URBAN BIODIVERSITY MANAGEMENT IN THE FACE OF CLIMATE CHANGE: LIVELIHOOD IMPACTS AND ADAPTATION STRATEGIES IN INANDA COMMUNITY OF ETHEKWINI METROPOLITAN AREA, KWAZULU-NATAL, SOUTH AFRICA

By

Mmaphuti Andrias Nkoana

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DECLARATION

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As the candidate's supervisors, we agree to the submission of this dissertation.

Signed: ______________________________ Date: ______________________
Dr E.W. Zegeye (Supervisor)

Signed: ______________________________ Date: ______________________
Professor G.F. Ortmann (Co-supervisor)

ABSTRACT

Natural forest resources are an integral part of biodiversity for the livelihoods of rural communities. Studies have shown that natural forest products contribute significantly to maintaining livelihoods in developing countries. Reduced access to and the use of forest resources would greatly affect the welfare of rural households and increase wealth differentiation among them. Full understanding of livelihood dependency on natural forest resources is needed, particularly where most rural communities derive their livelihoods from nature-based enterprises.

The study examines how rural livelihoods are linked to the status of natural forest resources and how that link is impacted by changes in the forest driven by factors including climate change. Furthermore, the study examines the coping and livelihood adaptive strategies of rural households in response to climate change impacts in the studied areas (Bhekuphiwa and Mgangeni). Data were collected through key informant interviews, group discussion, participant observation and household questionnaire surveys. The survey data were collected from a total of 150 households, randomly selected from the above two areas. The proxy used to measure the dependence on natural forest resources was the proportion of forest income to total household income (relative share of household income that is derived from such natural forest resources). A logit-transformed OLS was used to examine the proportion response variable that represents dependence on natural forest resources. Furthermore, a multinomial logit model was used to examine the coping and livelihood adaptive strategies of rural households in response to climate change.

The empirical results indicated that forest income forms an integral part of the households' income. About 56% of the sampled households generated income from forest products. The average contribution of forest resources to household income in Inanda community was 26%. The empirical results indicated that off-farm incomes, employment income, vouchers from the ‘Wildlands project’ pays in exchange for planting trees, assets values, changing of time and dates in visiting the forest for the collection of forest products and perceived average changes in temperature have significant impacts on rural livelihoods. Cluster 1, representing a livelihood adaptation strategy out of the forest sector, is the largest of the three livelihood adaptation strategies, representing 66% of the total sample of households. One-third of the sampled households indicated that they would adapt by starting small businesses. However, a livelihood adaptation strategy seeking alternative forest or substitute forest products constituted 23.3% of the sample households. A no livelihood adaptation strategy constitutes the smallest cluster with only 10.7% of the sample households. These results imply that most of the sampled households reported to adapt to climate change out of the forest sector. The empirical evidence from this study indicates the choice of livelihood adaptation strategies is significantly influenced by gender of the household head, educational level of the household head, land size owned by household head, household income and perceived average changes in rainfall and temperature. The analysis of barriers to adaptation to climate change also indicated five major constraints. These are lack of information and agricultural inputs (seeds, water, and fertilizers), lack of finance, shortage of labour, shortage of land, and poor infrastructure. It can be concluded that sampled households can adapt through close interaction and intervention of government to address these constraints for sustainable welfare outcomes and poverty reduction.

The empirical results suggest the necessary policy measures that need to be taken to improve rural livelihoods in response to climatic change and make forest ecosystems more sustainable to lift the standard of living of people engaged in informal activities (such as forest products collection). This study recommends strong community-based resource management institutions. Furthermore, broad policy interventions are required for rural development including interventions such as securing and enhancing the natural resource base, designing participatory management and monitoring systems, and securing poor people's rights of use and access to natural resources. Government and community members should collectively treat adaptation to climate change as part of development.

Keywords: adaptation; climate change; forests; Non-timber forest products; sustainable rural livelihoods; Inanda community

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DEDICATION

This study is dedicated to the loving memory of my father, Lesiba Jonas Nkoana. I will always remember you.

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LIST OF ACRONYMS

CIFOR.......................	Centre for International Forestry Research
CPRs..........................	Common Pool Resources
CBNRM……………	Community-Based Natural Resources Management Strategies
DEAT………………	Department of Environmental Affairs and Tourism
EMEMD…………….	EThekwini Municipality Environmental Management Department
FAO...........................	Food and Agriculture Organisation of the United Nations
GHG…………………	Greenhouse Gases
HIV/AIDS...................	Human Immunodeficiency Virus/ Acquired Immune Deficiency Syndrome
IFRC………………..	International Federation of Red Cross
IFAD………………..	International Fund for Agricultural Development
IPCC………………..	Inter-governmental Panel for Climate Change
MCPP………………	Municipal Climate Protection Programme
MNL.........................	Multinomial Logit Model
NGOs.........................	Non-governmental Organisations
NMSA……………...	National Meteorological Services Agency
NTFPs.......................	Non-Timber Forest Products
OLS…………………	Ordinary Least Squares
SAWS……………….	South African Weather Services
IBM SPSS ………….	SPSS-IBM Statistics Software 21
SSA...........................	Sub-Saharan Africa
UNDP........................	United Nations Development Programme
UNFCCC……………	United Nations Framework Conference on Climate Change
VIF..............................	Variance Inflation Factor
VCA…………………	Vulnerability and Capacity Assessment

CHAPTER 1. INTRODUCTION

1.1 Background

Biodiversity is defined as the degree of variation of life forms within a given ecosystem, biome, or an entire planet (EMEMD, 2009). It plays an important role to South African economic growth as a source of food, raw materials for industries as well as a means of livelihoods. Biodiversity needs to be conserved, not only for its own sake and for future generations, but because intact natural habitats offer many benefits to humankind, including an improved quality of life and health through the many ecosystem goods and services they provide (Aylett, 2011).

Biodiversity management ensures that biodiversity and nature are mainstreamed into everyday life, which includes delivering tangible benefits to rural and urban communities. Natural forests are an integral part of biodiversity for the livelihoods in rural communities of developing countries (World Bank, 2001; Gautam, 2009). Although many people now know the significance of biological diversity, most are unaware of its economic value and the socio-economic costs of losing it. Costs of environmental damage and depletion of natural resources have frequently been disregarded (Shackleton and Shackleton, 2004). For instance, local pressures arise from communities using forests to provide sources of food, fuel and farmland (FAO, 2003). Poverty and population pressure lead to the loss of forest cover, trapping people in perpetual poverty. Whilst millions of people still cut down trees to make a living for their families, a major cause of deforestation is now large-scale agriculture driven by consumer demand (Mamo *et al.,* 2007).

Many South African rural households depend directly or indirectly on natural resources from forests to meet their livelihoods (Shackleton and Shackleton, 2004). Most common natural forest resources are referred to as Non-Timber Forest Products (NTFPs), including wild spinaches, fuelwood, charcoal, wooden utensils, grass fodder, thatching materials, medical plants, edible fruits, construction poles, bark, roots, tubers, leaves, flowers, seeds, resins, honey, and mushrooms (Gautam, 2009). Fuelwood is an essential energy source for the rural poor where there are no other alternatives. Fuelwood, charcoal and other products are often traded for urban consumption from which the poor can benefit in terms of additional employment and income.

There is growing evidence that NTFPs contribute significantly to maintaining livelihoods in rural Africa, Asia and elsewhere in developing countries (Shackleton and Shackleton, 2004; Mamo *et al.,* 2007; Rist *et al.,* 2012). NTFPs have three main functions in the household economy of rural communities living in or adjacent to the forest (Shackleton *et al.,* 2007; Heubach *et al.,* 2011; Mutenje *et al.,* 2011). Firstly, they help to fulfil households' subsistence and consumption needs in terms of energy and nutrition as well as medical and construction purposes (Shackleton *et al.*, 2007). Secondly, they serve as a safety net during crises for rural households and communities in times of economic crisis, illness or agricultural shortfalls (Mutenje *et al.*, 2011). NTFPs provide a wide array of products that meet numerous households' needs (Heubach *et al.,* 2011). Thirdly, some NTFPs provide regular cash income for highly dependent rural households (Kamanga *et al.,* 2008; Mamo *et al.,* 2007; Narain *et al.,* 2008). Most common natural forest resources that are exposed to and threatened by the impacts of climate change throughout the world, among others, may still support rural communities (Fisher *et al.,* 2010; Soltani *et al.*, 2012).

Climate change poses a variety of new challenges to natural resources, agriculture and biodiversity conservation, and impacts negatively on the livelihoods of people (Gbetibouo, 2009). Livelihood and climate-driven impacts of the change in the status of natural resources and community adaptation strategies have economic, social, poverty, food security, gender and environmental dimensions (Mutenje *et al.*, 2011; Soltani *et al.,* 2012). Full understanding of the livelihood dependency on natural resources of rural people in developing countries is needed, including South Africa where many rural communities derive their livelihoods from nature-based enterprises. However, there are expected to be gains and losses to farming systems with the presence of climate change impacts (Benhin, 2006; Mertz *et al.,* 2009). If policy makers and rural households are able to identify where the gains and losses are, and direct the appropriate policies and adaptation strategies to those areas, the expected overall negative effect of climate change may be reduced, and it is even possible that the agricultural sector in South Africa may reap benefits from climate change (Benhin, 2006).

Prior to this study, no study has attempted to examine households' level of forest dependence and choice of adaptation methods and perceptions of climate change in Inanda community of KwaZulu-Natal. Therefore, this project aims to improve the understanding of coping and adaptive strategies of natural resources dependent societies in the KwaZulu-Natal Sandstone

Sourveld (KZNSS) in response to climate change impacts. Moreover, this study will examine linkages between the status of natural forest resources, rural household livelihoods and adaptation strategies in response to changes in the forest status due to climate change and other factors that threaten their livelihoods in Inanda community of eThekwini Municipality. Knowing how households respond to shocks (for example, climate-driven change, forest degradation, invasive species and other evolving challenges) is of critical importance since this can reveal what rural households can do to help themselves in these circumstances and what government policy can do to support their livelihoods.

The adaptation strategies by community households depend on the availability of different types of capital assets (natural, physical, human, financial, and social) (Stern, 2007; Fisher *et al.*, 2010). Community households with sufficient capital assets, higher incomes and alternative livelihood options are in a better position to adapt to and cope with livelihoods in response to the climate change. A better understanding of how rural households or farmers perceive climate change and their coping and adaptive measures is needed in developing countries (Mertz *et al.*, 2009). However, there are factors influencing their decision to cope and adapt farming practices (Stern, 2007). Therefore, policies and programs are initiated in developing countries, including South Africa, aimed at promoting successful adaptation of the agricultural sector for sustainable livelihoods and poverty reduction (Benhin, 2006; Bryan *et al.*, 2009; Gbetibouo, 2009).

1.2 Research problem and opportunity statement

Climate change significantly affects rural communities particularly in South Africa who depend on agriculture and natural forest resources for their livelihoods (Kurukulasuriya and Mendelsohn 2006a; Deressa, 2007; IPCC, 2007b; Alam *et al.*, 2011; UNFCCC, 2011). It is one of the most serious threats the world faces and disproportionately impacts millions of poor rural people. It puts more people at risk of hunger and makes it more difficult to reduce the proportion of people living in extreme poverty (UNFCCC, 2011). Deforestation and land degradation also continue to be important global environmental challenges, leading to poverty and loss of biodiversity in local communities of developing countries for sustainable development and livelihoods (Gautam, 2009; Soltani *et al.*, 2012). South Africa is expected to experience increases in temperature and declining rainfall patterns, whilst some other areas become wetter in the eastern part of the country, as well as increased frequency of extreme climate events such as droughts and floods (Dale, 1997; Nhemachena, 2008; Nelson, 2009).

However, the role of NTFPs in sustaining rural economies of developing countries has been underestimated because of inadequate policy recognition (Shackleton and Shackleton, 2004). As a result, factors affecting the sustainability of these important resources are being undermined. According to Eriksen and Naess (2003), rural community livelihoods are linked with the status of natural-based resources, meaning that they are more dependent on such resources for their livelihoods and enhancing poverty reduction. They argue that natural resources are used as sources of livelihoods, which represent the way people deal with both poverty and vulnerability. As climate change is expected to have marked effects on natural resources and agriculture, it is then climate change that is intricately connected to livelihoods (Bhusal, 2009; IPCC, 2007b). As a result of an expanding population, urbanisation and industrial growth, the natural environment upon which the poor depend for their livelihoods is being degraded at an alarming rate.

Climate change knowledge in rural communities of developing countries, also in South Africa, is seriously constrained by lack of studies and published literature (Erasmus *et al.*, 2000; Deressa, 2007; IPCC, 2007b). According to NMSA (2001), the average annual minimum temperature in Africa has been increasing by about 0.25^{o}C every decade, while the average annual maximum temperature has been increasing by about 0.1^{o}C every decade. Even though the change in precipitation was not as pronounced as the change in temperature, there is a decreasing trend (Nelson, 2009; NMSA, 2001). South Africa, despite its relative wealth and greater endowment of financial resources and infrastructure, also faces similar problems and threats to its economy from climatic conditions like other African countries (Nelson, 2009; UNEP, 2009).

Information and knowledge on how to mitigate the current and future effects of climate change in South Africa is still not well developed and established in rural communities (Erasmus *et al.*, 2000; Olufunso, 2010; Alam *et al.*, 2011). For example, the nature of impacts such as change in rainfall patterns, mean temperatures, crop diseases, water supply, climatic hazards, forest fires, invasive species and extinction risks of valuable species are widely discussed but no empirical evidence is available in South Africa (Benhin, 2006; Olufunso, 2010). The scientific knowledge on impacts of climate change is increasing over time, as are practical experiences in responding to adaptation needs (IPCC, 2007a; Bhusal, 2009). In South Africa, lack of research and credible evidence on the impacts of climate change is a major challenge in marginal communities (Olufunso, 2010). There is limited understanding of the impacts of climate-driven change on land-use (agriculture) and natural forest resources, especially where most rural communities derive their livelihoods from agriculture and nature–based resources. Finally, more detailed studies are needed to establish the impacts of climate change on community livelihoods and biodiversity, and streamline coping and adaptation strategies that address the negative effects of climate-driven changes.

There are different coping and adaptive strategies on how well rural households are dealing with their environmental and economic conditions (Mertz *et al.,* 2009). Therefore, this study aims to improve the understanding of coping and adaptive strategies of agricultural and natural resources dependent societies in the KwaZulu-Natal Sandstone Sourveld (KZNSS) in response to the climate change impacts. The investigations are based on their perceptions and on how rural households and farmers are coping and adapting to past and current impacts due to climate-driven changes. According to Deressa *et al.* (2005) and Deressa (2007), the adaptation to climate change is a two-step process: the households must perceive that the climate is changing and that change is affecting their economic activities, and then respond to changes through coping and adaptation strategies. Furthermore, it is recognized that the concept of coping strategy is more directly related to short term survival whilst the concept of adaptive strategy refers to a longer time frame and requires some learning (Bhusal, 2009; Stern, 2007).

The rural communities of developing countries, also in South Africa, are exposed to climatic conditions. They are subjected to land and forest degradation because of overstocking and excessive harvesting of forest resources due to open access forest type (Mokhahlane, 2009; Giliba *et al.*, 2011; Soltani *et al.*, 2012). This degradation is perceived as reducing some of the natural resources within the forests such as wood for fuel and building materials, medicinal plants and wild fruits. When these natural resources are scarce, users will lose part of their means of livelihoods. The result, therefore, is increased poverty, food insecurity and unsustainable livelihoods. Furthermore, there is need for policy measures to improve rural livelihoods in response to climatic change and make forest ecosystems more sustainable to lift the standard of living of people engaged in informal activities (such as forest products collection). However, a bottom-up approach in the formulation of these policies and their successful implementation is deemed essential. The regulations should also be stringent to protect the exploitative tendencies of non-villagers in the collection of forest products.

1.3 Research objectives

Considering the increasingly important challenges (such as climate change and forest degradation) linked to biodiversity, land-use, forest resources and lack of time-tested and contextually relevant forest management strategies, the purpose of this study is to examine how rural livelihoods are linked to the status of natural forest resources and how that link is impacted by changes in the forest cover driven by various factors including climate change. To examine this issue, the Inanda community of KwaZulu-Natal (under KZNSS) was taken as a case study. The specific objectives of the study include examining:

- how rural livelihoods are linked to the status of natural forest resources and how that link is impacted by changes in the forest driven by factors including climate change;
- the coping and livelihood adaptation strategies of rural households and communities in response to changes in the forest status that threaten their livelihoods.

The research results are relevant to policy measures related to changes in natural forests, community livelihoods and adaptation strategies as a result of climate change in rural communities. This information can feed into community-based natural resources management strategies. The study will also contribute to policy in terms of developing optimal strategies and adaptive institutional capacity to harmoniously manage natural forests for sustainable development and livelihoods. Specific deliverables to be expected include: (1) Household dependence on forest products or the contribution of forest products to rural livelihoods in Inanda community of KwaZulu-Natal; and (2) how rural households and communities cope and adapt in response to changes in the forest status that threaten their livelihoods.

1.4 Scope and limitations of the study

The study was conducted at household level and only household heads were interviewed for the survey. Thus, the views of the other household members which might be different from those of the household heads were not elicited directly. Data collection did not start at the expected time due to many changes that had to be made to the questionnaire to contextually adapt the questions, with the guidance from the supervisors. Questions that were unclear, especially in the climate change perception section, were modified to ensure their applicability in the local language. Lack of a translator and enumerators also formed part of the delay. Time, language and culture had negative impacts on the collection of data during fieldwork. With regard to lack of time, only four weeks of fieldwork were scheduled for collecting data and some respondents were not available in the households during the day.

As the case-study area was located in a remote region with poor infrastructure, time-management was essential to cover the two areas (Bhekuphiwa and Mgangeni), leaving no option open for flexibility. Likewise, with language and experience of the study area, each enumerator was accompanied by one community facilitator to perform questionnaire interviews in the households. Also, the interviews were more time-consuming than expected as most questions and answers needed to be clearly explained, especially the section on climate change components (rainfall, temperature, droughts, floods and wind). Additional limitations encountered were the responses of some of the survey questions. Respondents were for instance asked to indicate their monthly income from different categorical sources. However, some respondents were not sure how much they received per month or were not eager to reveal it. Total income per month was therefore to be treated with caution or as a categorical variable. Income from piece-jobs (sand collection, brick layers, decorations, and weed eradication) was regarded as other sources of income. The same problem applies to questions in relation to measurements; most respondents had no idea how large their piece of land was or how much they would grow per season.

When analysing the empirical results, only the number of household members living together for six months were counted, meaning that those who come at the end of the year were not taken into consideration. In all income calculations, cost of own labour was not taken into account because of substantial existing variations in labour prices, and that the possibility of multiple work at the same time can lead to under- or over-estimations of own labour costs. All total incomes reported are the sum of cash and subsistence per month and converted to annual household incomes. The livestock values were combined (cattle and goats) and all costs of harvesting forest products and crop production were not deducted.

1.5 Organization of the dissertation

The remainder of this dissertation is divided into six chapters. The following chapter constitutes the literature review for the study, and deals mainly with climate change impacts on land-use changes (agriculture), biodiversity and its relationships with natural forests, community livelihoods and adaptation strategies. Chapter 3 presents the research methodology approaches followed in this study and explains the method of data collection and data analysis methods. This includes study area choice, data collection instruments, sampling methods and the empirical model analysis. The study area is briefly described before discussing data collection methods and procedures. The conceptual framework and the empirical models that were used in this study are presented subsequently. Lastly, it provides a description of both the dependent and independent variables used in both models.

Chapter 4 reports and discusses the descriptive results of the study, while chapter 5 provides the empirical results and discussions on the dependence of rural livelihoods on natural forest products. Chapter 6 presents empirical results and discussions on the choice of coping and livelihood adaptation strategies in response to climate change. Finally, chapter 7 presents the main conclusions and policy recommendations based on the empirical results of the study, and makes recommendations for further research and future research directions.

CHAPTER 2. CLIMATE CHANGE, AGRICULTURE, FOREST RESOURCES AND LOCAL COMMUNITIES: AN OVERVIEW OF THE LITERATURE

2.1 Introduction

Climate change impacts result in vulnerability in rural communities who derive their livelihoods from land-use and natural-based forest resources (Mertz *et al.,* 2009). These include loss of ecosystem services from degraded forests, the loss of subsistence materials (food, fuelwood, medicines, construction material) from forest fires, storms, disease or drought and the loss of revenues (Erasmus *et al.,* 2000; Mamo *et al.,* 2007). The loss of revenues from tourism, the sale of forest products and recreational services might be due to vast areas of dead or dying forests reduce scenic appeal and access to forests is closed off or becomes difficult (Gbetibouo, 2009; Giliba *et al.,* 2011). In addition, lack of preventive measures of the effects of climate change may eventually affect ecosystems by reducing biodiversity (Richards, 2008; Sala *et al.,* 2000). Moreover, adaptation is widely recognized as a vital factor of any policy response to climate change (Mertz *et al.,* 2009).

This chapter reviews the literature related to climate change impacts on land-use changes (agriculture), biodiversity and its relationships with natural forests, community livelihoods and adaptation strategies. It will also provide an overview of livelihood dependency on natural resources, biodiversity management and current and future impacts of climate-driven change in Africa, particularly South Africa. The chapter will also examine livelihood adaptive and coping strategies of local communities to climate change impacts. Perceptions about climate change affect how people respond to the change in terms of their coping and adaption strategies since perceptions are derived from experiences and those experiences, in turn, affect actions.

2.2 Defining terminologies

2.2.1 Climate change

Climate change refers to the change in weather patterns such as temperature, precipitation and wind over a period of time, ranging from months to millions of years (IPCC, 2007b). The United Nations Framework Convention on Climate Change (UNFCCC, 2009) has defined climate change as a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere; this is, in addition to natural climate variability observed over comparable time periods. Therefore, in this study, climate change is defined as the variety of general shifts in weather conditions, including temperature, wind, rainfall, and drought. Climate change will interfere with African rural livelihoods at many levels; this interference is expected to produce both negative and positive effects on the rural poor, with the negative effects being more significant (Eriksen and Naess, 2003; UNFCCC, 2009). According to Eriksen and Naess (2003), livelihoods are linked with natural resource management and poverty reduction. They argue that natural resources are used as sources of livelihoods, but livelihoods represent the way that people deal with both poverty and vulnerability. As climate change is expected to have marked effects on natural resources, climate change is intricately connected to livelihoods.

Climate variabilities such as heavy rains, higher temperatures, droughts have negative impacts on rural communities of developing countries (Hannah *et al.,* 2005). For example, heavy precipitation can more readily impose dangerous flooding in areas denuded of forests. Localized warming can be intensified in sprawling cities through the urban heat island effect (IPCC, 2007b). The impact of increases in extreme rainfalls will be exacerbated by impervious road surfaces and inadequate drainage, making cities more prone to flooding (Dale, 1997; Hannah *et al.,* 2005). Higher temperatures can significantly affect agricultural productivity, farm income and food security (Van Aalst *et al.,* 2008). Negative impacts on food production sources will compound current overharvesting of natural forest resources and intensive animal production (Fisher *et al.,* 2010). Climate change may also cause more frequent and greater intensity of forest wildfires, outbreaks of insects and pathogens (Adger *et al.,* 2003; Gbetibouo, 2009). Moreover, extreme events such as high winds may be more important than the direct impact of higher temperatures and elevated carbon dioxide. Even without fires or insect damage, the change in frequency of extreme events (such as strong winds, winter storms, droughts, *etc*.) can bring substantial losses to natural forests. High wind events can damage trees through branch breaking, crown loss, trunk breakage, or complete stand destruction, especially caused by faster build-up of growing stocks in a warmer climate.

2.2.2 Rural livelihoods

Livelihoods refer to the access that individuals or households have to different types of capital (natural, physical, human, financial and social), opportunities and services (Ellis, 2000). According to Babulo *et al.* (2008: 148), livelihood is defined as comprising ‘‘the capabilities, assets (including both material and social resources), activities essential for a means of living and considered to be sustainable when it can survive and recuperate from stress and shocks and maintain or boost its capabilities and assets both now and in the future, while not undermining the natural resource base.” A livelihood also includes access to, and benefits derived from, social and public services provided by the state such as education, health services, roads, water supplies and so on (Lipton and van der Gaag, 1993; Babulo *et al.*, 2008).

According to Chambers and Conway (1992), livelihoods comprise people, their capabilities, means of earning a living, including food, income and assets. Sustainable livelihoods are those that can cope and recover from stresses and shocks, maintain and enhance local and global assets on which livelihoods depend, imparting bequests and opportunities for future generations (Carney, 1998). Shocks are sudden changes or disturbances in the economy which transform into trends or cycles when the events are prolonged or analysed over time. Integrating expectations of future generations in today’s decision making processes is necessary for the achievement of sustainable livelihoods. Ellis (1998) singles out failure to identify sources of livelihoods as one of the weaknesses of this definition of sustainable livelihoods.

Rural livelihoods in developing countries are firmly connected to agriculture and to natural resource use (Shaanker *et al.*, 2004). Rural households are generally poor and a majority report food shortages several months per year (Francis, 2002; Niehof, 2004). In rural Africa, livestock acquisition remains a key form of wealth accumulation (World Bank, 2001; Niehof, 2004). Goats, poultry (domestic chickens) and cattle are relatively liquid assets that can be sold in response to price signals, to smooth consumption, or to provide financial capital to start a business. Rural households also harvest raw materials such as fuelwood, medical herbs and timber and benefit from public goods such as erosion control, climate stability and clean drinking water. Strategies that build natural assets in the hands of the rural communities who are most dependent on them could help to alleviate poverty and prevent deforestation. Agricultural production (crop cultivation and livestock) is the main source of livelihood in the study area, which comprises of mainly poor households. The farming system of the study area can be classified as mixed crop and livestock subsistence farming. Recently it has been recognised that household food insecurity in rural and urban southern Africa cannot be properly understood if climate change is not factored into the analysis (Babulo *et al.*, 2008). Fundamental to the framework referred to is the analysis of formal and informal organisational and institutional factors that influence sustainable natural resource outcomes. This study deliberated some of the livelihood adaptation strategies and operational implications of sustainable livelihoods in the Inanda community who depend on the natural forest resources and land-use. Figure 2.1 below shows the sustainable livelihoods framework.

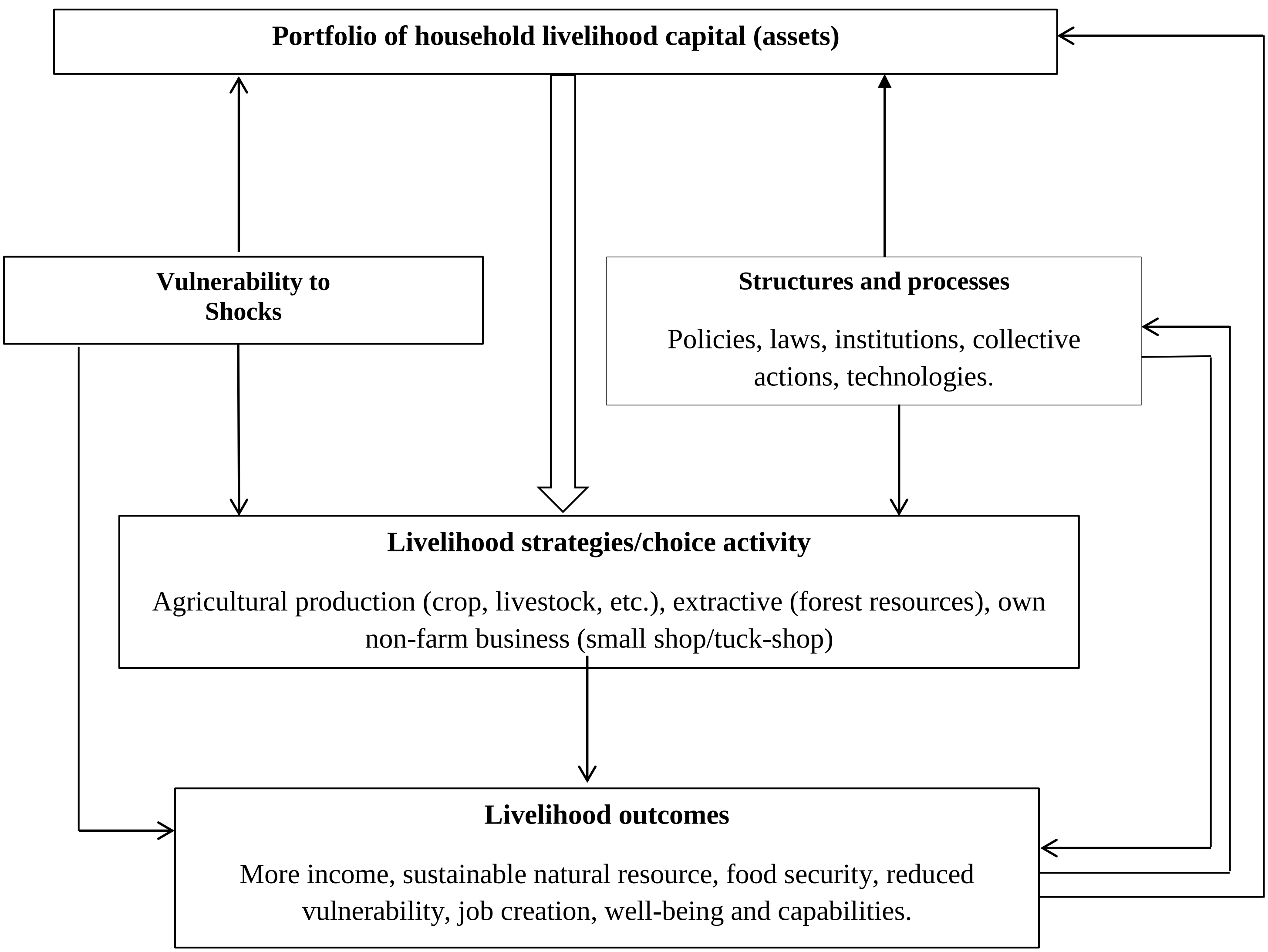

Figure 2.1 The sustainable livelihoods framework

Source: Adapted from Babulo *et al.* (2008)

The sustainable livelihoods framework shown in Figure 2.1 presents the main factors that affect people's livelihoods and typical relationships between those factors, and possible adaptation strategies in order to achieve the sustainable livelihood outcomes. The arrows within the sustainable livelihoods framework are used as shorthand to denote a variety of different types of relationships, all of which are highly dynamic. None of the arrows imply direct causality, though all imply a certain level of influence. There is a need for access to capital assets or livelihood resources (such as natural, human, physical, financial and social capital assets) in order to maintain sustainable livelihoods outcomes. Assets in the form of natural and physical resources, human capital, and social networks determine households' capacity to self-insure and manage risk in the face of calamity, thereby influencing their vulnerability to shocks (World Bank, 2001). In order to create livelihoods, therefore, people must combine their capital endowments/assets that they have access to and control over, and on which they draw when pursuing different livelihood strategies.

2.2.3 Vulnerability of rural communities

Vulnerability to climate change is the degree to which geophysical, biological and socio-economic systems are susceptible to, and unable to cope with, adverse impacts of climate change, including climate variability and extremes (IPCC, 2007a; Thomas, 2008). It is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. The major climate change vulnerabilities in developing countries are desertification, sea level rise, reduced freshwater availability, cyclones, deforestation, loss of forest quality, degradation of woodlands, coral bleaching, spread of malaria and impacts on food security (IPCC, 2007a). Rural households tend to rely heavily on climate-sensitive resources such as local water supplies and agricultural land; climate-sensitive activities such as arable farming and livestock husbandry, and natural resources such as fuelwood, wild fruits, wild spinaches and herbs (Mutenje *et al.*, 2011; Mulenga *et al.*, 2012). Climate change can reduce the availability of these local natural resources, limiting the options for rural households that depend on natural resources for consumption or trade (IPCC, 2007a). Land may become less fertile, fewer reeds may be available for basket making, and there may be less local fuelwood for cooking. Climate change is expected to increase the vulnerability of villages in Inanda community of KwaZulu-Natal. In order for these villages to cope and adapt to the challenges for climate change by investing in new livelihood adaptation strategies, it is important to gain a wider understanding of how vulnerable villages in Inanda community are.

According to Mertz *et al.* (2009), the notion of vulnerability is further captured by reference to the resilience and sensitivity of the livelihood system. However, resilience means the ability of the system to absorb change or even utilise change to advantage. Sensitivity refers to the susceptibility of the natural resource base to change following human interference. According to these ideas, the most robust livelihood system is one displaying high resilience and low sensitivity; while the most vulnerable displays low resilience and high sensitivity. For example, livelihood systems in rural communities of developing countries are highly sensitive, thus prone to natural resource changes, but surprisingly resilient (Bhusal, 2009; Mertz *et al.,* 2009).

However, Bhusal (2009) defined vulnerability as the characteristics of a person or group in terms of their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard. Moreover, the problem of vulnerability is rooted in impaired adaptive capabilities in addition to defencelessness and structural disadvantage (Ellis, 2000). Vulnerability can also be the product of many processes, including: poverty and marginalization, social instability and conflict, population growth, coastal and floodplain settlement, rapid and unplanned urbanisation, overloaded infrastructure, growing economic value of the built environment, and environmental degradation. Several studies outlined that vulnerability to the hazards of climate change for a particular community depends on technology, wealth, education, information, skills, infrastructure, and management capabilities (IPCC, 2007a; Bhusal, 2009; Bryan *et al.,* 2009; Alam *et al.*, 2011).

2.2.4 Livelihood adaptation strategies

A further concept that arises in the context of coping behaviour is that of adaptation. Livelihood adaptation has been defined as the continuous process of changes to livelihoods which either enhance existing security and wealth or try to reduce vulnerability and poverty (Ellis, 2000; Bhusal, 2009; Mulenga *et al.,* 2012). Adaptation methods are those strategies that enable the individual or the community to cope with or adjust to the impacts of the climate in the local areas (Van Aalst *et al.,* 2008; Fisher *et al.,* 2010). Adaptation is often defined as the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, to moderately exploit beneficial opportunities (Bhusal, 2009; UNFCCC, 2009; Alam *et al.,* 2011). Adaptation to climate change has become an important policy issue in international negotiations in recent years (IPCC, 2007a). Adaptation will require the involvement of multiple stakeholders, including policymakers, extension agents, NGOs, researchers, communities, and farmers (Bryan *et al.,* 2009). Adaptation at the community level is referred to as the ability to maintain and preferably improve the current living standards in the face of expected changes in climate trends that may affect people's livelihoods (Alam *et al.*, 2011). However, it has yet to become a major policy agenda in developing countries. Many have noted the important role of disaster risk reduction in climate change adaptation (UNFCCC, 2004; IPCC, 2007b; Erasmus *et al.*, 2000).

In order to adapt to climate change, farmers/households must first perceive that changes are taking place. According to Ban and Hawkins (2000), perception is defined as the process by which individuals receive information or stimuli from the environment and transform it into psychological awareness. The investigations of this study will be based on the perceptions of rural households and on how they are coping with and adapting to past and current impacts of climate-driven changes. Furthermore, it is recognized that the concept of coping strategy is more directly related to short term survival whilst the concept of adaptive strategy refers to a longer time frame (Bhusal, 2009; Stern, 2007). According to Deressa (2007), the adaptation to climate change is a two-step process: the household must perceive that the climate is changing and that change is affecting their economic activities, and then respond to changes through coping and adaptation strategies.

2.3 The contribution of natural forests to rural livelihoods

Forest products are divided into two main categories - timber and non-timber forest products (NTFPs). The timber category usually includes sawn wood, pulp, panel boards and other industrial uses. The NTFP category includes fuelwood, wild spinaches and fruits, traditional medicinal plants, fish, honey, bush meat, resins, essential oils valuable for their chemical components, and fibres such as bamboos, rattans and other palms used for weaving and structural applications (Belcher, 2003). According to Belcher (2003) and Heltberg *et al.* (2000), fuelwood and carving wood fall into one category and used as energy for cooking. The present research will focus on sustaining long-term livelihoods of natural forest product dependent societies.

However, there is a disparity between the expected contribution of NTFPs in poverty reduction strategies due to increased population, climate changes and other evolving challenges impacting negatively on natural forests. According to Wunder (2001) and Arnold (2002a), although natural forests serve a function as safety nets, there are challenges in raising producer benefits sufficiently for forests to make a significant contribution to poverty alleviation. According to the World Bank (2001), 1.6 billion people depend to varying degrees on forests for their livelihoods, with 350 million living in or near dense forests depending on them to a high degree. In the same line, the Food and Agriculture Organization estimates that 80 percent of the population in the developing countries relies on NTFPs for nutritional and health needs (FAO, 2003).

Natural forest resources are the most accessible sources of products and incomes for many adjacent rural communities of developing countries (Mutenje *et al.,* 2011). NTFPs contribute significantly to a rural household's livelihood in the African semi-arid tropics (Heubach *et al.,* 2011). Likewise, in the first chapter it was explained that the NTFPs contribute significantly to maintain livelihoods worldwide (Cavendish, 2000; Fisher, 2004; Shackleton and Shackleton, 2004; Shaanker *et al.,* 2004; Rist *et al.,* 2012). They have three main functions in the household economy of rural communities, thereby helping to fulfil households' subsistence and consumption needs as well as construction purposes (Shackleton *et al.*, 2007). They also serve as a safety net during crises (e.g. income shortages due to crop failure) and provide regular cash income (Cavendish, 2002; Kamanga *et al.,* 2008; Narain *et al.,* 2008). The daily importance of forests for physical resources (fuelwood, timber for shelter, non-timber forest products) and psychological needs (wilderness areas for spiritual purposes and for stress relief) are increasingly recognized (Stein *et al.,* 1999; Dolisca *et al.*, 2006).

Socio-culturally, the role and access to some NTFPs have been associated with spiritual values, such as ancestral spirits that tend to depict peoples' historical traditions and their relationship with resources (Shaanker, 2004). For example, parts of young baobab trees (mainly roots and bark) are used for rituals that tend to symbolise the fattening of babies. Similarly, the bark of baobabs is often processed and used as birth stimulants by pregnant women, believed to reduce pains during natural delivery. There are other medicinal uses, and dead plants, together with the fallen leaves, provide organic fertilizer. On the other hand, honey is often used for food and medicine. It provides important cash income, while candles made from bees wax are important in spirit ceremonies and rituals.

2.4 Climate change: an overview on impacts, policies and strategies

2.4.1 Climate change globally and in Africa

Climate change is one of the greatest environmental, social and economic threats worldwide (Bryan *et al.,* 2009; UNFCCC, 2011). According to the UN Intergovernmental Panel for Climate Change, evidence of recent warming is growing. Since the late 1950s, the global average surface temperature has increased by 0.6 ^{O}C, and snow cover and ice extent have diminished. During the past century, the sea level has risen on average by 1020cm and the temperature of the oceans has increased (IPCC, 2007b). Midrange estimates for future climate change are 3°C global mean warming and a rise in the sea level of 45 cm by 2100 (IPCC, 2007b).

Greenhouse gases (GHGs) are important for their ability to trap heat from the sun and create an atmosphere that supports life on Earth (UNFCCC, 2011). Evidence confirms that greenhouse gas emissions attributable to human induced factors such as burning of fossil fuels, deforestation, agriculture, industries, and automobiles are a major cause of global warming leading to climate change (IPCC, 2007a). The warming has manifold impacts on ecosystem and biological behaviour (Alam *et al.,* 2011). Some widely discussed impacts include snow melt, glacier retreat, shift in weather patterns, intensification of droughts and desertification, flooding, fires, species shift, rise of disease incidence and sea level rise (UNFCCC, 2011). These ecological and biological responses have serious consequences for human wellbeing. Poor households are mostly found in remote areas (rural communities) of developing countries, which are exposed to climate-related changes.

Climate change is often attributed to both natural and anthropogenic factors (IPCC, 2001; IPCC, 2007b). Natural factors such as solar variations and volcanic activities occur beyond human involvement. Anthropogenic factors are human-based activities causing changes in the earth’s atmospheric concentrations of greenhouse gases and aerosols, in solar radiation and in land surface properties. As atmospheric carbon dioxide increases over the next century, it is expected to become one of the drivers of global biodiversity loss (Sala *et al.,* 2000). This will result in the alteration of the energy balance of the climate system and manifestation as increases in temperature, changes in rainfall patterns, and more frequent and severe extreme events, among other effects (IPCC, 2007b). Global average temperatures have increased by 0.2 ^{o}C per decade since the 1970s, and global average precipitation has increased by 2% in the last 100 years (IPCC, 2007a).

Africa is one of the most vulnerable regions to climate change mainly due to poverty, lack of awareness, lack of access to knowledge and a high dependence on natural resources and rain-fed agriculture (Bryan *et al.,* 2009). About 70% of the people in Africa depend on agriculture and natural forests for their livelihoods, whilst economic activities based on this sector contribute 40% to exports (IPCC, 2001). Moreover, African countries also face the daunting challenge of economic development under conditions of widespread poverty and pandemics such as HIV/AIDS. Previous studies indicate that Africa's agriculture is negatively affected by climate change (Pearce *et al*., 1996; McCarthy *et al*., 2001). Adaptation is one of the policy options for reducing the negative impacts of climate change (Adger *et al*., 2003; Kurukulasuriya and Mendelsohn 2006a). The African continent is, however, extremely vulnerable to climate change, largely because of its inability to respond and adapt to changing conditions, which is due to a number of factors, including lack of infrastructure, general under-development, the absence or limitation of institutional or human capacity and poor disaster management processes (IPCC, 2007; Bryan *et al.,* 2009).

In eastern and western African regions, climate change has a cascading effect on the livelihoods of communities reliant on agriculture and natural resources for subsistence (Admassie and Adenew, 2008; Fisher *et al.,* 2010; Maddison, 2006). For example, less frequent and more intense rainfall impacts a community's livelihood by limiting the ability to properly plan for crop production and causing damage to crops and homes alike through flooding. In Ethiopia, the decrease in surface water sources has resulted in a decrease in pastoralism, since communities no longer sustain and maintain their livestock (Admassie and Adenew, 2008; Deressa *et al.,* 2009). In Kenya and Nigeria, this caused more frequent migration and an increased amount of time spent collecting water (Deressa *et al.,* 2005). It was found that water and sanitation improvements were key factors in the empowerment of women in Ethiopia (Kurukulasuriya and Mendelsohn, 2006a). However, women do not have a strong voice at community level meetings and have limited capacities to debate on important issues affecting them in front of men. Therefore, community livelihoods become vulnerable as men often migrate in search of water and pasture to nearby towns to seek employment (Kurukulasuriya and Mendelsohn 2006a).

Several studies have been conducted to investigate the likely impacts of climate change on agriculture and community households (Admassie and Adenew, 2008; NMSA 2001; Deressa 2007; Mertz *et al.*, 2009; Nhemachena, 2008). According to Deressa *et al.* (2005) and Deressa (2007), the adaptation to climate change is a two-step process: the household must perceive that the climate is changing and then respond to changes through adaptation. Deressa (2007) and Deressa *et al.* (2005) employed the Ricardian approach to estimate the monetary impact of climate change on Ethiopian agriculture. One of the important advantages of the Ricardian approach is that it takes into account efficient adaptation, which implies that farmers will make adjustments if it makes them better off. Even though the approach commonly applied includes adaptation, it does not identify the determinants of each of the adaptation methods used by farmers. Potential adaptation measures for coping with adverse impacts of climate change on crop and livestock production in Ethiopia have been identified (NMSA, 2001; Deressa 2007). Deressa *et al.* (2009) criticized NMSA (2001) and Deressa (2007) that they both failed to indicate factors that influence the choice of adaptation measures to climate change by farmers. According to Deressa *et al.* (2009), limited empirical studies are conducted that can guide decision makers to identify the important factors and promote adaptation to climate change in developing countries, particularly in Ethiopia. Therefore, in this study, the socio-economic characteristics of households are considered to influence the choice of adaptation measures to mitigate climate change for sustainable livelihoods.

Climate change is one of the most serious threats the world faces (UNFCCC, 2011). It has a disproportionate impact on millions of poor rural people. It puts more people at risk of hunger and makes it more difficult to reduce the proportion of people living in extreme poverty. For example, the developmental work to be effective, there is a need to help poor rural people cope with and adapt to the impact of climate change (Gbetibouo, 2009). According to UNFCCC (2011), nearly 2 billion people live on less than a US dollar per day (International Fund for Agricultural Development (IFAD, 2011)) in rural areas of developing countries. Poor rural people are the most vulnerable to the effects of climate change. Many live on ecologically fragile land and depend on agriculture, livestock, fisheries and forestry (Benhin, 2006; Mertz *et al.*, 2009). Poor rural people do not have the access to financing and infrastructure that would allow them to withstand the impact of climate change. According to Mertz *et al.* (2009), crop failures and livestock deaths are causing higher economic losses, contributing to higher food prices and undermining food security with ever-greater frequency, especially in parts of sub-Saharan Africa. Rain fed crop yields could drop by 50 percent by 2020 in some African countries (IPCC, 2007a). At the same time, rapidly increasing populations mean that demand for food is rising. Moreover, food production in developing countries will need to double by 2050 to meet demand. The historical climate record for Africa shows warming of approximately 0.7°C over most of the continent during the twentieth century, a decrease in rainfall over large portions of the Sahel (the semi-arid region south of the Sahara), and an increase in rainfall in east-central Africa (Deressa *et al.*, 2005; Richards, 2008).

2.4.2 Climate change in South Africa

Climate change is a relatively contemporary issue in South Africa affecting both urban and rural communities (SANCCRS, 2004). Education, training, research and public awareness about the effect of climate change still lag behind the requisite standards for mitigation. Similarly, government does not have the necessary capacity to deal with climate change on an effective basis, especially in rural communities (Deressa *et al.*, 2005; Richards, 2008). Industries are better placed regarding technical skills. However, these skills are not usually available for climate change related activities. Raising public awareness on climate-related issues is promoted by the government through the Department of Environmental Affairs and Tourism (DEAT) and the South African Weather Services (SAWS) (SANCCRS, 2004). Presentations and exhibitions are used as a mechanism to promote awareness on climate change, for example through the national atmospheric week, world environment day and world meteorological day. Publications which highlight trends in important environmental issues, such as the environmental education fact sheet, are produced by DEAT.

According to UNCCC (2011), South Africa is particularly vulnerable to climate change because a large proportion of the population has a low resilience to extreme climate events (e.g. poverty; high disease burden; inadequate housing infrastructure and location). Large parts of South Africa already have low and variable rainfall, especially in poor rural communities. Although poor remote communities are only minor contributors to climate change, they are the most vulnerable and, hence, will be the most impacted. In a significant proportion of rural communities in developing countries, including South Africa, surface water resources are already fully allocated; agriculture, natural forests and fisheries are important for food security and local livelihoods (Richards, 2008).

However, it has been predicted that if nothing is done to climate change and people continue to burn fossil fuels and chop down forests trees at current rates, then South Africa's coastal regions will warm by around 1-2°C by about 2050 and around 3-4°C by about 2100 (UNCCC, 2011). Furthermore, South Africa's interior regions will warm by around 3-4°C by about 2050 and around 6-7°C by about 2100. Therefore, there will be significant changes in rainfall patterns which, coupled with increased evaporation, might result in significant changes in respect of water availability, e.g. the western side of the country is likely to experience significant reductions in the flow of streams. South African biodiversity will also be severely impacted, especially the grasslands, fynbos and succulent Karoo where a high level of extinction is predicted (Gbetibouo, 2009; UNEP, 2009).

In South Africa, climate change is expected to have the largest impact on rainfall, temperature and water availability, with western regions predicted to have a 30% reduced water availability by 2050 (Hannah *et al.*, 2005). The country has been identified as one of the countries on the African continent that will experience considerable water scarcity by 2025 (UNEP, 2009) due to the effects of climate change (Richards, 2008). Moreover, drastic qualitative changes in the water supply extend to losses in biodiversity and rangelands, which impact on the agricultural sector and possible increases in infectious and respiratory diseases (Kiker, 2000).The combinations of stress and resilience factors give rise to complex positive and negative livelihood trends, depending largely on policy environments. Urban population growth in many large developing cities is greater than 4% per annum, and rural migrants account for between 35% and 60% of recorded urban population growth (UNEP, 2009). Within rural areas of developing countries, there is a diversification away from agriculture to non-farm economic activities, which already accounts for 30–50% of rural income (Adger, 2003).

South Africa will have to adapt to the unavoidable impacts of climate change through the management of risk and the reduction of vulnerability (Nhemachena, 2008). Although there will be costs associated with South Africa's greenhouse gas emission reduction efforts, there will also be significant short and long-term social and economic benefits, including improved international competitiveness that will result from a transition to a low carbon economy. However, these costs will be far less than the costs of delay and inaction. Government should continue to engage actively and meaningfully in international climate change negotiations, specifically the United Nations Framework Convention on Climate Change (UNFCCC) negotiations. These will secure mutual effective and efficient measures to limit the average global temperature increase to at least below 2°C above pre-industrial levels. However, it will be a credible outcome that is equitable, fair and inclusive and having a balance between adaptation and mitigation responses. South Africa is the third most bio-diverse country after Brazil and Indonesia and is the only country in the world with more than one biodiversity hotspot (Aylett, 2011). Durban is located in the middle of one of these hotspots, called the Maputaland-Pondoland-Albany Region. This includes terrestrial ecosystems (like grasslands and forests) and aquatic ecosystems (like rivers, oceans and estuaries). In Durban alone, there are over 2000 plant species, 82 terrestrial mammal species and 380 species of birds. There are also 69 species of reptiles, 25 endemic invertebrates (e.g. butterflies, millipedes and snails) and 37 frog species (Aylett, 2011).

According to Benhin (2006), 90% of the respondents in KwaZulu-Natal had noticed a long-term change in the temperature and rainfall. They also stated that the province became hotter, with the maximum temperature increasing from 28°C to 32°C since the late 1990s. They had also observed an increase in the occurrence of droughts. The beginning of the winter season has also shifted from early April to May. For most of them the rainfall has become more erratic from year to year. The annual average rainfall has decreased and its distribution throughout the year has also changed, being concentrated in shorter periods and much heavier. However, he did not show how these changes in weather affected the livelihood of rural communities who depend on natural resources and agricultural production in KwaZulu-Natal.

Durban is the largest city in KwaZulu-Natal, South Africa and as such represents a place where climate change poses significant and on-going challenges to sustainable development and human well-being. Against the backdrop of a population that is already vulnerable in terms of poverty, health, water and food security, the implications of climate change are likely to be dramatic (Aylett, 2011). The way in which Durban has responded to these impending threats stands as an example not only to other cities in South Africa and Africa, but also to the rest of the world (EMEMD, 2009). Durban provides an example of what is possible in the face of numerous developmental challenges and minimal resources and as such, is increasingly being acknowledged as South Africa's climate capital, and also as a global leader in the field of climate protection planning. In 2004, in response to the challenge of climate change, eThekwini Municipality initiated a Municipal Climate Protection Programme (MCPP) with the purpose of assessing the local impacts of climate change on the Municipality; highlighting the key interventions that would be required by the Municipality to adapt successfully to climate change; developing tools to assist strategic decision making in the city in the context of climate change; and mainstreaming climate change concerns into city planning and development (EMEMD, 2009).

2.4.3 The impacts of climate change on natural forest resources

Forests are particularly sensitive to climate change, because the long life-span of trees does not allow for rapid adaptation to environmental changes (Fisher *et al.,* 2010; Olufunso, 2010). Unlike in agriculture, adaptation measures for forestry need to be planned well in advance of expected changes in growing conditions. However, because the forests regenerated today will have to cope with the future climate conditions of at least several decades, often even more than 100 years (Fisher *et al.,* 2010; Maddison, 2006). Forest ecosystems play an important role in the global biogeochemical cycles (Adger *et al.,* 2003; Narain *et al.,* 2008). Recent studies demonstrated that mankind is having a significant impact on the carbon balance of temperate regions (Maddison, 2006; Olufunso, 2010; Fisher *et al.,* 2010), either directly (through forest management) or indirectly (through nitrogen deposition). Forests act both as sources and sinks of greenhouse gases (GHGs), through which they exert significant influence on the earth's climate. Forests can contribute to the mitigation of climate change, but under the existing global climate policy frame this alone will not be enough to halt climate change (Olufunso, 2010). Research on the possible impacts of climate change on forests in Europe, Africa and Asia and the development of adaptation and mitigation strategies started in the early 1990s, shortly after first concerns were raised about the consequences for Earth's climate of anthropogenic greenhouse gas emissions (UNCCC, 2011). Since then, assessments of climate change, its impacts and subsequent consequences to natural resource management have been the focus of continuous research efforts on changes in forest area and competition between species (Fisher, 2004), and changes in damage caused by natural disturbances (Nhemachena and Hassan, 2007). It was also recognised that protective functions of forests will be affected by climate change as well.

The Food and Agriculture Organization (FAO) of the United Nations developed decision models for managing forests under uncertainty, and management options for intensively managed forests in regeneration, tending, harvesting, protection, conservation and management planning (Richard and Klein, 2004; Stern, 2007). Unfortunately, in forests which are managed at low intensity or not at all, particularly the tropical forests, fewer options exist and uncertainty is more pronounced regarding climate change adaptation. Intensifying assessment and monitoring, establishing new tools and indicators to rate vulnerability and targeting research efforts appear most promising to cope with climate change in those forests. Studies have been undertaken on adaptation to climate change and its impact on biodiversity and natural forests through management over the last two decades (McNeely *et al.,* 1990; Nhemachena and Hassan, 2007). McNeely *et al.* (1990) did not include measures or incentives to biodiversity or park managers to build and test adaptation strategies to preserve biodiversity under climate change. Cavendish (2000) reviewed similar literature but focused on park management, not on natural resources and biodiversity, to mitigate the negative impact of climate change.

Recent studies on the impact of climate change on natural forests support the Intergovernmental Panel for Climate Change report (IPCC), which includes conclusions about increasing global timber supply and a slow increase in demand for forest production, followed by falling prices (Porte and Bartelink, 2002; Gbetibouo, 2009). However, if wood-based ethanol becomes competitive with other biofuels, this will lead to growing demand and higher prices for biofuels which may result in higher demand of fuelwood for industrial purposes and as result these forest products will be degraded or exploited. Various studies revealed that impacts of a particular climate change may be exacerbated by human activities (Adger *et al.,* 2003; Nhemachena and Hassan, 2007; Gbetibouo, 2009). For example, forest cutting, road development, and urban expansion create land-cover patterns that may impede the natural processes of seed dispersal and plant establishment that might otherwise compensate for changes occurring in the forest. On the other hand, some human activities may mitigate effects of climate change on forests. For example, some tree species may not be able to migrate to the regions where climate change produces appropriate habitats but seedlings of those species could be intentionally planted.

2.4.4 The impacts of climate change on agricultural production

Agriculture and climate change are inextricably linked (Bryan *et al.,* 2009; Nelson, 2009). Solar energy, air and precipitation are important factors for agriculture production (Bryan *et al.,* 2009). Climatic hazards like floods, drought, a cold wave and new diseases are the challenges for the agricultural sector. Nelson (2009) stated that agriculture is part of the climate change problem, contributing about 13.5 percent of annual greenhouse gas emissions (with forestry contributing an additional 19 percent), compared with 13.1 percent from transportation. However, it is also part of the solution, offering promising opportunities for mitigating emissions through carbon sequestration, soil and land use management, and biomass production (Deressa *et al.,* 2005; Bryan *et al.,* 2009; Mertz *et al.,* 2009; Fisher *et al.,* 2010).

South African commercial agriculture is one of the highly sophisticated and successful sectors contributing towards the country's economic growth (NDA, 2005). The dominant form of agricultural production in the country is the medium- to large-scale farm (Benhin, 2006). These farms, which are commercially oriented, capital intensive, and generally produce a surplus, account for 90% of the value added and cover 86% of the agricultural land (NDA, 2011). On the other hand, the small-scale farms, worked by a high proportion of the farming population (86%), are mainly subsistence in nature and rely mainly on traditional methods of production (Benhin, 2006). The most important factor limiting agricultural production in South Africa is the availability of water (DWAF, 2010). Rainfall is distributed unevenly across the country, with humid, subtropical conditions in the east and dry, desert conditions in the west. The country's average annual rainfall is 450mm per year, well below the world's average of 860mm, while evaporation is comparatively high (DWAF, 2010). Only 10% of the country receives an annual precipitation of more than 750mm and more than 50% of South Africa's water resource is used for agricultural purposes. Both commercial farming and especially subsistence farming may be affected by less availability of water owing to adverse climate change. This is expected to vary across the different agro-climatic zones, provinces and different agricultural systems in the country (NDA, 2011).

According to Deressa *et al.* (2005) and Mertz *et al.* (2009), climate change threatens agricultural production through higher and more variable temperatures, changes in precipitation patterns and increased occurrences of extreme events like droughts and floods. The increase in temperature has both negative and positive impacts on agriculture, as IPCC (2007) projected that the potential food production to increase with increase in local average temperature over a range of 1 to 3 ^{0}C, but above this it is projected to decrease. The agricultural sector (crops and livestock), which is the main source of food and income for the majority of local people in the area, appears to have improved considerably in recent years, but mainly through increases in the area under cultivation and immigration of livestock (Benhin, 2006). This may probably lead to a tendency to overlook the real impacts of climate change on productivity. Moreover, total production per household may be increasing due to farm expansion but the overall agricultural productivity will be highly affected by climate change and variability.

The concern with climate change is heightened given the linkage of the agricultural sector to poverty (Adger *et al.,* 2003; Erasmus *et al.,* 2000). In particular, it is anticipated that adverse impacts on the agricultural sector will exacerbate the incidence of rural poverty as many of the rural poor are dependent on agriculture. Impacts on poverty are likely to be especially severe in developing countries where the agricultural sector is an important source of livelihood for most rural people. Land-use and agricultural production remains the main source of livelihood for rural communities in Africa, providing employment to more than 60 percent of the population and contributing about 30% of gross domestic product (Bryan *et al.,* 2009; Nhemachena and Hassan, 2007). Decreasing rainfall can lead to the need for irrigation for agricultural production. Changing temperature or rainfall patterns can affect which crops are most suitable for an area. However, land managers can frequently identify replacement varieties or crops that perform equally well under new climatic conditions.

Climate change can also impact on agricultural livestock production in South Africa (Erasmus *et al.,* 2000). Higher temperatures suit small farm animals like goats and sheep because they are heat tolerant, but large farm animals like cattle are relatively less heat tolerant. Increased precipitation is likely to be harmful to grazing animals because it implies a shift from grasslands to forests and an increase in harmful diseases and a shift from livestock to crops (Adger, 2003). Smallholder, subsistent and pastoral systems, especially those located in marginal environments, areas of high rainfall variability or high risks of natural hazards, are often characterized by adaptive livelihood strategies that have evolved to reduce overall vulnerability to climate shocks, and to manage their impacts ex-post (coping strategies) (Easterling *et al.*, 1993; Adger *et al.*, 2003; Stern, 2007).

Despite uncertainty on the exact impacts of climate change on natural forests and agriculture and specifically food production, it is largely agreed that (Erasmus *et al.*, 2000; Giliba *et al.*, 2011):

- Frequency and intensity of extreme events such as droughts and floods are likely to increase, leading to reduced yield levels and disruption in production.
- Temperature rise and changes in timing, magnitude, and distribution of precipitation are likely to increase moisture and heat stress on crops and livestock, with the subtropics being the most affected.
- Agricultural systems will face increasing risks of soil erosion, runoff, landslides and pest invasions.
- Pest and diseases are sensitive to climate and are likely to change in unpredictable ways, with some becoming more prevalent in areas where they were previously unknown.
- Climate change impacts become increasingly magnified where poverty is pervasive and social safety nets are weak.

2.4.5 Agricultural policies and strategies towards climate change

Climate change is expected to adversely affect agricultural production and natural forests in African continent, including South Africa (Bryan *et al.*, 2009). However, Agricultural production remains the main source of income for most rural communities in the country (NDA, 2005). Adaptation to climate change impacts in the agricultural sector is imperative to protect the livelihoods of the poor and to ensure food security. A better understanding of farmers' perceptions of climate change, on-going coping and adaptation measures, and the decision-making process is important to inform policies aimed at promoting successful adaptation strategies for the agricultural sector (Stern, 2007). However, there are expected to be gains and losses to farming systems with the presence of climate change impacts (Benhin, 2006; Mertz *et* *al.*, 2009). If policy makers and farmers are able to identify where the gains and losses are, and direct the appropriate policies and adaptation strategies to those areas, the expected overall negative effect may be reduced, and it is even possible that the agricultural sector in South Africa may reap benefits from climate change.

One important issue in agricultural adaptation to climate change is the manner in which farmers update their expectations of the climate in response to unusual weather patterns (Adger, 2003). Farmers need to adapt to climate change. Knowledge of the adaptation methods and factors affecting farmers' choices enhances policies directed toward tackling the challenges that climate change imposes on agricultural production (Deressa, 2007). However, it is very important to make them aware about future risk of climate change, especially climate change related socioeconomic vulnerabilities (Alam *et al.*, 2011). They need to respond to adverse situations. The production practices of farms and individual farmers need to be kept up to date with the changes in climate factors. They should also take all precautions and be aware of the uncertainty of low and heavy rainfall. There will be a need to manage water differently, both in terms of irrigation facilities and quick water facilities (McNeely *et al.*, 1990).

Apart from that, farmers need to understand the importance of proper timing and react quickly at the expectation of upcoming rainfall events. They should be informed about crop rotation, crop portfolio, and crop substitutions to address the environmental variations and economic risk associated with climate change (Deressa, 2007; Alam *et al.*, 2011). Moreover, they need to utilize land properly, knowing which suitable agricultural production practises to be made and change the location of crop production if possible to cope with extreme cases. Furthermore, they need to develop efficient irrigation practices to address moisture deficiencies and drought associated with climate change (McNeely *et al.*, 1990; Yirga, 2007). Finally, they need to adapt to the changing duration of growing seasons and associated changes in climate factors with the help of extension services via effective and efficient information (Yirga, 2007). Several studies outlined that many agricultural dependent communities in the world have historically adapted to impacts of changing climate, including the following (IPCC, 2007a):

- Increasing land for agriculture. This strategy was reported to aim at increasing overall production to compensate for the lost productivity in the traditionally small farms in case of unfavourable climatic conditions.

- Improved farming technologies, such as use of improved seeds, fast growing seeds and agricultural implements like ploughs. This is aimed at improving agricultural productivity even when expansion of farmland becomes not feasible. For instance, by planting improved seeds it is possible to harvest more from a unit area, whereas fast maturing varieties ensure that some harvest is attained even within a short duration of rainfall. Achievement of such aims is facilitated by timeliness in farm operations, which can be achieved through mechanization, involving the use of ploughs.
- Cultivation of drought tolerant crops such as cassava is yet another adaptation strategy. In a situation with unreliable rainfall, growing of drought tolerant crops enhances the food security situation of the area.
- Early planting of crops was also mentioned to be an important adaptation strategy. Timeliness in planting ensures that the crop plants optimize the use of early rains.

  Regarding shortage of water, however, to make such an adaptation strategy sustainable there is a need to dig deep wells that could provide sufficient volumes of water to all community members and throughout the year.

2.4.6 Community-level climate change adaptation strategies

Agricultural production and natural forests remain the main sources of livelihoods for rural communities in Africa, including South Africa. Adaptation strategies in agricultural production to ameliorate the impacts of climate change involve several actions (such as changing from crops to livestock or vice versa, adjusting livestock management practices, switching from farming to non-farming or vice versa, increasing use of irrigation, changing the use of chemicals (fertilizers, pesticides and herbicides), increasing soil and water conservation, shading and shelter, and use of insurance). According to Deressa *et al.* (2005) and Deressa (2007), the adaptation to climate change is a two-step process; the household head or farmers must perceive that the climate is changing and then respond to changes through coping and adaptation strategies. Furthermore, it is recognized that the concept of coping strategy is more directly related to short term survival whilst the concept of adaptive strategy refers to a longer time frame (Bhusal, 2009; Stern, 2007).

Adaptation to climate change has received increasing attention, especially in the United Nations Framework Convention on Climate Change (UNFCCC) and among development and disaster specialists throughout the world (Van Aalst *et al.,* 2008). Adaptation at the community level means being able to maintain (and preferably improve) the current living standards in the face of expected changes in climate trends and the intensity and frequency of severe events that may affect people's livelihoods (Bryan *et al.*, 2009; Van Aalst *et al.*, 2008). Adaptation can greatly reduce vulnerability to climate change by making rural communities better able to adjust to climate change and variability, moderating potential damages, and helping them cope with adverse consequences (IPCC, 2007a). Moreover, the adaptation strategies by community households depend on the availability of different types of capital assets (natural, physical, human, financial, and social) (Stern, 2007). Rural households' characteristics (e.g., income, age, and education) influence the ability of households to cope and adapt in response to climate change impacts in Inanda community of eThekwini metropolitan area. However, it is expected that community households with sufficient capital assets, higher incomes and alternative livelihood options are in a better position to adapt to and cope with livelihood and climatic shocks.

Van Aalst *et al.* (2008) outlined that the vulnerability and capacity assessment (VCA) supported by the International Federation of Red Cross (IFRC) and Red Crescent Societies identified interlink ages of contemporary issues driven by climate change and adaptive measures in Zambia. Those issues involve drought, food security, poverty, HIV/AIDS, pollution, floods, malaria and other health issues related to water quantity and quality. They noted that drought directly affects water quantity and quality, which result in poverty. For malaria, they noted that communities identified methods such as cutting of grasses, general cleaning of surroundings, spraying of stagnant ponds to repel mosquitoes with traditional methods (herbs and cow dung) and the use of bed nets. However, in terms of bed nets and spraying of stagnant ponds to repel mosquitoes to mitigate malaria, it could be argued that only wealthier households are able to afford these, since the bed nets and spraying of stagnant ponds to repel mosquitoes are likely to be relatively expensive.

2.5 The importance of community forest management

It is internationally recognized that greater community participation in forest management can contribute to reducing the over-exploitation of forest resources and the negative impacts of climate change. Community forest management is widespread in rural areas of developing countries (Adhikari *et al.* 2004). Common property resources (CPRs) (such as forests) are important since the majority of the population live in rural areas and many rely on them to provide at least part of their livelihoods (Heltberg, 2002). CPRs contribute to the diverse livelihood choices made by rural communities. However, the poor and common property regimes allow communities to spread the risks created by ecological uncertainty (Arnold, 1998; Ostrom, 2000). Furthermore, broad policy interventions are required for rural development, including interventions such as securing and enhancing the natural resource base, designing participatory management and monitoring systems, securing poor people's rights of use and access to such resources. However, it is important to include community forest users to participate in forest management. This could perhaps create opportunities for local people to utilize and benefit from the forest and it may not be difficult to incentivise local communities to become involved in forest management.

According to Agrawal and Gibson (1999), government policies and regulations should often assert state control over the forest resource, thereby further undermining the authority and effectiveness of community level institutions to control and manage forest use. It is important to realise that local knowledge is not necessarily static and culturally specific; it is dynamic and continuously evolving (Thomas *et al*. 2004). This change is influenced by cultural variation, rising populations, market opportunities, and policy shifts. In the face of market pressures, efforts by some village leaders to enforce local rules proved ineffective in Nepal (Adhikari *et al*. 2004). However, other villages subjected to many of the same market pressures were able to maintain their forests because of their historically strong social cohesion and strong leadership. If biodiversity is to be maintained in the forest ecosystems, there is need to recognise that these forests are present because of the actions of the local people who live in and around them (Bromley and Cernea, 1989; Berkes and Folke, 2002). The role of government should be to assist local people in their reconstruction of emerging knowledge systems and the adaptation of strategies for interacting with large- and global-scale political economic realities (Agrawal, 2007).

Several researchers (Adhikari, 2001; FAO 2003; Narain *et al.,* 2008; Shackleton *et al.,* 2007; Shimizu, 2006; Tesfaye, 2011) suggested that local communities can create and sustain local institutions to manage their collectively owned resources quite effectively in the face of adverse pressures from the state, demographical changes and market forces. FAO (2003) noted that adaptive management of forests contribute to sustaining the livelihoods of over two billion people worldwide. The introduction of biodiversity programmes and community-based natural resource management strategies (CBNRM) to mitigate the effect of climate change are some of the achievements in developing countries (Kamanga *et al.*, 2008; Narain *et al.*, 2008; Angelsen and Wunder, 2003; Shackleton and Shackleton, 2004). Behera (2009) stated that an introduction of forest resource management and access rights to local communities became a vital policy tool to mitigate the negative impact of climate changes for developing countries which enhance sustainable use of the forest resources and livelihoods. Common property resources (CPR) institutions are said to be unable to provide a significant contribution to the livelihood of poor and marginalized people due to their failure to take into account broader socio-economic and distributional issues (Adhikari, 2001). Moreover, South Africa's improvement in physical infrastructure, forest and trees resources on both public and private lands, but equitable use of forests products (such as fuel wood, fodder, timber, other non-timber forest products) has not been clearly established.

2.6 Livelihood dependence on forest products and climate change adaptation strategies

2.6.1 Socio-economic factors

Socio-economic factors are important determinants of economic activities, livelihood strategies and decisions undertaken by households (Agrawal and Angelsen, 2010). They involve the human, social, political, institutional, physical capital and economic environment under which households operate to improve their welfare. Human capital and socio-demographic variables include household characteristics (such as age, gender, marital status, employment status, educational level, household income and household size). Physical capital variables include farm income, total land size and productive assets owned (such as hoe, slash, fork, tractors, ploughs, wheel barrows, fishing nets, and animal traction). Physical capital also facilitates effectiveness of economic activities, like marketing of agricultural and forest products, easier access to health facilities and access to safe water. Social capital can be important in enabling households pursue some economic activities where, for example, labour is shared. Social and institutional assets may include community characteristics related to population, networking, remoteness, and access to markets. Social capital can be seen as connecting all aspects of livelihoods that require networks.

Socio-economic factors are also useful in determining the extent in the extraction of forest products and market participation behaviour (Mulenga *et al.*, 2012). They help in accessing the basic social service's needs, in terms of the engagement in the collection of forest products and agricultural production in rural communities of developing countries. They also influence the capacity of rural communities in adapting to climate-driven changes (Agrawal and Angelsen, 2010). Moreover, it is essential to include household demographic characteristics in analysing the coping and adaptive strategies of rural communities in response to climate change that threaten their livelihoods. According to Heubach *et al.* (2011), different household and farm characteristics, infrastructure, and institutional factors influence the use and the extraction of forest resources by rural households. They also influence the capacity of rural communities in adapting to climate-driven changes that threaten their livelihoods (Van Aalst *et al.*, 2008).

2.6.2 Institutional factors

Institutions are vital enabling factors for effective governance of the forest in rural communities for sustainable use of the forest products (North, 1990; Mutenje *et al.*, 2011). According to Agrawal (2001), institutions are referred to a set of accepted social norms and rules for making decisions about access to and the use of community based resources. They help as to guide who should control the resource, how the conflicts over resource use are resolved and how the resource could be managed and exploited. Rural communities with small, interdependent and more homogeneous groups that are more dependent on the resource for their livelihood are more likely to create institutions that help to manage forest commons more effectively. According to Hertbbeg (2002), institutions help in reducing transaction costs since they coordinate the formation of expectations, encouraging cooperation and collective action. Rules and regulations should be easy to understand and help to deal with conflicts, taking into consideration local leaders' presence, for sustainable forest dependent livelihoods.

Institutions are also formulated rules to govern relationships between individuals or groups of people involved in common activities (North, 1990). Moreover, institutions provide for more confidence in human interaction amongst rural communities. Institutions are divided into formal and informal rules (Niehof, 2004). Informal rules are non-legal rules such as norms, traditions, customs, value systems, religions and sociological trends (Kherallah and Kirsten, 2001). Informal rules are usually taken as exogenous factors because they change slowly and may retain agreements or habits for a long time, even if they have become less suitable (Niehof, 2004). It is through these formal and informal rules that knowledge is then revealed and employed to assist coordination of forest resource programmes. Institutional factors are important factors in influencing livelihood adaptation strategies of natural-resource-dependent societies in rural communities in response to climate change. These include transaction costs, market information flows, trust, norms and the institutional environment. Rural community households lack sufficient information and contractual provisions, lack lobbies in the legal environment and are not easily receptive to changes in their economic activities. Extension officers are considered to be the most crucial source of information among rural households and farmers. Households with access to climate change information through extension services are likely to adapt (Deressa et *al.,* 2009).

2.6.3 Climate change perceptions

Perceptions of rural households with regards to climate change, particularly on forest dependency, may differ among households according to their socio-economic and demographic characteristics (Adger *et al.,* 2009). According to Bryan *et al.* (2009), perceptions of climate change by rural households influence the ability of households in the extraction of natural forest products and, hence, their marketing participation level. Climate change components such as rainfall, temperature, wind, floods and drought as climatic attributes or variability are used to gather information. Deressa *et al.* (2009) obtained information on the perceptions of climate change by asking farmers if they have observed any change in temperature or the amount of rainfall over the past 20 years.

Perceptions of climate change go in hand with knowledge and experience as ascribed to rainfall patterns and temperature changes in rural communities. Rural communities change their way of living in terms of generating their livelihoods due to perceived climate-driven changes. Forest dependent societies change their time of visiting the community forest due to changes in rainfall patterns and temperature and hence influence their commercial purpose. Education also enhances the powers of conduct within the rural communities in terms of social awareness and knowledge about the perception of climate change. Awareness, as reported by Alarima (2011), is a critical determinant of perception. With low awareness, understanding of climate change and its effect on natural forest products, crops, animals and on the environment in general will be a difficult in order to achieve sustainable economic activities. This implies that the higher the level of awareness, the higher the perception of climatic conditions and then adaptation. Maddison (2007) reported that farmers' awareness of changes in climate attributes (temperature and precipitation) is important for adaptation decision making. Several studies have found those farmers' awareness and perceptions of agricultural and soil erosion problems positively and significantly affected their decisions to adopt soil conservation measures (Maddison, 2007; Deressa *et al.,* 2009). Deressa *et al.* (2009) showed that farmers who noticed and are aware of changes in climate take up adaptation strategies to reduce losses and take advantage of the opportunities associated with these changes.

2.6.4 Poverty and income inequality

South Africa has among the highest levels of income inequality in the world and compares poorly in most social indicators to countries with similar income levels (FAO, 2003; Agrawal, 2003). Most people would define inequality as the gap between rich and poor. However, it is remarkably difficult to define precise measures of poverty and inequality in rural communities. Poverty is referred to as the inability to attain a minimal standard of living, measured in terms of basic consumption needs or the income (May, 1998). In South Africa, rural poverty and chronic deprivation is partly ascribed to the poor endowments in natural resources of former homeland areas (Fraser *et al.*, 2003; Mukherjee and Benson, 2003). Moreover, poverty is closely related to poor education and lack of employment. Furthermore, higher incomes are accompanied by higher educational levels and increased awareness of climate-driven change and its harmful effects. Indeed, poverty has many dimensions, among which low consumption is only one, linked to others, i.e. malnutrition, illiteracy, low life expectancy, insecurity, powerlessness and low self-esteem (Carter and May, 1999). Poverty is also linked to frustrated capabilities due to assets-based deprivation (land, markets, information, credit, etc.), inability to afford decent health and education, and lack of power (Mukherjee and Benson, 2003). It usually results in alienation from the community, food insecurity, crowded homes, usage of unsafe and inefficient forms of energy, lack of adequately paid and secure jobs, and fragmentation of the family. As a result, poverty has a strong racial dimension with poverty concentrated among the African population (FAO, 2003).

An important issue affecting rural communities of developing countries, including South Africa, is food security (FAO, 2003). Food security is generally defined in terms of access by all people at all times to sufficient food for active, healthy lives (World Bank, 2005). As such, food security depends not only on how much food is available but also on the access that people (e.g., individuals, households, and nations) have to food whether by purchasing it or by producing it themselves. Access, in turn, depends on economic variables, such as food prices and household incomes, as well as on agricultural productivity and the quality of natural resources (Arnold, 2002a). In the study area, food security is also linked with poverty and economic variables in terms of the way rural households access food for their livelihoods. Agricultural production, forest products and purchasing food are their main sources of food, although these sources may be constrained by climatic changes.

2.6.5 Users' attitudes and perceptions about forest products

According to Moehrke (2010), an attitude refers to a tendency of evaluating a specific object or issue with some degree of favour or disfavour. Attitudes are the most explanatory factors influencing the capacity of natural-resource-dependent societies in the collection of forest products and related environmental goods and services. People have different attitudes about most things and their caring capacity also differs. These attitudes are derived from perceived benefits of forest products by rural communities, such as ecological, economical and spiritual or cultural benefits of sustainable alternatives to traditional natural resource extraction. These attitudes are also associated with socio-economic characteristics such as age, gender, education, income, occupation, and the frequency of use of forest products. Wealth shapes attitudes toward community environmental forestry, ecotourism and wildlife, implicitly endorsing the principle of 'conservation for community development' (Mehta and Kellert, 1998). Mehta and Kellert (1998) surprisingly found that age and education do not help much in explaining variations in locals' attitudes toward major policy programmes. Knowledge and perception of individuals are crucial components of attitudes towards forest resources and environmental goods and services. Thus, knowledge of forest users' attitudes and perception and the valuation of natural forest products by various stakeholders provide important information for planning environmental resource management. Knowledge informs policies and recommendations on how to identify factors that influence the success or failure of common resource management in rural communities adjacent to the forests.

2.6.6 Social capital

Social capital refers to features of social organizations, such as networks, norms and trust that enable stakeholders (community members and government officials) to act together more effectively to follow common objectives (Putnam, 1993; Adger, 2003). It is based on the connections across multiple systems including the microsystem, ecosystem and macro system, and is controversial in institutional and development economics because it needs substantial cooperation, trust and agreement among groups of individuals (Putnam, 1993). Social capital can be enhanced by organizing individuals into neighbourhood groups, connecting different groups, and eventually linking these groups with government officials when implementing to prepare for and respond to the evolving challenges in resource use (Nyangena, 2005). It is the cooperation between and active participation by local beneficiaries through their community institutions that determines successful outcomes. The existence of sustainable outcomes from forest enhancing sustainable livelihoods in rural communities requires social capital by the dependent groups. This is based upon the existence of trust, norms and networks that stakeholders and rural communities believe is effective and efficient for sustainable livelihoods (Adger *et al.,* 2003).

The socio-economic characteristics of groups, including size and homogeneity, do influence the ability of some resource users to gain trust that others will not break the rules and substantially over-harvest. It is hard to establish the management of common forest use without the reliability of substantial trust by community beneficiaries. Therefore, social capital is an important input which influences the collection of forest products and hence their commercial purposes. Social capital is also represented by the number of relatives of a household in the local area which may imply cheaper labour resources if they are available for the collection of natural products

(Dasgupta, 2003). Social capital also encourages market participation with its features such as network, norms and trust amongst homogeneous groups to adapt during economic crisis (Soltani *et al.*, 2012).

Social capital is also an important factor adapting to climate change because it connects people at different levels of power, such as community members, traditional leaders and government officials (Reid and Salmen, 2000). Studies have shown that adaptation to climate change risks need to take place at the individual, family, community, and government levels (Putnam, 1993; Dasgupta, 2003; Adger, 2003; Soltani *et al.*, 2012). According to Adger (2003), decisions on adaptation to climatic conditions are made by individuals, groups within society, organizations, and governments on behalf of society. Therefore, adaptation processes involve the interdependence of agents through their relationships with each other, with the institutions in which they reside, and with the resource base on which they depend. Social capital also gives a role to civil society and collective action for both instrumental and democratic reasons and seeks to explain differential spatial patterns of societal interaction. Dasgupta (2003) argued that multiple institutional forms are derived from the networks and trust generated through collective action. It is expected that rural households involved in extensive social capital are likely to adapt to changing climatic conditions.

2.7 Conclusions

A key conclusion emanating from this literature review is that climate change is an issue of international concern and is a major challenge in developing countries, including South Africa. Climate changes significantly affect South African society who depend on agriculture and natural forest resources and have important impacts on rural community livelihoods and their coping and adaptation strategies. The increase in temperature has both negative and positive impacts on agriculture and natural based resources, and the challenges are on how rural communities in developing countries response to the climate change impacts threatening their livelihoods. Therefore, it is important to assess adaptation mechanisms to reduce these vulnerabilities. Strategies to cope with current climate variability provide a good starting point for addressing adaptation needs in the context of poverty reduction. Present conclusions emanating from the literature review are aimed to assist policy makers, agricultural producers and forest planners to reduce the vulnerability of the sectors to climate change. It will also contribute with adaptive measures and strategies, including enhancing the protection of forests against, among others, forest fires, and to maintain the protective functions of forests against the increasing threat of extreme weather for rural sustainable livelihoods.

CHAPTER 3. RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the methodological approaches followed in this study. This includes study area choice, data collection instruments, sampling methods and the empirical model of analysis. The study area is briefly described before discussing data collection methods and procedures. The conceptual framework and the empirical models that were used in this study are presented subsequently.

3.2 Methods of data collection

3.2.1 The study area

The Inanda community is located in eThekwini Municipality of KwaZulu-Natal Province. It is situated 24km northwest of Durban. Figure 3.1 below shows the location of Inanda community depicted by the shaded part in the map of eThekwini Municipality forming part of the KwaZulu-Natal Sandstone Sourveld.

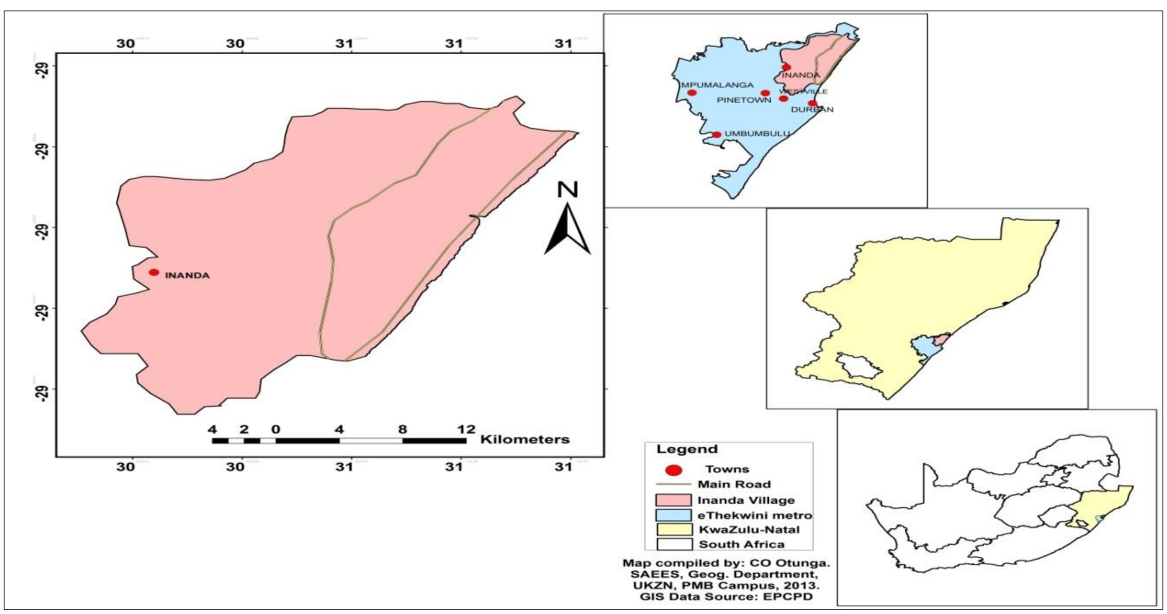

Figure 3.1 Location of Inanda community of eThekwini Municipality, KwaZulu-Natal

Agricultural production (crop cultivation and livestock) is the main source of livelihood in the study area, which comprises of mainly poor households. The farming system can be classified as mixed crop and livestock subsistence farming. However, it is still argued that agriculture, especially crop farming, is a common occupation because households lack alternatives due to differences in access to assets that generally exist in societies in developing countries. In the selected Bhekuphiwa and Mgangeni areas of Inanda community, maize, beetroots, beans, spinach, onions, bananas, butternuts, groundnuts, potatoes, tomatoes, carrots and cabbages were common crops grown. Cattle, goats and poultry were reported to be the most important livestock enterprises by more than half of the interviewed households. Rain-fed crop production is reported to involve challenges because the two areas (Bhekuphiwa and Mgangeni) are often hot and dry. Moreover, the shortage of drinking water was reported to be a problem by more than half of the interviewed households, with water being supplied from the municipality with trucks.

Inanda community forest also indirectly assists households by offering opportunities to earn cash or vouchers from the Wildlands project to buy food in the study area. Forest activities that provided sources of income to the study area were classified as forest employment (cutting invasive alien plants with the Wildlands project), seeds exchange with vouchers from the Wildlands project, extraction of NTFPs (firewood, traditional medicine, construction poles, wild spinach, wild fruits, wild honey, and bush meat) for sale or home consumption. Demand for forest products in the study area varies across seasons or the availability of household's assets; for example, demand for fuelwood as energy for cooking is very high for poor households without electricity. Firewood demand for heating is also relatively high in the winter season. Categories of household income sources in the study area include: income from crops, livestock, forests, off-farm employment, vouchers from the Wildlands project, and income from other sources (primarily remittances, pensions, child social grants, and land rentals). The preliminary descriptive results show that the main sources of income in the study area are crop production, pension, child social grants, employment and extraction of forest products.

The major challenges discovered in the Inanda community were poverty, the inability to afford larger land sizes, and less access to land holdings. Low income does not allow members in the community to afford standard housing. Most household earnings in Inanda community are based on government social support grants (old age pension, child-support and disability grants), remittances, working as a daily labourer in the forest, sale of collected NTFPs, and agricultural crop and livestock production. These income sources are usually only sufficient for them to subsist. Comparing study findings in the literature and observations in Inanda community of KwaZulu-Natal reveals similar experiences with the negative impacts of climate change. Additionally, community members perceived changes in weather patterns. Reports of people practicing agriculture and the collection of natural forest products in rural communities of developing countries mention significant shifts in weather patterns affecting their usual ways of farming and other livelihood supporting businesses. They also report changes in species compositions, such as dominant tree species gradually decreasing after frequent disease outbreaks and inadequate succession as a result of poor regeneration. On the other hand, emergence of new invasive species has also been issues of wider concern (IPCC, 2007b, UNFCCC, 2009).

Regarding the adaptation strategies of rural households of Inanda community in response to changes in the forest status that threaten their livelihoods as a result of climate-driven land use changes, households interviewed have mentioned different adaptation strategies. These adaptation strategies include: engaging in home gardening, crop production, starting small businesses (crafting mats, decorations, sewing traditional clothes, crafting traditional jewelleries, and tuck-shops), finding informal employment, switching to other alternative forests, buying forest products elsewhere, using paraffin or electricity and, in some cases, no adaptation strategies at all. Households perceive that the climate is changing and that change is affecting their economic activities and that they need to adapt to sustain their livelihoods.

3.2.2 Data collection instruments

Data were collected over a period of four weeks from Mid-April to Mid-May 2013 using a team of five enumerators who speak the local isiZulu language. The enumerators attended a two-day training session, focusing on the interview and the contents of the questionnaire, before embarking on the field work. Questionnaires were translated into isiZulu before the training sessions and were pre-tested before being administered. During the pre-testing period, a sample of 15 households was randomly interviewed in two selected areas, i.e. 7 and 8 households were interviewed from Bhekuphiwa and Mgangeni, respectively. Questions that were found to overlap during the questionnaire's pre-testing were deleted and others that were ambiguous were modified to ensure clarity. The questionnaire's pre-testing also helped to improve translation of the questionnaire into isiZulu in terms of which crops and forest products to include in the survey questions and to allow the flow of questions. The household in this study represents a sampling unit. The household head interviewed was the person who makes all or most of the farm management and livelihood decisions on activities affecting the welfare of all household members. In their absence, household members responsible for such decisions were interviewed.

The study sites were visited during July and October 2012 to gather general information from community members. The main objective of those visits was to become familiar with the study area and design the subsequent empirical data collection strategies. Several methods were employed to understand the local context, including community assessment, key informant interviews, group discussions and observations. Focus group discussions were held with members of the community to obtain information on specific topics such as population dynamics, forest dependence, institutional issues, etc. Discussions were also held with some key informants (such as the chief, forest manager of the Wildlands project, elders, extension officers, forest invasive plant eradicators, community members and different gender groups) to obtain contextual information relevant to the study, including population dynamics, forest dependence, institutional issues, community level statistics, and forest status over time. Two meetings were set up with the chief and forest officers and discussions focused on demography, administration, infrastructure, occupational structure, socioeconomic issues and how the residents use and perceive the forest resource. The relationship of residents to the forest was also documented. Members of the community expressed their perceptions on climate change which threaten their livelihoods and also discussed how they access and use the forest for their sustainable livelihoods.

Key informant interviews and focus group discussions were conducted to obtain information on issues captured in the survey questionnaire, for further analysis in chapters 5 and 6. Key informants were selected from the community members who were from different social status and forest community projects. A group interview was held with an old villager who has lived in the village since his birth, a teacher, Wildlands project officers, traditional leader, headmen, and community members were chosen and interviewed. The qualitative data collection activities were followed by household surveys using a detailed questionnaire to generate primary data. The information on basic socio-economic household characteristics, such as the relationship between head of the household and household members, age, gender, marital status, employment status and educational level, was collected. The questionnaire also included measures of household socio-economic characteristics like wealth endowments, agricultural production assets, livestock ownership, type of houses, agricultural production activities, and household income sources and amounts (see Appendix A). Questions were also formulated to elicit forest use information from the respondent households. The questionnaire also included perceptions on climate change and its impacts, livelihood strategies and dependence on forest resources, and adaptation strategies when that dependence breaks. Secondary data on mean rainfall and temperature over time were gathered from the Mount-Edgecombe weather station.

3.2.3 Sampling procedures

Sampling is a process of selecting units from a population of interest, so that by studying the sample, the results obtained from the sample may be generalized to the population from which the sample had been chosen (Greene, 2003). According to Fisher (2004), the characteristics obtained from the sample should reflect approximately the same characteristics as the population. Since the data obtained from a sample was generalized to the whole population, the manner in which the sample units were selected was vital. A sample should be representative; therefore, the sample size should be large enough to conduct reliable statistical analyses. According to Gujarati and Porter (2009), in order to get reliable statistics, a sample should have at least 30 units. In this study, two villages (Bhekuphiwa and Mgangeni) were chosen from four areas (Bhekuphiwa, Mgangeni, Ngcukwini and Mbozamo) of Maphephetheni in Inanda community.

The areas were selected after preliminary visits of the entire Inanda Maphephetheni villages (Bhekuphiwa, Mgangeni, Ngcukwini and Mbozamo) to gather information on the dependence of communities on natural forest products. Following the pre-visiting of the above-mentioned areas of Inanda Maphephetheni village, it was found that households in Bhekuphiwa and Mgangeni areas were the ones most dependent on the forest products rather than Ngcukwini and Mbozamo.

This, among other factors, is due to their proximity to the Inanda Forest Mountain. Due to time and distance through Inanda dam, Ngcukwini and Mbozamo areas were likely to depend less on the Inanda Mountain forest products. Hence, these two sites were not considered to form part of this study.

A list of households from the two selected areas was obtained from the traditional leaders, headmen and the ward councillor. From the two selected areas (Bhekuphiwa and Mgangeni) simple random selection was done to obtain a sample of 150 households based on probability proportional to size. The total number of households for the two selected areas was 720, with Bhekuphiwa consisting of 330 households and Mgangeni of 390 households. Based on probability proportional to size, 46% and 54% of the total number of households were interviewed from Bhekuphiwa and Mgangeni, respectively (Table 3.1). This implies that 69 household heads from Bhekuphiwa and 81 from Mgangeni were interviewed to form the targeted sample size of 150 households. More than a 10% proportional sample size was collected for both selected areas. This sample on average represents 21% of the total number of households in the selected areas. Table 3.1 below shows the sample size in the respective areas of Inanda community.

Table 3.1 Sample size in the respective sites of Inanda community, eThekwini Municipality, KwaZulu-Natal

Areas	Mgangeni	Bhekuphiwa	Total
Total number of households	390	330	720
Percentages (%)	54	46	100
Proportional to size (390/720 and 330/720)	0.54	0.46	1
Households interviewed	81	69	150

3.3 The conceptual framework

3.3.1 Linking rural livelihoods to natural forest resources

Livelihood in this study is defined as the range of activities used to generate income for rural households in order improve their economic welfare. To examine how rural livelihoods are linked to the status of natural forest resources and how that link is impacted by changes in the forest driven by factors including climate change in Inanda community of eThekwini metropolitan area, household income generated from the forest products is used as a proxy to measure livelihood. The proxy used for dependence on natural forest resources is the share of household income, or the relative income, that is derived from such natural forest resources. This is in line with common practice in the field (Heubach *et al.*, 2011; Vedeld *et al.*, 2004).

According to Heubach *et al.* (2011), being resource-poor indicates asset and welfare poverty. Rural households in a state of welfare poverty can adopt available coping and livelihood strategies, including forest extraction activities. In this study, sampled household heads were asked to rank their sources of household income in 2012, where one represents the most important. Household income sources in the study area include: income from the extraction of forest products, income from crop production, income from off-farm activities (such as pensions, child support grants, remittances, and disable grants), income from employment (salaries and wages) and other sources of income engaged by household members.

Ostrom (1999) noted an increasing consensus that forest resources could help to alleviate poverty among local community households in developing countries. However, disadvantaged poor people do depend more directly on forest resources than wealthier households, even if the latter often may have a higher total income from such resources. According to Adhikari *et al.* (2004), larger families have a greater demand for natural resources and labour to meet the entire demand. However, it appears that household composition, gender and age structure are more important than mere household size.

Households with more adult labour are in a better position to liquidate communally owned natural stock than households with less or no adult labour. Alternatively, ample adult labour could motivate the household to invest more in agriculture or rural employment that can fetch higher incomes than gathering activities. Cavendish (2000) argued that older people have difficulty carrying out arduous agricultural tasks and may turn to experience-based resource collection activities that demand less physical labour and that are free of entry barriers even though farming needs experience. Therefore, older members of households may manage to use their experiences to more productive agriculture and help in the collection of forest products since most of these products require less power during harvesting.

In male-dominated rural settings, forest-based low-return cash activities are often taken up by female-headed households that cannot make a significant living from agriculture due to the absence of male labour for ploughing. According to Kamanga *et al.* (2009), female-headed households may be more likely to engage in informal activities such as collection of natural forest products. This is because most NTFPs are well-known and collected by women. It was hypothesized that households with more women members have more dependence on NTFPs. Ageing affects dependence on non-timber forest products positively since people lose strength to engage in labour-demanding jobs (Adhikari *et al.*, 2004).

According to Vedeld *et al.* (2004) educational level of the household head influences the collection of forest products and, hence, market participation level. Following the study by Babulo *et al.* (2008), formal education of the household head creates access to greater diversity of income opportunities within the household. Therefore, it was expected that the higher is formal education, the lower the dependence on NTFPs. This was because the opportunity cost of labour is relatively high for more educated household members due to better access to formal employment opportunities.

3.3.2 Coping and adaptive strategies of rural communities

To examine the coping and adaptation strategies of rural households and communities in response to changes in the forest status that threaten their livelihoods as a result of climate-driven land use changes, households interviewed mentioned different adaptation strategies, which include: engaging in home gardening, crop production, starting small businesses (crafting mats, decorations, sewing traditional clothes, crafting traditional jewelleries, and tuck-shops), finding informal employment, switching to other alternative forests, buying forest products elsewhere, using paraffin or electricity and, in some cases, no adaptation strategies at all. Households perceive that climate is changing and that change is affecting their economic activities on the forest status and need to adapt for their sustainable livelihoods. In order to examine livelihood adaptation strategies, the Multinomial Logit (MNL) model was appropriate for the empirical analysis, since there are more than two adaptation strategies reported by households interviewed in the study area. One of the advantages of this Model is that it permits the analysis of decisions across more than two categories, allowing the determination of choice probabilities for different categories.

According to Carter-Hill *et al.* (2008), the MNL provides a convenient closed form for underlying choice probabilities, with no need for multivariate integration, making it simple to compute choice situations characterized by many alternatives. Therefore, in this study adaptation strategies were reported to be more than two and this model is thus appropriate. According to Alam *et al.* (2011), adaptation at the community level refers to the ability to maintain and preferably improve the current living standards in the face of unexpected changes in economic shocks that may affect people's livelihoods. Livelihood adaptation has been defined as the continuous process of changes to livelihoods which either enhance existing security, welfare in terms of income and wealth, or reduce vulnerability and poverty (Ellis, 2000; Bhusal, 2009).

3.3.3 Variables to examine coping and adaptation strategies

Adaptation methods are those strategies that enable the individual or the community to cope with the impacts of climate in the local areas (Fisher *et al.,* 2010; Van Aalst *et al.,* 2008). Studies have shown that livelihood adaptation strategies in response to climate-driven changes depend on the socio-economic characteristics and related environmental aspects (Deressa *et al.,* 2009; Kandlinkar and Risbey, 2000; Nhemachena, 2008). According to Kandlinkar and Risbey (2000), natural capital resource limitations coupled with household characteristics and poor infrastructure limit the ability of most rural households to take up adaptation strategies in response to changes in climate. Table 3.3 below presents the variables that will be considered in this analysis and the expected signs of the estimated coefficients. The theory behind the expected signs is presented in chapter 6, section 6.3.

Table 3.2 Variables used to study household livelihood adaptation strategies, eThekwini Municipality, KwaZulu-Natal

Variable	Explanation	Expected sign
Livelihood adaptation strategies	Livelihood adaptation strategy out of the forest sector	
	No livelihood adaptation strategy	
	Livelihood adaptation strategy seeking alternative forests or substitute forest products	
AGE	Age of the household head (years)	+/-
GENDER	Dummy: 1 if household head is male and 0 otherwise	+
EDUC	Dummy: 1 if household head went to school (educated) and 0 otherwise	+
ABOVE15	The number of household adult members living together for six months (Proxy to measure the available labour resources)	+
INCABVE	Dummy: 1 if households have total household income above mean income and 0 otherwise	+
MARKET	Dummy: 1 if household head has access to market and 0 otherwise	+
ASSTS_V	Average values of productive assets owned by household head (Rand)	+
LAND_OWND	Total land owned by household head (in hectares)	+
RAINFALL	Dummy: 1 if household head has perceived changes in rainfall in the last 30 years and 0 otherwise	+
TEMPERATURE	Dummy: 1 if household head has perceived changes in temperature in the last 30 years and 0 otherwise	+

3.4 Empirical models

3.4.1 Logit transformed OLS regression to examine the link between rural livelihoods and natural forest resources

Ordinary Least Squares (OLS) regression can be used to estimate the parameters of an equation showing the proportion of forest income (share of total household income contributed by forest extraction) to total household income as a dependent variable. However, for a proportion-dependent variable ranging between zero and one, the classical OLS is inappropriate because the prediction can be beyond the zero-one limits (Papke and Wooldridge, 1993, Wale, 2010). For this reason, this study adopted a logit transformation procedure that has been used, for example, by Wale (2010) and Sharaunga and Wale (2013). It was a model of choice assumed to be a linear function of socio-economic and institutional explanatory variables. The model is used to empirically examine the dependence of rural livelihoods on Non-Timber Forest Products (NTFPs). The dependent variable is the natural log of the transformed proportion variable. The independent variables are described in Table 3.2, with the expected signs presented based on past literature and economic theory. After OLS, Stata's 'protab' option was used to predict the effect of significant variables on the proportions.

Total forest income (TFI) is summation of both cash and subsistence returns from forest products. Relative forest income (RFI) is a measure of the share of income obtained from consumption or sale of forest products in total household income (TI). This is derived as:

RFI =TFI/TI……………………………………………………………………. (1)

The proportion of forest income to total household income (RFI) was transformed as below:

$$\text{Trans RFI} = \ln\left[\frac{\text{RFI}}{1-\text{RFI}}\right]$$

The model is specified in general form as:

$$\text{Trans RFI} = \beta_0 + \beta_1X_1 + \ldots + \beta_nX_n + U_t \ldots \quad (2)$$

Where;

Trans RFI = dependent variable representing the transformed relative forest income – the share of total household income contributed by forest extraction

β_1............ β_n = coefficients (marginal effects)

X_1……… X_n= explanatory variables

U_t = *error* term

Table 3.2 below summarizes the variables considered in this study and the expected signs of their estimated coefficients. The theory behind the expected signs is presented in chapter 5, section 5.3.

Table 3.3 Variables used to study the link between rural livelihoods and the status of natural forest resources, eThekwini Municipality, KwaZulu-Natal

Variable	**Explanation**	**Expected sign**
Dependent variable		
TRANS_SHR	Transformed proportion of forest income to total household income generated from NTFPs (Rand)	
Explanatory variables		
GENDER	Dummy: 1 if household head is male and 0 otherwise	-
MARIT	Dummy: 1 if household head is married and 0 otherwise	+
EDUC	Dummy:1 if household head went to school (educated) and 0 otherwise	-
LABOURF	The number of household members living together for six months (continuous) (Proxy to measure the available labour resources)	+
DPNDT_RATIO	Members who depend solely on forest income but excluded in the collection of the natural resources and economic activities (continuous)	-
EMPLYINC	The level of employment income generated by household head (Rand) (categorical)	-
FARMINC	The level of farm income generated by household head (Rand) (categorical)	-
UNEARINC	The level of income generated by household head from any of these sources: old age pension grant, child support grants, disability grants, and remittances (Rand) (categorical)	-
NMBERINC	Number of income sources of household head	-
VOUCHER	The value of voucher received by household head (Rand)	+
ACC_LAND	Dummy: 1 if household head has access to land and 0 otherwise	-
DISTANCE	The walking distance from household to the forest, measured as time taken to get to the forest (in minutes)	-
ACC_MRKT	Dummy:1 if household head has access to market and 0 otherwise	+
ASSTS_V	Average value of productive assets owned by household head (Rand)	-
LVSTCK_V	Average values of livestock owned by household head (Rand)	-
CHNG_VST	Dummy: 1 if household head changes visiting dates and time to the forest and 0 otherwise	-
RAINFALL	Dummy: 1 if household head has perceived changes in rainfall in the last 30 years and 0 otherwise	-
TEMPERATURE	Dummy: 1 if household head has perceived changes in temperature in the last 30 years and 0 otherwise	-

3.4.2 Multinomial Logit Model (MNL) to examine the coping and adaptive strategies of rural communities

To examine the coping and adaptation strategies of rural households and communities in response to changes in the forest status as a result of climate-driven land use changes, households interviewed have mentioned different adaptation strategies. The MNL model was used to estimate the livelihood adaptation strategy of households since the response variable had multiple (more than two) categories. The dependent variable was the livelihood adaptation strategies (1 = livelihood adaptation strategy out of the forest sector, 2 = no livelihood adaptation strategy, and 3 = livelihood adaptation strategy seeking alternative forests or substitute forest products). The livelihood adaptation strategy seeking alternative forest or substitute forest products was clustered based on the sector adaptive strategies reported by sampled households which include: the use of paraffin or electricity, buying forest products elsewhere, getting forest products from alternative forests and changing forest time and date visits.

A livelihood adaptation strategy out of the forest sector was also clustered and included: starting household small businesses (i.e. sewing traditional clothes and jewelleries, crafting mats, decorations enterprise and tuck-shop selling snacks, selling airtimes, breads etc.), finding informal employment, home gardening, crop and livestock production. In this study, this category (livelihood adaptation strategy out of the forest sector) was chosen as the reference category. According to Gujarati and Porter (2009) and Maddala (1983), the reference category is usually the one that makes most sense and which is of most interest to the researcher. The livelihood adaptation strategy out of the forest sector is a category of interest because adaptation to it is the core of the study. Choosing this as the reference category allowed comparison with those households adapting with the other sectors and those not adapting at all.

Letting P_j (j=1, 2, 3) to be the probabilities of a household being in each adaptation strategy and assuming that (j=1) is the reference category, the MNL showing the relative probabilities of being in the three adaptation strategies as a linear function of X_k for the i^{th} household, according to Greene (2003), is estimated as:

$$\ln(P_j/P_1) = \beta_{0j} + \beta_{1j}X_{1i} + \ldots + \beta_{kj} X_{ki} + U_{ij} \quad \text{...} \ (2)$$

For j = 2, 3 and i = 1, 2…n households where:

- ✓ ln= natural logarithm
- ✓ P_1 = the probability of a household being in the reference category (adapting with economic activities out of the forest sector)
- ✓ P_2 = the probability that a household is not adapting to any livelihood strategy
- ✓ P_3 = the probability that a household is adapting by seeking alternative forests or substitute forest products)
- ✓ $\beta_1 \ldots \beta_{kj}$ are MNL coefficients to be estimated and,
- ✓ $X_1 \ldots X_{ki}$ are the K^{th} explanatory variables describing the i^{th} household.
- ✓ U_{ij} = error term

Following Carter-Hill *et al.* (2008), the conditional probability of the i^{th} household being in the three alternative categories (j=1,2 or 3) are estimated by equations (3) to (5) as a function of the estimated β_{kj} and X_{ki} as

$$P(j=1) = \frac{1}{1+\exp(\beta_{02}+\beta_{12}X_{1i}+\cdots+\beta_{k2}X_{ki})+\exp(\beta_{03}+\beta_{13}X_{1i}+\cdots+\beta_{k3}X_{ki})} \quad (3)$$

$$P(j=2) = \frac{\exp(\beta_{02}+\beta_{12}X_{1i}+\cdots+\beta_{k2}X_{ki})}{1+\exp(\beta_{02}+\beta_{12}X_{1i}+\cdots+\beta_{k2}X_{ki})+\exp(\beta_{03}+\beta_{13}X_{1i}+\cdots+\beta_{k3}X_{ki})} \quad (4)$$

$$P(j=3) = \frac{\exp(\beta_{03}+\beta_{13}X1i+\cdots+\beta_{k3}X_{ki})}{1+\exp(\beta_{02}+\beta_{12}X_{1i}+\cdots+\beta_{k2}X_{ki})+\exp(\beta_{03}+\beta_{13}X_{1i}+\cdots+\beta_{k3}X_{ki})} \quad (5)$$

It is hypothesized in the MNL that the choice of the coping and livelihood adaptation strategy is a function of household characteristics (X_s) and engagement in particular forest, economic and agricultural activities. The household characteristics can be interpreted as age, gender, and educational level of household head, total household income, capital asset endowments and contextual factors.

However, unbiased and consistent parameter estimates of the MNL model in Equations (3) to (5) require the assumption of independence of irrelevant alternatives (IIA) to hold. More specifically, the IIA assumption requires that the probability of using a certain livelihood adaptation strategy by a given household needs to be independent from the probability of choosing another livelihood adaptation strategy (that is, P_j/P_k is independent of the remaining probabilities). This assumption requires that the inclusion or exclusion of any category (e.g., no adaptation strategy) does not affect the relative risks associated with the regressors in the remaining categories (adapting by seeking alternative forests or substitute forest products and out of the forest sector). The Hausman test (Hausman and McFadden, 1984) was performed to check whether or not the IIA assumption was violated in this study. The process involves estimating a full model that includes all j categories and a restricted model where one category is eliminated.

The parameter estimates of the MNL model provide only the direction of the effect of the independent variables on the dependent (response) variable; i.e. estimates do not represent either the actual magnitude of change nor probabilities. Differentiating Equation (3) to (5) with respect to the explanatory variables provides marginal effects of the explanatory variables, given as:

$$\frac{\partial P_J}{\partial X_K} = P_J\left(\beta_{JK} - \sum_{J=1}^{J} P_K \beta_{JK}\right) \quad (6)$$

The marginal effects or marginal probabilities are functions of the probability itself and measure the expected change in probability of a particular choice being made with respect to a unit change in an independent variable from the mean (Green, 2000). Data collected from Maphephetheni village (Bhekuphiwa and Mgangeni area) of Inanda community of KwaZulu-Natal were analyzed using both IBM (SPSS) statistical package (version 21) and STATA version 11. To analyze data, descriptive, a logit transformed OLS and multinomial logistic regression models were used. The main descriptive indicators that are employed are frequencies, t-tests, chi-squared tests, standard deviation and mean values. These are useful in analyzing household characteristics. Testing the significance of a logit transformed OLS regression model was done using the F-statistic and the R^2 measures of fit. The goodness-of-fit of the MNL model was assessed with Deviance χ^2 and Pearson χ^2. The Wald χ^2 statistic was used to assess the likelihood ratio statistics. The model classification accuracy was analyzed using IBM SPSS 21 software package. The OLS was used to test for heteroscedasticity, multicollinearity and correlation matrix coefficients. In this study, multicollinearity was checked by examining variance inflation factors (VIFs) using STATA version 11. Heteroscedasticity in the OLS regression model was tested using the Breusch-Pagan/Cook-Weisberg test (Gujarati and Porter, 2009). The next chapter presents the descriptive statistics of the sampled households.

CHAPTER 4. DESCRIPTIVE RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter descriptively analyses and discusses the results of the field survey that was carried in Inanda community over a period of four weeks from Mid-April to Mid-May 2013. The data were collected from 150 households adjacent to the forest who are involved in the collection of forest products and agricultural production. The chapter begins with brief explanations of data collection instruments (such as key informant interviews, group discussions, and participant observation) and the demographic characteristics of the sampled households. This is followed by an overview of households' assets ownership and perceived changes in climate change components (rainfall and temperature). It then presents socio-economic characteristics of households, giving special attention to aspects related to the collection of forest products and agricultural production and factors (such as climate-driven changes) influencing them.

4.2 Key informant interviews, group discussion and participant observation

The key information interview was vital to obtain critical information such as history of the community in terms of their economic activities, traditional livelihood strategies, and informal and formal issues in relation to the collection of forest products within the community. Establishing a good relationship with the community members was necessary to make the local people willingly express their ideas and knowledge about their lifestyle. Key information interview was useful to gather information on community level statistics in terms of population and the number of homestead in the study area. This was also useful as it gave a light and better understanding on sampling procedures such as sample size and questionnaire design.

The group discussion method was used to gather information from different groups within the study area. Discussions were held with the chief (traditional leaders), community members and Wildlands project officers to seek information about community development, their responsibilities and their perspectives on natural forest products and agricultural production. Group discussions were also held with the community members to understand the institutional setting (such as formal and informal rules used by traditional leaders to regulate the community), economic activities and climate change knowledge and perceptions. In addition, information on peoples' access to the forest and use of forest products was obtained. This approach enhanced understanding of the community, and members' livelihood strategies and perceptions of natural forest products and climate change. Participant observation was used to explore and facilitate the on-going development activities of the project such as questionnaire design and data collection procedures (e.g. a figure of total sampled households). This provided a better understanding of the geography of the study area. The community forest was visited with Wildlands project officers and community members to observe the type of forest products available in the forest. The most important results of the group discussions and participant observation were that natural forest products and agricultural production (crop cultivation and livestock) were the main source of livelihoods. The details on the outcomes of the discussions are reported below.

4.3 Description of the survey data

4.3.1 Socio-economic characteristics

The results presented in Table 4.1 below show that nearly all sampled households collect fuelwood (97%), followed by construction poles (62%) and traditional medicinal herbs (42%). This implies that most sampled households in the study area depend on forest resources for their daily livelihoods. Non-timber forest products such as mushrooms, wild fruits, and wild spinaches are also important. Sampled households reported that firewood is the main source for cooking and construction poles for building houses, while some sampled households reported they collect NTFPs to supplement their income to use for food purchases. According to sampled households, most forest products are labour intensive; this implies that households with a large number of active household members would probably not have major constraints in the collection of forest products. It was reported by most sample households and during group discussions that traditional medicinal plants are occasionally collected and most are sold by a 64 year-old woman in the study area. These plants are generally still common in the community forest. However, several people are concerned that these medicinal plants will be harder to find due to climate-driven impacts and forest degradation. Table 4.1 below summarizes the types of forest products collected by sampled households.

Table 4.1 Forest product types collected by sampled households, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Forest product types	Frequency	Percentage (%)
Fuelwood	146	97
Construction poles	96	64
Traditional medicinal herbs	62	42
Mushrooms	30	20
Wild fruits	44	29
Wild spinaches	51	34
Honey	3	2
Hunting	2	1

Source: Survey data (Mid-April to Mid-May 2013)

However, the extractions of natural forest products depend on the availability of socio-economic characteristics such as age, gender, employment status, educational level and asset-based endowments within rural households. Therefore, the results of these factors with respect to the collection of natural forest products are presented. Figure 4.1 below shows the distribution of educational level and forest product types.

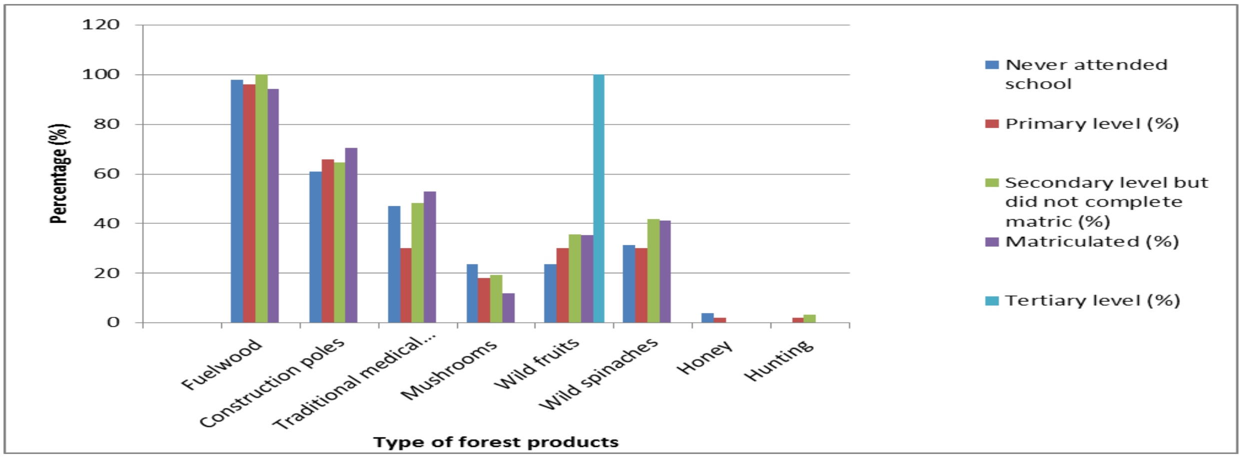

Figure 4.1 Educational level distributions among sampled household heads and forest product types, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

Most of the sampled household heads never attended school. The results show that, irrespective of educational level, 90% of sampled household heads collect fuelwood from the community forest. About 60% of sampled households collect construction poles, and about 53% of sampled household heads collect traditional medical plants. Less than 50% of sampled households collect wild spinaches, bush meat and honey irrespective of whether they are educated or not. Figure 4.2 below shows the employment status of the household heads.

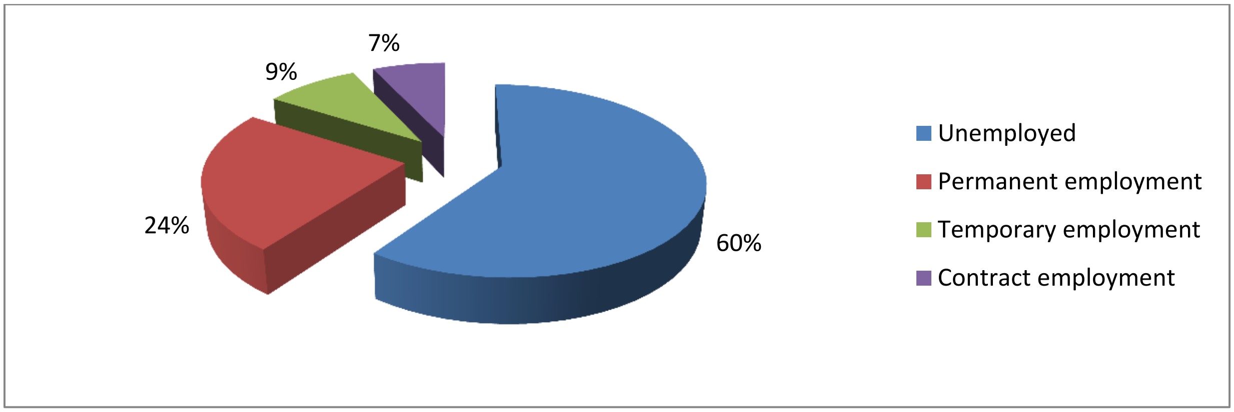

Figure 4.2 Employment status of the sampled household heads, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

The employment status of household heads was recorded to determine the impact of this variable on the collection of forest products and related economic activities for sustainable livelihoods. Household heads working far from their homesteads are likely to engage less in the collection of forest products compared to unemployed ones. Figure 4.2 shows that about 60% of the sampled household heads are unemployed, 24% are permanent workers, 9% are temporary workers, and 7% are contract workers. The relatively high proportion of unemployed household heads gives an indication of the time available for the collection of natural forest products, reflecting low opportunity cost of rural unskilled labour. Figure 4.3 presents the relationship between gender of household heads and forest products.

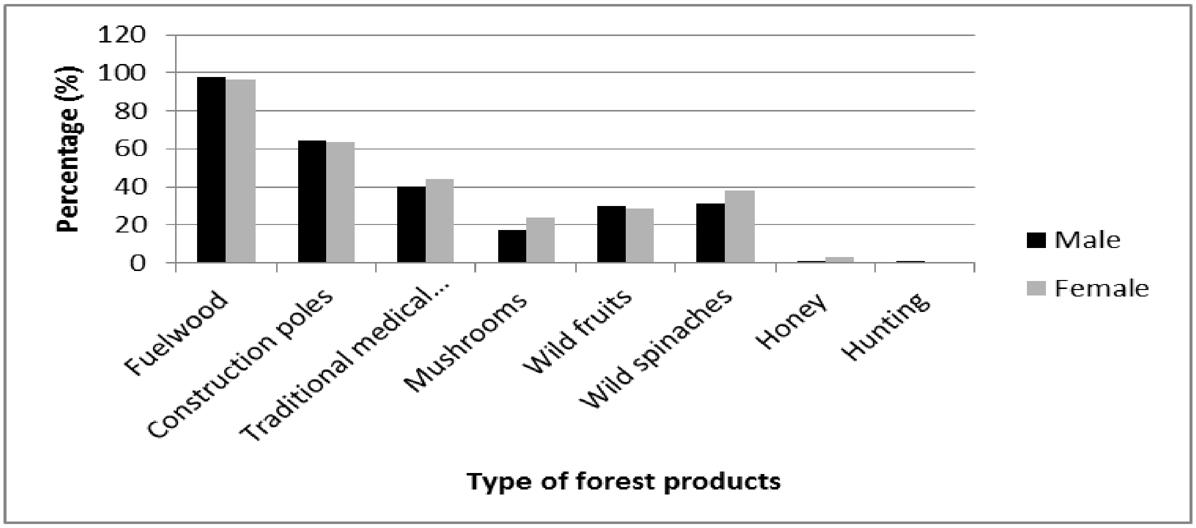

Figure 4.3 Forest product collection disaggregated by gender, eThekwini Municipality, 2013 (n=150), eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

Figure 4.3 shows that there are a large proportion of sampled households collecting fuelwood, with 98% and 97% for male-headed and female-headed households, respectively. This suggests that both male-headed and female-headed households in the study area are highly dependent on fuelwood for their daily livelihoods. About 56% male-headed and 40% female-headed households collect construction poles, and about 44% of female-headed households and 40% of male-headed collect traditional medicinal herbs.

4.3.2 Households endowments

The greatest area of land size owned by sampled household heads in Inanda community was 6 ha with a standard deviation of 1.08 ha. The average area land owned by household heads in the study area was 0.94 ha. Population of Inanda community has increased in the last decade. Overall population of the Inanda community was estimated at 17 000 people in 2011, constituting 2300 homesteads, implying an average of 9 people per household. The average proxy of labour resources is 7 members. With regard to an increased population, new settlers are requested to pay a total amount of R700 to the chief (induna) and king to acquire land. Land for commercial agriculture in Inanda community so far is limited. Household heads are required to get the land size of 2ha per homestead which will cover the land for agricultural production. This implies that community members access small plots for agricultural production. So far, there is no ‘’tragedy of the commons’’ (Hardin, 1968) to the community forest. There are no communal arrangements that exclude or limit access to non-community members and regulate the use among the community users. However, one would expect complete degradation of the forest due to the “tragedy of the open access” outcome. In this connection, there are reasons for the existence of the forest, mainly due to informal rules or sanctions that implicitly prohibit community members from destructive use of the forest. For example, it is illegal for community members to burn the community forest for individual benefits.

Sampled households own cattle, poultry and goats. The mean value of livestock per household was R8.958, while the mean productive assets value (such as hoe, tractor and fork) reported by sampled households at market price was R894.63. Some households did not collect any items from the forest, despite having physical access. They instead bought forest products from those that had collected. This is due to other income opportunities, and the opportunity cost of harvesting resources was high for them. The income sources were categorized since respondents were not sure how much they receive per month or were not eager to reveal the exact income amount. The sources of incomes involved are farm (crop and livestock production), non-farm income, and employment income (temporary, contract and permanent). Non-farm incomes include old age pension grants, child support grants, and remittances from relatives and migrants. Forest incomes were the summation of all forest products sold in 2012.

Table 4.2 shows that 56% of sampled households generated income from forest products. The average contribution of forest resources to the total income of the sampled households in Inanda community was 26%. The average amount of vouchers from the ‘Wildlands project’ pays in exchange for planting trees of the sampled households in Inanda community was R125. However, others reported that they just started whilst others not to be aware about the barter exchanging activities. Table 4.2 below summarizes the income sources of sampled households.

Table 4.2 Household sources of income, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Income sources	Received or not	Frequency	Percentage (%)
Farm income	Received	42	28
	Not received	108	72
Forest income	Received	84	56
	Not received	66	44
Remittances	Received	14	9.3
	Not received	136	90.7
Old age pensions	Received	68	45.3
	Not received	82	54.7
Child-support grants	Received	107	71.3
	Not received	43	28.7
Employment income	Received	111	74
	Not received	39	26
Other sources of income	Received	20	13.3
	Not received	130	86.7

Source: Survey data (Mid-April to Mid-May 2013)

Employment incomes and child-support grants were the most important non-agricultural income sources for over 70% of the respondents. However, Table 4.2 showed farm income (28%), old age pensions (45.3%), other sources of income (13.3%) and remittances (9.3%) as important sources of income.

4.3.3 Perceived changes in the extraction of non-timber forest products

Figure 4.4 below summarizes the sampled households' perceptions of non-timber forest products over the last three years.

Figure 4.4 shows that most of the sampled households perceive that non-timber forest products are decreasing over time. To get this information, households were asked if they had observed or noticed any change (increased, decreased, or constant) on non-timber forest products over the past 30 years. About 75%, 23%, and10% of sampled household's perceived fuelwood as decreasing, remaining the same and increasing, respectively.

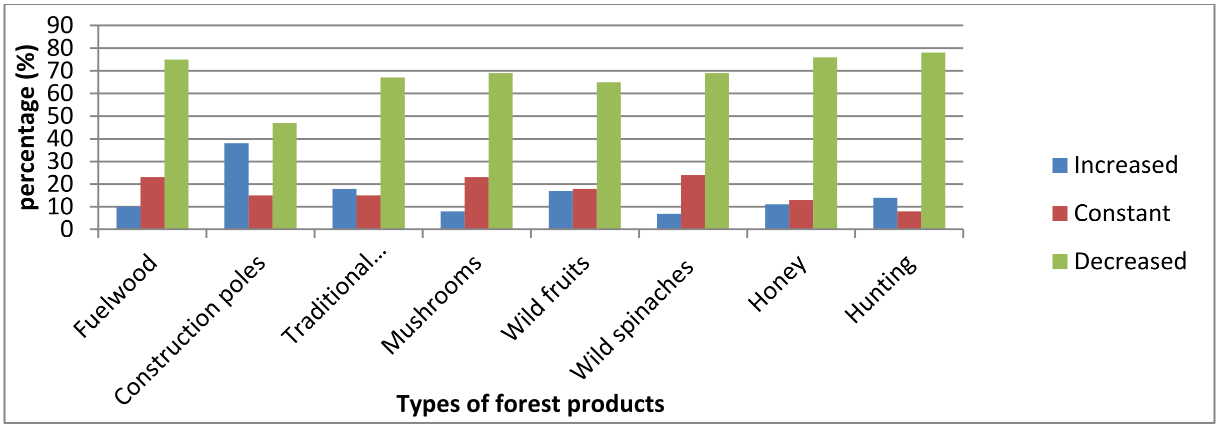

Figure 4.4 Sampled households' perceptions of non-timber forest products, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

Similarly, 69%, 23% and 8% perceived mushrooms as decreasing, remaining the same and increasing, respectively. However, more than one- third (38%) of sampled households perceived construction poles as increasing. More than 75% of sampled households perceived honey and hunting (bushmeat) as decreasing.

4.3.4 Rural households' perceptions of climate change over the last 30 years

Figure 4.5 below summarizes the sampled households' perceptions of climate change. It shows that most of the sampled households in this study are aware of the fact that both temperature and rainfall are increasing. To get information on their perceptions of climate change, households were asked if they had observed or noticed any change in temperature or the amount of rainfall over the past 30 years. To clarify this, sampled households were also asked whether the number of hot or rainy days had increased, decreased, or stayed the same over the past 30 years. The responses from the sampled households are in line with the report by the South African Weather Service (Mount-Edgecombe weather station), which depicted an increasing temperature level and disagreed with the response about rainfall, which showed a declining pattern.

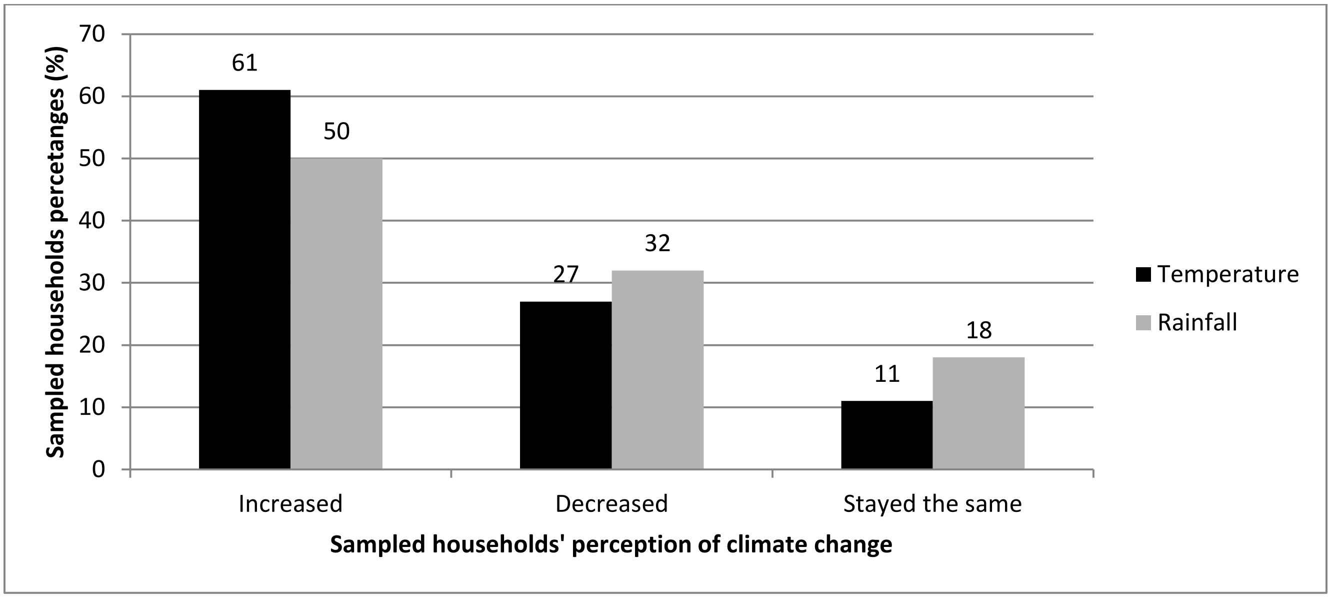

Figure 4.5 Sampled household's perceptions of climate change, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

About 61%, 27%, and 11% of sampled household's perceived temperature as increasing, decreasing and remaining the same, respectively. Similarly, 50%, 32% and 18% perceived annual rainfall as increasing, declining and remaining the same, respectively. Overall, increased temperature and rainfall are the predominant perceptions in the study area. In response to long-term perceived changes, rural households have to undertake a number of livelihood adaptation strategies. Sampled households reported epidemics of diarrhoea, fever and cholera in the area which they think is caused by climate change. These illnesses in the summer season show an increasing trend in the community due to rise in temperature, low sanitation level and poor housing conditions. However, in the winter season it is expected that influenza would be more prevalent among children and older people as winter is harsh near the Inanda dam and insufficient warm clothes are available in the households.

4.3.5 Livelihood adaptation strategies

The coping and livelihood adaptation strategies in response to climate change were clustered into three diversified groups (Table 4.3). Cluster 1, representing a livelihood adaptation strategy out of the forest sector, is the largest of the three livelihood adaptation strategies, representing 66% of the total sample of households. One-third of the sampled households indicated that they would adapt by starting small businesses. This is because most sampled households reported a lack of access to information, poor infrastructure, land and productive assets to take up agricultural production as an economic activity. These small businesses include sewing traditional clothes and jewelleries, crafting mats and decorations, and managing a tuck-shop selling snacks, airtime and breads. Nearly 15% of the sampled households would engage in crop and livestock production followed by finding informal employment and home gardening with 11.3% and 6.7%, respectively. Table 4.3 below shows the dominant livelihood adaptation strategies of sampled households.

Table 4.3 Dominant livelihood adaptation strategies, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Cluster	**Livelihood adaptation strategies**	**Frequency**	**Percentage (%)**	**Total**	
				Frequency	**Percentage (%)**
Cluster 1	**Livelihood adaptation strategy out of the forest sector**			99	66
Starting small businesses		50	33.33		
Crop and livestock production		22	14.67		
Home gardening		10	6.67		
Finding informal employment		17	11.33		
Cluster 2	**No livelihood adaptation strategy**	16	10.67	16	10.67
Cluster 3	**Livelihood adaptation strategy seeking alternative forest or substitute forest products**			35	23.33
Buying forest products		13	8.67		
Getting forest products from alternative forest		7	4.67		
Use of paraffin		3	2		
Use of electricity		5	3.33		
Changing forest time and date visits		7	4.67		

Source: Survey data (Mid-April to Mid-May 2013)

Cluster 2, representing no livelihood adaptation strategy, is the smallest cluster with only 10.7% of the sample households. Cluster 3, representing the livelihood adaptation strategy seeking alternative forest or substitute forest products (23.3%) comprises of buying forest products, getting forest products from alternative forests, use of paraffin, use of electricity and changing forest time and date visits (see Table 4.3). However, rural households might be constrained by socio-economic factors (such as age, income, educational level and lack of agricultural inputs) in adapting to climate change. These constraints are the subjects of the following section.

4.3.6 Barriers in adapting to new livelihood adaptation strategies

Figure 4.6 below shows barriers in adapting to new livelihood adaptation strategies. The results presented in Figure 4.6 below shows barriers (constraints) of adapting in response to climate change reported by sampled households. The five major constraints include lack of information and lack of access to agricultural inputs (seeds, water, and fertilizers), lack of finance, shortage of labour, shortage of land, and poor infrastructure.

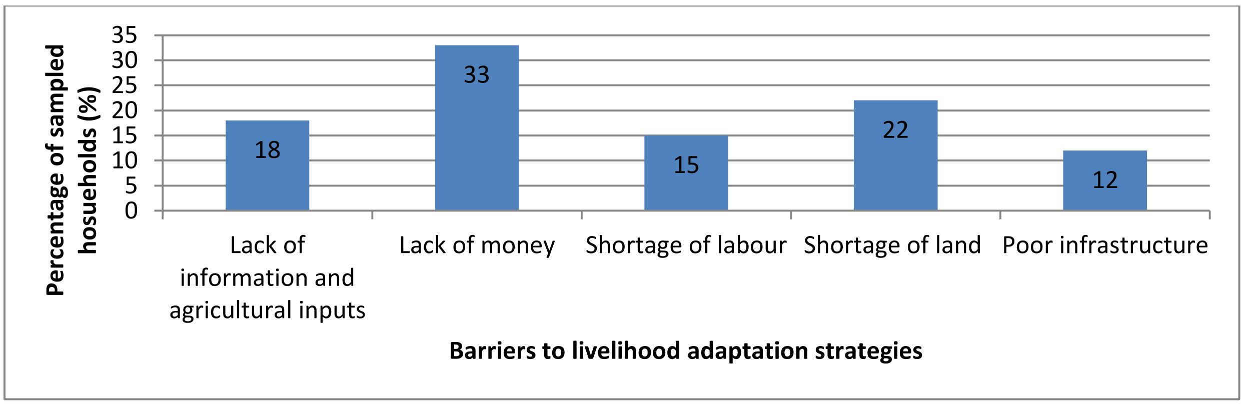

Figure 4.6 Barriers in adapting to new economic activities, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Source: Survey data (Mid-April to Mid-May 2013)

Most of these constraints are associated with poverty. For instance, lack of information on appropriate adaptation options could be attributed to the lack of research on climate change and adaptation options in the study area. Lack of money hinders rural households from getting the necessary resources and technologies that facilitate adapting to climate change and to enhance better welfare outcomes. Rural households in Inanda community are very poor and cannot afford to invest in irrigation technology and purchase productive assets to adapt to climate change or sustain their livelihoods during harsh climatic extremes, such as drought. Figure 4.8 shows that 33% of the sampled households reported to be constrained by lack of financial resources to adapt to climate change. Shortage of land has been associated with high population pressure, with 22%

of sampled households reporting this as a constraint. Poor infrastructure, shortage of labour and lack of information and lack of access to agricultural inputs were constraints indicated by 12%, 15% and 18% of sampled households, respectively. Table 4.4 below shows the independence of categorical variables that were used in the empirical model to explain their effects on the dependent variable using chi-squared tests. The chi-squared test of independence of categorical variables is used to determine whether the effects of one variable depend on the value of another variable. In this study, it was used to test if the choice of livelihood adaptation strategy of each household depended on household head's gender, educational level, access to market and household income above total average income.

Table 4.4 Categorical variables description, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable definition	**Categories**	**Livelihood adaptation strategies**			**Chi-squared (χ^2) test**
		Livelihood adaptation strategy out of the forest sector (n=99)	**No livelihood adaptation strategy (n=16)**	**Livelihood adaptation strategy seeking alternative forest or substitute forest products (n=35)**	
Gender of the household head	0= female 1= male	40 (40%) 59 (59.6%)	7 (43.8%) 9 (56.3%)	16 (45.7%) 19 (54.3%)	0.851
Educational level of the household head	0=illiterate 1=literate continuous variable made dummy	65 (65.7%) 34 (34.3%)	10 (62.5%) 6 (37.5%)	25 (71.4%) 10 (28.6%)	0.768
Access to market	0= no 1=yes continuous variable made dummy	26 (26.3%) 73 (73.7%)	6 (37.5%) 10 (62.5%)	9 (25.7%) 26 (74.3%)	0.626
Household income above total average income	Below average Above average continuous variable made dummy	47 (47.5%) 52 (52.5%)	8 (50%) 8 (50%)	24 (68.6%) 11 (31.4%)	0.097*

Source: Survey data (Mid-April to Mid-May 2013)

Notes:* means statistically significant at the 10% level

Table 4.4 shows the results of the chi-squared (χ^2) test. The statistically significant chi-square value of household income above total average income negatively influenced household livelihood adaptation strategies. A larger proportion of sampled households adapting out of the forest sector (52.5%) were above total average income compared to those that will adapt by seeking alternative forest or substitute forest products (31.4%) and those that will not adapt at all (50%). A larger proportion of respondents adapting by seeking alternative forest or substitute forest products (68.6%) were below total average income compared to those that will adapt out of the forest sector (47.5%) and those that will not adapt at all (50%). The results presented in Table 4.4 also indicate that there were no significant differences between household head's gender, educational level, and access to market. Since sampled households are from Inanda community, it is expected that their socio-economic characteristics do not vary significantly. Table 4.5 below shows the independence of continuous variables that were used in the empirical model to explain their effects on the dependent variable using t statistics.

Table 4.5 Continuous variables description, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable definition	**Mean**	**Standard. Deviation**	**T-test (Sig. 2-tailed)**
Age of the household head	54.84	12.99	51.71***
Value of productive assets	894.63	816.61	1.34
Adult members above 15 years	4.81	1.96	18.61***
Land owned by household head	0.94	1.08	10.72***
Rainfall	0.77	0.37	25.23***
Temperature	0.58	0.30	23.56***

Source: Survey data (Mid-April to Mid-May 2013)
Notes: *** means statistically significant at the 1% level

The t-test results, presented in Table 4.5, indicate that there were strongly significant mean differences between household head's age, household size, land owned and perceived average rainfall and temperature. The statistically significant t-test value of household head's age, adult members above 15 years, land owned and perceived average rainfall and temperature influenced the choice of coping and household livelihood adaptation strategies. However, assets value does not influence the choice of coping and livelihood adaptation strategy in the study area.

4.4 Summary

This chapter presented the descriptive results for the socio-economic factors, household endowments and perceptions of climate change in relation to the collection of the types of natural forest products and the coping and livelihood adaptation strategies in Inanda community. The gender distribution results of the sampled household heads show that males outnumber females. Both male and female household heads collect forest products and practise different farm enterprises (such as cattle and crop farming). The average age of the household heads and household size in Inanda community is 55 years and 9 members. The analyses also showed that a larger proportion of construction poles harvested are by male-headed opposed to female-headed households. Most of the sampled households perceived that climate is changing and that both temperature and rainfall are increasing. Most of the sampled households in this study are aware of the fact that non-timber forest products are decreasing over time. However, knowledge about climate change in the study area is still limited among other sampled households.

A livelihood adaptation strategy out of the forest sector was the largest of the three clustered livelihood adaptation strategies, representing 66% of the total sample of households. One-third of the sampled households indicated that they would adapt by starting small businesses. A livelihood adaptation strategy seeking alternative forests or substitute forest products and no livelihood adaptation strategy constituted 34% of sampled households. The analysis also indicated five major constraints to adaptation in Inanda community of KwaZulu-Natal. These are lack of information and lack of access to agricultural inputs (such as seeds, water, and fertilizers), lack of finance, shortage of labour, shortage of land and poor infrastructure. Most of these constraints are associated with the prevailing poverty in the study areas. The next chapter presents the empirical results on rural livelihoods and forest resources of the sampled households.

CHAPTER 5. EMPIRICAL MODEL RESULTS ON RURAL LIVELIHOODS AND FOREST RESOURCES

5.1 Introduction

The previous chapter presented the description of the data. This chapter will provide empirical results and discussion of the dependence of rural livelihoods on Non-Timber Forest Products (NTFPs). The main purpose is to present the empirical results that address the link between rural livelihoods and forest resources. The results of the transformed-logit model are presented and discussed. Within the chapter, the significance of the coefficients of the independent variables were tested for their significance and conclusions were drawn. The chapter commences with the specification of the empirical model, where the explanatory variables are presented. These variables are then defined, giving their anticipated signs and how each of them was captured.

The model developed in chapter 3 explains the relationship between dependence on NTFPs (given as the relative share of income from forest products, the dependent variable) and socio-economic characteristics, perceived climate change components (such as rainfall, temperature, wind, drought, and floods) and assets-based endowments, the explanatory variables. The predicted relationship between the dependent variable and the explanatory variables was shown in chapter 3 (Table 3.1).

The empirical model can be presented as:

$$TRANS\_SHR = \beta_0 + \beta_1 MARIT + \beta_2 GEND\_R + \beta_3 EDUC + \beta_4 EMPLY\_INC + \beta_5 FARMINC + \beta_6 UNEARDINC + \beta_7 NMBERINC + \beta_8 VOUCHER + \beta_9 LABOURF + \beta_{10} DPNDNT\_RARIO + \beta_{11} DISTANCE + \beta_{12} ACC\_LAND + \beta_{13} ACC\_MRKT + \beta_{14} ASSTS\_V + \beta_{15} LVSTCK\_V + \beta_{16} CHNG\_VST + \beta_{17} RAINFA\_LL + \beta_{18} TEMPERATURE + U_t \quad (1)$$

The long-term contribution of forests to the livelihoods of the rural poor has been long appreciated (Shaanker, *et al.,* 2004; Mamo *et al.,* 2007; Kamanga *et al.,* 2008; Soltani *et al.,* 2012). Forest products (such as firewood, construction materials, grass fodder, *etc*.) play an important role in generating income for the household and improving people's standard of living (Mutenje *et al.,* 2011; Rist *et al.,* 2012). However, the contribution of non-timber forest products (NTFPs) (particularly firewood) to income generation is not often substantial though they are important as complements to other income sources (Kamanga *et al.,* 2008; Mamo *et al.,* 2007). The opportunity to gather open access resources (such as NTFPs) and convert them into marketable products needs a source of income and safety net for rural households in developing countries (Arnold, 2000). The results by Mulenga et al. (2012) in Zambia indicated that NTFPs contribute 34% of total household income for participating households. It was, therefore, evident that rural households will continue to rely on NTFPs for many years to come. Since NTFPs seem to play an important part in supporting rural household livelihoods, rural residents should be made to understand that the continued availability of NTFPs depends largely on the integrity of the forests. NTFPs can, therefore, act as incentives for more sustainable use of forest resources (Soltani *et al.,* 2012).

Forest resources play different roles in the livelihood strategies of each type of user, ranging from being a substantial source of food, materials, medicines and equipment in relatively undisturbed forest conditions, to sources of supplementary products in situations where alternative livelihood options are available (Mamo *et al.,* 2007). However, forest-based dependent societies as well as other rural livelihoods are undergoing rapid changes due to climate-driven changes (Soltani *et al.,* 2012). Several studies have been conducted worldwide, particularly in developing countries, to examine the economic contribution of natural forest resources and the importance of common natural resource management to rural communities adjacent to the forests (Adhikari *et al.,* 2004; Vedeld *et al.,* 2004; Jumbe and Angelsen, 2007; Mamo *et al.,* 2007; Narain *et al*, 2008; Behera, 2009). Adhikari *et al.* (2004) conducted a study analysing key household characteristics and household forest dependency. They found that poorer households faced more restricted access to community forests, and forest product collection from community forests was significantly dependent on various socio-economic variables such as age, household size, income and education. Vedeld *et al.* (2004) found that forest products contribute between 20% and 40% of total income of households in forest areas, and that poor households tend to be disproportionately dependent on forest resources (especially fuelwood and fodder). These high use levels are often cited as a rationale for investing in NTFPs as a way to achieve poverty reduction.

About 56% of sampled households generated income from forest products. The average contribution of forest resources to the total income of the sampled households in Inanda community was found to be about 26%. Several empirical studies have focused on how socioeconomic characteristics of users influence forest access and dependency (Ellis, 2000; Adhikari *et al.*, 2004; Fisher, 2004; Mamo *et al.*, 2007; Narain *et al.*, 2008; Kamanga *et al.*, 2009). Most of the studies used forest income as a proxy to measure livelihoods. Ellis (2000) pointed out that total household income is the most direct and measurable outcome of the livelihood activities. Mamo *et al.* (2007) outlined that the proxy for the dependence on natural forest resources is the share of absolute household income, or the relative income. They also conducted a study on economic dependence on forest resources in Ethiopia, and maintained that the average contribution of forest resources to household income was 39%. Firewood, grass fodder, honey, and construction materials were the major sources of forest income. Firewood constituted the largest proportion of forest income (59%), which was utilized for both home consumption and sale. Construction materials for houses, storage facilities, fences, furniture, and farm implements represented 21% of forest income, followed by fodder grazed and browsed (18%). Honey contributed the remaining 2% of annual forest income. The results by Mulenga *et al.* (2012) indicated that NTFPs contribute 34% of total household income for participating households. In addition to income and tangible goods, the community forests also provide non-tangible benefits such as tourists' attraction, burial yard services, biodiversity and ecosystem services that are contributing to the livelihoods.

5.2 Empirical model results

This section presents the results of the transformed logit model and discusses the variables that explain the dependency of natural forest products in Inanda community. The estimated coefficients, standard errors, t-ratios and significance values of the respective independent variables are presented in Table 5.3. The proxy that was used for dependence on natural forest resources was the relative share of forest income to the total household income. As this variable is a proportion variable, the logit transformation procedure was used to generate a variable (TRANS_SHAR) that was then used as a response variable in the OLS. To analyze the relationships between forest income dependence and household level factors, an ordinary least squares regression was run on the transformed proportion of forest income against household characteristics, asset endowment, and other contextual variables. This type of analysis is commonly employed by various studies in other developing countries (Birkhaeuser *et al.*, 1991;

Wale, 2010; Sharaunga and Wale, 2013). OLS has also been used without transforming the proportion variable (Vedeld *et al.,* 2004; Mamo *et al.*, 2007; Kamanga *et al.,* 2008). But the prediction of OLS would be outside the proportion range and that has motivated the use of Logit-transformed OLS in this chapter.

Off-farm incomes include earnings from permanent and temporary employment. Farm income is composed of the sale of livestock and crop production. Both assets and livestock values reported by sampled households were compared and were consistent with their market prices. This was done by calculating average values of each respective reported productive assets and livestock types to compare them with their average market prices. Income from forest was a summation of the sale of various forest products, which were collected from the forest. Non-farm incomes included old age pension grants, child support grants, disability grants, and remittances. Remittances are values of all income transfers both in kind and cash between households and often from relatives. Total forest income (TFI) is summation of both cash and subsistent returns from forest products. Relative forest income (RFI) is a measure of the share of income in total household income while income is derived from consumption and sale of forest products. This is derived as:

TFI/TI……………………………………………………………………………………. (2)

Where:

TI is total household income

TFI is total forest income.

Economic, cultural and social heterogeneity was observed among households, in terms of access to endowments such as land, labour and capital, motivations and skills and income generation activities (Barrett *et al.,* 2005). According to Kamanga *et al*. (2008), a broader heterogeneity relates to availability of resources across time and space and economic, cultural, political and legal conditions beyond the direct control of individual households. Sampled households were different in terms of the availability of socio-economic (age, asset-based endowments) and contextual factors (perceived changes in climate).

The model was tested for multicollinearity and heteroscedasticity. Multicollinearity was checked by examining variance inflation factors. However, the correlation matrix of variables used in the transformed logit model is also presented (see Appendix B4). Table 5.1 below shows how multicollinearity was assessed. The degree of multicollinearity among the explanatory variables, given by average variance inflation factors of 1.33 (Table 5.1) was by far less than the critical value of 10 (Gujarati and Porter, 2009).

Table 5.1 Diagnostics to assess the degree of multicollinearity, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable	**Collinearity Statistics**
EDUC	1.86
GENDER	1.73
MARIT	1.55
EMPLYINC	1.40
FARMINC	1.35
ACC_MRKT	1.34
NUMBERINC	1.33
LABOURF	1.31
ACC_LAND	1.24
TEMPERATURE	1.23
RAINFALL	1.20
UNEARDINC	1.20
DPDNT_RATIO	1.20
DISTANCE	1.16
LVSTCK_V	1.12
CHNG_VST	1.12
ASSTS_V	1.11
VOUCHER	1.11
Mean VIF	**1.31**

Source: Survey data (Mid-April to Mid-May 2013)

There was no heteroscedasticity since the calculated χ^2 value (0.29) was smaller than the tabulated χ^2 value (3.38) at the 5% significance level and one degree of freedom Table 5.2 below shows how heteroscedasticity was assessed.

Table 5.2 The results of the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable	**χ^2 (1)**	**Prob > χ^2**	**Tabulated χ^2 value**
TRANS_SHR	0.29	0.5892	3.84

Source: Survey data (Mid-April to Mid-May 2013)

5.3 The determinants of rural household dependence on natural forests

Table 5.3 below provides the logit-transformed OLS empirical results showing socio-economic characteristics and other contextual variables influencing the dependence of rural people on natural forest products.

Table 5.3 Logit-transformed OLS results, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable	**Type of variable**			
	TRANS_SHR			
	Coeff.	**Robust s. e.**	**t**	**P>t**
MARIT	-0.0007	0.16	0.00	0.996
GENDER	-0.0857	0.19	-0.46	0.646
EDUC	-0.1359	0.20	-0.69	0.493
VOUCHER	0.0002***	0.00	2.43	0.017
LABOURF	-0.0039	0.04	-0.1	0.917
DPDNT_RATIO	-0.0554	0.06	-0.91	0.366
FARMINC	-0.1167	0.12	-1.00	0.319
NUMBERINC	-0.0855	0.10	-0.90	0.373
UNEARDINC	-0.3724***	0.10	-3.65	0.000
EMPLYINC	-0.2045***	0.04	-5.71	0.000
ACC_MRKT	0.1806	0.18	1.00	0.322
ACC_LAND	-0.1585	0.28	-0.58	0.567
ASSTS_V	-0.0007*	0.00	-1.67	0.100
LVSTCK_V	-0.000004	0.00	-0.75	0.455
DISTANCE	0.0262	0.07	0.36	0.716
CHNG_VST	-0.2418*	0.14	-1.72	0.089
RAINFALL	0.258096	0.21	1.24	0.220
TEMPERATURE	-0.4242*	0.22	-1.91	0.060
CONSTANT	1.3858	0.52	2.67	0.009
F.sig R^2			5.41	0.000 0.45

Source: Survey data (Mid-April to Mid-May 2013)

Notes:*, **, *** means statistically significant at the 10, 5 and 1% levels, respectively.

The F-statistic for the OLS regression model was statistically significant at 5% level of significance with goodness of fit R^2= 0.45. The linktest for model specification was used to detect the model's specification error. The test of P_hatsq is not significant (see Appendix B3).

Thus, linktest failed to reject the assumption that the model is specified correctly. Therefore, there was no specification error.

Empirical evidence from previous studies (e.g. Cavendish, 2002; Mamo *et al.,* 2007) indicates that poor households derive a relatively large share of their income from forests compared to better-off households within the same community. The variables EMPLYINC, FARMINC and UNEARDINC reflected the number of income sources based on different economic activities within the household. The variable EMPLYINC and UNEARND_INC reflected the off-farm income generated from employment (wages or salaries) and other sources (old age pension grants, child support grants, disability grants, and remittances). The variable FARMINC reflects income generated from crop and livestock production. Diversification of income sources (NUMBERINC) has a negative relationship with the proportion of NTFP dependency, which was also a result reported in Heubach *et al.* (2011). All these income sources were categorized with respect to the income level generated by sampled households. All income sources were expected to have a negative relationship with natural forest products dependency. Households with better opportunities to allocate human capital will not invest in low return forest activities. For poorer households, forest activities can often be their only source of cash income (Vedeld *et al.,* 2004).

Productive assets value (ASSTS_V), changing of visiting dates and time to the forest (CHNG_VST) and the perceived increase in temperature changes by sampled households (TEMPERATURE) also influence the proportion of the dependency of natural forest products negatively (Table 5.3). Other households did not collect any items from the natural forest, despite their access to physical assets. They instead bought forest products from those who collected. This is because they had other income opportunities and the opportunity cost of harvesting resources was high to them.

Evidence from empirical results reported in Table 5.3 shows that off-farm incomes (UNEARDINC) and income generated from employment (EMPLYINC) by household head negatively influence the proportion of natural forest product dependency. These findings confirm to prior expectations and support evidences from other studies showing that an increase in off-farm and employment income decrease the dependence on natural forest products (Fisher, 2004; Mamo *et al.,* 2007; Heubach *et al.,* 2011; Hogarth *et al.,* 2012). The study conducted by Heubach *et al.* (2011) has shown that the greater the possibility to make use of different available income sources, the lower the share of the forest income activity in total household economy. On the other hand, Mamo *et al.* (2007) have shown that improved off-farm employment opportunities and access to credit may reduce forest clearance as a gap-filling activity. After OLS, Stata's 'protab' option was used to predict the impact of these significant variables. The parameter estimate for unearned income (UNEARDINC) suggests that households generating more income from off-farm activities are less dependent on the natural forest products. This suggests that as unearned income (UNEARDINC) increases from 0 to greater than 1500, proportion decreases from 0.38 to 0.17. However, according to Hogarth *et al.* (2012), the conventional economic theory suggests that unearned incomes undermine labour force by reducing the opportunity cost of engaging in the collection of forest products. Fisher (2004) also argued that socio-economic factors such as the easy availability of subsidies, social grants and related unearned incomes negatively affect the collection of forest products in rural communities. However, such arguments should not mean to promote social grants.

The negative and statistically significant parameter estimate corresponding to employment income (EMPLYINC) suggests that households generating more employment income are less dependent on the natural forest products. The employment income of the household head (EMPLYINC) showed highly statistical significance at 1%, implying that proportion of forest income by employed household heads decreases as employment income increases.. This suggests that as employment income increases from 0 to greater than 4000, proportion decreases from 0.40 to 0.17 (see Appendix B8). This finding is in agreement with the results of prior studies which have shown that the dependence of local people on natural forest products reduces with the increase in family income (Godoy *et al.,* 1995; Fisher, 2004; Vedeld *et al.,* 2004; Heubach *et al.,* 2011). The study by Godoy *et al.* (1995) also concluded that as income rises, the importance of non-timber forest products in the household economy shrinks. This implies that the economic importance of other income sources such as agriculture, wage employment and self-employment would rise relative to the income from environmental resources. In contrast to this study, Vedeld *et al.* (2007) supported that households with higher income levels are more likely to engage in informal activities such as agricultural production and the collection of forest products to generate more income for their sustainable livelihoods. In contrast, poorer households have to face higher opportunity costs in terms of extraction.

On the other hand, Hogarth *et al.* (2012) argues that certain types of social transfer programmes, particularly public work and community-based schemes promote labour market and employment in rural communities of developing countries. Research results by Vedeld *et al.* (2007) suggest that receipt of unearned incomes from government is associated with increased opportunity cost of labour in the market, possibly because cash makes job seeking easier in terms of less transport and food costs. Furthermore, it was suggested by Heubach *et al.* (2011) that the greater the possibility to make use of different available income sources, the lower the likelihood for natural forest dependency in the household economy. Therefore, unearned and employment incomes in this study perhaps show disincentives for households in the collection and use of forest products. However, the parameter estimates corresponding to farm income (FARMINC) and number of income sources received (NMBERINC) were not statistically significant. Most sampled households in the studied areas were generally composed of low income households. However, those households that had more incomes depended less on natural forest products.

Households with more productive assets (ASSTS_V and LVSTCK_V) are regarded as being relatively wealthy and have an incentive to engage in crop production rather than extraction of forest products. Wealthy households are expected to face higher opportunity costs of household labour to extract NTFPs. Both asset and livestock values were captured as average market values reported by sampled households. The parameter estimates for the value of productive assets (ASSTS_V) is negatively associated with the proportion of forest income as was expected and highly statistically significant. The forest dependence decreases with an increase in the value of household productive assets. This implies that households with less productive assets are generally more dependent on forest incomes. As the average value of household productive assets increases from 0 to 895, the average proportion of forest income to the total household income decreases from 0.23 to 0. This is not uncommon, for instance, with the results in the study conducted by Fisher (2004) in Malawi who concluded that the value of productive assets value is negatively related to forest dependence. This finding suggests the potential of interventions that enable farmers build productive assets to reduce forest dependence.

The variable CHNG_VST reflected the changing of time and dates in visiting the forest for the collection of forest products due to climatic conditions. Sampled households were asked “Has there been a change in their time and dates of extracting forest products due to harsh weather conditions”? Sample households reported to change their time and dates during heavy rains as the forest becomes slippery and bushier. However, during hot days they go early in the morning and late in the afternoon, thus, their livelihoods status somehow is affected due to climatic conditions. The variable goes hand in hand with perception, awareness and experience in terms of temperature changes and precipitation affecting natural forest products. Sampled households were asked if the changes in temperature and rainfall pattern affect their visiting dates and times and hence extraction of natural forest products. The variable was captured as a dummy where household changes visiting dates and time to the forest took the value of one and zero otherwise. This variable was expected to have a negative relationship with natural forest products dependency. The results showed negative and statistically significant relationship between natural forest products dependence and the variable change in visiting dates (CHNG_VST). According to the Stata’s ‘protab’ results, as household members change their usual visiting dates and time to the collection of forest products, the proportion decreases from 0.30 to 0.26. This finding is consistent with recent studies (Deressa *et al.,* 2009; Soltani *et al.,* 2012) and could perhaps be concluded that climate change poses negative impact on the livelihoods of natural forest dependent societies. Rural households who perceived increased rainfall and temperature changes are generally less dependent on natural forest products resulting in the change in their frequent use and harvest of forest status. This implies that there is sufficient evidence to say that change in visiting dates result in rural households to derive less income from the forest.

The variables RAINFALL and TEMPERATURE reflected perceptions of household heads on climate change components: rainfall and temperature. As suggested by Alarima (2011), perception goes hand in hand with environmental awareness and experience in terms of temperature changes and precipitation. Sampled households were asked “has the number of abnormal hot days increased during summer in their area over the past 30 years”? Or “if they perceived increased or any changes in terms of temperature and rainfall patterns in the last 30 years”. To clarify this, sampled households were also asked whether the number of hot or rainy days had increased, decreased, or stayed the same over the last 30 years. Both of these variables were captured as dummies where households that perceived changes in temperature and rainfall took the value of one and zero otherwise. In this study, the two variables were expected to have negative relationships with natural forest products dependency. The parameter estimate change in temperature (TEMPERATURE) is negatively and statistically significant. It was as expected that perceived increase in temperature reduces the proportion of the dependence on natural forest products. This indicates that households who perceive increase in temperature change reduce the frequency of their visit and use of the forest products and hence derive a cascading forest income. As sampled household perceive an increase in temperature changes, the proportion of the dependence on forest products decreases from 0.32 to 0.24.

The variable VOUCHER reflected vouchers from the 'Wildlands project' pays in exchange for planting trees to exchange for a voucher forming part of household forest income. The voucher forms part of forest income because it showed the amount of money that the household used to buy food. This variable was included in the model to capture the contribution of the voucher to rural livelihoods. It was captured as a continuous variable where the household head participated in the barter economy and received the value of the voucher, which depends on the amount of seeds/seedlings or trees that the households collect. However, households that were more dependent on forests engaged in vouchers from the 'Wildlands project' pays in exchange for planting trees (VOUCHER), showed positive influence on the proportion of forest income. It was expected that the voucher with the Wildlands project would have a positive relationship with natural forest products dependency. The coefficient estimate of the variable capturing barter exchange activities (VOUCHER) is positive and statistically significant. This implies that rural households engaged in barter exchange activities with wildlands project depend more on natural forest products for their livelihoods. As the average amount of voucher increases from 0 to 125, the average proportion of forest income increases from 0 to 0.43. These vouchers from the 'Wildlands project' activities involve the exchange of seeds or trees planted by households to improve their welfare. However, it was reported that the amount of voucher depends on the amount of seeds or trees the households collect and plant. This encourages rural households to extract more voucher-related forest products since the more the seeds or trees planted the more the voucher they get. The result of this variable (VOUCHER) of barter exchange activities with natural forest products for livelihoods is quiet interesting and it is one aspect that makes this study different from previous studies. As far as the author is aware, no study has been conducted with the inclusion of this kind of variable in rural communities of developing countries or elsewhere (Fisher, 2004; Shackleton and Shackleton, 2004; Vedeld *et al.,* 2004; Kamanga *et al.,* 2009).

The parameter estimates for the variable livestock value (LVSTCK_V) is negatively related to proportion of forest dependence. This was as expected and was also confirmed by a similar study in border-region of Southern China (Hogarth *et al.,* 2012). However, the variable is statistically not significant. Access to markets was reflected by the variable ACC_MRKT determining the ability of households to participate in the marketing channel of harvested forest products. The coefficient estimate of the variable access to market (ACC_MRKT) has positive sign which is consistent with *a priori* expectations. On the other hand, it is surprising that the parameter estimate in rainfall (RAINFALL) is positively related to the proportion of natural forest products dependency, but statistically not significant, confirming the rejection of the null hypothesis.

There is no significant relationship between labour endowments, dependency ratio and natural forest products dependency. The results imply that there is no sufficient evidence to say that labour endowments (LABOURF) and dependency ratio (DPDNT_RATIO) affect the rural community dependence on natural forest products. The variable LABOURF was used to determine the proxy for availability of labour resources with respect to age within the sampled households. Higher age of rural adult members was assumed to be linked to greater indigenous knowledge of usable NTFPs and appropriate skills and wisdom related to their extraction. As indicated before, the unit of analysis for this study was a household, but for the availability of labour endowments in the household and income, the unit of comparison was an adult equivalent (Atkinson, 1995). Working rates of the household members were converted into adult equivalent. The number of adult equivalents in a household was determined by means of average working rates in terms of different ages in the household as explained in Appendix B9 i.e.

No of adult equivalent = No. adults male (15-55years) + 0.84*No. female adults (15-55years) + 0.24*No. male children (6-9 years) + 0.19*female children (6-9 years) + 0.84*male children (10-15years) + 0.66*female children (10-15years) + 0.61*No. male adults (>55years) + 0.47*No. male adults (>55years).

However, the variable DPDNT_RATIO reflected the total sum ratio of dependents within the household (household members at most15 years and at least 55 years) to the adult working members engaged in the collection of forest products. The variable was used to serve as a proxy to measure the level of consumption within the household. Dependence ratio was hypothesized to have a negative relationship with household NTFPs dependency, although it is not statistically significant. Moreover, the variable MARIT reflected the marital status of the household head. Marital status determined the availability of a household head living in the community permanently and, hence, being entitled to the use and collection of natural forest products. Married household heads tend to be more secure in the collection of forest products and, hence, marketing because of their availability when labour resource is in high demand (Fisher, 2004). The result imply that there is no sufficient evidence to say that marital status of the household head affects the dependence on natural forest product since it is not statistically significant. The parameter estimate of the variable EDUC reflected the level of education of the household heads' and statistically not significant. Moreover, the parameter estimates of distance from homestead to the forest (DISTANCE) and access to land (ACC_LAND) were expected to reduce the dependency of natural forest products; however, the parameter estimates are statistically insignificant. However, the study conducted by Sharaunga *et al.* (2013) found that households that were further away from the forest were more likely dependent on the forest products as they tend to have higher resource scarcity than those close to the forests.

5.4 Summary

This chapter empirically examines the link between rural livelihoods and the status of natural forest resources in Bhekuphiwa and Mgangeni areas of Maphephetheni village under Inanda community of KwaZulu-Natal. The proxy that was used to measure the contribution of natural forests to rural livelihoods was the share of total household income contributed by forest extraction. The overall results indicate that sampled households are dependent on natural forest products for their livelihoods. The empirical results indicated that household socio-economic characteristics and contextual factors such as off-farm incomes, employment income, voucher, assets and livestock values, and access to market, perceived average changes in rainfall and temperature have significant impact on rural livelihoods. This study found that off-farm and employment incomes, assets and livestock values reduce the dependence of rural people on natural forest products.

However, higher income derived from forest products helps households to recognize the benefit from protecting forests, therefore, creating incentives to participate in forest management programmes. On the other hand, evidence from various studies have revealed that without creating opportunities for local people to utilize and benefit from the forest, it would be difficult to create incentives for them to become involved in forest management. The conclusions and policy implications drawn from these empirical results are further presented chapter 7. The next chapter presents empirical results of the choice of coping and livelihood adaptation strategies.

CHAPTER 6. EMPIRICAL MODEL RESULTS ON ADAPTATION STRATEGIES

6.1 Introduction

This chapter provides empirical results of the choice of coping and livelihood adaptation strategies in response to climate change in the studied areas of Inanda community of KwaZulu-Natal. The results of the multinomial logit model are presented and discussed. Like in the previous chapter, the main purpose is to present the empirical results explaining adaptation strategies. The validity of the model is tested and conclusions are drawn based on the findings. The chapter commences with empirical model specification and variables are defined, giving their expected signs. The significant variables are discussed followed by the summary. The model presented in chapter 3 explains the relationship between the choices of coping and livelihood adaptation strategies and socio-economic factors and other contextual factors influencing such choices. The dependent variables were clustered into three livelihood adaptation strategies. The dependent variable in the empirical estimation is the choice of livelihood adaptation strategy. The choices of the explanatory variables are based on data availability, economic theory and the literature. The set of explanatory variables differs across the cluster contrasts and in terms of marginal effects.

According to Soltani *et al.* (2012) with regard to the impacts of climate change, there should be a growing tendency among forest-adjacent communities to seek a livelihood strategy which combines forest-based production with farming and off-farm activities. The opportunities available will be directly related to socio-economic characteristics, access to urban markets and available infrastructure. However, these locational factors should be taken into account when assessing the scope for improved forest-based livelihoods. Moreover, attention should be given to the role of NTFP production in areas where forests perform an important environmental function and be part of a participatory, multifunctional forest management strategy.

The MNL was run and tested for the assumption of the independence of irrelevant alternatives (IIA). There was no evidence that this assumption was violated when the Hausman test was run, justifying the application of the MNL specification. The null hypothesis of independence could not be rejected as the difference between the full and restricted models' estimates χ^2= -3.88 (10 degrees of freedom) was not statistically significant ($p > 0.1$), suggesting that the use of MNL was appropriate. This result shows strong evidence of failing to reject the null hypothesis of independence of the climate change adaptation options in the studied areas. The premise of the IIA assumption is the independent and homoscedastic disturbance terms of the basic model in Equations (3) to (5) in chapter 3.

6.2 Empirical model results

This section presents the results of the multinomial logit model and discusses the variables that explain the choice of coping and livelihood adaptation strategies in the studied areas of Inanda community. The results for the MNL model were estimated with STATA's robust standard errors. Following the study conducted by Mutenje *et al.* (2010), the livelihood adaptation strategy out of the forest sector was selected as the base category for the MNL because it was the most diversified livelihood adaptation strategy and contained the highest proportion of sampled households. An OLS model was run to test for multicollinearity using the variance inflation factor (VIF). Table 6.1 below reports the results. The VIFs for all variables are less than 10 with an average of 1.16.

Table 6.1 Diagnostics to assess the degree of multicollinearity, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Variable	**VIF**
EDUC	1.54
ACC_MRKT	1.25
AGE	1.2
GENDER	1.18
TEMPERATURE	1.12
RAINFALL	1.10
ABOVE15	1.05
INC_ABVE	1.04
ASSTS_V	1.04
LAND_OWN	1.04
Mean VIF	**1.16**

Source: Survey data (Mid-April to Mid-May 2013)

The correlation matrix coefficients reported in Table 6.2 below also indicate that multicollinearity is not a serious problem in this model (Gujarati and Porter, 2009).

Table 6.2 Correlation matrix of variables used in the MNL model, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

VAR	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
A	1.00										
B	-0.06	1.00									
C	-0.05	-0.24***	1.00								
D	-0.05	0.35***	-0.34***	1.00							
E	-0.17	0.03	-0.03	0.09	1.00						
F	-0.08	-0.06	-0.08	0.05	0.11	1.00					
G	-0.01	0.15*	-0.16**	0.43***	0.01	0.07	1.00				
H	-0.06	0.01	-0.10	-0.06	-0.08	0.05	0.05	1.00			
I	0.10	0.10	-0.03	0.07	0.08	-0.10	0.01	-0.07	1.00		
J	-0.57***	-0.00	-0.04	-0.11	-0.01	0.05	-0.02	0.05	-0.03	1.00	
K	-0.26***	0.11	-0.07	0.02	-0.08	0.07	0.04	-0.02	-0.07	0.27***	1.00

Source: Survey data (Mid-April to Mid-May 2013)
Notes:*, **, *** means statistically significant at the 10, 5 and 1% levels; A = LIVADAPS; B = AGE; C = GENDER; D = EDUC; E= INC_ABVE; F = ABOVE15; G = ACC_MRKT; H= ASSTS_V; I = LAND_OWN; J= RAINFALL; K = TEMPERATURE

Table 6.2 shows that AGE was significantly negatively correlated with GENDER ($p < 0.01$), and positively with EDUC ($p < 0.01$) and ACC_MRKT ($p > 0.05$). GENDER was also significantly negatively correlated with EDUC ($p < 0.01$) and ACC_MRKT ($p < 0.05$). Furthermore, some evidence of statistically significant relationships between EDUC, GENDER, AGE and ACC_MRKT were detected. RAINFALL was also significantly positively correlated with TEMPERATURE ($p < 0.01$). However, given that the highest correlation coefficient was 0.567, this relationship between the dependent variable and RAINFALL are not considered an issue in obtaining reliable parameter estimates from the MNL as the variables were reasonably independent of one another. The empirical MNL results are presented in the next sub-section.

An OLS model was run to test for heteroscedasticity using the Breusch-Pagan/Cook-Weisberg test. There was no heteroscedasticity since the calculated χ^2 value (0.65) was smaller than the tabulated χ^2 value (3.38) at the 5% significance level and one degree of freedom.

6.3 Determinants of the choice of coping and livelihood adaptation strategies

Table 6.3 below shows the results of the multinomial logit coefficient estimates and the corresponding marginal effects. The MNL estimated results for the choice of coping and livelihood adaptation strategy are presented in Table 6.3. The goodness-of-fit of the model is relatively well. The estimated Deviance χ^2 of 134.48 and Pearson χ^2 of 167.11 with 274 degrees of freedom (df) show statistical significance relatively well above the 5% level, suggesting that the MNL adequately fits the data and are consistent with the MNL assumptions. The overall classification accuracy of the model is relatively well at 80%, with livelihood adaptation strategy out of the forest sector classified very well 97% and no livelihood adaptation strategy and livelihood adaptation strategy seeking alternative forest or substitute forest products (56.3%; and 42.9% respectively). The estimated Wald χ^2 statistic of 78.42 indicates that the likelihood ratio statistics are highly statistically significant ($p<0.001$), suggesting that the MNL has strong explanatory power. This implies that the explanatory variables explain variation in the choice of coping and livelihood adaptation strategies relatively well. The estimated coefficients and marginal effect results along with the levels of statistical significance are shown in Table 6.3. The set of explanatory variables differs across the choice of coping and livelihood adaptation strategies and in terms of marginal effects. In all cases, the results for the coping and livelihood adaptation strategies are compared to the base category of a livelihood adaptation strategy out of the forest sector.

The sign of coefficient estimate for gender (GENDER) of the household head in both contrasts is negative but statistically significant in the second contrast (adapting by seeking alternative forest or substitute forest products relative to adaptation out of the forest sector). This implies that as the number of male-headed households' increases, the likelihood of adapting by seeking alternative forest products relative to the base category decreases. The negative marginal effects of gender of the household head shows that a unit increase in this variable reduces the probability of adapting by seeking alternative forest or substitute forest products relative to the base category by 10%.

Table 6.3 Multinomial logit coefficient and marginal effect estimates, Inanda community, eThekwini Municipality, KwaZulu-Natal, 2013 (n=150)

Explanatory variables	$Ln(P_2/P_1)$ No livelihood adaptation strategy vs livelihood adaptation strategy out of the forest sector			$Ln(P_3/P_1)$ Livelihood adaptation strategy seeking alternative forest or substitute forest products vs livelihood adaptation strategy out of the forest sector		
	Contrast 1			**Contrast 2**		
	Coeff	**Marginal effects**		**Coeff**	**Marginal effects**	
		dy/dx	P-value		dy/dx	P-value
CONSTANT	6.713 (2.648)		0.011	7.311 (2.258)		0.001
AGE	-0.011 (0.029)	-0.001	0.709	-0.016 (0.020)	-0.001	0.426
GENDER	-0.900 (0.836)	-0.046	0.282	-1.418** (0.621)	-0.096	0.022
EDUC	-0.657 (1.132)	-0.030	0.562	-1.228** (0.653)	-0.064	0.060
INC_ABVE	-1.393* (0.838)	-0.071	0.097	-1.542*** (0.629)	-0.091	0.014
ABOVE15	0.129 (0.181)	0.007	0.476	0.027 (0.134)	0.001	0.840
ACC_MRKT	-0.792 (0.855)	-0.054	0.354	0.350 (0.689)	0.023	0.612
ASSTS_V	-0.00002 (0.000)	0.00001	0.195	-0.002 (0.002)	-0.0001	0.175
LAND_OWN	-0.056 (0.382)	-0.005	0.883	0.462* (0.253)	0.029	0.068
RAINFALL	-7.941*** (1.132)	-0.419	0.000	-6.071*** (1.194)	-0.344	0.000
TEMPERATURE	-2.197 (1.403)	-0.115	0.117	-1.957** (0.857)	-0.113	0.022

Diagnostics
Base category = Livelihood adaptation strategy out of the forest sector (P_1)
Number of observations= 150
Wald χ^2 statistic = 78.42***
Log likelihood= -74.94
Pseudo-R^2= 0.41
Deviance χ^2 (274) = 134.48 and Pearson χ^2 (274) = 167.11 (significant level=1.000)
Classification accuracy (correctly predicted)
Livelihood adaptation strategy out of the forest sector = 97%; no livelihood adaptation strategy = 56.3%; livelihood adaptation strategy seeking alternative forest or substitute forest products = 42.9%; overall model = 80%
dy/dx is for discrete change of dummy variable from 0 to 1
standard errors are in parentheses
Notes:*, **, *** means statistically significant at the 10, 5 and 1% leve1

Source: Survey data (Mid-April to Mid-May 2013). The dependent variable is the choice of coping and livelihood adaptation strategies (LIVADPS).

The results suggest that male-headed households are less likely to adapt by seeking alternative forest or substitute forest products relative to adaptation out of the forest sector. This result was not expected *a priori* since it was hypothesized that male-headed households are more likely to have experience and get information about new technologies and undertake risky businesses than female-headed households (Nhemachena and Hassan, 2007). Male-headed households are 10% less likely to adapt to climate change by seeking alternative forest or substitute forest products relative to the base category. These results support other findings (Dolisca *et al.*, 2006; Nhemachena, 2008), who have shown that female rural households were found to be more likely to adapt to climatic conditions because they are responsible for much of the agricultural work and have greater experience and access to information on farming practices.

The coefficient estimate for educational level (EDUC) of the household head in both contrasts is negative but statistically significant in the second contrast (adapting by seeking alternative forests or substitute forest products relative to adaptation out of the forest sector). This result implies that as the household head gets more educated, the likelihood of adapting by seeking alternative forest or substitute forest products relative to adaptation out of the forest sector reduces. The negative marginal effects of educational level of the household head show that a unit increase in this variable reduces the probability of adapting by seeking alternative forest or substitute forest products relative to the base category by 6%. In this study, most sampled households are illiterate and more dependent on agricultural production and natural resources for their livelihoods. In short, access to education reduces rural household dependence on forests. The study conducted by Dolisca *et al.* (2006) and Hassan and Nhemachena (2008) found that educated individuals have more knowledge and information about climate change and will adapt relatively quickly. Arnold and Townson (1998) found that households that were more dependent on the forest products and agricultural enterprises for their livelihoods are less educated. The more the level of education, the better the chance of getting formal employment opportunities and adapting to climate change (Hassan and Nhemachena, 2008; Deressa *et al.*, 2009). Most studies in the past showed the important role of education in adapting to climate change for sustainable welfare (Barrett *et al.*, 2005; Deressa *et al.*, 2009).

In this study, sampled households with income above total average income were regarded as being in a better position to have access to credit. The coefficient estimates and marginal effects for higher level of household income above total average income (INC_ABVE) are negative and statistically significant in both contrasts. The negative coefficient the first contrast shows that sampled households that had income above the mean were statistically less likely to adapt relative to the base category, but remains with no adaptation strategy. This also suggests that the likelihood of adapting to climate change by seeking alternative forest or substitute forest products as opposed to base category decreases with an increase in average household income. These findings are dissimilar to the results by Nhemachena (2008) who has shown a positive relationship between the level of adoption and the availability of income. Households with income above the mean income are relatively more capable of owning and purchasing goods and services and are in a better position to adapt to climate change for sustainable welfare. Deressa *et al.* (2009) have shown that availability of sufficient income in rural households eases the cash constraints and allows households to purchase inputs (such as paraffin, electricity, fertilizer, improved crop varieties, and irrigation facilities). This result perhaps could be ascribed to a high rate of unemployment and the dependence on governmental grant support funds (old age pension, child and disability support grants) in the studied areas.

However, the negative marginal effect of household mean income shows that with a unit increase in this variable, there is a higher probability that the household will adapt to climate change out of the forest sector, as opposed to seeking alternative forest or substitute forest products and remains with no adaptation strategy. This implies that a unit increase in household average income reduces the probability of no adaptation and seeking alternative forest or substitute forest products by 9.1% and 6.4% relative to the livelihood adaptation strategy out of forest sector. Furthermore, this result perhaps shows the lack of institutional support in promoting the use of adaptation options to reduce the negative impact of climate change in the studied areas. Therefore, there is enough evidence to say that rural households in the studied areas are willing to adapt to climate change even though they are constrained with lack of opportunities and institutional support. These results imply that natural forest dependent societies with household total income above the average income in Inanda community have a larger probability to adapt to climate change by engaging in economic activities out of the forest sector.

The coefficient estimates for land owned by the household (LAND_OWN) for the first contrast is negative but not statistically significant. This negative coefficient for land access suggests that the likelihood of no livelihood adaptation strategy relative to livelihood adaptation strategy out of the forest sector decreases with an increase in land size. It was as expected *a priori* that land operated by the household head has a positive relationship with the choice of coping and livelihood adaptation strategies in response to climate change. However, the positive coefficient for this variable in the second contrast is statistically significant, suggesting that the likelihood of seeking alternative forest or substitute forest products relative to the base category increases as the land size increases. This result implies that a unit increase in land size owned by the household increases the probability of seeking alternative forest or substitute forest products by 3%, as opposed to 73% of adapting out of the forest sector. This implies that sampled forest dependent households with access to more land will adapt by buying forest products or going to alternative forests, as opposed to engaging in agricultural production or starting small business enterprises to improve their welfare. However, other studies found that farmers with larger farms were found to have more land to allocate for constructing soil bunds, irrigation and drainage systems for agricultural productivity (Yirga, 2007; Nhemachena, 2008; Deressa *et al.,* 2009). On the other hand, Nyangena (2005) found that farmers with a small area of land were more likely to invest in soil conservation than those with a large area.

The coefficient estimates and marginal effects for perceived changes in rainfall (RAINFALL) are negative and highly statistically significant for both contrasts. This suggests that the likelihood of either not adapting or adapting by seeking alternative forest or substitute forest products, as opposed to adapting out of the forest sector, decreases as perceived average rainfall by the i^{th} household increases. The negative, statistically significant coefficient suggests that as the perceived changes in rainfall for the i^{th} household increases, there is a higher probability that the household will adapt out of the forest sector as opposed to no adaptation strategy and seeking alternative forest or substitute forest products. A unit increase in perceived changes in rainfall decreases the probability of not adapting and seeking alternative forest or substitute forest products by 42% and 34%, respectively. This could perhaps be attributed to the estimated results in chapter 5, thus, more rainfall creates opportunities in the studied areas and low rate of educational level of the sampled households. These results are also supported by previous studies that have shown that perception of climate change components (such as rainfall, temperature) goes hand in hand with education, experience and awareness (Deressa *et al.,* 2009; Maddison, 2007). Deressa *et al.* (2009) have shown that farmers who noticed and are aware of changes in climate take up adaptation strategies to reduce losses and take advantage of the opportunities associated with these relative changes.

Likewise, the coefficient estimates and marginal effects for perceived changes in temperature (TEMPERATURE) are negative and statistically significant in the second contrast. This suggests that the likelihood of either not adapting or adapting by seeking alternative forest or substitute forest products, as opposed to adapting out of the forest sector, decreases as perceived changes in temperature by the i^{th} household increases. The negative and statistically significant coefficient in the second contrast suggests that as the perceived changes in temperature for the i^{th} household increases, there is a higher probability that the household will adapt out of the forest sector as opposed to no adaptation strategy and seeking alternative forest or substitute forest products. A unit increase in perceived changes in temperature decreases the probability of adapting by seeking alternative forests or substitute forest products by 11%. It also implied that the higher the levels of climate change perception of the rural dwellers the higher their chances of taking adaptation strategies.

The coefficient estimates for adult members (ABOVE15) is positive and statistically not significant in both contrasts, indicating that the likelihood of not adapting and adapting by seeking alternative forest or substitute forest products relative to adaptation out of the forest sector increases as the number of adult members increases. This implies that household labour endowment did not show the largest effect on not adapting and adapting by seeking alternative forest or substitute forest products relative to the base category possibly because the choice of this livelihood adaptation strategy was not that labour intensive. Deressa *et al.* (2009) reported that larger households are forced to divert part of the labour force to off-farm activities to generate to more income so as to influence their consumption pressure. This implies that large families in the study face larger opportunity costs of finding alternative livelihood strategies and tend to stick to local-based strategies. The other possibility causing such results could be the fact that most forest dependent households in the studied areas reported to adapt out of the forest sector, thereby by starting their own businesses, engaging in agricultural production, finding informal employment and home gardening for their better welfare outcomes. Additionally, there are other factors (such as access to credit, extension services, and access to land) to be considered when adapting to these livelihood adaptation strategies. For example, it will be difficult or impossible for the household to engage in crop enterprises without access to land. The parameter estimate for market access (ACC_MRKT) for the first contrast is negative and not statistically significant. This negative coefficient suggests that the likelihood of no livelihood adaptation strategy relative to the base category decreases with an increase in access to market. However, the positive coefficient in the second contrast suggests that the likelihood of seeking alternative forest or substitute forest products relative to the base category increases with an increase in access to market. Furthermore, the coefficient estimate for productive assets value (ASSTS_VA) is negative in both contrasts and statistically not significant. This suggests that the likelihood of adapting by seeking alternative forest or substitute forest products and no adaptation strategy relative to the base category decreases with an increase in the value of productive assets. There is insufficient evidence to say by how much probability these variables (ACC_MRKT, ABOVE15, and ASSTS_VA) influence the choice of coping and livelihood adaptation strategies in the studied areas.

6.4 Summary

This chapter empirically examined the coping and livelihood adaptation strategies of rural households and communities in response to changes in the forest status that threaten their livelihoods. The study used the multinomial logit (MNL) model to examine the factors influencing household choices of climate change adaptation strategies. The dependent variable is clustered livelihood adaptation strategies and the explanatory variables include socio-economic factors, asset endowments, perceived seasonal climate variables (rainfall and temperature) and contextual (institutional and social) factors.

The survey data suggest that the sample of 150 households in the studied areas often choose one of the three clustered livelihood adaptation strategies (1 = livelihood adaptation strategy out of the forest sector, 2 = no livelihood adaptation strategy, and 3= livelihood adaptation strategy seeking alternative forest or substitute forest products). Larger proportion of forest dependent sampled households in the studied areas of Inanda community reported to adapt out of the forest sector. This might entail starting their own businesses, engaging in agricultural production, finding informal employment and home gardening for their better welfare outcomes. However, sampled households reported lack of information and agricultural inputs (seeds, water, and fertilizers), lack of finance, shortage of labor, shortage of land, and poor infrastructure constraining their choice of coping and livelihood adaptation strategies.

The MNL was run and tested for the assumption of the independence of irrelevant alternatives (IIA) using Hausman test. The results justify the application of the MNL specification. Moreover, statistical tests indicated that the model fits the data well and there are no multicollinearity / heteroscedasticity problems. The overall classification accuracy of the model is about 80%. The results from the marginal analysis indicated that household characteristics such as gender of the household head, educational level of the household head, land size owned by household head and household income above average, perceived average changes in rainfall and temperature have significant impacts on livelihood adaptation to climate change. The conclusions and policy implications drawn from these empirical results are further presented in the next chapter.

CHAPTER 7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Recapping the purpose of the research

The forest sector in developing countries, particularly in South Africa, has potential to contribute to growth in the rural areas, reduce poverty and income disparity, and hence, contribute to economic growth. In South Africa, lack of research and credible evidence on the impacts of climate change on the link between rural livelihoods and forest status is a major challenge, especially in marginal and vulnerable communities. Moreover, the value of local knowledge in developing countries, particularly in South Africa, to climate change policy is not given adequate attention. The overall objective of the study was to examine how rural livelihoods are linked to the status of natural forest resources and how that link is impacted by changes in the forest cover driven by factors including climate change. Furthermore, the study examined the choice of coping and livelihood adaptation strategies of rural communities in response to changes in the forest status that threaten their livelihoods.

To achieve these objectives, the Inanda community of KwaZulu-Natal (under KZNSS) was taken as a case study. A cross-sectional data from a total sample of 150 rural households was generated through questionnaire survey using random sampling procedure. The study objectives were examined in two parts. Firstly, natural forest resources were taken as an integral part of biodiversity and therefore, examining their contribution to the rural livelihoods. The data analysis involved both descriptive and econometric techniques. Data from key informants interviews, group discussions and participant observation were also used to support the results of the econometric models.

The proxy that was used to measure the role of natural forests to rural livelihoods was the share of total household income contributed by forest extraction. Logit transformation procedure followed by OLS was employed to examine the factors that affect the contribution of natural forest to rural livelihoods. Multinomial logit model was employed to examine the choice of coping and livelihood adaptive strategies. The choice response variable was clustered as the livelihood adaptation strategies. This chapter closes the dissertation by presenting the main conclusions and policy recommendations based on the empirical results of the study. Furthermore, it presents recommendations for further research in the future.

7.2 Conclusions

This study has found that households in Inanda community have diversified livelihood strategies. Most households fulfill subsistence needs through both agricultural and forest incomes. Due to increasing population sizes in developing countries, including South Africa, both the demand for NTFPs and the pressure for agricultural land are likely to increase. This study also confirmed an important role of forests in securing livelihoods among the poorest rural dwellers. Forest products collected in the studied areas include fuel-wood, construction poles, traditional medical plants, mushrooms, bush-meat, wild spinach and fruits, seeds and seedlings for vouchers from the 'Wildlands project' pays in exchange. However, the rate of the collection of non-timber forest products is not sustainable since most of the sampled households reported that non-timber forest products are decreasing over time. Some of non-timber forest products such as mushrooms, traditional medicine plants and wild spinaches only regenerate during heavy rains, meaning that they occur or are seen during rainy seasons as compared to other forest products such as fuelwood.

Households selling forest resources do not generate much cash from such activities, but manage to meet some of their current consumption needs in this way. The empirical model indicated that forest income forms an integral part of the households' income generation activities. About 56% of sampled households generated income from forest products. The average contribution of forest resources to household income in Inanda community was 26%. Based on the study results, it is clear that access to market and awareness of changes in rainfall and voucher in terms of the barter exchange activities would improve the income and livelihoods of the lower income households in the studied areas. Since these variables are proved to improve rural livelihoods, there is a need for government or other stakeholders to put more attention or interventions to enhance them through decision making process.

The literature highlighted that global market pressures to develop rural areas commercially and to privatize forests for timber production may cause the degradation of these resources and limit access and use rights for the locals. This study could not compare forest use under government control and community ownership, since the forest was reported to be an open access, but it provides some evidence that rural households have access to the use and extraction of natural forest products. However, one would have expected a complete destruction of the forest as an open access resource. There are informal rules reported by most sampled households that have historically prevented that from happening. For example, community members are not allowed to burn the forest. This indicates that the community members are aware of this informal rule as no fire incident was reported by sample households. Collective action is seen as playing the important role of ensuring that the community makes collective decisions on the rules and regulations that are implemented for the best use of their resources. Therefore, since patterns of forest use differ among rural households, local management institutions need to take these into account to ensure sustainable welfare of the rural poor. The results obtained from this study do not only help the communities, but also the policy makers because they will be in a position to know community needs in terms of managing their resources and they will also know how effective these rules are so that if they are not effective, they can be adjusted to best suit the communities. Moreover, where local leadership does not appear to be effective, trained community organizers can assist in explaining the advantages of organizing, providing the initial leadership and identifying others in the community that can take over.

On the other hand, sampled households that were more dependent on forests engaged in the vouchers from the 'Wildlands project' pays in exchange for planting trees showed positive influence on the dependence of local people on natural forest products. This encourages rural households to extract more voucher-related forest products since the more the seeds or trees planted the more the voucher they get. Other households did not collect any items from the natural forest, despite having access to physical assets for agricultural production and were constrained by poor infrastructure. They instead bought forest products from those that collected. This is because they had other income opportunities and the opportunity cost of harvesting from natural resources was too high for them. The study recommends inclusion of forest incomes in all rural income assessments and creation of forest resource management and forest employment to broaden livelihood strategies among rural people. However, as agriculture is the main source of income and employer in most rural areas of South Africa, there is scope for productive investment in research and extension to support them. This will also enhance employment opportunities for lower income households and certainly encourage efforts to focus on improving the traditional income base of agriculture and forest enterprises. This perhaps could prove important in establishing policies to promote forest management and rural welfare. Public investment in health care and education services will help rural forest-based households that are identified as particularly vulnerable and should receive priority in the implementation of these policies.

Both the qualitative and quantitative analyses presented in this study suggest that the extractions of natural forest products are correlated with household socioeconomic attributes. The empirical results indicated that off-farm incomes, employment income, productive assets value, changing of visiting dates and time to the forest and the perceived increase in temperature changes also reduce local peoples' dependence on natural forest products. This study found that employment income and unearned incomes such as remittances, child-support grant, disability grant and old age pensions, and household income generated from the employment reduce local peoples' dependence of local people on natural forest products. Thus, the greater the possibilities to make use of different available income sources, the more the chance to reduce the pressure on natural resources.

About 89% of the sampled households indicated that they will do something in response to climate change, implying that rural households perceive and are aware of the change in climatic conditions. The cluster analysis applied to generate dominant livelihood adaptation strategies yielded three clusters, namely,

1. Livelihood adaptation strategy out of forest sector,
2. No livelihood adaptation strategy, and
3. Livelihood adaptation strategy seeking alternative forest or substitute forest products or other forestry sector.

A livelihood adaptation strategy out of the forest sector was the largest of the three clustered livelihood adaptation strategies, representing 66% of the total sample of households. One-third (33%) of the sampled households indicated that they would adapt by starting small businesses (i.e. sewing traditional clothes and jewelleries, crafting mats, decorations enterprise and tuck-shop selling snacks, airtimes, breads *etc.*). Moreover, finding informal employment, home gardening and crop and livestock production also constituted 33%. A livelihood adaptation strategy seeking alternative forests or substitute forest products (use of paraffin or electricity, buying forest products elsewhere, getting forest products from alternative forests and changing forest time and date visits) constituted 23.3% of sampled households, while a no livelihood adaptation strategy constitutes the smallest cluster with only 10.7% of the sample households.

These results have policy implications for government and other stakeholders in response to climate change in rural areas of South Africa. For example, research findings reinforce the need to focus on investing in building institutions, improving access to micro-credit and capacity within forest communities. Furthermore, this might be useful in facilitating the transfer of rights and responsibilities for local resource management as a pathway to poverty alleviation and sustainable welfare. Moreover, it could perhaps provide opportunities for empowerment and improved capabilities for sustainable livelihoods of natural forest dependent societies. It can also serve as a critically important means to improving income and employment through improved resource management and better skills to engage in the access to market. The results of the multinomial logistic regression model revealed that differences in socio-economic factors, asset endowments and averaged perceived climate change components (rainfall and temperature) were the main determinants of the choices of livelihood strategies. Although the determinants were variable across the cluster contrasts and in terms of marginal effects, male-headed households were less likely to adapt to climate change in the second contrast. The results suggest that male-headed households are less likely to adapt by seeking alternative forests or substitute forest products relative to adaptation out of the forest.

Likewise in the second contrast, the results also revealed that the likelihood of adapting by seeking alternative forests or substitute forest products relative to adaptation out of the forest sector decreases as the household head gets more educated. On the other hand, the results highlight that sampled households that had income above the mean were less likely to adapt in response to perceived climate change in both contrasts. Therefore, there is enough evidence to say that rural households are willing to adapt to climate change even though they are constrained with financial and institutional support. The results also revealed that rural households firstly perceive that climate is changing and then cope and adapt to it.

The empirical results suggest that rural households will adapt to climate change out of the forest sector meaning that they will start small businesses, finding informal employment, home gardening, and crop and livestock production. Most sampled households reported to start their own businesses followed by agricultural production. However, access to financial resources may constrain such ventures. There are other socio-economic factors (such as educational level, access to credit, extension services, and access to land) to be considered when adapting to these livelihood adaptation strategies. For example, one cannot engage in crop enterprises without access to land, employment opportunities and access to information through extension services. Therefore, government need to identify challenges and diversity of rural household livelihoods for action plans and therefore, reflect on the most suitable ways of promoting the wellbeing of rural communities that are vulnerable to climate changes. Policy-makers should, therefore, ensure that rural households have access to affordable credit to increase their ability and flexibility to change production strategies in response to the forecasted climate conditions, as access to credit increases the resilience of rural households to climate variability, and the capacity of their adaptations. Thus, for example, investment in rural agricultural enterprises and infrastructure by government and other stakeholders can enhance employment opportunities, poverty reduction and food security for the sustainable rural welfare

The analysis of barriers to adaptation to climate change in Inanda community indicated five major constraints to adaptation including lack of information and agricultural inputs (seeds, water, and fertilizers), lack of finance, shortage of labor, shortage of land, and poor infrastructure. Households can adapt better through close interaction and intervention of government to address their constraints for sustainable welfare and poverty reduction. There is a need for interventions that can encourage informal social networks promoting group discussions and better information flows and thereby enhancing adaptation to climate change. For example, the combination of supplying information and awareness about the causes and the effects of climate change and the availability of means of production may encourage rural households to become involved in forest management. The empirical results suggest that introducing more financial incentives to rural households is vital to create greater social, environmental and economic awareness and participation in the mitigation of climate change. Based on the empirical results the following section provides specific recommendations to policy makers.

7.3 Policy recommendations

The study recommends inclusion of forest incomes in all rural income assessments and creation of non-farm employment to broaden livelihood strategies among rural people. Therefore, greater government commitment to policies that recognize the importance of natural forest resources or NTFPs for local livelihoods is needed. The analysis also indicated five major constraints to livelihood adaptation strategy in response to climate change in the study area. Knowledge and awareness about the current and future impacts and effects of climate change should be enhanced. This study recommends strong community-based resource management institutions. Furthermore, broad policy interventions are required for rural development including interventions such as securing and enhancing the natural resource base, designing participatory management and monitoring systems, securing poor people's rights of use and access to such resources. Since most of the rural communities are poor, this community forest management program should be deliberate in the way that the resources can make significant contribution to poverty reduction whilst preventing over-harvesting and forest degradation. More equal distribution of forest-related benefits is needed and this would address the inequalities in the access to forest resources and in the ways they are used and managed. Without creating opportunities for local people to utilize and benefit from the forest, it would be difficult to create incentives for local communities to become involved in forest management.

Government and community members should collectively treat adaptation to climate change as part of the local development agenda: this will also provide additional services needed to adapt and adds complexity to the achievement of other development objectives for sustainable welfare. Policy-makers should consider forest management and improve forest governance as part of climate change adaptation system in rural communities. Adaptive and sustainable management of forest ecosystem services will promote the maintenance and improvement of environmental quality, social justice, and economic wellbeing. Moreover, enhancing participation of forest dependent people in adapting to and mitigating climate change is prerequisite for sustainable development and welfare.

Despite the importance of voucher receipts, few sampled households received them as others were just started whilst others were unaware about the exchange activities with the Wildlands project. Therefore, there is a need for increased government visibility among rural households to address this issue for better welfare outcomes in Inanda community of KwaZulu-Natal. Furthermore, this study recommends that the exchanging activities with Wildlands project need to be well known or briefly explained to all community members to make significant contribution to poverty reduction for sustainable rural livelihoods.

Access to the use and collection of natural forest products in rural communities alone cannot be enough to significantly reduce poverty. There is a need to further diversify rural livelihoods so that pressure on forest resources can be reduced. Other rural traditional economic activities or projects such as agricultural production and small businesses should be supported among rural households so that rural poverty is meaningfully reduced. It is also recommended to improve access to land for agriculture, access to agricultural extension services, access to market and improved farming technologies. Investment on rural infrastructure will enhance employment opportunities; improve access to market and increase the efficiency of crop production systems in order to avoid high transaction costs. For example, irrigation and drainage systems will reduce the negative impacts on farm households of future droughts and floods.

Given the fact that impacts of climate change on biodiversity and community livelihoods is compounded by other non-climate stressors (such as poverty, lack of financial resources, poor infrastructure, and high rate of unemployment), it is recommended that there should be collective action by community members and policy-makers in addressing this issues so as to minimize potential negative impacts of climate change. There should be a co-management between the community and government, rather than government management alone. Collective action (such as by engaging district officers, private associations, traditional leaders, community members, community extension officers, local/regional governments) and networks among community members can facilitate access to information and even allow farmers to participate in technology development. The most vulnerable and marginalized rural groups often lack access to resources (that is, either they have no access and/or when they have they face insecure property rights) and find participation in collective action too costly because of lack of time and resources. Therefore, enhancing rights to even relatively small homestead plots can increase food security by allowing women to grow gardens, and rights to common property often provide insurance for the poor. Tenure security provides key assets for poverty reduction, allowing the poor to help themselves by growing food, investing in more productive activities, or using property as collateral to access credit.

Collective action can increase food security through mutual insurance, for example, participation in economic activities (agricultural and harvesting forest products) and political decisions provide individuals with a sense of value and identity which result as an important means to voice the needs of vulnerable population groups. Therefore, it is also important that policymakers not presume that they are the only relevant actors in efforts to solve collective action problems. Moreover, policymakers should understand the importance of local initiatives (bottom-up approach) in addressing better collective action outcomes. Government agencies need to change how they work with communities, becoming more conscious in their efforts to strengthen local management institutions and allowing more local decision-making without imposing external rules. Therefore, awareness promotion on the different causes and consequences of climate change should be initiated for the community.

7.4 Recommendations for further research

The influence of social capital on the dependence of local communities on natural forest products has not been examined in this study. It would provide further insights if an investigation is conducted on how factors such as trust among group members affect rural household decisions in the use and the extraction of natural forest products. Therefore, it is also crucial to investigate the socio-economic characteristics of households that would be interested to participate in community-based forest management for better welfare outcomes and sustainable forest management. Additional research is also needed to better assess the extent to which access to forests in rural South Africa and in other developing countries can help the poor to adapt to climate variability and change. The degree to which research about climatic conditions and non-climate stressors are conducted or investigated in rural communities, community members will effectively combine their capabilities of maintaining and improving their standard of living and reducing their vulnerability.

Understanding the interactions between the different forms of climate change impacts will require further research. The investigation about the impacts of climate change on local projects such as agricultural production and the extraction of natural forest products should be further studied. Moreover, a further need is for research on the impacts of climate change on the storage and marketing of the harvested natural forest products and produced crops. For example, losses to insect pests and pathogens of crops stored, damage in transport (for example caused by deteriorated rural roads), and indirect costs of being less able to store in the households and more vulnerable to seasonal price swings. Knowledge of crop responses to climate change also needs to be extended to more crops, livestock, and wild species of interest to rural households.

During the data collection period, Wildlands officers and community forest workers were busy clearing alien invasive plants and other well-known trees which are mostly used by community households for their livelihoods. Community members can still access natural forest products, because the forest has not been completely cleared yet. However, the resources will no longer exist as the community members continue to clear the trees. Therefore, the questions that should be asked are: what will happen to the local livelihoods, health etc. and how will the local people adapt with new situation when the resources are gone? There is a need to examine climate change impacts on natural forest and agricultural production. More investment would still be required on research and adaptation on the impacts of climate change on agriculture, forests and forest-based livelihoods.

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APPENDICES

APPENDIX A: SURVEY QUESTIONNAIRE

UNIVERSITY OF KWAZULU-NATAL

DISCIPLINE OF AGRICULTURAL ECONOMICS

PROJECT: URBAN BIODIVERSITY MANAGEMENT IN THE FACE OF CLIMATE CHANGE: LIVELIHOOD IMPACTS AND ADAPTATION STRATEGIES IN INANDA COMMUNITY OF eTHEKWINI METROPOLITAN AREA

Please read the following statement carefully before signing or completing the questionnaire. This questionnaire is meant to address the preceding project. It is to be completed by the head of the household with the help of the enumerator. It is meant to generate information on socio-economic characteristics of the households, households' dependency on natural forest resources, livelihoods strategies, community members' perception of climate change and households' coping and adaptation strategies when their livelihoods are threatened by climate-driven forest cover change. The information provided will be used only for the purposes of this research and will be treated strictly confidentially, with no mention of names in the analysis. Please tick the appropriate boxes when necessary or fill the blank spaces provided.

Please mark with an X if you agree or not to complete the questionnaire. I do not wish to complete the questionnaire ____

I agree to complete the questionnaire and do so in a completely voluntary manner. I understand that my responses will be kept confidential. ______Signature ______________Date __________

RESPONDENT IDENTIFICATION

QUESTIONNAIRE PARTICULARS	
Enumerator's name	
Respondent's name	
Date	
Village/Area	
Questionnaire reference number	

SECTION A: HOUSEHOLD CHARACTERISTCS

NB: Household members refer to members who live, cook and eat from the same food stock together with other household members for at least the last six months.

1. **What is the name of the household head?** ....

2. HOUSEHOLD KEY SOCIO-ECONOMIC CHARACTERISTICS

Household members (initials)	Relation with the household head	Marital status	Gender 1= male 2=female	Age	Highest level of formal education	Employment status

Key: Use the codes mentioned in the table below to answer the table above.

Relation with the head of the household	Marital status	Highest level of formal education	Employment status
1Father 2 Mother 3 Daughter 4 Son 5 Daughter in law 6 Son in law 7 Other: specify	1 Married 2 Single 3 Divorced 4 Widowed	1 Never attended school 2 Primary level 3 Secondary level but did not complete matric 4 Matriculated 5 Tertiary level	1 Unemployed 2 Permanent employment 3 Temporarily employment 4 Contract employment

3. Household income in 2012

3.1 What are your major household income sources? Please rank these according to their importance, where one (1) represents the most important

Household income sources	Please tick	Rank
Crop production		
Forest resources		
Livestock production		
Pensions		
Employment		
Gifts from relatives		
Social grants		
Off-farm income		
Other: specify		

3.2 **Other income sources per month in 2012 and please tick**

Farm income (R)		Remittances (Gifts) (R)		Child social grants (R)		Employment (wages and salaries) (R)		Pensions (R)		Disability grant		Other specify …………… ……………	
<500		<500		<300		<1000		<1000		<700		<500	
500-1000		500-700		300- 500		1000-1500		1000-2000		700-1200		500-800	
1001-1500		701-900		501-800		1501-2000		2001-3000		1201-1700		801-1100	
1501-2000		901-1200		801-1100		2001-2500		3001-4500		1701-2200		1001-1400	
2501-3000		1201-1500		1101-1400		2501-4000		4501-5500		2201-2700		1401-1700	
>3000		>1500		>1400		>4000		>5500		>2700		>1700	

3.3 Estimated total household income per year **…………………………………. (R)**

SECTION B: HOUSEHOLD ENDOWMENTS

1. What type of house do you live in? ……………………………………
2. Do you own a house in town? ……

1 Yes	0 No

3. If yes, state the location and estimate its current value …………………

4. **LAND USE (AGRICULTURAL PRODUCTION)**

4.1 Did you cultivate the land last year? ....

1=Yes	0=No

4.2 If yes, please complete the table below.

Plot	**Name of the crop cultivated**	**Size in hectares (ha) (1ha= 10000m2)**	**Distance from homestead (km) N= near F= far**	**How do you measure quantity harvested (1=kg or 2=bag)**	**Average price for sales (per kg or bag)**	**Willing to sell if not selling (1=Yes 0=N0)**
1						
2						
3						
4						
5						

Suggestions: 1= maize, 2=beetroots, 3=beans,4= spinach,5= onions, 6=bananas, 7=butternuts, 8=groundnuts, 9=potatoes, 10=tomatoes

5. LIVESTOCK OWNERSHIP

Type of livestock and poultry	**Number owned**	**Current value per unit (R)**
Cows		
calves		
Oxen		
Sheep		
Goats		
Domestic chickens		
Others: specify		

6. **OTHER HOUSEHOLD PRODUCTION ASSETS**

Assets (Farm implements)	**Number owned**	**Number hired/borrowed**	**Current value per unit (R)**	**Rental price (if rented or borrowed per day) (value in R)**

Suggestions: Planter, Ripper, Tractor, Harrow, Mouldboard plough, Oxen drawn plough

7. **HOUSEHOLD FOOD SECURITY**

8.1 How many times do you take meals per day?	1 = ones	2 =2 times	3 = 3times	4 = none

8.2 Please tick and rank these examples of food sources according to their importance, where one (1) represents the most important.

Sources	**Tick**	**Rank**
Own production		
Purchases		
Gifts		
Wild (natural resources) based food		
Donor food from government/ Wildlands exchange		
Borrow from friends or relatives		
Others: specify		

SECTION C: NATURAL FOREST RESOURCES DEPENDENCE

1. What are the most common forest products you harvest from the forest? And please rank the products, where one (1) represents the most harvested product.
   Estimated total forest income per year…………………………

Suggestions: 1=Firewood, 2= Construction poles, 3=Traditional medicines, 4=water, 5= Edible fruits,

Forest products (name)	**Frequency of use 1=everyday 2=seldom 3= seasonally**	**Do you sell these products (1=Yes 0= No)**	**How do you measure your harvested when selling (per kg or bag or load) and how much per kg or bag?**	**Perceived trends in the last 30 years (1=increased, 2=constant, 3=decreased**	**Rank**

6=Mushrooms, 7= Honey, 8= wild spinaches, 9= Hunting, 10 Livestock grass fodder, 11=Thatching material, 12 sand, 13 =other specify…………………

2. How many times per month do you visit the forest to collect for home use or sale?
   …………………………………………………………………………………………………….
3. Where is the market for these products? .... **(1= local people; 2= local towns and cities; 3= local supermarket; 4= no market.**
4. If you sell in the city or town how much transport cost do you pay in return? ....
5. Do you save any money from the sold forest products? .... **(1= Yes; 0=No)**
6. Apart from this forest, where else do you get these main products? **.........(1 = no alternative; 2 = buying from elsewhere; 3 = get them elsewhere for free)**

7. **Household dependency on forests**

Does your household collect firewood from the forest? **(1= Yes; 0 = No)**	
If no, why? **(1= prohibited; 2= we have electricity; 3= get it from elsewhere 4= no need)**	
Do you think firewood save your electric current per month? **(1= Yes 0=No)**	
How long does it take you to walk from your homestead to the forest? **(1=<30min; 2=31-50min; 3=51-60min; 4=>60min)**	
Dependence on forest for construction poles	
Do you use timber for constructing your houses?	

(1= Yes; 0 = No)	
If yes, where did you get the timber for constructing your house(s)?**(1 = from the forest; 2 = bought elsewhere; 3 = elsewhere for free)**	
If you got them elsewhere, why didn't you get them from this forest? **(1= we are prohibited; 2 = no need; 3= buy elsewhere; 4 = get it elsewhere for free; 5 = the poles are poor quality)**	
Do you use wooden poles to construct livestock pens? (1= Yes; 0 = No)	
If yes, where did you get the timber for constructing your livestock pens? **(1 = from the forest; 2 = bought elsewhere; 3 = elsewhere for free**	
If you got them elsewhere, why didn't you get them from the forest? **(1= we are prohibited; 2 = no need; 3 = the poles are poor quality)**	
How do you feed for your livestock? ………………………………………………………………………………………………………	
Do you have burial logs in the forest? **(1 = Yes; 0= No)**	
If yes, have you ever used burial logs after the death of a family member**? (1 = Yes; 0= No)**	

SECTION D: PERCEPTIONS OF COMMUNITY MEMBERS ABOUT CLIMATE CHANGE AND ITS IMPACTS ON NATURAL FORESTS

NB: In this study climate change is defined as the variety of general shifts in weather conditions (changes in the weather and the seasons) including temperature rainfall, wind, and other factors (such as floods, drought).

1. Local peoples' perceptions of change in <u>temperature</u> (cold and heat) on farming/ agriculture over the last 30 years

1.1 Have you noticed an increase in abnormal temperature in your area over the last 30 years?....

1Yes	0 No

1.2 Have the number of abnormal hot days increased or decreased or stayed the same during summer in your area over the past 30 years? …

Increased	Decreased	Stayed the same

1.3 Have the number of abnormal cold days increased or decreased or stayed the same during winter in your area over the past 30 years? …

Increased	Decreased	Stayed the same

2. Local peoples' perceptions of change in <u>rainfall</u> pattern on farming/agriculture over the last 30 years

2.1 Do you think there has been more rainfall during rainy season in your area over the last 30 years? ....

1Yes	0 No

2.2 Have the number of rainy days increased or decreased or stayed the same during rainy season in your area over the past 30 years? …..…….

Increased	Decreased	Stayed the same

3. Local peoples' perceptions of change in <u>drought</u> occurrences on farming/agriculture over the last 30 years

3.1 Have there been more droughts in your area over the past 30 years? ……

1 Yes	0 No

4. Local peoples' perceptions of change in <u>floods</u> occurrences on farming/agriculture over the last 30 years

1 Yes	0 No

4.1 Have there been more floods in your area over the past 30 years? ……

5. Local peoples' perceptions of change in wind occurrences on farming/agriculture over the last 30 years

1 Yes	0 No

5.1 Have the number of abnormal windy days increased in your area over the past 30 years? .....

6. Perceived effects of heat, cold and rainfall on human health problems/diseases.

6.1 Do you think these changes in temperature, rainfall, wind, and drought and floods cause's human health problems? Please explain

………

………

6.2 What do you think are the reasons for these changes to human health problems?

………

………

7. Local peoples' perceptions of change in temperature, rainfall, wind, and other factors (such as floods, drought) on farming/ agriculture over the last 30 years (see codes below the table).

Climate change components	**a. Have these changes affected the forest? (1=Yes 0=No)**	**b. How have these changes affected your use of the forest?**	**c. How have these changes affected your agricultural production?**	**d. What have you done to deal with these changes in your agricultural production?**	**e. What were constraints/problems to deal with these changes in your agricultural production?**
Changes in Rainfall					
Changes in temperature					
Changes in wind					
Drought events					
Floods events					

Codes:

Codes for 1.1c.	**Codes for 1.1d.**	**Codes for 1.1e.**
1= Low farm income	1= Adopting intercropping	1= Lack of information
2 = Crops dying	2= Changing the planting dates	2= Lack of funds
3 =Livestock dying/diseases	3= Adopting crops rotation	3= Shortage of agricultural inputs/seeds
4 = High costs of production	4= Adopting new crop varieties	4 = Old fashion of available agricultural inputs
5 = None	5= Diversification of production	5 = Lack of access to market
6 = Other specify…………	6= partial abandonment	6 = Lack of enough labour

	7 = No need or No adaptation	7 = Poor infrastructure
	8= Changing irrigation schedule	8 = Lack of access to land
	9= Leasing/selling out part of the farmland	9 = Lack of interest and motivation
	10= Shifting to other crops/plants	10 = High competition
	11= Leasing/selling out entire landholding	11 = Lack of time
	12= Land abandonment	12 = Other specify…………
	13 = Find off-farm job	
	14= Change from crop to livestock	
	15 = Constructing grass strips	
	16= Change from livestock to crop	
	17= Reduce number of livestock	
	18= Using more mineral fertilizers/pesticides	
	19 = Build a water-harvesting scheme	
	20= Adopting new land preparation practices	
	21 = Buy insurance	
	22 = Plant trees for shading	
	23 = Migration	
	24 = Implement soil conservation techniques	
	25 = Other specify…………………..	

8. Have these changes had any positive impact on your economic activities and how?

1Yes	0 No

……..
....

SECTION E: INSTITUTIONAL ARRANGEMENTSFORMAL AND INFORMAL RULES IN MANAGING THE NATURAL FOREST AND ADAPTATION TO CLIMATE CHANGE

1. Are there any formal or informal rules in managing the natural forest? ....

1Yes	0 No

2. If no, you can skip the following table and move to the next question?
3. If yes, what are those rules? Please list them.

Rules	**Who sets the rules**	**Who ensures that users follow them**

4. Do you think that the use of the forest in your community should be monitored, controlled or should be limited?

1Yes	0 No

5. If yes to 3, who do you think who should be involved in monitoring the use of the forest?
....
....

6. Please tick on the table below and rank them, where one (1) represents the most important management.

Management	**Please tick**	**Rank**
Traditional leaders		
Traditional and local political leadership (councillors, chiefs, headmen)		

Local government		
Community members		
Collective action (government, community members, and traditional leaders)		
Other: specify		

1Yes	0 No

7. Do you think there will be constraints in monitoring or managing the forest? ....
8. If yes to 6, what do you think those constraints will be?
   ....
   ....

SECTION F: LIVELIHOOD ADAPTATION STRATEGIES TO COPE WITH CLIMATE CHANGE IN THE WEATHER OR THE SEASONS

1. When your dependency on forest resources is threatened, will you take up new economic activities? ....

1Yes	0 No	Never thought of any but might do

2. If yes, what kind of economic activities would you take up?
   ……
   …………………………………………………………………………………………
3. Please tick in the table below and rank according to your first choice of preference, where one (1) represents the most important.

Livelihood adaptation strategies	**Please tick**	**Rank**
Crop production		
Off-farm activities		
Home gardening		
Informal temporary employment		
Livestock production		
Migration		
Alternative forest		
Others: specify		

4. What constraints do often face in adapting to new economic activities for a living?
   ....
   ....
5. Please give us any comments / inputs in relation to community natural resources, your livelihoods, changes in the weather or the seasons, and change in adaptation strategies in your community.
   ……
   ……………………………………………………………………………………………………….
   ……………………………………………………………………

THANK YOU FOR PARTICIPATING IN THIS STUDY AND KINDLY INFORMING US!

APPENDIX B: ADDITIONAL EMPIRICAL MODEL RESULTS

Appendix B1: Logit-transformed regression results, multicollinearity and heteroscedasticity tests

```
. regress TRANS_SHR MARIT GENDER EDUC VOUCHER LABOURF DPDNT_RATIO FARMINC NUMBERINC UNEARDINC EMPLYINC  ACC_MRKT ACC_
> LAND ASSTS_V LVSTCK_V DISTANCE  CHNG_VST RAINFALL TEMPERATURE

      Source |       SS       df       MS              Number of obs =      99
-------------+------------------------------           F( 18,    80) =    5.41
       Model |  40.2560309    18  2.23644616           Prob > F      =  0.0000
    Residual |  33.0662357    80  .413327946           R-squared     =  0.5490
-------------+------------------------------           Adj R-squared =  0.4476
       Total |  73.3222666    98  .748186394           Root MSE      =  .64291

------------------------------------------------------------------------------
   TRANS_SHR |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MARIT |  -.0007158   .1620427    -0.00   0.996     -.323191    .3217594
      GENDER |  -.0857238   .1860769    -0.46   0.646    -.4560286    .2845811
        EDUC |  -.1359465   .1974592    -0.69   0.493    -.5289028    .2570097
     VOUCHER |   .0002372   .0000976     2.43   0.017     .0000429    .0004315
     LABOURF |   -.003895    .037323    -0.10   0.917    -.0781702    .0703802
 DPDNT_RATIO |  -.0553496   .0608971    -0.91   0.366    -.1765387    .0658395
     FARMINC |   -.116674   .1162341    -1.00   0.319    -.3479873    .1146393
   NUMBERINC |    -.08547   .0954126    -0.90   0.373    -.2753471    .1044072
   UNEARDINC |  -.3724341   .1020304    -3.65   0.000     -.575481   -.1693872
    EMPLYINC |  -.2044591   .0358318    -5.71   0.000    -.2757667   -.1331516
    ACC_MRKT |   .1805742   .1811412     1.00   0.322    -.1799084    .5410567
    ACC_LAND |  -.1585355   .2754459    -0.58   0.567    -.7066902    .3896193
     ASSTS_V |  -.0007231   .0004341    -1.67   0.100    -.0015869    .0001407
    LVSTCK_V |  -3.74e-06   4.98e-06    -0.75   0.455    -.0000137    6.17e-06
    DISTANCE |   .0262248   .0718596     0.36   0.716    -.1167803    .1692299
    CHNG_VST |  -.2418207   .1403001    -1.72   0.089    -.5210268    .0373854
    RAINFALL |   .2580963   .2087423     1.24   0.220     -.157314    .6735066
 TEMPERATURE |   -.424193   .2224975    -1.91   0.060    -.8669771    .0185911
       _cons |   1.385747   .5187931     2.67   0.009      .353316    2.418178
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
        EDUC |      1.86    0.537844
      GENDER |      1.73    0.578399
       MARIT |      1.55    0.644900
    EMPLYINC |      1.40    0.716168
     FARMINC |      1.35    0.741805
    ACC_MRKT |      1.34    0.744739
   NUMBERINC |      1.33    0.754034
     LABOURF |      1.31    0.761372
    ACC_LAND |      1.24    0.805981
 TEMPERATURE |      1.23    0.809843
    RAINFALL |      1.20    0.829997
   UNEARDINC |      1.20    0.830655
 DPDNT_RATIO |      1.20    0.833215
    DISTANCE |      1.16    0.860577
    LVSTCK_V |      1.12    0.892988
    CHNG_VST |      1.12    0.894605
     ASSTS_V |      1.11    0.900124
     VOUCHER |      1.11    0.900216
-------------+----------------------
    Mean VIF |      1.31
```


```
. regress TRANS_SHR MARIT GENDER EDUC VOUCHER LABOURF DPDNT_RATIO FARMINC NUMBERINC UNEARDINC EMPLYINC  ACC_MRKT ACC_
> LAND ASSTS_V LVSTCK_V DISTANCE  CHNG_VST RAINFALL TEMPERATURE

      Source |       SS       df       MS              Number of obs =      99
-------------+------------------------------           F( 18,    80) =    5.41
       Model |  40.2560309    18  2.23644616           Prob > F      =  0.0000
    Residual |  33.0662357    80  .413327946           R-squared     =  0.5490
-------------+------------------------------           Adj R-squared =  0.4476
       Total |  73.3222666    98  .748186394           Root MSE      =  .64291

------------------------------------------------------------------------------
   TRANS_SHR |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       MARIT |  -.0007158   .1620427    -0.00   0.996     -.323191    .3217594
      GENDER |  -.0857238   .1860769    -0.46   0.646    -.4560286    .2845811
        EDUC |  -.1359465   .1974592    -0.69   0.493    -.5289028    .2570097
     VOUCHER |   .0002372   .0000976     2.43   0.017     .0000429    .0004315
     LABOURF |   -.003895    .037323    -0.10   0.917    -.0781702    .0703802
 DPDNT_RATIO |  -.0553496   .0608971    -0.91   0.366    -.1765387    .0658395
     FARMINC |   -.116674   .1162341    -1.00   0.319    -.3479873    .1146393
   NUMBERINC |    -.08547   .0954126    -0.90   0.373    -.2753471    .1044072
   UNEARDINC |  -.3724341   .1020304    -3.65   0.000     -.575481   -.1693872
    EMPLYINC |  -.2044591   .0358318    -5.71   0.000    -.2757667   -.1331516
    ACC_MRKT |   .1805742   .1811412     1.00   0.322    -.1799084    .5410567
    ACC_LAND |  -.1585355   .2754459    -0.58   0.567    -.7066902    .3896193
     ASSTS_V |  -.0007231   .0004341    -1.67   0.100    -.0015869    .0001407
    LVSTCK_V |  -3.74e-06   4.98e-06    -0.75   0.455    -.0000137    6.17e-06
    DISTANCE |   .0262248   .0718596     0.36   0.716    -.1167803    .1692299
    CHNG_VST |  -.2418207   .1403001    -1.72   0.089    -.5210268    .0373854
    RAINFALL |   .2580963   .2087423     1.24   0.220     -.157314    .6735066
 TEMPERATURE |   -.424193   .2224975    -1.91   0.060    -.8669771    .0185911
       _cons |   1.385747   .5187931     2.67   0.009      .353316    2.418178
------------------------------------------------------------------------------
```


```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of TRANS_SHR

         chi2(1)      =     0.29
         Prob > chi2  =   0.5892
```

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B2: Logit-transformed OLS results of relative share of forest income

```
. regress RLTV_SHARE MARIT GENDER EDUC VOUCHER LABOURF DPDNT_RATIO FARMINC NUMBERINC UNEARDINC EMPLYINC  ACC_MRKT ACC
> _LAND ASSTS_V LVSTCK_V DISTANCE  CHNG_VST RAINFALL TEMPERATURE
```

Source	SS	df	MS
Model	3.16748208	18	.175971227
Residual	5.5405814	131	.042294514
Total	8.70806348	149	.058443379

Number of obs =	150
F(18, 131) =	4.16
Prob > F =	0.0000
R-squared =	0.3637
Adj R-squared =	0.2763
Root MSE =	.20566

RLTV_SHARE	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MARIT	.0034858	.0418233	0.08	0.934	-.0792507	.0862224
GENDER	-.0214346	.0447346	-0.48	0.633	-.1099303	.0670612
EDUC	-.0654339	.0485707	-1.35	0.180	-.1615183	.0306505
VOUCHER	.0000919	.0000301	3.05	0.003	.0000324	.0001515
LABOURF	.0018153	.0093413	0.19	0.846	-.0166641	.0202947
DPDNT_RATIO	-.0167984	.0136928	-1.23	0.222	-.043886	.0102892
FARMINC	-.0276688	.0318401	-0.87	0.386	-.0906561	.0353185
NUMBERINC	-.0105321	.0230579	-0.46	0.649	-.0561462	.035082
UNEARDINC	-.0444592	.0242422	-1.83	0.069	-.0924161	.0034977
EMPLYINC	-.0294009	.0090501	-3.25	0.001	-.0473042	-.0114976
ACC_MRKT	.1000352	.0436597	2.29	0.024	.0136659	.1864044
ACC_LAND	-.0323466	.0717499	-0.45	0.653	-.174285	.1095919
ASSTS_V	-2.86e-06	2.18e-06	-1.31	0.191	-7.16e-06	1.45e-06
LVSTCK_V	-1.89e-06	9.36e-07	-2.01	0.046	-3.74e-06	-3.44e-08
DISTANCE	-.0204307	.0155103	-1.32	0.190	-.0511138	.0102524
CHNG_VST	-.1834497	.0374774	-4.89	0.000	-.2575889	-.1093105
RAINFALL	.1004524	.0494784	2.03	0.044	.0025723	.1983324
TEMPERATURE	-.1227176	.0621058	-1.98	0.050	-.2455778	.0001425
_cons	.6173566	.1382891	4.46	0.000	.3437877	.8909255

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B3: Logit-transformed OLS results for the linktest for model specification

```
. regress TRANS_SHR MARIT GENDER EDUC VOUCHER LABOURF DPDNT_RATIO FARMINC NUMBERINC UNEARDINC EMPLYINC  ACC_MRKT ACC_
> LAND ASSTS_V LVSTCK_V DISTANCE  CHNG_VST RAINFALL TEMPERATURE P_hatsq
```

Source	SS	df	MS
Model	40.4623391	19	2.12959679
Residual	32.8599275	79	.41594845
Total	73.3222666	98	.748186394

Number of obs =	99
F(19, 79) =	5.12
Prob > F =	0.0000
R-squared =	0.5518
Adj R-squared =	0.4441
Root MSE =	.64494

TRANS_SHR	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MARIT	.00679	.1629045	0.04	0.967	-.3174634	.3310433
GENDER	-.08155	.1867599	-0.44	0.664	-.4532863	.2901863
EDUC	-.1126041	.2008379	-0.56	0.577	-.5123619	.2871537
VOUCHER	.0002497	.0000995	2.51	0.014	.0000516	.0004478
LABOURF	-.003754	.0374417	-0.10	0.920	-.0782798	.0707718
DPDNT_RATIO	-.058721	.0612771	-0.96	0.341	-.18069	.063248
FARMINC	-.1275243	.1176154	-1.08	0.282	-.361632	.1065833
NUMBERINC	-.1020949	.0985826	-1.04	0.304	-.2983187	.0941288
UNEARDINC	-.4179034	.1210145	-3.45	0.001	-.6587767	-.1770301
EMPLYINC	-.2255507	.0467862	-4.82	0.000	-.3186763	-.1324251
ACC_MRKT	.1854458	.1818462	1.02	0.311	-.1765099	.5474015
ACC_LAND	-.1926164	.2805232	-0.69	0.494	-.7509838	.3657509
ASSTS_V	-.0008828	.000491	-1.80	0.076	-.00186	.0000944
LVSTCK_V	-3.87e-06	5.00e-06	-0.77	0.441	-.0000138	6.08e-06
DISTANCE	.0306265	.0723574	0.42	0.673	-.1133974	.1746503
CHNG_VST	-.2537405	.1417582	-1.79	0.077	-.5359031	.028422
RAINFALL	.3153171	.2246128	1.40	0.164	-.1317635	.7623977
TEMPERATURE	-.4740096	.234142	-2.02	0.046	-.9400575	-.0079617
P_hatsq	.113677	.1614114	0.70	0.483	-.2076043	.4349583
_cons	1.519391	.5539515	2.74	0.008	.4167777	2.622003

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B4: The correlation matrix

```
. corr TRANS_SHR MARIT GENDER EDUC VOUCHER LABOURF DPDNT_RATIO FARMINC NUMBERINC UNEARDINC EMPLYINC  ACC_MRKT ACC_LAN
> D ASSTS_V LVSTCK_V DISTANCE  CHNG_VST RAINFALL TEMPERATURE
(obs=99)
```

	TRANS_~R	MARIT	GENDER	EDUC	VOUCHER	LABOURF	DPDNT_~O	FARMINC	NUMBER~C	UNEARD~C	EMPLYINC
TRANS_SHR	1.0000										
MARIT	0.0513	1.0000									
GENDER	0.0623	0.4802	1.0000								
EDUC	-0.1189	-0.1798	-0.5151	1.0000							
VOUCHER	0.1807	0.0018	0.1130	-0.0913	1.0000						
LABOURF	-0.0448	0.0559	-0.2793	0.3859	-0.0160	1.0000					
DPDNT_RATIO	-0.0367	-0.1558	-0.2156	0.2130	0.0318	-0.1789	1.0000				
FARMINC	-0.1891	-0.1074	0.0265	-0.0434	-0.2043	0.0140	-0.0564	1.0000			
NUMBERINC	-0.3344	0.0451	0.1022	-0.0525	-0.0622	0.0206	-0.0479	0.2979	1.0000		
UNEARDINC	-0.3430	-0.0743	-0.1509	0.0993	-0.1153	0.0421	0.1120	0.0441	0.0114	1.0000	
EMPLYINC	-0.4723	-0.0789	-0.0149	0.0563	0.1619	-0.0021	-0.0310	0.0680	0.3269	-0.1814	1.0000
ACC_MRKT	0.0496	-0.2300	-0.2364	0.3909	0.0322	0.1507	0.1520	0.0914	-0.1082	-0.0650	-0.0299
ACC_LAND	-0.0202	0.1998	0.1681	-0.3149	0.0736	-0.1283	0.0031	0.0057	-0.0287	-0.0362	0.0194
ASSTS_V	-0.3399	-0.1324	-0.1179	0.0290	-0.0881	0.0236	-0.0500	0.1661	0.2681	0.2627	0.1051
LVSTCK_V	-0.1293	-0.0508	-0.0256	-0.1187	0.0263	-0.0197	-0.1632	0.0573	0.1035	0.0793	0.0662
DISTANCE	-0.0178	-0.1627	-0.1630	-0.0926	0.1997	0.0272	0.0405	-0.1653	-0.1136	-0.0350	0.2223
CHNG_VST	-0.0032	-0.0106	0.1041	-0.0349	-0.0378	0.1155	-0.0811	0.0058	0.0282	-0.0093	-0.1908
RAINFALL	0.1580	-0.0085	-0.0288	-0.0852	-0.0292	0.0407	0.1025	-0.0500	0.0192	-0.0667	-0.1572
TEMPERATURE	-0.1882	0.0429	-0.1280	0.1586	0.0576	0.1391	0.0308	-0.2127	-0.0844	0.2036	0.0337

	ACC_MRKT	ACC_LAND	ASSTS_V	LVSTCK_V	DISTANCE	CHNG_VST	RAINFALL	TEMPER~E
ACC_MRKT	1.0000							
ACC_LAND	-0.1560	1.0000						
ASSTS_V	0.1263	0.0240	1.0000					
LVSTCK_V	0.0776	0.0697	0.1726	1.0000				
DISTANCE	0.0148	0.1401	0.1049	0.1894	1.0000			
CHNG_VST	0.1230	-0.0255	-0.0686	0.0247	-0.1290	1.0000		
RAINFALL	0.0021	0.0057	-0.0859	0.0726	0.1577	0.1608	1.0000	
TEMPERATURE	0.1284	-0.0391	0.1056	0.0825	0.1421	-0.0605	0.2163	1.0000

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B5: The marginal effects for Logit transformed OLS using Stata's 'protab'

Value of TEMPERATURE	Predicted Proportions
0	.3231192
1	.23800162

Value of EMPLYINC	Predicted Proportions
0	.404082
1	.35595957
2	.31058122
3	.26857537
4	.23035253
5	.19611093
6	.16586239

```
. protab  UNEARDIN
```

Value of UNEARDINC	Predicted Proportions
0	.37897694
1	.29601916
2	.22465172
3	.16642275

Value of CHNG_VST	Predicted Proportions
0	.3045118
1	.25583599

```
151-user Stata network perpetual license:
       Serial number:  30110517083
         Licensed to:  UKZN3361
                       UKZN3361

Notes:
      1.  (/m# option or -set memory-) 10.00 MB allocated to data

. use "G:\Data\NEW RESULTS\OLS MODEL3.dta"

. summarize RLTVSHARE
```

Variable	Obs	Mean	Std. Dev.	Min	Max
RLTVSHARE	150	.2645514	.2417507	0	.7905688

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B6: Multinomial logit coefficient and marginal effect estimates

Multinomial logistic regression — Number of obs = 150
Wald chi2(20) = 78.42
Prob > chi2 = 0.0000
Log pseudolikelihood = -74.943347 — Pseudo R2 = 0.4140

LIVADAPS	Coef.	Robust Std. Err.	z	P>|z|	[95% Conf.	Interval]
livelihood~o	(base outcome)					
No_livelih~g						
AGE	-.0107765	.0288457	-0.37	0.709	-.0673131	.0457601
GENDER	-.8998178	.835564	-1.08	0.282	-2.537493	.7378577
EDUC	-.6569632	1.13235	-0.58	0.562	-2.876329	1.562402
INC_ABVE	-1.392923	.8381967	-1.66	0.097	-3.035758	.2499122
ABOVE15	.1292773	.1812661	0.71	0.476	-.2259976	.4845522
ACC_MRKT	-.7923781	.8552605	-0.93	0.354	-2.468658	.8839017
ASSTS_V	-.0000208	.000016	-1.30	0.195	-.0000522	.0000106
LAND_OWN	-.0562467	.3815655	-0.15	0.883	-.8041013	.6916079
RAINFALL	-7.94142	1.13176	-7.02	0.000	-10.15963	-5.723211
TEMPERATURE	-2.196926	1.402965	-1.57	0.117	-4.946686	.5528348
_cons	6.713425	2.648442	2.53	0.011	1.522574	11.90428
livelihood~s						
AGE	-.0162735	.0204329	-0.80	0.426	-.0563213	.0237743
GENDER	-1.417935	.6207983	-2.28	0.022	-2.634677	-.2011922
EDUC	-1.22771	.6532764	-1.88	0.060	-2.508108	.052688
INC_ABVE	-1.541525	.6292923	-2.45	0.014	-2.774916	-.3081349
ABOVE15	.0271308	.1341131	0.20	0.840	-.235726	.2899877
ACC_MRKT	.3495595	.6885314	0.51	0.612	-.9999372	1.699056
ASSTS_V	-.002288	.0016888	-1.35	0.175	-.005598	.001022
LAND_OWN	.4623522	.2529984	1.83	0.068	-.0335156	.95822
RAINFALL	-6.070762	1.193776	-5.09	0.000	-8.410521	-3.731004
TEMPERATURE	-1.957175	.8572805	-2.28	0.022	-3.637414	-.2769358
_cons	7.311428	2.257937	3.24	0.001	2.885953	11.7369

.

Marginal effects after mlogit
y = Pr(LIVADAPS==No_livelihood_adaptation_strateg) (predict, outcome(2))
= .05923527

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
AGE	-.0005366	.00164	-0.33	0.743	-.003742	.002669	54.8467
GENDER*	-.046057	.05058	-0.91	0.363	-.1452	.053086	.58
EDUC*	-.0297727	.05105	-0.58	0.560	-.129828	.070282	.333333
INC_ABVE*	-.0711555	.05297	-1.34	0.179	-.174978	.032667	.473333
ABOVE15	.0070976	.00934	0.76	0.447	-.011208	.025404	4.81333
ACC_MRKT*	-.054227	.06637	-0.82	0.414	-.184306	.075852	.726667
ASSTS_V	7.83e-06	.00000	1.62	0.105	-1.6e-06	.000017	894.633
LAND_OWN	-.0049511	.0212	-0.23	0.815	-.046511	.036609	.941867
RAINFALL	-.418694	.19103	-2.19	0.028	-.7931	-.044288	.77
TEMPER~E	-.1147368	.08407	-1.36	0.172	-.279512	.050038	.58

(*) dy/dx is for discrete change of dummy variable from 0 to 1

. mfx, predict(outcome(3))

Marginal effects after mlogit
y = Pr(LIVADAPS==livelihood_adaptation_strategy_s) (predict, outcome(3))
= .06633196

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
AGE	-.0009655	.00147	-0.66	0.511	-.003844	.001913	54.8467
GENDER*	-.0957407	.09784	-0.98	0.328	-.287495	.096013	.58
EDUC*	-.064232	.06547	-0.98	0.327	-.192551	.064087	.333333
INC_ABVE*	-.090548	.10133	-0.89	0.372	-.289157	.108061	.473333
ABOVE15	.0011723	.00783	0.15	0.881	-.014174	.016519	4.81333
ACC_MRKT*	.0234467	.03765	0.62	0.533	-.050343	.097236	.726667
ASSTS_V	-.0001416	.00005	-2.86	0.004	-.000239	-.000044	894.633
LAND_OWN	.0288554	.02955	0.98	0.329	-.029052	.086763	.941867
RAINFALL	-.3447713	.32582	-1.06	0.290	-.983365	.293823	.77
TEMPER~E	-.1125797	.11638	-0.97	0.333	-.340673	.115514	.58

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B7: Diagnostics to assess the degree of multicollinearity and heterscedasticity for MNL model

```
. regress LIVADAPS AGE GENDER EDUC  INC_ABVE   ABOVE15 ACC_MRKT  LAND_OWN ASSTS_V RAINFALL TEMPERATURE

      Source |       SS       df       MS              Number of obs =     150
-------------+------------------------------           F( 10,   139) =    9.42
       Model |  43.1025769    10  4.31025769           Prob > F      =  0.0000
    Residual |  63.5907564   139  .457487456           R-squared     =  0.4040
-------------+------------------------------           Adj R-squared =  0.3611
       Total |  106.693333   149   .71606264           Root MSE      =  .67638

------------------------------------------------------------------------------
    LIVADAPS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         AGE |  -.0026448   .0046636    -0.57   0.572    -.0118657     .006576
      GENDER |  -.2361142   .1217278    -1.94   0.054    -.4767917    .0045634
        EDUC |  -.2623854   .1453212    -1.81   0.073    -.5497112    .0249405
    INC_ABVE |  -.3066166   .1129792    -2.71   0.007    -.5299966   -.0832367
     ABOVE15 |  -.0100595   .0290129    -0.35   0.729    -.0674232    .0473042
    ACC_MRKT |   .0756069   .1383941     0.55   0.586    -.1980228    .3492366
    LAND_OWN |   .0741957   .0524487     1.41   0.159    -.0295046     .177896
     ASSTS_V |  -6.31e-06   6.93e-06    -0.91   0.364      -.00002    7.39e-06
    RAINFALL |   -1.24419   .1557713    -7.99   0.000    -1.552177    -.936202
 TEMPERATURE |  -.3412662   .1941099    -1.76   0.081     -.725056    .0425236
       _cons |   3.173132   .3504745     9.05   0.000     2.480181    3.866082
------------------------------------------------------------------------------

. estat vif

    Variable |       VIF       1/VIF
-------------+----------------------
        EDUC |      1.54    0.649894
    ACC_MRKT |      1.25    0.801724
         AGE |      1.20    0.836703
      GENDER |      1.18    0.844950
 TEMPERATURE |      1.12    0.896737
    RAINFALL |      1.10    0.905790
     ABOVE15 |      1.05    0.952211
    INC_ABVE |      1.04    0.958491
     ASSTS_V |      1.04    0.959139
    LAND_OWN |      1.04    0.963526
-------------+----------------------
    Mean VIF |      1.16
```


```
. regress LIVADAPS AGE GENDER EDUC  INC_ABVE   ABOVE15 ACC_MRKT  LAND_OWN ASSTS_V RAINFALL TEMPERATURE

      Source |       SS       df       MS              Number of obs =     150
-------------+------------------------------           F( 10,   139) =    9.42
       Model |  43.1025769    10  4.31025769           Prob > F      =  0.0000
    Residual |  63.5907564   139  .457487456           R-squared     =  0.4040
-------------+------------------------------           Adj R-squared =  0.3611
       Total |  106.693333   149   .71606264           Root MSE      =  .67638

------------------------------------------------------------------------------
    LIVADAPS |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         AGE |  -.0026448   .0046636    -0.57   0.572    -.0118657     .006576
      GENDER |  -.2361142   .1217278    -1.94   0.054    -.4767917    .0045634
        EDUC |  -.2623854   .1453212    -1.81   0.073    -.5497112    .0249405
    INC_ABVE |  -.3066166   .1129792    -2.71   0.007    -.5299966   -.0832367
     ABOVE15 |  -.0100595   .0290129    -0.35   0.729    -.0674232    .0473042
    ACC_MRKT |   .0756069   .1383941     0.55   0.586    -.1980228    .3492366
    LAND_OWN |   .0741957   .0524487     1.41   0.159    -.0295046     .177896
     ASSTS_V |  -6.31e-06   6.93e-06    -0.91   0.364      -.00002    7.39e-06
    RAINFALL |   -1.24419   .1557713    -7.99   0.000    -1.552177    -.936202
 TEMPERATURE |  -.3412662   .1941099    -1.76   0.081     -.725056    .0425236
       _cons |   3.173132   .3504745     9.05   0.000     2.480181    3.866082
------------------------------------------------------------------------------
```


```
. estat hettest

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: fitted values of LIVADAPS

         chi2(1)      =     0.65
         Prob > chi2  =   0.4190
```

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B8: The MNL results of correlation matrix coefficients

```
. pwcorr LIVADAPS AGE GENDER EDUC INC_ABVE ABOVE15 ACC_MRKT  ASSTS_V LAND_OWN RAINFALL TEMPERATURE, sig

             | LIVADAPS      AGE   GENDER     EDUC INC_ABVE  ABOVE15 ACC_MRKT
-------------+---------------------------------------------------------------
    LIVADAPS |   1.0000
             |
         AGE |  -0.0628   1.0000
             |   0.4454
      GENDER |  -0.0461  -0.2365   1.0000
             |   0.5751   0.0036
        EDUC |  -0.0447   0.3525  -0.3438   1.0000
             |   0.5869   0.0000   0.0000
    INC_ABVE |  -0.1695   0.0329  -0.0319   0.0944   1.0000
             |   0.0381   0.6895   0.6982   0.2505
     ABOVE15 |  -0.0808  -0.0579  -0.0745   0.0459   0.1113   1.0000
             |   0.3255   0.4816   0.3649   0.5769   0.1753
    ACC_MRKT |  -0.0088   0.1453  -0.1582   0.4337   0.0122   0.0717   1.0000
             |   0.9154   0.0761   0.0532   0.0000   0.8824   0.3834
     ASSTS_V |  -0.0558   0.0139  -0.0982  -0.0576  -0.0759   0.0528   0.0519
             |   0.4977   0.8661   0.2319   0.4840   0.3562   0.5213   0.5281
    LAND_OWN |   0.1019   0.0990  -0.0304   0.0677   0.0831  -0.1005   0.0128
             |   0.2146   0.2279   0.7121   0.4103   0.3119   0.2212   0.8766
    RAINFALL |  -0.5670  -0.0018  -0.0359  -0.1139  -0.0061   0.0464  -0.0173
             |   0.0000   0.9827   0.6628   0.1652   0.9410   0.5727   0.8339
 TEMPERATURE |  -0.2599   0.1137  -0.0656   0.0235  -0.0747   0.0653   0.0388
             |   0.0013   0.1659   0.4248   0.7750   0.3639   0.4273   0.6370
             |

             |  ASSTS_V LAND_OWN RAINFALL TEMPER~E
-------------+------------------------------------
     ASSTS_V |   1.0000
             |
    LAND_OWN |  -0.0702   1.0000
             |   0.3932
    RAINFALL |   0.0488  -0.0306   1.0000
             |   0.5532   0.7099
 TEMPERATURE |  -0.0200  -0.0693   0.2686   1.0000
             |   0.8077   0.3991   0.0009
             |

.
```

Source: Survey data (Mid-April to Mid-May 2013) and STATA version 11 software package

Appendix B9: Labour endowments calculations in adult equivvalent

Labour category	Task					
	Clearing	Hoe-ridging	Leading bullocks	Planting	Weeding	Harvesting
	adult-male equivalent					
Males						
6-9 years	0.10	0.10	0.35	0.41	0.10	0.35
10-15 years	0.75	0.75	0.95	0.90	0.85	0.85
15-55 years	1.00	1.00	1.00	1.00	1.00	1.00
> 55 years	0.50	0.50	0.70	0.65	0.65	0.65
Females						
6-9 years	0.00	0.00	0.25	0.41	0.10	0.35
10-15 years	0.40	0.35	0.75	0.90	0.65	0.90
15-55 years	0.75	0.65	0.85	1.00	0.80	1.00
> 55 years	0.45	0.25	0.00	0.81	0.45	0.85

Source: Atkinson (1995) cited FAO (2005) and OECD (1982)