades.

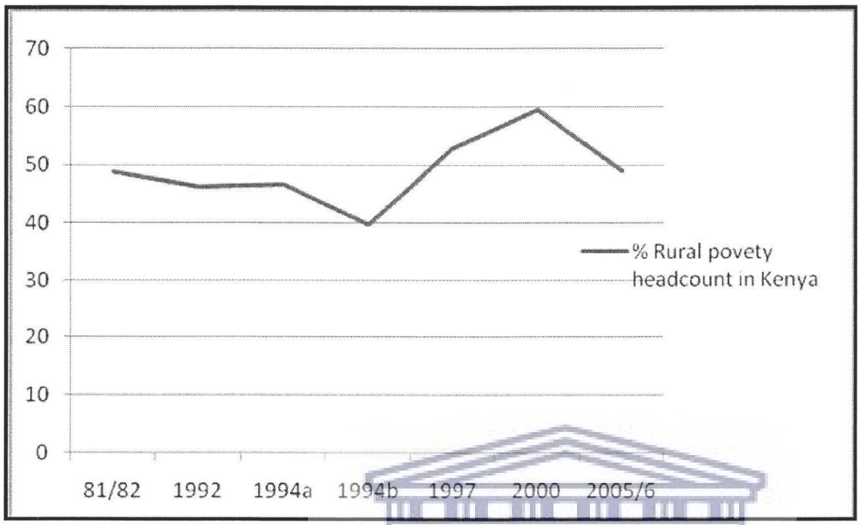

Figure 1:1 - Time series poverty headcount in Kenya (KNBS, 2007).

1.5 Problem statement

Poverty in developing countries is a complex phenomenon. Following the description above, it is clear that there is neither general consensus of the real causes of it, nor a general agreement on the appropriateness of the policies implemented to counter it. Chances are that policies implemented actually increased the level of poverty and had no positive impact as a result of negative feedback. The poverty problem therefore seems to resist well intentioned policies. Additionally, well intentioned policies to alleviate food insecurity and poverty in the past have often had unanticipated effects. These, over time, have cemented or even worsened the existing problem(s) (Saeed, 2003). Existing econometric and statistical tools have not succeeded to map the relationship between the various variables and parameters beyond causation and correlation in explaining poverty traps. Most importantly, the feedback that results from the system has not been taken into account in existing poverty research. Whereas the issue of poverty is complex, the scope of this research was not intended to model it comprehensively. The researcher therefore intended to establish a boundary and model the

[1] The Poverty line used is the Cost-of-Basic Needs approach outlined in Ravallion (1994, 1998) that stipulates a consumption bundle seems to be adequate for basic consumption and estimates what this bundle costs in reference to prices.

relationship between population growth, food security and the poverty trap. This will leave room for expansion of the model to cover all variables in poverty dynamics in subsequent research.

Whereas this model is generic to represent a typical developing country context, data from Kenya was used. This data helped develop a reference behaviour pattern as well as a basis for estimation of parameters in the model.

1.5.1 Aims of the research

The aim of this research is therefore to model the relationship between population growth, food security/insecurity and their link to poverty traps. Specific aims of this research include to:

- Develop an understanding of the dynamic relationship between poverty, food security and changes in population and of the effect of delays and nonlinear relationships between cause and effect on the dynamics of poverty traps.
- Analyse certain existing food security policies and determine their implications for poverty reduction in the context of the model.
- Derive policy relevant conclusions and make suggestions for further research.

1.5.2 Research Design

The research design employed in this project is mainly quantitative with the building of the quantitative structural system dynamics model being the main activity. Given the nature of the topic being addressed, this paradigm is the most suitable as it enables presentation of the variables that are important in understanding the dynamic relationships that keep poor people entrapped in poverty.

> 'Modellers believe not only that aggregate human actions can be quantified into computer equations and that computer equations can be grouped into representations or models of social systems but also that these models are at least potentially better representations than any others that might be used as a basis for social decisions' (Meadows, 1980:26).

Consequently, this project will seek to quantify these relationships by building a computer model that will be used to analyse poverty traps, providing insights into their nature and make recommendations on further research with the aim of understanding poverty reduction policy resistance that has been experienced in many developing countries.

Many statistical models are validated based on the value of the coefficient of determination (R^2), which represents the statistical fit of the model simulation compared to the equivalent data series. In this instance, the validity of this model will be based on the validity and logical consistency of its structure (Saeed, 1980). Consistency of these two aspects of the model will mean that the model has a realistic representation of simplified reality with respect to the problematic system reproduced.

1.5.3 Research Methodology

A variety of research tools were used in this research. These are briefly summarised below:

- The literature review provided a thorough theoretical underpinning of the concept of the simulation model, conceptualisation of poverty and poverty theory. It provided a rich background on which to base the assumptions used in building the relationships in the model as well as providing a framework for interpretation of model simulations.
- The collection of secondary data was necessary to ground the model in reference modes of behaviour. This data consists of parameter values that represent real life equivalent of variables within the system being addressed.
- A system dynamics model was developed with the aim of reproducing the dynamic interaction of the three sectors including population changes, food production among both capitalist and peasant classes and how these impact on peasant decisions with regard to land ownership. A more detailed discussion of the development of the model will be dealt with at a later stage.
- Validation of the model included conducting an examination of the assumptions that form the basis of the structure of the model. This is to ensure that they are consistent with sound scholarship and observation. Furthermore, specific structure and parameter sensitivity tests were performed to ensure soundness of the model structure.
- Policy analysis followed the validation of the model. A number of policies were analysed in order to give insights into the behaviour of some variables of interest in the model including land holding between capitalists and peasants, food availability among others.

1.5.4 Research procedure

The research steps progressed as follows:

1) Literature review of existing literature on poverty theory and related research.
2) Conceptualisation of the model, i.e. formulation of the model structure consisting of the relevant endogenous and exogenous variables and the relationships between them. Qualitative analysis of the conceptual model in terms of reinforcing and balancing processes was conducted before actual modelling took place.
3) Collection of secondary data to fit in the model and also set a reference behaviour pattern. The data was collected from the Government of Kenya Publications by the Central Bureau of Statistics, Nairobi.
4) Development of the quantitative simulation model using *Vensim* simulation software.
5) Validation and testing of the model.
6) Report writing and presentation of the findings in the form of stock and flow diagrams, causal loop diagrams and simulation graphs.

Having outlined the above, the next chapter will provide a literature review and theoretical framework as a basis for conceptualising poverty as well as justification for this modelling effort. Chapter three will focus on the conceptual model by defining the problem, establishing a dynamic hypothesis and providing a basis to begin model development. Chapter Four will describe the actual model, walking through the structural assumptions that have been employed in its development as well as presenting the formal model. Chapter Five will present validation tests to enhance confidence in the model structure before conducting policy analysis and eventually conclusions and recommendations.

2 LITERATURE REVIEW AND THEORETICAL FRAMEWORK

Poverty is a rampant phenomenon in the developing world. Millions of people are trapped in poverty and do not seem to have any hope of a reprieve or improving their living standards. Currently, over 800,000 million people go without food every day. Moreover, eight million people die each year due to lack of food and malnutrition (Sachs, 2005). The World Food Programme reports that 25,000 people die each day due to hunger and food deficiency related illnesses. These are disturbing statistics, especially knowing that the world has more than enough food to feed everyone (Forster and Leathers, 1999). It is therefore of utmost importance to investigate and understand the underlying processes that keep people trapped in poverty.

Whereas poverty is a complex concept that has numerous influences and factors, this project has investigated the link between population growth, food security and its inherent dynamics that sustain people in poverty. This investigation will therefore shed some light on what can be done to improve the lot of the poor and make it possible for them to live better lives.

The following section outlines a summarised review of the literature on poverty, food security and population growth and indicates their link to poverty. This will form the conceptual framework upon which the model will be developed.

2.1 Definition of Poverty

Whereas there are divergent views of how different people view poverty, there is consensus that the particular view of poverty will influence the approach employed in its measurement (Diekmeyer, 1998) and affect the design of actions against it (Sen, 1981). Rowntree (1901) was the first to do empirical studies on poverty. He developed a standard measure for individual families based on nutritional and other requirements.

Further developments in the 1960's shifted the attention to macro-economic indicators including the Gross Domestic Product and per capita income. During the 1970's, poverty was thrust to prominence by the McNamara address to the World Bank Board of Governors in Nairobi in 1973 with an emphasis on redistribution with growth. Runciman (978) and Townsend (1979) took the definition of poverty a little further, beyond nutritional and subsistence, focussing on the failure to keep up with the standards prevalent in a particular society. New layers of complexity were added with a move beyond income to non-monetary aspects, focussing on vulnerabilities, and livelihoods as the lack of capabilities as pioneered by Amartya Sen starting in the 1990's. Recently, the spotlight has been on inclusion of gender relations in the study on poverty (Maxwell, 1999).

Definitions of poverty are many and varied and highly dependent on the context, approach used in its measure, perceptions by society on what constitutes poverty and perceptions of the poor themselves on what poverty is all about. There is no universally agreed definition, no general consensus on the best method to measure it, nor is there consensus on its remedy. These questions make poverty research critical as scholars try to find commonality of discourse.

Noble, Ratcliffe and Wright (2004) argue that a society's definition and conceptualisation of poverty is a mirror image of that society. This implies therefore that how society views poverty will depend mainly on the peculiar context of that society. Diekmeyer (1998) declares that many do not regard poverty levels as absolute numbers. He is of the opinion that poverty depends on how much money people need and how much money people need will depend on where they live. This is implying that poverty is context specific. He further argues that a society's definition of what constitutes the basic needs of a society will vary as a nation's level of wealth increases.

Consensus at the national level is especially critical, because it enables uniformity of policy making and social action. But, as has been seen from several countries, many groups of people have a vested interest in poverty. Alcock notes that "Poverty is inherently a political concept- and thus inherently a contested one" (Alcock, 1993:3). For Estivill, defining and measuring poverty has both technocratic and political implications:

> "Quantification of poverty, which is subject to methodological debates, leans towards identification rather than understanding, management rather than change, and when it attains high volumes it discourages politicians and gives rise to scepticism in relation to remedial measures as captured in the saying that there have always been poor people and always will be" (Estivill, 2003: 21).

Causes of poverty and factors that contribute towards poverty and deprivation have been researched over time. However, there has been a raging debate exactly on the role of the different factors in perpetuating poverty. For this reason, many social scientists have attempted to explain the nature of interaction of the different variables identified as contributing to poverty. If we can map the exact nature of the relationship, we can provide a solution to the problem.

Whereas the debates continue on who is considered poor, there is consensus that in principle there exists a minimum standard of living that individuals and households should be able to attain in order to live a fulfilling life (Glewwe, 2005; Maxwell, 1999; Hardiman & Midgley, 1989; ILO,1995). The debate, however, is active on what constitutes that bundle of goods or services that create vulnerability and hence poverty.

2.2 Poverty and food security

Food is a basic human need. Reutlinger (1987) describes foods security as the access by all people at all times to enough food to enable them to lead normal, healthy lives. Regrettably, not everyone has this privilege. Sen (1987) notes, very significantly, that the worst famines that have happened, took place with no significant decline in food production. This means therefore that while addressing the issue of food insecurity, we should address food production as well as distribution. He further argues that starvation depends on both food supply and distribution, and that this distribution is dependent on the distribution of entitlements across the population.

The concepts of poverty and food security are closely intertwined. Therefore, it will be incomplete to discuss poverty without addressing issues of food security. Usually the poor are faced with a risk of starvation. Several policy interventions in the past that focussed mainly on increasing food production and reduction in the population growth rate have not succeeded (IFPRI, 2001). This informs us that to understand the actual causes of food insecurity, it will be important to have a more holistic understanding of the complex food system and determine what policy works and what does not.

I will dedicate the section below to highlight the causes of food insecurity as found in poverty and food security literature.

2.2.1 Causes of food insecurity

Poverty and food security have been blessed with a rich amount of research and the summary below will not do justice to the voluminous amount that exists on the subject. This section will describe a number of factors that determine the status of food security of a particular group of people. This listing is by no means exhaustive.

2.2.1.1 Food Production

As stated earlier in this research, food production has been one of the key foci of policies aimed at enhancing food security. Whereas there is consensus that increasing food production alone would not solve the food crisis, decline in food production will surely deepen the crisis. Saeed (1987) argues that incentives aimed at increasing food production, especially mechanisation, end up in the large scale capitalist farms and hence do not trickle down to the poor who need them most. Falcon et al (1987) echoes the same sentiments by noting that in the short run, high food prices increase may increase the suffering among those who do not benefit from production incentives.

In the meantime, Daily and Ehrlich (1992) indicated that increasing food production could prove disastrously self defeating. He argues that by expanding production, humanity is in essence depleting irreplaceable parts of its life support systems which include fertile soils, groundwater and the diversity of living species. In spite of the debates, there is consensus that adequate food supply can only be solved by increasing production and reorganising distribution within the countries facing food security problems (Falcon et al, 1987; Sen, 1987; Saeed, 1987).

2.2.1.2 Land Productivity

Before the 1950's, growth in world food production was almost entirely derived from an increase in the land under cultivation. As the frontiers of agricultural land diminished, the world began to systematically increase land productivity. There was an increase of 160% in global grain productivity between 1950 and 2000 with a corresponding increase in only 14% in land under cultivation (USDA, 2003).

The productivity of the land is an important determinant of how much food is produced. Foster and Leathers (1999) indicate that the level of food production in a farming household is influenced by a complex set of variables including amount and quality of land available, amongst other factors.

Factors affecting land productivity are both man-made and environmental. Droughts and floods will reduce the productivity of crops. This is especially so given that most of the farming in developing countries is dependent on natural rainfall. The quality of the land also diminishes owing to overuse, as minerals especially Phosphorous are eroded from the soil over time (Saeed, 1987; Sachs, 2005). Given that many of the farmers in the developing world either have no access to or cannot afford fertilizers, the deteriorated farming lands can only deteriorate further and so will the productivity of their farms. Land conservation and increase in productivity needs investment in order to be maintained. However, in many cases, the poor cannot afford the investment needed to conserve their land and thus ensure continued productivity.

> 'The combination of low economic growth, rapid population growth and environmental degradation imposes a self reinforcing vicious cycle which worsens poverty and environmental deterioration unless a concerted effort is made to promote economic growth and deal effectively with the problem of land degradation.' (Shifferaw& Holden,1998:234).

Holden et al (1998) found that poverty leads to higher consumption and a lower incentive to invest in conservation to prevent land degradation. In light of this therefore, it is clear that the deteriorating land owned by the poor, owing to extended use over time, is likely to affect productivity and hence affect the amount of food available per household.

2.2.1.3 Land Access and ownership

For most people in developing countries, land is the primary means for generating a livelihood and the main vehicle for investing, accumulating wealth and transferring it between generations.

> 'Land is also a key element of household wealth. In Uganda, land constitutes between 50 and 60 percent of the asset endowment of the poorest households' (Deininger, 2006: XX).

There is little debate that rights to land have positive effects on economic growth and poverty reduction (Deininger, 2006). It is clear that the role of land ownership in the lives of most people in developing countries cannot be overestimated. Land forms the single most important productive resource for the majority in this group of people. Sen (1987), while addressing the issue of entitlements, asserts that individual entitlements to assets determine a person's ability to enjoy the functionings that result from value attached to the ownership.

Foster and Leathers (1999) state that the poorest people are generally landless. This means that they acquire their livelihood by working on other people's farms. The level of food production in farming households are influenced by a complex set of variables including the amount and quality of available land, education of the farm manager and his workers, quantity and quality of technology, export taxes, price controls and subsidies on purchased inputs. The level of food produced then influences the price of food. This level will determine the amount of supply which then influences the price of food in the market.

Sen (1992) argues that a person will be exposed to hunger and starvation if the entitlement he/she has does not contain a sufficient bundle of food. Ownership of sufficient productive resources is therefore a necessary condition for people to be safeguarded against food shocks.

Besides this, land access and ownership provides a safety net for the poorest of the poor. Broad based land access provides a basic safety net that costs much less than alternative government programs, thus enabling the government to focus their funds on productive infrastructure (Deininger, 2006). Ownership of land among the poor gives them a sense of prestige and reduces the stigma of landlessness that landless people often face in their communities.

2.2.2 Population Growth and Poverty

Thomas Malthus (1798) was one of the earliest scholars to predict a possible catastrophe because of the exponential population growth that outpaces agricultural production. According to Malthus, the imbalance between population and food production is likely to cause a return to subsistence level conditions. However, as described elsewhere in this paper, there have been advances in agricultural productivity and agricultural intensification (Daily et al, 1998) that enables an increase in agricultural production with negligible increase in the amount of land under cultivation.

Rapid population growth is likely to reduce per capita income growth and wellbeing. In densely populated developing countries, with pressure on land, rapid population growth increases landlessness and hence the incidence of poverty (Ahlburg, 1996).

Widespread food shortages as a result of both population increase compounded by environmental factors have also been reported to be a cause of high mortality rates in Kenya (KDNLP, 2005). Figueroa and Rodriguez-Garcia (2002) argue that nutrition and population growth are intimately linked. A population's ability to nourish itself is a major determinant of fertility and mortality rates. They argue that maternal nutritional status affects fecundity and this has been well observed during famines when birth rates drop markedly. Understanding that the poor often have to grapple with nutritional issues, it would therefore be in order to conclude that less than adequate access to proper nutrition by the poor will adversely affect them by decreasing fertility and increasing mortality. The opposite is also true.

Saeed (1998) argues, however, that population growth increases with an increase in the amount of food available. The availability of food encourages people to have more children, especially among the poor, to increase chances of survival. However, the same research argues that as the living standards of the poor increase, they tend to reduce the number of children per head. This is attributed to higher mobility of families with higher standards of living which requires portability and a desire to provide a good quality life to their children. Meadows (2006) notes that throughout the world the poor have the most children. The argument posed by the poor for having so many children is the prospect of security and survival. Given the high mortality of the poor, they tend to have more children to increase chances of survival. Todaro (2000) arguesthat widespread inequality and poverty deprive the poor of investment opportunities leading them to have many children as a way of ensuring financial security.

Grapperud (1994) found that population pressure relative to the carrying capacity was an increasingly important determinant not only for land degradation, but food production as well. The Kenyan population increased from 16 Million in 1980 to 32 Million in 2005. T is further projected to reach 41 Million in 2030 (UNFPA, 2005). This more than doubling of the population is contrasted to a paltry increase in land under agricultural production from 25, 580 square kilometres in 1980 to 27, 021 in 2005 (UNFPA, 2005). The pressure on the land is likely to affect the poor more negatively than the middle class and the rich. This is because unlike other groups, the poor do not have alternative sources of livelihood that can cushion them against pressures as a result of population increase.

3 THE CONCEPTUAL MODEL

3.1 Introduction

Poverty is a complex problem that needs careful analysis in order to develop insights into its nature. Before this project embarks on the actual development of the model, it is important to conceptualise the problem in such a way as to define the dynamic problem, identify key stocks and flows and define the dynamic hypothesis. This is an important addition to the methodology already discussed as it forms the basis for the development of the model itself.

This section will also define the boundaries to the model. Poverty is impacted by many variables that are not included in this model. It will provide a justification for the choice of the existing set of chosen variables as well as deepen the understanding of poverty trap dynamics at a conceptual level.

3.2 Defining the poverty trap dynamically

Following the foregoing, it is clear that poverty is a complex phenomenon. There are many variables that have been proposed as being responsible for keeping people impoverished which influence policy making. Unfortunately, many of the policies targeted at the poor have not succeeded in reducing the incidence of poverty in many countries. This could be partly because policies have either ignored some important factors that are important or policy makers have not been aware of these factors at all. The purpose of this modelling project therefore is to formulate one aspect of this phenomenon within the boundaries of population growth and food security and develop insights on how these two factors dynamically contribute to the poverty trap.

3.2.1 Definition of the problem

Whereas the poor can be found in every society, whether developed or developing, the incidence of poverty traps is predominantly found in the developing world. The responsibility to address this problem lies with developing country governments. It is therefore their responsibility to undertake research into causes of poverty traps and implement informed policies aimed at freeing their citizenry from poverty.

3.2.2 Reference behaviour pattern

The manifestation of poverty differs from place to place. Some places have widespread poverty with massive portions of the population considered poor, while others are distinguished by the pitiable condition of the poor. It will take careful analysis of different countries' specific situations to be able to reproduce the behaviour observed in each setting. However, in the context of this research, given the fact that boundaries set do not include all possible variables responsible for the poverty trap, it will be unrealistic to expect it to replicate a poverty trap reference behaviour pattern. Moreover, there is scanty data available with regard to the stock variables envisaged in this model, with no data of a time series nature available that is consistently long enough to produce an adequate reference behaviour pattern. In this instance therefore, we use 'historical tendency' as opposed to historical data owing to the lack of sufficient historical behaviour data (Saeed, 1980). This implies that by looking at historical tendencies over time, it emerges that land has consistently been concentrated in the capitalist sector compared to the peasant sector. This therefore means that the 'historical tendency' used in this model will tend to concentrate land in the hands of the capitalists at the model's equilibrium condition. This model will therefore try reproducing a base case scenario where land is concentrated in the capitalist sector.

3.2.3 Model purpose

The purpose of this modelling effort is threefold and includes the following:

1. To gain a better understanding of the dynamic relationship between population growth, food security and how these variables interact to contribute to maintaining people in the poverty trap.
2. To test policies aimed at increasing food security, sustainable population growth as well as poverty reduction.
3. To identify further factors/variables that are not endogenous to the model that may need to be endogenised in order to produce a more accurate simulation of the actual system.

3.2.4 Model Boundaries

The poverty trap is a slow process that engenders itself and spreads among populations over a long period of time. Therefore it is realistic to consider five years as short term and ten years and over as long term.

The variables in this model have a high degree of aggregation. Land is the only factor of production taken into consideration in formulating the production function with other variables considered constant. However, disaggregated production functions would take into consideration capital, labour and technology amongst other factors of production. The wages are set as exogenous and considered to be constant, while these could be influenced by several other factors. Peasant (small scale farmers) accumulated savings are influenced by production, wages and land sales. In reality, there are other sources of income that may include transfers, income from livestock, as well as micro-enterprise among others.

The model is designed in such a manner that land acquisition decisions are actively made only by peasants. Changes in capitalists' land result from changes in peasant land. In reality, capitalists' decisions are much more powerful than peasants' decisions. Providing small scale peasants with more power than they have in real life, helps in identifying the structural processes that keep the poor trapped, despite their apparent decision making powers within the model. This is important for policy makers who are concerned with weakening these undesirable structures.

3.2.5 Identification of Key Stocks and Flows

Table 3.1 illustrates a list of key stocks and flows. Stocks are accumulations of variables over a given period of time. For example, the amount of food available in a given geographical boundary is a stock. Flows on the other hand are rates of increase or decrease of stocks (Sterman, 2000). In this model various variables will be identified either as stocks, flows or explanatory variables. These are further classified into endogenous, exogenous and excluded categories. Endogenous variables represent those that have been defined in such a way that their behaviour in the model is as a result of the dynamic interactions within the model. Exogenous variables on the other hand represent those that have been included in the model, but are in no way receiving feedback from the dynamics in the model. These impact on the model, but their values do not change as a result of changes within the system. Finally, excluded variables are those that may be related to some of the processes in the model, but have been excluded from the model and are therefore not considered.

Table 3.1: List of Stocks, Flows and Variables

Endogenous	**Exogenous**	**Excluded**
Stocks	**Variables**	**Variables**
Population	Population growth	Capitalist Investment
Peasant food available	Food consumption per capita	
Food shortage	Peasant Fraction in population	
Peasant accumulated savings	Indicated Wage rate	
Capitalist production	Peasant Inventory coverage	
Peasant land	Initial Peasant Accumulated Savings (IAS)	
Capitalist land	Fraction of Savings Invested	
	Normal Land Investment Fraction	
Flows	Land Productivity	
Births	Cost of Land	
Deaths		
Capitalist production		
Capitalist consumption		
Peasant production and purchases		
Peasant consumption and sales		
Peasant savings rate		
Peasant investment rate		
Peasant land purchase rate		
Peasant land sales rate		

3.3 Description of Key Stocks and Flows

This section will provide a brief description of stocks and flows in this model. Stocks increase as a result of Inflows and decrease as a result of Outflows. Net increase in the level of a stock is therefore as a result of the Net-Flow (Sterman, 2000) which is the difference between the Inflow and Outflow at a Unit time. There are six stocks in this model and ten flows and a number of variables. The stocks and flows are described briefly below.

3.3.1 Population

The population stock is set to units of persons. This stock changes due to changes in the births and deaths as determined by the birth and death rates. This is illustrated by Figure 3.1 below.

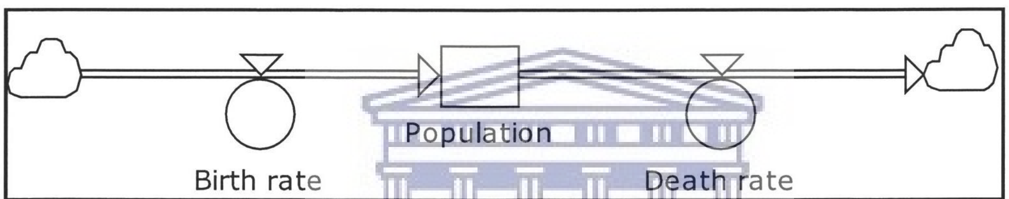

Figure 3:1 Population Stocks and Flows

This stock tracks the total number of persons in the population. It aggregates both the numbers of people in the capitalist and the peasant sectors of the population. The birth and death rates are therefore also jointly affected by changes in population in both sectors as well.

3.3.2 Capitalist food produced

The stock of food produced represents the amount of food produced by the capitalists. Capitalists are, according to the model, described as the people who own large tracts of land but employ other people to work on the land in exchange for wages. The stock of capitalist food produces changes with changes in food production, capitalist consumption and wages paid by the capitalist. The stock and its flows are as represented in Figure 3.2 below.

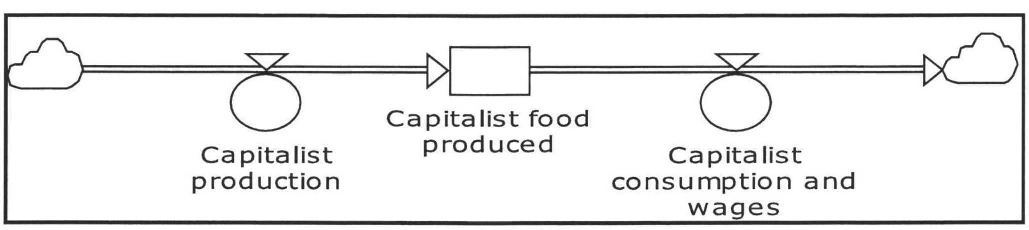

Figure 3:2 - Capitalist Food stock and flows

3.3.3 Peasant food available

This stock consists of food available to the peasants. This stock increase as a result of production from peasant land owned, wages received and land sold to fund consumption. Both the wages and the land sold are converted in food unit equivalent to increase the peasant food available stock. This stock decreases as a result of consumption which based on the population. This structure is shown in Figure 3.3 below.

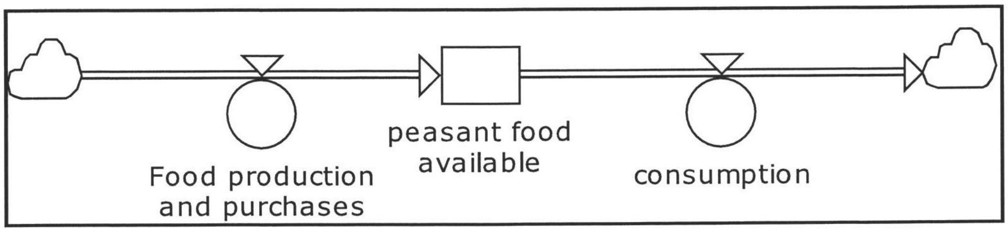

Figure 3:3: Peasant Production stock and flows

3.3.4 Peasant Accumulated savings

This stock represents peasant savings accumulated as a result of running a surplus in the peasant food available. This stock increases with surplus in consumption. It decreases with investment of the savings. This stock and its flows are shown in the diagram below.

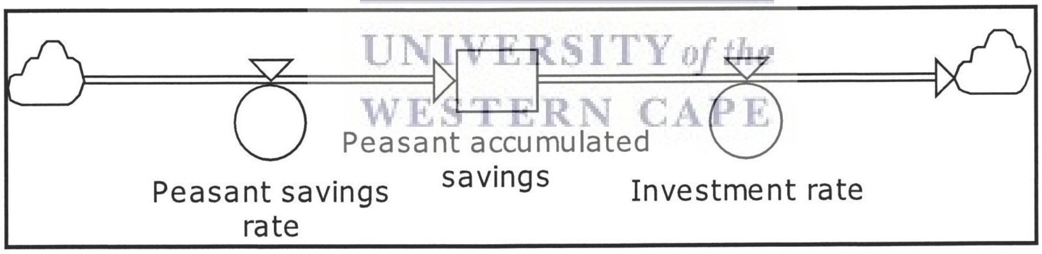

Figure 3:4: Peasant Accumulated Savings stocks and flows

3.3.5 Peasant land and Capitalist land

These two stocks represent the total amount of land available to both capitalists and peasants. The total of these two stocks is taken to represent the total of privately owned land. Therefore, changes in the stock of one will influence change of the other in the opposite direction. An increase in capitalist land therefore decreases peasant land holding by the same amount and vice versa. These changes are reflected by the peasant land purchase rate and the peasant land sales rate. These stocks are shown in Figure 3.5 below.

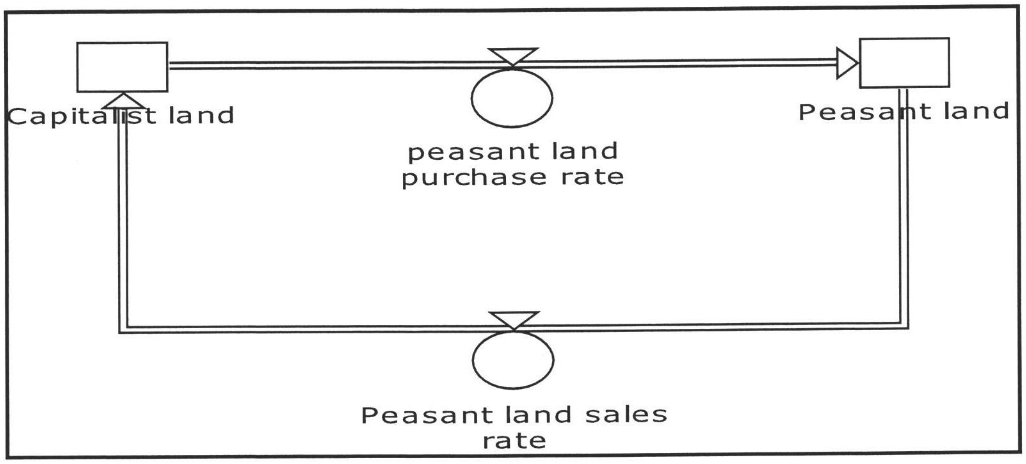

Figure 3:5: Land Stock and Flows

3.4 Dynamic Hypothesis

The expanding gap between the poor and the non-poor can be explained in terms of the success-to-the-successful archetype (Senge, 2006). This means that if one group of people have more resources than another equally capable group, the group with greater resources has a higher likelihood of succeeding. This necessarily suggests that the first group's initial success justified devoting more resources thus further widening the performance gap between the two groups. This is the hypothesized dynamic hypothesis for poverty traps with respect to land in Kenya. In the success-to-the-successful archetype, the system rewards winners, while losers are penalised.

3.4.1 Causal Loop Diagrams

Causal Loop Diagrams are used to trace the pattern of feedback identified within a system. These are represented by arrows as shown in Figure 3.6 below. Causal Loop Diagrams are used in identifying the two types of feedback relationships that exist in all dynamic systems (Sterman, 2000). These feedback relationships include:

Positive Feedback Loops: These tend to amplify or reinforce whatever is happening in the loop. For example, if you invest a certain amount of money, you expect to get a return on the investment. This return on the investment will increase the size of the investment which will in turn increase the return on the investment in subsequent periods and so on.

Negative Feedback Loops: These tend to counteract and oppose change. The classical economic relationship between demand and supply is a negative feedback process. Here, the higher the price of a commodity, the lower the demand for it, leading to excess production which will drive supply up, forcing the price down in order to eliminate the excess inventory.

The identification of the loops in the system under study is outlined in the following section. Figure 3.6 is the causal loop diagram detailing the main loops in the model.

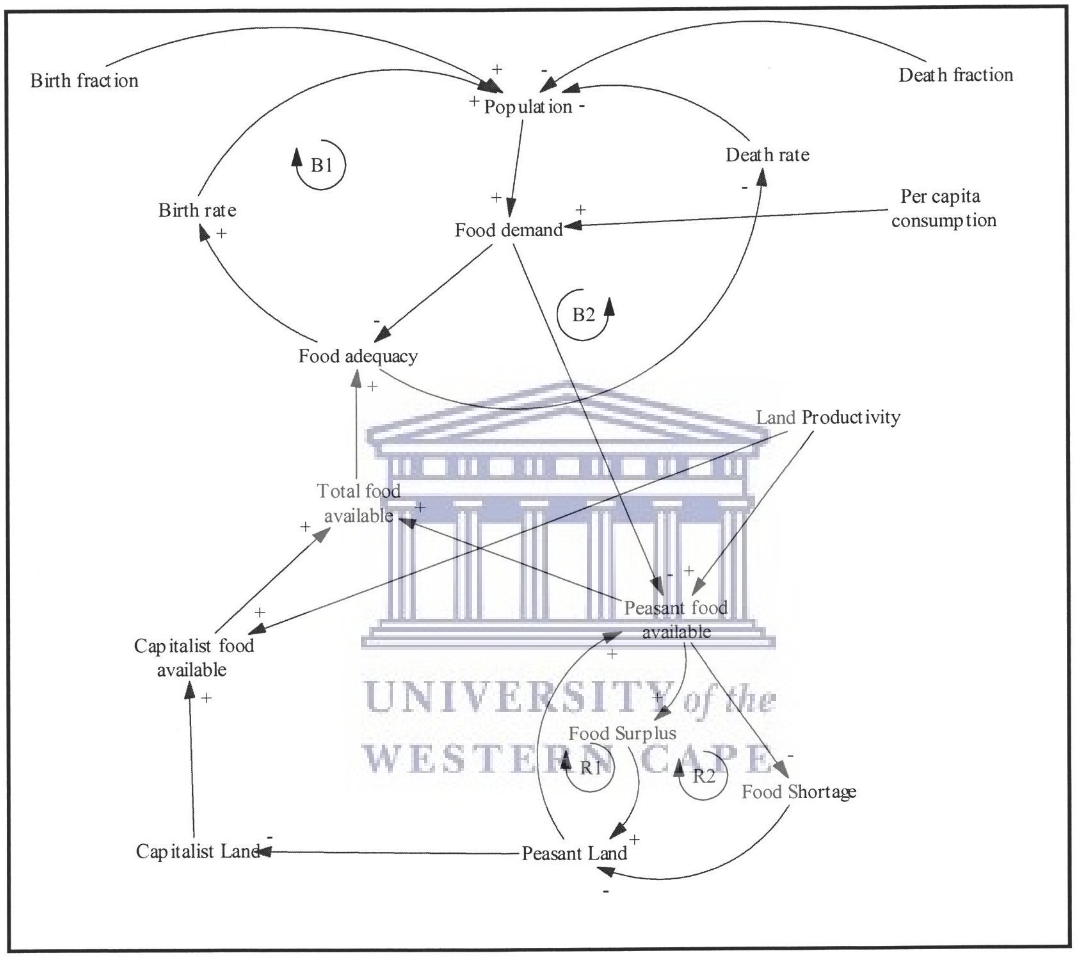

Figure 3:6: Overall Causal Loop Diagram

The causal loop diagram in Figure 3.6 above represents the general structure of the model. Here, the stock of population changes with births and deaths. However, birth and death rates are also influenced by the amount of available food. The level of population sets the food demand at a certain level, based on per capita consumption. The comparison of this food demand with the total food available gives a measure of food adequacy. Food adequacy has an impact on the death rate and the birth rate by influencing fertility and mortality.

Furthermore, population levels determine levels of consumption which by extension determines the existence of either shortages or surplus. The amount of peasant surplus increases peasant landholding, while shortages decrease it. Given that land is the sole factor of production, changes in ownership of land affects distribution of food between the two sectors.

3.4.2 Reinforcing feedback loops

In the peasant sector, there exists two reinforcing feedback loops. These loops, however, work at different times and toward different directions. Assuming sufficient food is available to the peasants (with a surplus available), the peasants will use the surplus to purchase more land. This will increase peasant land holding. Given that land is the sole factor of production in the system, an increase in land will be translated into increase in food produced by the same extent. This will further increase peasant surplus, hence strengthening the position of the peasants and their ability to purchase land for productive purposes. Noting that the model reserves the right to buy land for the peasants, this process will repeat itself till the peasants have purchased all the land from the capitalists rendering them landless. This loop is labelled *R1* in the Causal loop diagram shown above.

On the other hand, assuming we start from a position of low or no food available to the peasants (meaning they have a shortage), the peasants will make a decision to sell land in order to fund the shortage in consumption. Assuming that the low amount of food available is as a result of low land holding (compared to the peasant population), selling their land will further weaken their food producing capacity, thereby crippling their ability to produce sufficient food. This will trigger further sales in order to fund the consumption shortage. A repetition of this process will result in the peasants selling all their land to the capitalists. With no more land to sell, peasants will solely depend on the capitalists (wages) for their consumption. This will generally reduce their population owing to accelerated death rates as a result of low food availability.

3.4.3 Balancing feedback loops

A small population will have little demand for food. Assuming the amount of food available at that moment is greater than the demand, there will be a positive influence on the birth rate thus increasing the birth rate. This increase in population will in turn increase the demand for food that will suppress food adequacy. This produces a balancing feedback loop represented by *B1* in the model above. This balancing feedback loop is expected to produce goal seeking behaviour in the system.

In the same breath, changes in food adequacy have a negative effect on the death rate. This means that high food adequacy will cause a decrease in the death rate. This will result in an increase in the population which in turn will increase demand for food. Increased food demand will lead to lower food adequacy. This is represented by the negative feedback loop marked *B2* in the causal loop diagram shown above.

There also exists two other major balancing feedback loops in the model that are not so obvious in the model illustrated in Figure 3.6 above. These loops transfer the effect of changes in the land ownership portfolio to the levels of population. These loops are shown in Figure 3.7 below.

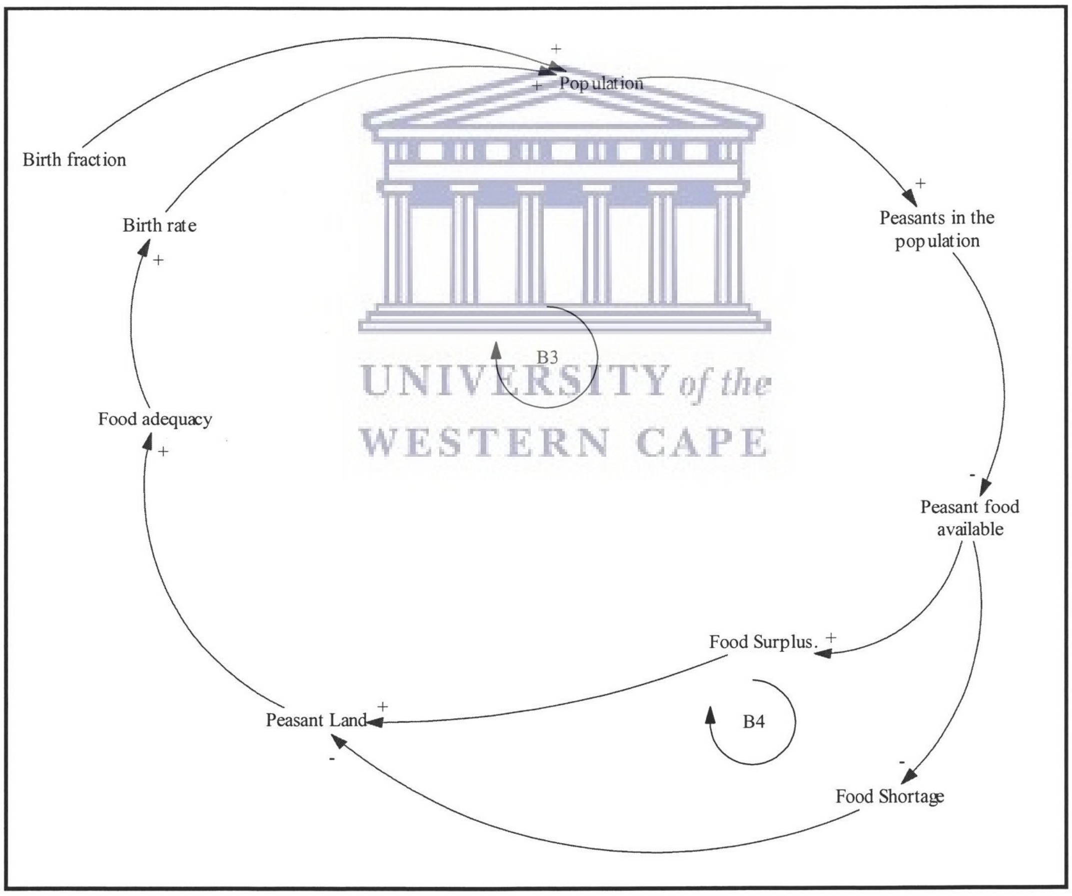

Figure 3:7: Balancing feedback Loop Causal Loop Diagram

This reinforcing feedback loop is responsible for channelling the changes in the population to impact in changes in the amount of land holding. Assuming we start with a large population, there will be a high number of peasants in the population. This will result in a peasant food consumption shortage that will need to be remedied by selling land. Once land is sold, there will be less food per capita, hence low food adequacy. Low food adequacy will suppress the birth rate and hence reduce the population. Starting with a large population and food shortage will work in similar fashion around the loop as indicated in Figure 3.7 above. These two are represented by the balancing feedback loop labelled *B3* and *B4*.

4 THE MODEL

4.1 Model Sectors

This model was developed with the aim of understanding the dynamics of poverty traps, with particular attention to factors that influence decisions of the poor with regard to management of the productive assets they own (in this case land). Particularly, the model seeks to establish the relationship between population growth, its impact on food availability given a fixed amount of land, and how this impacts on the survival choices that poor people have to make. This model is divided into four sectors as briefly described below:

1. Population sector: This sector briefly models the population growth dynamics taking into consideration births and deaths.
2. Capitalist production sector: This sector tracks food production in the large scale rural sector.
3. Peasant production sector: This tracks food production among small scale farmers in the rural sector, wage employment and the dynamics of net savings/deficits depending on available resources.
4. Land sector: This sector tracks movement of land from people considered as large scale farmers to people considered small scale peasants.

Development of these sectors has been based on the review of the literature on population growth, food security and land dynamics. This has been supplemented by observations of the researcher. All these form the basis for establishing this structure. Whereas this model is a simplification of the reality of the dynamics of poverty traps, a number of important insights have been achieved that will enrich understanding of poverty traps[2]. This will enable poverty researchers to ask informed questions with regard to finding lasting solutions to poverty and poverty traps.

The sectors briefly described above are dealt with in greater detail in the following section.

[2] A summary of these insights will be outlined in the section on policy analysis in chapter seven.

4.1.1 Population Sector

The population sector models the dynamics in the rural population. This sector consists of one stock of population that includes the total number of people in a rural setting. This stock includes both small scale peasants and large scale farmers. The detailed stock and flow diagram representing the population sector is shown in Figure 4.1 below.

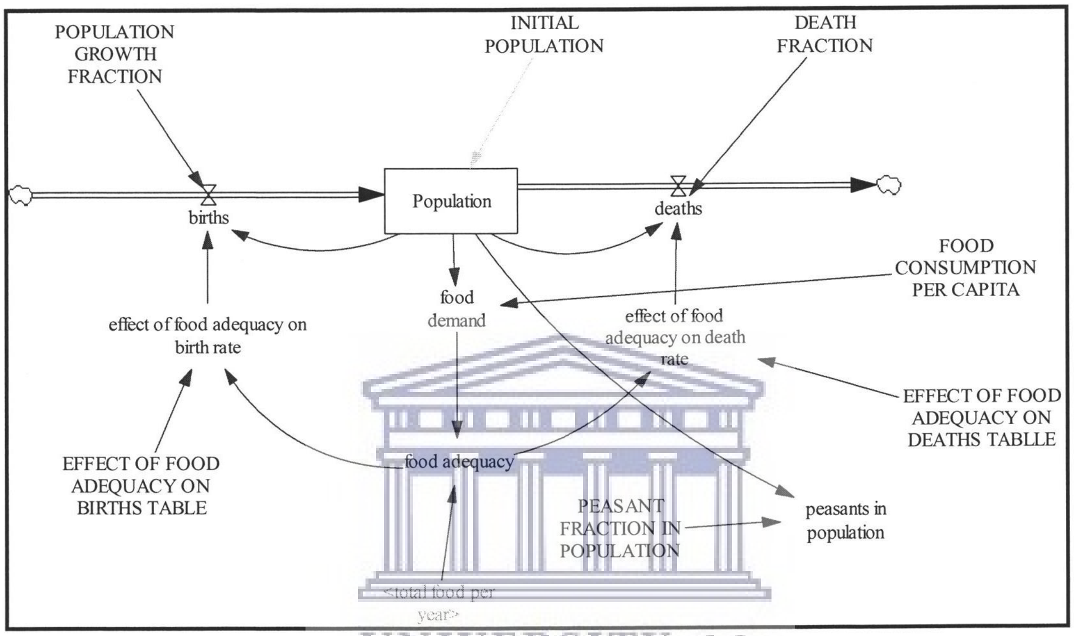

Figure 4:1: Population Sector stock and flow diagram

According to Figure 4.1, population increases as a result of births and decreases due to deaths. Moreover, there is an effect of the level of food adequacy on both births and deaths. Food demand is calculated on the basis of the level of population and 'food consumption per capita'. This demand, when compared to the available food, gives the level of food adequacy. High food adequacy will mean adequate nutrition that will increase fertility and reduce infant mortality. It will also translate into a reduction in death rates as a result of adequate nutrition. This will increase the population. Low food adequacy on the other hand leads to malnutrition, which will lead to high mortality translating into higher death rates and higher infant mortality. This decreases the birth rates and consequently the population. The effect of food adequacy on birth rates table is represented in Figure 4.2 below.

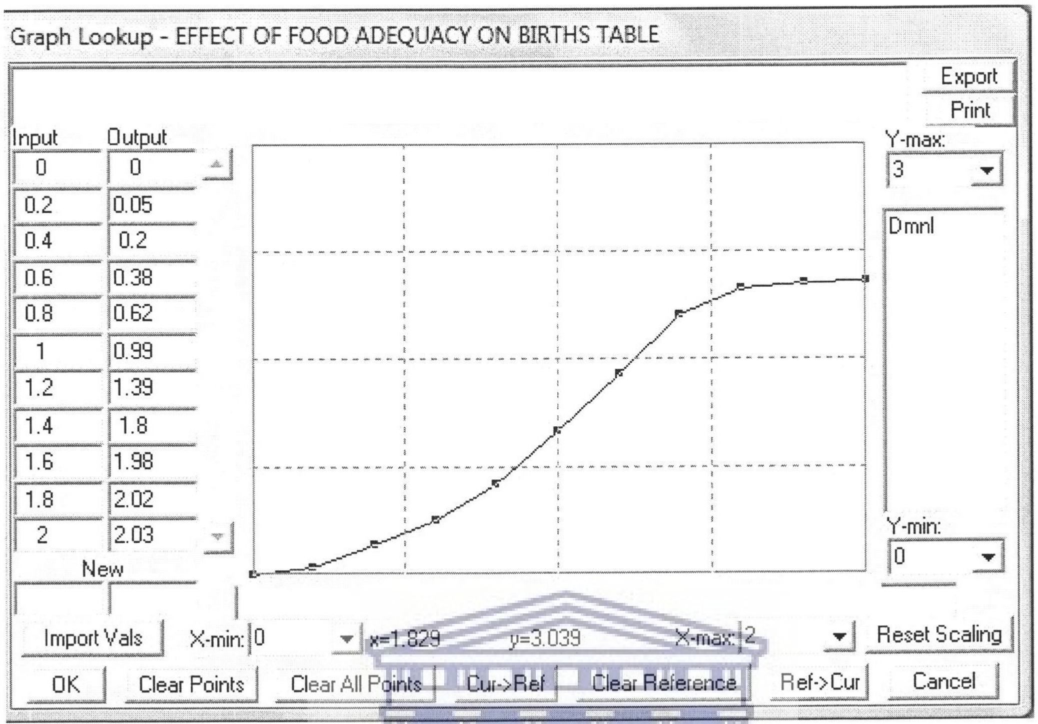

Figure 4:2: Effect of food adequacy on birth rates

The graph shown in Figure 4.2 above indicates that at very low levels of food adequacy (input), birth rates (output) remain very low. As food adequacy starts to increase, so do birth rates. However, this reaches a certain maximum level where increase in food adequacy does not have any impact on the birth rate.

The effect of food adequacy on death rates table is shown Figure 4.3 below.

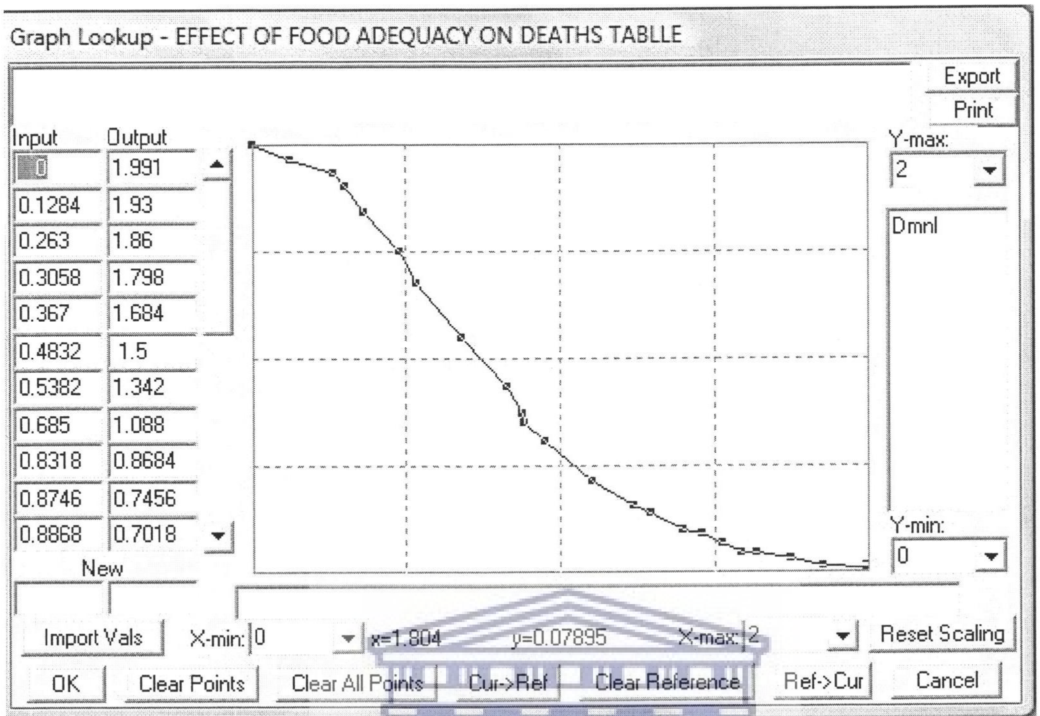

Figure 4:3: Effect of food adequacy on death rates

In Figure 4.3 above, the death rate (output) is very high at very low levels of food adequacy. However as food adequacy increase, the mortality rates decrease to a point beyond which further increases in food adequacy do not have any impact on the population death rate.

4.1.2 Capitalist (Large scale) production sector

Capitalist production represents the amount of food produced among large scale farmers. These farmers are characterised by ownership of large pieces of land per person. A part of the production from this sector is used to pay wages to wage workers from the peasant (small scale subsistence producers) sector. The stock and flow diagram representing this sector is shown in Figure 4.4 below:

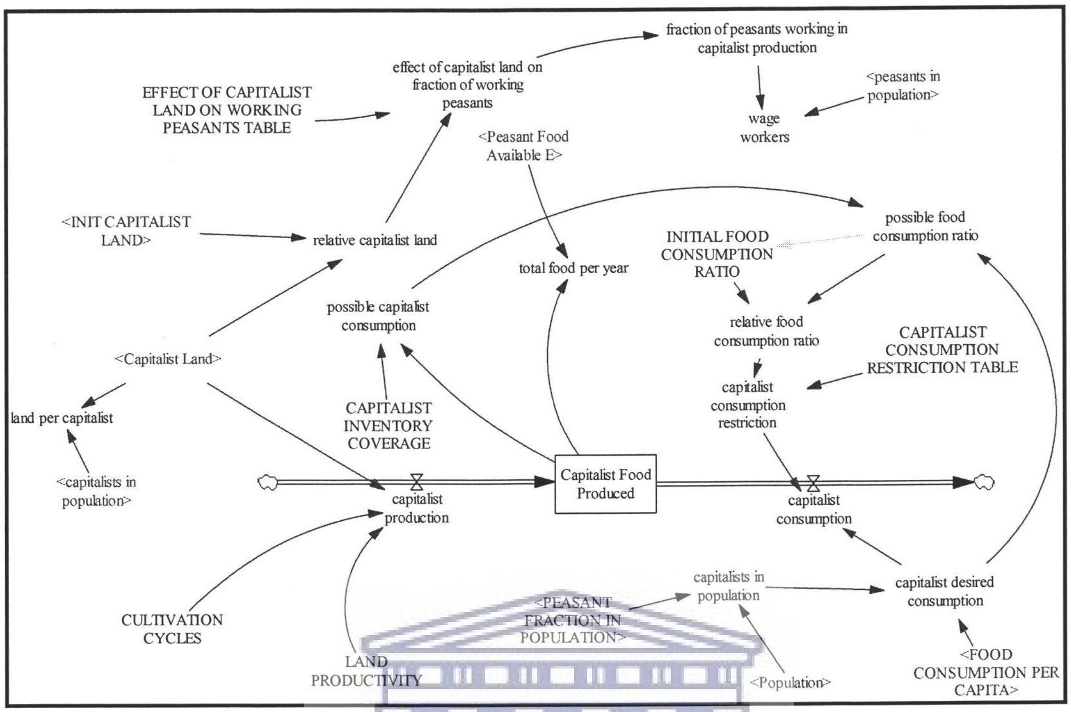

Figure 4:4 - Capitalist Sector Stock and Flow Diagram

The stock and flow diagram in Figure 4.4 represents dynamics taking place in the capitalist sector given the boundaries set up in the context of this modelling effort. Land is the sole factor of production in this model, with the amount of food produced therefore being determined by the amount of land owned by people in this sector. We assume that productivity is constant across sectors (capitalist and peasant sectors). Food produced in this sector is consumed for food and is also used to pay wages of wageworkers who work on the farms.

The number of workers in this sector is dependent on the amount of land owned by members of the population in this sector. This effect of capitalist land on the number of wage workers is illustrated in Figure 4.5 below.

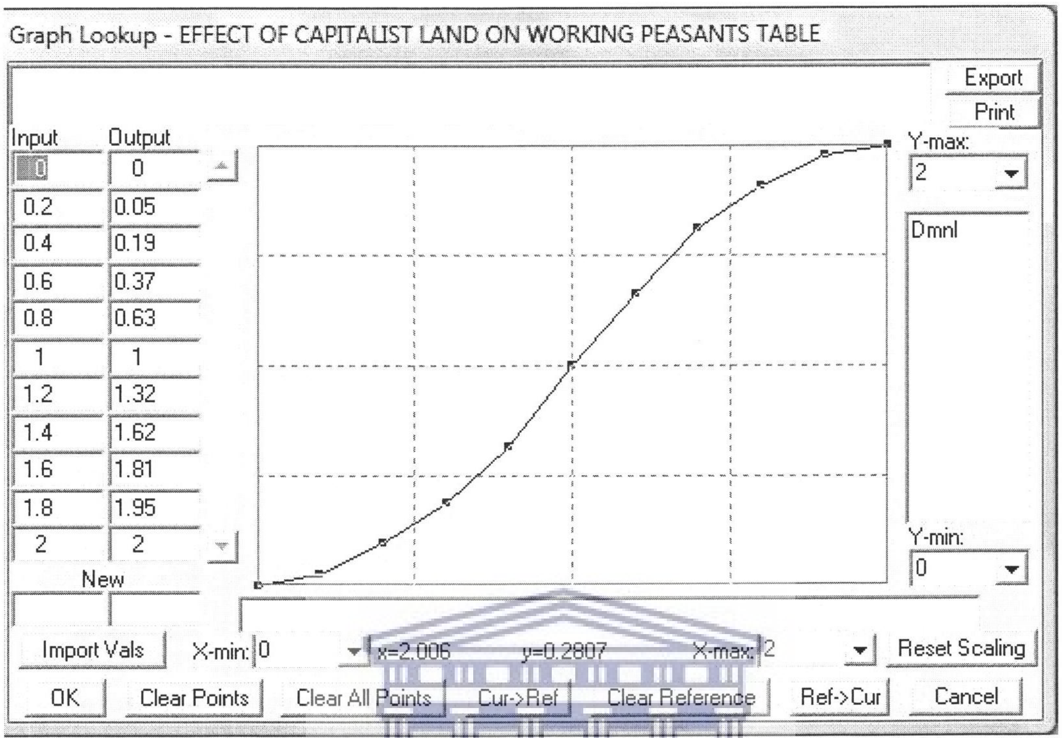

Figure 4:5: Effect of capitalist land on working peasants

In Figure 4.5 above, changes in capitalist land, relative to initial land holding at the beginning of the simulation, has an effect on the number of people employed as wage workers in large scale commercial farms. Where capitalist land holding is very low, there are very few wage workers. However, as this relative landholding increases, so does the number of people needed to work in these farms from among the peasant population.

4.1.3 Peasant (small scale) production sector

This sector represents the production processes amongst peasant farmers in the area. This includes food production from the land owned by the small scale peasant farms. As is the case with the large scale farms, land is the only factor of productivity while productivity is assumed to be constant. Therefore the amount of food produced here is dependent on land owned by the peasants. Wages from work on peasant farms is also translated into units of food thereby increasing the amount of food available.

Whereas the capitalist sector is silent on the use of food produced with regard to treatment of surplus or deficit, this is the primary focus of the analysis in the peasant sector. Here, in the case of a food surplus, it is converted into monetary units and invested to acquire land from the capitalist sector. In the event that there is a food deficit, the peasants will solve this by selling a portion of their land to satisfy their demand for food for survival. This model attempts to identify whether any structural characteristics exist, besides capitalist activities that are responsible for their ability or inability to accumulate sufficient land for food production. The stock and flow diagram representing the dynamics in the peasant production sector are reproduced in Figure 4.6 shown below.

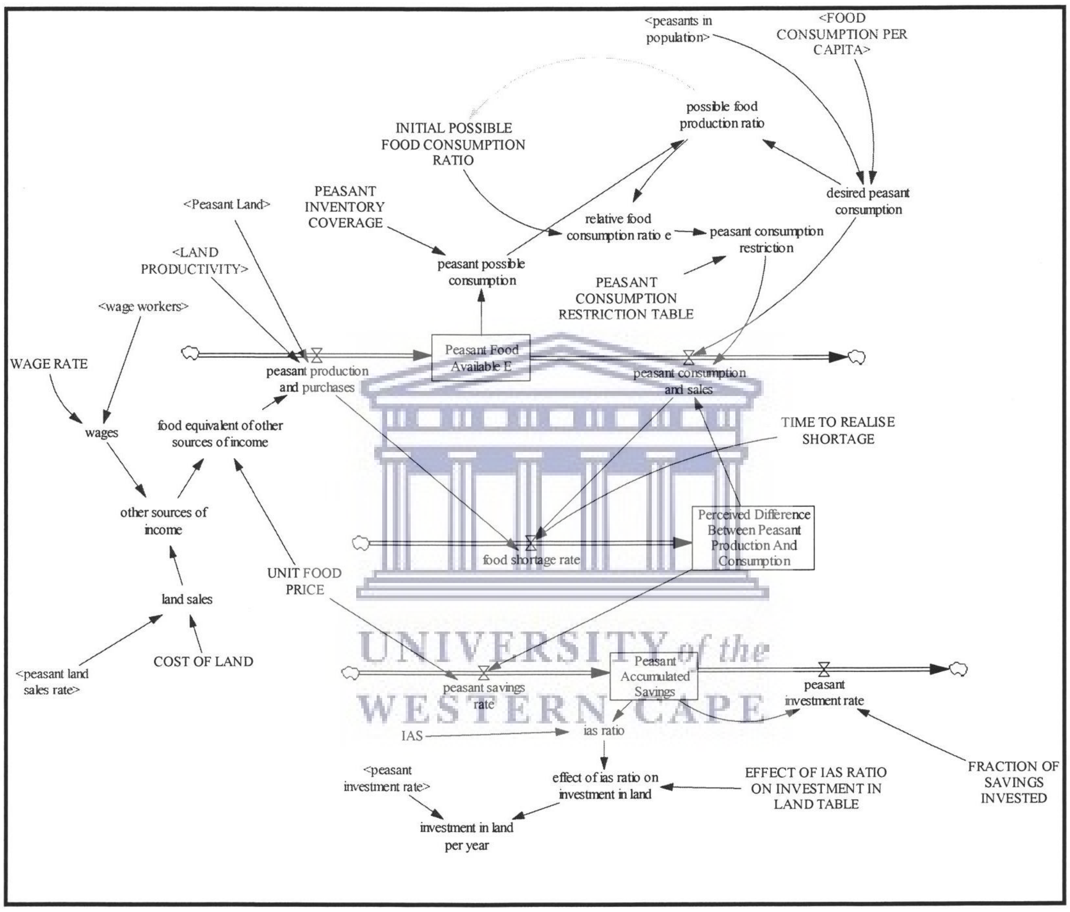

Figure 4:6: Peasant Sector Stock and Flow diagram

As can be seen from Figure 4.6 above, food produced is the summation of food produced from land owned by small scale farmers and the wage equivalent received by working on large scale capitalist land. The formula given for the variable 'peasant production and purchase is as follows:

*Food equivalent of other sources of income + (Peasant Land * LAND PRODUCTIVITY * CULTIVATION CYCLES).*

Consumption from this sector is assumed to be only food related based on a constant food consumption per capita. The surplus is sold and invested and a portion of this investement is allocated to land which is procured from the large scale capitalist sector. This increases the amount of food produced in the peasant sector in subsequent periods. When there is a deficit, given that land is the only asset owned by these people, they sell land and the proceeds are converted into their food equivalent based on the price of food in order to fund food consumption. This further reduces their landholding and food produced in subsequent periods.

The decisions leading to the sale or acquisition of land to or from the capitalist sector is not instant. This is a decision based on information feedback from either the presence of a surplus or deficit. This is represented by the stock labelled '*Perceived difference between peasant production and consumption'*. This is an information stock that forms the background of the decision of whether to buy or sell land.

According to this model, food produced in a given year is meant to last for one year untill the next year's harvest. Consequently, if left at that, it would mean the food produced, no matter how large in quantity, will be wholly consumed at the end of the year irrespective of the population size. This has been addressed by use of the 'peasant consumption restriction table' to ensure that food available in a year is used accordingly, taking into consideration individual food needs and population levels. This table is illustrated in Figure 4.7 below.

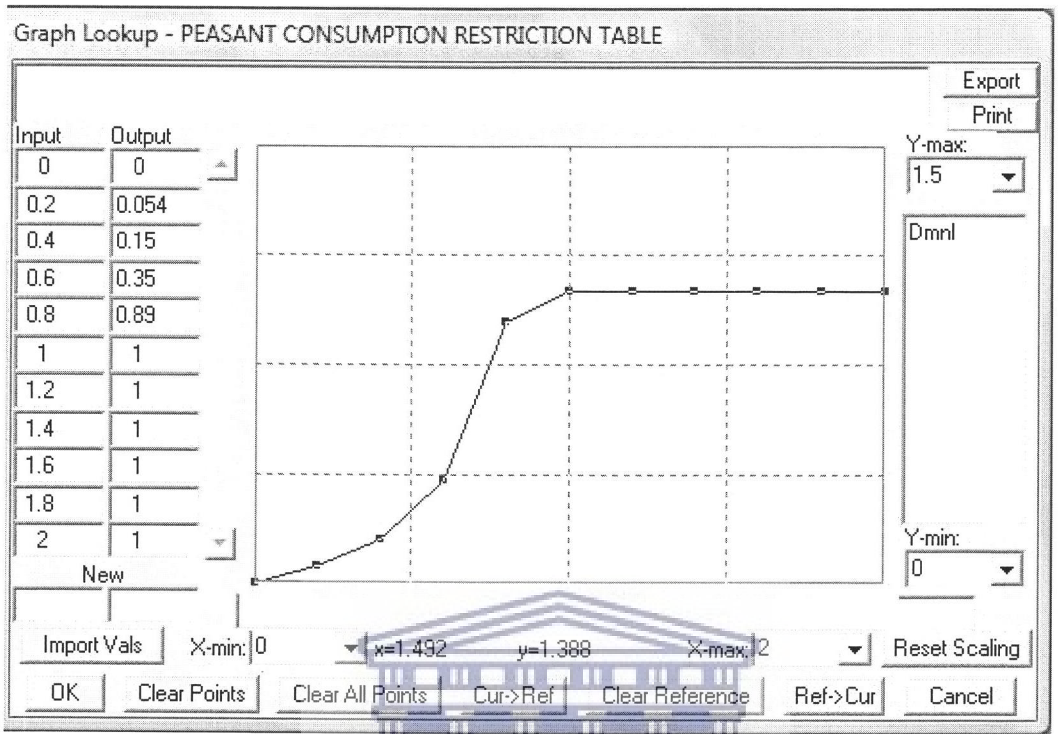

Figure 4:7: Peasant consumption restriction

On the other hand, food adequacy will impact on the death rate in completely the opposite way. Figure 4.8 below represents the graph function describing the effect of low food adequacy on the death rate.

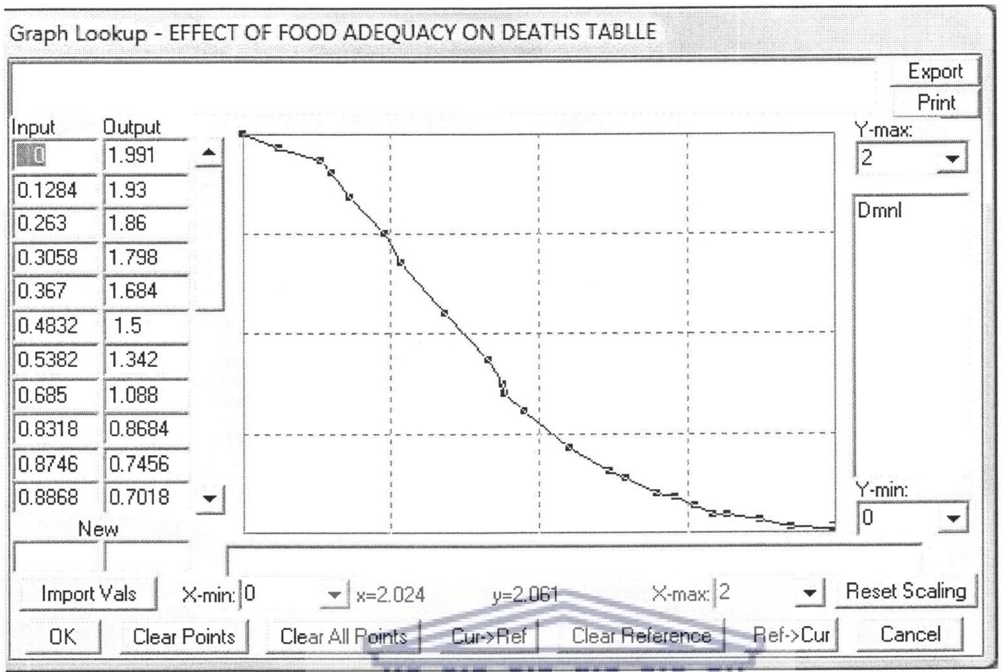

Figure 4:8 - Nonlinear function for the relationship between food adequacy and death rate

As you will notice from Figure 4.8, a higher than normal food adequacy will result in a decrease in the death rate. This is because there is plenty of food that will increase people's life expectancy resulting in a reduced death rate. However, in moments of low food availability, people starve and die thus increasing overall mortality. This increases the death rate accordingly.

4.1.4 Land sector

The land sector represents the transfer of land between the large scale farmers (capitalists) and small scale landowners (peasants). The transfer of land as mentioned previously is triggered by changes within the peasant production sector. In this model, land is only bought or sold by the peasant community. It is important to note once again that the researcher held the dynamics of the large scale sector constant in order to isolate the existence of any structural characterstics in the rural system that may prevent rural small scale farmers from acquiring sufficient land for themselves. The stock and flow diagram for the land sector is represented in Figure 4.9 shown below.

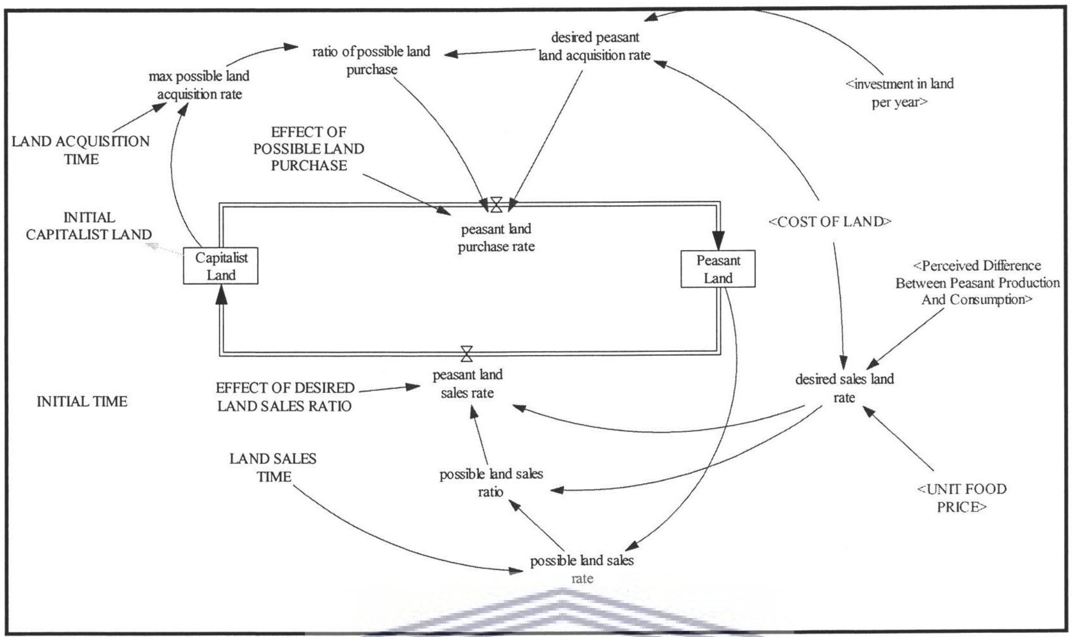

Figure 4:9: Land Sector Stock and Flow structure

Figure 4.8 above represents the land sector within the context of this model. The land sector consists of two stocks, namely Capitalist Land and Peasant Land. Land either flows from the capitalist stock to the peasant stock, when purchased by peasants or from the peasants stock to capital stock when peasants sell it to raise money for consumption.

This model was calibrated with Kenya national population data collected between 1980 and 2005. Further, rural poverty headcount statistics from the Kenya Bureau of Statistics (KENBS, 2006) for the same period were used to trace historical tendencies of rural poverty with the intent to correlate them to land distribution between small and large scale rural farmers. This is meant to understand land access trends for the small holders and understand the dynamics that prevent them from increasing their landholding.

The next chapter will examine the structure of the model for validity. The model will be exposed to a number of structural tests to test for its robustness as a means of creating confidence in the analysis based on it.

5 VALIDATION

Validation is the process of building confidence in a model. It enables users to become confident that the model is fulfilling the purpose for which it is built. Different types of models are developed to fulfil different purposes. For example, models could be built for prediction, to understand the relationship between variables of interest, to test the impact of policy, to understand the nature of policy resistance or understand some complex dynamics. In this case, the model built is meant to understand the dynamic relationship between population growth, food security and poverty traps.

Barlas (1996) argues that a model's validity should be judged with respect to its purpose. Once this purpose has been established, it then becomes necessary to critique the usefulness of the purpose itself. This would imply that different models will have different validation criteria dependent on the nature of purpose the model addresses. Sterman (2000) argues that no model is perfect and that models should be judged based on their ability to adequately address the purpose for which they are intended. Therefore, models ideally should never be adapted to a purpose other than that for which they were intended in the first place. The model in this paper has been developed to understand the dynamics of the relationship between population growth, food security and the role of these two in engendering poverty traps.

Furthermore this model demonstrates the usefulness of system dynamics in addressing public policy issues and stimulating interest in further research to understand poverty dynamics. This model will need to be specified a little further for it to be useful in enabling recommendation of policy. However, it provides useful insights on the dynamic interaction between population changes and food available and how this relationship dynamically impacts poverty traps.

5.1 Validation Tests

5.1.1 Structural Tests

This being a structural model, its validity therefore will be assessed based on the validity of its structure. The information used in the development of the structure of this model is derived from a number of sources. This includes examination of literature on the subject of food security, population growth, and poverty traps, together with observations and expert feedback. This information that forms the set of assumptions used in this model is described in detail in Chapter 4 of this thesis. This validation is meant to ensure that the model developed is consistent with relevant descriptive knowledge of the system (Sterman, 2000). Besides this, a number of tests have been conducted on the structure of this model to test its robustness. The results of these tests are outlined in the section below.

5.1.1.1 Extreme Condition tests

The purpose of this test is to ascertain whether the model responds plausibly when exposed to extreme values of parameters, shocks or policies. A test was performed to gauge this response by changing the value of land productivity. The results are shown in the section below.

Extreme Productivity

The model was subjected to 1kg/acre land productivity, which is considered to be a very low level of productivity. The rest of the parameters were left same as in the base case. The plausible implication of this would be that there will be very little food available to feed the population. This is expected to reduce the amount of food available per person leading to widespread starvation and hence high mortality. The graph showing the reduction in the total food available result of this extremely low level of productivity is shown in Figure 5.1 below.

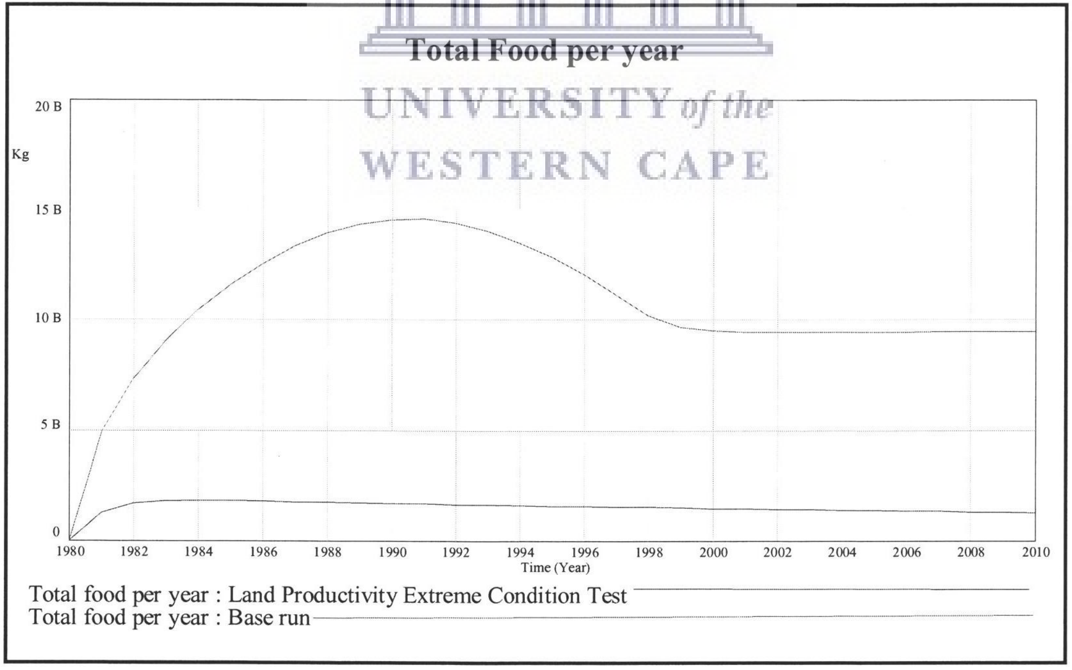

Figure 5:1: Behaviour of Total Food per year at 1kg/acre productivity

Figure 5.1 above indicates a general decrease in the amount of food available over time. Even then, the food indicated in the graph is not produced from the farms as these produce almost nothing. It comes from purchases based on wages received from peasants working in other sectors. The resultant distribution of land between the two sectors is shown in Figure 5.2 below.

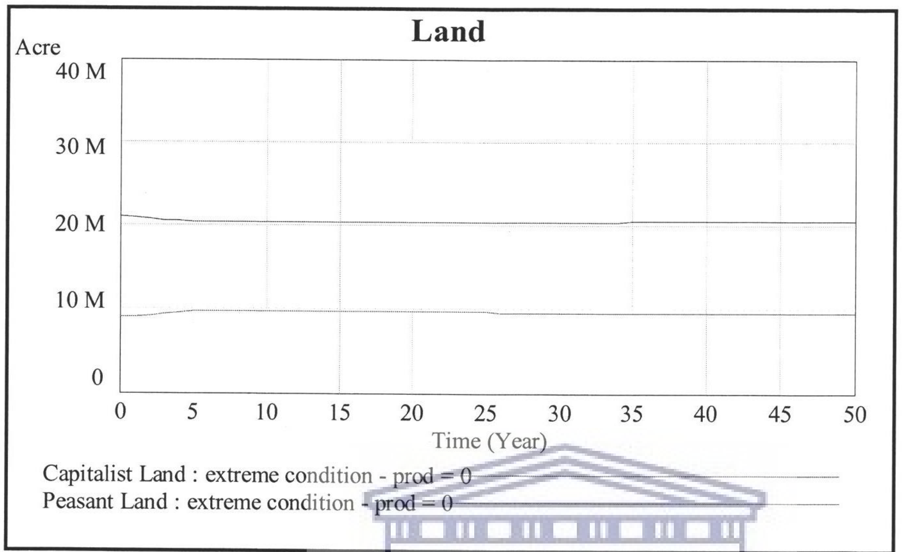

Figure 5:2 - Base case Land Distribution

Decreased productivity means that the amount of food produced from the farms is not sufficient for consumption in such a way that a surplus will result that can be used for new land purchases. This leaves the land distribution relatively unchanged over this period of time. This very low levels of food available will also result in an increased mortality rate, thereby decreasing the population. However, with these very low levels of productivity, people will try to find alternative sources of livelihoods that they will translate to food. This scenario is illustrated in Figure 5.3 below indicating the trends in the population.

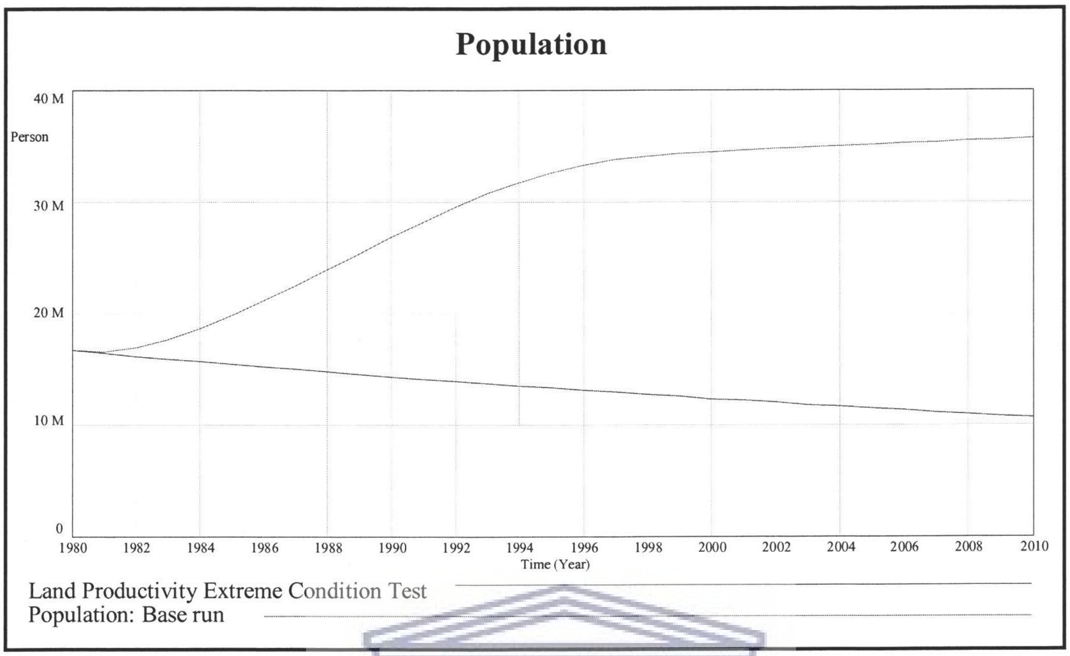

Figure 5:3 - Behaviour of population at 1kg/acre land productivity

5.1.1.2 Sensitivity Analysis

Sensitivity analysis is meant to determine how sensitive a model is to changes in the value of certain parameters. Generally system dynamics models are insensitive to changes in the values of the parameters (Breierova and Choudhari, 1996). The structure of the system is responsible for the behaviour observed in the model. A number of tests were carried out to check the sensitivity of model behaviour to different parameter values. The results are reproduced below.

Sensitivity of Fraction of savings invested.

The default fraction of savings invested in the model is assumed to be 0.3. To determine the sensitivity of this parameter value to the overall population behaviour, we change this value to 0.4. The resultant behaviour of land owned by peasants is shown Figure 5.4 below.

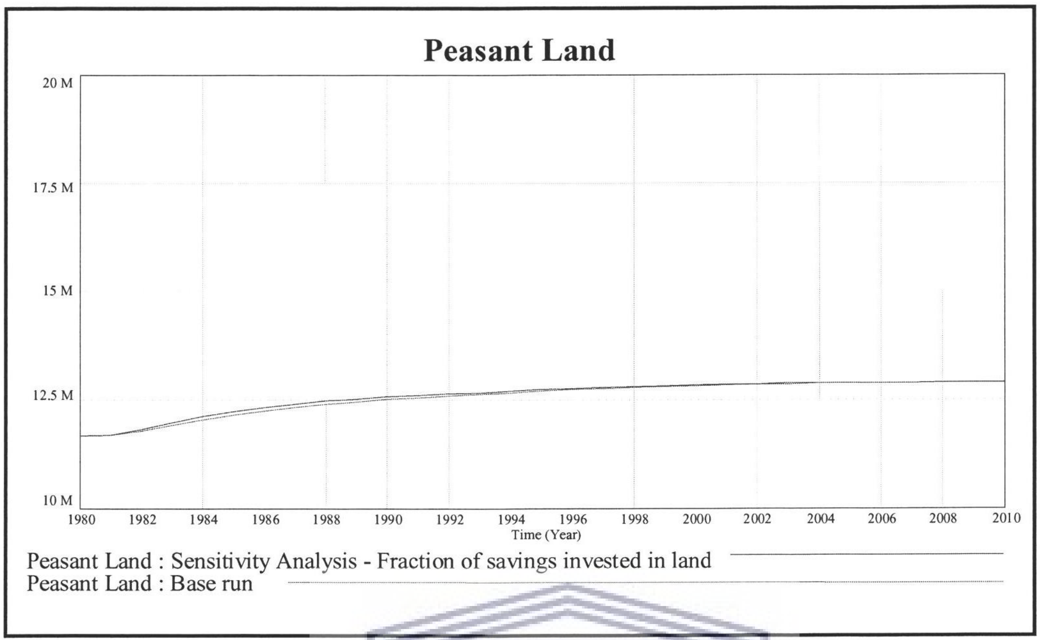

Figure 5:4 - Sensitivity of Fraction of savings invested to Peasant Land

Looking at Figure 5.4 above, the behaviour of peasant land held remains almost the same. This implies that the model is not sensitive to moderate changes in the fraction of savings invested.

Sensitivity of the cost of land

Increasing the cost of land from the base run value of Ksh. 250,000 per acre to Ksh. 350,000 per acre also does not change the behaviour of the system. The land distribution after this parameter change is shown in the diagram below:

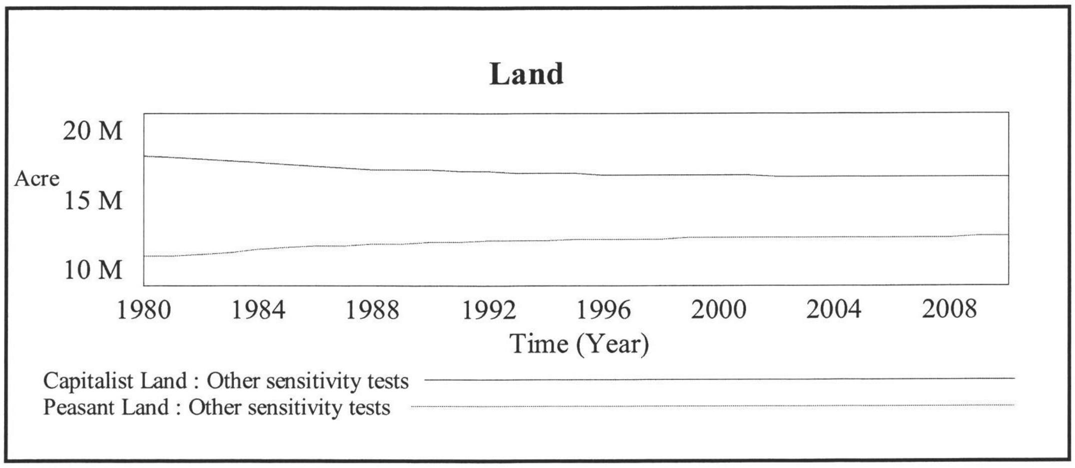

Figure 5:5 - Sensitivity of the cost of land to land distribution

5.1.1.3 Integration error tests

System dynamics models are usually formulated in continuous time and solved by numerical integration. Therefore the choice of numerical integration method and time-step must yield a good approximation of the underlying dynamics of the for the purpose of the model (Sterman, 2000). This model was therefore taken through two integration error tests including:

Doubling the time-step

The default time-step used for this model is 0.01565. This time step was doubled to 0.03125. The resultant behaviour of the behaviour of the land distribution pattern is shown in Figure 5.6 below.

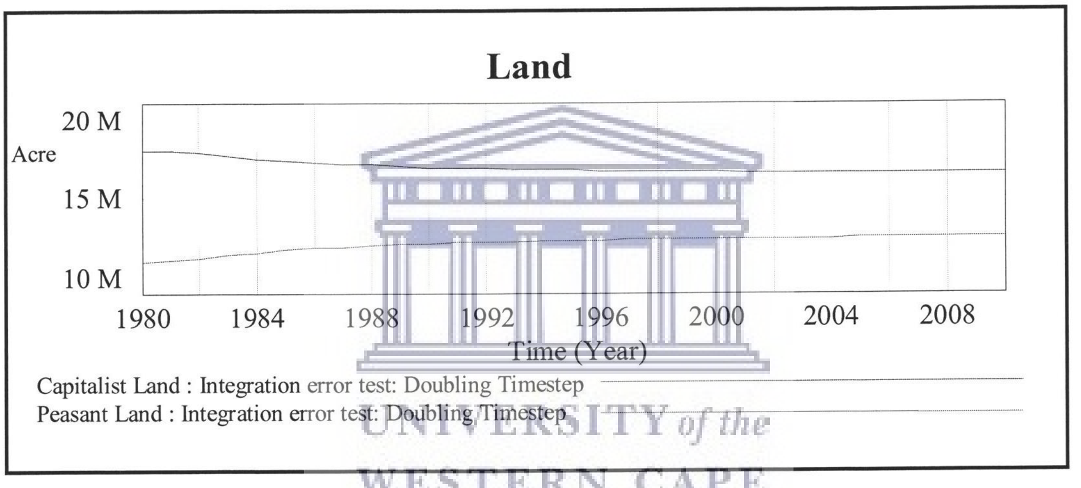

Figure 5:6 - Effect of doubling the time-step on Land distribution behaviour

In Figure 5.6 above, land distribution maintains the same behaviour trends seen before the doubling of the time-step. This is further proof that the behaviour of the model is not biased as a result of the choice of the specific time-step used.

Changing the integration method

Changing the integration method from the default Euler Integration to Runge Kutta revealed the same behaviour with regard to land distribution as shown in Figure 5.7 below.

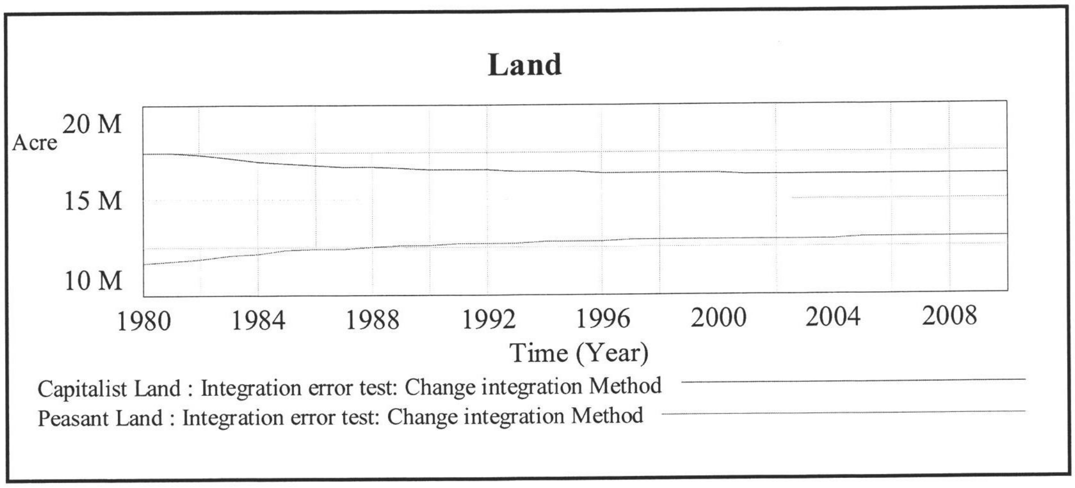

Figure 5:7 – Effect of change in integration method on and distribution behaviour

Once again the behaviour of the model remains the same as the base run, meaning that we achieve the same results irrespective of the type of numerical integration method used.

5.1.2 Behaviour reproduction tests

Using time series population data collected at different times between 1980 and 2005, the model simulated and compared the data. The fit of the population data and model simulation is illustrated in the diagram below.

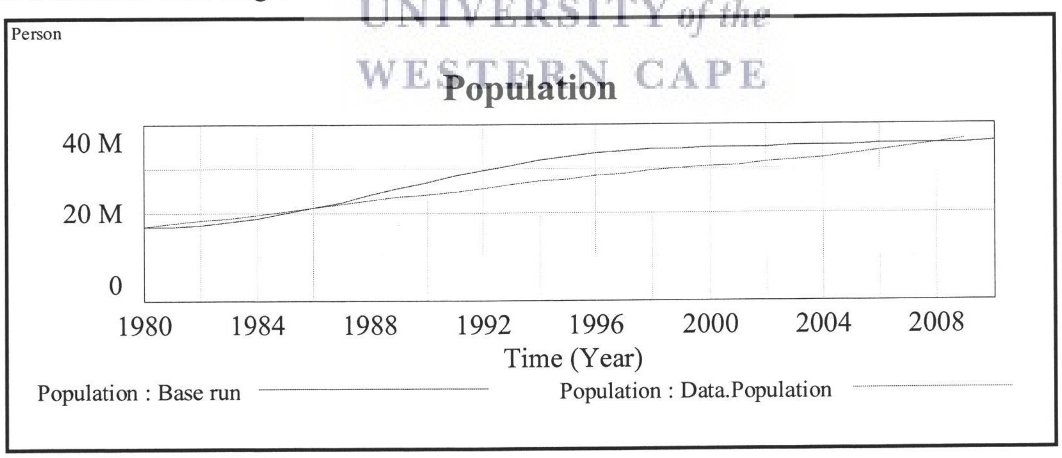

Figure 5:8 - Fit of Population simulation and Population data

In Figure 5.8, the red line represents the population data over time while the blue line represents the model simulation. The R^2 achieved in this fit is 0.917. This represents a good fit of the model simulation to the data over this period.

Having established the validity of the model in this project, the next chapter will discuss results and lessons learnt from the base run of this model.

6 RESULTS

One of the specific objectives of this research project was to understand the dynamic relationship between changes in population levels, food security and poverty traps. This chapter will therefore present the simulation results achieved from the model's base run describing this dynamic relationship. These results include the major indicators being investigated in this model as well as descriptions of the insights gained from the model concerning poverty trap dynamics. These results described below are grouped together under each sector represented in the model.

The results presented in this chapter take into consideration replication of overall population trends over time. However, there is specific focus on interactions between the core issues being studied in this project including food availability, population changes and land distribution between large scale and peasant communities.

6.1 Population

There are two feedback loops that are responsible for the growth and collapse of the population in the dynamic model. These two balancing loops B1 and B2 ensure that population changes respond to levels of available food. This will maintain a population level that can be supported by the food available or food producing capacity available. These two balancing feedback loops are illustrated in the causal loop diagram shown in Figure 6.1 below.

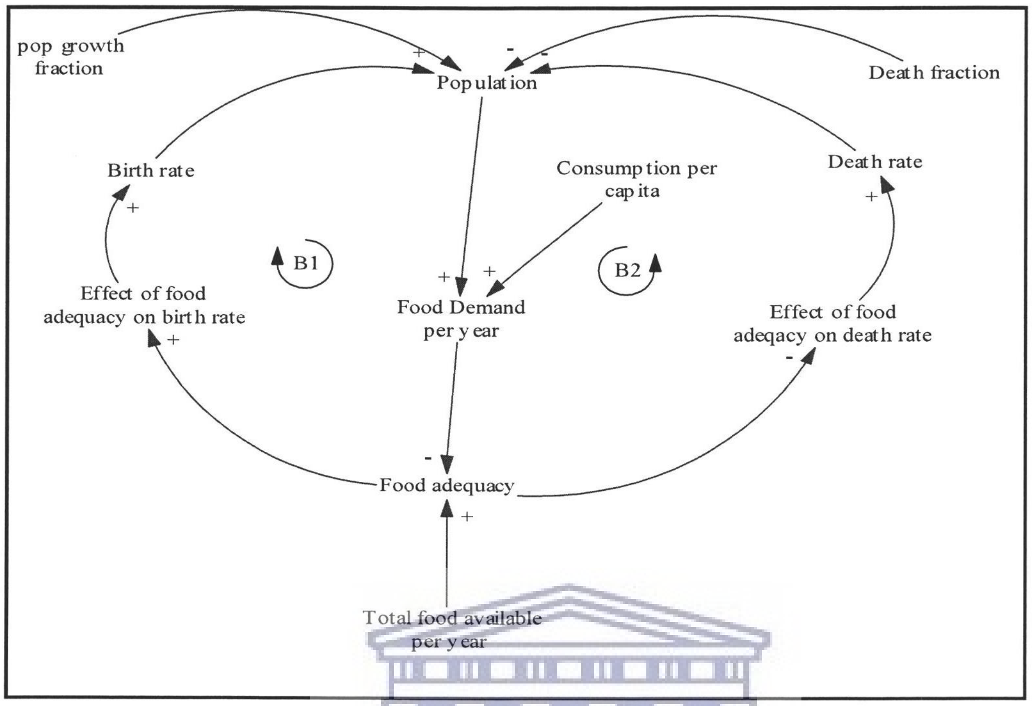

Figure 6:1 - Population Causal Loop diagram

These loops shown Figure 6.1 above are responsible for the population behaviour shown by the red line in Figure 6.2 below.

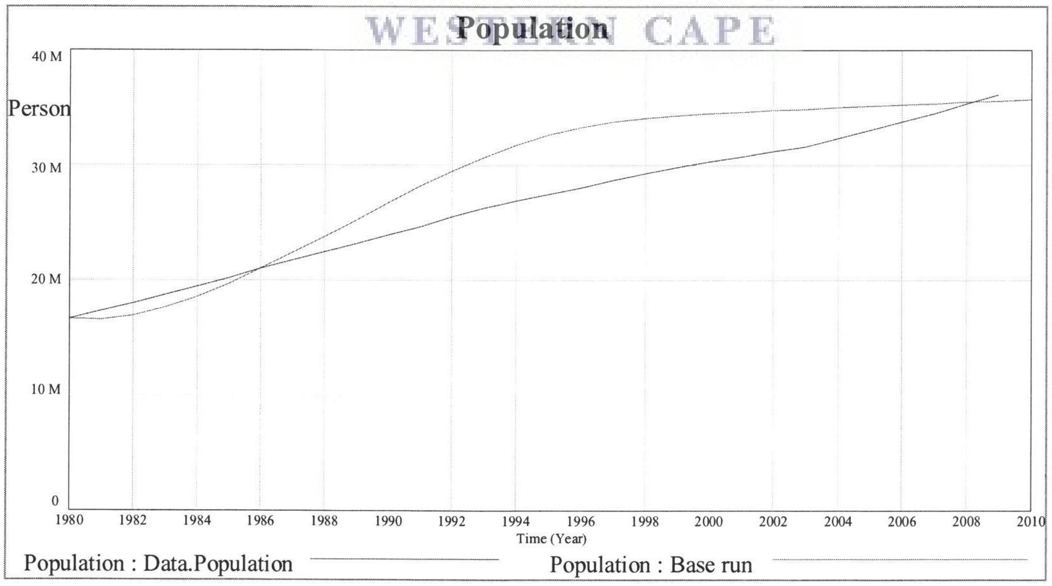

Figure 6:2 - Population Behaviour

The red line in Figure 6.2 above represents the total population behaviour over time while the blue line represents population data since 1980 to 2009. In the beginning owing to the low population, the excess food available increases the birth rate exponentially. In spite of an increase in population and demand for food, food available is still more than food demand, thereby maintaining high food adequacy which is a condition for an increase in the birth rate and a decrease in the death rate. This happens until the system reaches the carrying capacity at a point where food available is equal to food demand. At this point the level of food adequacy cannot allow the population to grow any higher. At high levels of food adequacy, there is a tendency of the population to grow exponentially. Owing to the faster increase in the amount of food than the increase in the population, there is a tendency of the population to grow exponentially in the beginning before the total food available stops growing.

Once the population has reached its maximum, it starts dropping gently. This is as a result of the activation of balancing loop B2 shown in Figure 6.1. Here, owing to a high population, there is a high demand for food. This will decrease food adequacy thereby strengthening loop B2 that increases the death rate, limits the number of children per family thus reducing the population. Note that a continued decrease in the amount of food available will suppress the level of population further to a new goal that will be determined by the amount of food available. Whereas access to food is an important consideration for population behaviour in rural Kenya, the slowing down of the population growth shown above is as a result of demographic change brought about by improvements in rural literacy, healthcare among other factors (KNBS, 2007).

6.2 Food availability

The model reveals that an increase in food available is followed by a brief time delay with an increase in population. Shortly after a decrease in the total food available, we see a decrease in the population. This is illustrated in the set of graphs presented below.

6.2.1 Total food

The graph representing total food available less consumption is shown in Figure 6.3 below.

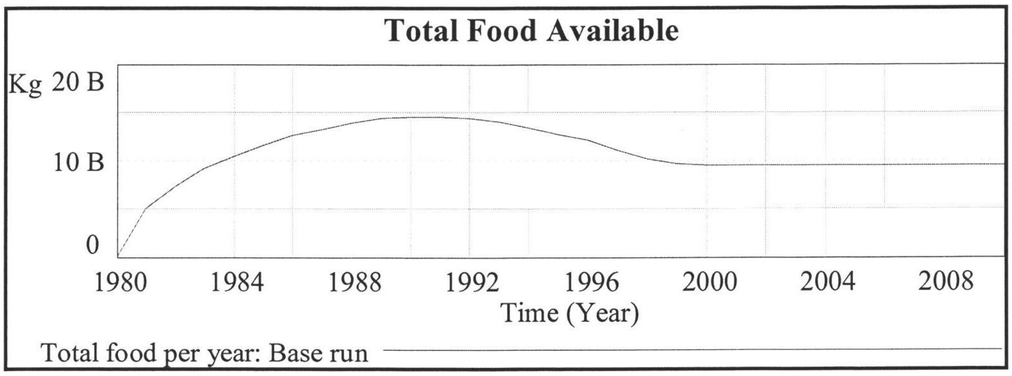

Figure 6:3 - Total Food Available

Figure 6.3 above represents the net food available over time in both the capitalist and peasant sectors. It indicates a sharp increase at the beginning of the simulation before this gently falls to remain at equilibrium from around year 1999. While the population remains low in compared to the amount of food produced at the beginning of the simulation, food surpluses are stocked making it possible to increase total food stocks but at a decreasing rate. This is because the increase in the amount of food available pushes up the population which eventually eats up the food already piled up. This causes the food to collapse when the population reaches its maximum as the increased demand for food eats up on the stocks of food. This continues till the food and population levels reach equilibrium as shown.

A closer examination of the contribution to the stock of available food between the capitalist and peasant sector reveals the scenario shown in Figure 6.below.

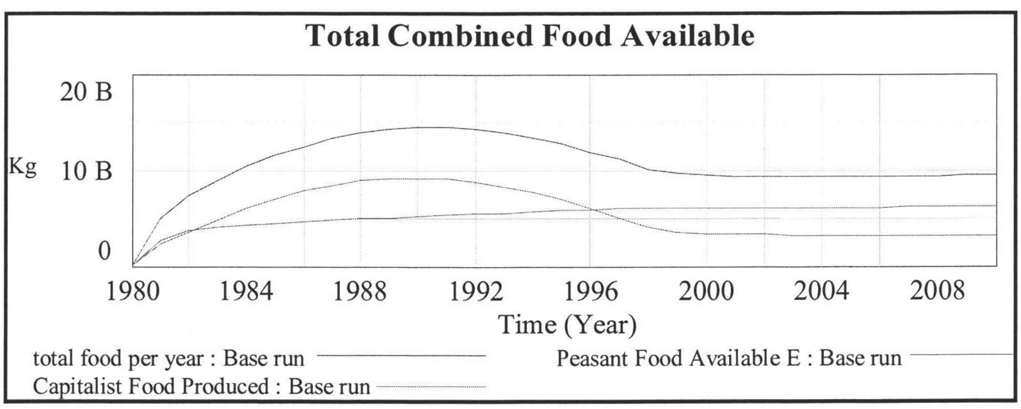

Figure 6:4 - Food Available in both sectors

The increased population raises the number of wage workers in the capitalist sector. This in turn increases the wage burden on the capitalist sector which flows to the wage workers from the peasant sector. These additional wages and land sales food equivalent in the peasant sector explains why the amount of food in the peasant sector remains somewhat constant even when capitalist food is falling.

Figure 6.4 above indicates that most of the accumulated total food in the population actually comes from the capitalist sector. This is because at the beginning of the simulation, the capitalists have a higher land holding and assumed to be only 30% of the population compared to the peasant sector who are assumed to constitute 70% of the population. There is therefore greater active consumption in the peasant sector thereby maintaining very low levels of food stocks.

6.2.2 Food adequacy

The model utilises a graph function that denotes the relationship between food adequacy and its impact on the birth rate and death rate. Food adequacy is determined by the ratio of food available and food demanded. This graph is represented in Figure 4.8.

Whereas food demand is determined by the population, food available is determined by the summation of net production from the capitalist sector and production plus the food equivalent of wages and land sales. A change in food availability will result in a change in population albeit with a time delay as shown in Figure 6.5 below. Here, the decrease in the population is as a result of a decrease in land productivity from 200kg/acre in the base case to 180kg/acre.

A high ratio will imply the existence of abundant food and hence will push up the birth rate. On the other hand, low food available will mean that there will not be enough food for the existing population. This results in a suppression of the birth rate.

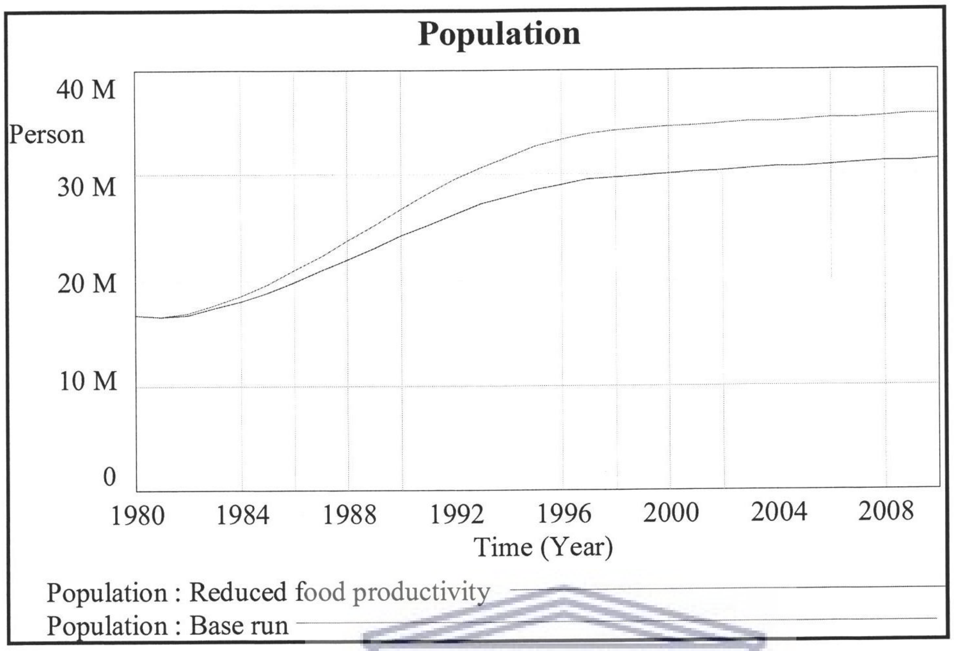

Figure 6:5 - Impact of changes in food availability on population behaviour

The discussion in the foregoing paragraphs has described the dynamic feedback of increased population on their flows (birth rate and death rate).

6.3 Peasant and Capitalist Landholding

This model utilises changes in peasant and capitalist landholding as the measure of change in the ability of people to produce food and thereby ensure food adequacy. Initialising the system using the Figures outlined above, the simulation for changes in land ownership is as shown in Figure 6.6 below.

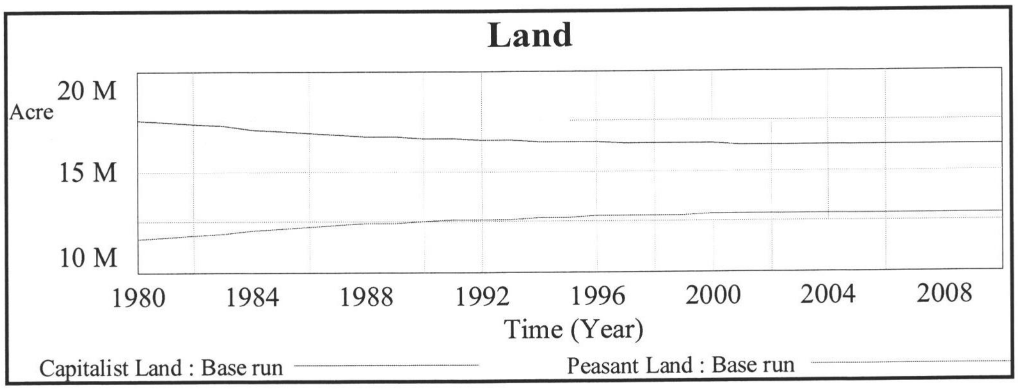

Figure 6:6 - Base case land distribution

At the beginning of the simulation in Figure 6.6 above, the small population relative to the food production capacity leads to surplus production in the peasant sector. This surplus is used to buy more land thus increasing peasant land share in the beginning and further increasing food in the peasant sector. However, the increased food also increases the birth rate and population (as described above) which then exerts pressure on the surplus available. This push in the opposite direction forces the system to settle at a peasant landholding goal that is higher than the original.

The historical tendency of the peasant land holding from colonial times in Kenya has been one of concentration in the hands of the few large scale landowners (Syagga, 2007). This scenario is well illustrated in Figure 6.7 below:

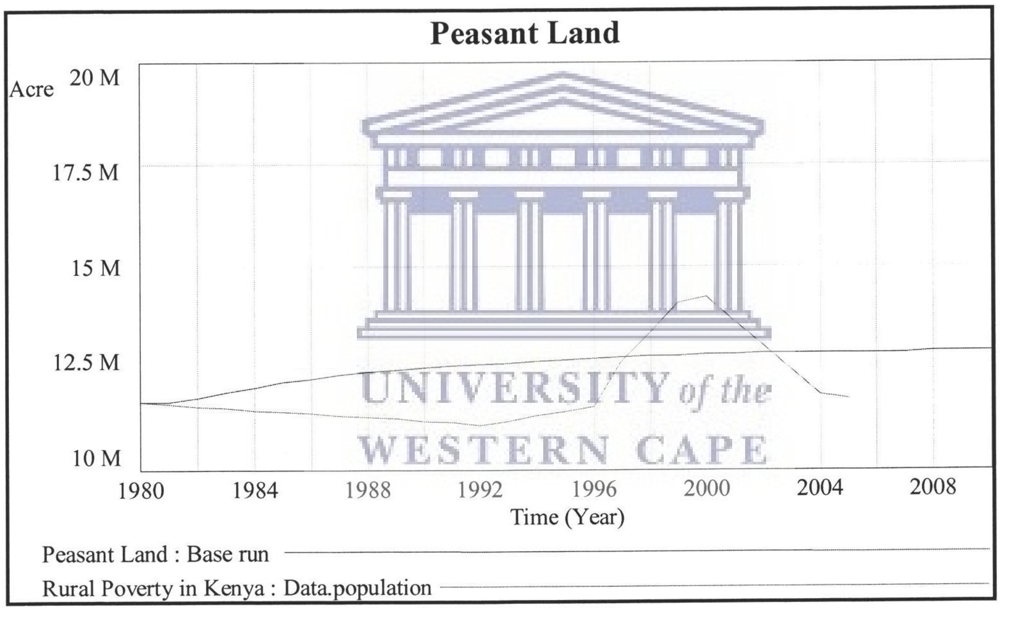

Figure 6:7 - Comparison of rural poverty and model simulation of historical tendency

The post colonial experience indicates that independence did not necessarily mean land inequality issues were conclusively addressed. In fact, a new crop of politically well connected individuals took over the land originally owned by the settlers. Only a small portion of colonially held land was subdivided to small holders (Syagga, 2007). The rural poor are almost entirely dependent on land (Quibria and Srinivasan, 1991 and Reardon, et al, 1992). Wambugu and Munga (2009) argue that poverty in rural Kenya can be explained by low access to physical assets (especially land). Figure 6.7 above sought to plot normalised actual data on rural poverty levels in Kenya and compare it with the simulation of the model regarding land allocation to the poor. The simulation (blue line) shows a little increase in land holding by small holders at the beginning, but which stagnates after a few years. This captures the general trend of the levels of rural poverty registered over the same period. The rural poverty levels have remained fairly unchanged, if not getting worse, except for a few oscillations.

The land holding further disaggregated in order to view the land available per person in both sectors. This provides a better understanding of what is happening to individuals in both sectors. This is illustrated in the Figure 6.8 below.

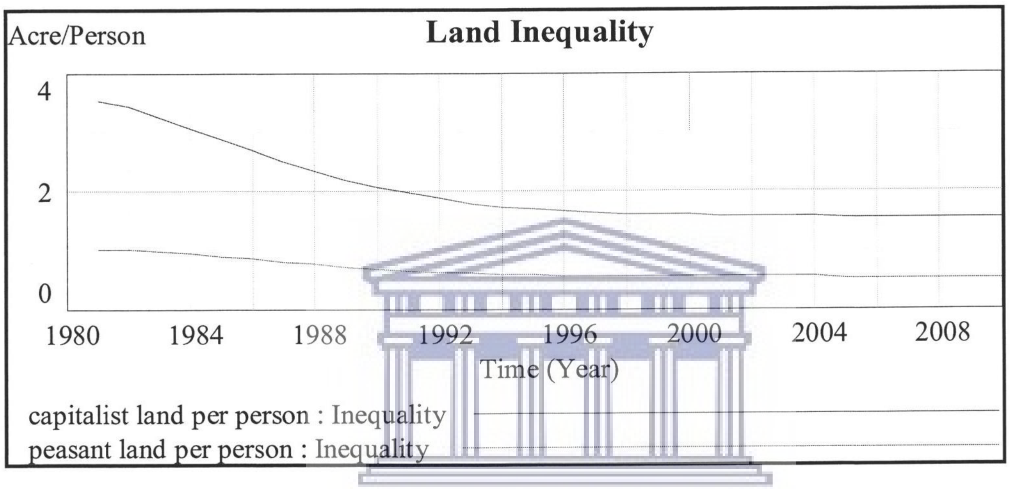

Figure 6:8 - Behaviour of land per person in both sectors

Figure 6.8 above indicates that at the very beginning of the simulation, there is a very wide gap between landholding per person in both sectors. As time passes, however, landholding per person reduces in both sectors. It is interesting to note that there is a slight increase in small scale land holding in general as shown in Figure 6.6. However, this increased holding is offset by the increase in the population, leading to no increase in the amount of land available for each member in the small holder group. Small holder farmers are therefore denied the possibility to break out of the poverty trap.

The following final chapter will discuss some implications of the lessons learnt in this model on policy, as well as test the policy implications of certain food security and poverty reduction policies.

7 ANALYSIS OF FOOD SECURITY AND POVERTY REDUCTION POLICIES

According to the model, as well as literature on food security and poverty (see Chapter 2), successful policies that would release people from rural poverty traps must address the issue of access to land. The most useful policies are those that will increase the flow of land from the capitalists to the peasants. Improvements or worsening of the status of land ownership will be observed by the changes in the amount of land owned by people initially considered peasants or capitalists as well as the amount of land per person in each group. The behaviour of land distribution between peasants and capitalists in the base case is shown in Figure 7.1 below.

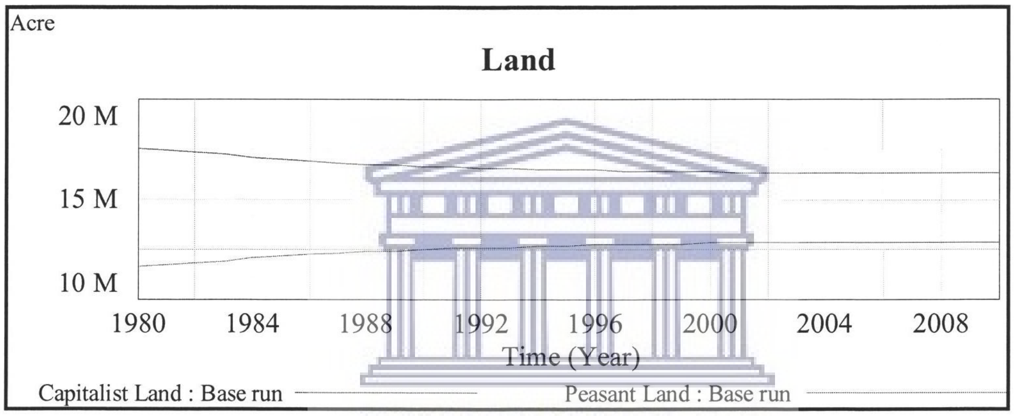

Figure 7:1- Initial Land distribution scenario

The diagram above represents the situation as it has been historically. The purpose of policy analysis is to scrutinise the impact of policies in order to ensure the red line belonging to the peasants increases in such a way that it is either at par with the blue line representing capitalist ownership or more. This would imply that the policy that raises the red line significantly is likely to succeed in redistributing farmland from the large scale capitalists to the poor peasants.

A related graph that is also important to take note of is the peasant land per person graph shown in Figure 7.2 below.

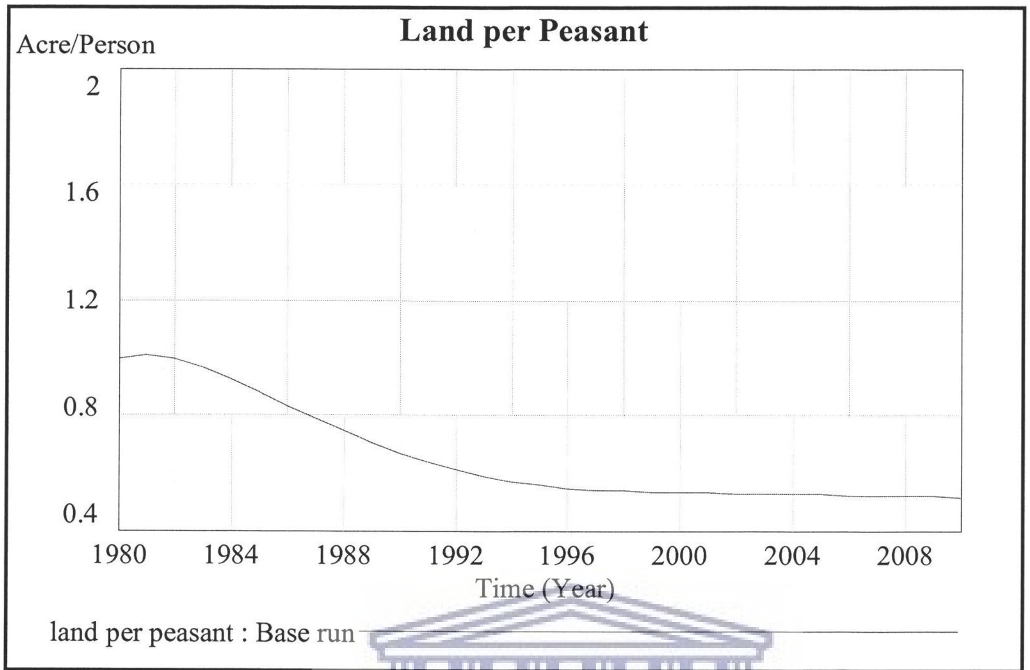

Figure 7:2 - Peasant Land per person

Examination of Figure 7.2 above indicates that land owned per person has been decreasing since 1980. This is in spite of the gains made in land ownership by the peasants which are more than compensated by the related increase in population. The increase in population could among other reasons be as a result of the plentiful food stocks available. If land ownership per person therefore is a reasonable measure of the individual livelihood of each peasant, then peasant livelihoods have been worsening over time since 1980.

The model was used to test two sets of policies to see whether either of them is effective in increasing peasant land holding as well as land owned per person among the peasants. These included:

1. Increase in land productivity.
2. Increase in the wage rate.

7.1 Increase in land productivity

In this model, land and food productivity are assumed to be the only factors of production. Food production changes with availability of land while productivity is constant throughout the model. The normal level of land productivity was 200kg/acre/year. Several tests were carried out on land productivity including doubling land productivity and tripling land productivity. The results of these tests will be discussed in the following section.

7.1.1 Doubling land productivity

Doubling land productivity from 200/acre/year to 400kg/acre/year resulted in land distribution behaviour between the two sectors as shown in Figure 7.3 below.

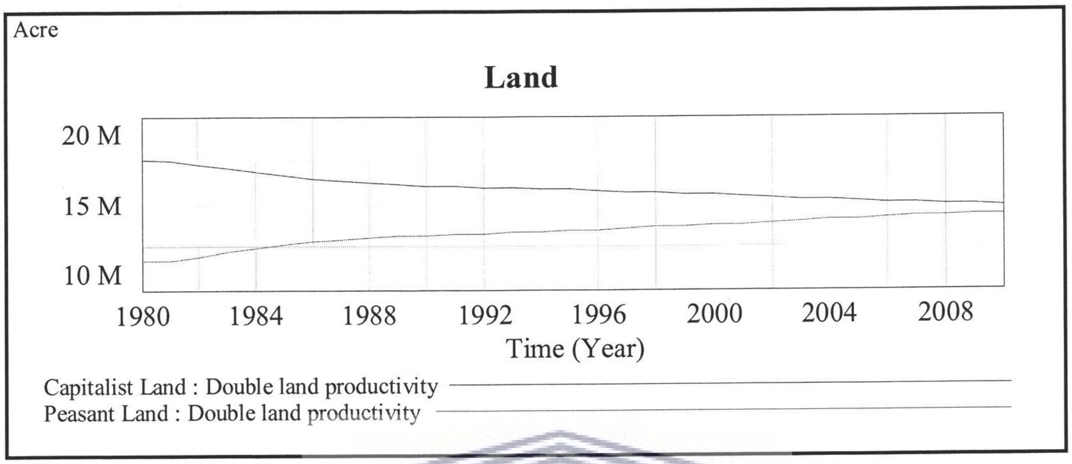

Figure 7:3 - Land distribution after doubling land productivity

Doubling land productivity in this model leads to a gradual period of gains in which peasants have enough to eat and a surplus that they can use to purchase more land. This gradually increases their land holding in such a way that after the 30 years from 1980, their land ownership has significantly grown and is still growing. However, in spite of this growth, the amount of land owned by each peasant does is not grow. This is illustrated in Figure 7.4 below.

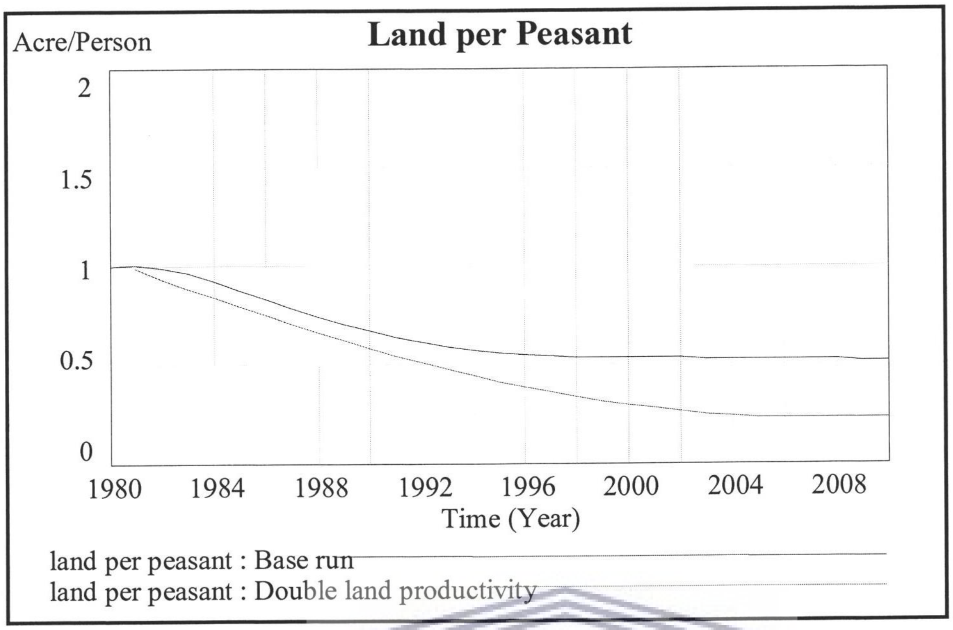

Figure 7:4 - Effect of doubling land productivity on peasant land per person

Figure 7.4 compares the land per person in the peasant sector before and after doubling land productivity. Here, the increase in land-holding by the peasants is more than compensated for by the growth in population. The increase in land holding is not sufficient to increase land attributable to each individual in the rural peasant sector. However, at around year 2004, this decrease flattens out when the population has reached equilibrium with respect to the food producing capacity of land owned by the peasants. According to this model, this scenario is likely to remain so for a while, unless the population changes or something happens to alter the food producing capacity of the total land. The impact of this policy is a good example of system induced policy resistance.

7.1.2 Tripling land productivity

Tripling land productivity from the initial of 200kg/acre/year to 600kg/acre/year produces the behaviour shown in Figure 7.5 below.

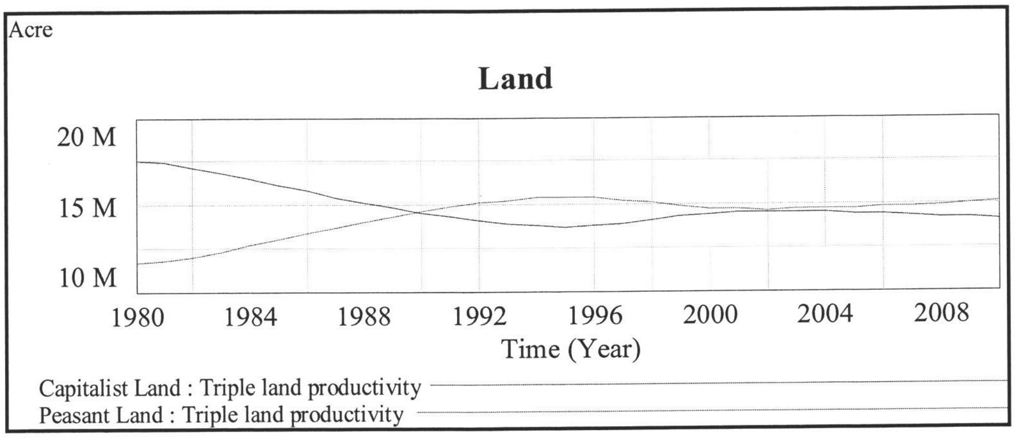

Figure 7:5 - Effect of tripling land productivity on land distribution

Tripling land productivity enables peasants to increase food surplus available which they rapidly deploy to increase their share of land owned. This available food has the effect of increasing the population growth rate exponentially, who consumes more and more of the food produced compared to the base case. This population explosion is shown in Figure 7.6 below.

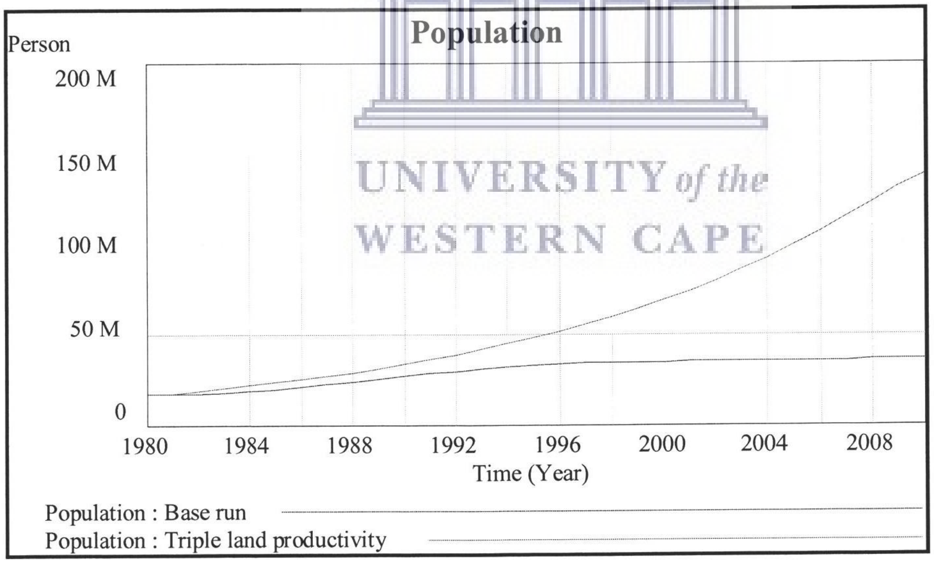

Figure 7:6 - Effect of tripling land productivity on population

This rapid increase in the population will likewise increase the demand for food. This is likely to lead to the peasants to respond at some point to this high demand for food by selling some land to cater for the food deficit. Figure 7.7 below illustrates a spike in peasant land sales to provide food for this increased population.

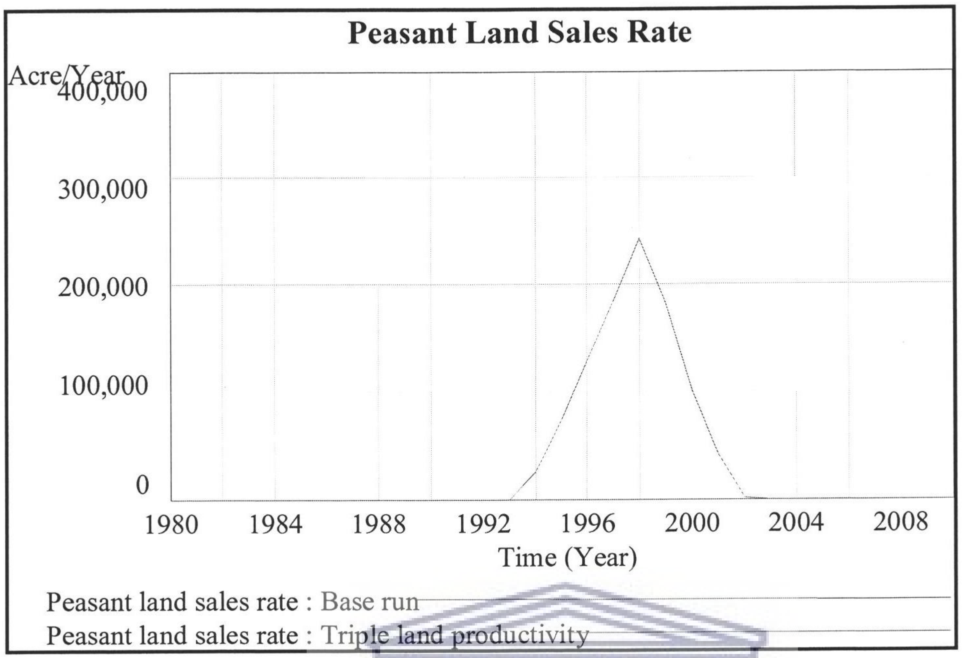

Figure 7:7 - Effect of tripling land productivity on peasant land sales

This sale of land shown in the above figure, to cater for population food deficits in the peasant sector, interrupts the ownership of land among the peasants, creating some damped oscillations as peasants wait to recoup their land losses once they have food surplus again.

Notice that this happens when land productivity is increased throughout the population (to both peasants and capitalists). A threefold increase in productivity will require huge capital investments and farm inputs that may be too expensive and perhaps out of reach of many peasants. Often increases in productivity are only available to capitalists because they can afford it. If this happens and supposing there is a feedback loop allowing capitalists to spend a portion of their food production surplus to purchase land from the peasants, this will work adversely against peasant landholding. The implication of this would be that if the Kenya government is intent on scaling up productivity, it must ensure that peasants as well as capitalists benefit, otherwise the peasants will be further locked into poverty. The scenario of peasant land per person is illustrated in Figure 7.8 below.

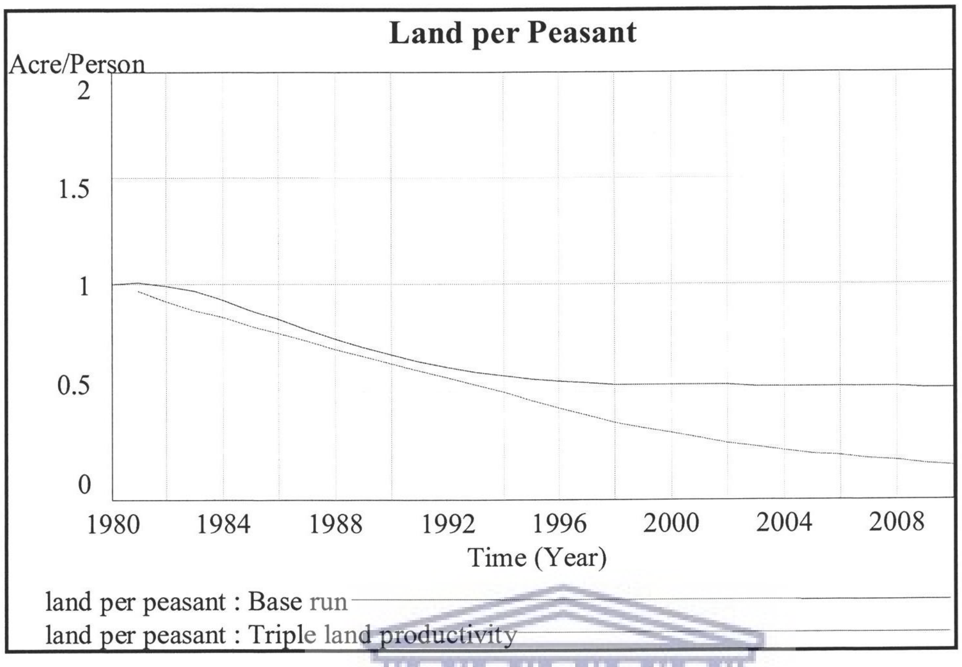

Figure 7:8 - Effect of tripling land productivity on peasant land per person

7.2 Increase in the wage rate

A fraction of peasants work in the capitalist sector. They earn wages which are then converted to their food equivalent thereby increasing the amount of food available in the peasant sector. The number of wage workers is influenced by both the population of the peasants and the amount of land held by capitalists. This scenario test is meant to evaluate the impact of changing the wage rate and observing the impact of this on land distribution.

7.2.1 Doubling the wage rate

The wage rate was doubled from the original Ksh. 24000/year to Ksh. 48000/year. Figure 7.9 below shows the resultant behaviour. It was observed that this increase only started showing signs of improving peasant land ownership after 50 years (which was the period of simulation).

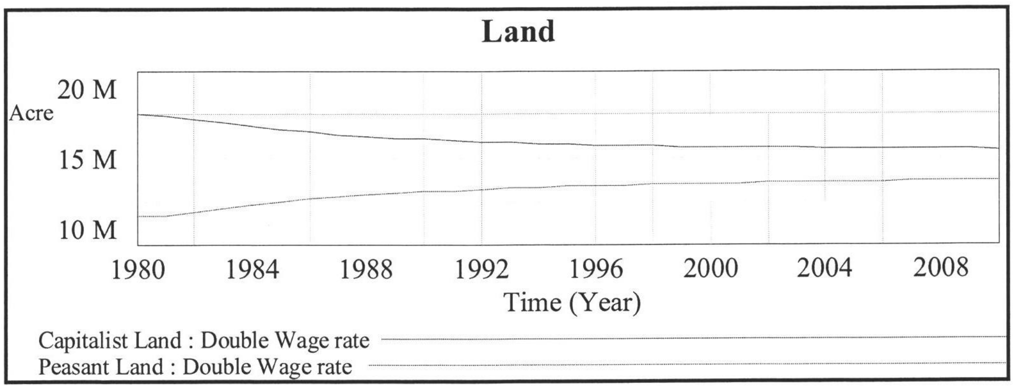

Figure 7:9 - Effect of doubling the wage rate on land distribution

This delay in improvement of the peasant land holding is because the increase in wages (which was low enough to start with) was not sufficient to generate a surplus after consumption which would allow peasant farmers to purchase extra land.

7.2.2 Five-fold increase in the wage rate

To test the impact of a five-fold wage increase, the wage rate is increased from Ksh. 24,000 per annum to Ksh. 120,000 per annum. This increase in the wage rate results in the land distribution behaviour illustrated in Figure 7.10 shown below.

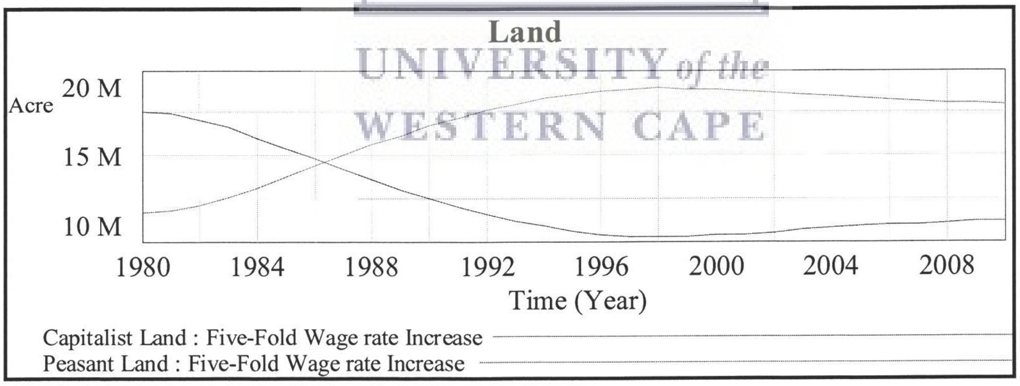

Figure 7:10 - Effect of a fivefold increase in the wage rate on land distribution

The above figure shows a gradual but steady increase in peasant land gains from year 1980 as a result of the five-fold increase in the peasant wage rate. Given this increase, peasants have enough for consumption and sufficient surplus to purchase more land. However, it should be noted that an instantaneous five-fold increase in the wage rate is not feasible in a developing country like Kenya. This will most likely be resisted by both the capitalists as well as increase the cost of food in the general population (impact of changes in wages on food prices is exogenous to this model).

The following chapter will make summary conclusions and draw recommendations for further research beyond the scope of what is described here.

8 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER STUDY

8.1 Conclusions

The objective of this study was to develop a tool that would provide insights into the dynamic relationship between food security, population growth and their impact on poverty traps. Furthermore, the project sought to test a few poverty reduction policies to determine their implications for poverty reduction as well as make policy relevant conclusions. The model was adapted to the Kenyan context, utilising Kenyan population data from 1980 to 2005, and rural poverty data for the same period collected by the Central Bureau of statistics.

The structure underlying this model was developed based on peer reviewed literature and observations from the project area. The model produced a simulation of the population data from 1980 to 2005 achieving an R^2 of 0.917. The model was also exposed to extreme condition, sensitivity and integration error tests and emerged as robust and consistent enough for the purpose intended.

This model was formulated to identify factors that impact on changes in land ownership between small holder peasant farmers and large scale capitalist farmers. An increase in the amount of land owned by the peasants is taken to be an improvement of their welfare and a possible way out of the poverty trap.

Whereas the amount of land available is constant, an increasing population will increase pressure on the land. This is felt as a result of increased demand for food. An increase in population without a corresponding increase in available land for food production will reduce the surplus necessary for investment sometimes and in some cases could lead to the disposal of productive assets to fund consumption. It therefore becomes of utmost importance for a country such as Kenya, to ensure that the population grows at a sustainable rate to avoid exerting undue pressure on the land that will lead to it being counterproductive in the years to come.

Secondly, it became clear that demographic changes take time, and their impact is only felt after a long period of time. Public strategies targeting population changes will therefore need to be anticipated in such a way that any foreseen negative impact is forestalled years before it happens. Furthermore, owing to the fact that peasant land per person in the population will eventually decrease even with an increase in peasant landholding, it becomes necessary for the government to promote alternative investment options for the small holders to forestall a situation where the land cannot be relied on as a means of production to take care of the existing growing population.

Policy analysis tests carried out revealed that a doubling and tripling of land productivity is not sufficient to increase peasant land per person. This is mainly owing to the increase in peasant population. It emerged that for increase in land productivity to be a policy of choice to address rural poverty traps, the government must ensure that increases in productivity are available to the small holder farmers. In practice, the cost of increased productivity is available to large scale farmers at the exclusion of the poor who need increased productivity most.

Doubling the wage rate does not significantly increase the ability of the peasants to increase their land holding. According to the model, it takes a ten-fold increase in the wage rate for the share of peasant farmland to increase significantly. However, it is not practically feasible to make a ten-fold increase in the wage rate. This will push up the prices of farm products and will most likely receive a great deal of resistance from the capitalist farmers themselves.

Further it became clear that the strength of certain feedback loops are responsible for the eventual reversal of the intended impact of some seemingly useful policy strategies including increase in land productivity and the wage rate. Therefore, policy makers will need to keep in mind these feedbacks in formulating appropriate strategies to address rural poverty traps in Kenya and developing countries in general.

8.2 Recommendations for Further Research

This model was developed with clearly defined narrow boundaries with respect to the causal factors responsible for poverty traps. In reality there are other factors that are responsible for stagnating people's livelihoods. Low educational attainment, poor healthcare, market imperfections and poor coordination of rural agriculture (KNBS, 2007; Barrett, 2008) have been documented as playing an important part in maintaining people in poverty. However, these have not been adequately dealt with by the model in this research as well in existing literature.

Further research would therefore explicitly find land allocation time-series data over time for each of the initially small holder and large scale farms and trace their evolution over a period of time. This would involve identification of the dynamics of rural land ownership over time and the study of key variables responsible for maintaining rural poverty.

Given the roughly stable land size and dynamic population changes, further research is needed to identify strategies that can establish a desirable demographic-ecosystem equilibrium that will foster improvement of livelihoods. This hopefully should identify a sustainable equilibrium capable of breaking rural poverty traps.

9 REFERENCES.

AFDB. (2005). *Kenya: Evaluation of Bank assistance to the agriculture and rural development sector*. Evaluation report. Tunis, Tunisia.

AFDB. (2007). *Annual Report*. Tunis, Tunisia.

Alcock, P. (1993). *Understanding poverty*. Basingstoke, United Kingdom: McMillan.

Aziz, S. (2001). How committed are we to ending hunger? Keynote speaker at Conference on sustainable food security for all by 2020, Bonn, Germany.

Baker, J.L. (2000). *Evaluating the impact of development projects on poverty: A handbook for practitioners*. Washington DC: World Bank.

Barlas, Y. (1996). Formal aspects of model validity and validation in system dynamics. *System Dynamics Review*, *12*(3), 183-210.

Booysen, F. (2002). *An overview and evaluation of composite indices in development.* Amsterdam: Kluwer Academic Publishers.

Coyle, R. G. (1996). *System dynamics modelling: A practical approach.* London: Chapman and Hall.

Daily, G. C. (Ed.). (1997). *Nature's services: Societal dependence on natural ecosystems.* Washington DC: Island Press.

Daily, G.C., & Ehrlich, P. R. (1992). Population, sustainability and Earth's carrying capacity. *BioScience*, *42*, 761-771.

Dao, M.Q. (2004). Rural poverty in developing countries: An empirical analysis. *Journal of Economic Studies*, *31* (6), 500-508.

Deaton, A. (1997). *An analysis of household surveys. A micro-econometric approach to development policy*. Washington DC: World Bank.

DFID. (2007). *Evaluation of DFID country programmes: Kenya, 2000 – 2006*. Evaluation Report. Retrieved on 22nd November 2008 from https://www.dfid.gov.uk/Documents/publications/evaluation/ev-s674.pdf

Diekmeyer, P. (2001). Measuring poverty. *CMA Magazine, 75*(9), 52-53.

Elkan, W. (1995). *An introduction to development economics*. London: Harvester Wheatsheaf

Estes, R. J. (2005). *Global change and indicators of social development in the handbook of community practice.* Thousand Oaks: Sage Publications.

Falcon, J. T. (1987). The world food and hunger problem: Changing perspectives and possibilities, 1974-1984. In Gittinger, J.L., Leslie, J., & Hoisington, D. (Eds.). *Food policy: Integrating supply, distribution and consumption.* Baltimore: John Hopkins University Press.

Ferguson, J. (1990). *The anti-politics machine: Development, de-politicization and bureaucratic power in Lesotho.* New York: Cambridge University Press.

Ford, F.A. (1999). *Modelling the environment: An introduction to system dynamics of environmental systems*. Washington DC: Island Press.

Foster, P., & Leathers, H. (1999). *The world food problem.* London: Lynne Rinner Publishers.

Glewwe, P. (2005). An overview of questionnaire design for household surveys in developing countries. In United Nations, *Household sample surveys in developing and transition countries*. New York: United Nations.

Griffith, G.T. (1926). *Population problems of the age of Malthus.* Cambridge, United Kingdom: CUP

Hardiman, M., & Midgley, J. (1989). *The social dimensions of development.* Aldershot, United Kingdom: London School of Economics.

Hermann, D. (1998). *From state maintenance grants to a new child support grant.* Unpublished Doctoral Dissertation. University of the Western Cape, Cape Town, South Africa.

Holden, S.T., Shifferaw, B., & Mette, W. (1998). Poverty, market imperfections and time preferences: Of relevance for environmental policy. *Environment and Development Economics*, *3*(1), 105-130.

ICARRD. (2006). Agrarian reforms and rural development: New challenges and options for revitalizing rural communities in Kenya – A national report on Kenya. Unpublished Paper presented at the International Conference on Agrarian Reforms and Rural Development: Revitalizing Rural Communities. Port Alegre, Brazil.

ILO (2003). *Concepts and strategies for combating social exclusion: An overview.* Geneva, Switzerland: Estivil, J.

ILO. (1995). The poverty agenda: Trends and policy options. In Rogers, G., & Hoeven, R.V. (Eds.). *New approaches to poverty analysis and policy*. International Labour Organisation Institute.

KNBS. (2007). *Kenya Integrated Household Budget Survey 2005/2006*. Nairobi, Kenya.

Lind, N.C. (1992). Some thoughts on the human development index. *Social Indicators Research*, *27*, 89–101.

Martinussen, J.D., & Pedersen, P.E. (2003). *Aid: Understanding international development cooperation*. New York: Zed Books.

Mason, A. (1996). Population, housing, and the economy. In Ahlburg, D., Kelley, A., & Mason, K.O (Eds.). *The impact of population growth on well being in developing countries.* Berlin: Springer.

Morris, M. D. (1979). *Measuring the conditions of the world's poor: The physical quality of life index*. New York: Pergamon Press.

Noble, M., Ratcliffe, A., & Wright, G. (2004). *Conceptualising, defining and measuring poverty in South Africa: An argument for a consensual approach*. Oxford, United Kingdom: CASASP.

ODI. (1999*). The meaning and measurement of poverty*. London: Maxwell, S.

Ogwang, T. (1994). The choice of principal variables for computing the Human Development Index. *World Development, 22*, 2011–2014.

Quibria, M.G. (Ed.). (1993). *Rural poverty in Asia: Priority issues and policy options.* Hong Kong: Oxford University Press.

Reardon, T., Delagado, C., & Matlon, P. (1992). Determinants and effects of income diversification among farmer households in Burkina Faso. *Journal of Development Studies*, *28* (2), 264-296.

Reutlinger, S. (1987). Food Security and Poverty in Developing countries. In Gittinger, J.L., Leslie, J., & Hoisington, D. (Eds.). *Food Policy: Integrating Supply, Distribution and Consumption*. Baltimore: John Hopkins University Press.

Richardson, G. P., & A. Pugh. (1981). *Introduction to system dynamics modelling with dynamo*. Cambridge, MA: MIT Press.

Robeyns, I. (2003). Sen's capability approach and gender inequality: selecting relevant capabilities. *Feminist Economics*, *9* (2), 61-92.

Rowntree, B.S. (1901). *A study of town life*. London: McMillan

Runciman, W.G. (1978). Processes, end-states and social justice. *Philosophical Quarterly, 28* (110), 37-45.

Saeed, K. (2003). Articulating developmental problems for policy intervention: A system dynamics modelling approach. *Simulation and Gaming*, *34*(3), 409-436.

Saeed, K. (1983). The underlying rationale for the tests of validity of system dynamics models. *Productivity India*, *24*(2), 125-134.

Saeed, K. (1987). A re-evaluation of the effort to alleviate poverty and hunger. *Socio Economic Planning Sciences*, *21*(5), 291-304.

Saeed, K. (1998). *Towards sustainable development: Essays on system analysis of national policy* (2nd Ed.). Aldershot, United Kingdom: Ashgate Publishing Company.

Sen, A. (1987). Poverty and entitlements. In Gittinger, J.L., Leslie, J., & Hoisington, D. (Eds.). *Food policy: Integrating supply, distribution and consumption*. Baltimore: John Hopkins University Press.

Sen, A. (1992). *Poverty and famines: An essay on entitlement and deprivation*. Oxford: Clarendon Press.

Senge, P.M. (2006). *The Fifth Discipline: The Art & Practice of the Learning Organisation*. New York: Century.

Shaar, N. (2004). Work on poverty in the Economic and Social Commission in Western Asia (ESCWA.). Paper Presented at the Fourth regional workshop on poverty statistics in the ESCWA region, Amman, Jordan.

Shifferaw, B., & Holden, S.T. (1998). Resource degradation and adoption of land conservation technologies in the Ethiopian highlands: A case study in Andit Tid, North Shewa. *Agricultural Economics*, *18*(3), 233-237.

Sterman, J. D. (2000). *Business dynamics: Systems Thinking and modelling for a complex world*. New York: McGraw-Hill Higher Education.

Syagga, P.M. (2007). Land ownership in Kenya: Policy prescriptions from an inequality perspective. In Readings on inequality: Sectoral perspectives and dynamics (1). Retrieved September 10, 2009 from http//www.hackenya.org/publications.

Todaro, M.P. (2000). *Growth, poverty and income distribution: Economic development* (7th Ed.). New York: Longman.

Townsend, P. (1979). *Poverty in the United Kingdom*. Harmondsworth, United Kingdom: Penguin.

Uma, L., & Candler, W. (1981). Food security: Some East African considerations. In Valdes, A. (Ed.). Food *security for developing countries*. Boulder, Colorado: Westview Press Inc.

UNDP. (1994). *Human Development Report*. Retrieved November 22nd, 2007 from http://hdr.undp.org/reports/global/1994/en/

UNDP. (1995). *Human Development Report*. Retrieved November 22nd, 2007 from http://hdr.undp.org/reports/global/1995/en/

UNDP. (2006). *Human Development Report*. Retrieved November 22nd, 2007 from http://hdr.undp.org/hdr2006/.

UNSD. (2004). *UN Guidelines and Recommendations of the Development of Disability Statistics, International Classification*. Retrieved September 13th, 2008 from http://www.unescap.org/Stat/meet/speca1/Improving%20Disability%20Statistics_ESCAP2.pdf.

USAID/Kenya (2005). *Final evaluation report of the AMKENI project*. Evaluation report. Nairobi, Kenya.

Wambugu, A., & Munga, B. (2009). *Growth, income and inequality in Kenya: Suggested policy options*. Nairobi: KIPPRA.

Wolstenholme, E. (1990). *System enquiry: A system dynamics approach*. Chichester, United Kingdom: John Wiley and Sons.

Memo: Medical Semseter Test 1 Man 234 2010

MCQ section (1 mark each)

1. In the capital asset pricing model, the beta coefficient is a measure of ___________ risk and an index of the degree of movement of an asset's return in response to a change in ________________.
   a. diversifiable; the prime rate
   b. non-diversifable; the Treasury Bill rate
   c. diversifiable; the Bond Index rate
   d. non-diversifiable; the market return

2. Which source of risk is **not** common to both financial managers and shareholders alike in South Africa?
   a. The risk that SARS may change the rates applicable on both income tax and capital gains tax
   b. The risk that the financial director of Standard Bank Group Ltd will fail to pay preferred dividends this year
   c. The risk that next month rentals may go up in response to an increase in the inflation rate
   d. The risk that the price of fuel may fluctuate due to a weakening of the rand against the US$
   e. All of the above

3. The beta of the market is always
   a. 1 b. Greater than 1 c. Less than 1 d. Cannot be determined

4. The relevant portion of an asset's risk attributable to market factors that affects all firms is called _____________
   a. Unsystematic risk b. Diversifiable risk **c. Systematic risk** d. None of these

5. CAPM is based on an assumed efficient market. Which of these is not a characteristic of efficient markets?
   a. Few, large corporate investors
   b.No taxes and no transaction costs
   c.Rational, risk averse investors
   d.All of the above
   e.None of the above.

6. The _________ is utilized to value preference share.
   (a) constant growth model
   (b) variable growth model
   (c) zero-growth model
   (d) Gordon model

7. A ordinary share currently has a beta of 1.7, the risk-free rate is 7 percent annually, and the market return is 12 percent annually. The share is expected to generate a constant dividend of R6.70 per share. A pending lawsuit has just been dismissed and the beta of the share drops to 1.4. The new equilibrium price of the share
   (a) will be R55.83.
   (b) will be R43.23.
   (c) will be R47.86.
   (d) cannot be determined from the information given

8) If expected return is greater than required return on an asset, rational investors will
   (a) buy the asset, which will drive the price up and cause expected return to reach the level of the required return.
   (b) sell the asset, which will drive the price down and cause the expected return to reach the level of the required return.
   (c) sell the asset, which will drive the price up and cause the expected return to reach the level of the required return.
   (d) buy the asset, since price is expected to increase.

9) Which of the following Treasury bonds will have the largest amount of interest rate risk?
   a. A 7 percent coupon bond which matures in 12 years.
   b. A 9 percent coupon bond which matures in 10 years.
   c. A 12 percent coupon bond which matures in 7 years.
   d. A 7 percent coupon bond which matures in 9 years.
   e. A 10 percent coupon bond which matures in 10 years

10) Palmer Products has outstanding bonds with an annual 8 percent coupon. The bonds have a par value of R1,000 and a price of R865. The bonds will mature in 11 years. What is the yield to maturity on the bonds?
   a. 10.09% b.11.13% c. 9.25% d. 8.00% e. 9.89%

11)) If interest rates fall from 8 percent to 7 percent, which of the following bonds will have the largest percentage increase in its value?
   a. A 10-year zero coupon bond.
   b. A 10-year bond with a 10 percent semiannual coupon.
   c. A 10-year bond with a 10 percent annual coupon.
   d. A 5-year zero coupon bond.
   e. A 5-year bond with a 12 percent annual coupon.

12) Share A has a beta = 1.2, while Share B has a beta = 0.6. Which of the following statements is most correct?

   a. Share B's required return is double that of Share A's.
   b. An equally weighted portfolio of Share A and Share B will have a beta less than 1.2.

Long Questions

1. Champion Breweries must choose between two asset purchases. The annual rate of return and related probabilities given below summarize the firm's analysis.

Asset A		Asset B	
Rate of Return	Probability	Rate of Return	Probability
10%	30%	5%	40%
15%	40%	15%	20%
20%	30%	25%	40%

For **each** asset, compute

a. the expected rate of return. (2)

b. the variance, standard deviation of the expected return. (10)

c. the coefficient of variation of the return. (2)

d. which asset should Champion select? (1)

Answer item a.

Asset A

Return * Pr

10% * 0.30=3%

15% * 0.40=6%

20% * 0.30=6%

Expected return(R asset A) = 15%

Asset B

Return * Pr

5% * 0.40 = 2%

15% *0.20= 3%

25% *0.40=10%

Expected return(R asset B) = 15%

Answer item b.

Asset A

(10%-15%)^2*0.30 = 7.5%

(15%-15%)^2*0.40 = 0%

(20%-15%)^2*0.30 = 7.5%

Variance **15%**

Standard Deviation A = sqrt of 15% = **3.87%**

Asset B

(5%-15%)^2*0.40 = 40%

(15%-15%)^2*0.20 = 0%

(25%-15%)^2*0.40 = 40%

Variance **80%**

Standard Deviation B = sqrt of 80%

= **8.94%**

Answer item c.

(CV_A) = 3.87 % / 15% = **0.26** **and** (CV_B) = 8.94 % / 15% = **0.60**

Answer item d.

Champion should select Asset A. The decision is based on the fact that Asset A has 15% rate of return and lesser risk, as supported by the lower std dev and CV.

2) A company currently pays a dividend of R2 per share. It is estimated that dividends will grow at a rate of 20% per year for the next 2 years, and then the dividend will grow at a constant rate of 7.% thereafter. The company share has a beta of 1.2, Rfr is 7.5% and market risk premium is 4%. What would you estimate is the share's current price? (tut) (7)

PV of D1=2.40(1.123) $^{-1}$ = 2.14 PV of D2 = 2.88 (1.123) $^{-2}$ = 2.28
Determine the price just before constant growth: P2= D3/k-g = 2.88(1.07)/ 0.053 = 58.14
Find PV of 58.14: Po = 58.14(1.123) $^{-2}$ = 46.10
Price of share now = PV of D1 +PV of D2 + PV of share before constant growth:
= 2.14 + 2.28 + 46.10 = 50.52

3) International Tools Inc. (ITI) has estimated the market value of its assets to be R1,250,000. What is the value of ITI's ordinary share if it has R900,000 in liabilities, R50,000 in preference share, and 7,500 shares of ordinary share outstanding?
value = (1,250,000 – 900,000 – 50,000)/7,500 = R40 (3)

4) The Salem Company bond currently sells for R955, has a 12% coupon interest rate and a R1000 par value, pays interest annually and has 15 years to maturity.
4.1) Calculate the yield to maturity.
4.2) Explain the relationship that exists between the coupon interest rate and YTM. (5)

4.1)Using a financial calculator the YTM is 12.685%. The correctness of this number is proven by putting the YTM in the bond valuation model. This proof is as follows:

$$B_o = 120 \text{ x } (PVIFA_{12.685\%,15}) + 1{,}000 \text{ X } (PVIF_{12.685\%,15})$$
$$B_o = R120 \text{ x } (6.569) + R1{,}000 \text{ x } (.167)$$
$$B_o = R788.28 + 167$$
$$B_o = R955.28$$

Since B_0 is R955.28 and the market value of the bond is R955, the YTM is equal to the rate derived on the financial calculator.

4.2) The market value of the bond approaches its par value as the time to maturity declines. The yield to maturity approaches the coupon interest rate as the time to maturity declines.

5) Gans's co. has today issued a 25 year bond with a par value of a R1 000.The coupon rate is 10%. The Kd is 12%.
5.1) Calculate the value of the bond today.
5.2) Calculate the value of the bond 5 years from today.
5.3) If coupons are paid semi-annually, calculate the value of the bond today. (5)

5.1) Bo = 100 (7.843) + 1000 (0.059) = 784.3 + 59 = 843
5.2) 20yrs left to maturity:
Bo = 100 (7.469) + 1000 (0.104) = 747 + 104 = 851
5.3) I = 50 Kd = 6% n = 50
Bo = 50 (15.762) + 1000 (0.054) = 788 + 54 =842