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NATURAL INSURANCE, CONSERVATION OF FORESTS AND POVERTY REDUCTION IN THE SEMI-ARID REGION OF TIGRAY, NORTHERN ETHIOPIA

Thesis presented by

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ABSTRACT

This study deals with the interaction of vulnerability to shocks, conservation intervention and poverty reduction using a survey of households living along the margins of forests in the semi-arid region of Tigray, Ethiopia. Five major conclusions that have wider policy implications are derived from this study. First, forest environmental resources provide a natural insurance for households vulnerable to idiosyncratic and covariate risks in rural Tigray, enforcing the widely held view that forests are important as economic buffer in hard times. Second, even if forests provide the food security and income they may perpetuate poverty. Third, households in rural Tigray are not driven into forest extraction for coping shocks only but also by diversification strategy, suggesting that the problem for local communities has both the characteristics of portfolio analysis and economics of insurance. Fourth, forest incomes decrease the incidence of poverty while it increases income inequality in rural Tigray. Finally, we find that the Productive Safety Net Program (PSNP) in Tigray contributes in pursuing the twin goals of poverty reduction and conservation of forests that have often been portrayed as opposing goals.

One important policy implication of this study is that government, policy-makers and natural resource managers need to acknowledge the livelihood safety- net role that forests play in rural livelihoods and recognize that environmental protection policies limiting or banning access and use of forest resources can deepen rural poverty. However, while more intensive forest management to increase accessibility of forest resources is itself a possible strategy, we must be cautious as to who would gain and who would lose from such activities. Finally, the study underlines the importance of promotion of public safety nets such as the Productive Safety Net Program (PSNP), and the promotion of government programmes and policies that increase the

productivity of agricultural production and support diversification into off-farm livelihood and income sources to provide positive incentives for forest conservation and sustainable use.

Key Words: forests, shocks, safety nets, poverty trap, heterogeneity, counterfactual income, propensity score matching, endogenous switching, Tigray, Ethiopia

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LIST OF ABBREVIATIONS

ADB	African Development Bank
ADLI	Agricultural Development Led Industrialization
ATT	Average Treatment of the Treated
BOFED	Bureau of Finance and Economic Development
CBADLI	Conservation Based Agricultural Development Led Industrialization
CBAD	Conservation Based Agricultural Development Strategy
CIA	Central Intelligence Agency
CPR	Common Pool Resources
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
FGT	Foster, Greer and Thorebecke
FHAPCO	Federal HIV/ AIDS Prevention and Control Office
FIML	Full Information Maximum Likelihood
FMOH	Federal Ministry of Health
FSP	Food Security Program
GTP	Growth and Transformation Plan
HRFA	High Return Forest Activities
LRFR	Low Return Forest Resources
M.a.s.l	Meter above Sea level
MDG	Millennium Development Goals
NFPA	National Forest Priority Areas
NTFP	Non – Timber Forest Products

OLS	Ordinary Least Square Estimation
PASDEP	Plan for Accelerated and Sustainable Development to End Poverty
PSM	Propensity Score Matching
PSNP	Productive Safety Net Program
RFPA	Regional Forest Priority Areas
SOPRP	Sustainable Development and Poverty Reduction Program
TRBPF	Tigray Region Bureau of Plan and Finance
WHO	World Health Organization of the United Nations

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DECLARATION

I hereby declare that this thesis submitted is my own work and has not been submitted for another degree, either at University College Cork or elsewhere.

Signed,

Nigussie Abadi

May 2017

CHAPTER ONE

INTRODUCTION

1.1. Background of the Thesis

Poor people often depend on biodiversity both for their livelihoods and as a safety net against deeper poverty (IIED, 2010).Moreover, of the 1.2 billion people estimated to live on less than US$ 1 a day (i.e. those that are the target of MDG1), 70% live in rural areas with a high dependence on natural resources for all or part of their livelihoods (http://www.tanzaniagateway.org/docs/MDGs_and_natural_resources_management_sustainable_livelihoods_resource.pdf). This direct dependence on services from ecosystems is highest amongst people living in arid and semi-arid lands such as Tigray where alternative livelihood options areoften limited and environments are particularlyfragile and risky (MA 2005b cited in Shackleton et al.2008).

Forest environmental resources play a significant role in the livelihoods of rural communities in Ethiopia (Mamoet al.2007, Babulo et al., 2009). Forest environmental income also accounts for 27% of the total household income on average, the second largest household income share next to crop income having a share of 43% in rural Tigray (Babulo et al. 2009). However, forests are also sensitive ecosystems that are threatened by human interventions. As in many other parts of the developing world, forests in Ethiopia, particularly in Tigray[1], suffer from extreme land degradation

[1]Between 1990 and 2000, 141,000 ha of forest were lost every year, which equals an average annual deforestation rate of 0.93%. Then between 2000 and 2005, the rate of deforestation increased by 10.4% to 1.03% per year , which totals to 14% (or around 2,114,000 hectares) of forest cover loss in the 15 years between 1990 and 2005(FAO, 2007)

and deforestation. High population growth combined with conversion of forests to agricultural land (Nayssen et al., 2004; Mokria et al., 2009), high dependency on biomass energy (Hagoset al.1999; Gebreegziher 2007) and free grazing (Feoli et al.2002) are the major causes of forest degradation in the region.

Since 1994, the current Ethiopian government has embarked on an economic development strategy known as Agricultural Development – Led industrialization (ADLI) (MOFED, 2002). In line with this national framework, the Tigray region is following a Conservation –Based Agricultural Development –Led Industrialization (CBADLI) strategy to achieve food security and reduce poverty (BOPED, 1995), while giving greater emphasis on community participation and mobilization of local resources in environmental rehabilitation (Tesfay , 2006)[2].

One of the major strategies of environmental rehabilitation in Tigray includes area enclosures and the establishment of community woodlots for ecological regeneration (Nyssen et al., 2009, Mokriaet al.,2003; Gebremedhin et al., 2000). In addition to enclosures, the regional government in Tigray created restrictions on the use of certain tree species that are enforced by the development agents who are assigned to each village for this purpose (Howard and Smith, 2006;Tesfay 2006; Gebreegzabher, 2007). However, despite many researchers such as those(Nyssen et al., 2009; and Mokria et al., 2009)and the international community alike[3]putting forward the positive environmental outcomes such a strategy , it is viewed by many as a constraint for achieving poverty reduction (Berhanu 2004; Howard and Smith 2006 and Geberemedhin et al. 2000), equity within

[2]A review of the recent history of devolution in forestry indicates undeniably that the area of land — although not necessarily forests — managed under devolved and community-based forest management (CBFM) systems has dramatically increased in many countries (White and Martin 2002). However, while devolution of forestry benefits the poor in some countries, it is also remained to be prone to be captured by local elites as any other valuable local resources (see for example,Malla et al., 2003 and Mahanty et al., 2006).

[3]Abriha Atsbiha a grass root environmental management program in the region has won the prestigious 2012 UNDP equator Prize

and between communities (Chisholm, 2000; Howard and Smith, 2006 ;and Nedassa et al., 2005) which calls into question whether results achieved are sustainable from an economic or environmental stand point (Nedassa et al., 2005 cited in Howard and Smith, 2006).

Over all, two overarching problems have been identified concerning the issues of common pool resources (CPR) management in Tigray (Howard and Smith, 2006): the first is the possibility to halt degradation and sustainably regenerate vegetative resources, and the second is the need to generate livelihood resources that can help to alleviate poverty, food insecurity and continued degradation in the area(Howard and Smith,2006). The general conclusion is that the conservation of common pool resources (CPR) and the poverty and food security aspects are linked. The CPR has been depleted due to drought and overuse, and has been overused because of changes in institutional and individual access rights[4] (Howard and Smith, 2006). However, this over use of the common pool resources such as forests may constitute a poverty trap as a result of a tragedy of the commons (Hardin 1968). Too many households in rural Tigray are in need of the resources and the resources cannot provide enough to properly insure all the population. They face thus the classic poverty- environment nexus, where poor people depend on the environment, and over use it (Delacote, 2007).The resultant increased pressure often has a negative feedback on the capacity of the ecosystems to deliver these services and create a downward spiral of increasing poverty and ecosystem degradation (Shackleton et al.2008) and this dependence of the poor on the fragile open access may confirm the suggestion in some recent literature (e.g. Angelsen and Wunder, 2003; Lavange, 2005, Delacote, 2007) of a resource based "poverty trap". The key issue is therefore, to

[4]With the exception of restrictions on certain woody species, most common land across the highlands is de-facto open access since rights regimes around them are lacking or ill-defined. On the other hand, the restrictions in place in enclosures, while increasing the availability of certain resources, generate greater pressure on these open areas (Howard and Smith, 2006)

present the conservation intervention and the dependence on forests as safety nets in locations where they are more than dead –end poverty traps.

Central to these issues is a greater perception and nuanced appreciation of (a) what is meant by poverty alleviation in relation to natural resources , distinguishing between poverty prevention or mitigation ; (b) the links between natural resources dependence and the potential of the natural resource to provide the pathways out of poverty; (c) the safety net of the forest resources and when and how might translate into poverty trap, (d) the extent to which opportunities associated with forest management can be made more pro-poor and thus contribute to the efforts to combat poverty and vulnerability, and (e) the role of social protection measures to provide win –win outcomes for conservation and poverty reduction etc. This research is therefore to address these issues in the context of Tigray Regional state of Ethiopia.

1.2. Objectives of the Study

The general objectives of the research are to contribute to the existing stock of knowledge on the contributions of forest environmental resources to the livelihood of rural households, on managing the trade-offs between conservation of forests and poverty reduction and on the methodological challenges in reaching conclusions on the links between forest biodiversity and poverty using survey of households living along the margins of forests in the region of Tigray, northern Ethiopia.

Specifically, the objectives of the research are:

1) To investigate the role of forest environmental resources as natural insurance for coping with shocks
2) To investigate the contribution of forest environmental resources for food security and household incomes

3) To analysethe contribution of forest environmental resources for povertyreduction and distribution of income

4) To investigate the role ofthe ProductiveSafetyNet Program (PSNP) in Ethiopia to reconcile poverty reduction and conservation of forest ecosystems.

1.3. Research Issues

The first topic deals with*therole of forests for coping with health related shocks*. The question is how idiosyncratic health related shocks affect the allocation of labour into forests and the forest dependency of households living along the margins of forests in the semi-arid region of Tigray, Ethiopia.

The second issue of this research addresses the *link between forests and food security of smallholder farmers along the margins of forests*. An attempt is made to explicitly focus on food security indicators, instead of restricting to annualized income in which the temporary contribution of forests do not always feature as significant. In addition, this research identifies the implication of forest - food security linkages on the long term livelihood outcome of the smallholder farm households. The main research questions in this respect are: Do forests contribute to food security of farm households? If yes, what are the characteristics of farm households who are dependent on forests for food security? Does diversification or coping strategy motivate farm households to participate in forest environmental resource extraction? What is the implication of forest dependency on the long term livelihood outcome of the smallholders?

The third issue is related to the second issue but deals with the *contribution of forest environmental resources commercialization to the annualized income of households and with the methodological challenge in measuring the contribution of forests*.The conventional wisdom on the dependence

on forest environmental resources claims that the poor tend to depend on forests disproportionately. However, where commercial production and sales are involved, this relationship may be reversed (Vira and Kontoleon, 2010). Moreover, the household decision to participate in forest environmental resource commercialization is one of the potential sources of endogeneity in household income. The purpose of this paper is to investigate the effects of participation in forest environmental resource commercialization on welfare of households. We examine three empirical questions that are central to forests and the household welfare debate. First, does participating in forest environmental resource commercialization contribute to household income? If it does, then failing to account for differences in participation in income modelling will lead to biased parameter estimates and misleading information for policy analysis. Second, does household income actually differ between households that participated and did not participate in forest environmental resource commercialization? Third, would household income change if all households participated? While the answer to the second question is directly observable, the last question requires an analysis that accounts for the effects of participation in forest environmental resource commercialization and other unobservable factors that may influence household income. These unobservable factors may play an important role in anticipating the potential outcomes from policies designed to influence household income.

The fourth issue that this study addresses relates to the contribution of *forest environmental resources to poverty and distribution of income under the current conservation intervention in rural Tigray*. It aims to consider the interdependency of participation in forest environmental resources extraction and other household characteristics before decomposing the poverty and inequality indicators that previous studies on the area of forest income, poverty and inequality have neglected.

Finally, the fifth issue that this study deals withis the impact of social protection programs such as the *Productive safety Net Program (PSNP) in Ethiopia to reduce the cost of ex-ante risk management such as depleting forests from commons in the semi-arid region of Tigray*. It aims to investigate whether the PSNP could provide a win-win for the goals of poverty reduction and conservation of forest environmental resources.

These five issues addressed in this study provide an in-depth insight into the poverty –environment nexus in the semi- arid region of Tigray and in finding a win- win for poverty reduction and conservation of the environment.

1.4. Organization of the thesis

The motivations for, and major issues addressed in this PhD thesis are explained briefly in the preceding sections of this chapter. The subsequent chapters of this study are organized as follows:

Chapter 2 briefly provides the setting of the research area focusing on the economic situation, environment and the development and natural resource management policies and strategies in Ethiopia, and the Tigray region in particular. It also provides a description of the research methodology and analytical approaches of the research.

Chapter 3 investigates household allocation of labour for coping with health related shock and forest dependency in rural Tigray. Because illness is not exogenous, the analysis uses an Instrumental Variables approach and the Propensity Score Matching (PSM) method that capture several dimensions of illness.

Chapter 4 focuses on the forest-food security linkage in rural Tigray and its implication in the long term livelihood outcome of smallholder farm households. We use propensity score matching

methods to account for a selection bias that normally occurs when unobservable factors influence both the participation in forest environmental resources extraction and food security outcomes.

Chapter 5 investigates the driving forces behind rural households' decisions to participate in forest environmental resource commercialization and the impact of the participation in commercialization of forests on the income of the households in rural Tigray. We estimate a simultaneous equations model with endogenous switching (following Di-falco and Veronesi, 2010) to account for the heterogeneity in the decision to participate in forest environmental resource commercialization or not, and for unobservable characteristics of households.

Chapter 6 focuses on the contribution of income from forest environmental resources on poverty and distribution of income in semi-arid region of Tigray under the existing forest management regime. Counterfactual incomes are estimated based on the endogenous switching regression model applied in chapter five, taking into account what the participant group of households would have earned had they not participated. The results are compared with alternative income estimates in which forest income is treated simplistically as exogenous income.

Chapter 7 investigates the potential of Productive Safety Net Program (PSNP) in Ethiopia to provide a win-win for poverty reduction and conservation of forests.

Chapter 8 discusses the major findings and outlines the main conclusions from this study. It draws out major policy implications and discusses issues for further research.

CHAPTER TWO

THE SOCIO-ECONOMIC SETTING OF THE STUDY AREA AND RESEARCH APPROACH

2.1. Location, Demography and Natural Conditions

Tigray is the northern most region of Ethiopia located at latitude of 12 to 15 degree North and Longitude of 36 c 30" to 41 30" East and covers an area of 53,000 square kilometres (Hagos et al., 1999; and Tesfay, 2006). Tigray's population is around 4.3 million and growing at 2.5 percent, where 80.5 percent resides in rural areas **(**Howard and Smith, 2006**).** Administratively, the region has 35 *woredas*, 12 town woredas , and 665 *tabias*. Each woreda is subdivided into tabias and each tabia is divided into *kushets*(Babulo, 2007)

The landform of the region is complex, composed of highlands (2300-3200 meter a.s.l) ,Lowland plains (500-1500 M), mountain peaks (as high of 3935 m), and high to moderate relief hills(1600-2200 m). By virtue of the complexities in topography, the region has diversified agro-ecological zones and niches, each with distinct soil, geology, vegetation cover, and natural resources (Taffere, 2003). Tigray is relatively dry and is subject to frequent drought (Howard and Smith 2006). Average annual rainfall ranges between 500 and 900 mm yr^{-1}, with a unimodal pattern except in the southern and eastern highlands where a second, smaller rainy season allows local growing of two successive crops within one year (Nyssen et al., 2005). Taking into account rainfall, atmospheric temperature, and evaporation, more than 90 % of the region is categorized as semi–arid (Taffere, 2003)

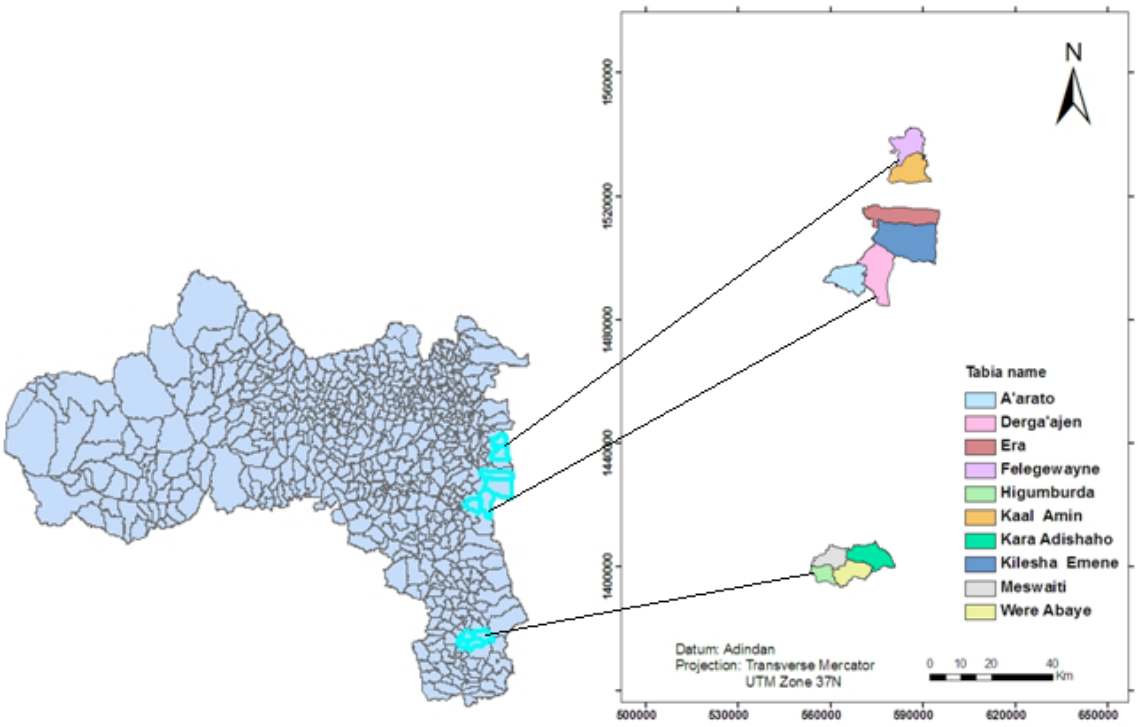
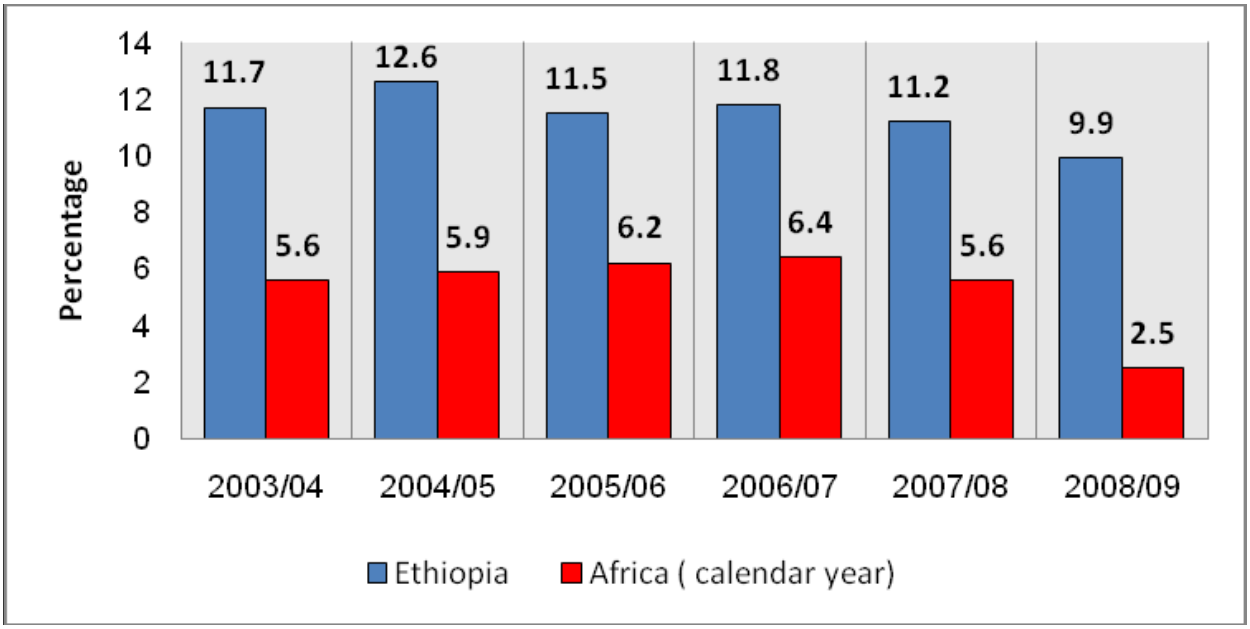


Figure 1. 1 Map of the study area

2.2. Socio- Economic Aspects

2.2.1. The Economy

Ethiopia has experienced strong economic growth in recent years. With real GDP growth at or near double digit levels since 2003/04, the country has consistently outperformed most other countries in Africa and expanded much faster than the continent –wide average (Figure 2). Real GDP growth averaged 11.2% per annum during the 2003/04 and 2008/09 period, placing Ethiopia among the top performing economies in Sub-Saharan Africa (ADB, 2010).



Source: ADB 2010

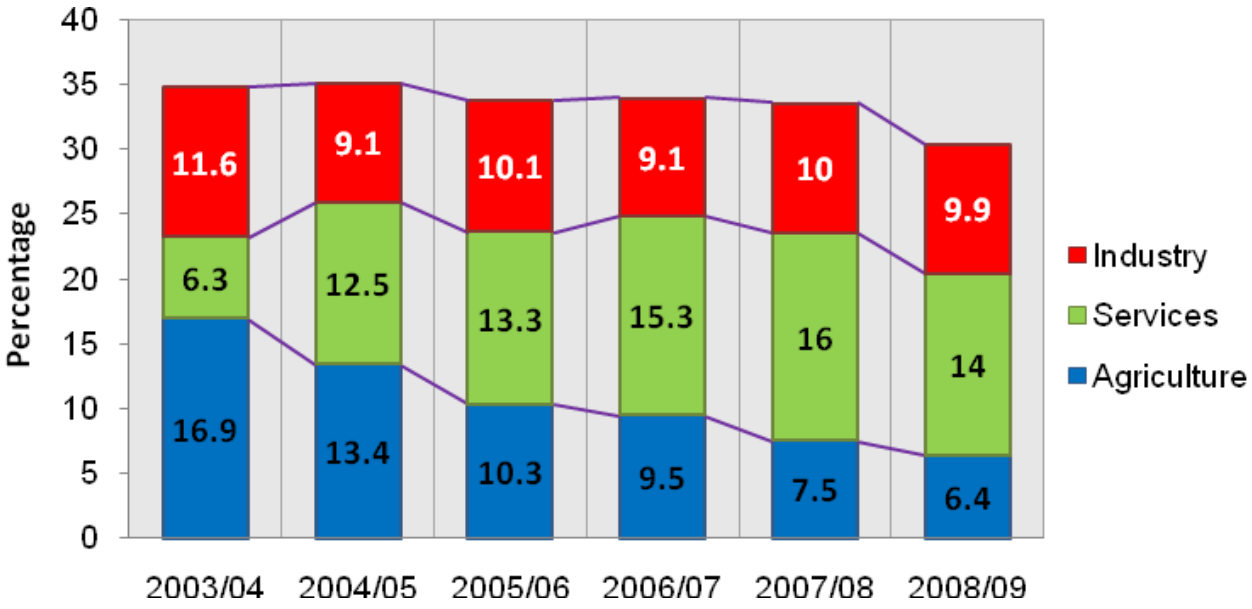
Figure 1. 2 GDP Growth Rate Comparison

Although the growth performance has been encouraging, the country exhibits the highest rate of inflation[5] in its history (CIA, 2009) and low international reserves (ADB, 2010) in the same period. High inflation is not only constraining growth but also represents a heavy tax burden on the poor and is eroding the gains made under the donor-funded social protection and social safety net programs (World Bank 2011). In addition despite the performance of the economy in recent years a number of issues warrant attention.

Ethiopia's economy is highly dependent on primary commodities and rain fed agriculture and thus is highly vulnerable to the vagaries of weather. Ethiopia has experienced no less than five major national droughts since 1980 and several local droughts (Yosuf et al., 2008). Agriculture accounts

[5] The driving forces behind the high general inflation rate in Ethiopia have been extensively discussed by the IMF (2008).

for about 40 % of national GDP, 90 % of exports, and 85% of employment (Di-Falco et al.,2011). There is also a strong correlation between weather conditions and Ethiopian's growth performance. A change of 1 percent in average annual rainfall is associated with a change of 0.3 percent in real GDP in the following year (ADB, 2010). Only about 10 % of cereal crop lands are irrigated, and yield variability at the regional level is one of the highest in the developing world (WFP, 2009). As illustrated in Figure 3, the pace of agricultural sector growth during the 2003/04-2008/09 period declined, while the industrial and service sectors grew more rapidly (ADB, 2010). Agricultural GDP and per capita cereal production has been falling over the last forty years with cereal yield stagnant at about 1.2 tons per hectare (Di-falco et al., 2010). However, the overall expansion of agricultural production has been driven by increases in the area of land cultivated, rather than major improvements in productivity (ADB, 2010).



Source: ADB 2010

Figure 1. 3 Sectoral Growth Rate

In Tigray, agriculture contributes 38.7 % of the regional GDP (TRBFB, 2010). Crop productivity is very low due to factors such as soil and water degradation and erratic rainfall. Average estimates of productivity loss due to soil degradation are estimated to be 2-3% annually, which explains most of the failure to realize the potential yields expected from agricultural intensification (World Bank, 2008). Cereal yields average less than one ton per hectare in the region (Pender and Geberemedhin, 2007). This is low compared to the national average of 1.2 tons per hectare (WFP, 2009). The average land holdings in the region are around 1.25 hectare (MORAD, 2009). Major crops in the region include teff, barley, sorghum, wheat and maize (Tesfay, 2006). Rural households in Tigray do not produce enough food to feed themselves, and they get most of the balance from the market (MORAD, 2009). Given the heavy dependence of most households on buying basic food, even in years of relatively good rainfall and production, the question of how people get cash is important to food security and livelihood analysis in relation to forest environmental resources.

Tigray has much livestock including 3.04 million cattle, 2.4 million sheep and goats, 2.3 million poultry, 187,000 beehives and good potential of lakes and river fishery (WFP, 2009). However, livestock production is secondary (Tesfay, 2006). In fact Babulo et al. (2009) challenged the traditional belief in Tigray that livestock is the major contributor of the household income. According to the authors forest environmental income contributes the second source of income share to rural households in Tigray.

2.2.2. Poverty Situation

Conditions of poverty, food insecurity, and malnutrition in Ethiopia are well documented and have been the focus of development efforts for more than half a century (see for example, Dercon and Krishnan, 1998 and Dercon et al., 2005). By most indicators, poverty and ill-being in Ethiopia are

appalling. Yet several surveys suggest that Ethiopians are better off than they have been. The general consensus is that Ethiopia remains one of the world's poorest countries, but that economic growth trends are positive and living standards are finally starting to catch up – at least with the rest of Africa (Devereux and Sharp, 2003). Out of 80 million (2008) people, 35 million people are living in abject poverty; most of them live in rural areas with agriculture as their main occupation, while food insecurity levels in the rural areas of the country rose from about 2 million people in 1995 to about 14 million in 2008, of which 7.5 million were covered by the safety net program of the government (WFP, 2009). Increased poverty, water scarcity, and food insecurity are just some of the negative impacts set to hit small-scale farmers and pastoralists in Ethiopia as a result of climate change in the region. While Ethiopia is no stranger to climatic variability, having suffered droughts that have contributed to hunger and even famine in the past, climate change is set to make the lives of the poorest even harder. The persistent lack of rainfall is a major factor in rural poverty. Recurring droughts leave poor farming families without food crops, causing periodic famines.

In Tigray, poverty is extremely high. More than 58% of the total population were living in absolute poverty (earning less than a dollar a day), which makes the region's situation more serious compared to the national average 44.4% (WFP, 2009).The average wealth breakdown for the 16 livelihood zones taken together is 20% very poor, 30 % poor , 34% middle and 16% better off (MORAD 2009).

A Growth and Transformation Plan (GTP) has been prepared at national level since 2011. The GTP aims to achieve the Millennium Development Goals in Ethiopia by 2015 and middle-income status for Ethiopia by 2020−2. Regional governments have also prepared similar documents based on the national GTP framework. To achieve the targets of GTP, a sustained average annual growth

rate of 11.2 percent is required, the same level as the reported growth rate under the previous 5-year plan (World Bank, 2011). In addition, climate resilient green economy is seen as a real opportunity to catalyse transformation, take advantage of international interest in funding, finance a new model of development (e.g., through the fast funding), and build a resource-based competitive advantage of the country, while protecting the country against the adverse effects of climate change (ECA, 2011). This will have a strong implication for the natural resource base of the country and the livelihood of the people who are mostly dependent on it.

2.2.3. Ethiopia's Food Security Program

Given Ethiopia's history of chronic food insecurity and recurrent catastrophic famines, it is hardly surprising that food security has always featured strongly as a priority in successive government development plans and strategies. Ethiopia's current Growth and Transformation Plan for the period 2011- 2015 takes forward a number of the same measures in its predecessor the Plan for Accelerated and Sustainable Development to End Poverty(PASDEP) which prioritized food security, rural development, human development and conservation of the environment. Meanwhile, the GTP also focused on a 'Green Growth' which gives more emphasis to climate resilient development strategy. In addition to its focus on agricultural commercialization, the GTP also renews the government's commitment to the food security program (FSP), which was initiated by the 'New Coalition for Food Security' after the food crisis of 2002.

The FSP aims to address food insecurity through a package of interventions that are intended to boost agricultural productivity for the estimated 8.3 million chronically (or 'predictably') food insecure, and to provide protection against agricultural vulnerability for estimated 6.7 million transitory ('unpredictable') food insecure Ethiopians (Devereux and Guenther, 2009).

The food security program has three main components, which together are designed to attain household food security: (1) the 'Productive Safety Net Program (PSNP): with two sub-components – public works and direct support – which bridges the food gap with cash or food transfers while building community assets; (2) Household Extension Packages, which support a range of non-farm household activities through a variety of assets and input packages for agriculture and non- agricultural activities; (3) Voluntary Resettlement Program, which relocates people from the most vulnerable highland communities to more productive land.

2.3. Land and Forest Policy Issues

2.3.1. Rural land administration

Historically, institutions/property rights to land in Ethiopia were vested in the risti system, the gulti system/ private land holding, or the church (Gebreegzabher et al., 2011).The overthrow of Haile Selassie following the 1974 famine signalled the abrupt ending of an essentially feudal system in Ethiopian agriculture. The Derg used its unfettered power to force a radical agrarian transformation on rural Ethiopia. Between 1976 and 1991, all farmland in the highlands was confiscated by the state and redistributed equally per capita within rural communities. This radical land redistribution was motivated by both egalitarian and efficiency concerns. The intention was not only to break the power of landlords over peasants, but to give all rural households the means to achieve sustainable increases in agricultural productivity and rural incomes (Devereux et al., 2005).Importantly, land was conceptualized as a safety net for rural households by the Derg, a view which is shared by the current government of Ethiopia.

The recent change in the land tenure system of Ethiopia came in the early 1990s following the change in government in 1991(Tesfay 2006). The December 1994 Constitution of the Federal

Democratic Republic of Ethiopia proclaimed that 'Land is a common property of the nations, nationalities and peoples of Ethiopia and shall not be subject to sale or to other means of transfer'. In 2005, the Government of Ethiopia issued a new *Rural Land Administration and Land Use Proclamation* (456/2005) (amended in 2007). The aim was to increase tenure security, improve productivity and avoid expectations of land re-distribution. Article 6(3) of the proclamation states that land holders will be issued with certificates that indicate the size and fertility of their holding as well as its borders (FDRE, 2005). Land certification is currently taking place in the Amhara, Oromia, SNNP and Tigray Regional States. However, the land registration activities have commenced without due regard for the sustainable use of forest resources because forests are not yet mapped and registered and rural households are able to clear land and stake a claim to it before the registration process begins(Abebe et al. 2009). Conditions of tenure security and its impact in various aspects in Ethiopia, particularly in Tigray region is well documented and has been the focus of research for decades (Pender et al., 2002; Pender and Gebremedhin, 2003; Hagos and Holden 2006; Deininger et al., 2009; Tenaw et al., 2009 and Ghebru and Holden, 2013).

2.3.2. Forest Policy

The new federal *Forest Development, Conservation and Utilization Proclamation* (542/2007)provides the framework for making fundamental changes to forest resource management across the country. Both the proclamation and the country's first policy and strategy on forest development that accompanies it demonstrate a much greater acceptance of community management, and the conceptual links being made between livelihoods and environmental resources (FDRE, 2007a; 2007b).

The overall objective of the new policy is '*…to meet public demand in forest products and foster the contribution of forests in enhancing the economy of the country through appropriately*

conserving and developing forest resources.' Significantly, this is to be achieved through an overall reduction in the role of the state, the promotion of private investment and the devolution of authority to regional administrations (FDRE, 2007b). To this end, the new proclamation allows for forests to be designated as either private or state owned. State forests constitute natural high forests preserved for biodiversity conservation and other purposes in which the property rights are vested in the state. It could be either national forestry area (NFPAs) or regional forestry priority areas (RFPAs). Cross boundary forest areas also fall within the category of state forests. The first priority within the context of these high forests is protection and conservation. State forests may be given as concessions for privately managed plantations or retained for conservation management by government organizations in participation with local communities (FDRE, 2007a).

The government of Ethiopia had classified 58 Forest Priority Areas (FPAs) covering 2.8 million hectares in the 1994 Ethiopian Forestry Action Programme (UNDP-GEF, 2005). Out of these 58 FPAs, 2 of them are found in the Tigray Regional State (Gebreegziabher 2007). However, the state forests appear to function more like unmanaged state forests with multiple resource uses (grazing, settlements, agriculture, fuel wood gathering etc), with low priority given to conservation and preservation of wild life and habitats(USAID, 2008). No official maps exist, no management plans have been prepared, and none have been gazetted. Regional and federal resources to delineate state forests and prepare management plans are extremely limited. Currently, the land registration process does not register individually held land located within high forests on the assumption that these areas are state forests. The policies do not refer to the location of these forests or explain how they can be identified implying that there are no legal grounds to resolve any conflict regarding the boundaries and locations of these state forests (USAID, 2008).

2.3.4. National Priority Areas (NPAs) in Tigray

With about 120,000 hectares, Desse'a is probably the largest natural forest in Tigray National Regional state. The forest stretches in a narrow corridor along the eastern escarpment from close to Senquata town near Adigrat to the east of Quiha town[6]. The topography in Dessa'a is varied and includes some flatter areas and gentle slopes as well as steep scarps. The forest extends in an easterly direction along and down the escarpment, and forms a climatic buffer zone between the cool highlands of Tigray and the hot lowlands in Afar Region. Most of the trees in the forest are found at the higher altitudes, and relatively undisturbed forest exists only on the steep eastern slopes. It appears that there is currently no natural forest regeneration. Grazing by domestic animals is given as a main cause for this, but the area is now very dry and climatic changes should not be ruled out.

On the other hand, Hugumburda and Grat-Kahsu are two contiguous forests situated between the towns of Mai Chew and Alamata, Southern Zone. Local people make extensive use of any easily accessible areas of forest to provide fuel wood and construction materials. Until the early 1990s, this part of Tigray was better known for its huge camps of famine victims than its natural resources, so it is not surprising that the forests have not been properly managed. Afforestation activities on the more accessible slopes began in the early 1970s, and the regional government is now helping to expand these further. Three tree nurseries in Korem, Ashenge and Addis-Fana are producing exotic species for the afforestation program.

[6] http://www.cbnrm.net/pdf/sussex_001_briefing_et18.pdf (Accessed on December 2011)

2.4. Research Methodology

2.4.1. Data sources and Description

Chapters 3 -7 of the thesis are based on household survey data. Primary data were collected via survey questionnaire. The primary sampling units were tabias within approximately 5 km radius of the National Priority Areas (NPAs). This distance is purposely chosen for convenience and since an empirical evidence from by (Guthiga and Mburu, 2006) also indicated that there were progressively fewer people that extract non-timber forest products beyond 5km stretch from forest in rural Kenya. Accordingly, a total of ten tabias, namely Arato, Derga -ajen, Hugumrda, Meswaeti, Kara_adishawo, Worebayu, Kal_amin, Kelisha_emni,andFelege-woini were selected for the survey (see figure 2.1).

Villages were randomly selected from each tabia. In each village 26 households were selected randomly, yielding a total sample of 260 households. However, due to budgetary and logistics problems the final survey ended up with 254 households. A multi-purpose questionnaire was used to gather information on household income and expenditure, farm and off farm activities, household assets, vulnerability to idiosyncratic and covariate shocks,participation in local institutions and a host of other information related to production and sales, climate change adaptation, participation in the Productive Safety Net Program (PSNP) and social networks. The survey was conducted from June-August 2010. The survey paid special attention to labour allocation to forests, participation in forest environmental resource extraction from private sources, enclosures, woodlots, and other common pool resources. Eight experienced enumerators who had served in similar surveys were hired for the data collection. The enumerators were given two days intensive training and one day pilot testing was made. During the survey field work, close and regular supervision was made. Filled out questionnaires were checked on the spot and those with

significant inconsistencies were made to be filled again. Survey data was processed using STATA 10 software. To determine the extent to which households in rural Tigray use forest environmental resources for their livelihood and their dependency in forests, we follow (Narrain et al., 2008) to calculate the income that each household obtained from major sources as follows.

2.4.2. Income Accounting

To determine the extent to which households in rural Tigray use forest environmental resources for their livelihood, we calculate the income that each household obtained from 8 major sources namely, (1) agriculture, (2) livestock, (3) forest environmental resources, (4) household business, (5) wage employment, (6) Productive safety net program, (7) financial transactions and (8) transfers.

Income from each source is calculated as the difference between total revenue obtained and total input costs incurred, where these totals include both market transactions and imputed values from non- market transactions.

Income definitions

Net crop Income: is defined as the difference between the revenue obtained from all crops and crop-residues harvested by the household using January-March 2010 local market price and the input costs incurred for crop production. Input costs, in turn are defined as the sum of wages paid to hired agricultural labour, cost of fertilizers, manure, pesticides; rent paid on land rented in; and rent paid for farm capital rented in. We also include income obtained by the household from trees on its private lands, equal to the revenues from fuel and construction wood, flowers, fruits extracted. Finally, we added any income from rental out of household's farm capital.

Net livestock income: is defined as the difference between revenue obtained from sales, products and services of the main types livestock found in Tigray, namely, cows, goats, sheep, donkeys, horse, camel and chickens and costs that include cost of veterinary services, hired labour to graze them and the cost of fodder to feed them that includes the imputed value of fodder grown as a crop and not sold, residue from other crops used as fodder, fodder collected from village commons and not sold, and fodder bought from the market.

Forest Environmental Income: To identify the forest environmental resources that rural households in Tigray collect, we prepared an open ended question during the pre-testing of the household survey. Then we listed all the main forest resources that the households use in the questionnaire. Our survey also asked households to list other forest resources obtained if any. We follow an approach by Babulo (2007) as a basis of valuation. We relied on household's own reported values for environmental goods from homestead, enclosures and other community owned forest resources and grazing fields. Respondents reported the weekly, monthly or yearly amount of each product harvested/ gathered by the household, the amount consumed/used, and the amount exchanged, the amount given to other households (gift), the amount sold, and the cash amount received from sales of these products. In case the forest products were bartered rather than sold, the retail sale price of the exchanged commodity was recorded as the cash income. But only in rare instances did the barter occur in our survey.

Income from Household Business: is defined as income from any non- agricultural business such as trade operated by the household.

Wage income: is defined as the sum of income in cash and in-kind wages received from in-village casual employment off the household's own farm, off-village casual employment and regular employment in the private and public sector.

Net income from financial transactions: Households in our sample own a variety of financial assets, including deposits at Dedebit micro finance, saving and credit associations, cooperatives, and loans given to relative or friends. They also owe debt to a number of sources - Dedebit micro finance, saving and credit associations/cooperatives, moneylenders, friends or relatives. During the survey year, households earned interest income on their deposits and paid out interest on their debts. Net interest (interest income earned less income paid out) constitute household's income from financial transactions.

Income from Transfer: is defined as the sum of PSNP and in-kind payments received by a household from its family, friends, the state, and any non–governmental organizations operating in the area.

2.4.3. Analytical Approach

The econometric analysis for this study mainly uses cross-sectional data collected in the year 2010. The hypotheses in each of the topics studied are derived from a review of theoretical and empirical literature on the respective subjects. For the econometric analysis the choice of feasible techniques is dictated by the nature of the dependent variable and research question. In each chapter an explanation is given for the choice of the econometric model. For example, in chapter 3, we used a Heckman selection model. In chapter 4, we also use PSM approach to control for the selection problem and endogeneity of participation in forest environmental resource extraction. We use the Full Information Maximum Likelihood Estimation in chapter 5. In chapter 6 we use Foster, Greer and Thorbecke (1984) poverty indices (commonly known as FGT indices) and Gini decomposition (Stark et al., 1986). Applying these analyses for "with forest income", "without forest income" and "counterfactual income" we were able to measure the contribution of forest income to rural poverty and inequality,using analytical methods which some previous studies have

not used, as a result of which their estimates of forest income –poverty and inequality may have been overestimated or underestimated. Finally, we use the Propensity Score Matching (PSM) in chapter 7 which is the most recent research tool in the program evaluation literature.

CHAPTER THREE

DO FORESTS HAVE A ROLE TO PLAY FOR COPING WITH IDIOSYNCRATIC HEATH SHOCKS IN RURAL ETHIOPIA?

3.1. Introduction

Low and volatile incomes coupled with the absence of or poor development of financial or risk sharing institutions make consumption smoothing an important issue in low – income countries like Ethiopia (Barrett et al. 2001). A typical household in rural areas of developing countries faces substantial idiosyncratic and covariate risk, resulting in high-income variability (Dercon et al., 2005). Covariate risks include uncertainties associated with nature, markets (both input and output), social unrest, policy and institutional failures etc. On the other hand, idiosyncratic risks include shocks related with income failure, illness, and shortage of agricultural inputs, (Weinberger and Jutting 2000). Usually, due to the absence of the first best solutions (formal risk sharing institutions), rural households in developing countries have developed their own risk reduction, mitigation, and coping strategies (Weinberger and Jutting 2000). Coping, broadly defined as a short-term strategy of households to prevent a negative effect of crises (Sauerborn et al., 1996) may take several forms. Some of the most common coping mechanisms in rural areas include: livestock husbandry (Reardon et al., 1992), reduction in consumption (Porter, 2008), sale of assets (Hoddinott, 2006), off-farm activities (Barrett et al. 2001) and social ties (Dercon et al., 2005).

In the livelihoods literature, forests are also identified as a prominent safety-net source, accessed principally by reallocating more labour to forest extraction (Wunder et al., 2014). This may be

because forest products are often available at times when other income sources are not, for example, when crops fail (Byron & Arnold, 1999; Pattanayak & Sills, 2001; Angelsen et al., 2007), and have better insurance properties than insurance markets in the presence of information and enforcement problems (Baland & Francois, 2005) which is a typical situation in developing countries like Ethiopia. The importance of resource extraction is amplified in the presence of risk, and such risk is expected to intensify as future climate change precipitates more extreme weather events, especially in marginal agricultural areas (Sivakumar et al., 2005 cited in Angelsen et al., 2007) such as northern Ethiopia.

Yet the empirical literature on biodiversity as a means of risk coping is ethnographic (McSweeney, 2004), considerably smaller than that on biodiversity as a source of livelihood (CBD, 2010, Vira and Kontoleon, 2010) and typically relates only extraction volume, income, or income share with total income or asset holdings (e.g., Cavendish, 2000; Coomes et al., 2001; Godoy et al., 1995). As a result, there is very little systematic analysis to help guide conservation and development promoters in their efforts to understand how the poor (and others) deal with negative shocks (McSweeney, 2004).

A few existing studies such as those by Pattanayak & Sills (2001), Takasaki et al.,(2004), McSweeney (2004), Debela et al., (2012) find positive correlation between shocks and forest extraction. For instance, Pattanayak & Sills (2001) argued that forest environmental resource extraction is correlated positively with agricultural shortfalls and expected agricultural risk in their study of the Brazilian Amazon. In the same way, Debela et al. (2012) argued that shocks tend to lead rural households in Uganda to depend on forests to meet subsistence and cash needs. Similarly, Takasaki et al. (2004) conclude that forests serve households in Peru to cope with flood shocks. On the other hand, Wunder et al, (2014) using global comparative data sets conclude that

forest resources may be less important as a buffer between agricultural harvests and in times of unforeseen hardship than has been found in many case studies. Drawing overall conclusions from these literatures is difficult due to wide differences across studies in fieldwork method, variable definitions (e.g., the type of shock experienced), and empirical model (Angelsen et al, 2007). For example, nearly all studies devoted to the link between shocks and forests have centred on Latin America (Pattanayak & Sills, 2001; Takasaki et al., 2004 and McSweeny, 2005) and Asia (Shively, 1997; Takasaki, 2009 and Volker & Waibel, 2010). Evidence from sub-Saharan Africa is much more limited. Important exceptions include Monica and Fisher, (2005); Debela et al. (2013). Thus, it is important to examine the role of forests as a risk coping strategy in an African setting. Our contribution here is that the present study was undertaken in another tropical ecosystem, dry deciduous woodlands, the dominant type in Southern and Eastern Africa (Campbell et.al, 2006 and Fisher and Shively, 2005).

There are also additional features that make this research work especially interesting. First, much of the research done on the insurance value of forests deals with covariate shocks (see for example Pattanayak & Sills, 2001; Takasaki et al., 2004; and Takasaki, 2009). Meanwhile, a growing body of empirical evidence suggests that idiosyncratic risk may be as important, or indeed may dominate covariate risk in rural Africa and Asia (Udry, 1990; Townsend, 1995; Deaton, 1997; Lybbert *et al.*, 2004; Morduch, 2004; Dercon, 2005; Kazianga and Udry, 2006). This relative importance of idiosyncratic risk and the relative dearth of attention given to it by researchers and policymakers alike raise the possibility of significant untapped potential for improved local risk management in developing countries, and significant impact for high quality research that tackles this topic in the African setting. Many critical questions remain: for example, do rural households cope with idiosyncratic health shocks of household members by increasing the rate of forest extraction? And,

if they do, what are the characteristics of households most reliant on forests for coping with idiosyncratic health shocks? Does reliance on forests for coping with idiosyncratic health shocks depend on the endowment of physical and human capital as well as access to institutional services? Answering these and other questions can enable us to develop recommendations that maximize the potential for "win – win" for both human and environmental health. Policy options on this front could be of two types, i.e. those policies to mitigate interactions that both aggravate the impacts of health shocks on households and concomitantly affect forests negatively. Thus, the primary objective of this paper is to examine the potential role of forests for coping with idiosyncratic health shocks of farm households living at the margins of protected forests, found in the north highlands of Ethiopia.

Dealing with health shocks is an important issue through which to view the poverty-environment nexus in many ways. First, many of the environmental hot spots in the world are located in impoverished regions where individuals live under the constant threat of serious illness (Rasmus and Lund, 2009). Second, the environmental impacts of health shocks are theoretically ambiguous (Volker and Waibel, 2010).Resource extraction and activities that use these resources for production tend to be labour intensive, suggesting greater environmental conservation in the face of significant morbidity. On the other hand, health may also affect discount rates households use when making trade-offs over time. Altered planning horizons due to shortened life expectations can undermine incentives to conserve, while increased medical costs and caloric needs can force households to liquidate capital, both physical and natural. As morbidity and mortality also decrease income, families may increasingly turn to less sustainable activities such as hunting, logging, and charcoal making for subsistence needs, precipitating environmental degradation (Joshua et al., 2010). Finally, poor households are more exposed to health shocks such as illness and death of a

household member than wealthier households (Tongruksawattana et al., 2008; Rasmus and Lund, 2009). In some circumstances, these households are even more fragile to health shocks than to crop income shocks (Kochar, 1995). As such, this poverty-health-environment link seems to limit the prospects for win-win outcomes of conservation-development initiatives proposed by policy makers and NGOs, especially if negative shocks of various sorts are likely to propel the poor to hit nature hard (Barrett and Arcese, 1998). Knowledge about the mechanisms is important for policy purposes. For instance, if differential access to health service were the main reason for the observed gradient, then improved access to health care for people around the forest margin would be one policy option one could use in order to weaken the gradient.

This chapter is structured as follows: section 3.2 provides an overview of the health and environment nexus in Ethiopia. Section 3.3 outlines the econometric procedure. Section 3.4 discusses the empirical results, while the final section draws concluding remarks.

3.2. Overview of the Health and Environment Nexus in Ethiopia

Millions of poor people in Ethiopia still depend on ecosystems and natural resources for their income and livelihoods. However, economic and political processes, often beyond their control, continue to degrade these resources in much of the region (Howard and Smith, 2006). There has been progressive degradation of forest resources in Ethiopia. Between 1990 and 2000, 141,000 ha of forest were lost every year, which equals an average annual deforestation rate of 0.93% (Babulo, 2007). Between 2000 and 2005, the rate of deforestation increased by 10.4% to 1.03% per year, which totals to 14% (or around 2,114,000 hectares) of forest cover loss in the 15 years between 1990 and 2005 (FAO 2007).

The challenge of poverty alleviation, promoting the conditions of improved health, securing the basis of rural households, and conserving the environment, is particularly acute in Ethiopia. The

country is home to about 94 million people many of whom still live in poverty despite recent economic growth. The health system of Ethiopia is still in a transitory stage and hence fragile. The Ethiopian population faces high rates of morbidity and mortality mainly resulting from a high prevalence of communicable infections (WHO 2009). About 75% of the population suffers from some type of communicable disease and malnutrition, which are potentially preventable. The leading causes of disease and death are malaria, bronchopneumonia and tuberculosis. Widespread poverty, along with generally low income levels, low educational levels (especially among women), inadequate access to clean water and sanitation facilities, and poor access to health services, have contributed to the high burden of ill-health in the country. Health expenditure in Ethiopia is still high and out of pocket payment for health care in relation to incomes and the total health expenditure is catastrophic[7].

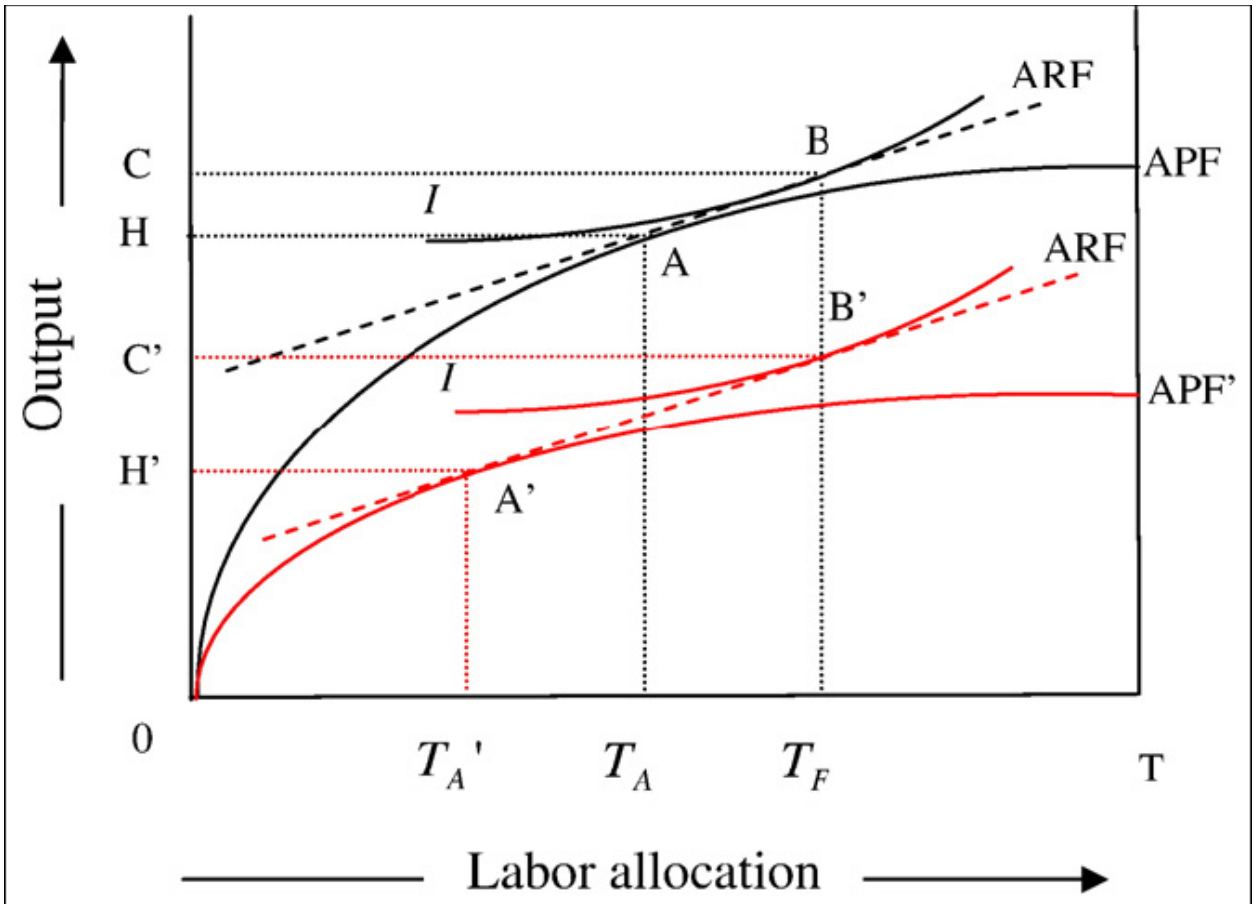
Moreover, health care is predominantly a forest – based service in Sub-Saharan Africa (Barany et al. 2001) including Ethiopia. Traditional healers are the dominant providers of medical care in forested areas, often providing between 70 and 95 % of primary health care (Colfer et al., 2006). Because of remoteness of many rural, and particularly forest dependent, communities, a lack of access to health care could be the primary cause for increased reliance on forest medicines and traditional healers. Whether the change in forest resource availability is sudden or gradual, forest degradation has potentially negative implications for households affected by illness. Such impacts could include: loss of income generating options; increase in labour required to collect forests; reduction in use of firewood (possibly leading to inadequate energy to meet household needs including cooking and sanitation); and reduced access to medicines (Barany et al.2005). For

[7] The economic burden of illness in terms of reduced per capita expenditure and farming productivity is well documented in Dercon et al.,(2005) and John (2009) respectively.

example, if important medicinal plant species become scarce, the results for an ill individual could be a loss of stamina and a compromised immune system. The repercussions of this cycle then could be a continued decrease in stamina, increased vulnerability to further infections and other diseases, and fewer livelihoods and food security as well as a reduced natural resource base. Thus, in rural areas such as Ethiopia, developmental and human health gains depend on ecosystem services (Costanza et al., 1997; Daily, 1997) and environmental sustainability is a criterion for population health (McMichael, 2002).

3.3. Theoretical model for Shocks and Labour allocation to Forests

The theoretical framework underlying the empirical analysis of forest extraction as a coping mechanism is based on "new home economics" theory (Becker, 1965) adapted after Volker and Waibel (2010) and Ellis (1993). The emphasis of the "new home economics" theory is on the household's time allocation assuming that labour is the major factor of production. Assuming there is no access to off-farm wage employment opportunities, figures 3.1 and 3.2 give a graphical presentation of the basic home economics household model showing household output in relation to available time. Time, depicted on the horizontal axis of the graphs, is divided into labour for agriculture (0TA), forest extraction (TATF) and leisure (TFT).The time constraint is determined by the total number of person days available for agricultural production, forest extraction and leisure. The graphs depict two scenarios of household labour allocation comparing a situation with and without shocks. Figure 3.1 represents a weather shock scenario with effects on agricultural output while Figure 3.2 represents a scenario where a family member is falling sick with corresponding effects on labour capacity.

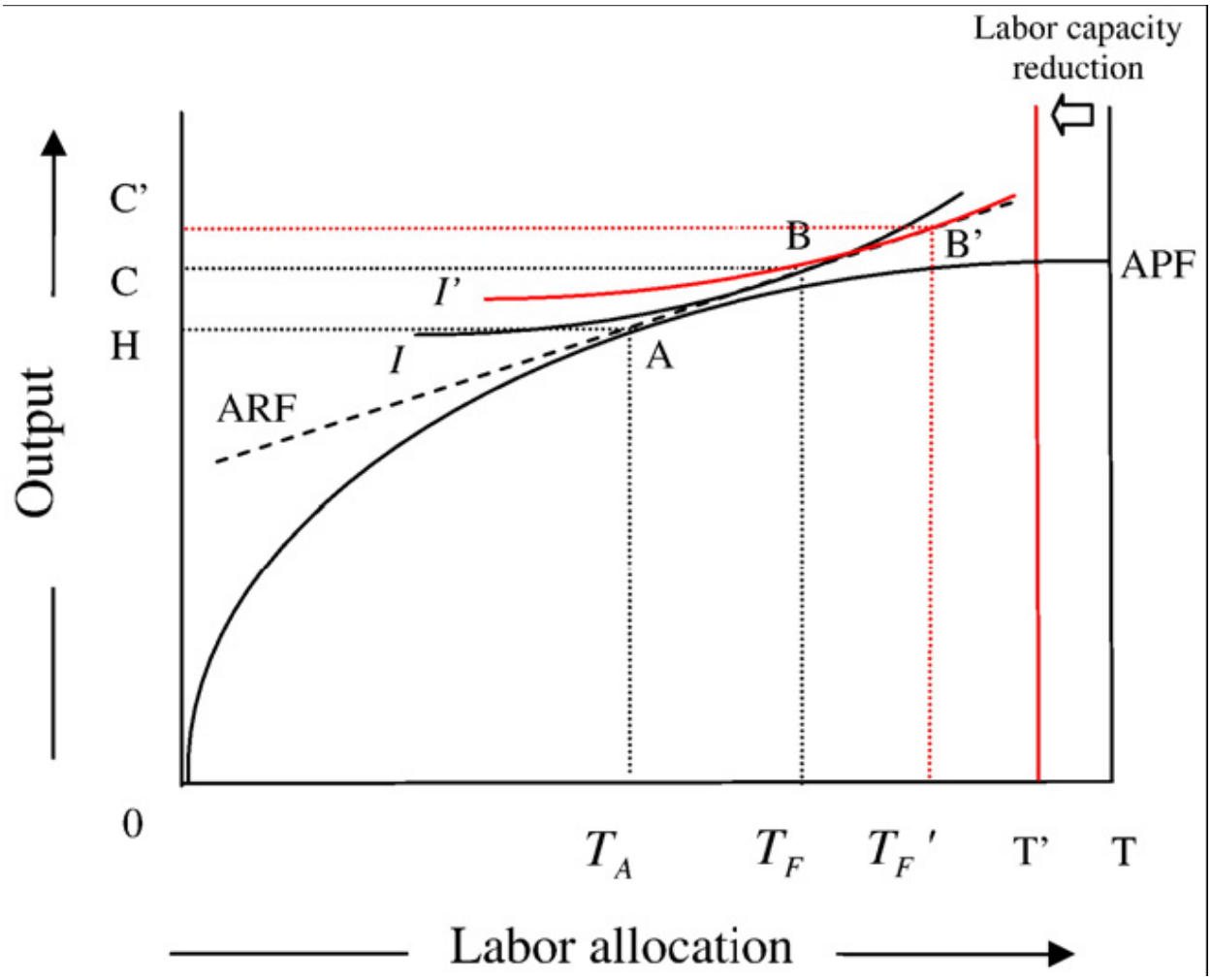


Adapted after Ellis (1993) and Volker and Waibel (2010)

Figure 3. 1 The Household Production Model under a weather Shock Scenario

To explore in more details the effects of a covariate weather shock on the time allocation of the household Figure. 3.1 is used as a framework. Weather shocks such as heavy rain or flooding lower agricultural output. A key assumption of the model is that weather risk associated with agricultural production is uncorrelated with forest extraction risk (as also suggested by McSweeney, 2004) and that even for weather risks like storms the effect on forests is comparatively small (unless it is an extremely strong typhoon) due to the diversity of products which can be extracted. Therefore the effect of a weather shock is modelled solely by its effect on the household's agricultural production function while the household's average returns to forest extraction (ARF) remain unaffected. Weather shocks reduce the household's agricultural production output in the form of crop yields and livestock products, thereby decreasing labour productivity. The shape of the agricultural

production function changes (APF to APF') and reflects a relatively poor input-output response as compared to the baseline scenario. Using the same amount of time for farm work, the household produces less output because the marginal productivity of time allocated to agricultural production has decreased. This results in a new equilibrium of the household in agricultural production (point A′ instead of point A), which shows that the household allocates less time to agriculture (0TA′ instead of 0TA) and accordingly more time to forest extraction (TA′TF instead of TATF). The time allocated to leisure remains the same as neither the indifference curve nor the average returns to forest extraction are assumed to be altered by the weather shock. Consequences of ex-ante weather risk can be modelled accordingly by assuming that households make time allocation decisions based on expected states of nature, meaning that pessimistic households face a relatively poor subjective ex-ante input– output response curve regarding agricultural production as compared to more optimistic households.



Adapted after Ellis (1993) and Volker and Waibel (2010)

Figure 3. 2 The Household Production Model under a health shock scenario

Figure 3.2 analyses the effects of a health shock. Health shocks relate to active household members who become ill. Illnesses of household members are assumed to have two effects. On the one hand, they reduce the total household time capacity if the affected household member is not able to carry out the normal amount of work. This is reflected by a shortening of the horizontal axis to the left. On the other hand, the household faces additional needs for health care which increases the family's preferences for consumption goods instead of leisure. This is reflected by the shape and position of the consumption– leisure indifference curve which has a shallower slope than in the baseline

scenario (I′ instead of I). Provided the household is able to reallocate leisure time to forest extraction, a new equilibrium in the consumption of goods emerges (point B′), which shows that the household allocates less time to leisure (TF′T′ instead of TFT) and accordingly more time to forest extraction (TATF ′ instead of TATF). The optimal production level of consumption goods (point A) remains the same as both the agricultural production function and the average returns to forest extraction are assumed to remain unaffected by the health shock. Again, consequences of respective ex-ante risk can be modelled accordingly. Households who have pessimistic expectations about future health shocks might face a shallower income–leisure indifference curve as they may want to accumulate savings for future times of hardship. The theoretical model suggests the hypothesis that a covariate weather shock and an idiosyncratic health shock, as well as decision makers' future expectations of such risks will make the household allocate more labour to forest extraction.

3.4. Econometric Methodology

3.4.1. Instrumental Variables (IV) Approach

Our main objective in this chapter is to measure the role of forests in coping with idiosyncratic shocks. The main econometric issue that arises in attempting to identify this role is the potential endogeneity of those shocks. For instance the standard probit estimate of the effect of weather shocks on forest labour supply could suffer from endogeneity bias as forest extraction in previous periods may determine both the frequency of weather shocks (because forest extraction deteriorates the erosion protection function of forests) and the probability of engaging in forest extraction (Volker and Waibel,2010). In addition, the perception of being sick or being healthy can lead to a significant measurement error problem. If measurement error is random, then we do

not need to worry about this. However, it is possible that the likelihood of reporting illness is closely related to the socio-economic status of the household (for example the income of the household or the education level of the most educated member of the family). In fact, Dercon et al. (2005) argued that illness shocks appear more important for richer households as measured by relative landholding in Ethiopia.

Additionally, our sample consists of households who have been exposed to the treatment (a health shock) and those who have not been. If households in the treatment group have a better knowledge about how to prevent sickness, or have better coping strategies because of training provided by the health service provider, then we could expect that either households in the treatment group are systematically less exposed to shocks or even when they experience such a shock we would not observe significant difference in coping strategies because of the specific awareness given to them. The presence of this unobserved heterogeneity could bias our results, so to deal with it we need to search for a variable that is correlated with the shock but does not directly affect participation in forest environmental resource extraction, and is not correlated with the idiosyncratic and covariate error term. Accordingly, we follow an instrumental variables (IV) approach to overcome this problem. The instrumental variables that we use are (1) Kebele (Tabia) rainfall, and (2) distance to health center. Rainfall is a good instrument because it is an exogenous variable to the households and cannot directly affect the outcome variable. Distance to clinic is also selected as an instrument, as it is assumed to be a significant determinant of households' reporting of illness shocks. However, it is unlikely that distance to clinic has a significant direct effect on forest activity.

For the participation in forest sales, we used an IV Probit since the dependent variable is binary: whether the household reported participation in forest commercialization (=1) or not (=0).

However, forest dependency and number of trips for forest collection can take a value of zero with positive probability, as many households do not participate in forest environmental resource extraction (in our sample almost 15% of the households do not participate in forest extraction). In order to deal with a censored sample we conducted estimation using instrumental variables two-stage least squares.

3.4.2. Using Alternative Estimation Techniques

To supplement the results from IV, we also chose to adopt the propensity score matching (PSM) strategy of Rosenbaum and Rubin (1983) that is now widely used in the program evaluation literature[8]. Typically, we would expect that the likelihood of reporting illness is closely related to individual/household characteristics. We therefore match households based on demographic, asset and institutional variables. This is essentially the route taken by Smith (2004) in that the onset of health shock is assumed exogenous (conditional on a set of observed covariates) in the labour outcomes equation.

Our empirical strategy relies on the possibility of conditioning on sufficient observable information to obtain a credible counterfactual against which we may measure the impact of the health shock. Let T =1, 0 indicate treatment (health shock) and control (no health shock) respectively and let Y_1 and Y_0 denote the outcome of interest (number of trips to forest) for households with treatment and without treatment respectively. Since we observe households to be

[8] In our case, PSM compares households who reported illness to those that did not, with the same (or similar) values of those variables thought to influence both illness and coping strategy. We can thinkof households reporting illness in our sample as the treatment group and the households that did not as the control group, following the program evaluation literature. Under the matching assumption, the only remaining difference between the two groups is reported sickness. Any difference in outcome between these two groups can be entirely attributed to the sickness effect provided we have made sufficient arguments to guarantee that there are no further systematic differences between these two groups.

either with treatment or without treatment, we cannot observe the causal effect of interest: Y_1 - Y_0 . Some features of this distribution are estimable, nevertheless. In particular, we may consider the Average Treatment Effect of the Treated (ATT):

$$\text{ATT} = E\left(Y_1 - Y_0 \mid T = 1\right) \tag{3.1}$$

This magnitude measures how much the outcome of interest changes on average for those households who undergo the treatment (who suffer the health shock to be defined below). Clearly, simply computing the difference in the average outcomes of those under treatment and those not under treatment is open to bias, as there are observed and unobserved characteristics that determine whether the household undergoes the treatment. That is,

$$E\left(Y_1 \mid T = 1\right) - E\left(Y_0 \mid T = 0\right) =$$

$$E\left(Y_1 \mid T = 1\right) - E\left(Y_0 \mid T = 1\right) + E\left(Y_0 \mid T = 1\right) - E\left(Y_0 \mid T = 0\right) =$$

$$E\left(Y_1 - Y_0 \mid T = 1\right) + E\left(Y_0 \mid T = 1\right) - E\left(Y_0 \mid T = 0\right) = \tag{3.2}$$

$$\underbrace{E\left(Y_1 - Y_0 \mid T=1\right)}_{\widetilde{ATT}} + \underbrace{\left(Y_0 \mid T=1\right) - E\left(Y_0 \mid T=0\right)}_{\widetilde{BIAS}}$$

Only if we can guarantee that outcomes of the control group are equal on average to what the outcomes of the treatment group would have been in the absence of treatment does this consistently estimate the ATT. With non-random sorting into treatment and control, this condition is rarely met.

Now suppose that by conditioning on an appropriate set of observables, X, the non-participation outcome Y_0 is independent of the participation status T. This is the weak version of the un-confoundness assumption, also called ignorable treatment assignment (Rosenbaum and Rubin,

1983) or conditional assumption (Lechner, 2000) or selection on the observables, which suffices when the parameter of interest is the ATT, as only assumptions about the potential outcomes of comparable individuals are needed to estimate counterfactuals.

$$Y_0 \perp T \mid \mathrm{X} \tag{3.3}$$

This implies that

$$E(Y_0 \mid T = 1, X) - E(Y_0 \mid T = 0, X) = 0 \tag{3.4}$$

In order to identify the ATT, the overlap or common–support condition is also assumed. It ensures that, for each treated household, there are control households with the same X.

$$Pr(T = 1 \mid X) < 1 \tag{3.5}$$

Therefore, under the assumptions stated in equation (3.3) and (3.5) above, we could estimate the ATT from the differences in outcomes between treated and controls within each cell defined by the conditioning variables (Blundell and Costa Dias, 2002). Using the law of iterated expectations and the conditional independence assumption, the ATT can be retrieved from observed data in the following way:

$$\begin{aligned}\text{ATT} &= E(Y_1 \mid T = 1) - E(Y_0 \mid T = 1) \\ &= E_X\left[\left(E(Y_1 \mid X, T = 1) - E(Y_0 \mid X, T = 1)\right) \mid T = 1\right] \\ &= E_X\left[\left(E(Y_1 \mid X, T = 1) - E(Y_0 \mid X, T = 0)\right) \mid T = 1\right] \end{aligned} \tag{3.6}$$

The estimate of ATT as shown in equation (3.6) turns out to be prohibitive in terms of data when the set of conditioning variables X is large. An alternative is to use the results of Rosenbaum and

Rubin (1983, 1984) and condition on the probability of treatment as a function of X, the propensity score $P(X)$, since the conditional independence assumption also implies that

$$E\left(Y_0 \mid T = 1, P(X)\right) - E\left(Y_0 \mid T = 0, P(X)\right) = 0 \qquad (3.7)$$

Therefore, we could estimate ATT from the differences in outcomes between treated and controls within each cell defined by values of P(X).

$$\text{ATT} = E\left(Y_1 \mid T = 1\right) - E\left(Y_0 \mid T = 1\right)$$

$$= E_{P(X)}\left[\left(E\left(Y_1 \mid P(X), T = 1\right) - E\left(Y_0 \mid P(X), T = 1\right)\right) \mid T = 1\right]$$

$$= E_{P(X)}\left[\left(E\left(Y_1 \mid P(X), T = 1\right) - E\left(Y_0 \mid P(X), T = 0\right)\right) \mid T = 1\right] \qquad (3.8)$$

Provided that the conditional participation probability can be estimated using a parametric method such as a probit model, matching on the univariate propensity score reduces the dimensionality problem.

To estimate the propensity score we estimate a probit model with binary dependent variable whether a member of household was reported to be sick (=1) or not (=0) using our sample data. So, we control for unobservables that may influence households' reporting of sickness. We then discard observations that do not have any common support and observations with households having very low or very high probability of sickness. We consider nearest neighbourhood and kernel matching. Thus we combine matching with the IV approach (due to measurement error) to estimate the effects of health shocks, and the role of forests in mitigating the consequences of shocks or serving as a coping mechanism for health shocks.

3.5. Results and Discussion

3.5.1. Descriptive Statistics

Table 3.1 presents the definitions and sample statistics of the variables used in the analysis. Panel A (Table 3.7) shows the treatment variable. We use self- reported health shocks: respondents in our survey were asked about new or ongoing and past illness of all household members in the household. This measure, while being simple to understand and compute is not particularly informative because of its binary nature. The problem is that an individual's self-reported health status is subjectively affected by an individual's social and cultural background, given the individual's subjective health. Schultz and Tansel (1997) argue that this is because of "cultural conditioning": the threshold of what is considered good health varies systematically across society, controlling for their subjective health status. For example, individuals who are more educated are wealthier and from socially advantaged groups, are typically more aware of the limitations imposed on them by their health status and are more likely to report themselves (and their family) as being of poor health. To control these unobservable characteristics of reporting health related shocks to the researcher, we used a rich data set of control variables based on the literature. 19 % of sample households report that some member of their household was affected by health related shocks in the survey year. The average frequency of shocks due to illness was 2.12.

<< INSERT TABLE 3.1 ABOUT HERE >>

Table 3.1 also presents descriptive statistics on other socio-economic and demographic factors. On average the age of the household head is 46.7 years and she/he has less than 2 years of formal education. Almost 85% of the households in the sample are male headed. The average size of the household is 5.74, while the number of adult male and female household member is 1.37 and 1.49

respectively. In terms of asset holdings, the average size of land holding in Tsimdi (= 0.25 hectare) is 4.36 while the average number of livestock owned in TLU is 3.11.

<< INSERT TABLE 3.2 ABOUT HERE >>

Also presented in table 3.2 is the difference in means of the variables for households affected by health related shocks and those that were not, alongside their significance levels. The significance levels suggest that there are some differences between the two groups with respect to socio-demographic characteristics. With regard to the outcome variables, there appear to be statistically significant differences between both groups. For example, the average forest income for households that have been affected by health related shocks was 3427 Ethiopian Birr, while the corresponding figure for households that did not report the same shock was 2534 Ethiopian Birr. In terms of forest dependency, households affected by the shock earn 31 % of their income from forests, while the same figure for the latter was only 24%. Finally, there is also a significant difference in the average trips for collection of forest environmental resources. On average households affected by health related shocks made 92.9 trips to collect forest environmental resources, while the corresponding figure for the control groups was 70.6.

<<INSERT TABLE 3.2>>

The findings from the previous section that simply compare mean differences in the outcome variables and other socio-demographic variables between the two groups suggest that households that are affected by health related shocks are generally more dependent on forest environmental resources than their counterparts. Given that comparisons of mean differences do not account for the effect of other characteristics of farm households, they may confound the effect of health shocks in the outcome variables with the influence of other characteristics. Multivariate

approaches, that account for the selection bias arising from the fact that households reporting illness shocks and those that did not may be systematically different, are essential in providing sound estimates of the health shocks and participation in forest environmental resource extraction.

3.5.2. Instrumental Variable Results

The results of the IV Probit model[9] for participation in forest commercialization are shown in table 3.3. Our parameter estimate indicates that age of the household head is negatively correlated with forest environmental resource commercialization. This is expected since the physical demands of forest activities should make forest commercialization less accessible to elderly households. The number of adult male households and dependency ratio are positively correlated with participation in forest related activities. With more adult members, households may have access to labour that could be involved in forest activity. Households with more dependents have higher food demand above what they produce, and depend on forest income to fill this gap. Households who have jewellery are less likely to participate in forest resources commercialization. This is also expected since jewellery is a relatively liquid asset that can be sold in response to price signals to smooth consumption, or to provide financial capital to start business. Households who are members of the household extension package, and have their own business, are less likely to participate in forest resource commercialization. These highly and statistically significant results of the two variables

[9]The instrumental variable regression is a two-stage regression where the first –stage regresses health shock on the instruments, in addition to other covariates. The second stage IV regression uses predicted values of health shocks from the first stage regression to estimate participation in forest activities.

support the idea that the household extension package that provides credit in cash or in kind helps poor households to diversify income and free up other sources of financing that can be used to directly smooth consumption. Access to irrigation was found to have a negative and significant effect on forest resource commercialization. This may be because with irrigation households can harvest more and engage themselves in high yielding agricultural activities instead of forest resources extraction which has been termed " an activity of the last resort" (Angelson and Wunder 2003).

<< INSERT TABLE 3.3 ABOUT HERE >>

Results from table 3.4 also show that forest dependency (share of forest income to the total household income) is negatively correlated with age and education of the household head, access to irrigation and liquid assets, ownership of business, access to transfers, extension package and awareness of climate change, while it is positively correlated with the number of dependents at the household level. A similar trend was also observed in table **3.5**.

The final step of the empirical analysis is to examine the effect that health-related shocks have on the probability of participating in forest resources commercialization. To do so we include in the estimations a dummy variable (ill_hhs) that takes the value of one, if according to the information obtained from the household questionnaire, the household were affected by health related shocks. Nevertheless, it could be argued that the causality could go the other way as participation in forest resource commercialization might affect the probability that a given household member is affected by health related shocks. For example, one could think that forest resource commercialization in a previous period may determine both the frequency of health shocks (because forest extraction

deteriorates the quality of forests[10] and causes deforestation[11]) and the probability of engaging in forest resource commercialization. Simply put, there is a potential endogeneity[12] problem when the variable (ill_hhs) is included in the econometric analysis. In fact, the Wald test for the variable (ill_hhs) shows that the variable is endogenous.

Turning to our variable of interest, health shocks, we find that health shocks related to a household member has a highly significant positive impact on participation in forest environmental resources sales. This echoes previous studies of the "Natural Insurance" literature (Pattanayak and Sills, 2001; McSweeney 2004; Takasaki et al.2004; Fisher et al. 2010) and may reflect that good health signals to prospective employers an individual's potential productivity, increasing the likelihood of being hired in relatively remunerative labour markets rather than engaging in forest related activities.

<< INSERT TABLE 3.4 and 3.5 ABOUT HERE >>

3.5.3. Propensity Score Matching Results

3.5.3.1. Propensity Scores

[10]Villages with a greater percentage of their forests under primary forest cover (as opposed to regenerating, or secondary forests, or agricultural lands) have lower incidence of child malaria when compared with villages with lower percentages of primary forests.

[11]Deforestation can also affect the local climate and thereby affect the spread of diseases by reducing moisture held by the vegetation, and raising ground temperatures.

[12]A wald test examines evidence of the correlation between unobserved explanatory variables from the equation to test the null hypothesis that there is no endogeneity bias (ill_hhs is not influenced by unobserved heterogeneity) i.e. $\rho = 0$. If the test shows that ρ is insignificant, then ill_hhs is not endogenous in the regression and the model can be estimated separately. However, if ρ is significant (i.e.$\rho \neq 0$) then endogeneity of the variable (ill_hhs) is confirmed.

Regarding the relevance of the instruments, the weak identification F-statistic is way greater than the usual accepted ($F \geq 10$) for all specifications. This is an indication of strong instruments and the over-identification test result of 0.009 Sergan score indicates that the instruments are valid (see Bound et al., 1995).

Measuring forest dependency as the difference in mean outcomes between all households reporting to have been affected by health related shocks and those not affected by the same shock may give biased estimates of the health related shocks. This bias arises if there are unobserved characteristics that affect the probability of reporting health related shocks in the household. One important source of this bias includes reporting of health related shocks based on the characteristics unobservable to the researcher. The Propensity Score Matching (PSM) estimator used in this analysis helps to control for these sources of selection bias and provides reliable, low – bias estimators of the impact of illness provided sufficient control variables relevant to modelling health related shocks are used (Heckman et al. 1997). Our data set contains a rich data set of conditioning variables to control for households reporting illness or health related shocks.

It has been widely documented that people of higher socio-economic position enjoy better health. This socio-economic gradient in health seems to hold up irrespective of what health measures are used (see e.g. Marmot 1999 and Smith 1998). People with higher education and income report worse health for a given condition (Etile and Milcent 2006).On the other hand, Pattanayak et.al.(2011) reported that individuals from lower socio-economic groups not only suffer from frequent health shocks but also suffer disproportionately for a given health shock. To capture this effect we include control variables which include whether the household head is educated or not, total asset value owned by the household, financial value owned, access to transfer, financial saving, and total expenditure per adult equivalent.

Access to credit can improve households' ability to cope with risks and reduce the risks they face. Accordingly, we include membership in the household extension package to control the effect of

access to credit on reporting health shocks. We also include awareness to climate change[13] and membership in local institutions to indicate the breadth and depth of household social connectedness to identify the role of these connections and access to information in reporting health shocks.

Finally, we include demographic factors (such as age of household head, number of adult male and number of adult female household members) associated with vulnerability to health shocks and our outcome variables. Adult household members, for example, may be correlated with exposure to participate in forest extraction because as a household member reaches adulthood, he/she participates in a greater number of chores, such as fuel wood and water collection, that involve going into forests. In addition, many cultures are preferential to boys so it is possible that girls will suffer from more diseases than boys will (Akin et al. 1985). Different behaviours between boys and girls could also lead to differences in disease rates (Kondrashin and Orlov 1989) and thus in reporting of vulnerability to health related shocks. With this rich set of control variables one can capture many of the determinants of reporting health related stocks that are typically unobservable to the researcher, which helps to reduce potentially significant sources of bias in the propensity score matching estimators.

Table 3.6 presents the empirical results of reporting illness used to create propensity scores for the matching algorithm. Results of the econometric analysis confirm that education level of the household, access to credit and membership in household extension packages and access to transfer (remittances) were associated with a higher probability of reporting illness. This echoes the findings of Etile and Milcent (2006); d'Uva et al.(2008) that people with higher education and

[13] We believe that households who are aware of climate change may take adaptation measures to avoid health related risks more than those who are not aware that climate is changing in their locality.

income report worse health for a given condition. Similarly, number of adult female household members had a significant and positive effect on reporting illness. As argued before, many cultures are preferential to boys so it is possible that girls suffer more from diseases than boys do (Akin et al., 1985). Interestingly, the number of months that the household had enough food stock is associated with a lower probability of reporting illness. Arguably, households with enough food stock have access to better nutrition and are less likely to be prone to disease.

Remoteness from basic infrastructure, measured by the distance to the nearest health post as well as distance to seasonal road, increases the probability of being sick. This is in line with the findings by Klemick et al, (2007) that in rural Tanzania, improvements in roads have a greater impact on health care access than improvements in health facilities because travel costs are one of the major impediments to health care access. Similarly, villages in Indonesia, the Philippines, and SriLanka participating in rural roads projects reported better access to health services based on several indicators compared with non-project villages (Hettige 2006).

<< INSERT TABLE 3. 6 ABOUT HERE>>

3.5.3.2. Average Treatment Effect

Table 3.7 below shows results of the Average Treatment Effects (ATT) estimated by the nearest neighbour and kernel matching techniques for the outcome variables, along with average differences and T-values for treated and control groups, where treatment is defined as a binary variable which equals one if the household has been affected by health related shocks in 2010, 0 otherwise. The results from both the matching algorithms produced consistent estimates of the treatment effects of health shocks. Focusing first on number of forest collection trips, the ATT reported in table 3.7 indicates that vulnerability to health related shocks exerts a positive and

significant effect on the number of trips for forest collection. The difference in ATT for treated and control groups from nearest neighbourhood and the kernel matching results is found to be 18.3 and 22.4 days per year respectively, These results are significant at 5% and 1% level respectively.

<< INSERT TABLE 3.7 ABOUT HERE >>

As shown in panel B of table 3.7 the second outcome estimated for treated and control groups was forest dependency (forest income as a proportion of total household income). This was also found to be positive and statistically significant, again implying that households affected by health shocks are more dependent on forest environmental resources than their counterpart households who were not affected by the same shock. The difference in ATT for treated and control groups is 1.5% and 5.9% for nearest neighbour and kernel matching respectively and both results are significant at the 10 % level of significance. However, despite a positive difference in the ATT for both groups, we found the difference in forest commercialization to be non-significant for non-poor households.

3.6. Conclusions and Policy Recommendations

Low and volatile incomes coupled with the absence of or poor development of financial or risk sharing institutions make consumption smoothing an important issue in low – income countries like Ethiopia (Barrett et al. 2001). One of the most common coping mechanisms in rural areas is forest extraction. Yet the empirical literature on forests as a means of risk coping is relatively limited, in some cases is qualitative/ethnographic (McSweeney, 2004), considerably smaller than that on biodiversity as a source of livelihood (CBD, 2010, Vira and Kontoleon, 2010) and typically relates only extraction volume, income, or income share with total income or asset holdings (e.g., Cavendish, 2000; Coomes et al., 2001; Godoy et al., 1995). As a result, there is little systematic analysis to help guide conservation and development promoters in their efforts to understand how

the poor (and others) deal with negative shocks (McSweeney, 2004). In this study, we analyse the role of forests for coping with idiosyncratic health shocks using sample data from Tigray Region in the northern highlands of Ethiopia. Previous studies used either forest sales or forest collection trips to show the role of forests in buffering misfortune. In this paper, we use a broader approach of outcome variables to analyse the issue. In addition, most of the previous economic studies on the impact of health effects and coping mechanisms treat them as exogenously given. In our study, we employ the Instrumental Variable Approach (IV) techniques and Propensity Score Matching (PSM) and thereby account for endogenous factors at the household level that may be associated with underlying health and labour allocation to forests.

In terms of conclusions, first, on a broader and quite positive note, forests appear to play a significant role in insuring households against idiosyncratic health shocks. This is in line with evidence from a number of different developing countries around the world regarding the role of forests in providing "natural insurance" (Pattanayak and Sills, 2001; McSweeney 2004; Takasaki et al.2004, Fisher et al .2010).

Second, access to institutional support and social capital are significantly and negatively related to forest dependency, forest sales and forest collection trips. In this regard access to credit, transfer, irrigation and ownership of jewellery were found to play a significant role. In addition, households who are aware of the change in their local climate tend to have lower trips to forest collection and lower forest sales. Finally, our results are robust to the econometric method used, i.e. results from the IV and PSM models are consistent.

These findings suggest that in order to achieve a win – win for human and environmental health, policies are needed which ensure that local values for forest resources (such as medicinal plants) are considered by forest management plans (Cofler et al.2006; Holding Anyonge et al.2006). In

addition, policy makers need to examine rural health delivery to determine the environmental consequences of access, or lack thereof, to health services. Also, policy makers need to promote a range of development measures such as improved access to credit through household extension packages and construction of health infrastructures so as to minimize the pressure on natural forests. .

Table 3. 1 Variables and summary statistics of the sample households

Variables	Descriptions and measurements	Mean	S.D
Ill_hhs	1 if the household is affected by health shock, 0 otherwise	0.19	0.39
Hhh_sex	Sex of the household head (1 if male,0 otherwise)	0.85	0.36
Age_hh_1	Age of the household head in years	46.7	12.5
Edu_hhh	Education of the household head in years	1.17	2.18
Family_size	Number of household members per adult equivalent	5.74	2.11
Aware_cc	Awareness of Climate change in the household(1= yes, 0 otherwise)	0.35	0.47
Male_adults	Number of male adult labour in the household	1.37	0.91
Female_adults	Number of female adult labour in the household	1.49	0.87
P_size _tsimdi	Plot size of land owned by the household in Tsimdi	4.36	2.93
Tlu	Number of livestock owned by the household in TLU	3.11	2.59
t_assets	Total value of assets owned by the household	1315	2099
t_hh_income	Total household income in Ethiopian Birr	11859	9054
Fooda_months	Number of months in a year that the household had enough food stock	5.7	3.42
Jewellery	Ownership of Jewellery in the household (1= yes, 0 otherwise)	0.33	0.47
D_health_post	Distance in minutes to the nearest health center	40.1	42.9
D_seasonal_road	Distance in minutes to the nearest seasonal road	9.1	14.6
M_hh_package	Household is a member of household package (1= yes, 0 otherwise)	0.18	0.37
Access_extension	Access to extension service (=1 yes, 0 otherwise)	0.84	0.36
N_ext_visit	Number of extension visit per year	7.79	9.92
D_transfer	Dummy if the household access to transfer (=1 yes, 0 otherwise)	0.31	0.46
Access_irrigation	1 if the household has access to irrigation, 0 otherwise	0.14	0.34
Log_dis_forests	Log transformed distance to forests in minutes	1.71	0.83
Log_dis_market	Log transformed distance to markets in minutes	1.24	1.33
Southern Zone	1 if the household lives in southern zone, 0 otherwise	0.41	0.49
South_Eastern	1 if the household lives in southern eastern zone, 0 otherwise	0.20	0.40
Eastern Zone	1 if the household lives in Eastern zone, 0 otherwise	0.39	0.48
Average Rainfall in mm	1 if the household lives in Eastern zone, 0 otherwise	589.4	100.5

Table 3. 2 Mean Separation Test of households affected by health shock and households that did not

Variable definition	Households reported health shock (n= 47)	Households did not report health shock (n= 204)	T-value
Age of Household head in years	48 (1.660)	46(0.894)	0.446
Sex of Household Heads (=1 if male, 0, otherwise)	0.89(0.045)	0.83(0.03)	0.342
Family size of the household	6.1 (0.14)	5.7(0.30)	0.252
Number of Female Adult household Members	1.83(0.153)	1.42(0.056)	0.003***
Number of male Adult household numbers	1.43(0.113)	1.36(0.066)	0.646
Education of the household head in years	1.45(0.32)	1.10(0.15)	0.331
Ownership of land in Tsimdi (equals 0.25 hectare)	3.80(0.40)	4.48(0.21)	0.146
Log total household expenditure per adult equivalent	7.48(0.006)	7.52(0.034)	0.638
Access to irrigation (=1 if yes , 0 otherwise)	0.26(0.064)	0.11(0.022)	0.007***
Number of months that the household had enough food in a year	4.79(0.480)	5.91(0.240)	0.042**
Ownership of Land in TLU	3.24(0.36)	3.08(0.18)	0.694
Forest income in Ethiopian Birr	3427(397.1)	2534(170.2)	0.027**
Participation in Forest Resource Extraction (=1 if yes, 0, otherwise)	0.91(0.04)	0.83(0.02)	0.160
Participation in forest Resource Commercialization (=1 if yes, 0 otherwise)	0.40(0.07)	0.31(0.03)	0.236
Forest Dependency (Share of forest income to overall household income)	0.31(0.035)	0.24(0.014)	0.036**
Average number of trips to forest per annum	92.9(7.50)	70.6(3.52)	0.006***
Access to any transfer (=1 if yes, 0, otherwise)	0.43(0.07)	0.28(0.03)	0.051*
Access to household extension package loans (=1 if yes, 0, otherwise)	0.32(0.07)	0.13(0.02)	0.002***
Participation in the Productive safety net program (=1 if yes, 0, otherwise)	0.55(0.07)	0.70(0.03)	0.061*
Access to extension visit (=1 if yes, 0, otherwise)	0.81(0.06)	0.86(0.02)	0.397
Membership in any organization ((=1 if yes, 0, otherwise)	0.57(0.07)	0.49(0.04)	0.272
Mean Annual Rainfall in MM	558(12.13)	596(7.21)	0.020**
Awareness of climate change (=1 if yes, 0 otherwise)	0.47(0.074)	0.33(0.329)	0.071*
Distance to the nearest health centre in minutes	63.0(7.8)	34.8(2.7)	0.000***
Log distance to local Market	3.98(0.177)	3.39(0.100)	0.010**
Distance to fuel wood collection	7.42(0.66)	10.39(0.47)	0.004***
Distance to Seasonal Road	17.8(3.39)	7.09(0.762)	0.000***
Distance to all weather road	46.4(6.96)	24.0(2.266)	0.001***

Significant level: * = 1%; ** = 5% and * = 10%.**

Table 3. 3 IV Probit estimates of health shocks and forest sales

Variable definition	Coefficient	S.E	T-value
Age of the household head	-0.020	0.009	0.023**
Education of the household head in years	-0.032	0.045	0.478
Gender of the household head (= 1 if Male, 0 otherwise)	0.009	0.350	0.979
Average grade of education in the household	-0.057	0.051	0.260
Number of Male Adult household member	0.511	0.240	0.033**
Number of Female Adult household member	0.248	0.256	0.332
Number of dependent household members	2.050	0.950	0.031**
Land owned by the household in Tsimdi	-0.037	0.051	0.467
Number of livestock owned in TLU	0.004	0.042	0.934
Family size	-0.194	0.119	0.102
Ownership of Jewellery	-0.512	0.208	0.014**
Dummy if the household is receiving any transfer (=1 if yes, 0 otherwise)	-0.284	0.190	0.135
Access to Irrigation (= 1 if yes, 0 otherwise)	-0.583	0.252	0.020**
Membership in the Household Extension package(=1 if yes, 0 otherwise)	-0.682	0.272	0.012**
Awareness of climate change in the household(=1 if yes, 0 otherwise)	-0.062	0.184	0.738
Access to Extension service (=1 if yes, 0 otherwise)	0.379	0.268	0.157
Dummy if the household has own business (= 1 if yes, 0 otherwise)	-0.670	0.240	0.005***
Shock related to illness of a household member (=1 if yes, 0 otherwise)	2.191	0.522	0.000***
Constant	-0.270	0.658	0.681

* significant at 10%; ** significant at 5%, *** significant at 1 %

Wald test of exogeneity (/athrho = 0): chi2(1) = 5.85 Prob > chi2 = 0.0156

Table 3. 4 IV2sls estimates of health shocks and forest dependency

Variable definition	Coefficient	S.E	T-value
Age of the household head	-0.004	0.001	0.003***
Education of the household head in years	-0.019	0.008	0.017**
Gender of the household head (= 1 if Male, 0 otherwise)	-0.006	0.574	0.918
Average grade of education in the household	0.003	0.007	0.660
Number of Male Adult household member	-0.303	0.343	0.376
Number of Female Adult household member	0.009	0.388	0.822
Number of dependent household members	0.266	0.164	0.017*
Land owned by the household in Tsimdi	0.004	0.007	0.580
Number of livestock owned in TLU	-0.006	0.007	0.410
Family size	-0.023	0.019	0.230
Ownership of Jewellery	-0.065	0.034	0.056*
Dummy if the household is receiving any transfer (=1 if yes, 0 otherwise)	-0.078	0.039	0.049**
Access to Irrigation (= 1 if yes, 0 otherwise)	-0.154	0.048	0.002***
Membership in the Household Extension package(=1 if yes, 0 otherwise)	-0.156	0.063	0.015**
Awareness of climate change in the household(=1 if yes, 0 otherwise)	-0.111	0.032	0.001***
Access to Extension service (=1 if yes, 0 otherwise)	0.139	0.043	0.749
Dummy if the household has own business (= 1 if yes, 0 otherwise)	-0.158	0.034	0.000***
Shock related to illness of a household member (=1 if yes, 0 otherwise)	0.735	0.250	0.003***
Constant	0.470	0.106	0.000***

*** Significant at 10%; ** significant at 5%, *** significant at 1 %**

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Table 3. 5 IV 2slsestimates of health shocks and forest trips

Variable definition	Coefficient	S.E	T-value
Age of the household head	-0.509	0.272	0.061*
Education of the household head in years	-6.196	1.637	0.000***
Gender of the household head (= 1 if Male , 0 otherwise)	-1.581	1.671	0.111
Average grade of education in the household	0.435	1.491	0.771
Number of Male Adult household member	-6.800	6.970	0.329
Number of Female Adult household member	1.399	7.883	0.859
Number of dependent household members	1.475	3.233	0.599
Land owned by the household in Tsimdi	0.269	1.485	0.856
Number of livestock owned in TLU	-0.451	1.491	0.762
Family size	2.872	3.907	0.462
Ownership of Jewellery	-1.663	1.908	0.034**
Dummy if the household is receiving any transfer (=1 if yes, 0 otherwise)	- 2.309	8.016	0.773
Access to Irrigation (= 1 if yes, 0 otherwise)	0.409	9.953	0.967
Membership in the Household Extension package(=1 if yes, 0 otherwise)	1.904	1.793	0.186
Awareness of climate change in the household(=1 if yes, 0 otherwise)	-1.325	1.601	0.267
Access to Extension service (=1 if yes, 0 otherwise)	1.853	0.836	0.265
Dummy if the household has own business (= 1 if yes, 0 otherwise)	3.910	2.998	0.576
Shock related to illness of a household member (=1 if yes, 0 otherwise)	1.149	0.744	0.063*
Constant	3.126	1.634	0.001***

*** Significant at 10%; ** significant at 5%, *** significant at 1 %**

Table 3. 6 Probit estimation of reporting illness

Variable definition	Coefficient	S.E	T-value
Age of the household head	0.01	0.01	0.263
Education of the household head in years	0.11	0.05	0.049**
Number of Male Adult household member	0.01	0.13	0.932
Number of Female Adult household member	0.25	0.13	0.041**
Total value of Durable assets owned by the household	-0.00	0.00	0.233
Financial Value of assets owned by the household	3.87	0.00	0.999
Log total expenditure per adult equivalent	0.27	0.28	0.334
Membership in social organization ((=1 if yes, 0 otherwise)	0.23	0.22	0.306
Access to Extension service (=1 if yes, 0 otherwise)	0.15	0.32	0.640
Membership in the Household Extension package(=1 if yes, 0 otherwise)	1.01	0.31	0.001***
Awareness of climate change in the household(=1 if yes, 0 otherwise)	0.30	0.24	0.219
Dummy if the household is receiving any transfer (=1 if yes, 0 otherwise)	0.52	0.24	0.029**
Number of months that the household had enough food in 2010	-0.08	0.04	0.064*
Log distance to Forests in minutes	0.21	0.15	0.165
Distance to the nearest health service in minutes	0.01	0.00	0.077*
Distance to all weather road in minutes	0.00	0.00	0.558
Distance to seasonal road in minutes	0.02	0.00	0.077*
Constant	-4.25	2.17	0.117

*** significant at 10%; ** significant at 5%, *** significant at 1 %**

Table 3. 7 Differences in ATT for treated and control groups

Outcome	Matching Algorism	E(Y) H=1	E(Y) H=0	Differences in Average outcome (ATT)	P –Value
PANEL A: Number of trips to forests per year					
Treatment : Dummy =1 if the household was affected by health related shocks, 0 otherwise					
Impact : Mean Impact					
Forest_trips	N-neighbor	92.9	74.6	18.3	0.010**
	K-matching	94.7	72.3	22.4	0.005***
PANEL B: Forest Dependency (Ratio of forest income to overall household income)					
Treatment : Dummy =1 if the household was affected by health related shocks , 0 otherwise					
Impact : Mean Impact					
Forest_dep	N-neighbor	31.0	29.5	1.5	0.086*
	K-matching	33.8	27.9	5.9	0.059*
PANEL C: Non-Poor Households					
Treatment : Dummy =1 if the household was affected by health related shocks , 0 otherwise					
Impact : Mean Impact					
Forest_sales	N-neighbor	61.7	40.4	21.3	0.242
	K-matching	56.8	39.0	17.8	0.299

* Significant at 10%; ** significant at 5%, *** significant at 1 %

Note: H =1 and H=0 refer to households affected by health shocks and those that were not, respectively.

CHAPTER FOUR

FOREST – FOOD SECURITY LINKAGES IN NORTH HIGHLANDS OF ETHIOPIA: SAFETY NETS OR POVERTY TRAPS?

4.1. Introduction

The importance of NTFP (non-timber forest products) captured the imagination of conservationists around the world, when an article by Peters et al (1989) published in Nature claimed that more money could be earned from tropical forests by collecting these products than from logging (Kaimowitz, 2004). The perception that NTFPs are more accessible to rural populations, especially to the rural poor (Saxena 2003) and that their exploitation is more benign than timber harvesting (Myers 1988) favored NTFP collection becoming an ecologically acceptable economic option for development. There was also an assumption, often implicit, that making forests more valuable to local users can encourage forest conservation (Plotkin and Famolare, 1992). As a result NTFP-based development was born as a new development paradigm capable of accommodating many potentially conflicting needs: of local livelihoods and of global markets; of balancing regional developmental aspirations with that of national growth; and above all that of reconciling environmental and development goals.

These developments initiated an increased level of research investigations and publications in the last two decades on different aspects of NTFP and in the process supported the global NTFP discussion leading to policy changes in many countries. However, the NTFP statistics in the form of macro and micro-economic indicators, portrayed in these discourses with varied degrees of claims on pro-poor benefits, also translate to very poor economic returns to the poorest. In fact

refocusing of the development agenda on poverty has led to recent reassessment of the role that bio-diversity plays in livelihoods and poverty alleviation. A profusion of new commentary has emerged. This poses many fresh questions, and, to some extent, tempers previous optimism regarding the ability of this sector to make a difference by providing a more subtle and complex picture of livelihood – biodiversity linkages. For example, Neumann and Hirch(2000) present evidence from an array of studies that show NTFP extraction is an activity of the poor, and Wunder (2001) and Angesen and Wunder(2003) argue that optimism about a win – win for development and conservation is unwarranted, and that NTFP extraction is generally a low- income activity that may even result in a poverty trap. The general conclusion is that the safety net and poverty trap aspects of NTFPs are linked, in as much as features that make non-timber forest products attractive to the poor also limit their potential for generating higher income and escaping their poverty (Angelson et al, 2007). However, many of the existing arguments and conclusions made on the link between poverty and biodiversity do not support their claims with strong evidence. Full understanding of the links between biodiversity and poverty require the ability to make causal inferences about the counterfactual, and few of the previous studies do this[14]. As a result, they have limitations in shedding light on the nature and the extent of linkages between biodiversity and poverty and hence miss opportunities for identifying common causes and common solutions to the two issues (Roe, 2005).

In a wide ranging review on the research done on the link between poverty and biodiversity, (CBD, 2010) reported that if nature's resources help to temporarily smooth consumption and incomes, their impacts may be better captured through an explicit focus on this temporality as part of our

[14]Delacote (2007) analyzes the role of the commons as insurance and how it might be linked to a poverty trap. However, his work is applied theoretic, which needs empirical testing.

poverty measure, instead of annualized income or consumption (in which these temporary contributions do not always feature as significant) (CBD, 2010). This relative importance of the temporality contribution of forests and the relative dearth of attention given to it by researchers and policy makers alike raise the possibility of significant untapped potential of forests to rural livelihoods, and provides an opportunity to increase our understanding about the specific roles of forests in different contexts and a significant impact for high quality research that tackles this topic. The main objective of this research is therefore to investigate the role of forest environmental resources in household food security and its implications on the long-term livelihood of farm households living along the margins of protected forests in the northern high lands of Ethiopia.

Our study contributes to the existing literature on biodiversity and poverty in two ways: first unlike the previous works done we are explicitly focusing on the temporality contribution of forests along with annualized consumption; second, we employ the Propensity Score Matching (PSM) method to consider the causal relationship between participation in forest environmental resource extraction and food security indicators, to address the counterfactual questions that may be significant in informing policy makers on the impact of forest environmental resources on the welfare of rural households in developing countries such as Ethiopia.

The chapter is structured as follows: Section 4.2 provides a review of literature on the role of forests as safety nets. Section 4.3 provides an overview of food security and forest environmental resources in Ethiopia. Section 4.4 provides a description of data. Section 4.5 discusses thetheoretical framework and empirical procedure of the study. Section 4.6 presents the empirical results, while section 4.7 explains households' choice of participation in forest environmental resources. The final section provides conclusions and policy implications.

4.2. Review of Related Literature on the safety net role of Forests

Several studies have examined the extent to which poor people depend upon biodiversity as means of subsistence or income to the poor and as insurance to the poor from risks and shocks(CBD, 2010).A substantial amount of the existing literature examines the dependency of the poor on biodiversity reflected in the proportion of income that is derived from forests (Vira and Kontoleon 2010), on income equity effects (e.g. Babulo et al., 2009) and on correlations rather than causal effects of income from forest environmental resources on household welfare (Pattanayak and Sills 2001). A few studies assess the role of tropical forests (and hence biodiversity rich ecosystems) as an insurance against food security (and income) variability (CBD, 2010; Vira and Kontoleon 2010).

Forest resources, such as non-timber forest products (NTFPs), have long served as safety nets or "natural insurance" to help cope with environmental and economic shocks (Angelsen & Wunder, 2003; Shively, 1997, Fisher et al., 2010), and are an important part of livelihood strategies in sub-Saharan Africa (Cavendish, 2000; Paumgarten, 2005; Shackleton &Shackleton, 2004; Mamo et al., 2007 Babulo et al., 2009). Rural households, which have limited credit and insurance options, choose a diversification of their activities in order to reduce aggregate risk (Delacote, 2007). For example, Fisher et al, (2010) in their study of southern Malawi found that forests are providing a source of cash for coping with weather related crop failure. They also found that households most reliant on forests have low income per person, are located close to forests, and are headed by individuals who are older, more risk averse, and less educated than their counterparts who are less forest-dependent. Similarly, Volker and Waibel (2010) found that households in Vietnam who are affected by idiosyncratic health shocks, experienced by economically active household members, and by severe weather shocks were more likely to extract forest products. Debela et al. (2012)

argued that shocks tend to lead rural households in Uganda to depend on forests to meet subsistence and cash needs. In Kenya and Tanzania, six out of 16 strategies for dealing with drought involved the use of indigenous plant species found in forests (Eriksen et al., 2005). Forest gathering was also an important strategy for coping with covariate flood shocks in Peru, particularly in households with few physical assets and more adult members (Takasaki et al., 2004). Similar findings are reported in Pattanayk and Sills (2001); McSweeney (2003); Fisher and Shively (2005).Hence, at least for the case of poor communities living close to tropical forests, there appears to be support for conjecture that forests act as a safety net against food insecurity (and income) variability (CBD, 2010; Vira and Kontoleon, 2010).

However, even if the above papers studied the insurance role of common property resources, many other researchers argued that resource reliance may represent a strategy that prevents the poor from participating fruitfully in other activities and escaping their poverty (Angelsen et al., 2007). Indeed existing overviews (Byron and Arnold 1999; Neumann and Hirsch 2000) suggest that most NTFPs produce low returns (particularly in terms of return per ha and often, also per labour unit), are primarily used for subsistence and often fill income gaps. They are accessible to the poor people precisely because no one else wants them. In economic terms, many are inferior goods which are substituted by superior products when incomes rise (Arnold and Perez 2001), and/or become intensively cultivated, in which case poorer people may be less well-placed to benefit (Homma 1996, Ruiz-Perez et al. 2003).

Delacote (2007) analyses the use ofthe commons as insurance, exploring whether the commons are a safety net or poverty trap. However, his work is applied theoretic, and was not tested empirically. It is therefore interesting to analyse the forest–food security linkage and test whether

it is a safety net or a poverty trap in the context of rural households who are dependent on forest environmental resources as part of their livelihood strategy.

4.3. Food Security and Common Pool Resources use in Ethiopia

Chronic food insecurity has been a defining feature of the poverty that has affected millions of Ethiopians for decades. The vast majority of these very poor households live in rural areas that are heavily reliant on rain fed agriculture and thus, in years of poor rainfall, the threat of widespread starvation is high (Hoddinott et al., 2009). Moreover, many smallholder farmers in the region need to supplement the income derived from rain fed agriculture. Income from forest products contributes as high as 27% and 39% for rural households living close to natural forests in Northern and Central Ethiopia, respectively (Babulo et al., 2009; Mamo et al., 2007). Studies have also shown that forest dependent people are poorer, live close to the forest, are younger, and have lower livestock and crop income (Illukpitiya and Yanagida, 2008; McElwee, 2008; Mamo et al., 2007). These factors often interact with one another resulting in a reinforcing cycle of the "poverty, food insecurity and natural resources degradation trap". This problem is most acute in the Ethiopian highlands (where over 85 percent of the country's population lives), which is affected by recurrent drought and famine affecting millions of people (FAO 2003).

To mitigate this poverty and resource degradation, closing degraded land areas from human and livestock intervention to promote natural regeneration of plants, commonly termed as enclosures, is among the major efforts to constrain resource use practiced in the highland areas of Tigray, northern Ethiopia (Tewelde-Berhan, 2002; Babulo, 2007).However, the adoption of restrictive use rules and the limitation in allowable harvests have led many local residents to view enclosures as a less favoured land use option (Babulo, 2007). There is also consensus in the relevant literature that benefit streams from enclosures to date are largely environmental and economic benefits for

most people are so far minimal (Howard and Smith, 2006). These arguments are partly because of a lack of clear understanding about the contribution of forest environmental resources to the food security of rural households in the region.

4.4. Data Description

A household survey was conducted in 2010/11 on 254 households in Tigray region of northern Ethiopia. A two stage sampling design was made in the study. The primary sampling units (PSUs) were tabias. Sample tabias were selected on the basis of secondary information collected from all the Woredas. In this category, a total of ten tabias namely Arato, Derga _ajen, Hugumrda, Meswaeti, Kara_adishawo, WorebayuKal_amin, Kelisha_emni,andFelege_woini were selected for the survey (see Figure 2.1). The tabias selected are representative of the three different agro-ecological zones of the region identified on the basis of altitude. Areas with altitude ranging from 1500- 2300 m.a.s.l. are locally termed as *woinadouga* i.e. midland areas, areas above 2300 m.a.s.l. are locally known as *dougai*.e. Highland areas and areas with altitude less than 1500 m.a.s.l. are termed as *kola* i.e., lowland. A multi-purpose questionnaire was used to gather information on household income, expenditure, household assets, vulnerability to shocks, labor allocation and local institutions alongside a host of other information related to production and sales.

The purpose of this part of the analysis is to examine the relationship between forest dependency and food security. The dependent variable used in the study is a dummy variable that takes the value of one, if the household participated in forest environmental resource extraction, and a value zero, if no participation was recorded. The outcome variables used in this study are log transformed total per capita expenditure per adult equivalent (Log_tot_exp_aue), the number of months in a year that the household had enough food stock available (Fooda_months), and one binary indicator that takes one, if the household mortgaged its assets (distress_sale) for current consumption during

the farming season, zero otherwise. These food security indicators were chosen to be in line with those suggested in the literature (Owusu and Abdulai, 2011).

<< INSERT TABLES 4.1 AND 4.2 ABOUT HERE >>

Table4.1 presents the definitions and sample statistics of the variables used in the analysis. Table 4.2 presents differences in means of the variables used in the matching analyses along with their significance levels. The significance levels suggest that there are some differences between participants and non-participants with respect to household and outcome variables. With regards to the outcome variables, there appear to be statistically significant differences in household total per capita expenditure per adult equivalent, distress sales and in the number of months in a year that the household had enough food stock available between participants and non-participants. There are also significant differences in sex and education of household head, household size, awareness of climate change, net financial assets, total assets, off farm income and total farm income.

There is a significant difference between participants and non-participants regarding awareness of climate change. 31% of the participants have awareness of climate change compared to 58% of non-participants;this suggests awareness of climate change might reduce participation in extractive activities. There are also significant differences between participants and non-participants in terms of education:on average, participants have a lower number of years of formal education than non-participants. With more education, households may access a broad variety of livelihood activities, have higher opportunity cost of time (Adhikari et al., 2004) and may disregard the collection of forest resources. In addition, participants have lower value of total assets, net financial assets and durable assets compared to their non-participant counterparts. As argued by Angelsen and Wunder (2003) households with more assets may easily access more profitable livelihood activities and

may give less priority to environmental resource incomes, which are often considered "employment of the last resort".

Many researchers argued that female-headed households may exhibit greater dependence on forest resources (Cavendish, 2000; Shackleton and Shackleton, 2006a, b), possibly because they often are poorer, have less access to adult labor (Vedeld et al., 2004), and may lack the means to seek employment away from their families (Shackleton and Shackleton, 2004). In contrast to this view, our survey indicated that male-headed households participate more in forest environmental resource collection;this finding is similar to Adhikari (2005). Furthermore, there is a significant difference between participants and non-participants in terms of family size:participants have higher family size than the corresponding figure of the non-participant counterparts. Larger households may collect forest resources for two reasons: they have more labor to allocate to this activity, but may also be forced to do so by greater dependence and consumer burdens (Godoy et al., 1997).

The findings from the previous section that simply compare mean differences in the outcome variables and other household variables between participants and non-participants suggest that non-participants are generally better off than participants. Given that the comparisons of mean differences do not account for the effect of other characteristics of farm households, they may confound the impact of participation in forest environmental resource extraction on food security status with the influence of other characteristics. Multivariate approaches that account for selection bias arising from the fact that participants and non-participants may be systematically different are essential in providing sound estimates of the impact of participation in forest extraction on household income and food security. The independent variables used in the probit regression models to predict the propensity scores were based on past research on the determinants of

participation in forest environmental resource extraction (Cavendish, 2000; Shackleton and Shackleton, 2006a,b, Vedeld et al., 2004 Adhikari et al., 2004 Adhikari, 2005, Babullo et al, 2009).

4.5. Theoretical Framework and Empirical Procedure

4.5.1. Theoretical issues

The conditions of the study area, where households live in relatively remote areas on forest margins and where household time endowments are their main factor input, are well matched to the basic assumptions of household production theory. The fundamental issue in household production theory is the non-separability of production and consumption decisions, and arises when markets are missing or incomplete.

Sills et al (2003) discuss some of the theoretical considerations in applying the household production model to households living on forest margins. The following briefly describes the main components of the theoretical model developed by Sills et al: their approach essentially provides the theoretical underpinning for the analysis conducted in this chapter. Their model assumes that a household engages in agriculture (A) and collection of NTFPs(F). It also assumes complete markets for agricultural products and for market goods(M), but incomplete markets for NTFPs and labour. The amount of labour and leisure available are constrained by the value of agricultural output plus any exogenous income(I) such as remittances. The household seeks to maximize a single utility function, which depends on consumption of agricultural goods(A_H), market goods(M_H), forest goods(F_H), and home time T_H, (including leisure, childcare, etc.). Household utility is conditioned on preferences (Φ).

Max $U(A_H, M_H, F_H, T_H;\ \Phi)$

s.t.

$$(1) T \geq T_H + T_A + T_F$$

$$(2) A = a(T_A, F_A, M_A; \Psi)$$

$$(3) F = f(T_f; B, H, \Psi) \qquad (4.1)$$

$$(4) F \geq F_H + F_A$$

$$(5) P_A(A - A_H) + I \geq P_M(M_H + M_A)$$

The constraints apply to (1) household income, (2) agricultural production, (3) non-timber forest production, (4) forest output allocation, and (5) budget. The choice variables are T_H, T_F, M_A, M_H, F_H, F_A, and A_H.

Agricultural production is a function (a) of household time allocated to agriculture (T_A) and other inputs collected from the forest (F_A) or purchased in the market (M_A), conditioned on fixed household production endowments (e.g., land, livestock) and technology (Ψ). Forest production (f) is also conditioned on fixed production endowments. However, the model also assumes that it does not compete with agriculture for land, but rather takes place in public forest, conditioned by its biophysical state (*B*) and household knowledge of the forest (*H*).The only variable input in forest product collection is household time (T_F). Forest products are either consumed (F_H) or used as inputs to agriculture (F_A).

Sills et al (2003) go on to derive first order conditions for utility maximisation. These include (i) that marginal cost equals marginal benefit in forest collection; (ii) the marginal utility of increased agricultural production arising from inputs of forest products must equal the marginal utility of household consumption of forest products. Taken together, these conditions imply that the shadow value of time must also equal the marginal utility of increased agricultural production due to forest inputs obtained with more time spent collecting.

Generally Sills et al (2003) demonstrate that the shadow values in their model – of time, income, increased agricultural production, and the "price" of NTFPs governing collection and consumption decisions - which are internal to each household, depend on all exogenous variables in the system. "*This dependence of production decisions on preference and endowments is termed nonseparability in the household production literature and results whenever key markets are missing or incomplete*"(Sills et al., 2003, pg 264).

As noted by Sills et al, if markets are incomplete, household behavior can be modeled *"as a function of socioeconomic and environmental characteristics reflecting preferences, technology, and input endowments, rather than prices."*(Sills et al, pg 267). No specific restrictions on the functional form of models are warranted under these conditions. Exogenous variables used in empirical estimation generally represent household demographics, assets, income opportunities/sources, possible substitutes, and Regional/locational characteristics.

4.5.2. Empirical estimation issues and procedures

The above theoretical considerations provide a guide for the empirical estimation procedures used in this chapter. In the analysis in this chapter, which is focused on factors influencing the decision to participate in forest environmental resource extraction, and the relationship between participation and food security status, the independent variables used in the analysis (Table 4.1) comprise demographic variables, asset variables, access to other employment, location dummies, a knowledge variable (awareness of climate change) and variables reflecting experience of shocks.

The decision to participate (Pi*) can be specified as an index function as follows:

$$P_i^* = \beta Z_i' + \mu_i$$
$$P_i = 1 \text{ if } P_i^* > 0 \qquad (4.2)$$
$$P_i = 0 \text{ if } P_i^* \leq 0$$

WhereZ_i' denotes a vector of variables such as household and location characteristics that influence decision to participate, andμ_i is the random disturbance term.

To analyse the relationship between participation in forest environmental resource extraction and outcomes such as household income and food security status, following Osuwu et al (2011) we can specify a linear function

$$Y_i = \lambda_i + \alpha_i X_i' + \delta_i P_i + \varepsilon_i \qquad (4.3)$$

Where $Y_i$is household income or food security status, P denotes a dummy variable representing one if the household participates in forest related activity and zero otherwise; X_i' is a vector of household characteristics, λ_i is a vector of unknown parameters, and ε_i is a random error term. Participation in forest related activity is treated as an exogenous variable on the basis that households participate in forest related activity to increase their income or improve their food security status. However, participation in forest environmental resource extraction may not be random, with the group of participants and non-participants being systematically different: if this is the case the measured return to participation in forest environmental resource collection may be biased. Therefore, it is necessary to ensure that there is a credible counterfactual against which we

may measure the impact of participation in forest environmental resource extraction on food security. Following Owusu et al (2011) we can resort in these circumstances to using the propensity score matching approach to overcome potential problems of selection bias. The steps involved in this approach are further discussed below.

Let P =1, 0 indicate treatment (participation in forest environmental resource extraction) and control (non-participation) respectively and let Y_1 and Y_0 denote the outcome of interest (food security) for households with treatment and without treatment respectively. Since we observe households to be either with treatment or without treatment, we cannot observe the causal effect of interest: $Y_1 - Y_0$. Some features of this distribution are estimable, nevertheless. In particular, we may consider the Average Treatment Effect of the Treated (ATT):

$$\text{ATT} = E\left(Y_1 - Y_0 \mid T = 1\right) \qquad (4.4)$$

The ATT measures how much the outcome of interest changes on average for those households who undergo the treatment (in this case, those who participated in forest environmental resource extraction). Clearly, simply computing the difference in the average outcomes of those households who are participating in forest environmental resources and those who did not is open to bias, as there are observed and unobserved characteristics that determine whether the household undergoes the treatment. That is,

$$E\left(Y_1 \mid P = 1\right) - E\left(Y_0 \mid P = 0\right) =$$

$$E\left(Y_1 \mid P = 1\right) - E\left(Y_0 \mid P = 1\right) + \left(Y_0 \mid P = 1\right) - E\left(Y_0 \mid P = 0\right) =$$

$$E\left(Y_1 - Y_0 \mid P = 1\right) + E\left(Y_0 \mid P = 1\right) - E\left(Y_0 \mid P = 0\right) =$$

$$\underbrace{E(Y_1 - Y_0 \mid P=1)}_{\widehat{ATT}} + \underbrace{(Y_0 \mid P=1) - E(Y_0 \mid P=0)}_{\widehat{BIAS}} \quad (4.5)$$

Only if we can guarantee that outcomes of the control group are equal on average to what the outcomes of the treatment group would have been in the absence of treatment does this consistently estimate the ATT. With non-random sorting into treatment and control, this condition is rarely met.

Now suppose that by conditioning on an appropriate set of observables, X, the non-participation outcome Y_0 is independent of the participation status P. This is the weak version of the un-confoundness assumption, also called ignorable treatment assignment (Rosenbaum and Rubin, 1983) or conditional assumption (Lechner, 2000) or selection on the observables, which suffices when the parameter of interest is the ATT, as only assumptions about the potential outcomes of comparable individuals are needed to estimate counterfactuals.

$$Y_0 \perp P \mid \mathrm{X} \quad (4.6)$$

This implies that

$$E(Y_0 \mid P = 1, X) - E(Y_0 \mid P = 0, X) = 0 \quad (4.7)$$

In order to identify the ATT, the overlap or common –support condition is also assumed. It ensures that, for each treated household, there are control households with the same X.

$$Pr(P = 1 \mid X) < 1 \quad (4.8)$$

Therefore, under the assumptions stated in equation (4.6) and (4.8) above, we could estimate the ATT from the differences in outcomes between treated and controls within each cell defined by

the conditioning variables (Blundell and Costa Dias, 2002). Using the law of iterated expectations and the conditional independence assumption, the ATT can be retrieved from observed data in the following way:

$$\text{ATT} = E(Y_1 \mid P = 1) - E(Y_0 \mid P = 1)$$

$$= E_X\left[\left(E(Y_1 \mid X, P = 1) - E(Y_0 \mid X, P = 1)\right) \mid P = 1\right]$$

$$= E_X\left[\left(E(Y_1 \mid X, P = 1) - E(Y_0 \mid X, P = 0)\right) \mid P = 1\right] \qquad (4.9)$$

The estimate of ATT as shown in equation (4.9) turns out to be prohibitive in terms of data when the set of conditioning variables X is large. An alternative is to use the results of Rosenbaum and Rubin (1983, 1984) and condition on the probability of treatment as a function of X, the propensity score$P(X)$, since the conditional independence assumption also implies that

$$E\left(Y_0 \mid P = 1, P(X)\right) - E\left(Y_0 \mid P = 0, P(X)\right) = 0 \qquad (4.10)$$

Therefore, we could estimate ATT from the differences in outcomes between treated and controls within each cell defined by values of P(X).

$$\text{ATT} = E(Y_1 \mid P = 1) - E(Y_0 \mid P = 1)$$

$$= E_{P(X)}\left[\left(E(Y_1 \mid P(X), P = 1) - E(Y_0 \mid P(X), P = 1)\right) \mid P = 1\right]$$

$$= E_{P(X)}\left[\left(E(Y_1 \mid P(X), P = 1) - E(Y_0 \mid P(X), P = 0)\right) \mid P = 1\right] \qquad (4.11)$$

Provided that the conditional participation probability can be estimated using a parametric method such as a probit model, matching on the univariate propensity score reduces the dimensionality problem.

To estimate the propensity score we estimate a probit model with the binary dependent variable - whether a member of household participated in forest environmental resource extraction (=1) or not (=0) - using our sample data. Using this approach, we are able to control for unobservable factors that may influence households' reported participation in forest environmental resource extraction. A number of matching algorithms are suggested in econometric literature: in this study we consider nearest neighbour and kernel matching methods.

4.6. Empirical Results and Discussions

4.6.1. Propensity Score Results

To construct the propensity score used to match participants and non-participants in forest environmental resource extraction, a probit regression model was estimated, where the dependent variable is a binary variable indicating whether the household participates in forest environmental resource collection or not, using a broad set of control variables. In propensity score matching, it is important to condition the match on variables that are highly associated with the outcome variables (Heckman and Navarro-Lozano, 2004). However, Smith and Todd (2005) argued that there is little guidance on how to select the set of conditioning variables used to construct the propensity score. As stated in the empirical strategy section, we focused on finding a set of conditioning variables that on theoretical grounds and information in the survey should be highly associated with the probability of participating in forest environmental resource extraction and with the outcomes of interest. In general the control variables were chosen based on empirical studies of rural households' reliance on forest environmental resources (Angelsen and Wunder,2003; Vedeld et al., 2004; Adhikari et al., 2004; Fisher and Shively, 2005; Cavendish, 2000 ; Babulo et al., 2009).

Table 4.3 presents the empirical results of participation in forest environmental resource extraction used to create propensity scores for the matching algorithm. The control variables chosen include household demographic variables (sex, age and education of the household head and the number of students in the household, number of male and female adult labor), whether the household is aware of climate change or not, whether the household experienced weather related shocks, death or illness of a household member, loss of livestock, whether the household earns off-farm income, whether the household has access to private forest, land holding in tsimdi, number of livestock owned in TLU and number of donkeys owned, log distance to market and to forest in minutes, and location dummies.

<<INSERT TABLE 4.3 ABOUT HERE>>

Results of the econometric analysis in table 4.3 confirm that education of household head is a significant determinant of participation in forest environmental resources extraction. Higher education levels of a household head are associated with lower probability of participating in forest environmental resource extraction. With more education, households may access a broad variety of livelihood activities, have higher opportunity cost of time (Adhikari et al., 2004) and may disregard the collection of forest resources. Second, our result indicated that the probability of participating in forest environmental extraction is significantly higher for male-headed households compared to female-headed households. This result is different from many other studies that have concluded that forest extraction isparticularly an activity of female headed households (Cavendish, 2000; Shackleton and Shackleton, 2006a, b), possibly because they often are poorer, have less access to adult labour (Vedeld et al., 2004), and may lack the means to seek employment away from their families (Shackleton and Shackleton, 2004). Our finding is similar to that of Adhikari (2005). Likewise, households engaged in off farm employment are less likely to participate in

forest extraction,which usually has lower returns on labor effort and typically requires quite strenuous physical activity (Angelsen and Wunder, 2003). It is interesting to note the negative and significant impact of awareness of climate change:farm households that are aware of climate change are less likely to participate in forest extraction.

The density distribution of the propensity score for households that are participating in forest extraction and those that did not shows a good overlap (see figure 4.1) suggesting that the common support condition is satisfied. The bottom half of the graph shows the propensity score distribution for the untreated, while the upper –half refers to treated households.

<< INSERT FIGURE 4.1 ABOUT HERE>>

Table 4.4 demonstrates how matching restricts the control sample in order to increase the similarity of the subsample of control cases that are directly compared with treated cases, in order to estimate the consequences of treatment. Table 4.4 presents the balancing information for the propensity scores and for each covariate before and after matching. We used the standardized bias differences between treatment and control samples as a convenient way to quantify the bias between treatment and control samples. In many cases, we found that sample differences in the unmatched data significantly exceed those in the samples of matched cases. The process of matching thus creates a high degree of covariate balance between the treatment and control groups that are used in the estimation procedure.

The imbalances between the treatment and control samples in terms of the propensity score had been more than 100 % before matching as shown in table 4.4. This bias was significantly reduced to a level of 4.3% after matching. The same table also shows that before matching, several

variables exhibit statistically significance differences, while after matching the covariates are balanced.

The low pseudo R^2 and the insignificance likelihood ratio tests also support the hypothesis that both groups have the same distribution in covariates after matching (see table 4.5). These results clearly show that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. We therefore used these results to evaluate the impact of forest extraction on food security among groups of households having similar observed characteristics. This allows us to compare outcomes for households participating in forest related activities with those of a comparison group showing common support.

4.6.2. Average Treatment Effects

Having looked at the determinants of the probability of participating in forest environment resource extraction in rural Tigray, we now examine the size of consumption expenditure per adult equivalent, distress sale and food availability during the critical periods between participants and non-participant households. We then split the sample into two sub samples: the poor (households belonging to the first and second quintiles) and the non – poor (households belonging to the two upper quintiles), and we do the same comparisons. This split enables us to see the extent to which participation in forest environmental resource is pro- poor or otherwise.

Table 4.6 presents estimates of the average impact of participation in forest environmental resource extraction. The outcomes considered include total expenditure per adult equivalent, distress sale of assets for immediate consumption and the number of months in a year that the household had enough food available. Panel A of table 4.6 shows the average level of food security outcomes defined above along with the average differences and P-values for treated and control variables, where treatment is defined by participation in forest environmental resource extraction for the

whole sample, while panels B (table 4.7) and C (table 4.8) present the same outcome for poor and non-poor households respectively.

The results indicate that the difference in household expenditure per adult equivalent between treated (participants in forest environmental resource extraction) and untreated (non-participants) households for the whole sample is substantial when households are matched based on demographic, assets and other covariates,usingnearest neighbor and kernel matching respectively. Participants in the matched sample have on average 0.11 and 0.18 lower per capita log expenditure per adult equivalent than non-participants in the same sample as shown by the nearest neighbor and kernel matching respectively. This suggests that participation in forest environmental resource extraction has a causal (negative) influence on total expenditure per adult equivalent when households are matched on relevant socio-demographic, assets and other covariates.

<< INSERT TABLE 4.6 ABOUT HERE>>

For the number of months that the household had enough stocks of food available (fooda_months), a similar trend is reflected. Treated households in the matched sample have fewer months of having enough food available during the year than non-participants in the same sample. The participants have enough food stock available on average for 1.74 months (24%) lower than non-participants and the difference is statistically significant at 5% levels of significance.

The third outcome estimated for participants and non-participants is distress sale of assets for immediate consumption (distress sale). Again, participants have higher levels of distress sale than non-participants in the same sample do. Participants have a distress sale level that is on average 0.05 points (i.e 13%) higher than non-participants and the difference is statistically significant at 1% level of significance.

To sum up, Panel A (table 4.6) indicated that treated households (those participating in forest resource extraction) have significantly lower food security outcomes than the untreated households in rural Tigray, and the finding is robust to whether we use different food security indicators or to the matching methods used.

In Panel B (table 4.7) and C (table 4.8), we split the sample into two sub samples: the poor (households belonging to the first and second quintiles) and the non–poor (households belonging to the two upper quintiles), and we do the same comparisons as panel A. This split enables us to see if the average impacts in panel A (table 4.6) mask significant impacts of participation in forest environmental resource extraction for some participants and to see the extent to which participation in forest environmental resource extraction is pro- poor or otherwise.

<< INSERT 4.7 ABOUT HERE>>

The results show that both poor and non-poor participants (treated) have lower total expenditure per adult equivalent than poor and non-poor untreated households (non-participants).Conversely, we find that the poor and non-poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non-participants in the same sample,supporting the widely held view that forests are important as an economic buffer in hard times. Finally while we find that the non-poor participants had higher number of months of food stock available compared to non-participants in the same sample,there was no significant different in the number of months thatpoor households had enough food available,between participants and non-participants. These results need to be treated with some caution due to the relatively small number of non-participants in the sample, but they do suggest the importance of conducting such disaggregated analysis to identify differences in the functions of forest resource utilization for different categories of households.

<< INSERT 4.8 ABOUT HERE >>

4.7. Does Diversification or Coping Strategy explain households' choice of Participation?

It is now generally established that the safety net use of NTFP extraction may take two forms, corresponding to two kinds of risk–management strategies: first, the diversification strategy, because the households use NTFP extraction as a risk-free asset (Alderman and Paxson, 1994); second, the coping strategy which consists of extracting NTFP only when agricultural output is too low, working as a "natural" insurance mechanism. Therefore, the problem for local communities has both the characteristics of portfolio analysis and economics of insurance (Delacote 2007). In the latter case, while NTFP extraction insures against a bad outcome (in case a household relied on just one risky activity) as discussed in section 4.2, it also potentially excludes the household from engaging in high return activities that come from specialization.

We therefore further explore the idea that participation in forest environmental resource collection is motivated by mitigation or reduction of the potentially high risk in agriculture. We measure the risks that households face in agriculture through the predicted probability that the farm households have zero or negative profits from their agricultural activities[15]. We compare this outcome across comparable groups of participant and non –participant households. Next, we matched participants and non-participants on the propensity score. Having obtained groups of comparable households, we calculate the average differences in the predicted probabilities of having zero and/or negative profit from farming across the participants and non-participants. These predicted probabilities are

[15]Farming profits are calculated as net income from farming. Net income is obtained even for households which do not sell on the market by applying to their farm production the average prices faced by the households in the same area. Moreover, in doing this part of analysis we exclude households who are landless although they are very few.

obtained through a probit model where having negative or zero profit from farming is a function of sets of variables which normally influence farming profits (see table 4.9).

Our results in Panel A of table 4.10 suggest that households in rural Tigray are not driven into NTFP extraction by risks in farm output. This finding is consistent with the diversification strategy usually observed in Latin American countries (Alderman and Paxson, 1994) that involves households raising ex ante the number of their activities, choosing possible activities that have low covariance.

However, the average pair-wise differences for poor and non-poor (panel B and C) of table 4.10 revealed that participants and non-participants are significantly different in their predicted probabilities of negative profit from farming. For example, results from panel B indicate that the difference in poor households' farming profit between treated (participants) and control (non-participants) is substantial (-0.05) and (-0.15) for the nearest neighbour and kernel matching respectively, i.e. participants in the matched sample from poor households have on average higher negative profit from farming than non-participants. Moreover, while participants from the subsample of non-poor households in panel C have on average 0.15 negative profits from farming, the non-participant households have on average zero negative farming profits. In this regard, our analysis suggests that the poor and non –poor farm households in Tigray are also driven into forest environmental resource extraction by risks in farm output or being more prone to volatile agricultural income. This finding is also consistent with the coping strategy which is observed in African countries (Alderman and Paxson, 1994) and which suggests that agricultural risk mitigation partially explains participation in forest resource extraction (Delacote, 2007, Pattanayak and Sills, 2001).Overall, it appears that the decision to participate in forest environmental resource extraction in rural Tigray is motivated by both the diversification and coping strategies.

4.8. Conclusions and Policy Implications

In this chapter, we investigate the differences in food security outcomes (total expenditure per adult equivalent, distress sale of assets for immediate consumption and number of months that the household had enough food stock available in a year) between households that participate in forest environmental resource extraction and those who do not, using 251 sample farm households from ten Peasant associations (tabias) living in Tigray Regional State Ethiopia. We use a propensity score matching method to account for selection bias that normally occurs when unobservable factors influence both participation in forest environmental resources extraction and food security outcomes. The paper also addresses household heterogeneity by explicitly providing separate estimates of the average treatment effect (ATT) for poor and non-poor households.

Our analysis leads to several interesting results. First we find that education, age and sex of household head, access to off–farm employment, shocks related to death or illness of a household member and awareness of climate change significantly affects participation in forest environmental resources. Second, we find that participation in forest environmental resource extraction in rural Tigray has significantly lower food security outcomes than farm households that are not participating. Third, we find that the poor and non-poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non-participants in the same sample, enforcing the widely held view that forests are important as an economic buffer in hard times. Fourth, households in rural Tigray are not driven into forest extraction by risks in farm output only but also by a diversification strategy, suggesting that the problem for local communities has both the characteristics of portfolio analysis and economics of insurance (Delacote 2007).

The implications of the above findings are that forests serve as a safety net by mitigating distress sale of assets for immediate consumption; at the same time households that are participating in forest resources are relatively poor in the sense that they have lower food security outcomes, supporting the widely held view that the poor appear to be linked with nature-based resource use, but that these may serve to perpetuate poverty and food insecurity (CBD, 2010). Thus, examining and promoting alternative livelihood strategies such as off-farm work and other social protection programs such as the productive safety net program in Ethiopia are warranted to solve the problems of food insecurity and resource degradation in the region.

Table 4. 1 Variables and summary statistics of the sample households

Variables	Descriptions and measurements	Mean	S.D
Forest_extraction	Dummy =1 if the household participates in forest extraction, 0 otherwise	0.85	0.36
Outcome Variables			
Log_tot_exp_aue	Log total expenditure of the household per adult equivalent units	7.51	0.48
Distress_sale_a	Food insecurity (Dummy =1 if the household reported distress sale of assets for immediate consumption, 0 otherwise	0.71	0.46
Fooda_months	Food Security (number of months in the year that the household had enough food stock)	5.70	3.43
Hhh_sex	Sex of the household head (1 if male ,0 otherwise)	0.85	0.36
Age_hh_1	Age of the household head in years	46.8	12.5
Edu_hhh	Education of the household head in years	1.17	2.18
Student number	Number of students in the household	1.51	1.43
Aware_cc	Awareness of Climate change in the household(1= yes, 0 otherwise)	0.35	0.48
Male_adults	Number of male adult labour in the household	1.37	0.91
Female_adults	Number of female adult labour in the household	1.49	0.87
P_size _tsimdi	Plot size of land owned by the household in Tsimdi	4.36	2.93
Tlu	Number of livestock owned by the household in TLU	3.11	2.59
N-donkey	Number of donkey owned by the household	0.75	0.84
Private_forest	Access to private forest (1 if male,0 otherwise)	0.45	0.50
Off_farm	Access to off farm employment by the household (1 if male,0 otherwise)	0.32	0.47
Log-dis_forests	Log distance to forests in minutes	1.24	1.33
Log_dis_market	Log distance to woreda market in minutes	1.71	0.82
S_wheather	Household experienced to any weather related shock (1= yes, 0 otherwise)	0.80	0.40
S-death_ill	Household experienced death or illness of a member (1= yes, 0 otherwise)	0.23	0.42
S_livestock_loss	Household experienced shock due to loss of livestock (1= yes, 0 otherwise)	0.45	0.50
PANEL G**: Location variables**			
Southern Zone	Household lives in southern zone(1= yes, 0 otherwise)	0.41	0.49
South_Eastern	Household lives in southern eastern zone(1= yes, 0 otherwise)	0.20	0.40
Eastern Zone	Household lives in Eastern zone(1= yes, 0 otherwise)	0.39	0.49

Table 4. 2 Mean separation tests of participants and non-participants in forest environmental resource extraction

Variable name	Non-Participant (n= 38)	Participant (n= 213)	p-value*
	Mean (SE)	Mean (SE)	
Log per capita expenditure per adult equivalent	7.84 (0.09)	7.45(0.03)	0.0000***
Distress Sale	0.45(0.82)	0.76(0.03)	0.0001***
Number of months with enough stock of food	6.77(0.56)	5.51(0.23)	0.0378**
Sex of household head	0.68(0.76)	0.88(0.22)	0.0020***
Ag e of household head	47.3(2.26)	46.7(0.84)	0.7584
Education of household head	2.42(0.48)	0.944(0.13)	0.0001***
Family Size	4.60(0.33)	5.95(0.14)	0.0003***
Awareness of Climate Change	0.58(0.08)	0.31(0.03)	0.0016**
Number of livestock in TLU	2.65(0.47)	3.29(0.16)	0.2341
Number of adult household member	2.53(0.20)	2.92(0.08)	0.0784*
Land holding in tsimdi	3.76(0.38)	4.46(0.21)	
Non-farm income	3352(1647)	733.92(137)	0.0007***
Food consumption expenditure per adult equivalent	7.55(0.08)	7.20(0.03)	0.0000***
Access to irrigation	0.21(0.07)	0.12(0.02)	0.1433
Off farm employment	0.55(0.08)	0.28(0.03)	0.0009***
Frequency of shocks (2005-2010)	1.82(0.21)	2.18(0.08)	0.0770*
Total Asset Value	2182(645)	1160(103)	0.0055***
Durable Asset Value	1882(617)	808.5(97)	0.0021***
Net financial asset	87.14(97.3)	-18.2(10.3)	0.0000**

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 3 Propensity score of participation in forest environmental resource extraction

Variable definition	Coefficient	S.E	P-value
Sex of the household head (=1 if male, 0, otherwise)	1.02	0.36	0.004***
Age of the household head in years	-0.03	0.01	0.006***
Education of the household head in years	-0.20	0.06	0.000***
Number of students in the household	0.12	0.98	0.230
Awareness of climate change in the household(=1 if yes, 0, otherwise)	-0.77	0.26	0.003***
Number of male adult household member	-0.04	0.14	0.808
Number of female adult household member	0.21	0.17	0.233
Land Holding in Tsimdi (= 0.25 hectare)	0.03	0.05	0.633
Number of Livestock owned in TLU	-0.02	0.07	0.752
Number of Donkey owned by the household	0.02	0.18	0.896
Access to private forest (=1 if yes , 0, otherwise)	0.12	0.07	0.613
Death or illness of a household member (=1 if yes, 0, otherwise)	0.56	0.33	0.091*
Weather related shocks (=1 if yes, 0, otherwise)	-0.11	0.40	0.790
Loss of livestock shocks (=1 if yes, 0, otherwise)	0.39	0.26	0.133
Access to off farm employment (=1 if yes, 0, otherwise)	-0.55	0.29	0.055*
Log transformed distance to forest	0.02	0.16	0.923
Log transformed distance to market	-0.04	0.10	0.671
South-Eastern (=1 if the household lives in South-Eastern zone, 0, otherwise)	-0.28	0.38	0.459
Eastern Zone (=1 if the household lives in Eastern zone, 0, otherwise)	0.04	0.31	0.890
Constant	1.83	0.78	0.020**
Number of Observations	251		
Pseudo R2	0.2685		
Log likelihood	-78.057317		

Significant level: * = 1%; ** = 5% and * = 10%.**

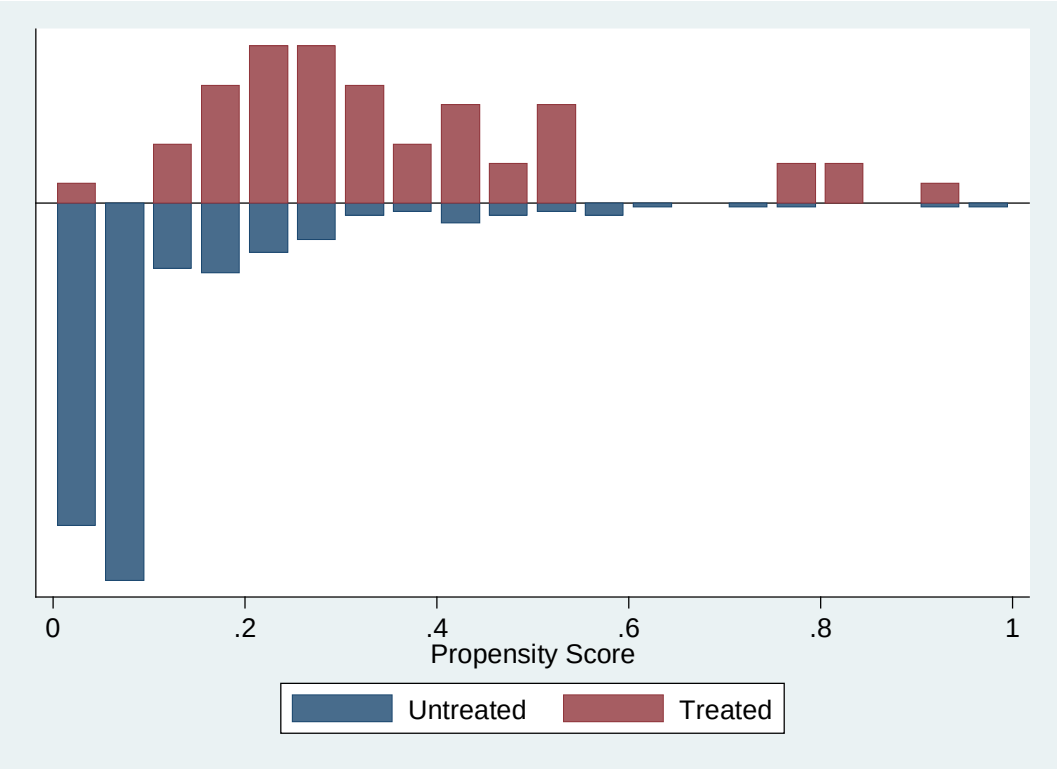


Figure 4. 1 Distribution of propensity scores

Table 4. 4 Propensity score and covariate balances

(Note: Figures in bold are significant variables)

Variable	Sample	Mean		% reduction		t- test	
		Treated	Control	% bias	|bias|	t	p>|t|
Propensity Score	Unmatched	0.88783	0.62147	135.5		9.75	**0.000**
	Matched	0.88783	0.87932	4.3	96.8	0.67	0.502
Hhh_sex	Unmatched	0.8774	0.6842	47.5		3.10	**0.002**
	Matched	0.8774	0.9067	-7.2	84.8	-0.97	0.332
Age_hh_1	Unmatched	46.604	47.342	-5.6		-0.33	0.739
	Matched	46.604	46.722	-0.9	84.0	-0.09	0.925
Edu_hhh	Unmatched	0.9481	2.4211	-59.1		-3.93	**0.000**
	Matched	0.9481	1.2910	-13.8	76.7	-1.61	0.109
Student_number	Unmatched	1.5708	1.1842	26.0		1.53	0.127
	Matched	1.5708	1.0229	36.9	-41.7	4.37	0.349
Dep_ratio	Unmatched	0.4882	0.4294	28.0		1.66	**0.097**
	Matched	0.4882	0.4739	6.8	75.7	0.78	0.436
CC_aware	Unmatched	0.3160	0.5789	-54.4		-3.17	**0.002**
	Matched	0.3160	0.4710	-32.0	41.1	-3.30	0.024
Male_adult	Unmatched	1.4057	1.1842	23.6		1.38	0.168
	Matched	1.4057	1.5585	-16.3	31.0	-1.69	**0.091**
Female_adult	Unmatched	1.5236	1.3421	22.1		1.19	0.237
	Matched	1.5236	1.4235	12.2	44.9	1.26	0.209
Land_size	Unmatched	4.4723	3.7625	26.2		1.38	0.170
	Matched	4.4723	4.8177	-12.8	51.4	-1.41	0.160
Livestock_TLU	Unmatched	3.1945	2.6468	20.1		1.20	0.231
	Matched	3.1945	3.2366	-1.5	92.3	-0.16	0.874
N_Donkey	Unmatched	0.7925	0.5526	28.4		1.63	0.104
	Matched	0.7925	0.8099	-2.1	92.7	-0.21	0.831
Private_forest	Unmatched	0.4670	0.3421	25.5		1.43	0.155
	Matched	0.4670	0.5074	-8.2	67.6	-0.83	0.406
Transfer	Unmatched	0.3113	0.2895	4.7		0.27	0.789
	Matched	0.3113	0.1684	31.3	-560.8	3.55	0.132

Death_ill	Unmatched	0.2359	0.1316	27.0		1.43	0.154
	Matched	0.2359	0.2250	2.8	89.6	0.26	0.792
Weather_shock	Unmatched	0.8113	0.7105	23.6		1.42	0.157
	Matched	0.8113	0.7399	16.7	29.1	1.79	0.178
Livestock_loss	Unmatched	0.4856	0.2632	46.9		2.56	**0.011**
	Matched	0.4856	0.4621	5.0	89.3	0.49	0.625
Off_farm	Unmatched	0.2830	0.5526	-56.4		-3.33	**0.001**
	Matched	0.2830	0.1733	22.9	59.3	2.71	0.015
Distance_forest	Unmatched	1.7119	1.7303	-2.3		-0.13	0.899
	Matched	1.7119	1.4009	38.4	-1586.0	4.17	0.677
Distance _market	Unmatched	1.3029	0.9392	24.8		1.55	0.122
	Matched	1.3029	1.6204	-21.7	12.7	-2.59	0.110

Table 4. 5 Other covariate balance indicators before and after matching

Indicator	Sample	
Pseudo R2	Unmatched	0.27
	Matched	0.14
LR X2 (p-value)	Unmatched	58.46(0.001)***
	Matched	29.02 (0.341)

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 6 Differences in food security outcomes for participants and non-participants for the whole sample

Outcome	Matching Algorism	E(Y) Participants	E(Y) Non-participants	Differences in Average outcome (ATT)	P –Value
PANEL A: All Households					
Treatment : Participation in Forest resource extraction					
Impact : Mean Impact					
Log_t_exp_aeu	N-neighbor	7.45	7.56	-0.11	0.000***
	K-matching	7.45	7.63	-0.18	0.000***
Distress_sale	N-neighbor	0.75	0.70	0.05	0.000***
	K-matching	0.75	0.67	0.09	0.000***
Fooda_months	N-neighbor	5.51	6.37	-0.85	0.046**
	K-matching	5.51	7.18	-1.67	0.045**

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 7 Differences in food security outcomes of poor households

Outcome	Matching Algorism	E(Y) Participants	E(Y) Non-participants	Differences in Average outcome (ATT)	P –Value
PANEL B: Poor Households					
Treatment : Participation in Forest resource extraction					
Impact : Mean Impact					
Log_t_exp_aeu	N-neighbor	7.27	7.48	-0.21	0.002***
	K-matching	7.27	7.47	-0.20	0.002***
Distress_sale	N-neighbor	0.67	0.84	-0.17	0.039**
	K-matching	0.66	0.81	-0.15	0.037**
Fooda_months	N-neighbor	5.15	6.73	-1.58	0.410
	K-matching	5.16	6.90	-1.74	0.281

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 8 Differences in food security outcomes of non-poor households

Outcome	Matching Algorism	E(Y) Participants	E(Y) Non-participants	Differences in Average outcome (ATT)	P –Value
PANEL C: Non-Poor Households					
Treatment : Participation in Forest resource extraction					
Impact : Mean Impact					
Log_t_exp_aeu	N-neighbor	7.63	7.99	-0.36	0.001***
	K-matching	7.63	7.95	-0.32	0.001***
Distress_sale	N-neighbor	0.84	0.93	-0.83	0.002***
	K-matching	0.84	0.91	-0.07	0.001***
Fooda_months	N-neighbor	5.86	5.15	0.71	0.036**
	K-matching	5.86	4.94	0.92	0.046**

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 9 Determinants of the predicted probability of zero and or negative farming profits

Variable definition	Coefficient	S.E	P-value
Dependent Variable : Dummy equals 1 if farming profit is negative , 0 otherwise			
Explanatory Variables			
Age of the household head in years	0.004	0.013	0.744
Education of the household head in years	0.072	0.073	0.325
Number of Adult Males in the household	-0.040	0.182	0.828
Participation in other business activities ((=1 if yes, 0, otherwise)	-0.102	0.354	0.772
Value of seed in Ethiopian Birr	0.001	0.000	0.007***
Land Holding in Tsimdi (= 0.25 hectare)	-0.081	0.083	0.327
Number of Livestock owned in TLU	-0.517	0.462	0.001***
Value of Fertilizer in Ethiopian Birr	0.001	0.001	0.327
Number of crops grown	-0.462	0.175	0.008***
Death or illness of a household member (=1 if yes, 0, otherwise)	-0.081	0.405	0.842
Loss of livestock shocks (=1 if yes, 0, otherwise)	0.755	0.326	0.020**
Access to credit ((=1 if yes, 0, otherwise)	-0.314	0.341	0.358
Number of Agricultural Extension Visit	-0.002	0.027	0.913
Log transformed distance to market	0.134	0.142	0.345
Distance to DA office in Munities	0.011	0.005	0.021**
South-Eastern (=1 if the household lives in South-Eastern zone, 0, otherwise)	0.798	0.397	0.044**
Eastern Zone (=1 if the household lives in Eastern zone, 0, otherwise)	0.420	0.241	0.890
Constant	-1.253	0.831	0.132
Number of Observations			
Pseudo R2	0.3230		
Log likelihood	-52.047128		

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 4. 10 Differences in farming profit between participants and non-participants

Outcome	Matching Algorism	E(Y) Participants	E(Y) non participants	Differences in Average outcome (ATT)	P –Value
PANEL A: All Households					
Treatment : Dummy =1if the household participates in forest extraction, zero otherwise					
Impact : Mean Impact					
Farming profit (=1 if zero or negative)	N-neighbour	0.15	0.06	-0.09	0.408
	K-matching	0.14	0.08	-0.06	0.425
PANEL B: Poor Households					
Treatment : Dummy =1if the household participates in forest extraction, zero otherwise					
Impact : Mean Impact					
Farming profit (=1 if zero or negative)	N-neighbour	0.14	0.09	-0.05	0.071*
	K-matching	0.15	0.00	-0.15	0.009***
PANEL C: Non-Poor Households					
Treatment : Dummy =1if the household participates in forest extraction, zero otherwise					
Impact : Mean Impact					
Farming profit (=1 if zero or negative)	N-neighbour	0.15	0.00	-0.15	0.008***
	K-matching	0.15	0.00	-0.15	0.009***

* significant at 10%; ** significant at 5%, *** significant at 1 %

CHAPTER FIVE

WELFARE IMPACTS OF FOREST ENVIRONMENTAL RESOURCE COMMERCIALIZATION: A MICRO- SIMULATION APPROACH FOR TIGRAY, ETHIOPIA

5.1. Introduction

Poverty in the developing world is concentrated in rural areas, and rural households, particularly in developing countries, depend on the environment for at least some of their income (Cavendish, 2000; Angelsen et al., 2001; World Bank, 2002). In this regard, commercialization of Non-Timber Forest Products (NTFPs) have been given a prominent role in many conservation and development projects based on the proposition that supporting the production and trade of NTFPs leads to livelihood improvements without compromising the environment. The attention given to the commercial extraction of NTFPs as a conservation strategy comes from three implicit assumptions: (1) commercial NTFP production can provide economically attractive options to farmers helping to increase their income and offering development opportunity (Peters et al., 1989; Clay & Clement, 1993); (2) NTFP production is a more benign way to use tropical forests than most land use alternatives, allowing for the conservation of key forest values (Myers, 1988); and (3) increased monetary value of the NTFPs will prevent people from converting the lands into other land uses (Evans, 1993). Accordingly, expectations have been raised that this sub-sector will play a significant role in reducing rural poverty, addressing international concerns for poverty reduction, conserving biodiversity and fulfilling the MDG goals (World Bank, 2002).

While the "picture" of the significance of natural product trade for livelihoods exists, the situation in reality is complex and variable, and limited empirical data from across a range of regions, vegetation types, and socio-economic contexts are available to assess the ability of these products to create lasting opportunities for local livelihood enhancement (FAO, 2003; Sunderlin et al., 2005). In fact, refocusing of the development agenda on poverty has led to recent reassessment of the role that biodiversity plays in livelihoods and poverty alleviation. This poses many fresh questions, and, to some extent, tempers previous optimism regarding the ability of this sector to make a difference by providing a more subtle and complex picture of livelihood –biodiversity linkages (e.g. Arnold, 2002a; Belcher, 2005; Koziell, 2001; Lawrence, 2003; Ros-Tonen and Wiersum, 2005; Scherr et al., 2004; Wunder, 2001). Central to these new enquiries is a more perceptive and nuanced appreciation of (a) what is by poverty alleviation in relation to natural resources, distinguishing between poverty prevention or mitigation and poverty elimination; (b) the links between natural resource dependence and the potential of natural product trade to provide pathways out of poverty ; and (c) the extent to which opportunities associated with natural product production and sale can be made more pro-poor and thus contribute to the efforts to combat poverty and vulnerability (FAO, 2003; Koziell,2001). A key area of debate is whether the trade in natural products can assist in improving livelihoods and income, or alternatively, whether it offers limited options serving only as a last resort, possibly contributing to persistent poverty (Belcher, 2005; Ros-Tonen and Wiersum, 2005; Wunder, 2001).

Yet most literature on natural product commercialization focuses on international value chains for charismatic products with high levels of external intervention (Taylor, 1999). In addition, few case comparisons to date (e,g, Belcher et al., 2005; Marshall et al., 2006) have sought to systematically investigate the livelihood and poverty outcomes from the commercialization of a range of products

produced and marketed within the same geographic setting. Moreover, most of the referred studies examine total forest or environmental income which includes critical subsistence products such as medicinal plants and wild foods (see e.g. Jodha, 1986; Reddy & Chakravarty, 1999; Belcher et al., 2005; Babulo et al., 2009). In addition, although there are a number of commercial non-timber forest products in Ethiopia[16], there is no systematic study to our knowledge that investigates whether commercialization of forest products enhances the welfare of the rural poor.

Moreover, although several studies have explored the role of forest income in reducing poverty and inequality and established empirical regularities about the positive impact of forests on the welfare of rural households (e.g. Jodha 1986; Reddy & Chakravarty, 1999; Belcher et al., 2005; Babulo et al., 2009; Lopez-Feldman, 2011), they have some methodological shortcomings. One such limitation is that none of the studies examine the question of whether participants and non-participants have inherent different income potentials, all things being equal. Their method provides a direct and simple measure of how forest income contributes to the total income under the simplifying assumption that the differences in income between households who are participating in forest environmental resource commercialization and those households that did not participate in forest commercialization could be due to observed heterogeneity. They therefore shed little light on the important policy issue of who might gain or lose from potential changes in forest policy.

To provide more accurate and policy-relevant results it is important to estimate what the households' income situation would have been in the absence of participation –the counterfactual income level- and then to compare that with the actual household income situation with forest

[16]The most commercial non-timber forest products in Tigray include, honey, bee wax, gums and resins, cactus, bamboo and charcoal.

income included as part of total income. Previous studies on the contribution of forests in Ethiopia and elsewhere have neglected this issue, choosing instead to compare actual income excluding forest income with income including forest income rather than estimating the counterfactual without-participation scenario. This could result in overestimation of the contribution of forests to household income.

Indeed, not distinguishing between the causal effect of forest commercialization and the effect of unobserved heterogeneity could lead to misleading policy implications (Di-falco and Veroseni, 2010;Carter and Milon, 2005). To this end, we used a simultaneous equation model with endogenous switching by full information maximum likelihood estimation (Di-falco and Veroseni, 2010;Di-Falco et al. 2011, Asfaw and Shiferaw, 2010;Carter and Milon, 2005) to account for the endogeneity of the participation in forest environmental resource commercialization. For the model to be identified, we use selection instruments such as distance to forest, distance to market and awareness of climate change. We have access to a particularly rich data set, which contains both households that did and did not participate in forest resource commercialization plus a very large set of control variables.

Our results are interesting in a number of respects. First, they show that the choice of methodology can have a significant impact on the estimated impacts and conclusions made about the impact of participation in forest environmental resource commercialization on the welfare of rural households. Second, the estimated heterogeneity revealed that, independent of participation, participant households would have less income on average than non- participants, implying that the group of farm households that are actually participating in forest environmental resource commercialization has systematically different characteristics than the group that did not participate. Third, the treatment effect analysis revealed that participation decreased income for

non- participant groups in the counterfactual case that they did participate, while it improved the income of households that actually participated. This suggests that participation in the forest environmental resource commercialization seems to be particularly important for the most vulnerable group of farm households by helping them to fill the income gap with the less vulnerable households in the same locality.

The following section presents an overview of forest conservation and poverty alleviation in rural Tigray, Ethiopia. Section 5.3 presents a brief description of the study area and descriptive statistics. Section 5.4 introduces the econometric model and estimation procedure. We describe a "treatment effects" approach (Heckman 2001; Di-Falco et al 2011) to evaluate the contribution of forest environmental resources commercialization on the household income per adult equivalent. Section 5.5 describes the estimated econometric results followed by discussion. We conclude with a summary and observations on the contribution of forest environmental resource commercialization to the household income and its implications for development policy in Ethiopia and similar developing countries.

5.2. Overview of forest Conservation and poverty Alleviation in Rural Tigray

Environmental degradation in Tigray has been well documented in the literature see for example (Chisholm 2000 and 2004; Gebremedhin et al., 2000; Howard and Smith, 2006). Forest resources of the region were overexploited and today forests and woodlots cover less than 2 percent of the region's total area (TFAP, 1996 cited in Babulo, 2007). Efforts to contain the problem of land degradation have been made at several levels (Nedessa et al., 2005).Closing degraded land areas from human and livestock intervention to promote natural regeneration of plants, commonly termed as enclosures, is among the major constraint efforts practiced in the highland areas of Tigray, northern Ethiopia (Tewelde-Berhan, 2002; Babulo, 2007). In addition to enclosures, the

regional government created restrictions on the use of certain tree species and the restrictions apply to all common land areas, regardless of whether they are open access or enclosed (FAO, 2006). This strategy is meant to benefit the environment and is a conservation effort that the community itself is operating (Gebrehiwot and van der Veen, 2010). The immediate positive environmental effects of the enclosures and the species restrictions are nearly universally acknowledged both by researchers and by local populations (Howard and Smith, 2006) and the international community alike.

However, the adoption of restrictive use rules and the limitation in allowable harvests have led many local residents to view enclosures as a less favoured land use option (Babulo, 2007). There is also consensus in the relevant literature that benefit streams from enclosures to date are largely environmental and economic benefits for most people are so far minimal (FAO, 2006). However, the arguments from both sides have been based essentially on qualitative narratives of the pros and cons of enclosure establishment and have not been backed up by quantitative reasoning and indicators (Babulo, 2007). This paper is therefore an attempt to quantitatively measure the welfare impacts of forest environmental resources commercialization for rural households living in Tigray and to provide some policy recommendations that can promote a win-win for conservation of forest environmental resources and poverty reduction in the region.

5.3. Data Description and Study Sites

A household survey was conducted in 2010/11 on 254 households in Tigray region of northern Ethiopia. However, because of missing data on some key variables for 3 households, our final estimating sample consists of 251. A two stage sampling design was made in the study. The primary sampling units (PSUs) were tabias. Sample tabias were selected on the basis of secondary information collected from all the Woredas. In selecting the sample tabias, a number of factors

that affect socio economic condition such as nearness to market, geographical location, the availability of both rain fed agriculture and irrigation, size of tabias based on population etc were considered so as to make the sampled tabias representative. In this category, a total of ten tabias namely Arato, Derga _ajen, Hugumrda, Meswaeti, Kara_adishawo, WorebayuKal_amin, Kelisha_emni,andFelege_woini were selected for the survey. The tabias selected are representative of the three different agro-ecological zones of the region identified on the basis of altitude. Areas with altitude ranging from 1500- 2300 m.a.s.l. are locally termed as *woinadouga*i.e midland areas, areas above 2300 m.a.s.l. are locally known as *douga*i.e highland areas and areas with altitude less than 1500 m.a.s.l. are termed as *kola* i.e., lowland. A multi-purpose questionnaire was used to gather information on household income, expenditure, off-farm income, household assets and local institutions alongside a host of other information related to production and sales.

<< INSERT FIGURE 2.1 ABOUT HERE >>

The dependent variable used in this study is a dummy variable that takes the value of one, if the household participated in forest environmental resources commercialization, and a value of zero, if no participation was recorded. The outcome variable used is the log transformed total per capita income in adult equivalent units. Tables 5.1, 5.2 and table 5.1A in the appendix present the sample statistics of the variables used in the analysis, the mean separation test for participants and non-participants and their definitions respectively.

<<INSERT TABLE5.1, 5.2 AND TABLE 5.1A ABOUT HERE>>

Out of the 251 households in the data set, about 33% of the households were participants during the year 2009/10. The average age of sample households is 46.76 years and 85 % are male headed. There is also a significant difference observed in the age and gender of participants and non-

participants. In addition participants seem to have significantly lower number of students and lower average grade of educational level than their counterpart non-participant households. The average land holding in tsimdi (=0.25 hectare) for participants is 3.75 while it is about 4.7 for non-participants, the difference is statistically significant. Moreover, households that are participating in forest commercialization are living far away from markets and are also prone to shocks such as weather and illness of a household member.

5.4. Econometric Model and Estimation Procedure

Households who are involved in forest environmental resource commercialization are likely to differ from households who do not. A household may participate in forest resource commercialization if he/she anticipates that the decision to participate in forest commercialization is worthwhile rather than entering by random assignment. Unobservable characteristics of households and their family may affect the participation decision in forest commercialization and the level of income, resulting in inconsistent estimates of the effect of participationon income (Di-falco et al, 2010). Accordingly, we used a simultaneous equations model with endogenous switching by full information Maximum likelihood (FIML) to determine the counterfactual income of forest resource commercialization following Di-falco et al. (2010) as shown below.

We specify the selection equation for participating in forest environmental resource commercialization as

(5.1) $A_i^* = Z_i\alpha + \eta_i$ with $A_i = \begin{cases} 1 & if \quad A_i^* > 0 \\ 0 & otherwise \end{cases}$

That is, households will choose to participate in forest extraction ($A_i = 1$) if $A^* > 0$, 0 otherwise, where A^* represents the expected benefits of participating in forest extraction with respect to not participating, Z is a vector of observed household characteristics or variables that are influencing

the decision to participate in forest commercialization or not. To complete the system of simultaneous equations model for household income, conditional on participation in forest environmental resource commercialization, we specify two equations following Di-falco et al., (2010), where (1) participation of households in forest commercialization and (2) non-participation in forest commercialization are defined as follows:

(5.2a) Regime 1: $y_{1i} = X_{1i}\beta_1 + \varepsilon_{1i}$ if $A_i = 1$

(5.2b) Regime 2: $y_{2i} = X_{2i}\beta_1 + \varepsilon_{2i}$ if $A_i = 0$

Where y_i is the income and food security level in regimes 1 and 2, X_i represents a vector of explanatory variables mentioned above.

Finally, the error terms are assumed to have a trivariate normal distribution, with zero mean and covariance matrix $\boldsymbol{\Sigma}$, i.e., $(\varepsilon_1, \varepsilon_2, \eta_1) \blacksquare N(0, \Sigma)$ with

$$\boldsymbol{\Sigma} = \begin{bmatrix} \sigma_n^2 & . & . \\ \sigma_{1\eta} & \sigma_1^2 & . \\ \sigma_{2\eta} & . & \sigma_2^2 \end{bmatrix},$$

Where σ_n^2 is the variance of the error term in the selection equation (5.1), (which can be assumed to be equal 1 since the coefficients are estimable only up to a scale factor), σ_1^2 and σ_2^2 are the variances of the error terms in the income function (5.2a) and (5.2b) , and $\sigma_{1\eta}$ and $\sigma_{2\eta}$ represent the covariance of η_i ,ε_{1i} and ε_{2i}. Since y_{1i} and y_{2i} are not observed simultaneously the covariance between ε_{1i} and ε_{2i} is not defined (Maddala, 1983 cited inDi-falco et al., 2010)). An important implication of the error structure is that because the error term of the selection equation (5.1) η_i is correlated with the error terms of the income equation (5.2a) and (5.2b) (ε_{1i} and ε_{2i}), the expected values of ε_{1i} and ε_{2i} conditional on the sample selection are non zero:

$E[\varepsilon_{1i}|A_i = 1] = \sigma_{1\eta}\frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)} = \sigma_{1\eta}\lambda_{1i}$, and $E[\varepsilon_{2i}|A_i = 0] = -\sigma_{2\eta}\frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)} = \sigma_{2\eta}\lambda_{2i}$,

Where $\phi(.)$ and$\Phi(.)$ are the standard normal probability function, $\Phi(.)$ the standard normal cumulative density function respectively, and $\lambda_{1i} = \frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)}$, $\lambda_{2i} = \frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)}$. Thus, if the estimates of the associated coefficients to the inverse Mill's ratios are found to be statistically different from zero, the hypothesis of the absence of sample selectivity bias can be rejected(Féres et al., 2007). This model is defined as a "switching regression model with endogenous switching" (Maddala and Nelson, 1975 cited in Di-falco et al., 2010). The full information maximum likelihood (FIML) is an efficient method to fit the endogenous switching regression model (Di-falco and Veroseni, 2010; Linh et al., 2014).

The logarithmic function given the previous assumption regarding the distribution of the error term as presented by Di-falco et al., (2010) is

(5.3) $\ln L_i = \sum_{i=1}^{N} A_i\left[\ln\phi\left(\frac{\varepsilon_{1i}}{\sigma_1}\right) - \ln\Phi + \ln\Phi(\theta_{1i})\right] + (1 - A_i)\left[\ln\Phi\left(\frac{\varepsilon_{2i}}{\sigma_2}\right) - \ln\sigma_2 + \ln\left(1 - \Phi(\theta_{2i})\right)\right]$,

Where $\theta_{ji} = \frac{(Z_i\alpha + \rho_j\varepsilon_{ji}/\sigma_j)}{\sqrt{1-\rho_j^2}}$, j = 1,2, with ρ_j denoting the correlation coefficient between the error term η_i of the selection equation (1) and the error term of ε_{ji} of equation (5.2a) and (5.2b), respectively.

5.4.1. Expected outcome and Treatment Effects

The expected outcomes with and without participation in forest environmental resource commercialization can be used to estimate the expected treatment effects in the two regimes. Table

5.3 shows the expected income and treatment effects of the household who have participated in forest environmental resource commercialization and those who did not. For example, (a) and (b) in table 5.3 show the actual or observed income in the sample , while (c) and (d) show the expected income without participation in forest environmental resource commercialization and this represents the counterfactual income. The conditional expectations for income status of the households are presented following Di-falco et al., (2010) below:

(5.4a) $E(y_{1i}|\, A_i = 1) = X_{1i}\beta_1 + \sigma_{1\eta}\lambda_{1i}$

(5.4b) $E(y_{2i}|\, A_i = 0) = X_{2i}\beta_2 + \sigma_{2\eta}\lambda_{2i}$

(5.4c) $E(y_{1i}|\, A_i = 1) = X_{2i}\beta_2 + \sigma_{2\eta}\lambda_{1i}$

(5.4d) $E(y_{1i}|\, A_i = 0) = X_{1i}\beta_1 + \sigma_{1\eta}\lambda_{2i}$

<< TABLE 5.3 ABOUT HERE >>

In addition, following Heckman et al., (2001) and Di-Falco et al., (2011) we calculate the heterogeneity and treatment effects as shown in equations 5.5 – 5.8; thus we seek to determine whether the effect of participation in forest resources commercialization is smaller or larger for participants who actually participated and those who did not participate relative to their counterfactual case. The effect of participation in forest environmental resource commercialization for those households who actually participated is the "effect of treatment on the treated" (TT) and the effect of participation in forest environmental resource commercialization for those households who did not participate, but could participate defined as the "effect of the treatment on the untreated"(TU) is calculated as follows (Di-Falco et al., 2011; Di-falco and Veroseni;2010;Carter and Milon, 2005):

(5.5) $TT = E(y_{1i}|\, A_i = 1) - E(y_{1i}|\, A_i = 0) = X_{1i}(\beta_1 - \beta_2) + (\sigma_{1\eta} - \sigma_{2\eta})\lambda_{1i}$,

(5.6) $TU = E(y_{2i}|\, A_i = 0) - E(y_{2i}|\, A_i = 1) = X_{2i}(\beta_1 - \beta_2) + (\sigma_{1\eta} - \sigma_{2\eta})\lambda_{2i}$,

The policy relevant treatment effects can also be distinguished from heterogeneity effects (Carter and Milon (2005). For example, those households who participated in forest environmental resource commercialization may have higher (lower) income regardless of their participation in forest environmental resource commercialization due to other unobservable factors that affect household income. This "base heterogeneity effect" (Carter and Milon, 2005; Di-falco and Veroseni, 2010;Di-Falco et al., 2011) for households that are actually participated in forest environmental resource commercialization and that did not is given in equations (5.7) and (5.8) respectively

(5.7) $BH_1 = E(y_{1i}|\, A_i = 1) - E(y_{1i}|\, A_i = 0) = (X_{1i} - X_{2i})\beta_{1i} + \sigma_{1\eta}(\lambda_{1i} - \lambda_{2i})$.

(5.8) $BH_2 = E(y_{2i}|\, A_i = 1) - E(y_{2i}|\, A_i = 0) = (X_{1i} - X_{2i})\beta_{2i} + \sigma_{2\eta}(\lambda_{1i} - \lambda_{2i})$.

Moreover, the income of the households who have participated in forest environmental resource commercialization may be higher (lower) because of their participation in forest environmental resource commercialization that those who didn't participate, if they had participated. This "transitional heterogeneity effect" (TH) (Carter and Milon, 2005; Di-falco et al, 2010;Di-Falco et al., 2011) is the difference between the effect of participation in forest environmental resource commercialization for the group of households who participated in forest environmental resource commercialization(TT) and those who did not (TU).

5.5. Results and Discussion

Estimated parameters for income function with endogenous switching due to participation in forest environmental resource commercialization are presented in table 5.4. For comparison, a single equation income function with no switching was estimated. A result from OLS estimates for the dummy variable (NTFC_C) equals 1 if the household participated in forest environmental resource commercialization or not is presented in the first column of table 5.4.The estimates of the selection equation (5.1) and for the income function for the group of households that have participated in forest environmental resource commercialization and those that did not participate is presented the last three columns of table 5.4.

<<INSERT TABLE 5.4 ABOUT HERE >>

Parameter estimates in table 5.4 revealed that the main factors that influence households' decision to participate in forest environmental resource commercialization include weather related shocks, sex of the household head being male, number of adult household numbers in the household and access to private forest. This finding is in line with the forest and livelihoods literature. For example with more adult members in the household, households may have access to labour that could be involved in forest environmental resource commercialization. In addition our result indicated that male headed households participate more in forest environmental resource commercialization. Our finding is similar to Adhikari (2005) because households headed by a woman might be at a disadvantage to participate in some income generating activities (e.g., women might not be allowed to work in agriculture) but they might also be restricted in their access to natural resources (Lopez –Feldman et al., 2011). Similarly, when insurance markets are not existent or incomplete households rely on different strategies to cover themselves against

covariate shocks. In this sense, it has been argued that environmental resources might provide households with a "natural insurance" (Pattanayak and Sills, 2001; Takasaki et al., 2004). Our finding also shows that households experienced with weather related shocks are more likely to participate in forest environmental resource commercialization. The positive sign in the variable distance to market also supports the hypothesis that households in isolated villages have less productive alternatives and are more likely to take part in low return activities like resource extraction and depend more on them as income generating activities (Lopez-Feldman et al., 2011).

Conversely, variables such as education, access to wage income and own business, and access to more land are found to be negatively correlated with forest environmental resource commercialization. With more education, households may have access to a broad variety of livelihood activities, have higher opportunity cost of time (Adhikari et al., 2004) and may disregard the collection and sales of forest resources. Similarly households with more assets may easily access more profitable livelihood activities and may give less priority to environmental resource incomes which are often considered "employment of the last resort" (Angelsen and Wunder, 2003).

We now turn to the contribution of participation in forest environmental resource commercialization to the household income. The simplest approach to investigate the effect of forest resource commercialization on the household income is an estimation of the income function via OLS using the participation in forest environmental resource commercialization as an explanatory variable as shown in the first column of table 5.4. The estimated result shows that participation in forest environmental resource commercialization affects household income positively though it is insignificant. However, this may be a misleading conclusion as OLS estimates do not explicitly account for potential structural differences between the income function

of households (Di-falco and Veroseni, 2010) that participated in forest environmental resource commercialization and the groups of households that did not. The likelihood ratio test indicates that the two equations are not independent (Prob> 0.00, table 2 bottom row)).

The endogenous switching in the income function estimates is presented in column 3 and 4. As shown in the 2nd row from bottom of the same table, the parameter coefficients of the terms ρ_j are statistically different from zero and have positive signs in the two equations implying (1) participation in forest environmental resource commercialization significantly increases income among participants; and (2) income levels are significantly higher among non-participants. This implies that the decision to participate in forest environmental resource commercialization and the income of households given the participation decision is affected by observed and non-observed factors. Moreover, results also show that there is self-selection in the participation of forest environmental resource commercialization as shown by the significance of the coefficient of correlation between the participation equation and the income of households that participated in forest environmental resource commercialization.

Finally, the income function of households that participated in forest environmental resource commercialization and those that did not is significantly different at 1 % level of significance. This implies the presence of heterogeneity in the sample (refer to the last two columns of table 5.4)

. <<INSERT TABLE 5.5 ABOUT HERE>>

Table 5.5 presents the expected income per capita under the actual and counterfactual conditions. Considering first the observed differences in the average household income per capita between the two groups of households as shown in cells (a) and (b) along the diagonal, the group of

households that participated earned 3,808.88(26.3%) Ethiopian Birr less, on average, than the group of households that did not participate in forest environmental resources commercialization.

This simple comparison is misleading however because it does not account for other unobserved factors (Di-falco and Veroseni, 2010; Carter and Milon, 2005) that may have affected income.

The treatment effect of participation in forest environmental resource commercialization is presented in the last column of table 5.5. For the group of households that participated in forest environmental resource commercialization, the first entry in the last column indicates that the mean effect of participation in forest resource commercialization (TT in table 5.3 and equation (5.5)) was an increase in per income of 1619.062 (17.9%) Ethiopian Birr. Similarly, if the group that did not participate in the forest environmental resource commercialization had participated (TU in table 5.3 and equation (5.6)), the mean effect would be a decrease in per capita income of 3630.48(25%) Ethiopian Birr. However, the effect of participation in forest environmental resource commercialization is larger for the group that did not participate in forest resource commercialization, resulting in a positive value of the transitional heterogeneity effect (TH in table 5.3). The estimated treatment effects indicate that both groups, if they participated in forest environmental resource commercialization, would decrease the contribution of participation in forest environmental resource commercialization to household income.

The base heterogeneity which shows the differences in the expected income per capita among households who participated in forest environmental resource commercialization and those that did not is presented in the last row of table 5.5. With the counterfactual condition that the non-participant group of households participated in forest environmental resource commercialization (BH1 in table 5.3 and equation (5.7)), the group who actually participated in forest environmental resource commercialization would be expected to earn 174.8 (1.6 %) Ethiopian Birr less on

average. However, this difference is not statistically significant. Similarly, with the counterfactual condition that the group of households that participated did not participate in forest resource commercialization (BH2 in table 5.3 and equation (5.8)), the group of participants would still significantly earn 5427.942 (37.5 %) Ethiopian Birr less per year. Under both counterfactual conditions, the group of households that actually participated in forest environmental resource commercialization would earn less. These differences reflect systematic sources of variation between the two groups that could not be fully accounted for in the observable determinants of the income model.

5.6. Conclusions and Policy Implications

This chapter investigates the factors affecting households' decision to participate in forest environmental resource commercialization and how participation in forest environmental resource commercialization impacts on the income of rural households living along the peripheries of protected forests in northern highlands of Ethiopia. We use household level data from 251 sample households living along the margins of protected forests found in northern highlands of Ethiopia to estimate a without-participation counterfactual household income scenario, against which to compare actual with-participation income.

Our results are interesting in a number of respects. First, they show that the choice of methodology can have a significant impact on the estimated impacts and conclusions made about the impact of participation in forest environmental resource commercialization on the welfare of rural households. We compare the estimated impacts using the counterfactual approach discussed above, with the more simplistic and more commonly used approach which treats forest income as an exogenous addition to other sources of household income. We find that the contribution of

forest environmental resource commercialization to the overall income is lower when the methodologically superior counter factual estimation is used.

Second, the estimated heterogeneity effects revealed that, independent of participation, participant households would have less income on average than non-participants, implying that the group of farm households that participated in forest environmental resources commercialization has systematically different characteristics from the group that did not participate. This systematic difference in income between the two groups could not be explained with observable determinants of the income model and indicates a more complex relationship between participation in forest environmental resource commercialization and household income, which could not be taken into account by the estimation of OLS regression.

Third, participation in forest environmental resource commercialization increases the income for the group of households who actually participated. However, the treatment effect analysis revealed the counterintuitive results that participation decreased income for non-participant groups in the counterfactual case they did participate. However, if this group of households had participated in forest environmental resource commercialization, they would have earned the same as the farm households that actually participated. Therefore, participation in forest environmental resource commercialization seems to be particularly important for the group of farm households most vulnerable to shocks, those who have no access to other high yielding activities such as off farm work or adequate land, by helping them to fill the income gap with the less vulnerable group of households in the same locality. While the result is surprising, it is consistent with the previous studies on the forest – poverty nexus that the poor households are more dependent on forests than the rich (Jodha ,1986; Reddy and Chakravarty, 1999 ; Cavandish 2000; Mamo et al.,2007; and Babulo et al.,2008), that most NTFPs produce low returns (particularly per ha and often, also per

labour unit), are primarily used for subsistence and often to fill income gaps (Byron and Arnold, 1999; Newmann and Hirsch, 2000).

Finally, to the extent the results from this sample are representative of other areas and development policies, further research inquiries are also needed to evaluate the effects of policies that promote forest resource commercialization. In this regard, the distinction made by Fisher (2003) between low return forest resources (LRFR) and high return forest activities (HRFA) would be important.

The results from this analysis particularly raise several issues for the forest-based livelihoods research and policies. First, predictions based on the assumption that participation in forest environmental resource commercialization increases income over all households living along the margins of forests may overestimate the impacts of forests' contribution in the livelihood of people. In this regard public policies and participation of NGOs could help in providing alternative livelihood and income generating options and minimizing the dependence of households on forest environmental resources. The introduction of crop insurance and health related insurance are other possible policies. Providing access to off farm work and enhancing the existing productive safety net programs are paramount in order for households to take risks and invest in high risk and high return activities rather than depending too much more on forest environmental resources.

Table 5. 1 Descriptive statistics of sample households

	Total		Participants		Non-participants	
	Mean	S. D	Mean	S. D	Mean	S. D
Variable name						
Dependent variables						
NTFP_C (1/0)	0.331	0.471	0.000	0.000	0.000	0.000
Log_inc_aue	9.161	0.670	9.200	0.554	9.142	0.749
Explanatory variables						
HH characteristics						
Hhh_sex	0.848	0.359	0.92	0.279	0.82	0.389
Age_hh_1	46.76	12.52	44.08	11.56	48.1	12.79
Family_size	5.745	2.114	5.843	2.334	5.964	2.002
Edu_hhh	1.167	2.184	0.964	1.685	1.268	2.391
Stu_number	1.509	1.435	1.12	1.334	1.71	1.445
Average_g	4.212	2.388	3.488	2.297	4.578	2.355
Adult_hhm	2.865	1.286	2.903	1.393	2.845	1.233
Aware_cc	0.355	0.479	0.337	0.476	0.363	0.482
Asset Holdings						
P_size _tsimdi	4.356	2.927	3.749	2.496	4.656	3.082
Tlu	3.107	2.585	3.107	2.252	3.142	2.740
Private_forest	0.450	0.499	0.482	0.503	0.435	0.497
F_saving	0.251	0.412	0.193	0.397	0.226	0.419
Access to factor market and inputs						
Wage_income	1844.1	2252.455	1533.9	1405.503	1997.5	2560.003
Own_business	0.355	0.479	0.157	0.366	0.405	0.492
Access_credit	0.375	0.485	0.373	0.487	0.375	0.486
Access_irrigation	0.135	0.343	0.120	0.328	0.143	0.351
Log _dis_market	1.243	1.335	1.777	1.083	0.978	1.370
Log_dis_forests	1.708	0.828	1.637	0.786	1.742	0.847
Shock dummies						
Weather_s	0.797	0.403	0.892	0.034	0.75	0.434
Death_ill_s	0.227	0.420	0.289	0.456	0.196	0.398
Price_s	0.323	0.468	0.349	0.479	0.309	0.464
Loss_live_s	0.454	0.499	0.469	0.502	0.446	0.498
Sample Size	251		83		168	

Table 5. 2 Mean separation test of participants and non-participants

	Participants		Non-participants		
	Mean	S. D.	Mean	S. D	P-Value
Variable name					
Income					
Log_inc_aue	9.200	0.608	9.142	0.058	0.5354
Explanatory variables					
HH characteristics					
Hhh_sex	0.92	0.279	0.82	0.389	0.0373**
Age_hh_1	44.08	11.56	48.1	12.79	0.0168**
Family_size	5.843	2.334	5.964	2.002	0.6055
Edu_hhh	0.964	1.685	1.268	2.391	0.3005
Stu_number	1.12	1.334	1.71	1.445	0.0017***
Average_g	3.488	2.297	4.578	2.355	0.0006***
Adult_hhm	2.903	1.393	2.845	1.233	0.7358
Aware_cc	0.337	0.476	0.363	0.482	0.6898
Asset Holdings					
P_size _tsimdi	3.749	2.496	4.656	3.082	0.0206**
Tlu	3.107	2.252	3.142	2.740	0.7606
Private_forest	0.482	0.503	0.435	0.497	0.4796
F_saving	0.193	0.397	0 .226	0.419	0.5463
Access to factor market and inputs					
Wage_income	1533.9	1405.503	1997.5	2560.003	0.1251
Own_business	0.157	0.366	0.405	0.492	0.0001***
Access_credit	0.373	0.487	0.375	0.486	0.9816
Access_irrigation	0.120	0.328	0.143	0.351	0.6277
Log _dis_market	1.777	1.083	0.978	1.370	0.0000***
Log_dis_forests	1.637	0.786	1.742	0.847	0.3425
Shock dummies					
Weather_s	0.892	0.034	0.75	0.434	0.0086***
Death_ill_s	0.289	0.456	0.196	0.398	0.0998***
Price_s	0.349	0.479	0.309	0.464	0.5269
Loss_live_s	0.469	0.502	0.446	0.498	0.7268
Sample Size	83		168		

*, **, *** significant at 10, 5 and 1 percent level of significance.

Table 5. 3 Definition of Expected income and treatment effects

	Decision Stage		
Sub-Sample	Participation	Non Participation	Treatment Effect
Households that participated	(a) $E(y_{1i}\mid A_i = 1)$	(c) $E(y_{2i}\mid A_i = 0)$	TT
Households that did not participate	(d) $E(y_{1i}\mid A_i = 1)$	(b) $E(y_{2i}\mid A_i = 0)$	TU
Heterogeneity effects	BH_1	BH_2	TH

Notes: (a) and (b) represent observed expected income;(C) and (d) represent counterfactual expected income

A_i = 1 if the farm households participated in forest sales; A_i=0 if farm households did not participate

Y_{1i} : income if the household participate in forest resource commercialization

Y_{2i} : income if the household did not participate in forest resource commercialization

TT : The effect of the treatment (i.e., participation) on the treated (i.e., farm households that participate

TU : The effect of the treatment (i.e., participation) on the untreated (i.e., farm households that did not participate)

BH_i : the effect of base heterogeneity for farm households that participate in forest resource commercialization $(i = 1)$, and did not participate $(i = 2)$;

$TH = (TT - TU)$, i.e. , transitional heterogeneity.

Source : Di-falco and Veroseni (2010)

Table 5. 4 OLS and Endogenous Switching Regression estimates

	(1)	(2)	(3)	(4)
			Endogenous Switching Regression[17]	
Model	OLS		Participation =1 (farm households that participate in forest commercialization	Participation = 0 (if the households did not participate in forest commercialization)
Dependent Variable	Annual household Income in Ethiopian Birr	Participation 1/0	Annual Household income in Ethiopian Birr	Annual Household income in Ethiopian Birr
Participation 1/0	0.122			
	(0.078)			
Sex of the household head (1if male	0.331***	0.656**	0.289	0.433***
0, otherwise	(0.104)	(0.309)	(0.194)	(0.130)
Education of the hh head	-0.009	-0.007	0.368	-0.014
	(0.017)	(0.500)	(0.332)	(0.020)
Average education level in the hh	-0.018	-0.121**	-0.069**	-0.032
	(0.017)	(0.049)	(0.032)	(0.021)
Number of Adult hh Members	0.060**	0.300***	0.103**	0.087**
	(0.029)	(0.090)	(0.047)	(0.039)
Livestock in TLU	0.065***	0.048	0.128***	0.063***
	(0.016)	(0.047)	(0.029)	(0.020)
Plot size in Tsimdi	0.019	-0.131***	-0.203	0.006***
	(0.014)	(0.043)	(0.026)	(0.019)
Access to Irrigation	0.385***	-0.463	-0.008	0.486
	(0.102)	(0.289)	(0.165)	(0.130)
Access to Credit	-0.007	0.185	-0.044	0.074
	(0.076)	(0.208)	(0.119)	(0.100)
Financial Saving	0.441***	0.255	0.093	0.548***
	(0.085)	(0.249)	(0.135)	(0.107)
Access to Wage income	0.001***	-0.001*	-1.960	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)
Weather related shocks	-0.286***	0.659**	0.038	-0.188
	(0.094)	(0.299)	(0.191)	(0.122)
Number of Students in the hh		-0.205***		
		(0.075)		
Log distance o forest		-0.143		
		(0.113)		
Log distance to Market		0.179**		
		(0.086)		

[17]Estimation of full information maximum likelihood at household level.

Own Business			-0.746***		
			(0.243)		
Access to Private forest			0.586***		
			(0.195)		
Constant		8.412***	-0.445	8.233***	8.426***
		(0.142)	(0.676)	(0.297)	(0.183)
	σ_i			0.501***	0.583***
				(0.061)	(0.045)
	ρ_i			0.655**	0.719***
				(0.187)	(0.149)
Adjusted R2		0.40			
Likelihood Ratio (LR) test of independent Equations : chi2 (2) = 10.40 Prob > chi2 = 0.0013					

* ,** and *** denotes significant at 10%; 5%, and 1 % respectively.

Sample size: 251. σ_i denotes the square-root of the variance of the error terms ε_{ij} in the outcome equation (2a) and (2b), respectively; ρ_j denotes the correlation coefficient between the error term η_i of the selection equation(1) and the error term ε_{ij} of the outcome equations (2a) and (2b), respectively.

Table 5. 5 Expected income and treatment effects

	Forest Commercialization		
Sub-Sample	Participation	Non Participation	Treatment Effect
Households that participated in forest commercialization	(a) 10673.91 (568.001)	(c)9054.848 (536.196)	TT = 1619.062** (394.436)
Households that did not participate in forest commercialization	(d) 10852.31 (612.223)	(b)14482.79 (546.392)	TU = -3630.48*** (820.586)
Heterogeneity effects	BH_1 = -178.4 (874.212)	BH_2 = -5427.942*** (952.636)	TH = 5249.542*** (295.334)

See notes of table 5.2 Standard Errors in parenthesis *** and ** denotes significant at 1% and 5% respectively

Appendix

Table 51AVariables definition

Variable name	Definition
Dependent variables	
NTFP_C (1/0)	Dummy = 1 if the household participated in forest resource commercialization, 0 otherwise
Log_inc_aue	Log income per adult equivalent unit in Ethiopian Birr
Explanatory variables	
HH characteristics	
Hhh_sex	= 1 if the head of the household is male, 0 otherwise
Age_hh_1	Household head's Age in years
Family_size	Household size
Edu_hhh	Educational level of the household head in years
Stu_number	Number of Students in the household
Average_g	Average educational grade level in the household
Adult_hhm	Number of adult household members
Aware_cc	Dummy = 1 if the household head is aware of climate change in his/her locality , 0 otherwise
Asset Holdings	
P_size _tsimdi	Plot size owned by the household in tsimdi (= 0.25 hectare)
Tlu	Number of livestock owned in Tropical Livestock Unit (TLU)
Private_forest	Dummy = 1 if the household owned private forest , 0 otherwise
F_saving	Dummy = 1 if the household has financial savings
Access to factor market and inputs	
Wage_income	Amount of wage income earned by the household in Ethiopian Birr
Own_business	Dummy = 1 if the household engaged in his/her own business ,0 otherwise
Access_credit	Dummy = 1 if the household has access to credit form micro finance 0.otherwise
Access_irrigation	Dummy =1 if the household has access to irrigation , 0 otherwise
Log _dis_market	Log transformed distance from home to market in minutes
Log_dis_forests	Log transformed distance from home to nearest forest in minutes
Shock dummies	
Weather_s	Dummy = 1 if the household experienced weather related shocks last year , 0 otherwise
Death_ill_s	Dummy =1 if the household experienced death or illness of a household member last year , 0 otherwise
Price_s	Dummy = 1 if the household experienced price related shocks last year , 0 otherwise
Loss_live_s	Dummy = 1 if the household experienced shocks related to loss of livestock last year , 0 otherwise

CHAPTER SIX

ENVIRONMENTAL RESOURCES, POVERTY AND INEQUALITY IN THE SEMI-ARID REGION OF TIGRAY, ETHIOPIA

6.1. Introduction

Poverty reduction is one of the international imperatives of the new millennium – an imperative stressed by the Millennium Development Goals (MDGs), the 2002 World Summit on Sustainable Development and, most recently, at the 2005 UN World Summit (Roe .D, and Elliot. J,, 2005). With rural poverty accounting for some 75% of world poverty, meeting this goal, together with the high levels of spatial concurrence between regions rich in biodiversity and the majority of the world's poor, has compelled scholars and practitioners operating at the environment – development interface to seek solutions to poverty that include natural resource – based activities.

The underlying reasoning of poverty reduction through biodiversity conservation initiatives is multifaceted. One aspect is the premise that many tropical forests have a greater long-term economic value if they are left standing. Second, local forest communities will tend towards careful, sustainable management of the forest if they receive direct economic benefits from harvesting its resources. Third, poverty in local forest communities is both a cause and result of

deforestation and environmental degradation. If poverty can be alleviated through the harvesting of forest resources, then deforestation pressures will be reduced (Newmann and Hirsch, 2000).

A literature has grown rapidly in recent years focused on examining the potential for forest-based poverty alleviation. Among the key authors are: Byron and Arnold (1999); Cavendish (2000); Arnold (2001); Wunder (2001); Scherr *et al*. (2002); Angelsen and Wunder (2003); Lopez –Feldman (2007); Mamo et al., (2007) and Babulo et al. (2009). Views diverge on whether there should be grounds for optimism or pessimism for forest-based poverty alleviation. Scherr *et al*. (2002) can be viewed as leaning in the optimistic direction, whereas Wunder (2001) clearly favours a pessimistic view (Sunderlin and Thu, 2005). A recurrent theme in this new literature is the need for additional research as there are many questions that remain to be answered (Angelsen and Wunder 2003).

Reducing income inequality has also become a major public policy challenge among development agencies and poverty reduction experts. In this regard the impact of Non Timber Forest Products (NTFPs) on income distribution is another important aspect. For example Griffin and Ickowitz (1997) stated "the importance of natural capital in the total stock of capital tends to vary inversely with the level of income per head". That is, the poorer the country, the more significant is natural capital likely to be in determining the overall distribution of wealth.

Inequality is also important for poverty discussion in many ways. One aspect is that people living in and around forests, just like other people, do not only care about their own absolute incomes:their welfare perceptions also depend on their income status "vis-a- vis "the joneses" – the individuals, households or communities of reference that they would like to keep up with" (Angelson and Wunder 2003). Second, it is also generally accepted that one of the causes of poverty is unequal distribution of assets and income and that those with few assets and income

tend to over-exploit their resources. Third, where NTFPs already provide significant household incomes, the distribution of that income may be highly uneven and complex (Newman and Hirsch, 2000). Fourth, levels of income inequality can also reflect inequalities in rights over assets and resources that are used to generate income (Anderson et al. 2006). More research can elucidate these patterns, and in particular suggest how, why and under what circumstances inequality exists, and with what consequences to marginalized groups and individuals engaged in NTFP extraction. Yet, quantitative studies of the relationship between natural resources, poverty and inequality are scarce (Lopez 2007). With few exceptions, discussions about poverty reduction strategies and the role of forests often focus almost exclusively on income growth, neglecting the potential roles of income re-distribution and inequality.

Jodha (1986) seems to be amongst the first stream of researchers who attempted to rigorously shed more light on the distributional implications of forest environmental income on poverty and inequality. He found that the Gini coefficient in dry regions in India increases by as much as 34 percent when income derived from forest gathering is ignored in Gini estimation. Also in India Reddy and Chakravarty (1999) found that when forest income is set to zero in poverty calculations, poverty increases by as much as 28 percent. However, the inequality effect of ignoring forest income was very marginal. Similarly, Lopez-Feldman et al.(2007) in their study of rural Mexico and the Lacandona Rainforest community area of Mexico, observed that when forest income is ignored in poverty calculations, the severity of poor people increases more at the regional and community levels (17.1% and 18.4% respectively), than at national level(10.8%). The headcount and poverty gap measures revealed a similar pattern of greater sensitivity of poverty at the regional and community levels than at the national level. In their inequality calculations, it was also observed that when forest income is increased by 10 percent, the Gini coefficient reduces by as

much as 0.36 and 0.11 percent, respectively, at the national and community levels. In the World Bank meta-study (Vedeld et al., 2004), the average increase in the Gini-coefficient when forest income was excluded was 0.13 (from 0.36 to 0.49). The same could be deduced from studies in Southern Malawi (Fisher 2004), Uganda (Aryal, 2002), Ethiopia (Mamo et al., 2007 and Babulo et al., 2009) and Nigeria (Fonta et al., 2011).

However, although the above studies explored the role of forest income in reducing rural poverty and inequality and tried to establish empirical regularity about the poverty reduction and equalizing effect of forest income, they suffer from methodological shortcomings. Their method provides a direct and simple measure of how forest income contributes to the total income under the simplifying assumption that forest income is exogenous and not a substitute for the participants' labour earnings on-farm and in other works. The focus of their analysis was principally on the decomposition techniques and the estimation of inequality indicators, using household income including and excluding forest incomes, without considering the interdependency of forest extraction and other household activities. Indeed, not distinguishing this interdependency could lead to biased decomposition of poverty and inequality indicators and misleading policy implications. In other words, these earlier studies did not attempt to estimate the opportunity costs of labour participation in forest extraction; that is, what the household members who participated in forest extraction would have contributed to household income had they not been involved in forest extraction. Neither were the indirect effects of forest income on other sources of income included in the analysis.

The implicit assumption of their approach is that forest income is an exogenous income transfer, which does not have any effect on labour supply, and other income sources of the household. This assumption implies that, for a given household, with a given level of farm income, an increase in

forest income raises total income by the same amount. This could be true if the participation in forest resource extraction was to compensate a short- term shock, such as a bad harvest or drought/flood. But, more often than not, participation in forest extraction is a long term alternative choice of participation in farm activities for households such as those in rural Tigray. In fact Gopalakrishnan et al., (2005) tested the hypothesis of competitive /complementary labour allocation between NTFP gathering and agriculture in their study of the Sinharaja rain forest region of SriLanka. The results of their analysis showed that labour requirement for tea production is negatively and significantly related to NTFP, implying that NTFP gathering and agriculture are competing for labour and that the household members' time in forest commercialization would contribute to the household in alternative ways if they did not participate in forest commercialization.

In addition the decision to participate in forest extraction and the subsequent income also affect the household's exposure to income risks, as well as its investment and production decisions. For example, the income from forest extraction might provide insurance and relieve the household's budget constraint which in turn might lead the household to adopt riskier or more costly production techniques with higher potential returns. On the downside, forest extraction might also affect the household's labour participation and supply decision or forest extraction may lead to deforestation which boosts the time allocated to fuel wood collection and thereby reduces agricultural output by shifting household members' time away from agricultural work.

As a result, when the indirect effects of insurance, investment and liquidity prevail, the marginal impact of forest commercialization on the total household income is hypothesized to be greater than unity. In contrast when the disincentive effects prevail, the marginal impact will be less than unity. Inter temporal, long -run effects might also be at play if households decide to invest their

forest income in productive assets, which then provide an additional contribution to households' total income in subsequent years.

The task of the research then is to estimate what households' per capita income situation would have been in the absence of forest commercialization (due to restrictive policy such as area closures or resource depletion) ‑ the counterfactual income level ‑ and then to compare with the actual household per capita income with forest income included as part of total income. Previous studies on the areas of forest income and inequality elsewhere have neglected this issue, choosing instead to treat forest income as an addition to what the household would have otherwise earned. In other words, rather than estimating a counterfactual without forest extraction scenario, previous studies have simply compared actual income excluding forest income with including forest income. This could result in an overestimation of the impact of forest income on both the level of household income (and poverty alleviation) and the distribution of income. In this paper we will compare the results following both methodological approaches, in order to allow us a clear estimation of the extent of over-estimation or under- estimation of these impacts in previous works.

Our results contribute a meaningful addition to the poverty-environment debate and Ethiopia's current conservation policy in many respects: First, we show that the choice of methodology can have a significant impact on the estimated contribution of forests and conclusions made about the role of forests on poverty and distribution of income. Second, we find that the contribution of forests to reduce the incidence of poverty is considerably weaker, and might increase the severity of poverty when the counterfactual estimation method is used. Third, in relation to income distribution, we find that after using the counterfactual approach, the impact of forest income on distribution is negative as against a positive contribution in the conventional approach. Fourth, these apparently contradictory findings, where forest income appears to reduce substantially the

poverty and inequality indicators when we use the conventional approach, but has little or negative impact on poverty and inequality indicators under the counterfactual approach, could be explained by the fact that participation in forest activities might have a disincentive effect on incomes from other activities which are not captured when forest income is treated as an exogenous addition to the existing household income.

The chapterr is outlined as follows: Section 6.2 provides an overview of forest management, poverty and distributional aspects in rural Tigray. Section 6.3 presents the data description and study sites. Section 6.4 outlines the econometric model and estimation procedure. Section 6.5 presents the results and discussion while the final section provides concluding remarks and policy implications.

6.2. Overview of Forest Management, Poverty and Distributional Aspects in Tigray

As late as the 1950s, nearly half of Tigray region's land area was covered in woodlands and forests, while less than 30 years later, in 1979 nine percent remained (Wolde-Giorgis, 1996 cited in Howard and Smith, 2006).Accelerated deforestation has led to severe soil erosion in regions where people are dependent on marginal, rain fed agriculture. Since 1991, the Ethiopian government has embarked on an economic development strategy known as Agricultural Development–Led Industrialization (ADLI), which places greater emphasis on agricultural development. Conservation programs also gained top priority in economic development in Tigray, which focuses on conservation of natural resources and community participation. Closing degraded land areas from human and livestock intervention to promote natural regeneration of plants, commonly termed as enclosures , is among the major constraint efforts practiced in the highland areas of Tigray, northern Ethiopia (Tewelde-Berhan, 2002; Babulo, 2007).

In addition to enclosures, the regional government created restrictions on the use of certain tree species and the restrictions apply to all common land areas, regardless of whether they are open access or enclosed (FAO, 2006). This strategy is meant to benefit the environment and is a conservation effort that the community itself is operating (Gebrehiwot and van der Veen, 2010). The immediate positive environmental effects of the enclosures and the species restrictions are nearly universally acknowledged both by researchers and by local populations (Howard and Smith, 2006) and the international community alike[18]. Nevertheless(Nedessa et al., 2005) called into question whether the results of the current conservation policy are effective or sustainable from an economic or environmental point of view. There is also a steadily growing body of literature questioning the impact of this policy in terms of its contribution to income and equity of distribution (Tesfay, 2006; Gebremedhin et al., 2004; (Chisholm, 2000; and Nedessa et al., 2005).

Local communities use woodlots/enclosures to cut and collect grass for animal feed and other purposes, to collect fruits and seeds, and to practice beekeeping .However, although these practices are widespread, they generate relatively small economic benefits (Gebremedhin et al., 2004), the economic benefits and costs of enclosures are distributed inequitably (Chisholm, 2000) and the rich households benefit triply (Nedessa et al., 2005). However, the arguments from both sides have been based essentially on qualitative narratives of the pros and cons of exclosure establishment and have not been backed up by quantitative reasoning and indicators (Babulo, 2007). For example, they evaluate the impacts of such policy on incomes and equity using only simple tabulations, without verifying if the reported regularities are significant using poverty and inequality decompositions. This indicates that there is untapped research potential to provide

[18]One of the communities in Tigray was awarded the 2012 UNDP Equator Prize for good management of the environment.

clarity under which conditions the current forest management contributes to poverty and distribution of incomes quantitatively. With the exception of (Babulo, 2007), current literature does not provide economic data that relates the contribution of the existing forest management to the distribution of income in the semi-arid region of Tigray.

6.3. Data Description and Study Sites

A household survey was conducted in 2010/11 on 254 households in Tigray region of northern Ethiopia. However, because of missing data on some key variables for 3 households, our final estimating sample consists of 251 households. A two stage sampling design was made in the study. The primary sampling units (PSUs) were tabias. Sample tabias were selected on the basis of secondary information collected from all the Woredas along the margins of the two protected forests in the region. In selecting the sample tabias, a number of factors that affect socio economic condition such as nearness to market, geographical location, the availability of both rain fed agriculture and irrigation, size of tabias based on population etc were considered so as to make the sampled tabias representative. In this category, a total of ten tabias namely Arato, Derga _ajen, Hugumrda, Meswaeti, Kara_adishawo, WorebayuKal_amin, Kelisha_emni,andFelege_woini were selected for the survey. The tabias selected are representative of the three different agro-ecological zones of the region identified on the basis of altitude. Areas with altitude ranging from 1500- 2300 m.a.s.l. are locally termed as *woinadouga*i.e midland areas, areas above 2300 m.a.s.l. are locally known as *douga*i.e. highland areas and areas with altitude less than 1500 m.a.s.l. are termed as *kola* i.e., lowland. To determine the extent to which households in rural Tigray use forest environmental resources for their livelihood, we follow (Narrain et al., 2008) to calculate the income that each household obtained from major sources.

6. 4. Econometric Model and Estimation Procedure

Households who are involved in forest activities are likely to differ from households who are not. A household may participate in forest extraction if he/she anticipates that the decision to participate in forest related activity is worthwhile rather than entering by random assignment. Unobservable characteristics of households and their family may affect the participation decision in forest activities and the level of income, resulting in inconsistent estimates of the effect of participationon income (Di-falco et al, 2011). Accordingly, we used a simultaneous equations model with endogenous switching by full information Maximum likelihood (FIML) to determine the counter factual income of forest resource extraction following Di-falco et al., (2011) as shown below.

The selection equation for participating in forest activities is specified as:

$$(6.1) \qquad P_i^* = z_i\alpha + \eta_i \text{ with} P_i = \begin{cases} 1 \; if \; P_i^* > 0 \\ 0 \; otherwise \end{cases}$$

That is, households will choose to participate in forest extraction ($A_i = 1$) if $A^* > 0$, 0 otherwise, where A^* represents the expected benefits of participating in forest extraction with respect to non-participation in forest related activities, Z is a vector of observed household characteristics or variables that are influencing the decision to participate in forest commercialization or otherwise. To complete the system of simultaneous equations model for household income, conditional on participation in forest environmental resource commercialization, we specify two equations following(Di-falco et al., 2011) where (1) participation of households in forest extraction and (2) non-participation in forest activity are defined as follows:

(6.2a) Regime 1: $y_{1i} = X_{1i}\beta_1 + \varepsilon_{1i}$ if $P_i = 1$

(6.2b) Regime 2: $y_{2i} = X_{2i}\beta_1 + \varepsilon_{2i}$ if $P_i = 0$

Where y_i represents the income and food security level in regimes 1 and 2, X_i represents a vector of explanatory variables mentioned above.

Finally, the error terms are assumed to have a trivariate normal distribution, with zero mean and covariance matrix $\boldsymbol{\Sigma}$, i.e., $(\varepsilon_1, \varepsilon_2, \eta_1) \blacksquare N(0, \Sigma)$ with

$$\boldsymbol{\Sigma} = \begin{bmatrix} \sigma_n^2 & . & . \\ \sigma_{1\eta} & \sigma_1^2 & . \\ \sigma_{2\eta} & . & \sigma_2^2 \end{bmatrix},$$

Where σ_n^2 is the variance of the error term in the selection equation (6.1), (which can be assumed to be equal 1 since the coefficients are estimable only up to a scale factor), σ_1^2 and σ_2^2 are the variances of the error terms in the income function (6.2a) and (6.2b) , and $\sigma_{1\eta}$ and $\sigma_{2\eta}$ represent the covariance of η_i ,ε_{1i} and ε_{2i}. Since y_{1i} and y_{2i} are not observed simultaneously the covariance between ε_{1i} and ε_{2i} is not defined (Maddala, 1983 cited inDi-falco et al, (2011)). An important implication of the error structure is that because the error term of the selection equation (6.1) η_i is correlated with the error terms of the income equation (6.2a) and (6.2b) (ε_{1i} and ε_{2i}), the expected values of ε_{1i} and ε_{2i} conditional on the sample selection are non zero:

$E[\varepsilon_{1i}|A_i = 1] = \sigma_{1\eta} \frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)} = \sigma_{1\eta}\lambda_{1i}$, and $E[\varepsilon_{2i}|A_i = 0] = -\sigma_{2\eta} \frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)} = \sigma_{2\eta}\lambda_{2i}$,

Where $\phi(.)$ and$\Phi(.)$ are the standard normal probability function, $\Phi(.)$ the standard normal cumulative density function respectively, and $\lambda_{1i} = \frac{\phi(Z_i\alpha)}{\Phi(Z_i\alpha)}$, $\lambda_{2i} = \frac{\phi(Z_i\alpha)}{1-\Phi(Z_i\alpha)}$. Thus, if the estimates of the associated coefficients to the inverse Mill's ratios are found to be statistically different from zero, the hypothesis of the absence of sample selectivity bias can be rejected(Féres et al., 2007). This model is defined as a "switching regression model with endogenous switching" (Maddala and Nelson, 1975 cited in Di-falco et al., 2010). The full information maximum likelihood (FIML) is

an efficient method to fit the endogenous switching regression model (Di-falco et al, 2011; Linh et al., 2014).

The logarithmic function given the previous assumption regarding the distribution of the error term as presented by Di-falco and Veroseni (2010) is

(6.3) $\ln L_i = \sum_{i=1}^{N} A_i \left[\ln \phi\left(\frac{\varepsilon_{1i}}{\sigma_1}\right) - \ln \Phi + \ln \Phi(\theta_{1i})\right] + (1 - A_i)\left[\ln \Phi\left(\frac{\varepsilon_{2i}}{\sigma_2}\right) - \ln \sigma_2 + \ln\left(1 - \Phi(\theta_{2i})\right)\right]$,

Where $\theta_{ji} = \frac{(Z_i\alpha + \rho_j \varepsilon_{ji}/\sigma_j)}{\sqrt{1-\rho_j^2}}$, j = 1,2, with ρ_j denoting the correlation coefficient between the error term η_i of the selection equation (1) and the error term of ε_{ji} of equation (6.2a) and (6.2b), respectively.

6.4.1. Expected outcome and Treatment Effects

The aforementioned endogenous switching regression model can be used to compare the expected income of the farm households that participate in forest extraction (6.4a) with respect to the farm households that did not participate (6.4b), and to investigate the expected income in the counterfactual hypothetical case (6.4c) that the participant farm households did not participate. The conditional expectations for income status in the four cases are defined following Di-falco et al. (2011) as follows:

(6.4a) $E(y_{1i} | P_i = 1) = X_{1i}\beta_1 + \sigma_{1\eta}\lambda_{1i}$

(6.4b) $E(y_{2i} | P_i = 0) = X_{2i}\beta_2 + \sigma_{2\eta}\lambda_{2i}$

(6.4c) $E(y_{1i} | P_i = 0) = X_{1i}\beta_2 + \sigma_{2\eta}\lambda_{1i}$

Cases (6.4a) and (6.4b) represent the actual income expectations observed in the sample for participants and non-participants respectively while case (6.4c) represents the counterfactual income of participants in the hypothetical case that the participants did not participate in commercialization of forests. Having simulated the income obtained if the household did not participate in forest commercialization, we can study the effect of forest income on rural households' poverty and inequality. We calculate respectively poverty measured by class of P_α indices (Foster et al., 1984) and inequality measured by Gini Coefficient of:

(1) Observed income, which is the sum of (6.4a) and(6. 4b)

(2) Observed income, without forest income

(3) Observed income for non–participants and the counter factual income for participants under the scenario of non-participation, which is the sum of (6.4b) and (6.4c).

If P_α under (1) which is the actual income including forest income is lower than P_α under (2) which is the observed income excluding forest income and the counterfactual scenario (3), forest incomes reduce poverty, and vice versa. Following the same idea, we study the impact of forest income on inequality. Overall three basic scenarios are analysed as follows.

In the first scenario- observed income without forest income – the indicators are estimated using observed income excluding forest income for all households. This scenario is used by all the previous studies in forest poverty analysis including those of Cavendish (2000); Botha (2003); Fisher (2004); Lopez-Feldman (2007) and Babulo et al (2009). This scenario treats forest income as an exogenous addition to income from other sources.

The second scenario – counterfactual income – uses the basic counterfactual methodology discussed in section 6.4.1 to estimate what the poverty indicators would be without participation in forest resource commercialization. The FGT indices are calculated using observed income for non-participants, and the counterfactual income for participants under the scenario of non-participation.

Finally, the third scenario uses the counterfactual methodology and the FGT index without forest income methodology to see whether previous studies such as those by Cavendish (2000); Botha (2003); Fisher (2004); Lopez-Feldman (2007) and Babulo et al (2009) were overestimating or underestimating the contribution of forest environmental resources on poverty and inequality.

6.4.2. Measuring Poverty

To analyse the contribution of forest incomes to poverty and inequality, we start from the standard Foster–Greer-Thorbecke (FGT) class of measures that incorporates the three most common poverty indexes. If we let $y = (y_1, y_2 , \dots . y_k)$ represent household income in increasing order and $z > 0$ denote the predetermined poverty line, the FGT poverty line is defined by:

$$(6.5) P(y; z) = \frac{1}{nz^{\alpha}} \sum_{k=1}^{q} g_k^{\alpha}$$

Where n is the total number of households, $q = q(y ; z)$ is the number of poor households, $g_k = z - y_k$ is the income short fall (the gap between the household's income and the poverty line) of the k-th (poor) household, and α is a parameter.

Three variants of the FGT poverty index are used to estimate the impacts of income from forests on rural poverty: the head-count measure $\alpha = 0$, $P_H(y ; z) = \frac{q}{n}$ measures the incidence of changes in forest income on rural poverty (i.e., the share of the population living below the poverty line);

the poverty gap $\alpha = 1$, $P_G(y\,;z) = \frac{1}{nz}\sum_{k=1}^{q} z - y_k$ measures the depth of poverty, or how far below the poverty line the average poor household's income falls; and finally , the squared poverty gap $\alpha = 2$, $P_{SG}(y\,;z) = \frac{1}{nz^2}\sum_{k=1}^{q}(z - y_k)^2$ measures the severity of poverty and is sensitive to changes in the distribution of income among the poor (Taylor et al., 2005).

6.4.3 Measuring inequality

To explore the impact of forest income on rural income inequality, we use Gini indices. Although various indices that can be used to measure inequality exist, the Gini is probably the most intuitive and allows for decomposition by income sources (Taylor et al., 2005). If we let $y = (y_1\,, \ldots . y_I)$ represent I components of household income, and if we define total income as $= \sum_{i=1}^{I} y_i$, we can write the extended Gini coefficient for village incomes as a function of the covariance between income and its cumulative distribution:

$$(6.6) G_Y = \frac{2\,cov[Y,F(Y)]}{\bar{Y}}$$

where $\bar{Y}$ is the mean of total income Y and F(Y) is the cumulative distribution of total incomes in the village. If we use the properties of covariance, we can re-write equation (10) as:

$$(6.7) G_Y = \frac{2\sum_{i=1}^{1} cov\left[y_i\,, F(Y)\right]}{\bar{Y}} = \sum_{i=1}^{1} R_i G_i\, S_i$$

In equation (6.7), S_i is the share of income from source i in total income, $S_i = \bar{Y}_i/\bar{Y}$, R_i is the Gini correlation of income from source i with the distribution of total income (CBO, 2011) , and G_i is the Gini index corresponding to the distribution of income from source i.

$$(6.8) R_i = \frac{COV\left[y_{i,F(Y)}\right]}{COV\left[y_{i,F(Y_i)}\right]}$$

In equation (6.7) the aggregate Gini coefficient G_Y that measures the total income inequality in a given population is expressed as the sum of the product's i^{th} income component in our case forest income, relative to its own Gini, and its correlation with the total income (Stark et al., 1986). One of the basic rationales for decomposing the total Gini to component income sources is to investigate how changes in a particular income source (in our case forest income) will affect the total income inequality, holding income from other sources constant.

Taking household labour and production decisions as given, if we increase an income source *j* by a factor e such that $y_j(e) = (1 + e)y_j$, the marginal effect on the Gini of total income is

$$(6.9)\ \frac{\partial G_Y}{\partial e} = S_j\left(R_j G_j - G_Y\right)$$

where S_j , R_j, G_j and G_Y are measured prior to the marginal income change, and the relative effect is given by

$$(6.10)\ \frac{\partial G_Y / \partial e}{G_Y} = \frac{S_j G_j R_j}{G_Y} - S_j$$

If R_j which is the Gini correlation between forest income and total income is negative or zero, an increase in forest income would decrease inequality. However, if R_j is positive, then the impact of an increase in forest income on inequality depends on the sign of $R_j G_j - G_Y$. Inequality will increase if the inequality of forest income exceeds the inequality of the total household income: $G_j > G_Y$(Stark et al., 1986).

6.5. Results and Discussion

6.5.1 Descriptive Statistics

Out of the 251 households in the data set, about 33% of the households were participating in forest commercialization during the year 2009/10. The average age of sample households is 46.76 years and 85 % are male headed. There is also a significant difference observed in the age and gender of participants and non-participants. In addition participants seem to have significantly lower number of students and lower average grade of educational level than their counterpart non-participant households. The average land holding in tsimdi (=0.25 hectare) for participants is 3.75 while it is about 4.7 for non- participants and the difference is statistically significant. The average walking distance to nearby market is significantly higher for participants.

<< INSERT TABLE 6.1.ABOUT HERE>>

6.5.2 Poverty and inequality Analysis

Using the conditional expectations and treatment effects discussed in section 6.4.1, we estimated the expected income of participants in the counterfactual hypothetical case that the participant group of households did not participate. This counterfactual income, which assumes participation in forest-related activity to be zero, is used to calculate per capita household income adjusted by adult equivalent scales. For comparability purposes, we use the FGT poverty index for the poverty analysis, while the Gini coefficient is used as a measure of inequality as discussed in section 6.4.3. We set the income poverty line 2100 Birr (an inflation-adjusted poverty line of the official baseline (poverty line of Birr 1075 set in 1995/96) as a measure of welfare corresponding to some minimum acceptable standard of living in Ethiopia(MOFED, 2006). Further more, we undertook ordinal poverty comparisons using stochastic dominance tests to check the robustness of the poverty ordering using the Distributive Analysis Stata Package (DASP).

Tables 6.2, 6.3 and 6.4 present the results for the analysis of poverty indicators, which were estimated using the household level data weighted by household size. The tables show the estimated FGT indices under each scenario, as well as their percentage change when compared against each indicator obtained using actual household income, including forest income.

A. Estimated Poverty indicators: Conventional vis-a-vis Counterfactual Scenario

Comparing the role of forest income in poverty and inequality indicators under each scenario shows some interesting similarities and differences with previous studies in Ethiopia (Babulo et al.,2009 and Mamo et al.2007) and elsewhere as discussed below.

<< INSERT TABLE 6.2 ABOUT HERE >>

Results from table 6.2 which uses the conventional approach of estimating the contribution of forests to poverty and distribution of income indicates that forest incomes lead to a decline in the incidence of poverty (P_0) from 61.6 % to 43.4%[19], in the depth of poverty (P_1) from 28.6% to 16.1 % and in the severity of poverty (P_2) from 17.1% to 8.1%. The strong impact on the depth and severity of poverty suggests that participation in forest environmental resource commercialization reduces the income gap among the poor and the gains in poverty reduction due to participation in forest environmental resource commercialization go disproportionately to the poorest households. This finding is consistent with Reddy and Chakravarty (1999); Cavandish (1999); Fisher (2004); Lopez – Feldman (2007) and Babulo et al (2009).

<< INSERT TABLE 6.3 ABOUT HERE >>

[19]In its five year (2010/11-2014/15) regional GTP, the regional government reported that the incidence of poverty to be 41% in the year 2009/10. In this regard our estimate reflects the real condition of the study area.

Table 6.3, which uses the predicted income of households that participate in forest environmental resource commercialization under the condition that they did not participate – the counterfactual approach, indicates that participation in forest environmental resource related activities still leads to a decline in the incidence of poverty (P_0) from 61.6 % to 53.4 %. These results provide strong evidence that participation in forest environmental resource commercialization and the subsequent income alleviate poverty in rural Tigray. However, under this scenario, the poverty headcount ratio decreases by 22.9 % while it declines by 44.2 % under the first scenario. Moreover, unlike the first scenario the depth of poverty (P_1) and the severity of poverty (P_2) increase from 15.8% to 16.1% and from 6.2% to 8.1% respectively. Even though it is not significant, the negative impact on the depth of poverty suggests that participation in forest related activities increases the income gap among the poor. And the negative impact on the severity of poverty, which assigns higher weights to the poorest of the poor, suggests that participation in forest activities did not improve the wellbeing of the poorest of the poor disproportionately. In other words, the gains in poverty reduction due to participation in forest environmental resource commercialization did not significantly go disproportionately to the poorest households. In this regard our finding differs from those of Reddy and Chakravarty (1999); Lopez – Feldman (2007) and Mariara and Gachoki(2008), who found that forest income has positive impacts on poverty, depth of poverty and severity and that the impact is greater in terms of lessening dire poverty than its effect in lifting poverty in India, Mexico and Kenya respectively.

<< INSERT TABLE 6.4 ABOUT HERE >>

Comparing the results of the counterfactual approach and the conventional approach in table 6.4, we observe that the contribution of forest income to poverty is substantially overestimated when the methodology, which simply treats forest income as an addition to the household income, is

used. The estimated contribution of forests is substantially lower when we use the more complex methodology in which forest incomes are assumed to be endogenous in the hypothetical, no participation in forest-related activity scenario. Using this counterfactual approach the contribution of forests to the incidence of poverty (P_0) is decreased by 0.0836, and the depth (P_1) and Severity (P_2) of poverty by 0.1284 and 0.1086 respectively. To check the robustness of our results we also compared the differences on poverty indexes between the conventional approach and the counterfactual approach vis-à-vis the poverty indices including forest income as shown in figures 6.1, 6.2 and 6.3. Our results unambiguously confirm that the contribution of forests to the incidence of poverty (P_0) is still positive but lower when we use the counterfactual scenario than the conventional without forest scenario regardless of the poverty line used. In contrast we observe that forests decrease the severity of poverty (P_2) if we use the conventional approach, while the severity of poverty (P_2)increases under the counterfactual approach. This is again robust regardless of the poverty line used. However, the difference on the contribution of forests to the depth of poverty(P_1) between the two approaches shows that it is lower under the counterfactual approach, yet comparing the result to the poverty indices that include forest income we observed that the result is inconclusive and sensitive to the poverty line used.

These results confirm that the choice of methodology for computing the contribution of forests on poverty has a significant impact on the results and the conclusions drawn, and that care should be taken to use appropriate methodology before reaching any conclusion and policy recommendations on the forest –poverty nexus.

<< INSERT FIGURES 6.1, 6.2 AND 6.3ABOUT HERE >>

B.Estimated Gini index: Conventional Vis-à-vis Counterfactual Scenario

<< INSERT TABLE 6.5 ABOUT HERE >>

When forest incomes are excluded from the total household income, i.e. under the conventional approach shown in table 6.5 above, the average increase in the Gini coefficient is 0.05 (from 0.34 to 0.39). This finding is again consistent with previous studies on the distributional impact of forest income in Zimbabwe (Cavendish 2000), Malawi(Fisher, 2004), Uganda (Aryal, 2002), Mexico (Lopez- Feldman 2007), Ethiopia (Babulo et al.2009 and Mamo et al.2007) and in the World Bank meta-study (Vedeld et al., 2004).

<< INSERT TABLE 6.6 ABOUT HERE >>

When the hypothetical counterfactual estimation method is used, the Gini coefficient shows a substantial decline by 0.06 (from 0.34 to 0.28) suggesting that forest income increases inequality, which is contrary to the findings of the conventional approach. Comparing the Gini index using both approaches as shown in table 6.7 below, we observed that the contribution of forests to income distribution is again overestimated under the conventional approach. Under the conventional approach, the Gini index is estimated to be 0.39 while the same index under the counterfactual approach is 0.28 shows a significant and substantial difference of 0.11.

<< INSERT TABLE 6.7 ABOUT HERE >>

The gap in the contribution of forests to income distribution when we use the conventional approach and counterfactual approach scenario, against which to compare actual with forest income, is further illustrated using the Lorenz curve in figure 6.4. The figure shows that the addition of forest income to household income reduces measured income inequality. This result accords with the previous studies in the literature. However, under the hypothetical counterfactual

estimation technique that we use it shows that participation in forest-related activity increases inequality.

<< INSERT FIGURE 6.4 ABOUT HERE >>

Although it is based more on conjecture and not supported by inequality decomposition, Narain et al. (2009) cautioned that the distributional outcomes of forest extraction would be worse if we are to include biodiversity resources in our analysis of inequality. Moreover, our results are similar to Adhikari et al., (2004) and Sapkota and Oden (2008).

These apparently contradictory findings, where forest income appears to reduce substantially the poverty and inequality indicators when we use the conventional approach that has been used in the forest-poverty nexus, but has little or negative impact on poverty and inequality indicators under the counterfactual approach, could be explained by the fact that participation in forest activities might have a disincentive effect on incomes from other activities which have higher returns to labour, which are not captured when forest income is treated as an exogenous addition to household income. For example participation in forest commercialization might affect the household's labour participation and supply decision or forest commercialization may lead to deforestation which boosts the time allocated to fuel wood collection and thereby reduces agricultural output by shifting household members' time away from agricultural work.

6.6 Conclusions and Policy Implications

This research investigates the contribution of forest commercialization to poverty and income distribution in semi-arid region of the Tigray regional state, Ethiopia. We use household survey data to estimate without forest income and counterfactual household income scenario, against which to compare actual with forest income.

Our study contributes to the study of the Poverty –Environment nexus in many respects.First, it provides an overview of forest management, poverty and distributional issues in the rural Tigray region of Ethiopia. Literature can be found on the measurement of poverty and inequality in relation to forests in Tigray but none has focused on the counterfactual income scenario.

Second, our results show that the choice of methodology can have a significant impact on the estimated contribution of forests and conclusions made about the role of forests on poverty and distribution of income. We compare the estimated contribution of forests using the counterfactual approach discussed in section 6.4, with the simpler and more commonly used method which treats forest income as an exogenous addition to other sources of household income. We find that the contribution of forests on poverty measures is considerably weaker, and despite forests decreasing the incidence of poverty they might increase the severity of poverty when the counterfactual estimation method is used. This is a new finding that has not been documented in previous studies. However, it has important policy implications. If forests increase the severity of poverty and if this forest management policy is left unresolved, the poor remain poorer than their counterparts and will eventually be less able to escape from the poverty trap. Our finding is consistent with the previous studies and conclusions made that the existing conservation policy in Ethiopia, particularly in the region has only environmental benefits and that economic benefits are yet to emerge.

Third, in relation to income distribution, we find that after using the counterfactual approach, the impact of forest income on distribution is negative as against a positive contribution in the conventional approach.

Fourth, these apparently contradictory findings, where forest income appears to reduce substantially the poverty and inequality indicators when we use the conventional approach, but has

little or negative impact on poverty and inequality indicators under the counterfactual approach, could be explained by the fact that participation in forest activities might have a disincentive effect on incomes from other activities which are not captured when forest income is treated as an exogenous addition to the existing household income.

Over all, this study makes a meaningful addition to the poverty-environment debate and Ethiopia's current conservation policy to better distribute resource rights, both property and procedural. The improved management of trees and forests cannot be pursued in isolation, through sectoral efforts and requires careful consideration of biological, economic, socio-cultural and institutional factors. Equally, policy should facilitate and strengthen linkages between agriculture and income diversification which provides alternative livelihood opportunities and pathways out of poverty. Finally inequality of access to natural assets must be addressed to warrant a win –win for conservation of the environment and poverty reduction.

Table 6. 1 Mean separation test of participants and non-participants

Variable name	Households that did not participate		Households that participate		P- Value
	Mean	Std. Dev.	Mean	Std. Dev.	
Log_inc_aue	9.142	0.749	9.200	0.554	0.5354
Hhh_sex	0.82	0.389	0.92	0.279	0.0373**
Age_hh_1	48.1	12.79	44.08	11.56	0.0168**
Family_size	5.964	2.002	5.843	2.334	0 .6055
Edu_hhh	1.268	2.391	0.964	1.685	0.3005
Stu_number	1.71	1.445	1.12	1.334	0.0017***
Average_g	4.578	2.355	3.488	2.297	0.0006***
Adult_hhm	2.845	1.233	2.903	1.393	0.7358
Aware_cc	0.363	0.482	0.337	0.476	0.6898
P_size _tsimdi	4.656	3.082	3.749	2.496	0.0206**
Tlu	3.142	2.740	3.107	2.252	0.7606
Private_forest	0.435	0.497	0.482	0.503	0.4796
F_saving	0.226	0.419	0.193	0.397	0.5463
Wage_income	1997.5	2560	1534	1406	0.1251
Own_business	0.405	0.492	0.157	0.366	0.0001***
Access_credit	0.375	0.486	0.373	0.487	0.9816
Access_irrigation	0.143	0.351	0.120	0.328	0.6277
Log _dis_market	0.978	1.370	1.777	1.083	0.0000***
Log_dis_forests	1.742	0.847	1.637	0.786	0.3425
Weather_s	0.75	0.434	0.892	0.034	0.0086***
Death_ill_s	0.196	0.398	0.289	0.456	0.0998***
Price_s	0.309	0.464	0.349	0.479	0.5269
Loss_live_s	0.446	0.498	0.469	0.502	0.7268
Sample Size	168		83		

*, **, *** significant at 10, 5 and 1 percent level of significance.

Table 6. 2 Poverty decomposition: Scenario 1

	Without forest income		With forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-value
FGT (0)	0.6175	0.0307	0.4343	0.0314	0.1832	7.49***
FGT (1)	0.2864	0.0188	0.1606	0.0149	0.1258	11.6***
FGT (2)	0.1709	0.0143	0.0813	0.0098	0.0896	9.91***

***,** and * represent 1, 5 and 10 percept level of significance respectively

Table 6. 3 Poverty decomposition: Scenario 2

	Counter factual income		With forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-statistic
FGT (0)	0.5339	0.0316	0.4343	0.0314	0.0996	3.06***
FGT (1)	0.1580	0.0122	0.1606	0.0149	-0.0026	-0.19
FGT (2)	0.0623	0.0063	0.0813	0.0098	-0.0190	-2.23***

***,** and * represent 1, 5 and 10 percept level of significance respectively

Table 6. 4 Differences in poverty index under counterfactual and conventional scenarios

	Counter factual income		Without forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-statistic
FGT (0)	0.5339	0.0316	0.6175	0.0307	-0.0836	-2.68***
FGT (1)	0.1580	0.0122	0.2864	0.0188	-0.1284	-8.66***
FGT (2)	0.0623	0.0063	0.1709	0.0143	-0.1086	-9.33***

***,** and * represent 1, 5 and 10 percept level of significance respectively

Table 6. 5 Gini Index: Scenario 1

	Without forest income		With forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-statistic
Gini Index	0.3920	0.0198	0.3425	0.0164	0.04955	5.36***

***, ** and * represent 1, 5 and 10 percept level of significance respectively

Table 6. 6 Gini Index: Scenario 2

	Counterfactual Income		With forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-statistic
Gini Index	0.2817	0.0139	0.3425	0.0164	0.0607	5.36***

***, ** and * represent 1, 5 and 10 percept level of significance respectively

Table 6. 7 Differences in Gini index under counterfactual and conventional scenarios: Scenario 3

	Counter factual income		Without forest income			
	Estimates	S.E	Estimates	S.E	Difference	t-statistic
Gini Index	0.2817	0.0139	0.3920	0.0198	0.1103	5.19***

***, ** and * represent 1, 5 and 10 percept level of significance respectively

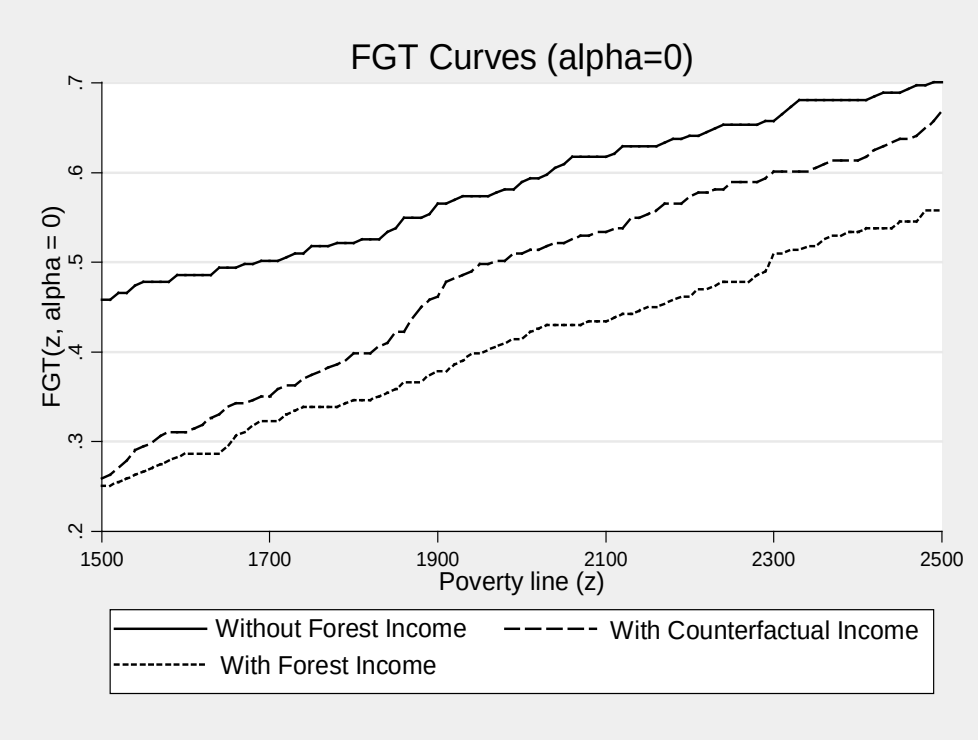


Figure 6. 1 FGT Curves for Incidence of Poverty

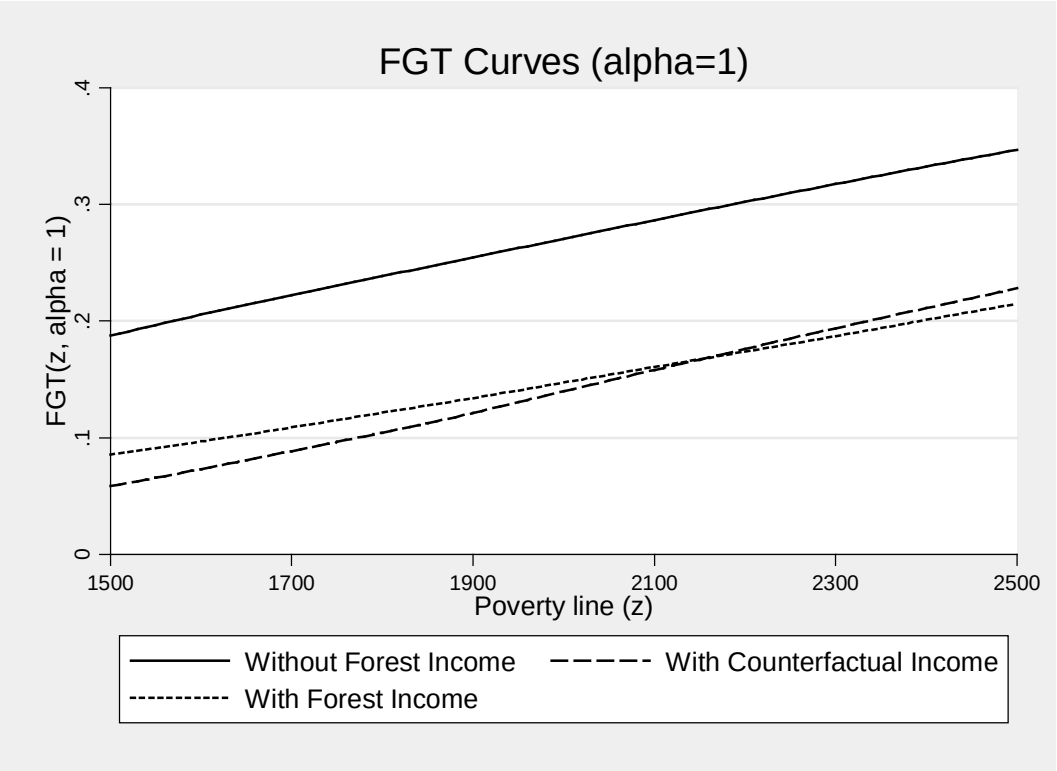


Figure 6. 2 FGT Curves for Depth of Poverty

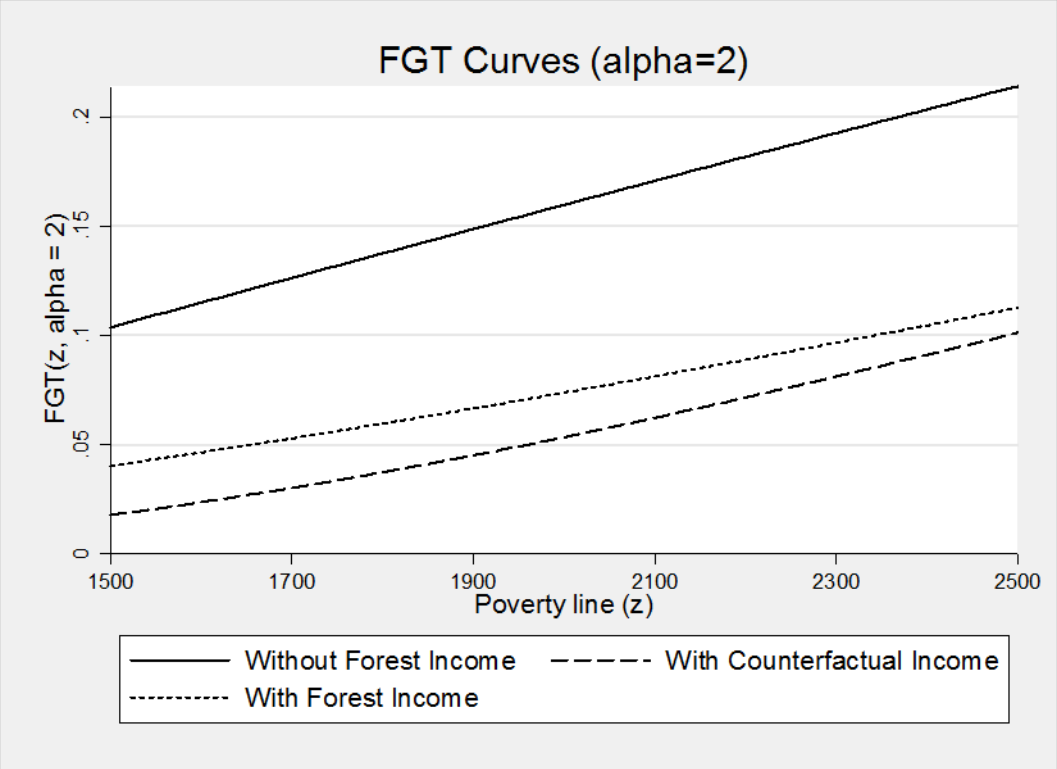


Figure 6. 3 FGT Curves for Severity of Poverty

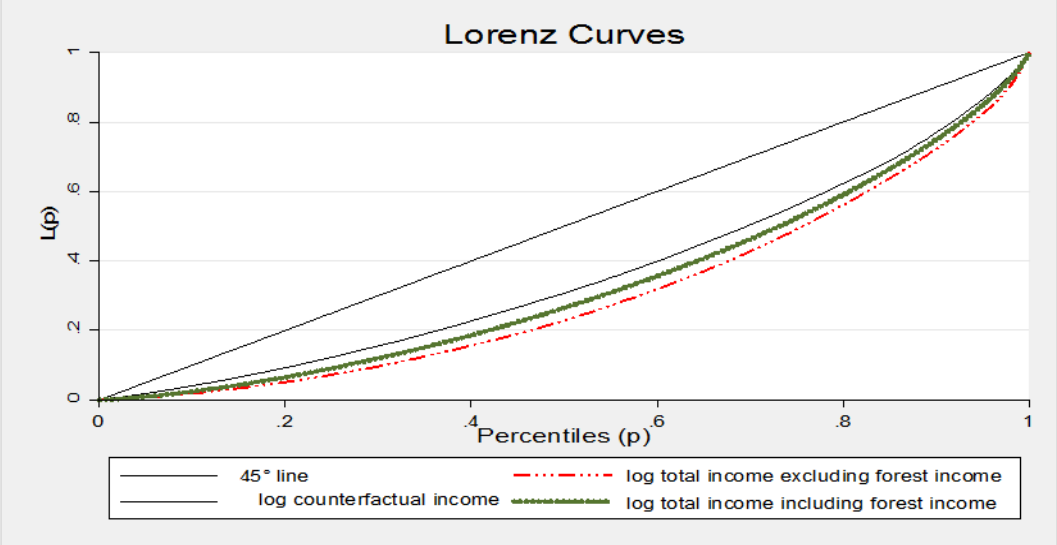


Figure 6. 4 Lorenz Curve of Forest Income Distribution, Different Scenarios

CHAPTER SEVEN

IMPACT OF THE PRODUCTIVE SAFETY NET PROGRAM (PSNP) IN ETHIOPIA IN CONSERVATION OF FORESTS

7.1. Introduction

Poor people often depend on biodiversityboth for their livelihoods and as a safety net againstdeeper poverty (IIED, 2010). In addition, of the 1.2 billion people estimated to live on less than US$ 1 a day (i.e. those that are the target of MDG1), 70% live in rural areas with a high dependence on natural resources for all or part of their livelihoods (Roe, D., 2003).. Moreover, direct dependence on services from ecosystems is highest amongst people living in arid and semi-arid lands such as Tigray where alternative livelihood options areoften limited and environments are particularlyfragile and risky (MA 2005b cited in Shackleton et al.2008).

However, this may constitute a poverty trap as a result of a tragedy of the commons (Hardin 1968).Too many households in rural Tigray depend on these resources as part of their livelihood and the resources cannot provide enough to properly insure all the population. They face thus the classic poverty-environment nexus, where poor people depend on the environment, and over use it (Delacote, 2007). The resultant increased pressure often has a negative feedback on the capacity of the ecosystems to deliver these services and creates a downward spiral of increasing poverty and ecosystem degradation (Shackleton et al., 2008).

Accordingly,finding synergistic solutions has been on local, national, and international agendas for decades, in the hope that humandevelopment and biodiversity conservation can be found to be less a zero-sum game of trade-offs and more a set of mutually reinforcing goals(Timmer, 2005). Yet there is little evidence that increasing incomes or poverty reduction affects the way in which poor people exploit naturalresources (Roe and Elliott, 2005).To this end research is needed under which win-win solutions can be found to advance poverty reduction and conservation biodiversity such as forest environmental resources. The objective of this paper is therefore to investigate whether the Productive Safety Net Program (PSNP) which is one of the largest social protection programs in Africa provides an appropriate framework to create synergies for poverty reduction and conservation of the environment.

The Productive Safety Net Program (PSNP) is a development-oriented social protection program launched in Ethiopia in 2005 (Debela et al., 2014).The PSNP has a short term objective ofprotecting the poor against shocks (consumption smoothing) as well as a long term objective of poverty reduction, growth enhancement and natural resource conservation (Nega et al., 2008). The PSNP operates as a safety net, targeting transfers to poor households in two ways, through Public Works and direct Support (Gilligan et al., 2008).

Given the importance of the program at national level, a rigorous impact evaluation design has been followed since the very early stages of the program and lauded for its success in achieving its objectives such as reducing chronic and transient poverty (Fredu et al., 2010); consumption; food security and assets (Gilligan and Hoddinot 2007; Gilligan et al., 2008); livestock and tree holding (Andersson et al.,2011); human capital formation and child labour (Woldehana 2010; Hoddinot et al., 2009); and crop portfolios (Andersson, 2010). More than eight years in the

program, however, there has not been any attention on the potential of the PSNP for exacerbating or mitigating forest pressure. On the one hand, the government explicitly states that the PSNP has a short term objective of protecting the poor against income shocks (income smoothing) as well as a long term objective of poverty reduction, growth enhancement and natural resource conservation. Therefore, the government clearly has an expectation that PSNP will result in improved environmental outcome. We focus here on forests as the environmental outcome of interest which is a key local resource and global public good.

However, even if we limit the scope to the relationship between public safety nets and forests, previous empirical results are mixed. Alix –Garcia et al., (2010) investigate the impact of large income transfers in Mexico called Oportunidades. They find that the income transfer increases deforestation, at least in the population that is just below the poverty level required to be able to receive payments. On the other hand, Fisher and Shively (2005) find that household forest use responds negatively to a receipt of a positive income shock (technology assistance package)in Malawi. Moreover, many of the empirical literatures on income-deforestation links have been hampered by concerns about the endogenieity of income growth (Alix –Garcia et al., 2010).

The objective of this study is therefore to analyse whether the interests of the global community, the Ethiopian government and local farm households can be reconciled through the PSNP. If the PSNP generates higher and more stable income while minimizing pressure on forests, it could be argued that such a program promotes conservation of forest biodiversity, i.e. renders development compatible with sustainability. The findings of this analysis bear implications for current discussions and initiatives seeking to promote “win-win” strategies for regions where poverty reduction and conservation of biodiversity are all high priorities and to the global efforts to limit greenhouse gas emissions from degradation and deforestation of forest ecosystems.

Analysing Ethiopia's PSNP allows us to make two contributions to the existing empirical literature. First, the implementation of the PSNP creates an exogenous source of variation in income, allowing for clean identification of causal effects that may be significant in predicting the impact of policy changes. Second, it contributes to the program evaluation literature by showing how a class of widely implemented public safety nets has important positive/negative environmental externalities.

We use propensity score matching methods to control the two important selection biases in the program[20], i.e. targeting of the program to recipients based on the characteristics unobservable to the researcher and self-selection into the program by eligible receipts (Gilligan and Hoddinot, 2007).

The chapter is outlined as follows: section 7.2 presents a brief introduction of the PSNP in Ethiopia. Section 7.3 provides the theoretical framework used for the study. Section 7.4 presents the empirical strategy. Section 7.5 presents empirical results and discussions, while the final section presents concluding remarks and policy implications.

7.2. Overview of the Productive Safety Nets Program (PSNP) in Ethiopia

Chronic food insecurity has been a defining feature of the poverty that has been affected millions of Ethiopians for decades (Hoddinot et al., 2009). One of the most important and tenacious problems that is argued to either cause or aggravate the drought-poverty-famine nexus in the plough based cereal farming system in the highlands is severe natural resource degradation, particularly manifest in soil erosion, deforestation, and degradation (Howard and Smith,

[20]The two most important sources of selection bias include "program placement" bias, resulting from effective targeting of the program to poor households, and self-selection bias, resulting from the fact that households that choose to participate in the program may be different from households with access to the program that choose not to participate.

2006).These factors often interact with one another resulting in a reinforcing cycle of the "poverty, food insecurity and natural resource degradation trap". This problem is most acute in Ethiopian highlands (where over 85% of the country's population lives), which is affected by recurrent drought and famine affecting millions of people (FAO, 2003).

Between 1994 and 2003, an average of five million Ethiopians were declared "at risk" and in need of emergency assistance every year (RHVP, 2007). As a result Ethiopia has been the largest recipient of food aid in Africa and one of the largest recipients in the world in the last two decades (Little, 2008 cited in Andersson et al., 2011). However, decades of large –scale food aid deliveries have done little to resolve the problem. Instead, dependency of food aid has steadily increased over time, as has the number of "chronically food insecure" Ethiopians. As a result, the number of individuals in need of emergency food assistance rose from approximately 2.1 million people in 1996 to 13.2 million in 2003, before falling back to 7.1 million in 2004 (Gilligan et al., 2008).

To address this problem of food insecurity and dependence on the previous system of emergency appeals, the Ethiopian government and a consortium of donors that include European Commission(EC), World Bank (WB), Development cooperation of Ireland (DCI), United States Agency for International Development (USAID), Canada International Development Agency (CIDA) and the UK Department for International Development (DFID) launched a new social protection program called the Productive Safety Net Programme (PSNP) in 2005.

The main objective of PSNP is reducing household vulnerability, improving households' resilience to shocks and breaking the cycle of dependence on food aid by bridging production deficits in chronically food insecure farming households, protecting household assets fromdistress sale and creating community assets (Devereux et al., 2006) using a multi annual, predictable resource

framework for predictable problems (RHVP 2007). With an annual budget of nearly US$ 500 million, the PSNP is the second largest social protection program in Africa, reaching more than 7 million Ethiopians (Gilligan et al., 2008).

Food aid targeting in Ethiopia has a long history of relying on community-based targeting systems which have been seen as effective. The PSNP adopted this system while further refining the targeting criteria to capture chronic food insecurity—defined as a three months food gap or more and receiving food aid for three consecutive years. The PSNP uses a mix of geographic and community-based targeting to identify chronically food-insecure households in chronically food-insecure *woredas*. After determining PSNP eligibility based on these criteria, households are assigned to public works or direct support: eligible households with able-bodied adults receive transfers for their participation in public works projects, while those households that cannot provide labor or other means of support receive unconditional transfers. Most beneficiary households participate in public works (90% of all PSNP transfers); a much smaller proportion receives direct support. In 2008, the program operated in the 290 most food-insecure of the approximately 670 *woredas* in rural Ethiopia (Coll-Black et al, 2013). Despite some regional variations PSNP has superior targeting in comparison to any of the African safety net programs by international standards (Coady et al, 2004). Generally, the targeting principles laid out in the Project Implementation Manual (PIM) are being followed and households do not generally perceive that religious affiliation, ethnicity, or personal connections affect the likelihood of selection into public works, the one exception being Oromiya (Coll-Black et al, 2013).

The PSNP operates as a safety net, targeting transfers to the poor households in two ways, thorough Public Works and Direct Support (Gilligan et al., 2008).Public works are labour intensive community-based activities which are designed to provide employment for chronically food

insecure people who have labour (MoARD, 2006), while the direct Support component provides assistance to households who are labour-poor and do not have reliable support (Woldehanna, 2009). Social transfers (direct support) contribute to risk coping and public works has elements of risk reduction, risk mitigation and risk coping, depending on what kinds of public work activities are undertaken (Devereux and Guenther 2007).

There are several ways in which we expect the PSNP to reduce the risk of vulnerability. It can (1) reduce income fluctuations because it increases income irrespective of shocks and thus have the same insurance properties as a permanent income that allow participants to save for the future and bad times; (2) displace non- desirable coping strategies such as child labour, depletion of assets and depletion of forest ecosystems. However, while the impact of PSNP with regard to child labour and depletion of assets has been undertaken there is no systematic study on the impact of PSNP on forest ecosystem conservation. In fact empirical studies on the role of public safety nets and forests have been mixed (see for example Monica and Shively, 2005 and Alix et al. 2010).

7.3. Conceptual Framework for Labour Allocation

The productive Safety Net Program (PSNP) combines a short term objective of protecting the poor against shocks (consumption smoothing) with a long term objective of poverty reduction, growth enhancement and natural resources conservation. With the exception of minor direct benefits for some households, the overall design for the PSNP in Ethiopia is directly related to employment of adults in beneficiary households. This public work requirement means that the program is not neutral in terms of adult labour supply and work incentives. To investigate the impact of PSNP on forest use, we draw on a farm household model and empirical studies of household labour allocation in developing countries (Abdulai and Delgado 1999; Jacoby 1993; Rosenzweig 1980; Fisher et al., 2002) similar to that presented by Fisher et al., (2005).

The model explicitly accounts for the fact that farm households in Ethiopia are both producers and consumers of agricultural and forest goods, and that markets for key factors and products are weak or absent. As a result, production decisions are influenced by consumption needs, and so production and consumption decisions in the model are assumed to be made jointly in response to changes in input and output prices.

We assume households allocate family labour across four major activities: Agricultural production, forest use, PSNP, and self employment. The household seeks to maximize household utility:

Max $U = U(C, F, O, L; H)$ (7.1)

Where utility is derived from consumption of a representative agricultural crop(C), a composite forest product(F), leisure (L) and other goods(O). We assume household and individual characteristics (H) influence preferences. Utility is maximized subject to production functions for crop and forest products, a full income constraint, a time constraint, and non-negativity constraints:

Q = Q$[L, X, A, A(L; K; I)]$ (7.2)

Q = A$(L; K, I)$ + f$(L\ ; K)$ (7.3)

Y = p $(Q - C)$ + p $(Q - F)$+ $p\ L$ + $p\ L$ + R – $p\ O$– $p\ X$ (7.4)

$T - L$ (7.5)

$F, C, O, X, Q, Q, L, \geq 0$ (7.6)

Equation (7.2) describes smallholder production of crops which is assumed to be a function of labour(L), purchased inputs such as fertilizer and seed (X), the household's land endowment (A)

and additional land acquired through land clearing, represented by a function $\mathrm{A}(*)$. Cultivated area in the model is endogenously determined. Note that crop production can occur either through intensification $(via\ X)$ or extensification $\left(via\ A(*)\right)$, or both. Although customary land ownership implies that land markets are generally absent in much of rural Ethiopia, land can be "purchased" by using labour (L) and capital (K), e.g. an axe to clear uncultivated and possibly forested land. The existence of forest management institutions(I) also enters as an argument in A reflecting the potential for institutions to restrain forest clearing.

Equation (7.3) describes production of forest goods. The production function $\mathrm{A}(*)$ illustrates that when forest is cleared for agricultural expansion, forest products arise as a joint product. The technology $f(*)$ describes forest "thinning" activities in which household labour is used to extract products from the forest, but land is not cleared in the process. Note that the existence of forest management institutions (I) appears as an argument in $\mathrm{A}(*)$ but not $f(*)$. This is consistent with the patterns of forest management in Ethiopia, which tends to be more effective at restraining forest clearing than limiting collection of forest products.

Equation (7.4) defines the household's full income. Prices and net hourly returns to labour are denoted by a vector of prices p. Households earn income from four sources: agriculture, forest use, PSNP and other non-/off-farm employment. Households also receive remittances(R^*), defined here as money received from relatives. Households make expenditures on crops (C), forest products (F), other goods (O) and agricultural inputs (X). A positive (negative) sign for $(Q-C)$ and $(Q-F)$ indicates the household is a net-seller (net-buyer) of crop and forest products. Equation (7.5) describes the household's time constraint. Finally, a set of non-negativity constraints (7.6) completes the model.

Two important assumptions inherent in the model should be noted. One, we assume that households sell but do not hire labour. Two, we assume that households do not engage in production of cash crops – beyond sales of surplus crop production. While the assumptions are strong, and not appropriate in the context of rural Ethiopia as a whole, they are reasonable within the context of the sample. Most sample households are net purchasers of food, constrained in both cash and crop and thereby rarely able to hire labour (often paid either with cash or in kind). Only a few sample households engaged in cash crop production during the sample period, partly because coffee, Ethiopia's main cash crop, has historically been produced outside the study area.

The Lagrangian for the household's maximization problem is:

$$L = U(C, F, O, T - L\,; H)$$

$$-\lambda \begin{bmatrix} Y - p\,\{Q[L\,, : X, A, A(L\,; K, I)] - C\} \\ -p\,\{[A(L\,; K, I) + f(L\,; K)] - F\} \\ -p\,L - p\,L - R\; + p\,O\; + P\,X \end{bmatrix} \qquad (7.7)$$

After some rearrangement of terms, first-order conditions for the problem can be expressed as:

$$\frac{\partial U}{\partial L} = \lambda p \frac{\partial Q}{\partial L} \quad (7.8a)$$

$$\frac{\partial U}{\partial L} = \lambda p \frac{\partial Q}{\partial A}\frac{\partial A}{\partial L} + \lambda p \frac{\partial A}{\partial L} + \lambda p \frac{\partial f}{\partial L} \quad (7.8b)$$

$$\frac{\partial U}{\partial L} = \lambda p \quad (7.8c)$$

$$\frac{\partial U}{\partial L} = \lambda p \quad (7.8d)$$

$$p \frac{\partial Q}{\partial X} = p \quad (7.8e)$$

$\frac{\partial U}{\partial C} = \lambda p$ (7.8f)

$\frac{\partial U}{\partial F} = \lambda p$ (7.8g)

$\frac{\partial U}{\partial O} = \lambda p$ (7.8h)

$Y = p\ (Q - C) + p\ (Q - F) + pL + pL + R - pO - pX$ (7.8i)

Equations (7.8a) through (7.8d) indicate that, at the optimum, households allocate labour across activities so as to equate the marginal value of household leisure with that of time spent on each productive activity, i.e. value of marginal product or net hourly returns to labour. Equations (7.8e) thorough (7.8h) equate marginal values with prices. Equation (7.8i) recovers the full income constraint.

Expressions of labour supply, input demand, and commodity demand can be derived as functions of all exogenous variables.

$$\left.\begin{matrix} L \\ L \\ L \\ L \end{matrix}\right\} = g\ (p,\ p,\ p,\ p, A, H, K, I, T) \qquad (7.9)$$

Consider the Slutsky equation relating a change in the net hourly returns from PSNP to the forest labour share. This is:

$$\frac{\partial L}{\partial p} = \frac{\partial L}{\partial p} \Big| \pm \frac{\partial L}{\partial Y}\ L \qquad (7.10)$$

where the first term on the right hand side of equation (7.10) is a substitution effect and is unambiguously non-positive. The second term is an income effect. While L is non- negative, the sign of $\partial L/\partial Y$ may be positive or negative. With rising income the demand for leisure (L) should

increase if leisure is a normal good, but for some reason the demand for forest products (F) should also increase. More leisure should mean a lower forest labour share. However, higher consumption of forest products could imply an increase in the forest labour share. This would be the case, for example, if the household collected rather than bought additional forest goods. Such behaviour might be expected for a household that is a net seller of forest products. In sum, the net effect of a change in the returns to PSNP on forest labour share is ambiguous. A negative relationship whereby higher income from PSNP reduces forest pressure is plausible and could arise under several different scenarios: if forest products are inferior goods, if forest products are normal goods but the income – induced demand for leisure outweighs that for forest products, if forest products are normal goods but the household buys rather than collects forest products, or if a negative substitution effect dominates a positive income effect. A positive relationship between p and L could arise if the income induced demand for forest goods outweighs that for leisure, the household is a net–seller of forest goods and the income effect dominates the substitution effect. The combination of these effects implies that the impact of PSNP on the pressure on forests is ambiguous from a theoretical point of view. The presence of any impact, and its direction, is ultimately an empirical question.

7.4. Methodological Framework

Let the impact of the PSNP on forest outcomes of interest Y for treated households be given by:

$$Y_i^T - Y_i^C \qquad (7.11)$$

Where T refers to the outcome of treated households and C denotes the counterfactual, the outcome for the same households had they been untreated. The above formalization assumes that each household is characterised by a pair of potential outcomes: Y_i^T for the outcome under the active

treatment (participation in PSNP) and Y_i^C for the outcome under comparison treatment (non-participation in PSNP).

Since it is impossible to observe the household treatment effect – because we cannot observe both treated and untreated situations for the same household- we aim to infer the impact of PSNP through its average effect in the population. If data on the outcome(s) of interest are available for treated (participants in PSNP) and untreated (non- participants in PSNP), we can then use the differences in outcome of treated and untreated households to obtain a (naive) estimate of the program impact:

$$E\left[Y_i^T - Y_i^C\right] \qquad (7.12)$$

In this case, the average outcome of untreated households is intended to act as a substitute for the unobservable counterfactual. However, treated households are usually different in a set of observable household characteristics – such as income, food security, and asset- from those households who are not targeted to the programme. This problem will be magnified if households self-select into the programme (for instance, with the aim of securing additional income, or due to their social connectedness etc), meaning that unobservable factors such as motivation are a key determinantof treatment assignment. This makes it difficult to isolate the differences between both groups which are due to already existing distinctions before the treatment – the selection bias- from those which are due to solely to the program's impact, as it can be seen by expanding equation (7.12) above:

$$E\left[Y_i^T - Y_i^C\right] = E[Y_i^T|T] - E\left[Y_i^C|C\right]$$

$$= E[Y_i^T|T] - E\left[Y_i^C|T\right] + E\left[Y_i^C|T\right] - E\left[Y_i^C|C\right]$$

$$= E\left[Y_i^T - Y_i^C | T\right] + E\left[Y_i^C | T\right] - E\left[Y_i^C | C\right] \quad (7.13)$$

The first term in equation (7.13) represents the average treatment effect on the treated, usually the parameter of interest we want to isolate (which will be formally defined below). This parameter will only be defined if the selection bias, represented by the second and third terms above, equals zero; this in turn, will only happen if there are no systematic differences in the average untreated outcomes between treatment and comparison groups.

Equation (7.13) guides us also regarding the direction of the bias. If households which participated in PSNP are on average more dependent on forests than their counterparts in the untreated group to begin with, then the selection bias term will be positive and the impact of PSNP on forest dependency will be overestimated. Conversely, if the comparison groups (untreated) households are more dependent on forests on average than those treated, then the selection bias term will be negative and the estimated treatment effect will underestimate the true impact of PSNP on forest dependency.

An evaluation design in which the selection bias problem tends to disappear is that in which treatment and comparison groups are randomly selected from a large population of potential beneficiaries. In other words, it may be assumed that, on average, those treated by PSNP are not different from those who did not participate either regarding observable characteristics (food security, education, age) or unobservable ones. Consequently, any statistically significant difference in the outcome variable (forest dependency) can be reliably attributed to PSNP.

In most real situations, nevertheless, public safety net programs such as the PSNP have been purposely implemented by governments – for instance by targeting households who are very poor on average than the average poverty level- and/or require households to self-select into the

programme by taking up the benefits. Various quasi-experimental and non-experimental methods have been used to address the bias problem (for details, see Heckman et al., 1998, Rosenbaum and Rubin, 1983 and Smith and Todd, 2001). One of the most commonly used quasi-experimental methods is Propensity Score Matching (PSM), which selects PSNP beneficiaries and non-beneficiaries who are as similar as possible in terms of observable characteristics expected to affect participation in PSNP as well as outcomes under certain assumptions. The differences in outcomes between the two matched groups can be interpreted as the impact of the program on the beneficiaries (Smith and Todd, 2001). These assumptions and the formal definitions of alternative matching estimators for investigating the impact of PSNP on forest dependency will be explained in the next section.

7.4.1. Definitions of Average Treatment Effects

The empirical literature on program evaluation has traditionally focused on estimating three main average treatment effects that include the Average Treatment of the Treated (ATT) or the participation effect, the Average Effect of the Untreated (ATU) and the Average Treatment Effect (ATE) when assessing the impact of single treatment such as PSNP. Becker and Ichino (2002) indicate that the parameter of interest in the estimation of propensity score is the ATT. However, under the assumption of unconfoundedness, Titus (2007) argued that an appropriate approach of evaluating policy–relevant outcomes in a counterfactual framework is to examine not only the ATT, but also the ATU, which captures the effect of treatment on households who do not

participate in PSNP. The definitions and identification conditions of each of these treatment effects will be discussed for the same context of evaluating the impact of PSNP on the outcome variable of interest for both participants and non-participants.

Average Treatment of the Treated (ATT): This parameter represents the average impact of PSNP on the outcome variable of interest (forest dependency) for those households who have been targeted for it. Formally, it is defined as:

$$ATT = E\left[Y_i^T - Y_i^C | T\right] = E[Y_i^T | T] - E\left[Y_i^C | T\right] \quad (7.14)$$

The second term after the last equality in equation (7.14) is the counterfactual to be estimated. The ATT is a measure of the average gain from PSNP to the treated households rather than to any households in the sample.

Average Treatment Effect on the Untreated (ATU): This alternative estimation represents the expected average impact of PSNP on the outcome variable (forest dependency) among those who have not been treated. In formal terms

$$ATU = E\left[Y_i^T - Y_i^C | C\right] = E[Y_i^T | C] - E\left[Y_i^C | C\right] \quad (7.15)$$

The first term after the last equality in equation (7.15) cannot be observed and must be estimated. The ATU parameter recovers the expected impact of PSNP on forest dependency on households randomly drawn from the sub-population of non-participants of PSNP, and is potentially useful to assess the impact of a program expansion to initially untreated households.

Average Treatment Effect (ATE): This is the third treatment effect corresponding to the average impact of PSNP for the entire population, whether or not a particular household has been treated, formally:

$$ATE = ATT * P(T) + ATU * P(C)$$

$$ATE = = E\left[Y_i^T - Y_i^C|T\right]* P(T) + E\left[Y_i^T - Y_i^C|C\right]* P(C) \quad (7.16)$$

Where $P(T)$ and $P(C)$ are the probabilities of belonging to the treatment and comparison groups, respectively. In the sample these probabilities correspond to the sample frequencies of treated and untreated households. As can be seen, counterfactuals must now be estimated for both components of the ATE. This parameter is relevant for poverty reduction interventions that could be universally expanded, addressing the question of what the treatment gain would be to randomly selecvted households of the population.

Estimation of the Average Treatment Effects using matching methods relies on two key assumptions. The first is the conditional independence assumption (CIA), which states that assignment to treatment group is independent of the outcomes but based on observable characteristics (selection on observables). Matching on every covariate is difficult when the set of covariates is large. To solve this problem, we estimated the *propensity score*[21] given as follows:

$$p(X) = p(D = 1 |X = x) = E[D|X = x] \quad (7.17)$$

The second assumption is the common support or overlap assumption. The common support is the area where the balancing score has positive density for treatment and comparison groups. No matches can be made to estimate the Average Treatment Effects when there is no overlap between the treatment and control groups.

[21]The propensity score is defined as the conditional probability the household will participate in PSNP conditional on observed characteristics(x) , Where D = 1 when the household participates in PSNP , and D=0 otherwise.

Several methods are possible for selecting matching observations. We used kernel matching method (using the normal density of Kernel), which uses a weighted average of "neighbours" (within a given range in terms of the propensity score) of a particular observation. Unlike the nearest–neighbour method, using a weighted average improves the efficiency of the estimator (Smith and Todd, 2011).

7.5. Empirical Results

7.5.1. Descriptive Statistics

A household survey was conducted in 2010/11 254 households in the Tigray region of northern Ethiopia. However, because of missing data on some key variables for 3 households, our final sample consists of 251 households (for details of the survey please refer section 2.4 of the thesis).

The dependent variable used in the study is a dummy variable that takes the value of one, if the household participated in the Productive safety net Program, and a value zero, if no participation was recorded. The outcome variables used in this study are one binary indicator of whether the household participates in forest environmental collection or not (forest_ext), forest dependency, measured in terms of the ratio of forest income to the total household income (forest_dep) and number of trips to forests by the household in the survey year (forest_trips). These outcome variables employed were chosen to be in line with those suggested in the literature (see for example, Vira and Kontoleon, 2010).

<<< INSERT TABLE 7.1 ABOUT HERE >>>

Descriptive statistics of the variables used in the analysis are also presented in table 7.1 and 7.2. About 67% of the sample households were participating in the PSNP, while the remaining 33%

did not participate. The survey also collected extensive information on several factors, including household characteristics, asset endowments, income and expenditure, household food security and vulnerability to shocks.

In many of the variables, we observed non-participants to be in a better position than the participant households. For example, non-participants had an average higher number of months food stock available, higher income per adult equivalent, better access to irrigation and transfer than their participant counterparts. Conversely, participants were vulnerable to weather and health related shocks. This is not however surprising, given the objective of the program is to protect the poor against shocks (consumption smoothing) as well as a long term objective of poverty reduction.

<< INSERT TABLE 7.2 ABOUT HERE>>

With regard to the outcome variables, our descriptive statistics did not show significant difference between participants and non-participants. These findings suggest that PSNP may not have a role in the outcome variables, but given that there are two important sources of selection bias in the PSNP - i.e. targeting of the programme to recipients based on characteristics unobservable to the researcher and self-selection into the programme by eligible recipients (Gilligan and Hoddinot, 2007) – a simple comparison of the outcome variables of the participants and non-participants has no causal interpretation. Therefore, we needed to conduct careful multivariate analysis to manage this econometric problem and test the impact of PSNP on the outcome variables.

7.5.2. Propensity Score Estimation Results

The propensity scores which were estimated with a probit model are reported in table 7.3. Propensity scores help as a device to balance the observed distribution of covariates across the treated and untreated groups (Lee, 2008). A detailed interpretation of the propensity score

estimates is not undertaken in this study. However, the results shown in table 7.3 indicate that most of the variables included in the estimators have the expected signs.

<< INSERT TABLE 7.3 ABOUT HERE>>

The density distribution of the propensity score for participants and no participants in the program shows a good overlap (see figure 7.2) suggesting that the common support condition is satisfied. The bottom half of the graph shows the propensity score distribution for the non-participants (untreated), while the upper –half refers to participants (treated).

<< INSERT FIGURE 7.2 ABOUT HERE>>

Table 7.4 demonstrates how matching restricts the control sample in order to increase the similarity of the subsample of control cases that are directly compared with treated cases, in order to estimate the consequences of treatment. Table 7.4 presents the balancing information for the propensity scores and for each covariate before and after matching. We used the standardized bias differences between treatment and control samples as a convenient way to quantify the bias between treatment and control samples. In many cases we found that sample differences in the unmatched data significantly exceed those in the samples of matched cases. The process of matching thus creates a high degree of covariate balance between the treatment (participants in PSNP) and control groups (non participants) that are used in the estimation procedure.

The imbalances between the treatment and control samples in terms of the propensity score had been more than 100 % before matching as shown in the table 7.4. This bias was significantly reduced to a level of 3.1% after matching. The same table also shows that before matching, several variables exhibit statistically significance differences, while after matching the covariates are balanced.

The low pseudo R^2 and the insignificance likelihood ratio tests also support the hypothesis that both groups have the same distribution in covariates X after matching (see table 7.5). These results clearly show that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. We therefore used these results to evaluate the impact of PSNP among groups of households having similar observed characteristics. This allows us to compare outcomes for participants with those of a comparison group showing a common support.

7.5.3. Average Treatment Effects

The results of treatment effects (ATT, ATU and ATE) all estimated by Kernel matching method are presented in table 7.6. Starting from the ATT, the matching estimates reported in table 7.6 generally indicate that participation in PSNP exerts negative and significant effect in all of the outcome variables. Specifically the ATT effect of 0.0438 indicates that participation in PSNP result in lowering the probability of households' participation in forest environmental resource extraction (Forest _ext) by 4.38 %.

<< INSERT TABLE 7.5 AND TABLE 7.6 ABOUT HERE>>

The effect of PSNP on forest dependency was also found to be negative and statistically significant, again implying that PSNP helped in lowering the dependency of households by 11.8 %. Thus, PSNP appears to be crucial in minimizing the pressure on forest ecosystems. The magnitude of the coefficients of the treatment effects indicate that the average treatment effect of the treated (ATT) is higher than the Average treatment effect of the untreated (ATU) and the average treatment effect of the entire sample (ATE). This finding reveals that households that have a higher probability of participating in PSNP are able to reduce their dependency on forests over and above those the households that have less probability of participating in PSNP. The implication of this

result is thus, the gains in terms of reducing forest dependency as the result of PSNP are higher for households with higher probability of participating PSNP than those of households with lower chances of involving in the program.Also presented in table (7.6) are the critical levels of gamma (Γ) called the Rosenbaum test obtained using Γ bounds command in STATA 10. The Rosenbaum test is proposed by Rosenbaum (2002) to test if our causal inference about the impact of PSNP on the outcome variables would be altered by unobservable factors that affect both treatment and outcome variables. The p-critical values represent the lower bound of the p-value. Given that the estimated treatment effect is negative, the upper bounds under the assumption that the true treatment effect has been overestimated were less interesting (Becker and Caliendo, 2007). As a result table 7.6 shows that the negative effect of PSNP is not sensitive to selection bias due to unobserved variables, even if we allow participants and non-participants to differ by as much as 40 % in terms of unobserved covariates. The critical value of $\boldsymbol{\Gamma}$, at which point we would have to question our conclusion of a negative impact of PSNP, starts from $\boldsymbol{\Gamma} = 1.4$. However, Becker and Caliendo (2007) argued that these sensitivity results are worst case scenario. Overall the critical values in the table 7.6 clearly indicates that even unobserved heterogeneity would not alter the influence about the treatment effects, suggesting that the findings are generally insensitive to hidden bias. As a result we can conclude that the treatment effects estimate in table 7.6 are a pure effect of PSNP.

7.6.Conclusions and Policy implications

This paper investigates the links between the Productive Safety Net Programme (PSNP) and pressure on forests in North highlands of Ethiopia. We estimated the propensity score matching model to account for self-selection bias that normally occurs when unobservable factors influence

both participation in PSNP and outcomes such as participation in forest environmental resource extraction, forest dependency and number of trips to forests that the household had.

Results of the propensity matching score suggest a negative and significant effect of PSNP and the outcome variables. These findings are generally consistent with the widely held view that programs designed to reduce economic vulnerability of low income households can improve human welfare and reduce forest pressure. Our results are similar with the findings of Fisher and Shively (2005), that households who were involved in the Starter Pack program in southern Malawi had lower forest extraction as compared to households without the program.

Our study complements a small amount of literature that highlights on the intended and unintended impacts of programmes designed for poverty reduction on conservation of forest ecosystems and biodiversity. However, the need for further research is indisputable because households are likely to respond differently to income changes from poverty reduction programs that are perceived to be substantial and permanent versus small and temporary (Alex- Garcia et al, 2010). Further research is thus suggested using panel data spanning several years and in different geographical locations. If the results of our study are confirmed through additional analysis, then they indicate that the growing interest of policy makers in Ethiopia in pursuing the twin goals of sustainable development – raising human living standards and conservation of forest biodiversity – are moving in the right direction. Moreover, our study has important implications for Reducing Emissions from Deforestation and Forest Degradation (REDD) in developing countries using programs such as the Productive Safety Net program in Ethiopia.

PSNP has elements of risk reduction, mitigation and risk coping; as a result it can reduce income fluctuations because it increases income irrespective of shocks and thus has the same insurance

properties as permanent income which allows beneficiaries to save for the future and bad times, and in the end displace non-desirable coping strategies such as depletion of forest ecosystems.

Given that the poor households are most dependent on forest ecosystems as source of livelihood and coping mechanisms, which exerts pressure on common pool resources such as forest biodiversity and ecosystems, policy measures could target them to lower their dependency on forest environmental resources. Finally, a wider set of policies should aim to reduce poor households' vulnerability to shocks and improve access to alternative livelihood strategies by providing improved access to micro credit, agriculture and health extension services..

Table 7. 1 Descriptive statistics of sample households

	Total Sample		Participants		Non-participants	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Variable name						
Treatment Variable						
PSNP (1/0)	0.67	0.33	0.00	0.00	0.00	0.00
Outcome Variables						
Forest_extraction(1/0)	0.85	0.36	0.86	0.34	0.81	0.40
Forest_dependency	0.25	0.20	0.26	0.21	0.23	0.21
Forest_trips	74.8	51.1	73.7	52.2	76.9	49.1
Explanatory variables						
HH characteristics						
Hhh_sex	0.85	0.36	0.86	0.35	0.83	0.38
Age_hh_1	46.7	12.5	45.2	11.6	50.0	13.8
Edu_hhh	1.17	2.18	1.21	2.30	1.07	1.94
Family_size	5.75	2.11	5.89	2.08	5.47	2.17
Dep_ratio	0.48	0.20	0.49	0.18	0.46	0.24
N_dep	2.88	1.59	2.30	1.51	2.66	1.72
Asset Holdings and access to inputs and factor market						
P_size _tsimdi	4.36	2.92	4.20	2.87	4.68	3.04
Tlu	3.11	2.59	2.97	2.38	3.39	2.96
Private_forest	0.45	0.50	0.48	0.50	0.38	0.49
Fooda_months	5.70	3.42	5.30	3.27	6.52	3.61
Access_irrigation (1/0)	0.14	0.34	0.08	0.27	0.25	0.43
M_hh_ext_pack	0.17	0.37	0.15	0.36	0.19	0.39
Transfer (1/0)	0.30	0.46	0.25	0.43	0.42	0.50
I_per_aue	2209	1527	2059	1263	2513	1928

T_asset_v	1316	2100	1323	1617	1301	2849
I_per capita						
Dummy_own _b	0.32	0.47	0.34	0.47	0.29	0.46
fol	0.50	0.50	0.52	0.50	0.46	0.50
Shock Dummies						
Weather_s	0.80	0.40	0.84	0.37	0.71	0.46
Death_ill_s	0.22	0.41	0.17	0.38	0.31	0.47
Loss_live_s	0.45	0.50	0.46	0.50	0.43	0.49
Sample Size	251		168		83	

Table 7. 2 Mean separation test of participants and non-participants in PSNP

	Participants		Non-participants		
	Mean	Std. Dev.	Mean	Std. Dev.	P-Value
Variable name					
Forest_extraction(1/0)	0.86	0.34	0.81	0.40	0.200
Forest_dependency	0.26	0.21	0.23	0.21	0.301
Forest_trips	73.7	52.2	76.9	49.1	0.642
Hhh_sex	0.86	0.35	0.83	0.38	0.593
Age_hh_1	45.2	11.6	50.0	13.8	0.004***
Edu_hhh	1.21	2.30	1.07	1.94	0.629
Family_size	5.89	2.08	5.47	2.17	0.148
Dependency_ratio	0.49	0.18	0.46	0.24	0.309
N_dep	2.30	1.51	2.66	1.72	0.127
P_size _tsimdi	4.20	2.87	4.68	3.04	0.222
Tlu	2.97	2.38	3.39	2.96	0.230
Private_forest	0.48	0.50	0.38	0.49	0.149
Fooda_months	5.30	3.27	6.52	3.61	0.008***
Access_irrigation (1/0)	0.08	0.27	0.25	0.43	0.000***
M_hh_ext_pack	0.15	0.36	0.19	0.39	0.449
Transfer (1/0)	0.25	0.43	0.42	0.50	0.005***
T_asset_v	1323	1617	1301	2849	0.940
I_per_aue	2059	1263	2513	1928	0.026**
Dummy_own _b	0.34	0.47	0.29	0.46	0.426
fol	0.52	0.50	0.46	0.50	0.327
Weather_s	0.84	0.37	0.71	0.46	0.017**

Death_ill_s	0.17	0.38	0.31	0.47	0.011**
Loss_live_s	0.46	0.50	0.43	0.49	0.649
	168		83		

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 7. 3 Estimation of propensity score: probit model

Dependent Variable : PSNP (1/0)			
Variable name	Coefficient	Standard Error	P- Value
Hhh_sex	-0.246	0.292	0.933
Age_hh_1	-0.014	0.008	0.075*
Edu_hhh	0.045	0.049	0.355
Family_size	0.198	0.108	0.066*
Dep_ratio	-0.673	0.927	0.469
N_dep	-0.186	0.195	0.339
P_size _tsimdi	-0.073	0.378	0.053*
Livestock in Tlu	-0.030	0.046	0.511
Private_forest	0.518	0.216	0.016**
Fooda_months	-0.056	0.029	0.065**
Access_ irrigation (1/0)	-0.874	0.276	0.002***
M_hh_ext_pack	-0.043	0.244	0.862
Transfer (1/0)	-0.442	0.196	0.024**
T_asset	0.001	0.001	0.774
I_per capita	0.001	0.001	0.774
Dummy_own _b	0.180	0.215	0.399
fol	0.134	0.186	0.473
Weather_s	0.790	0.269	0.003***
Death_ill_s	-0.526	0.239	0.027**
Loss_live_s	0.058	0.206	0.777
constant	0.309	0.696	0.657
Number of observations	251		
Pseudo R^2	0.18		
LR-chi-square	58.52***		
Log likelihood	-130.03795		

* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 7. 4 Propensity score and covariate balances

(Note: Figures in bold are significant variables)

Variable	Sample	Mean		% reduction		t- test	
		Treated	Control	% bias	|bias|	t	p>|t|
Propensity Score	Unmatched	0.7441	0.5178	108.5		8.42	**0.000**
	Matched	0.7353	0.7287	3.1	97.1	0.33	0.740
Hhh_sex	Unmatched	0.8571	0.8313	7.1		0.54	0.593
	Matched	0.8519	0.8508	0.3	96.1	0.03	0.980
Age_hh_1	Unmatched	45.167	50.000	-38		-2.92	**0.004**
	Matched	45.29	44.712	4.5	88	0.42	0.672
Edu_hhh	Unmatched	1.2143	1.0723	6.7		0.48	0.629
	Matched	1.2284	1.4234	-9.2	-37.3	-0.81	0.417
Family_size	Unmatched	5.881	5.4699	19.3		1.45	0.148
	Matched	5.8148	5.6328	8.6	55.7	0.78	0.434
Dep_ratio	Unmatched	0.4888	0.4613	12.9		1.02	0.310
	Matched	0.4863	0.4812	2.4	81.2	0.23	0.816
N_dep	Unmatched	2.9881	2.6627	20.1		1.53	0.127
	Matched	2.9506	2.8276	7.6	62.2	0.69	0.490
P_size _tsimdi	Unmatched	4.1971	4.6778	-16.3		-1.22	0.222
	Matched	4.2603	4.6277	-12.3	24.2	-1.06	0.288
Tlu	Unmatched	2.9695	3.3859	-15.5		-1.20	0.231
	Matched	2.9978	2.9916	0.5	98.5	0.02	0.981
Private_forest	Unmatched	0.4821	0.3855	19.5		1.45	0.149
	Matched	0.4691	0.4457	4.7	75.7	0.42	0.673
Fooda_months	Unmatched	5.2976	6.5181	-35.4		-2.69	**0.008**
	Matched	5.4136	5.7345	-9.3	73.7	-0.88	0.378
Access_irrigation	Unmatched	0.7738	0.2530	-48.4		-3.93	**0.000**
	Matched	0.0803	0.0593	5.8	88.1	0.74	0.460

M_hh_ext_pack	Unmatched	0.1548	0.1928	-10.0		-0.76	0.450
	Matched	0.1605	0.2178	-15.1	-50.7	-1.32	0.189
Transfer	Unmatched	0.2500	0.4217	-36.8		-2.81	**0.005**
	Matched	0.2593	0.2386	4.4	87.9	0.43	0.668
T_asset	Unmatched	1322.6	1301.4	0.9		0.08	0.940
	Matched	1328	1295	1.4	-58.0	0.13	0.895
I_per capita	Unmatched	2058.9	2512.7	-27.8		-2.23	**0.026**
	Matched	2061.7	2254.5	-11.8	57.5	-1.21	0.228
Dummy_own_b	Unmatched	0.3393	0.2892	10.6		0.80	0.426
	Matched	0.3272	0.3408	-2.9	72.9	-0.26	0.796
fol	Unmatched	0.5238	0.4578	13.2		0.98	0.327
	Matched	0.5062	0.4901	3.2	75.7	0.29	0.774
weather_shock	Unmatched	0.8393	0.7108	31.0		2.40	**0.017**
	Matched	0.8333	0.7811	12.6	59.4	1.19	0.235
Death_ill_shock	Unmatched	0.1726	0.3133	-33.1		-2.56	**0.011**
	Matched	0.1790	0.1790	0.00	100	0.00	0.999
Loss_livestock	Unmatched	0.4643	0.4337	6.1		0.46	0.649
	Matched	0.4630	0.4623	0.1	98.0	0.01	0.991

Table 7. 5 Other covariate balance indicators before and after matching

Indicator	Sample	
Pseudo R2	Unmatched	0.18
	Matched	0.04
LR X2 (p-value)	Unmatched	59.35(0.000)***
	Matched	18.35 (0.685

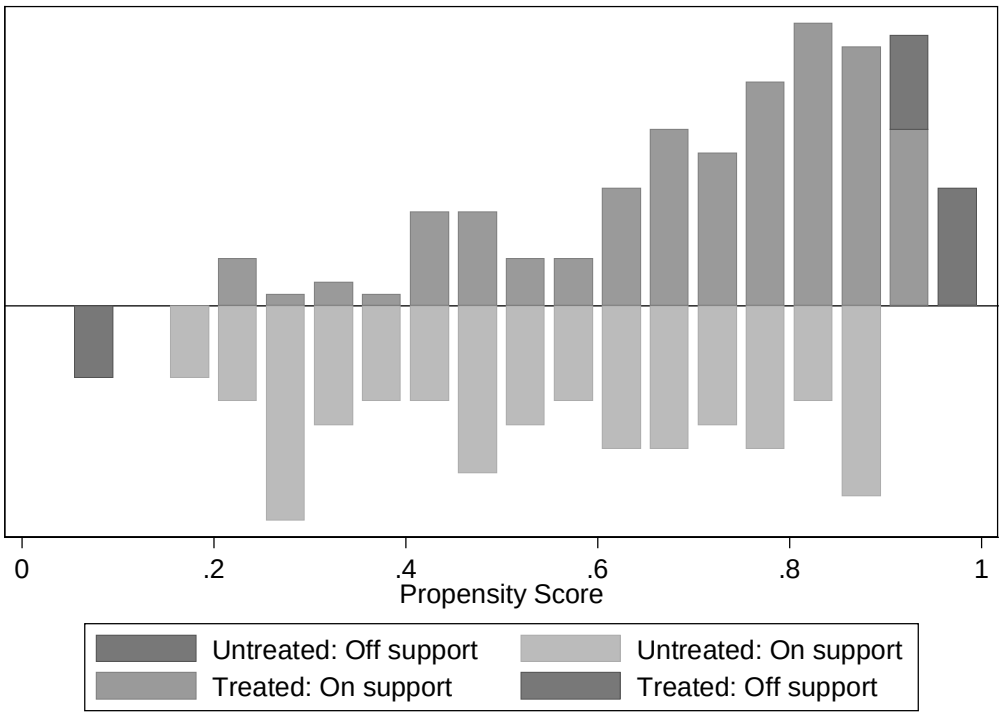
* significant at 10%; ** significant at 5%, *** significant at 1 %

Table 7. 6 Treatment effect and sensitivity analysis

Outcome Indicators	PSM			Critical Value of r (hidden bias)	Treated		Untreated	
	ATT	ATU	ATE		On support	Off-support	On support	Off-support
Forest_ext	-0.044**	0.108	0.020	1.4	150	18	3	80
	(-1.94)	(2.17)	(2.43)					
Forest_dep	-0.118***	-0.006	-0.081**	1.7	150	18	3	80
	(-2.41)	(-0.13	(-1.69)					
Forest_trip	-8.410*	0.414	-0.341	1.5	150	18	3	80
	(-2.75)	(0.15)	(-0.21)					

* significant at 10%; ** significant at 5%, *** significant at 1 %

Figure 7. 1 Distribution of propensity scores



Appendix

Table 71ADefinition of Variables

Variable name	Definition
Treatment Variable	
PSNP (1/0)	Equals 1 if the household is participating in the Productive Safety Net Program (PSNP) , 0 otherwise
Outcome Variables	
Forest_extraction (1/0)	Dummy =1 if the household participated in forest environmental resource extraction, 0 otherwise
Forest_dep	Ratio of income from forest environmental resources to the overall household income
Ftrips_year	Number of trips to forests by the household during the survey year.
Explanatory variables	
Sex _hhh (1/0)	Equals 1 if the household head is male, 0 otherwise
Age_hh_1	Household head' age in years
Edu_hhh	Educational level of the household head in years
Family_size	Family size of the household
Dep_ratio	Dependency ratio in the household
N-dep	Number of Dependents in the household
P_size _tsimdi	Plot size owned by the household in tsimdi (= 0.25 hectare)
Tlu	Number of livestock owned in Tropical Livestock Unit (TLU)
Private_forest (1/0)	Dummy = 1 if the household owned private forest , 0 otherwise
Fooda_months	Number of months in the year that the household had enough food stock
Access_irrigation (1/0)	Dummy = 1 if the household had access to irrigation, 0 otherwise
M_hh_ext_pack	Dummy =1 if the household is a beneficiary of the household extension package during the survey year , 0 otherwise
Transfer (1/0)	Dummy =1 if the household had access to transfer , 0 otherwise
T_asset	Total value of assets owned by the household in Ethiopian Birr

I_per capita	Household income per adult equivalent in Ethiopia Birr
Dummy_own _b	Dummy = 1 if the household has his/her own business , 0 otherwise
fol	Dummy = 1 if the household is a member of any social group institution , 0 otherwise
Weather_s	Dummy = 1 if the household experienced weather related shocks last year , 0 otherwise
Death_ill_s	Dummy =1 if the household experienced death or illness of a household member last year , 0 otherwise
Loss_live_s	Dummy = 1 if the household experienced shocks related to loss of livestock last year , 0 otherwise

CHAPTER EIGHT

DISCUSSIONS AND CONCLUSIONS

8.1. Forest management, Shocks and Poverty reduction

Poor people often depend on biodiversityboth for their livelihoods and as a safety net againstdeeper poverty (IIED, 2010).Moreover, direct dependence on services from ecosystems is highest amongst people living in arid and semi-arid lands such as Tigray, where alternative livelihood options areoften limited and environments are particularlyfragile and risky (MA 2005b cited in Shackleton et al., 2008).The resultant increased pressure often has a negative feedback on the capacity of the ecosystems to deliver these services and create a downward spiral of increasing poverty and ecosystem degradation (Shackleton et al., 2008) and this dependence of the poor on the fragile open access may confirm the suggestion in some recent literature (e.g. Angelsen and Wunder, 2003; Lavange, 2005; Delacote, 2007) of a resource based "poverty trap."

Accordingly,finding synergistic solutions has been on local, national, and international agendas for decades, in the hope that humandevelopment and biodiversity conservation can be found to be less a zero-sum game of trade-offs and more a set of mutually reinforcing goals(Timmer, 2005).In the same way Howard and Smith(2006) identified two over arching problems of Common Pool Resources Management (CPR) in Tigray: the possibility to halt degradation and sustainably regenerate vegetative resources, and the need to generate livelihood resources that can help to alleviate poverty, food insecurity and continued degradation in the area (Howard and Smith, 2006).

In line with the national development strategy framework known as Agricultural Development Led Industrialization (ADLI), the regional government of Tigray followed a Conservation based

Agricultural Development Strategy (CBAD) since 1994. One of the major strategies of environmental rehabilitation includes area enclosures and establishment of community woodlots for ecological restoration. The immediate positive environmental effects of the enclosures and the species restrictions are universally acknowledged by researchers, local populations(Howard and Smith, 2006) and the international community as well. However, there is also a steady growing body of literature questioning the impact of such policy interventions in terms of economic benefits to farm households who are dependent on the forest resources for insurance and source of income, suggesting the gains in the conservation of forest biodiversity in the region require a corresponding focus on the economic and social issues of the intervention. To this end clarity is needed under which conditions the current forest management contributes to the livelihood of farm households in the region.

This study has addressed five major issues of relevance to attaining win –win solutions for human development and conservation of forest biodiversity in the region. *The first issue examined how forest environmental resources provide a "natural insurance" for households affected by idiosyncratic health related shocks*. It examines the difference in the number of trips to forests, forest sales and forest dependency between households that are affected by health related shocks and that were not, and the factors that explain households' participation in forest environmental resources for coping with health related shocks.

Refocusing on the role that forest plays in livelihoods and poverty reduction, Wunder (2001) and Angelsen and Wunder (2003) also argued that optimism about a win-win development and conservation outcome is unwarranted and that NTFP extraction is generally a low–return activity that may even lead to a "poverty trap". Thus, *the second issue addressed in this research deals with forest –food security linkages and its implication for the long term livelihood outcomes of*

smallholder farming households in Tigray. It tries to explicitly focus on food security indicators as outcome variables to investigate the role of forest environmental resources on these indicators. In addition, this section also tries to identify whether a risk management strategy or diversification strategy explain households' choice of participation in forest environmental resource extraction in rural Tigray.

Full understanding of the links between forests and welfare of households requires the ability to make causal inferences about a counterfactual (CBD, 2010). *The third issue of this study is therefore to investigate the welfare impact of forest environmental resource commercialization in rural Tigray using counterfactual income analysis*. It tries to identify conditional expectations, treatment and heterogeneity effects of participation in forest environmental resource commercialization and its implication on the welfare of rural households in Tigray.

Poverty in local forest communities is considered both a cause and result of deforestation and environmental degradation. If poverty can be alleviated through the harvesting of forest environmental resources, then deforestation pressures will be reduced. It is also claimed that the poorer the country, the more significant is natural capital likely to be in determining the overall distribution of wealth. Thus, *the fourth issue that this study addressed is the contribution of forest environmental resources for poverty reduction and distribution of income in rural Tigray*.

Finally, as mentioned in section 8.1., the two overarching problems identified by researchers with the issue of Common Pool Resources (CPRs) in Tigray are the possibility to halt degradation and sustainably regenerate vegetative resources on the one hand, and the need to generate livelihood resources that can help to alleviate poverty, food insecurity and continued degradation on the area on the other (Howard and Smith, 2006). Thus, *the final issue addressed in this research is whether the Productive Safety Net Program (PSNP) in the region provides an appropriate strategy*

for reconciling conservation of the environment and poverty reduction. It identified some of the major problems in the program and policy inputs required to strengthen the role of the program to bring a win-win solution for conservation and poverty reduction.

Discussion on the findings of each research issue and conclusions are presented in subsequent sections. Section 8.2 presents the findings and conclusions on the role of natural insurance for coping with idiosyncratic health related shocks. Section 8.3 presents the main findings and conclusions of forests-food security linkages and their impact on the long term livelihood outcomes of smallholder farming in Tigray. Section 8.4 presents the findings and conclusions on the welfare impact of forest environmental resources along with the conditional expectations, treatment and heterogeneity effects of participation in rural Tigray. Section 8.5 presents a discussion and conclusions on the contribution of forest environmental resources on poverty reduction and income distribution under the existing management system in rural Tigray. Section 8.6 presents a discussion of the findings and conclusions on the role of the productive safety net program in providing win-win environmental conservation and poverty reduction. Finally, in section 8.7 the main policy implications of the overall research and further research needs are discussed.

8.1.1. Idiosyncratic Health Shocks and Forest Environmental Resources

A typical household in rural areas of developing countries is exposed to covariate and/or idiosyncratic risks. Low and volatile incomes coupled with the absence of or poor development of financial and risk sharing institutions in such areas make consumption smoothing an important issue in both theoretical and empirical studies in development economics. In the absence of functioning financial and insurance markets households use different coping mechanisms when

exposed to shocks (Dercon et al, 2005; Dercon & Krishnan, 2005). One of the emergent literatures in relation to consumption smoothing is the issue of "natural insurance" (Angelsen et al., 2007).

However, much of the existing literature on natural insurance deals with covariate shocks such as drought and flooding. Meanwhile, a growing body of empirical evidence suggests that idiosyncratic risk may be as important, or indeed may dominate covariate risks in rural Africa and Asia (Udry, 1990; Townsend, 1995; Deaton, 1997; Libbert et al., 2004; Morduch , 2004; Dercon, 2005; Kaziange and Udry, 2006). In this research we investigated the role of "natural insurance" for coping with idiosyncratic health shocks in rural Tigray, both in the context of the region and in the light of the scholarly debate on the subject.

Controlling for other factors, the empirical results revealed that participation in forest environmental resource extraction and number of trips to forests is positively and significantly associated with health related shocks in Tigray. In the same way, households who are affected by health related shocks are more dependent on forest environmental income. This suggests that forest environmental resources play an important role as a safety net or provide "natural insurance" for the poor households affected by idiosyncratic health related shocks.

8.1.2. Forest-Food Security Linkages

Since the last two decades NTFP-based development was born as a new development paradigm capable of accommodating many conflicting needs - of local livelihoods and of global markets; of balancing regional developmental aspirations with that of national growth; and above all of reconciling environment and development. However, refocusing of the development agenda on poverty has led to recent reassessment of the role that bio-diversity plays in livelihoods and poverty alleviation. A profusion of new commentary has emerged. This poses many fresh questions, and, to some extent, tempers previous optimism regarding the ability of this sector to make a difference

by providing a more subtle and complex picture of livelihood – biodiversity linkages (Shackleton, 2006). For example, Neumann and Hirch (2000) present evidence from an array of studies that show that NTFP extraction is an activity of the poor, and Wunder (2001) and Angelsen and Wunder (2003) argue that optimism about a win – win development and conservation outcome is unwarranted, and that NTFP extraction is generally a low-income activity that may even result in a poverty trap. Similarly, Lavange et al., (2005 cited in CBD, 2010) claim that biodiversity resource dependence is a symptom of poverty, and it is only by "leaving the forest" that the poor can hope to escape poverty.A plausible alternative to the downward spiralscenarios is a pattern in which poor rural households convert natural capital into physical and human capital, and use these investments to gradually move out of poverty and reduce their reliance on destructive resource extraction (Angelsen et al., 2007).

The general conclusion in the current literature is that the safety net and poverty trap aspects of NTFPs are linked, in as much as features that make forest products attractive to the poor also limit their potential for generating higher income and escaping their poverty (Shackleton, 2006).

However, much of the existing arguments and conclusions made on the link between poverty and biodiversity suffer from an overload of conjectural and anecdotal assertion rather than evidence (Roy et al., 2010). Full understanding of the links between biodiversity and poverty require the ability to make causal inferences about the counterfactual (CBD, 2010; Vira and Kontoleon, 2010) – and none of the previous studies in the region do this. In a wide ranging review on the research done on the link between poverty and biodiversity, CBD, (2010); Vira and Kontoleon, (2010) also argued that if nature's resources help to temporarily smooth consumption and incomes, their impacts may be better captured through an explicit focus on this temporality as part of our poverty

measure, instead of annualized income or consumption (in which these temporary contributions do not always feature as significant).

In this research we investigated the role of forest environmental resources in food security outcomes of the households in rural Tigray and its implication for long term livelihoods. Three food security outcomes were considered in the analysis: (1) distress sale of assets for immediate consumption, (2) number of months that the household had enough food stock available during the survey year, and (3) total expenditure per adult household equivalent.

The empirical findings show that controlling for other factors, higher educational level and age of the household head, access to off farm employment, and awareness of climate change in the locality decrease the probability of participation in forest environmental resource extraction, while vulnerability to shocks and gender of the household head being male increase the probability of participation in forest environmental resources. Second, we find that participants in forest environmental resource extraction in rural Tigray have significantly lower food security outcomes. Third, we find that the poor and non-poor households that are participating in forest extraction had lower distress sale of assets for immediate consumption than non-participants in the same sample, enforcing the widely held view that forests are important as an economic buffer in hard times. Fourth, households in rural Tigray are not driven into forest extraction by risks in farm output only but also by diversification strategy, suggesting that the problem for local communities has both the characteristics of portfolio analysis and the economics of insurance.

Finally our findings support the widely held view that the poor appear to be linked with nature-based resource use, but these may serve to perpetuate poverty and food insecurity (CBD, 2010; Vira and Kontoleon, 2010).

8.1.3. Forest commercialization and Household income

In a wide ranging review, Roe et al. (2010) warned that case studies that reach conclusions about poverty-conservation mechanisms without reference to a counterfactual have to be treated cautiously because income (or any other welfare related measures) may have been affected by other confounding effects. In this section we investigate the contribution of forest environmental resource commercialization on the welfare of rural households in Tigray. We estimated a simultaneous equation model with endogenous switching to account for the heterogeneity in the decision to participate or not, and for unobservable household characteristics.

Our empirical results show that education of the household head, access to wage income and own business enterprise, and higher size of land ownership were found to be negatively correlated to forest related activities, while higher distance to market, vulnerability to shocks and household head being male were found to be positively correlated. Second, the estimated heterogeneity effect revealed that independent of participation, participant households would have less income on average than non-participants, implying the group of farm households that actually participated in forest environmental resource commercialization have systematically different characteristics than the group that did not participate. Third, the treatment effect analysis shows that participation decreased income for non–participant groups in the counterfactual case they did participate, while it improved the income of households who actually participated. This suggests that participation in forest related activities in rural Tigray seems to be particularly important for the group of farm households most vulnerable to shocks.

8.1.4. Forests income poverty and inequality

Despite a wealth of case studies on the link between biodiversity conservation and poverty reduction, the vast majority of the existing body of work does not use analytical and empirical

methods required to make reliable inferences about the actual impact of conservation initiatives on measurable poverty indicators (CBD, 2010). To appropriately answer these types of impact assessment questions, there is a need for greater use of counterfactual cases. Before and after assessments of conservation initiatives are not sufficient (Roe et al., 2010). In this section we estimated the poverty and inequality indicators using data from rural Tigray taking into account the counterfactual situation. The poverty and inequality indicators were also estimated using the traditional "conventional" approach in order to allow us a clear estimation of the extent of over-estimation and/or underestimation of the impacts of forest environmental resources on poverty and inequality in previous works.

The empirical results show that the choice of methodology can have a significant impact on the estimated contribution of forests and conclusions made about the link between forest biodiversity and poverty reduction. Second, we find that the contribution of forests to reduce the incidence of poverty is considerably weaker, and might increase the severity of poverty when the counterfactual estimation method is used.

Third, in relation to income distribution, we find that after using the counterfactual approach, the impact of forest income on distribution is negative as against a positive contribution in the conventional approach. Fourth, these apparently contradictory findings, where forest income appears to reduce substantially the poverty and inequality indicators when we use the conventional approach, but has little or negative impact on poverty and inequality indicators under the counterfactual approach, could be explained by the fact that participation in forest activities might have a disincentive effect on incomes from other activities which are not captured when forest income is treated as an exogenous addition to the existing household income.

8.1.5. PSNP and forest pressure

The findings of our previous sections revealed that forest environmental resources play an important role for households vulnerable to idiosyncratic and covariate shocks. Findings also show that it is the poor and vulnerable households in rural Tigray who are most dependent on forest environmental resources and forest environmental resources provide food security, enforcing the widely held view that forests provide a buffer during economic misfortunes for the poor. Meanwhile, our discussion in section 8.1.2 also warned that dependence of households on forest environmental resources as a" natural insurance" may serve to perpetuate poverty. This implies that forest environmental resources have both the advantage of offering the poor households an activity to survive, with the disadvantage of keeping them in poverty (Delacote, 2007). This suggests the potential existence of risk induced poverty traps, whereby those who can insure their consumption against income shocks can take advantage of the more profitable opportunities and possibly grow out of poverty, while others are stuck with low return, low risk activities, trapping them into poverty, even though their inherent risk preferences may fundamentally be the same (Dercon, 2007). Indeed common resource extraction may constitute a poverty trap as a result of a tragedy of the commons. Too many households are in need of insurance and the resource cannot provide enough to properly insure all the population. They face thus the classic poverty – environment nexus, where poor people depend too much on their environment, and over use it (Delacote 2007).

An implication of the above cases and our findings from the previous chapters is that current consumption of households in rural Tigray is maintained through actions that seriously, sometimes irreversibly, compromise future livelihoods, actions that could have been avoided if households were able to use other alternatives to anchor consumption to average income. In this paper we

investigated whether social protection programmes such as the Productive Safety Net Programme (PSNP) in Ethiopia could provide a win –win for poverty reduction and conservation of forests in rural Tigray by reducing the pressure on forests.

The empirical findings revealed that the PSNP decreases the pressure on the forest ecosystem by decreasing trips to forest environmental resource collection and forest dependency. The findings also show that those households that have a higher probability of participating in PSNP were able to reduce their dependency on forests over and above the households that have less probability of participating in PSNP. The implication of this result is thus, the gains in terms of reducing forest dependency as a result of PSNP are higher for households with higher probability of participating in PSNP than those of households with lower chances of involving in the program. These findings are generally consistent with the widely held view that programs designed to reduce economic vulnerability of low income households can improve human welfare and reduce forest pressure, .i.e. PSNP could help in promoting a win-win for poverty reduction and forest ecosystem conservation.

8.2. Policy Implications and Further Research

8.2.1. Policy Implications

The issues addressed in this thesis are interrelated and can be seen within the context of bringing overall sustainable development in Tigray**.** The very nature of sustainable development emphasises the integration of its pillars – economic, social and environmental – and this implies a need not just to focus on one of its pillars to achieve sustainable development but, for example to consider how environment – and natural resource management – can be integrated across the other pillars of economics and society which are dependent on it for health, food security, and income (and

equally to consider how progress towards the other pillars such as human health, poverty reduction and equity might impact on environmental sustainability).

One important policy implication of this study is that policy makers need to simultaneously address the issue of human and environmental health. In this regard, our specific policy proposal to safeguard the forest resource-related needs of households affected by illness in a particular setting could include those that: ensure local values for forest resources (such as medicinal plants) are protected by forest management plans (Colfer et al., 2006) ; promote agro forestry as a means to assisting rural residents to establish and manage tree crops, particularly those possessing medicinal properties (Barany et al., 2000); and examine rural health delivery to determine the environmental consequences of access, or lack of thereof, to health services. Moreover, institutional support through access to credit and creating awareness to climate change could also play a role in minimizing the pressure on forests.

Second, while it is agreed that forest resource conservation is critical, how it happens, what is conserved, and for whom, requires a complex set of trade-offs that the current conservation intervention could not achieve. Ensuring that the forest resources contribute to poverty reduction rather than exacerbating poverty implies a need to adopt different approaches to resource conservation that provide benefits for the poor people and to meet social justice objectives. The existing intervention does have the potential to contribute a win-win for conservation and poverty reduction, but provided that thorough impact assessment is undertaken with full participation of indigenous people and local communities to identify potential negative impacts, provision is made for full and fair compensation or mitigation where appropriate, mechanisms for including local values (based on utility) and global values are introduced in determining conservation priorities; and equitable sharing of rights, responsibilities, costs and benefits between all stakeholders that

requires balancing customary and formal norms of institutions, and recognizing historic tenure rights. Over all, government, policy-makers and natural resource managers need to acknowledge the livelihood safety-net role that forests play in rural livelihoods and recognize that environmental protection policies limiting or banning access and use of forest resources can deepen rural poverty, as the poor suffer more from the deprivation of these resources. Therefore, there is a need to invest in the development and promotion of sustainable use forest management practices that allow the poor to utilize forest environmental resources to enhance their economic wellbeing with minimum adverse effects on forest ecological conditions.

Finally, the policy implication that can be drawn from the study result is the importance of and the promotion of public safety nets such as the Productive Safety Net Program (PSNP) for the poor and the promotion of government programmes and policies that increase the productivity of agricultural production and support diversification into off-farm livelihood and income sources to provide positive incentives for forest conservation and sustainable use. This suggests that sustainable forest management has to be integrated with the broader framework of rural development programs aimed at reducing poverty in order to provide the necessary incentives for the poor to adapt sustainable resource management options.

8.2.2. Further Research

Consideration needs to be given to dynamic elements and nature of the issues addressed in this study. For instance, the issue of forests as safety nets or poverty traps extends beyond one year. Poverty trap is a dynamic issue that needs longitudinal data and the poverty trap implications in the cross sectional analyses used here do not necessary imply a poverty trap in the long run.

Moreover, our conclusion on the positive role of the PSNP in pursuing the twin goals of sustainable development i.e. raising human living standards and conservation of forest biodiversity, also needs

further research using longitudinal data, because households are likely to respond differently to income changes from poverty reduction programs that are perceived to be substantial and permanent versus small and temporary (Alix- Garcia et al, 2010).

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ANNEX A. HOUSEHOLD QUESTIONNAIRE

Name of Enumerator

Household Questionnaire

HOUSEHOLD IDENTIFICATION	**NAME**		**CODE**
Household head			
Name of village			
Tabia Name			
Woreda			
Region			
Name of interviewee			**Sex** 1= Male 2=Female
Distance to DA office from home	Distance to Nursery	Distance to Health post	Distance to Veterinary

	Distance to seasonal road Distance to all weather road	Distance to School Distance to Forest	Distance to input distribution
Distance to local market			
Distance to Woreda Market			
Date of interview	**Date:……./……/2010/11** **Start time:……..:……..** **Finish time:……:……..**		**Checked by:** **……..** **Approved:** **…….....**
Reasons for not conducting interview:			**Household location GPS Coordinates:** **N……** **E……**

A. Provide the details of each household member

Member ID	Name of household member	Sex	Relationship with HH head	Marital status	Age	Education			Main occupation	How many months did the name live here in the last 12 months	If they left the home when did they live?	How many times did the name face serious illness in the past season for more than 3 weeks.
A1		A2	A3	A4	A5	A6			A7	A8	A9	A10
						Number of years of schooling (a6.1)	*Highest class attended (a6.2)*	*Highest level of education completed (a6.3)*	*What is the name of proffesion or activity*			
01												
02												
03												
04												
05												
06												
07												
08												
09												
10												
11												
12												
13												
14												

Code

A2 1=female 2=male

A3 1= husband 2= wife 3= son 4= daughter 5= Grandchild 6=Brothet 7=sister 8=neice 9= nephew 10=other relatives (specify)

A4 1=Married 2=Widowed 3=Divorced 4= separated 5=Never married
A6.3 0=none 1=std 1-4 2= std 5-8 3= Attend sec 4=MSCE 5=Techn. Colle 7=University
A7 0=none 1= Farming 2=bussiness 3=ganyu (labour) 4=Salaried work 5=schooling 6=Unemployed 7=other (specify)
A10 0=none 1=once 2=twice 3=three times 4=whole season

B: Assets ownership

Items	**Does your household own the following items** **B1** 1=yes 0=no (go to D6)	**How many items do you have?** **B2**	**How much did you pay for it? (Birr)** **B2.1**			**When did you acquire them?** **(year)** **B3**			**When acquired, was the item new?** **B3.1** 1=yes 0=no			**If you were to sell them today what will be the price?** **(Birr)** **B4**		
Metal or Wooden Bed														
Metal or Wooden Table														
Metal washing Pot (Tisti)														
Plastic Washing Pot (lastic Tisti)														
Stone Mills (Methan)														
Saddle (Korecha)														
Fanus (Betromakis)														
Gas Midija														
Blanket (Koberta)														
Wooden Box (satsun)														
Metal box (satsun)														
Bermel														
Jerikan														
Plowing Set (Mesarei)														
Mahresha														
Hoe + Af kutu (Mekuati)														
Spade (badela)														
Sickle (Meatsid)														
Hammer (Martello + Medosha)														
Axe + Fas (misar)														
Saw (megaz)														
Bunta														
Miran + Gemed														

Arebia														
Cart (Gari)														
Radio														
Tape														
Wrist Watch														
Silver (grms)														
Gold (grms)														
Beehive (Kefo)														

C: NON-FARM ACTIVITIES AND INCOME

C.1 EMPLOYMENT FOR WAGE

1. In the last twelve months, did any of the household members work off the household's land either on someone else's land or in some other employment or against payment in cash/kind? If yes give the following details. Yes ---- 1 No ----- 2

ID code of H.H Member	C2. Kind of work *[code a]*	C3. Location of employment *[code b]*	C4. Did s/he need Qualification/ Experience/ educational training *[code i]*	C5. Is it permanent (=1) or temporary (=2) work?	C6. Total days worked in each season			C7. Total amount earned in Birr			C8. What is the income from this activity used for? *[code* c] Multiple codes are possible
--------	--------	--------	--------	--------	1st season (Jan-April)	2nd season May- August	3rd season Sept-December	1st season	2nd season	3rd season	----------

Code (a) Type of employment
Farm Worker (for pay) = 1; Traditional labor sharing = 2
Professional (teacher, government worker, administration, health worker, clerical) = 3
This kushet = 1; Other kushet in the same Tabia = 2;
This Woreda = 3; This neighbouring Woreda = 4; Mekelle = 5;
Migration to another zone = 6; Migration to another state = 7;
Migration to foreign country = 8;

Other = 9, specify

Code (b) Location of employment
This kushet = 1; Other kushet in the same Tabia = 2;
This Woreda = 3; This neighbouring Woreda = 4; Mekelle = 5;
Migration to another zone = 6; Migration to another state = 7;
Migration to foreign country = 8;
Other = 9, specify

Code (c) Use of income
General purchase for the household =1;
Personal purchases from the person who runs the business = 3;
Saved = 5;
For payment of taxes and contribution = 7;
For debt settlement = 9
Other = 11, specify

Invested into the business = 2;
Expenditure for the children = 4;
Purchase livestock/other asset = 6;
Payment for school = 8;
purchase of fertilizer = 10

C9. If any member of your household gets additional daily work would s/he work?_____ (YES…..1 NO…..2)

C10. If your answer to Q.9 is no, why did no member(s) seek other/more employment? Put according to their importance *[code d]*.

Reason 1: _____; Reason 2: _____; Reason 3: _____

C11. Would any of the household members like to work more for wages during planting time _____; weeding time ____ harvesting season ___;

Threshing season _____ (yes…..l; no…..2)

C12, **HOUSEHOLD MOTIVATION TO WORK ON FARM AND OFF FARM** (Multiple codes are possible)

1. Why did you choose to work only on the farm?_____ *[codes for the reason to work only on the farm code k]*
2. Why did you choose to work also on the farm and/or only off the farm? _____*[codes for the reason to work off the farm code L]*

Code (d) Reasons for not seeking other work
No employment opportunities = 1
Needed on farm = 2
Jobs too far away = 3
Wages too low for the kind of work = 4
Just do not want to work off farm = 5
Respect holidays = 6
Others = 7, specify

Code (k) codes for the reason to work only on the farm
Because I don't like and I am not interested working off the farm =1;
Because off-farm work is less profitable than farm work = 3;
Because I am retired = 5;
Because I can not sell or rent my land = 7;

Because I can not find any job off the farm = 2;
Because working on the farm allows caring for my family = 4
Because I need more labour for on farm work = 6;
other = 8

Code (L)codes for the reason to work off the farm

Because no more labor is needed on farm =1;
Because I do not have enough land to support family = 3;
Because of farm work is more profitable = 5;
Because I can not buy additional land = 7;
Because my education is outside agriculture = 2;
Because I do not like/I am not interested to work on farm = 4
Because farm work would be in sufficient for living = 6;
other = 8

C13. Are you a beneficiary of Productive Safety Net Program? (PSNP) 1. Yes 2. No

C14. If yes, in which component of PSNP are you involved? 1. Public works 2. Direct Support

C15. If you are involved in public works program, how many of the household members are involved? ----------

C16. Are you a beneficiary of household extension packages? 1. Yes 2. No

C17. If yes what agricultural production development input supplies and technologies were you getting? 1. Fertilizer 2. Improved Seed 3. Improved livestock 4. Modern Beehive 5. Irrigation technology 6. Credit services 7 Others, Please specify ----------

C18.Did you use those inputs and technologies prior to the Household extension package program? 1. Yes 2. No

C19. What is the amount of Credit you get from the household extension package? ----------

C21. OWN BUSINESS ACTIVITIES

1. Would like to ask you about your income earning activities such as craft, trades, or other business, carried out by any of the household members this year. If any of the household members are involved in such activities fill the following.

Activities	HH member responsible [ID code]	C22 How much has the household earned net? If given in kind, change to cash and include it as payment *[tirfi Tirah] and put it in Birr earned in each season*			C23 Total days worked by the HH			C24 Total hired labour used		C25 what is the income usually used for General purchase for the household =1; Invested into the business = 2; Personal purchases from the person who runs the business =3; Expenditure for the children = 4; Saved = 5; Purchase livestock/other asset = 6; For payment of taxes and contribution = 7; Payment for school = 8; For debt settlement = 9purchase of fertilizer = 10 Other = 11, specify _____
		1st season (Jan-April)	2nd season March-.Augu	3rd season Sept-Decembe	1st season (Jan-April)	2nd season March-Aug	3rd season Sept-decemb	Total hours worked	Paid wage in Birr	
Weaving (shimena)										
Milling (metehan)										

Handicraft, including pottery										
Trade in grain/general										
Trade in livestock										
Traditional healer/ Religious teacher										
Transport (by pack animal)										
Selling Tela, Arequi,										
Teii, Kolo, and iniera										
Other, specify										

C26. OWN BUSINESS ACTIVITIES

1. Would like to ask you about your income earning activities such as selling fuel wood and charcoal, carried out by any of the household members this year. If any of the household members are involved in such activities fill the following.

Activities	HH member responsible [ID code]	**C27** How much has the household earned net? If given in kind, change to cash and include it as payment *[tirfi Tirah] and put it in Birr earned in each season*			**C28** Total days worked by the HH			**C29** Total hired labour used		**C30** what is the income usually used for General purchase for the household =1; Invested into the business = 2; Personal purchases from the person who runs the business =3; Expenditure for the children = 4; Saved = 5; Purchase livestock/other asset = 6; For payment of taxes and contribution = 7; Payment for school = 8; For debt settlement = 9purchase of fertilizer = 10 Other = 11, specify _____
		1st season (Jan-April)	2nd season March-.Augu	3rd season Sept-December	1st season (Jan-April)	2nd season March-Aug	3rd season Sept-decemb	Total hours worked	Paid wage in Birr	
Selling Honey										
Selling Cactus										
Thatching grass										

Fuel Wood										
Charcoal										
Leaves Crop Residue										
Selling Wood animal)										
Other, specify										

C31. TRANSFERS (REMITTANCE AND AID)

C31.1. Has the household received any other income (such as remittance, gifts or other transfers) this year? ☐ es ---- 1 (Give details) No -- 2

C31.1 Type of receipt Remittance.. 1; Food Aid … 2; Gift …… 3; Inheritance.. 4; Dowry …… 5; Other …….. 6 Specify _____	**C32.** Person who receive it (ID code)	**C33** The person who send the transfer Non residence household member .. 1; Relatives of household member .. 2; Friends …… 3; Gov't/organization.. 4; NGO …. 5; Other …. 6 Specify _____	**C34** Amount received. If it is given in kind change it to cash Amount in Birr	**C35** What was this income mainly used for General purchase for the household =1; Invested into the business = 2; Personal purchases from the person who runs the business =3; Expenditure for the children = 4; Saved = 5; Purchase livestock/other asset = 6; For payment of taxes and contribution = 7; Payment for school = 8; For debt settlement = 9purchase of fertilizer = 10 Other = 11, specify _____

C36: MIGRATION AND INCOME

1. Has any member left the household to seek work this year? Yes ….. 1 (Give Details) 2. No

ID code Of HH member	C37 where did s/he go [code b]	C38 date of departure Day/month/ year	C39 Date of return (if s/he has returned)	C40 did s/he get work? Yes… 1; No…..2	C41 Type of work [code a]	C42 How much s/he earn? (in Birr)	C43 How much s/he send back? (in Birr)	C44 How much did you bring back when you returned (if s/he is returned) (in Birr)	C45 Did the HH have land allocated away while this person is away? if so how many tsemdies? *[yes=l, no=2]*	C46 did you come back to avoid losing land *[yes=l, no=2]*

a) Type of employment

Farm Worker (for pay) = 1; Traditional labour sharing = 2
Professional (teacher, government worker, administration, health worker, clerical) = 3
Labourer (skilled i.e. builder, thatcher, hair cutting or dressing) = 4
Trader =5 ; soldier = 6 ; driver/Mechanic= 7 ; unskilled worker = 8
Domestic servant = (yebet agelgay) = 9; Food for work = 10; Others = 11 Specify

b) Where did she/he go or migrate
Regional City (Mekelle= 1; Humera/shire =2
Addis Abeba = 3; other region in Ethiopia = 4;
Foregib country = 5; Other = 6 specify

C47. Availability of Food During each month last year (2009/10)

C47.1. During which month of the last year ,did your household had enough or shortage of food

No	Month	Jan	Feb	March	April	May	June	July	August	Sep.	Oct.	Nov.	Dec.
1	enough												
2	Not -enough												

C47.2. Did you sell assets for immediate consumption during 2009/10 ? 1. Yes 2. No if yes Please specify ? ----------

L. FOOD CONSUMPTION AND EXPENDITURE

L.1. How many meals per day did your household eat in the last four weeks? _____

L.2.We would like to ask you about all the food that was bought for consumption and/or was consumed from your own stock, in this year. Please do not include food bought for resale, even after processing (the sum from the different sources should be equal to the total amount consumed).

	Food type consumed	Code	L3 Total food consumed [KG, Birr]		L4 Consumed from purchased		L5 Consumed from own harvest		L6 Consumed from gift or food aid		L7 Consumed from other sources	
			Amount *{KG!*	Value *{Birr!*	Amount *[KG!*	Value *{Birr]*	Amount *{KG!*	Value *{Birr!*	Amount *{KG]*	value *[Birr!*	Amount *{KG!*	Value *[Birr]*

Cereals	Teff											
	Barley											
	Wheat											
	Maize											
	Sorghum											
	Finger millet											
	Karka'eta											
Pulses	Lentils											
	Faba Bean											
	Field peas											
	Chick peas											
	Guaya											
Oil crops	Linseed											
	rape seed											
	sesame											
	sun/sufI flower											
	Nug											

	Food type consumed	Code	L3 Total food consumed [KG, Birr]		L4 Consumed from purchased		L5 Consumed from own harvest		L6 Consumed from gift or food aid		L7 Consumed from other source	
			Amount [KGl	value [Birr]	Amount *[KG]*	value [Birr]	Amount *[KG]*	value *[Birr]*	Amount *[KG]*	value *[Birr]*	Amount *(KG)*	Value *(KG)*
Milk and animal products	milk/yogurt, cheese											
	beef meat											
	mutton/goat											

	meet											
	Chicken											
	eggs											
Beverage (liters)	Tella											
	Arequi											
	Teji											
	Birra											
	Soft drink											
	Coffee											
	Honey											
	Sugar											
	Tea											
	Salt											
	Cooking oil											
	karialberbere											
	Onion											
	garlic											
	Other spices											

	Food type consumed	Code	L3 Total food consumed [KG, Birr]		L4 Consumed from purchased		L5 Consumed from own harvest		L6 Consumed from gift or food aid		L7 Consumed from other source	
			Amount *[KG]*	Value *[Birr]*	Amount *[KG]*	Value *[Birr]*	Amount *[KG]*	Value [Birr]	Amount *[KG]*	Value *[Birr]*	Amount *[KG]*	Value *[Birr]*
	Bread											
	Macaroni											
	Potato											

	Sweet potato											
Vegetables	Green leaf											

L8. Has the household purchased any prepared foods, or eaten elsewhere against payment in the year?

[Yes…. 1; no….2]_____ If yes, total expenditure in this year [in Birr]_____

L. Non – Food Expenditure

Which of the following items did you buy or pay for in the last 7 days? **L1a**	***Yes=1 No=0*** **L1a**	**How much did you pay for it? L1b**	**Which of the following items did you buy or pay for in the last month?** **L2a**	***Yes=1 No=0*** **L2a**	**How much did you pay for it? L2b**
shoes, fabric for ADULTS (MEN AND WOMEN)			Soap, Omo		
Clothes/ shoes, fabric for CHILDREN (BOTH BOYS AND GIRLS)			Linens (sheets, towel, blankets)		
Cosmetic (butter) for MEN, WOMEN, BOYS AND GIRLS			Furniture and Lamp/torch		
Entertainment by MEN			Transport materials		
Entertainment by WOMEN			Building material for house		
Entertainment by BOYS and GIRLS			Ceremonial expense		
Kitchen equipment (cooking pots, Medija)			Contribution to *EDIR*		
Energy consumption (Kerosene, Fuel wood, charcoal, match)			Contribution to Associations (women, youth, farmers association)		
Modern medical treatment and medicine			Donation to organization (TDA, TPLF etc)		
Traditional medical treatment and medicine			Donation to Community church/Mosque		
School fees			Taxes and contributions to Tabia		

Characteristics of Plots owned by the household in 2009/2010 (2001)

Plot ID	**Name of plot**	**Distance from**	**What is the size of your**	Is it Irrigated type? (1=	**What is the general texture of the soil?**	**What is the slope**	**What is the general**	**How did you acquire this plot?**	***Is the plot titled? (1= yes, 2= No)***	***What was the primary use of the plot during***

	F1	**home to the plot** *F2*	**plot in tsimdi ? F3**	yes ,2= No) **F4**	**F5**	**of the plot? F6**	**fertility of the plot? F7**	**F8**	*F9*	***Belg2001 and Meher 2002 F10***
1										
2										
3										
4										
5										
6										
7										
8										
					1=sandy 2=loam 3=clay	1-flat 2-slight 3-steep	1-very fertilie 2-average 3-not fertile			1= annual crops 2= permanent crops 3= grazing land 4=left fallow 5= other

Codes F8= 1=granted by local leaders, 2=Inherited from mothers side (wife) , 3=Inherited from fathers side(wife), 4=Inherited from mothers side (husband) , 5=Inherited from fathers side(hasband) ,6=Rented, 7=purchased , 8=farming as

G. List crops and inputs on each plot in the last cropping season (2009/10)

Plot ID	**Crop Code**	**SEEDS**				**PESTICIDES**				**FERTILISER**				
		Source	**Type / Variety**	**Amount** *G4*	**Cost**	**Source**	**Type / Variety**	**Amount** *G4*	**Cost**	**Source**	**Type / Variety**	**Amount** *G4*	**Cost**	**Did you use subsidized fertilizer on this plot?** ***1-yes 0-no G14***
1														
2														

G2, G6 G10; 1=own 2=bought(own money) 3 bought (credit) 4= bought(coupon) 5 =gift 6=others

G9;1=CAN 2= Urea, 3=23:21:0, 4=20:20:0, 5=D compound, 6= super D, 7= SA, 8= others (specify

Input use cont --------

Plot ID	*Plot name*	**Did you apply any manure on this plot?** *1-yes 0-no* ***G15***	**What was the type of manure?** ***G16***	**Manure** **Amount of manure** ***G17***		**Source of manure** ***G18***	**If bought how much did it cost (MK)** ***G19***	**How many days did it take you to apply the manure?** ***G20***
				Quantity	**Unit**			
1								
2								
3								
4								
5								
6								
7								
8			1=Compost 2=wastes 3=livestock 4=green manure 5= tobacco stems 6=others		1= basket 2= oxcart 3=pail 4=wheeelbarrow 5=bags (50kg) 6=bags (90kg) 7= bales 8=Nkhokwe 9= lichelo (basin) 9=others	1 self made (compost) 2 own animal manure 3 given by friend relative 4 bought 5 other		
9								
10								
11								

Plot ID	What crops were grown on this plot last season (2009/10)?				Identify type of Cropping System	What factors are taken into account in making decision on what crops to grow on each plot or leaving the plot fallow? (in order of priority starting with the most important)				What major reasons did the household have for monocropping or mixed cropping? (in order of priority starting with the most important)			
	1st *Fc1*	2nd *Fc2*	3rd *Fc3*	4th *Fc4*	*Fc5*	*Fc7*				*Fc8*			
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
	Crop codes **0 fallow** 1 Maize Hybrid 2 Compost Maize (OPV) 3 Maize Local 4 Beans Dry 5 Beans Green (Zitheba) 6 Peas 7 Ground nuts 8 Tobacco 9 Cassava 10 Pigeon peas 11 Irish potato 12 Sweet Potato 13 Cabbage		14 Tomatoes 15 Onions 16 Lettuce 17 Rape 18 Mpiru 19 Pumpkins 20 Garlic 21 Cucumber 22 rice 23 Millet 24 sorgum 25 sugarcane **26 soyabeans** **27 other (specify)**		**1= Mixed cropping** 2= Monocropping 3= Intercropping	1= Land availability 2= Labour availability 3= Prevailing market prices 4= Seeds, fertiliser, availability 5= Meeting household basic consumption needs Credit 6= Past crop performance (in previous seasons 7= Expected rainfall patterns. 8= Crop rotation 9= Other (specify)				1= Maximise revenue from land 2= Allow positive complementarity efects among crops (e.g. N-fixing,) 3= Save time and labour in crop management 4= To produce quality standards for exclusive for marketing 5= other			

Fc: Crops grown on each plot

Labor use on plots

For each of the plots and crops cultivated by the household indicate how many man-days did household member work in the following activities within the last season (2009/10)

Plot ID	Land preparation G21		Planting G23		Fertilizer application G25		Weeding G26		Harvesting G27	
	No of members	No of days	No of members	No of days	No of members	No of days	No of members	No of days	No of members	No of days
1										
2										
3										
4										
5										
6										
7										
8										

Hired Labor

Plot ID	Plot Name	Did you hire any labor to work on this plot?(1=Yes, 2=No) G28	Why did you hire in labor on this plot? G29	For how many man days did you hire the labor G30		How much did you pay for the labor? G31	
1				No of workers	No of days	Cash	In kind
2							

3							
4							
5							
6							
7							
8							

H. Harvest

How much did you harvest last season (2009/10)

	Crop code				**Harvest 2009/2010**							Indicate the major reasons for the change
					1st		2nd		3rd		4th Others	
	H1				***Quantity*** ***H2***	***Unit Code*** ***H3***	***Qunatity*** ***H4***	***Unit code*** ***H5***	***Quantity*** ***H6***	***Unit code*** ***H7***	***Estimated value*** ***H8***	***H11***
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

	Use Crop codes		

Code H3, H5, H7: 1= basket 2=oxcart 3=pail 4=wheelbarrow 5=bags (50kg) 6=bags (90kg) 7= bales 8=Nkhokwe 9= lichelo (basin) 10=others

Ys:Forest Products, Sales and markets

			If answer to Ys2 is YES							If Ys2 is NO		Transport costs		State of yield in 5 years	Reasons for the change
Product code	**Estimate the amount of forest products**	**Did you sell your forest products last year (2008/2009)?** *1-yes 0-no*	**Harvest was sold?**		**Average price of the product**	**Distance to market**	**Type of market**	**Total value sales**		**Why wasn't some products sold?**	**Estimate the value not sold**	**Means of transport to the market**	**Average total cost of transport**		
			Qty	***Units***											
Ys1	***Ys1.1***	***Ys2***	***Ys3***	***Ys4***	***Y5***	***Ys6***	***Ys7***	***Ys8***		***Ys9***	***Ys11***	***Ys12***	***Ys13***	***Ys 14***	***Ys 15***

Ys1 *1= firewood, 2= charcoal,3. honey , 4=food from the forest, 5= medicine, 6= forage 7. Cactus 8. Gums and resins 7= other specify*

Ys4 *1= basket, 2= oxcart 3=pail 4=wheeelbarrow 5=bags (50kg) 6=bags (90kg) 7=headload 8=others*
Ys6 *Walking 5 Km/hrs Oxcart 4km/hr Bicycle 15km/hr*
Ys7*1= Forest-gate, 2= Local (primary) markets, 3= District Assembly markets, 4= Urban markets, 5 = Other (specify)*
Ys9*1=home consumption 2=lack of market 3=other (specify)*
Ys12 *1=Head load, 2 Ox cart, 3 Bicycle, 4 Vehicle, 5 Wheel barrow, 6 others*
Ys14 *1=increasing 2=decreasing 3=constant*

H. Marketing. (For each crop that was sold, please ask)

	What was the means of transport to the market? ***Hs12***	**What was the cost of transport to the market?** ***Hs13***	**When did the household sell the crop?** ***Hs14***	**Why did the household opt to sell/store at that period?** ***Hs15***		**If they stored, what kind of storage mechanisms did the household use?** ***Hs16***		**How long was the produce stored in months?** ***Hs17***	**Did you incur any problems when you stored your crops for sale?** ***Hs18***		**Did you grade your produce before selling?** ***Hs19***
				Sell Hs15a	Store Hs15b						
Use crop code	1 Head load 2 Ox cart 3 Bicycle 4 Vehicle 5 Wheel barrow 6 others		1= Immediately after harvest 2= They stored and sold at later date 3=Sold some after harvest but stocked some for sale at later period 4= Other	1=Household needed an immediate source of income 2=To take advantage of prevailing high prices at the time 3=Lacked storage place/ mechanism 4= Wanted to wait for better prices after harvest season 5=Others (specify)		1=Granary (Nkhokwe) 2=In the home kept in Bags, sacks, baskets 3=Late harvest 4=pit storage 5=Others (specify)			0=No 1=Theft 2= Loss of quality 3=Destruction by pests 4= Prices never went up 5= Other (specify)		0= No 1= Yes

FO: Farmer Organizations

Fo1: Do you belong to a farmer farming organisation? 1=Yes 0=No

If yes to Fo1

What kind of organisation is it? ***Fo2***	**How long have you been a member?** ***Fo3***		**Why did you join the organisation?** ***Fo4***	**What 3 important functions does the FO carry out?** ***Fo5***		
	Years	Months				
1= Farmer cooperative 2=Farmer club 3=Association 4= Others (specify)				0= Nothing 1=Helps farmers access inputs on loan 2=Markets produce for farmers 3=Provides extension advice 4=Others (specify)		

Fo4: 1 = reqired to join 2 = Everybody belongs 3 = invited to join 4 = volunteered 5 = family/friends helped me to join.

I. Animal Husbandry

Livestock code I1	How many do you have now? I2	What is the estimated price if you were to sell today? I2.1	Did you buy any during the last four Months?			Did you sell any during the last four Months?			How many slaughtered in the last four months I3.7	How many have died I3.8	How many were stolen I3.9
			Number bought (if none, 0) I3.1	Total purchase value I3.2	Source of finance I3.3	Number sold (if none, 0) I3.4	Total sales value I3.5	Reason for Sale I3.6			
bulls/oxen											
Cows											
Sheep											
Goats											
Camels											
Donkey/mules/horse											
Chicken											
Bees											
Others											

Livestock Expenditure and Income

During the last four months , have you had expenditure related to livestock during the last four months L1a	Cash value (if in kind estimate cash value L1b	Gross income from the sale of household's animal product during the last four months? L2a	*Did you sale any* *Yes=1* *No=0* L2a	Amount sold L2b	Unit L2c	Total revenue obtained L2d
Type of Expenditure		**Type**				
Labor for herding		Meat				
Feed, including salt		Hides and skins				
Veterinary services/Medicine		Butter /cheese				
Transport of animal feed		Milk /Cream				
Commission on the sale of animals		Dung cakes				

Other expenses(specify)		Chicken				
		eggs				

E2. Proportion of Labor allocated to the different activities in a Year (Out of 20 matchsticks, how many would you give in terms of labor allocated to the following Activities)

Member ID	Household Activities E21	Collecting Firewood E22	Other Forest Activities E23	Main Agricultural fields E24	PSNP E25	Other Agricultural Activities E26	Non Agricultural activities E27

E.28. Indicate distance (in km) from home to forest thinning or forest clearing area:_____
E.29. Indicate distance (in km) from home to firewood collection area:_____
E.30. Indicate distance (in km) from home to forest based area of wage……
E.31. Wage per hour of forest based wage work……

M. Forest Resources and Tenure

M.1. Do you have private woodland or grass land ? 1. Yes 2. No

If yes , Please state your total collection of non – timber forest products from natural forest (Private forest)

Forest product	Qt collected per trip	Number of trips a month	Most frequent used quarter	Total time spent per trip					Average time to go to Natural Forest	
				AM	AF	YM	YF		Adults	Young
Resins and gums										
Honey										
Cactus										
Fuel wood										
leaves										
Crop residues										
Medicinal herbs										
Thatching grass										
Fruit /nuts										
Bee wax										

Other, specify										

Am= Adult male, AF = Adult Female, YM = Young male, YF = Young Female

M.1. How much income did you generate from sale of the non- timber forest products obtained from your private woodlot ? ----------
M.2. Assuming that all the benefits you obtain and use it from your private woodland/grass were obtained through purchase, how much would you incur /pay month ? -------

Please state your total collection of non – timber forest products from natural forest other than private forest

Forest product	Qt collected per trip	Number of trips a month	Most frequent used quarter	Total time spent per trip					Average time to go to Natural Forest	
				AM	AF	YM	YF		Adults	Young
Resins and gums										
Honey										
Cactus										
Fuel wood										
leaves										
Crop residues										
Medicinal herbs										
Thatching grass										
Fruit /nuts										
Timber										
Other, specify										

Am= Adult male, AF = Adult Female, YM = Young male, YF = Young Female

M.3. How much income did you generate from sale of the non- timber forest products obtained from other forests? ----------
M.4. Assuming that all the benefits you obtain and use it from other forests obtained through purchase, how much would you incur /pay month? -------

N. Climate change Related Issues

N.1. Have you noticed any long –term changes in climate over the last 20 years? 1. Yes 2. No

N.2. If yes what are the manifestations of change in climate change (multiple answers possible) 1. Increase in temperature 2. Decrease in Temperature 3. Increase in Rainfall 4. Decrease in Rainfall 5= other , specify

N.3. Do you have access to information related to climate change 1. Yes 2. No

N.4. How many times did you encounter complete crop failure due to climate change? ----------
N.5. Have you made any adjustments in your farming practice due to climate change? 1. Yes 2. No

N.6. If yes , what adjustments related to farming, livestock and forests have you made to the change in climate

No	Farming Practice	Livestock	Forests

RS.Recent shocks to household welfare

Has this household experienced ANY major shock since 2006?

GO THROUGH THE ENTIRE LIST	**Did you experience a shock this year?** 1-yes 0-no **R1.1**	**The year shock occurred** **R1.2**	**Note down the three most significant shocks you experienced for each year R2**		**Degree of coverage R3**	**Duration of shocks in weeks R4**	**Effect of the shock R5**	**Estimated total value of loss** (not for 11-14) **R6**	**What did you do in response to this shock to try to regain your former welfare level? R7**		
1- Lower yields due to drought or flood		**2006/7**	1								
2-Crop disease or crop pests			2								
3-Livestock dies or were stolen			3								
4-Large fall in sale prices for crops											
5-Household buisness failure		**2007/8**	1								
6-Loss of salaried employment			2								
7-Non-payment of salary			3								
8-End of regular assistance, aid, or remittances from outside HH											
9-Large rise in price of food		**2008/9**	1								
11-Death of HH head			2								
12-Death of working members of the HH			3								
13-Illness or accident of household member		**2009/10**	1								
14-Death of other family member			2								
16-Dwelling damaged, destroyed			3								
17-Theft											
18-Other (specify)			1								

R3: 1=Own HH only 2=Some other HHs too 3=All HHs in community
R5: 1=Reduction in income 2=Reduction in assets 3=Both 4=Nothing
R7: 0=Nothing
1=Spent cash savings
2=Sold assests (tools etc)
3=Sold forest products
4=Sold animals
5=Sold more crops
6=Worked more (incl. other HH members,)
7=Started a new buisness
8=Removed children from school to work
9=Sent children to live with relatives
10=Went elsewhere to find work for more than one month
11=Borrowed money (relatives, bank, local money lender)
12=Received help (govervent, NGO, etc)
13=Reduced food consumption (smaller proportions, fewer meals per day)
14=Diversify food consumption (Wild foods, meal sharing, no meat or fish)

S. Social capital and welfare perceptions

	Questions	Answers	Codes
S1	All things considered, how satisfied are you with your life over the past 12 months?		*1=very unsatisfied; 2=unsatisfied; 3=neither unsatisfied or satisfied; 4=satisfied; 5=very satisfied*
S2	Has the household's food production and income over the past 12 months been sufficient to cover what you consider to be the needs of the household?		*0=no 1=yes 2=reasonable (just about sufficient)*
S3	Compared with other households in the village (or community), how well-off is your household?		*1=worse-off 2=about average 3=better-off*
S4	How well-off is your household today compared with the situation 5 years ago? **If 1 or 3, go to S5. If 2, go to S6.**		*1=less well-off now 2=about the same 3=better off now*
S5	If **worse- or better-off**: what is the main reason for the change? *Please rank the most important responses, max 3.*		*1=off farm employment* *2=land holding (e.g., bought/sold land)* *3=forest resources* *4=output prices (forest, agric,…)* *5=outside support (govt., NGO,..)* *6=remittances* *7=cost of living (e.g., high inflation)* *8= civil strife, unrest* *9=conflicts in village (non-violent)* *10=change in family situation (e.g. loss of family member/a major bread-winner)* *11= illness* *12=good infrustracture (access, e.g. new road…)* *13=other (specify):*
S6	Do you consider your village (community) to be a good place to live?		*0=no 1=yes 2=partly*
S7	Do you in general trust people in the village (community) whencooperating on ?		*0=no 1=yes 2=partly, trust some and not others*

S8	Can you get help from other people in the village (community) if you are in need, for example, if you need extra money because someone in your family is sick?		*1=Definitely 2=Probably 3=Probably not 4=Definitely not*
S9	About how many friends do you (HOUSEHOLD HEAD) have in your community these days? These are people you feel at ease with, can talk to about private matters or call on for help.		
S10	About how many friends do you/does your SPOUSE have in your community these days? These are people she/he feels at ease with, can talk to about private matters or call on for help.		
S11	In the past 12 months, how many people with personal problems have turned to you for any form of assistance?		

W. Credit, Saving and Extension Services

W.1. Have you taken any financial Credit in 2009/10? 1. Ye s 2. No If yes, give the following details

Outstanding Loans

	Loan source W2		**Original reason for taking out loan W3** (Multiple answers possible)		**When was the loan originally taken? W4**		**Amount borrowed W5**		**Amount need to be repaid W6**		**What was the loan money actually used for? W7** (Multiple answers possible)		**What is the amount of interest W8**	
	1. Bureau of Agriculture (HH extension package) 2. Moneylender 3. Friend/neighbor/ relatives 4. Partner (*tirf yegara*) 5. Bank 6. DECSI (DEDEBIT) 7. Cooperatives 8. Other (specify)		1. To buy livestock 2. To buy food 3. To buy/have agricultural inputs (fertilizer, seed, irrigation) 4. Health expenses 5. Educational expenses 6. Housing materials expenses 7. To pay for hired labor 8. To start new business 9. Other (specify)		(Month and year in Ethiopian calendar)		(Indicate birr or value in birr)		(Indicate birr or value in birr)		1. To buy livestock 2. To buy food 3. To buy agricultural inputs 4. Health expenses 5. Educational expenses 6. Housing materials expenses 7. To pay for hired labor 8. To start new business 9. Other (specify) 10. Has not used loan yet			
LOAN 1	30.1		31.1		32.1		33.1		34.1		35.1		36.1	
LOAN 2	30.2		31.2		32.2		33.2		34.2		35.2		36.2	
LOAN 3	30.3		31.3		32.3		33.3		34.3		35.3		36.3	

W9. Did you have any financial savings in the Bank? 1. Yes 2. No

W10. If yes how much did you save in Birr **?** ----------

W11. Did you have visits from extension staff last year? 1. Yes 2. No

W12. If yes how many times? ----------

W13. Is the extension advice you get in the last 5 years teach about climate change ? 1. Yes 2. No