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Poverty, Institutions, Peasant Behavior and Conservation Investment in Northern Ethiopia

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To the millions of Ethiopian farm households who had to live in perpetual state of abject poverty and insecurity: May the future have something on hold for these compassionate and hardworking fellow citizens.

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Errata

P.45, Table 4.1 is corrected as follows:

Table 4.1: Aggregate poverty profiles

Poverty indices	1997 (n= 397)	2000 (n= 401)	% Change in poverty measures	Significance test t-test‡
Indices based on food poverty line (extreme poverty).				
P_0	0.67	0.50	-17	-5.81 (0.002)**
P_1	0.25	0.16	-9	-7.02 (0.001)**
P_2	0.12	0.07	-5	-9.64 (0.001)**
Indices based on cost of basic needs (moderate poverty)				
P_0	0.81	0.66	-20	-6.49 (0.001)**
P_1	0.37	0.27	-10	-6.08 (0.001)**
P_2	0.21	0.14	-7	-7.45 (0.001)**

‡Significance test for the difference in poverty levels in the two periods. Standard errors are given in parenthesis.

***** and * significant at 1% and 5 % level of significance with corresponding z score values ≥ 2.58 and 1.96 respectively.***

Table 4.1 shows that there were remarkable improvements in levels of poverty, by all measures, between 1997 and 2000 in the region, although stochastic test results (see p.51) depict that the incidence of poverty remained significantly the same.

P.167, Table 2 is also corrected as follows:

Table 2: Calculated continuous time discount rates

Future value	EB 10		EB 100		EB 1000	
Time frame	Husband	Wife	Husband	Wife	Husband	Wife
Two weeks	5.369	5.378	-	-	-	-
One month	3.914	3.89	-	-	-	-
Six months	-	-	2.109	2.077	-	-
1 year	-	-	1.449	1.417	-	-
2 years	-	-	0.690	0.685	-	-
5 years	-	-	-	-	0.480	0.495
Ten years	-	-	-	-	0.188	0.198

p.144 paragraph 2, lines 3 and 4 is corrected as "the response of households vary, as either time frame or magnitude of the reward increases, pointing to the presence of time and magnitude effects.

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Fitsum Hagos
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Poverty, institutions, peasant behavior and conservation investment in northern Ethiopia

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1. Introduction

The Ethiopian highland is one of the areas on the African continent with highest agricultural potential. War, policy failures, technology stagnation, high population pressure, land degradation, and drought have contributed, however, to Ethiopia being one of the poorest countries in the world (World Bank, 2001). Continued rapid population growth has also contributed to a fall in food production per capita in the country as a whole over the last 30 years (Shiferaw and Holden, 1998).

Land degradation, taking the form of severe soil erosion and nutrient depletion, is the most serious environmental problem (Hagos and Holden) calling for combative action if sustainable agricultural development and environmental rehabilitation is to take place. The average net soil loss from cropland in the highlands has been estimated to be 100 t/ha/year but may vary from 50 to 170 t/ha/year for the various agro-ecological zones and altitude zones. The highest rates are found in the High Potential Cereal Zone in the 2000-2500 m.a.s.l altitude zone (FAO, 1986). For the entire country, on cultivated land average soil loss rates of 42 t/ha/year have been estimated, while soil loss on single fields may reach up to 300 t/ha/year (Hurni, 1993). A study of soil conditions in 38 SSA countries estimated the average net nutrient loss per hectare to be 20 kg N, 10 kg P_2O_5, and 20 kg K_2O (Stoorvogel and Smaling, 1990). The study reported considerable differences between SSA countries. Burundi, Ethiopia, Kenya, Lesotho, Malawi and Rwanda were rated among those with highest nutrient depletion rates. The largest amounts of nutrients disappear through soil loss (erosion) and yields, while removal through residues, leaching, and gaseous emissions are less important. The supply of nutrients comes from fertilizer, manure, depositions, soil formation and N-fixation. Average fertilizer (nutrient) use rates are low in SSA countries, estimated at 9 kg/ha cultivated area compared to 47 kg in Latin America, 69

kg in South Asia, 190 kg in East Asia and 142 kg in Europe in 1989/90 (World Bank, 1992). In contrast, Ethiopia's average fertilizer consumption is only about 7 kg per hectare (FAO, 1998). Thus, only a meager proportion of the plant nutrients lost are replaced in SSA since withdrawal by far exceeds the supply of nutrients by fertilization.

Ethiopia is the largest, both in terms of population and in terms of area, of the above mentioned countries of SSA with severe land degradation problems. With a per capita GDP of US$ 110, Ethiopia is also among the poorest countries in the world (World Bank, 2001). As much as 94 % of the agricultural production in the country has been estimated to take place in the peasant sector (FAO, 1986). Smallholder peasant agriculture contributes 45% of GDP, 85% of export income, and 80 % of employment in the country (World Bank, 1992). The "income" of these peasants is mainly their subsistence production as they sell only small surpluses and as they are only partially integrated into markets.

The Ethiopian highlands (more than 1500 m.a.s.l) constitute 43% of the country but supports about 88% of the population (MNRDEP, 1994), and accounts for 95% of the regularly cropped land and 70% of the livestock (FAO, 1986). The population density is close to ten times that of the lowlands. FAO (1986) estimated that 50% of the highlands were significantly eroded, 25% were seriously eroded and 4% had reached the point of no return.

In response to the massive and accelerating degradation of productive agricultural land in the country, a large scale soil conservation program was initiated following the 1973/74 famine. The extensive rehabilitation scheme was implemented via the food-for-work program (FFW) provided by the World Food Program (WFP). Although considerable areas of agricultural land were treated with conservation structures through this program, emphasis on uniform physical structures, the exclusion of the land users, and lack of sufficient scientific data[1] to design effective soil and water conservation techniques, have had severe drawbacks on the effectiveness of the FFW.

Socio-economic research in relation to land degradation and conservation has largely been missing up to 1994 although the need for such has been highly appreciated.

[1] The Soil Conservation Research Project (SCRP) was established in 1981 to provide, among other things, data on erosion processes and test new conservation techniques appropriate for different agro-ecological zones. As a result, the SCRP organized under the Ministry of Agriculture has carried out extensive research in soil and water conservation since 1981[1]. None of this research was carried out in Tigray, however.

Economic analysis on the tested conservation technologies is still at its early stage. It is now widely recognized that economic and institutional factors have a significant role to play in deterring or promoting the successful implementation of technically effective conservation technologies. Soil and water conservation programs in the past which emphasized technical solutions to the complex land degradation problem of the developing countries without due consideration to economic and institutional interventions have provided several examples of failures (e.g. see Bojö, 1991). Several recent studies on technology adoption have also demonstrated the crucial role of institutional and economic incentives for adoption of innovations intended to improve sustainability of smallholder farming (e.g. see Fujisaka, 1994; Orji, 1991; Ervin and Ervin, 1982).

Economic and institutional analysis of tested soil and water conservation technologies, as stated above, is of vital importance for creating the necessary policies and institutional structures, and thus incentives to promote sustainable land use in the highlands of Ethiopia. Past soil conservation programs were carried out based on a top-down planning approach with standardized conservation technologies that were not adapted to local conditions. These programs largely overlooked the role of the land users' perceptions, attitudes and priorities in relation to land conservation. These are frequently cited reasons, which led to the rejection of innovations, intended to promote sustainability of smallholder farming.

Lately, there are has been progress in understanding the role of various economic, institutional incentives and other factors that encourage sustainable use of land and resources by peasant households (Shiferaw, 1998), the economic benefits of conservations structures on yield and profitability and analysis of factors that influence adoption and sustained use of conservation practices (Gebremedhin, 1998). Furthermore, there was an extensive attempt to understand the impact of the various underlying causes of land degradation on livelihood strategies and land management practices and the effect of these responses on agricultural productivity, household welfare and the condition of the natural resources (Benin et al., 2002; Pender et al., 2002). The thrust of the last two papers is to add to the discourse on factors affecting farm households' investment behavior on land conservation by bringing in the role of behavioral responses of farm households facing chronic poverty and risk of livelihood collapse due to persistent exposure to external shocks. It also assesses the impact of poverty reduction policies on household welfare and, hence, on the environment.

Finally, it also picks up on the issue of the role of institutions such as tenure security, local institutions and public programs on investment behavior of households. By doing so this dissertation aims to contribute to an improved understanding of the relationship between poverty, institutions, peasant behavior and sustainability of resource use. It also provides an in-depth analysis of poverty, its distribution, dynamics and its causes. The short summary below will try to provide an overview of the motivation for the papers included in this thesis by placing the papers within the broad context of development and environment discourse.

2. Poverty, productivity and environment linkages

The nexus of poverty, agricultural production and environment poses controversial policy and research challenges (Vosti and Reardon, 1997; Scherr, 2000). Poverty is more prevalent and usually deeper in rural regions and the rural poor depend on natural resources for their subsistence, and their behavior affects a significant portion of those resources (Lopez, 1998; Malik, 1999). Continued agricultural growth is a necessity, not an option, for most developing countries, and this growth must be achieved on a sustainable basis so as not to jeopardize the underlying natural resource base or to impose costly externalities on others. It must also be equitable if it is to contribute to the alleviation of poverty and food insecurity[2]. These broad policy goals are not necessarily complementary, and their simultaneous achievement cannot be taken for granted (Hazell, 1998). But they are not mutually exclusive either. The challenge is devising appropriate government policies, investments, institutional development, and agricultural research to meet the so-called 'critical triangle' of development objectives (Vosti and Reardon, 1997; Hazell, 1998).

As poverty is the worst kind of social and material deprivation (Sen, 1999), alleviating poverty is certainly one of the primary ways of ensuring social justice. Moreover, not only economic growth contributes to poverty alleviation, but also poverty alleviation itself is an important prerequisite for economic efficiency and growth (World Bank, 2000). Poverty also carries environmental implications[3] as the very poor people may be driven to destroy their environment, and environmental

[2] Food insecurity is almost inevitably a result of (closely intertwined to) poverty (see Reardon and Vosti 1995, Maxwell and Frankenberger, 1992).

[3] On the one hand, the poor themselves are the greatest victims of land degradation problems linked to health problems and productivity effects (Serageldin and Steer, 1994).

degradation frequently affects their welfare and the welfare of others. The 'downward spiral' of rural poverty and environmental degradation constrains development options and forces unpalatable trade-offs. Poverty is recognized as a significant constraint on agricultural growth because the poor may be 'too poor to be efficient' (Holden and Biswanger, 1998). The behavioral response of the poor may perpetuate poverty and, hence, degrade the environment. First, the poor's behavior is characterized by risk aversion. If risk diffusion is not sufficient, farmers tend to overinvest in those inputs that reduce risk and underinvest in high-risk inputs, leading to a factor mix that is inefficient from the standpoint of profit maximization (Holden and Biswanger, 1998). Poverty combined with liquidity constraints also leads to high discount rates (Holden and Binswanger, 1998) leading to myopic behavior of households.

These effects may be aggravated due to market imperfections. Faced with market imperfections, households may be better-off choosing self-sufficiency in that good or factor (Sadoulet and de Janvry, 1995). With market imperfections due to high transaction cost and imperfect information, the corresponding good or factor becomes a non-tradable. When a household needs to decide what to produce and how to earn income in different activities in a situation where some markets are imperfect, then there is no longer separability between production and consumption decisions (Singh et. al., 1986; Sadoulet and de Janvry, 1995). Nonseparability implies that consumption needs and asset distribution may have significant impacts on production and investment decisions and thus on natural resource management decisions. Incomplete information and absence of markets may lead to the development of "functional but imperfect institutions", which may have adverse effects on efficiency and natural resource management.

The above arguments underline that alleviation of poverty is an imperative not only for equity (social justice) considerations but also to promote economic growth and sustainable resource use. Design of poverty reduction strategies requires, however, an understanding of poverty, identifying who the poor are, the distribution, the dynamics and the causes of poverty. Designing appropriate poverty reduction strategies are important not only from cost-effectiveness considerations but also increasing their efficacy in reducing poverty.

Conditioned by the institutional innovation of making credit provision less risky, micro-credit was considered as one of the policy tools promoted to alleviate poverty.

Micro-finance as a policy tool is interesting not only because it targets poverty but also has an important implication on household decisions related to land management. Workfare programs were also promoted not only to alleviate short-term shocks (as safety net) but also promoting investment in public goods (such as infrastructure, conservation investment, etc.) with expected long-term benefits to agricultural productivity and land management (Von Braun, 1995; Barrett et al., 2001). A critical evaluation of such poverty reduction strategies is important to ensure cost-effectiveness of public investments and also to reorient policy priorities.

While discussing the interplay of poverty and technology choice at the household level, it is also important to consider the role of institutions in that interaction. Property rights, for instance, by defining the poor's access to resources affect long-term agricultural productivity and incentives for conservation and investment in resource improvement (Scherr, 2000). Moreover, local institutions supportive of the poor play an important role in the poverty-environment interactions and outcomes in relation to agriculture through their influence on the poor's capacity to respond positively to natural resource management challenges. Finally, effective resource management, whether for private, communal or public resources, often requires collective regulation and/or collective investment (Scherr, 2000)

3. Theoretical framework

The Ethiopian case has been identified as resembling more with a neo-Malthusian than a Boserupian scenario for development (Grepperud, 1996). The instability caused by the long devastating civil war and pervasive policy failure may be an important reason for this. The question is whether rural development in Ethiopia can be put on a more sustainable path in the future to come. Careful studies of rural economies is required to investigate this, taking into consideration the strength of the various forces pulling in different directions. The main theoretical basis for this study will be in economics but it will draw on knowledge from agricultural and environmental sciences as well as behavioral sciences. Within economics, theories from development economics, agricultural economics, and environmental economics will be integrated. These include:

A. Economics of Rural Organization

Macro-meso-micro linkages are important and the main focus of the economics of rural organization. This is a new strand of institutional development economics giving emphasis to the importance of imperfect information and transactions costs for the institutional structure (including markets) and functioning of rural economies (Hoff et al. 1993). Market imperfections are widespread in rural economies of developing countries. There may be missing markets, thin markets, rationing, interlinkages of markets, and there may be other institutional arrangements replacing markets. Of particular importance are the functioning of labor markets, land markets and land tenure system, credit markets, and input and output markets. These institutional structures represent one part of the framework, which form the basis for decisions about land use by agents at micro level. They may represent the part where policy interventions may be relevant to influence the behavior of land users, e.g. to achieve more sustainable use of natural resources.

B. Theories of Farm Household Behavior

Within the economics of rural organization, agents are seen as rational, advancing their objectives given the information and opportunities they perceive to have (Stiglitz 1986; Hoff et al. 1993). In Ethiopia land use decisions are largely made by farm households (peasants) and these decisions are influenced by their policy environment (including terms of trade) the characteristics of the households (composition, dependency ratio, age, education, etc.), and their access to resources/wealth (land of varying quality, animals, tools and equipment, cash resources, etc.). In addition they have their preferences, built on their basic needs (including risk and time preferences), their goals and values (built on cultural heritage, religious beliefs, social norms, etc.). Farm household economics is a well developed field (Singh et al. 1986; de Janvry et al. 1991), particularly the work of de Janvry and Sadoulet (1992), de Janvry et al. (1991) provides a theoretical framework suitable for analysis of farm household behavior and policy response in situations with missing and imperfect markets (see also Sadoulet and de Janvry 1995).

Poverty may affect farm household behavior. It may lead to myopia of high rates of time preference in situations when capital/credit markets do not function perfectly, which is the rule rather than the exception in rural areas in developing countries (Holden et al. 1998; Hoff et al. 1993). Poverty may thus drove households towards

non-sustainable forms of land use and may result in too low investment in land conservation from society's perspective. This may be a form of market failure, which require remedial action.

Lack of clearly specified private property rights might have a similar effect and result in open access situations and depletion of land resources. This may also be an area where policy interventions are required. We are particularly interested in testing which of these possible causes of non-optimal land utilization is most important and in identifying appropriate policies to deal with them.

C. Environmental Economics

For the analysis of land degradation as the most severe environmental problem in Ethiopia and many other developing countries, an environmental economics perspective will be used. This will be used to investigate the degree to which remedial action to reduce the land degradation problem can be defended. The problems of applying this theory in a second-best world will have to be considered. Theories on market failures, externalities and policies to internalize externalities will be used as a basis for the analysis (Bator 1958; Arrow 1970; Baumol and Oates 1988; Pearce and Turner 1990; Carlson et al. 1993; Papandreou 1994).

4. Study site and sampling strategy

Tigray is the northern most region of Ethiopia. Drought and famine are more frequent in the region. Severe environmental degradation problems, mainly soil erosion and nutrient depletion constrain agricultural production in the region (Hagos et al., 1999). This is also a particularly interesting area since a lot of effort has gone into land conservation during the last few years. The mainstay of the economy is agriculture, which is mainly rain-fed, in a region where rainfall is erratic and drought is prevalent. Furthermore, after a period of relative stability, after a period of prolonged civil war, during 1991 to 1998, a war erupted between Ethiopia and Eritrea in May 1998 that ended two years later with serious consequences on household welfare.

Two rounds[4] of household surveys on 400 households were conducted during 1998 and 2001 in Tigray, Northern Ethiopia. The survey covered 16 villages in four zones –

[4] The first and second rounds of fieldwork were funded by the Norwegian Research Council (Norway) and Policies for Sustainable Land Management in the Highlands of Tigray, a collaborative research

southern, eastern, central and western – of Tigray with differences in distance to market, population density and agricultural potential conditions. Stratification and sampling was done using the following criteria:

- The lowland pastoral areas (< 1,500 m.a.s.l.) were excluded
- Geographical zone (Eastern, Southern, Central and Western). These zones reflect significant variation in rainfall, agricultural potential and development pathways.
- Distance to market: Far from market (> 10 km) vs. close to market (< 10 km)
- Population density: High population density relative to low population density
- Irrigation projects: Communities with and without irrigation projects.

Four communities were selected from each of the four zones in Tigray, as this would include a systematic variation in agro-climatic conditions, agricultural potential, population density and market access conditions. We selected three communities out of the sample with irrigation projects. Among communities far from markets, we strategically selected one with low population density and one with high population density from each zone. In the Eastern and Western zones, we also selected one with high population density and one with low population density among villages close to markets. In the Southern zone, we had only one distant from market and with irrigation project. The two other communities with irrigation projects were located in the Central zone, one with short distance to markets, the other far from markets. These communities constitute a sub-sample of of the sample of 100 communities where IFPRI, ILRI and MU did carry out a community, household and plot level surveys between 1998/99-2000/01. We selected 25 households from each community from a list of all households using a simple random sampling technique. Multi-purpose questionnaires were used to gather information on community, household and plot level variables. The data collected during these two rounds of filed survey form the basis for empirical analysis in the thesis.

5. A summary of research findings

There are five articles in this PhD dissertation. They are briefly described below. In the spirit of reducing redundancy we present an overview of the results, the reader is encouraged to see the results in context.

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project between International Food Policy Research Institute (IFPRI), International Livestock Research Institute (ILRI) and Mekelle University (MU), respectively.

Article 1

Rural household poverty dynamics in northern Ethiopia

Article 1 attempted to understand who the poor are, the distribution, dynamics and causes of poverty in northern Ethiopia. By doing so, the paper tries to lay the background to the other articles in the thesis as poverty, be it asset or consumption poverty, plays a crucial role in the subsequent discussions of measuring policy impacts in poverty reduction but also households' decisions to undertake land quality enhancing conservation investments.

The article places the discussion of poverty reduction within the framework of the role of policy reforms on poverty reduction in a remote, unstable and environmentally troubled region. The approach focusing on the cost of basic needs (CBN) approach, defines a poverty line, undertakes poverty decomposition by selected socio-economic factors, runs statistical and dominance tests to compare poverty across zones and time. It also examines the mobility of people across welfare profiles and expenditure quintiles by constructing poverty transition matrices. Finally, the article runs an econometric estimation of determinants of poverty in 1997 and 2000, and changes in poverty between the two periods, in the light of a host of household characteristics, asset holdings, access to services and village level differences to understand the main dimensions of poverty and its correlates.

The article concludes that incidence of poverty in the region has remained statistically the same in spite of a moderate but significant decrease in the depth and severity of poverty. It also shows that there were significant differences in the geographic distribution of poverty among the zones in both 1997 and 2000 where zones, which were initially poor, remained poor during the period pointing to the presence of a geographic trap to poverty. The analysis of the dynamics of poverty also underlines the chronic nature of poverty in the region.

The article underscores the significance of enhancing the poor's human and physical endowments in poverty reduction and calls for policy measures that attack poverty through increased investments for employment creation. Finally, the article also shows the importance of stability, improved market access and reducing agriculture's dependency on rainfall to reduce poverty.

Article 2

The effect of program credit on participation in off-farm employment and welfare of rural households in northern Ethiopia

Provision of micro-credit has been promoted as an important policy tool in poverty alleviation. Micro-finance is expected to improve the asset holding of the poor, either by endowing them with additional financial, fixed, human, natural, or social assets, by increasing the productivity of assets they already hold or both. Access to credit also eases consumption smoothing.

Article 2 addresses the issue of the efficacy of a micro-finance program in reaching out to the poor and measures the impact of program participation on households' participation in non-farm employment and level of income generated from non-farm employment (by distinguishing between wage and self-employment) and poverty reduction (as measured by changes in consumption expenditure). The article highlights the difficulties involved in measuring impacts of micro-finance on poverty within a cross-sectional setting. The article exploits the panel nature of the data in (1) testing recursively the factors that contributed to explain households' involvement in wage and self- employment and level of income generated, and (2) measuring the impact of micro-finance on long-term changes in consumption expenditure.

The article shows, given the program's focus on providing production credit, that the program does not target the relatively worse-off households. The article also shows that program participation has positive and statistically significant effect on the change in the level of income derived from self-employment (but insignificant effect on wage employment) underlining the importance of capital constraints to access to self-employment. The impact of participation in program credit and observed credit demand on change in per capita consumption was also positive and highly significant.

Article 3

Participation of rural households in food-for-work programs in northern Ethiopia: Application of selection models

Workfare programs (in this case taking the form of food-for-work) have been widely used for fighting poverty in areas persistently affected by chronic food deficit or in crises caused by agro-climatic shocks or civil unrest in which large numbers of poor, able-bodied people are unemployed. Workfare programs require participants to work in order to obtain benefits. Such programs have important roles in addressing

immediate food security (safety nets) concerns of the poor and long–term growth in public goods. The literature underlines the importance of targeting in such programs due to cost effectiveness considerations and avoiding unnecessary market distortion (disincentive) effects.

Article 3 examines the efficacy of workfare programs in targeting the poor. The article argues that perfect targeting of such programs may not be attainable not only due to flaws in operational and institutional designs but also due to imperfections in factor markets. In testing this, the article examines factors that explain households' decisions whether to participate or not and the degree of participation in FFW. The article utilizes econometric estimation techniques that accounts for sample selection bias.

The article shows that there are significant differences in the geographical distribution and across households in mean participation rates and level of participation. Explaining the households' decisions to participate in FFW, the article shows the importance of labor endowment of households implying that the poor, but labor rich, households are selected into the programs pointing towards efficient program targeting although, once households have decided to participate in FFW programs, the intensity of participation is not strongly determined by the labor endowment of households. Asset holding of rural households seems to have influenced the amount of labor supplied, which may involve a serious leakage in targeting. The paper argues that this problem of mistargeting could be related at least as much to structural issues as to operational failures.

Article 4

Fertilizer use decision of smallholder households in northern Ethiopia: do risk preferences matter?

In the discussion of the farm households' decision to adopt new technologies (e.g. use of purchase inputs), the interplay of households' consideration of risk and risk aversion have been given a central role in the development literature. Poor household's failures to adopt purchased technologies that are yield enhancing but highly risky have been attributed to households risk aversion. Lately, this view has been put under serious scrutiny partly because poor rural households do not appear to systematically underproduce given their productive resources and the absorptive capacity of the market for agricultural products. Besides, if people are poor and are concerned about their survival, the solution clearly is not to underproduce, and hence,

to underinvest. There have been important theoretical developments that strengthen this position in the literature. There is little empirical evidence on this, however.

Article 4 attempts to find empirical evidence on the interaction between direct measures of risk preference, households' consumption preferences and strive for food self-sufficiency and households' decision to use fertilizer. The paper, hence, examines the probability and level of fertilizer use and how these are affected by households' elicited risk preferences while controlling for tenure insecurity, plot, household and village level factors.

The article concludes that risk preferences do not seem to adversely affect households' decision to use fertilizer. On the contrary, the decision to use fertilizer increased with increasing household risk aversion. Fertilizer use intensity is not significantly affected by risk preferences, either. The article shows that poverty (including assets) and liquidity constraints (access to credit), better access to market and human capital related factors are important in the households decision to use purchased inputs. Finally, the article points to the possible complementarities between land conservation investment and fertilizer use that may also provide another entry point for policy in promoting fertilizer use through targeted public sector support for long-term conservation investment.

Article 5

Tenure security, resource poverty, risk aversion, public programs and household plot level conservation investment in the highlands of northern Ethiopia

Promotion of medium to long-term conservation investment by smallholder farmers has been one of the important policy challenges to policy makers and researcher in developing countries. The literature provides a whole set of factors such as tenure security, poverty and high discount rates, market imperfections, etc. that are said to explain the reasons why farmers undertake (or fail to undertake) conservation investments that do not offer immediate economic returns. While these results provide an important insight into the dynamics of farmer decision-making, most of the literature neglected the role of the interplay of these factors with local institutions, specifically the role collective regulation or promotion of collective investment by the public sector. The later may be especially important given imperfections in factor markets and intertemporal markets, which make an easy transfer of resources between

economic agents difficult and increase the importance of household preferences and resource endowments in the households' investment decisions.

Article 5 assesses the role of public investment in conservation on private investment in land conservation while controlling for a host household, plot and village level factors including tenure insecurity, poverty (resource poverty and high discount rates), and risk and risk preferences. The article focuses on investments which are of medium- to long-term nature to assess the effect of the degree of tenure security, risk preferences and poverty-induced myopic behavior on conservation investments whose benefits, while perhaps causing short-term costs, accrue in the medium to long-tem.

The empirical results point to the importance of collective investment organized by public led conservation programs in significantly stimulating private investment in land conservation. The article also emphasizes the importance of plot level variables and households' perceptions (including risk preferences) on returns from conservation investments, in terms of improved land quality and increased crop yield, in the decision to invest and intensify soil conservation. It also indicates the relative significance of factors such as tenure security, household resource endowments and liquidity constraints are minimized once there are mechanisms to coordinate conservation investments across farms and promote collective investment by mobilizing labor.

6. Policy implications

Poverty in the region is deep-rooted, widespread and it is mainly chronic in nature. The level and nature of poverty in the region is directly related to the poor performance of the economy (mainly agriculture). Agriculture in the region is highly dependent on weather conditions, which are unreliable. The production condition is characterized by limited use of external input partly because of the prevailing poverty. Alleviating poverty in the region should be one of the major tasks of policy makers. And policy needs to attack chronic poverty. This calls for a concerted and long-term investment on the poor. Ensuring the poor's access to physical and human assets could be a good entry point for policy. Provision of micro-finance seems to be promising in terms of improving consumption poverty, encouraging participation of households in non-farm employment and use of purchased inputs, even though there is inadequate evidence about its role in asset building. Investment in employment generation could contribute massively to poverty reduction addressing both the short-

term food insecurity problems and, perhaps, generation of public goods in the long-term. In this respect, although the impact of workfare (e.g. FFW) on the quality and sustainability of public goods is not well studied, such programs seem to work well in attracting the physically able household members.

Whether widespread and intensive use of external inputs is a sustainable livelihood strategy in a semi arid environment, like the region we are studying, is debatable, empirical evidences, however, suggest that households respond positively to polices that promote market access and ease their liquidity constraints indicating that households may undertake a widespread adoption and sustained use of such inputs. This could still be an important policy focus at least in areas where rainfall is adequate and/or where there is potential for irrigation development. The conservation programs may play a complementary role in this respect as well. The evidence suggests that households are more likely to use fertilizer on conserved lands. On the other hand, given the role of poverty and risk, there is a need for new technologies, which are risk reducing and yield immediate benefits to the poor. This is and will be a major challenge to the research and extension establishment.

Finally, in emphasizing the role of institutions and incentives for sustainable resource use, mechanisms of collective investment (through labor mobilization) and the public sector's role of coordination and provision of technical inputs could contribute to continued investment in land conservation given poverty and imperfections in factor market and perhaps tenure insecurity.

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Rural household poverty dynamics in northern Ethiopia

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Abstract

In spite of a moderate and significant decrease in the depth and severity of poverty, the incidence of poverty has significantly remained the same. Decomposition results indicate that there are significant differences in the geographic distribution of poverty and zones with initially highest level of poverty remained so during the period perhaps indicating the presence of a geographic trap to poverty. The analysis of the dynamics of poverty indicated that the proportion of the people falling into poverty was far higher than those escaping poverty, and people found initially in extreme poverty are found to have difficulty of moving out of poverty. This underlines the chronic nature of poverty in the region and the need for longer-term investments in the poor while supporting those temporarily falling into poverty.

In the analysis of the determinants of poverty, human and physical capital endowments were positively related to improved household welfare underscoring the importance of enhancing the poor's human and physical endowments in poverty reduction. On the other hand, household labor endowment seems not to have generally contributed to improvement in welfare perhaps pointing to the poor functioning of labor markets in the region. This calls for policy measures that attack poverty through increased investment for employment creation. Households' access to services was not found to have a significant effect on welfare perhaps indicating to the limited aggregate effect of these programs on poverty reduction in a remote, socially unstable and fragile environment. Finally, regression results also show the adverse effects of village level variables such as political risk (war) and weather related factors underlining the importance of peace and political stability and investments in irrigation in poverty reduction. Better access to markets, through investments in marketing infrastructure may also contribute to poverty reduction, although it may leave poor households vulnerable to external shocks until they are fully integrated into the market.

Key terms: Poverty profile, characteristics of the poor, poverty dynamics, determinants of poverty; northern Ethiopia

1. Introduction

Poverty still poses a major problem in most of the developing world, especially in sub-Saharan Africa. By many accounts, Ethiopia is one of the poorest countries in Sub-Saharan Africa[5]. Rural poverty constitutes the major form of poverty in Ethiopia (Fassil, 1993; Demery, 1999).

[5] The average per capita income is $ 599 in 1999 $ purchasing power parity terms. Life expectancy at birth is 44 years while adult literacy rate account only for 36.3 percent. Infant and under five mortality rates amount to 107/1000 and 173/1000 respectively while children under 5 who are malnourished account for 48 percent (UNDP, 2000; WDR, 2001).

After years of political instability and economic decline, economic reform programs in Ethiopia started in the late 1980's. The first phase of the reforms program focused on liberalization of food markets (Dercon, 2000; Dercon, 2002). Since 1994, Ethiopia stepped-up on a structural adjustment program sponsored by the World Bank and IMF, focusing on reforms related to exchange rate determination, investment and trade liberalization and removal of fertilizer subsidies. Ethiopia is claimed to have witnessed genuine economic recovery, as measured by increase in per capita GDP, after 1996 (Dercon, 2000; Dercon, 2001). This improved macroeconomic performance is said to have led to significant reduction in poverty (IMF, 1999; Demery, 1999; Dercon, 2000; Dercon, 2001).

Poverty reduction policies in Ethiopia have focused on strategies to enhance agricultural productivity of the smallholder sector, the main stay of the majority of the population, through access to improved extension packages, provision of input and credit supply services, building of infrastructure, mainly rural roads and water supply, and expansion of primary education and health care services (MEDaC, 1999; Dercon, 2000; FDRE 2000). This has been complemented with targeted food transfers, either in the form of direct food handouts or food/cash-for-work programs, aimed at alleviating temporary food security problems and financing investments on public works such as rural roads, irrigation facilities, schools and clinics (MEDaC, 1999; FDRE 1996).

Evaluation of the effect of these polices on poverty reduction in Ethiopia has been limited due to the lack of appropriate micro-data. Only recently, relative availability of good quality data has made analysis of this kind possible (Dercon and Krishnan, 1998 and later; Woldehanna and Alemu, 2000; Bigsten et al., 2003). The most comprehensive poverty study in Ethiopia to date is that of Woldehanna and Alemu (2002), which gives a comprehensive picture of poverty profiles of all regions of the country. A thorough and careful analysis of poverty, although based on limited sample households and communities, is that of Dercon and Krishnan (1998), Dercon (2000), Dercon and Krishnan (2000), Dercon (2001) and Bigsten et al. (2003). While Dercon's series of papers based on relatively smaller sample size from 6 communities in the country and the study by Bigsten et al. (2003) showed significant improvement

in levels poverty in the country[6], Woldehanna and Alemu (2000), using a data set of more than 16 000 households from the whole country, showed that the incidence of poverty, at best, has remained unchanged, although there was a significant reduction in the depth of and inequality in poverty. In fact, Dercon (2002) indicated that the data set is small and is not a representative sample of rural Ethiopia and the results should not be viewed as evidence of overall poverty trends. The consumption growth rates in the sample communities were found to be higher than in the national account figures. Moreover, Dercon (2001) also indicated that there are diverse experiences across households and villages in the sample underlining that policy reforms could affect households and regions differently. This paper provides an in-depth study of poverty in one of the regions of Ethiopia[7], Tigray, and by examining the possible determinants of poverty and changes in poverty.

The region is predominantly semi-arid, located far from the nationally surplus producing areas and is chronically food deficit. The region was a scene of major drought, famine and social conflict for the last two or more decades (Webb et al., 1992). The latest border conflict between Ethiopia and Eritrea (1998-2000) affected the region directly with huge budgetary consequences, dislocations of people (Dercon, 2000) and household welfare. To date there was no micro data to examine the effect of the war on household welfare. The availability of panel household level data collected in 1998 and 2001, before and after the war, made it possible to assess the overall change in levels of poverty between 1997 and 2000 in northern Ethiopia as well as to examine the differential impact of the conflict on household welfare between those villages directly affected and those further away from the conflict area. This study is, hence, important in understanding the effect of economic reform programs in remote, socially unstable and ecologically fragile environment and thereby complements earlier studies to present a complete picture of how poverty has changed over time after economic recovery programs in the country.

The main objectives of this paper are the estimation of a poverty line using the cost of basic needs (CBN) approach to construct aggregate poverty measures. We undertake poverty decomposition exercises relying on region of residence (zones and tabias), household characteristics and specific attributes of the household head, asset holding

[6] Bigsten et al. (2003) used the same data set (plus a 1997 panel) as Dercon and Krishnan (1998) to estimate rural poverty profiles and panel data sets for selected urban centers to develop urban poverty profiles.

[7] Two of the villages from Tigray were included in the study by Dercon and Krishnan (1998).

(e.g. farm size, livestock and oxen holding), and access to services such as credit, irrigation services, off-farm employment and food transfers. By decomposing across geographic locations, we want to examine if some geographical regions, due to the variations in weather conditions and agricultural potential, population density and market access are more prone to poverty than others are. Given the availability of panel data we also tried to assess the mobility of people across welfare profiles and expenditure quintiles. We also checked if the effect of the war between Ethiopia and Eritrea has differential impacts on the 16 villages close and distant to the conflict zone. We run statistical and stochastic dominance tests to compare distributions of welfare indicators and to make ordinal judgments on how poverty has changed across locations and time. Finally, we run an econometric estimation of determinants of poverty in 1997 and 2000, and changes thereof, in the light of a host of household and household head specific characteristics, asset holdings, access to services and village level differences such as agricultural potential (rainfall distribution), market access and population density and zone dummies.

The paper proceeds as follows. Part II presents the methodology used to construct poverty lines, a brief outline of the aggregate poverty measures and poverty profiles and outlines significance level tests on differences and changes in poverty. Part III presents study site, policy context and sampling techniques. Part IV outlines the results of poverty measures and poverty decomposition across locations and other socio-economic factors followed by statistical and dominance tests on differences across social groups and changes in poverty between 1997 and 2000. Part V presents changes on welfare mobility of households using transition matrices. Part VI presents the regression models used to analyse the determinants of poverty, changes in poverty and discusses regression results. Finally part VII concludes.

2. Methodology

Poverty comparisons involve the choice of a welfare measure, (a) poverty line(s) and selection of poverty indices to enable aggregation of poverty. In the poverty literature, consumption expenditure is preferred over income because the latter is volatile while households are assumed to seek stable levels of welfare over time (Ravallion, 1994; Streeten, 1998; Deaton and Grosh, 2000). We scale household consumption by adult equivalent (see Table 2A) to get consumption expenditure per adult equivalent using standards adopted from WHO (1985). We consider purchased food and the imputed

value of auto-consumption to construct the welfare indicator. We follow the Cost of Basic Needs (CBN) approach in estimating the poverty line. The advantage of CBN approach is that the poverty line guarantees that poverty comparisons are consistent in the sense that two individuals with the same level of welfare are treated the same way (Ravallion, 1994).

The CBN approach[8] stipulates consumption bundles that are deemed to be adequate in meeting basic consumption needs. Anchored to nutritional requirements for good health and composition of local food diets, CBN typically settles on a bundle of foodstuffs as the food component of a CBN poverty line. A food poverty line is defined based on the poorest 50 percent of the households deemed to be typical to the poor in the region. Once the food component of the poverty line is selected, allowance is given to the non-food component. We follow the approach of Ravallion and Bidani (1994) to derive the non-food components of the poverty line.

Of all the poverty measure indices developed (Sen 1976; Foster, 1984; Foster and Shorrocks, 1984; Foster et al., 1984), the Foster-Greer-Thorbecke (FGT) class of poverty measures is found to meet the fundamental axiomatic requirements of such poverty indexes, mainly, consistency and additive decomposability (see Foster et al., 1984). Moreover, the poverty orderings correspond precisely to the α-degree stochastic dominance of partial orderings. Interesting welfare interpretations of the poverty orderings can be given for the three members of the class P_α measures (Foster and Shorrocks, 1988).

The Foster- Greer-Thorbecke (FGT) class of poverty measures is given as:

$$P_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left(\frac{z-y_i}{z}\right)^\alpha, \qquad (4)$$

where α = Poverty aversion parameter

n = Total number of individuals in the population

q = Total number of poor individuals

Z = Poverty line

[8] Others have used the Food Energy Intake (FEI) approach that tries to anchor the poverty line to the most basic consumption need - food energy requirement – based on actual consumption data (see Anand and Harris, 1994; Greer and Thorbecke, 1986).

y_i = Expenditure of individuals below poverty line $i = 1, 2 \ldots q$.

In contrast to Sen's measure (1976) that adopts a rank-order weighting scheme, P_α takes the weights to be the shortfalls themselves. In this case, deprivation depends on the distance between a poor household's actual expenditure and the poverty line, not the number of households that lie between a given household and the poverty line. It also meets the relative deprivation – the expenditure shortfall of that household-criterion of poverty.

If $\alpha = 0 \rightarrow P_0 = \frac{q}{n}$. This index is a head count ratio index that reflects the proportion of the poor in total population measuring the incidence of poverty in the whole population. The advantage of the head count measure is that the overall progress in reducing poverty can be assessed right away. Nevertheless, it is insensitive to the depth or severity of poverty and hence, not good to assess the impact of a policy measure. The latter is captured by the poverty-gap index.

If $\alpha = 1 \rightarrow P_1 = \frac{1}{nz}\sum_{i=1}^{q}(z - y_i)$. This measure, known as poverty gap, estimates the average distance separating the poor from the poverty line. The poverty gap could be understood as the amount of income transfer needed to close up the gap. P_1 is sensitive to the depth of poverty but not to its severity.

If $\alpha = 2 \rightarrow P_2 = \frac{1}{nz^2}\sum_{i=1}^{q}(z - y_i)^2$. This is a measure of the severity of poverty. It depicts the severity of poverty by assigning each individual a weight equal to his/her distance from the poverty line. Hence, P_2 takes into account not only the distance separating the poor from the poverty line, but also the inequality among the poor.

In developing the poverty line, we identified the poorest 50% of the population as the reference group. We use the consumption behaviour of the reference group to determine the quantities of the basic food items that will make up the reference food basket. In this case, the basket is made up of the mean consumption levels (purchased and auto-consumption) of 19 food items (see Table A3) by the poorest 50 percent of the population in adult equivalent terms. This is estimated to be the regional reference food basket. With the information on the caloric content of food items of each of the 19 food items (see FAO, 1979; USDA, 2002), we estimate the total calories received by an individual who consumes this average basket. The minimum level of calorie

consumption is chosen to be 2200 calories/adult/day[9]. The reference food basket estimated is unlikely to sum to this amount, so we scale the consumption levels up or down by a constant to attain 2200 calories/person/day.

Due to lack of regional price indexes, we estimated median prices for each item in the respective zones based on internal price data. Using estimated unit median prices, we determined the cost of consuming the reference basket of 19 food items. Moreover, we expressed consumption expenditures in terms of 2000 southern zone prices (see Table 4A). Hence, we estimated a regional poverty line given 'regional' prices of individual items.

Following Ravallion and Bidani (1994), we estimated the non-food component of the poverty line by examining the consumption behaviour of those households who can just afford the reference food basket. The non-food share of total expenditure is estimated by regressing the food share (s) of each household i on a constant and the log of the ratio of consumption expenditures to the food poverty line:

$$S_i = \alpha + \beta \log\left(\frac{y_i}{Z^f}\right) + \varepsilon_i \qquad (5)$$

For those whose total expenditure is just equal to the food poverty line $\left(y_i = Z^f\right)$, the food share is α, and consequently the non-food share of expenditures is $(1-\alpha)$. Thus the poverty line is

$$Z = Z^f(2-\alpha) \qquad (6)$$

Three measures, which are part of the FGT class of poverty measures, are used for the poverty profiles.

Realizing that we have only a sample of households and not the entire population, we estimated standard errors for the poverty measures so that we could test for differences in poverty across zones, among social groups, and between the two periods. We follow Kakwani (1993) in estimation of standard errors to test differences in poverty measures given the same poverty line. However, poverty comparisons can be sensitive to the choice of the poverty line. The important issue is that the poverty line yields consistent comparisons (Ravallion, 1994). Stochastic tests to test the robustness of ordinal poverty comparisons prove to be useful in poverty analysis

[9] 2200 kcal/adult/day is adopted to be able to compare our results with results of similar studies in Ethiopia (e.g. Dercon and Krishnan, 1998; Woldehanna and Alemu, 2001).

(Atkinson, 1987). The idea of standard welfare dominance is to compare distributions of welfare indicators in order to make ordinal judgment on how poverty changes (spatially or inter-temporally) for a class of poverty measures over a range of poverty lines (Ravallion, 1994; Davidson and Duclos (1998).

3. Study site and sample data description

Tigray is the northern most region of Ethiopia. Drought and famine are more frequent in the region. Severe environmental degradation problems, mainly soil erosion and nutrient depletion constrain agricultural production in the region (Hagos et al., 1999). The mainstay of the economy is agriculture, which is mainly rain-fed, in a region where rainfall is erratic and drought is prevalent. Furthermore, after a period of relative stability during 1991 to 1998, after a period of prolonged civil war, a war erupted between Ethiopia and Eritrea in May 1998 that ended two years later with serious consequences on household welfare.

Current policies in the country put emphasis on agricultural development, particularly in the smallholder sector (MEDaC, 1999; FDRE, 2000). The development strategy of the region, named Conservation-based Agricultural Development Led Industrialization, builds upon the national strategy by taking into account the agricultural constraints and potentials of the region, and the extent of environmental degradation. It focuses on conservation of natural resources, developing and promoting use of improved agricultural technologies through improved agricultural research, extension support, input supply, credit schemes and expansion of small-scale irrigation with the aim to attain food self-sufficiency and fast economic growth (see BoPED, 1995). Besides, food transfer programs, taking the form of free food handouts (called food aid) and food-for-work (FFW), are integrated into food security and poverty alleviation strategy of the region.

Two rounds of household surveys[10] on 400 households were conducted during 1998 and 2001 in Tigray, Northern Ethiopia. The survey covered 16 villages (tabias)[11] in four zones – southern, eastern, central and western – of Tigray with differences in distance to market, population density and agricultural potential conditions.

[10] We had an attrition rate of 12 percent in the second round of the survey partly due to redefinition of boundaries of villages. We also omitted three observations due to missing values.

[11] *Tabia* is the lowest administrative unit in Tigray. Many *tabias* make up a *wereda* (district) and many of the later make up a zone. There are five zones in the region including Mekelle (the capital) that constitutes a zone.

Stratification and sampling was done based on altitude[12], market access, population density and presence of irrigation projects. List of the name of the tabias by weredas and zones, together with few key village level variables is given in Table 1A. We selected 25 households from each community from a list of all households using a simple random sampling technique. Multi-purpose questionnaires were used to gather information on household income, expenditure, access to public services and safety nets (FFW and FA), off-farm income, and household assets alongside a host of other information related to production and sale of agricultural products. Comparability of the data set is assured because the data collection process relied on similar sampling procedure and standardized questionnaire and the surveys were carried out during similar seasons, minimizing seasonal variability of income and prices. The years 1997 and 2000 were relatively comparable in terms of weather and agricultural production conditions (FAO/WFP, 1997; FAO/WFP, 2000). Moreover, the necessary statistical adjustment in prices was made to make spatial and temporary comparison of poverty possible.

4. Poverty profiles

Based on the CBN approach, the estimated regional poverty line is Birr 1033.45 compared to Birr[13] 909.44 based on the food poverty line. These estimates are not significantly different from the ones used by Dercon and Krishnan (1998) and Woldehanna and Alemu (2002), which established the food poverty line and moderate poverty line to be Birr 806.27 and 1075 respectively. To be able to compare our results with results of earlier studies (Dercon and Krishnan, 1998;Woldehanna and Alemu, 2002), we adopted throughout the paper Birrs 806.27 and 1075 to represent extreme and moderate poverty lines respectively. The poverty indexes calculated, based on these poverty lines for the region is given in Table 4.1.

Following the food poverty line, close to 50 percent of the population in the region in both periods lived below the poverty line of just meeting its food requirements. On the other hand, about 61 and 66 percent of the population in the region in 1997 and 2000 respectively lived under the poverty line of meeting basic consumption requirements. In the region as a whole, there is no evidence of a decline in the

[12] The sample villages included only those in the highland, i.e. those above 1500 m.a.s.l.

[13] 1 USD is equivalent to 8.56.

proportion of the population living under poverty. On the contrary, the proportion of the population living under poverty has increased at 1 and 5 percent in terms of meeting their basic food and other consumption requirements respectively. However, with respect to the poverty gap, we see a fall in poverty level of four and close eight percent in 1997 and 2000 respectively perhaps indicating a positive impact of policy reform on poverty. The poverty gap squared also show a moderate fall (3%) in the severity of poverty.

We compared the calculated regional poverty profiles from this study with the results of Dercon (2000) and Woldehanna and Alemu (2002). The results are reproduced in Table 5A. Our poverty estimates are comparable with these estimates. Poverty levels in Tigray are staggeringly high compared to national figures, perhaps because the initial conditions were bad or the effect of reform programs is weak in remote, politically unstable and fragile environments.

4.1 Geographical decomposition of poverty

By decomposing across geographic locations, zones and tabias, we acquire a differentiated picture of the distribution of poverty and changes in poverty during the period. As can be seen, from Tables 4.2-4.5, a high proportion of the population in all zones lived under poverty in 1997.

By 2000, we witness a modest improvement in poverty levels in the other zones compared to 1997, although still overall poverty is higher in the southern and central compared to the western and eastern zones.

The poorest villages in 1997 were all tabias in the southern zone followed by three tabias (Hagere Selam) in the eastern, (Adi Selam) central zones and (Mai Adrasha) in western with a head count ratios exceeding 87 percent. Genfel, a village in the eastern zone, showed the lowest incidence of poverty. The picture with respect to the depth of poverty and severity of poverty is not substantially different from the trends indicated by the incidence of poverty. Both the depth and severity of poverty seem to be highest in villages with highest incidence of poverty.

By 2000, there is remarkable improvement in a good deal of the villages in all zones. Nonetheless, Hadegti (in western), Hagere Selam (in eastern), May Keyahti (in central) and Hinatlo and Mai Alem (in southern) showed incidences of poverty exceeding 83 percent. Here again, the poverty gap and poverty gap squared remained highest in those villages with the highest incidence of poverty.

We also run statistical significance tests on the changes in P_α measures for the four zones between 1997 and 2000. Accordingly, there is a significant fall in the incidence of poverty in the southern zone. On the other hand, in spit of the apparently remarkable decline in the incidence of poverty in the other zones, test results show that none of the statistical test results rejected the null hypotheses of no difference between the two periods (see Table 4.6). Similarly, there was a significant increase in the severity of poverty in the eastern zone in 2000 compared to in 1997.

4.2. Who are the Poor?

We tried to gain additional insight into the question of who the poor are by decomposing poverty profiles of households by other socio-economic variables. We used variables such as sex of the household head, asset holding (mainly farm and oxen holding) and access to services like formal credit, food transfers, off-farm employment and a host of village related variables such as distance to market, population density, presence of irrigation projects and whether the particular village was affected by the recent conflict. We tested for differences in poverty across socio-economic groups in the two periods using mean separation tests.

As can be seen from Table 4.7, female-headed households have apparently lower poverty in terms of the incidence, depth and severity of poverty although not in a statistically significant manner.

Not surprisingly, poverty seems to be closely related to asset holding. Ox holding is considered an important economic asset not only because it is a major source of traction power but also a source of social prestige. Households with ox holding greater or equal to a pair of oxen displayed significantly lower poverty measures, especially in 1997. Similarly, households with farm holding greater or equal to the regional mean, depict lower poverty levels than those having farm holding less than the mean.

There is also a significant difference in incidence, depth and severity of poverty depending on whether households have access to formal credit. Access to off-farm employment has led also to significant difference in poverty levels in 2000. The incidence, depth and severity of poverty are higher in households with access to FFW and food aid, in the latter especially in 1997. This may point to food transfers, taking either form, is targeted to the poor. It may also show, even in the face of food

targeting, poverty is still higher among those targeted indicating the depth and severity of poverty underlining the huge income flow needed to fill the gap.

Households in communities with irrigation projects have lower incidence of poverty. The depth and severity of poverty, however, is not lower in households with access to irrigation projects. The very low level of irrigation development in the region allowing only few households to benefit from it could perhaps explain this. Better access to markets, as measured by distance to major (wereda) market, seems to reduce poverty. The incidence, depth and severity of poverty are significantly higher in those villages that are far from major market. Population density seem to be positively correlated to increased poverty as can be witnessed in the increased incidence, depth and severity of poverty in 1997 and 2000. Finally, the effect of the conflict on household welfare is reflected in increased incidence, depth and severity of poverty in 2000 compared to the pre-war welfare standing of the same communities and relative to those communities located far from the conflict.

4.3. Stochastic dominance tests

An implicit assumption behind estimating standard errors for various poverty measures is that our welfare indicators are the true measures, and that the standard errors around the poverty measures derive solely from the fact that we have a sample household, not from measurement errors. The serious problem of such mean separation tests is that it assumes that the poverty line is fixed and it is not a random variable and the poverty line is estimated without error. If the poverty line is random and estimated with error, the formulas developed for testing do not work (Woldehanna and Alemu, 2003). Hence, we need to undertake ordinal poverty comparisons using stochastic dominance tests to test the robustness of the poverty orderings. The idea here is to make ordinal judgments on how poverty changes for a wide class of poverty measures over a range of poverty lines. Results of these tests are given in Figures 1.1–1.3, 2.1–2.3 and 3.1-3.3.

Comparing the head count ratios in 1997 and 2000, the first order stochastic dominance tests could not establish unambiguously that poverty is significantly different in the two periods (Figure 1.1). This confirms that the incidence of poverty in the region has remained the same during the period 1997 to 2000.

In terms of the depth and severity of poverty, however, the second and third order stochastic dominance tests showed that there was a significant fall in poverty (see

Figures 1.2-1.3). The depth of poverty in 2000 was significantly lower for the majority of the population (for those having consumption expenditures less or equal to 1.5 time the poverty line) than in 1997. This may be accounted to the positive impact of policy reforms on poverty reduction.

Similarly, the severity of poverty in 2000 is significantly lower than in 1997. This may confirm presence of a moderate, but significant, fall in the depth of poverty and inequality in the region during the period although the proportion of the population living under poverty remained the same.

We also tested for the robustness of poverty orderings among zones in 1997 and 2000. The results are given in Figures 2.1-2.3 and 3.1-3.3. As can be seen from Figure 2.1, in 1997 the incidence of poverty was unambiguously highest in the southern zone and lowest in the eastern zones. We cannot unambiguously establish the difference in the incidence of poverty between the central and western zones, though they lay unambiguously between the two.

The depth of poverty was unambiguously highest in the southern followed by the central, western and eastern zones. Similarly, the severity of poverty was unambiguously highest in the southern followed by the central, western and eastern zones.

By 2000, the incidence of poverty was still highest in the southern and central zones followed by the western zone and eastern zone respectively. The depth of poverty, however, was significantly higher in the eastern zone followed by the southern, central and western zones respectively (Figure 3.2). This might point to the limited effect of poverty reduction strategies, which, in turn, might be related to the precarious weather conditions in the zone and the possible effect of the war. The severity of poverty, in 2000, was unambiguously higher in the southern, followed by central, eastern and western zones.

In a nutshell, in spite of the few exceptions, the zones, which were initially poor, remained poor during the whole period underling the presence of a geographic trap to poverty.

5. Mobility and poverty dynamics

The incidence of poverty rose from 61 to 66 percent between 1997 and 2000. Following the trajectories of the same households over a period, we could distinguish between the people falling into or moving out of poverty and those remaining in poverty revealing a more complex picture. This distinction has an important policy implication because different policy measures are needed to address the long-term poor in contrast to the temporarily poor. While the former calls for long-term investment in the poor, the latter may call for design of programs that complement the income (resource) of the poor temporarily (Grootaert et al, 1995). The figures in parenthesis (in column 1 Table 5.1) show the poverty standing in 1997 by focusing on 351 households.

As can be seen from Table 5, from the non-poor in 1997, 56 percent moved into poverty, out of which close to 18 percent moved into extreme poverty, the remaining 44 percent remained non-poor. On the other hand, from the poor in 1997, close to 30 percent fell into extreme poverty in contrast to 27 percent that escaped poverty. From the extreme poor, who accounted to 41 percent of the population in 1997, close to 17 percent remained in extreme poverty while the remaining proportion moved out of extreme poverty, although still they remained poor. Only 17 percent made it to move out of poverty, though, underlining that the extreme poor have difficulty escaping out of poverty.

A detailed mobility matrix is given in Table 5.2 that depicts the percentage of the individuals in each welfare class in 1997 that were observed in 2000 classes as defined in terms of absolute levels of well being (i.e. consumption expenditure in adult equivalent terms). The main diagonal elements of the matrix provide the percentage of individuals in each row that did not change their positions over 1997-2000. The people that remained poor throughout are the once in chronic poverty while those people that temporarily move in or out of poverty are said to be in transient poverty (Jalan and Ravallion, 1998). From the transition matrix, we could see that a considerable proportion of the population in the lower category (I and II) have remained in those categories. Of the people that had consumption expenditures lower or equal to half of the poverty line, 23 percent of them moved out of poverty into the third, fourth and fifth classes.

From those initially in category II, close to 32 percent moved out of poverty while the remaining 68 percent of the population remained in poverty. From those initially outside of poverty (categories III, IV and V), the predominant majority of them fell into poverty (in to category I and II). We defer the detailed discussion of the socio-economic characteristics of those that remained poor, moved into or out of poverty into another paper. We, however, report those factors that explained the changes in welfare standing of households in part VII.

6. Determinants of poverty: regression models

In the previous section, we presented a big picture as to what happened to poverty in Tigray region between 1997 and 2000. An analysis of poverty will not be complete without explaining why people are poor and remain poor over time. Within a microeconomic context, the simplest way to analyse the correlates of poverty consists in using a regression analysis in order to see the impact of household and demographic factors, specific individual/household head characteristics, asset holdings, village level factors, and policy related variables. Let the welfare indicator W_i be gives as:

$$W_i = Y_i / Z \qquad (7)$$

where Z is the poverty line and Y_i is the consumption expenditure per adult equivalent. Denoting by X_i the vector of independent variables, the following regression

$$LogW_i = \beta' X_i + \varepsilon_i \qquad (8)$$

could be estimated by OLS. In this regression, the logarithm of consumption expenditure (divided by the poverty line) is used as the left-hand variable. The right hand variables in the regressions include (a) household characteristics including the number of babies, children under 5, seniors (beyond 65 years) and other demographic factors; (b) characteristics of the household head, including sex and age (and its square), his/ her level of education (according to the categories: illiterate vs. literate), and any acquired skills and whether the household has a secondary occupation apart from his/her primary occupation (access to off-farm income); (c) some set of characteristics for the spouse of the household head such as education level and whether the spouse has any acquired skill; d) asset holding: oxen holding, livestock

size (in TLU)[14] and farm size all in per adult equivalent terms, adult labour (by sex) and household members with primary and secondary education; e) access to different public services: credit, extension and food transfers; and f) the geographical location of the household (in this case zones[15]), and some community characteristics such as distance to a major market, population density, presence of irrigation projects, and a war dummy. We wanted to capture the effect of the war on those villages directly affected by the conflict vs. those not directly affected because of their proximity to the conflict area. Moreover, we introduced a conscription dummy to account for those households who had to send somebody into the war. We expect the effect of a household member being conscripted on household welfare to go both ways. Due to the transfer of income in the form of remittances, the household may improve its consumption level, hence, welfare standing. On other hand, the withdrawal of labour from production may have a negative impact on household welfare, especially on those labour constrained households.

We estimated a model for changes in welfare status of households using the following regression model:

$$\nabla W_i = \gamma' X_{t-1} + v_i \qquad (9)$$

where ∇W_i is the difference in consumption expenditure in adult equivalent terms between 1997 and 2000 divided by the poverty line (Z), which may yield a positive or negative value implying an improvement or deterioration in welfare standing of the household[16]. The vector X_{t-1} includes regressors similar to equation (8) most of them taking their initial (1997) values to test for time recursive causality. We believe that initial conditions matter because households' response to a changing economic environment is very much a function of the level of endowments prior to the change, and the prevalent behavior with respect to income generation (Grootaert et al., 1995). It also includes variables such as the war related dummies and other village level fixed effects.

The β coefficients in equation (8) are the partial correlation coefficients that reflect the degree of association between the variables and levels of welfare and not

[14] Given in tropical livestock units (TLU) based on information in Jahnke (1982).

[15] *Tabia* dummies were found to be collinear with many regressors.

[16] A probit model, where ∇W_i takes values zero or one, was tried to estimate equation (9). However, the results, not surprisingly, were not as strong as the results from the survey regression model we reported here.

necessarily their causal relationship. The parameter estimates could be interpreted as returns of poverty to the characteristics (Wodon, 1999). The γ coefficients in (9) are factors that might have caused a positive or negative change in welfare between 1997 and 2000.

We used survey regression estimation techniques in both cases to account for the stratified sampling technique and, hence, adjust the standard errors to both stratification and clustering effects and thereby deal with the problem of heteroskedasticity. We also tested for other possible misspecifications (e.g. normality and multicollinearity).

6.1. Results and discussion

Descriptive statistics

The descriptive summary of the explanatory variables used in the regressions is presented in Table 6.1 below.

Average consumption expenditure per adult equivalent has increased from about Birr 528 to Birr 647, showing a growth rate of 18 percent. The average household size (adult equivalent) has increased from 4.69 (3.98) to 5.47 (4.55) implying an annual growth rate of 2.6 percent. The composition of the sexes in the total population seems to be equally distributed, especially in 1997. The ratio of dependent household members (babies, children and seniors) to those economically active is 1 to 0.94. About 82 percent of the households are male-headed.

Education levels are extremely low with illiteracy rate of household heads of 90 and 61 percent for 1997 and 2000 respectively. Education of spouse is ridiculously low accounting for 2 and 24 percent in 1997 and 2000 respectively. The proportion of household heads and spouses with acquired skills are very low accounting for close 15 and 35 percent during the same period. The proportion of members with either elementary or secondary education is also low accounting for 0.23, 1.1, 0.3, and 0.21 individuals/household in 1997 and 2000 respectively.

In terms of asset holding, the farm size per adult equivalent is below one hectare. The oxen holding per adult equivalent for 1997 and 2000 is 0.245 and 0.188 oxen units respectively. Similarly, the livestock holding per adult equivalent for 1997 and 2000 is slightly higher amounting to 0.377 and 0.414 TLU in 1997 and 2000 respectively.

Credit intake, mainly for farm inputs, has declined between 1997 and 2000 by about 24 percent. On average, however, more than 40 percent of the households have access

to formal credit market. The number of households who supplement their income from off-farm sources has increased from 34 percent to 55 percent. Food transfers, in the form of direct handouts and food-for-work programs, play an important role to rural households in Tigray region. About 18 and 58 percent of the households had access to food aid in 1997 and 2000 compared to 56 and 57 percent to food-for-work during the same period.

Access to irrigation remains very low. In general, not more than 25 percent of the households in Tigray region are located in areas with irrigation projects. Close to 50 percent of the households are categorized as having better access to major markets with < 10 kms separating them from major market centres. More than 62 percent of the households are located in densely populated villages with > 200 person/km^2. Finally, more than 31 percent of the households are located in villages affected by the recent border conflict.

Regression results

The results of the expenditure regressions are given in Table 6.2. In the 1997 expenditure regression, welfare was found to be a decreasing function of the number of dependents in a household. The coefficient for seniors was also negative and highly significant. Female composition of households was found to be positively correlated with welfare. In the 2000 expenditure regression, from among the household and demographic characteristics, the dependency ratio was found to be marginally significant and with the expected negative sign. Recruitment into the army of a household member turned out be positive and significant at 10 percent level.

From the household head/spouse specific factors, age of the head was found to be negative and significantly correlated with welfare in 1997. Education of the head was also found to be significant and positive, albeit at 10 percent, in both 1997 and 2000 regressions, where as education of spouse was not statistically significant in both regressions. Similarly, in 2000 household heads with any kind of acquired skill were found to have marginally higher welfare levels.

Asset holdings of households were closely related with the households' welfare status. In the 1997 regression, households with larger asset holdings such as farm, oxen, livestock holdings per adult equivalent and have got members with primary education have significantly higher consumption expenditures. Similarly, in 2000 regression, households with larger farm and livestock holdings had significantly higher welfare

levels. Oxen holding were also found to be highly significant but with a negative sign. On the other hand, adult labour (both female and male) was found to be highly significant and negative in both regressions perhaps underlining negative marginal returns to labour and the poor functioning of labour markets in the region.

As far the effects of households' access to services are concerned, none of the coefficients was significantly related with household welfare perhaps pointing to weak aggregate effect of these policy measures on poverty. This result is, however, less conclusive because a more rigorous analysis is needed, than the ordinary regression used here, to measure the impact of policy programs on household welfare (See Hagos and Holden, 2002).

Few village-related variables were found to be significant in explaining household welfare. In 2000, the coefficient for the war dummy turned out to be highly significant and negative underlining the adverse effects of the conflict on those communities close to the conflict. Poor access to market was also highly significant in 2000 and negatively related to welfare. The coefficient for rainfall index turned out to be positive and significant in both regressions indicating importance of weather related factors to the welfare of rural households. This is not surprising given the dominance of rain-fed agriculture in the region. Finally, the coefficients for the four zone dummies were found to be negative and highly significant in the 2000 regression perhaps capturing other effects not directly controlled for. These dummies were not significant in the 1997 regression, however.

The factors that explain the changes in household welfare are reported in column three of Table 6.2. Generally, the regression results are not as strong as the individual welfare regression results reported in the two columns in the same table.

Households who had members with secondary education in 1997 showed improvement in welfare during the period. Like in the individual regressions, households with initially larger farm holding showed a positive change in welfare. Moreover, households who had access to off-farm employment in 1997 did experience positive changes in welfare. On the other hand, contrary to our expectations, households with more dependents seem to have witnessed a positive change in welfare.

From among the services rendered, food aid seems to have contributed negatively to changes in welfare, which might point more to the indirect effects (e.g. disincentive effects) of food aid on poverty reduction. Finally, from among the village level

variables, households in communities with poor access to markets showed positive improvements in welfare. This might reflect that households far from market are less vulnerable to external shocks (policy or political risk) than communities with better access, but not fully integrated into the market.

7. Conclusion

The incidence of poverty in the region, in spite of a 5 percent increase between 1997 and 2000, has remained statistically the same, and it remained staggeringly high compared to national figures. There is, however, a moderate but significant decrease in the depth and severity of poverty in the region. The decrease in the depth of poverty might show the positive effect of policy reforms on poverty reduction. The growth in consumption per capita expenditure has also led to reduction in the level of inequality.

Decomposition results and stochastic dominance tests showed that there were significant differences in the geographic distribution of poverty among the zones in both 1997 and 2000. Moreover, in spite of the few changes in poverty conditions across the four zones in the region, the zones which were initially poor remained poor during the whole period underling the presence of a geographic trap to poverty.

The analysis of the dynamics of poverty showed that the proportion of the people falling into poverty was far higher than those escaping poverty. Furthermore, people living in extreme poverty had difficulty of escaping poverty pointing to poverty trap and thereby underlining the chronic nature of poverty in the region. This calls for policy measures that target long-term poverty while at the same time designing programs to support the income of those temporarily falling into poverty.

In the analysis of the determinants of poverty, households having educated head and with any kind of acquired skills seem to have achieved significantly higher welfare. Similarly, human capital resources such as household members with primary and secondary education in the 1997 and 2000 regressions respectively, had significantly higher welfare. Moreover, a positive change in welfare was associated with households having members with secondary education. Increased physical asset holding of households, in terms of farm and livestock holding, was highly correlated with improved welfare status of households. Change in welfare of households was significantly related to initial farm holding. These results underline the significance of enhancing the poor's human and physical endowments in poverty reduction.

On the other hand, the size of adult labour in the household seems not to have generally contributed to improved welfare of households perhaps underlining negative marginal returns to labour and the poor functioning of labour markets in the region. This calls for policy measures that attack poverty through increased investments for employment creation that tap on the idle labour resource. This is strengthened by the positive effect of access to off-farm income in 1997 on positive changes in household welfare.

As far as the effect of households' access to services are concerned, none of the service related variables have significant effect on welfare perhaps pointing to the limited effect of these programs on poverty reduction. This result, although less conclusive, might indicate the limited effectiveness of such programs in remote, politically unstable and fragile environments compared to areas with high potential and better market access conditions. This might also be related to the need for a sustained long-term investment in poverty reduction measures until such measures show tangible results in terms of improved welfare reaching the majority of the poor.

Regression results also showed the importance of village level factors such as war, market access and rainfall. The coefficient for war points to the adverse effects of political risk to poverty reduction. Peace and social stability are quite important to economic development and poverty reduction. Increased access to markets, through investments in marketing infrastructure may also contribute to poverty reduction, although it may expose poor households to external shocks until they are fully integrated into the market. Finally, agricultural production in the region is highly dependent on weather related factors. This calls for a public intervention to reduce the heavy dependence of rural production on unreliable rainfall through investments in irrigation. This is imperative given the chronic nature of poverty and the recurrent drought in the region triggering famine of massive proportions.

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Table 4.1: Aggregate poverty profiles

Poverty indices	1997 (n= 397)	2000 (n= 401)	% Change in poverty measures	Significance test t-test‡
Indices based on food poverty line (extreme poverty).				
P_0	0.49	0.50	1	-5.64 (0.002)**
P_1	0.20	0.16	-4	-7.350 (0.001)**
P_2	0.10	0.07	-3	-10.122 (0.002)**
Indices based on cost of basic needs (moderate poverty)				
P_0	0.61	0.66	5	-5.867 (0.002)**
P_1	0.29	0.27	-7.8	-6.287 (0.001)**
P_2	0.17	0.14	-3	-7.799 (0.552)**

‡Significance test for the difference in poverty levels in the two periods. Standard errors are given in parenthesis.

** and * significant at 1% and 5 % level of significance with corresponding z score values ≥ 2.58 and 1.96 respectively.

Table 4.2: Poverty profiles in the southern zone

Tabia	Poverty profiles					
	1997 (n= 100)			2000 (n= 100)		
	P_0	**P_1**	**P_2**	**P_0**	**P_1**	**P_2**
Hintalo	0.98	0.48	0.27	0.85	0.36	0.20
Mahbere Genet	0.97	0.60	0.39	0.73	0.30	0.15
Mai Alem	0.98	0.61	0.42	0.87	0.37	0.18
Samre	0.87	0.45	0.26	0.52	0.19	0.09
Zonal aggregate	**0.95**	**0.53**	**0.34**	**0.76**	**0.32**	**0.16**

Table 4.3: Poverty profiles in the eastern zone

Tabia	Poverty profiles					
	1997 (n= 100)			2000 (n=100)		
	P_0	**P_1**	**P_2**	**P_0**	**P_1**	**P_2**
Emba Asmena	0.62	0.28	0.16	0.44	0.20	0.11
Genfel	0.33	0.09	0.03	0.27	0.07	0.03
Hagere Selam	0.88	0.35	0.17	0.97	0.45	0.24
Kihen	0.65	0.18	0.06	0.34	0.13	0.06
Zonal aggregate	**0.60**	**0.21**	**0.09**	**0.50**	**0.21**	**0.11**

Table 4.4: Poverty profiles in the central zone

	Poverty profiles					
Tabia	1997 (n= 97)			2000 (n= 101)		
	P_0	**P_1**	**P_2**	**P_0**	**P_1**	**P_2**
Adi Selam	0.95	0.51	0.31	0.78	0.35	0.18
Debedebo	0.84	0.29	0.14	0.72	0.24	0.11
May Keyahti	0.80	0.39	0.21	0.91	0.40	0.21
Seret	0.82	0.36	0.19	0.53	0.15	0.06
Zonal aggregate	**0.86**	**0.40**	**0.22**	**0.74**	**0.29**	**0.14**

Table 4.5: Poverty profiles in the western zone

	Poverty profiles					
	1997 (n= 100)			2000 (n= 100)		
Tabia	**P_0**	**P_1**	**P_2**	**P_0**	**P_1**	**P_2**
Adi Menabir	0.81	0.35	0.17	0.55	0.25	0.13
Hadegti	0.85	0.37	0.19	0.83	0.35	0.19
Mai Adrasha	0.87	0.37	0.18	0.51	0.19	0.08
Tsaeda Ambora	0.82	0.29	0.11	0.54	0.20	0.09
Zonal aggregate	**0.84**	**0.34**	**0.16**	**0.61**	**0.25**	**0.17**

Table 4.6: Statistical tests for changes in poverty levels across zones between 1997 and 2000

	Head count	Poverty gap index	Poverty gap index squared
Zones	t-test	t-test	t-test
Southern	-2.085 (0.004)*	-0.146 (0.006)	-1.669 (0.005)
Eastern	-1.428 (0.007)	-1.736 (0.005)	-2.358 (0.004)*
Central	-1.777 (0.005)	-1.479 (0.006)	-1.824 (0.005)
Western	-1.638 (0.006)	1.552 (0.006)	-1.905 (0.0053

****, * s**ignificant at 1 and 5 percent respectively.

Table 4.7: Socio-economic decomposition

	1997				2000			
	Poverty indexes				Poverty indexes			
Socio-economic variables	**n**	**P_0**	**P_1**	**P_2**	**n**	**P_0**	**P_1**	**P_2**
Sex of household head								
Male	378	0.62	0.29	0.17	344	0.67	0.27	0.14
Female	70	0.53	0.25	0.14	57	0.54	0.24	0.12
t-test*	-	-1.373	-1.557	-1.965	-	-1.129	-1.315	-1.727
		(0.007)	(0.006)	(0.005)*		(0.008)	(0.007)	(0.005)
Oxen holding								
< a pair	290	0.66	0.33	0.19	333	0.70	0.30	0.15
≥ a pair	107	0.50	0.21	0.11	68	0.47	0.15	0.06
t-test	-	-2.020	-2.416	-3.103	-	-1.339	-1.842	-2.324*
		(0.004)*	(0.004)*	(0.003)**		(0.005)	(0.005)	(0.004)
Farm size								
< mean	282	0.63	0.31	0.19	272	0.72	0.31	0.15
≥ mean	115	0.52	0.20	0.09	129	0.46	0.17	0.08
t-test	-	-2.141	-2.600	-3.507	-	-2.380	-2.965	-4.033
		(0.004)*	(0.002) *	(0.002)**		(0.004)*	(0.003)**	(0.002)**
Access to credit								
Yes	226	0.57	0.26	0.15	130	0.65	0.31	0.17
No	171	0.68	0.34	0.20	272	0.66	0.25	0.12
t-test	-	-2.858	-2.956	-3.542	-	-2.462	-2.565	-3.198
		(0.003)**	(0.003)**	(0.002)**		(0.004)**	(0.003)*	(0.001)**
Access to food-for-work								
Yes	223	0.67	0.32	0.19	230	0.69	0.28	0.14
No	174	0.50	0.23	0.13	171	0.61	0.25	0.12
t-test	-	-2.858	-2.956	-3.542	-	-2.462	-2.565	-2.565
		(0.003)**	(0.003)**	(0.002)**		(0.004)*	(0.003)*	(0.003)*
Access to off-farm								
Yes	365	0.60	0.28	0.16	222	0.64	0.24	0.11
No	32	0.74	0.42	0.27	179	0.67	0.29	0.15
	-	-0.726	-0.646	-0.718	-	-2.939	-3.142	-4.094
		(0.013)	(0.015)	(0.013)		(0.003)**	(0.003)**	(0.002)**
Access to food aid								
Yes	73	0.81	0.36	0.20	233	0.70	0.29	0.15
No	324	0.57	0.28	0.16	168	0.59	0.23	0.11
t-test	-	-1.789	-1.488	-1.787	-	-2.835	-3.151	-4.146
		(0.005)	(0.006)	(0.005)*		(0.003)**	(0.003)**	(0.002)**
Access to irrigation water								
Yes	100	0.57	0.29	0.17	92	0.57	0.23	0.11
No	297	0.62	0.29	0.17	309	0.68	0.28	0.14
t-test	-	-1.191	-2.088	-2.523	-	-1.789	-2.083	-2.792
		(0.005)	(0.004)*	(0.004)*		(0.005)*	(0.004)*	(0.003)*
Distance to market								
< 10 km	199	0.56	0.28	0.17	201	0.63	0.25	0.12
≥ 10 km	198	0.65	0.29	0.16	200	0.69	0.29	0.15
t-test	-	-2.883	-3.109	-3.782	-	-2.999	-3.196	-4.151
		(0.003)**	(0.003)**	(0.002)**		(0.003)**	(0.003)**	(0.002)**
Population density								
< 200 persons/ km^2	149	0.46	0.17	0.08	150	0.58	0.22	0.11
≥ 200 persons/ km^2	248	0.71	0.36	0.22	251	0.70	0.28	0.15
t-test	-	-2.622	-3.146	-4.047	-	-2.670	-3.053	-3.978
		(0.003)*	(0.003)**	(0.002)**		(0.003)**	(0.003)**	(0.002)
Effect of conflict[±]								
Directly affected	123	0.52	0.27	0.13	125	0.77	0.32	0.17
Not affected	274	0.65	0.31	0.18	276	0.61	0.25	0.12
t-test	-	-2.262	-2.509	-3.254	-	-2.629	-2.470	-3.098
		(0.004)*	(0. 003)*	(0.003)		(0.004)**	(0.004)	(0.003)**

[±] The figures for 1997 imply welfare standing of the villages before the conflict started.
****, * s**ignificant at 1 and 5 percent respectively.

Table 5.1: Poverty transitions 1997-2000

	Poverty status in 2000			
Poverty status in 1997	**Non poor**	**Poor**	**Extreme poor**	**Total**
Non poor [0.54]	**0.444**	0.376	0.185	1.00
Poor [0.46]	0.272	**0.549**	0.296	1.00
Extreme poor [0.41]	0.172	0.524	**0.167**	1.00

Table 5.2: Transition matrix between 1997 and 2000

Scaled expenditure per adult equivalent in (1997)	**Scaled expenditure per adult equivalent in (2000)** ♣					
	I	**II**	**III**	**IV**	**V**	**Total**
I [0.24]	**0.258**	0.517	0.082	0.129	0.017	1.00
II [0.298]	0.238	**0.439**	0.079	0.185	0.053	1.00
III [0.077]	0.235	0.415	**0.104**	0.193	0.047	1.00
IV [0.153]	0.220	0.409	0.091	**0.212**	0.063	1.00
V [0.241]	0.194	0.387	0.153	0.245	**0.020**	1.00

♣I = $\leq 0.5^{*} Z$, II = $\leq Z$, III $\leq 1.25^{*} Z$, IV= $\leq 2.5^{*} Z$ and V $\geq 2.5^{*} Z$ where Z is the poverty line.

Table 6.1: Descriptive statistics of the explanatory variable in the regression models

		1997		2000	
Variables	**Description**	**Mean**	**Std. Error**	**Mean**	**Std. Error**
Household Characteristics					
Hhsize	Household size	4.69	0.116	5.47	0.029
Aduleqv	Adult equivalent	3.981	0.095	4.546	0.101
Babies	No of babies	0.118	0.016	0.184	0.019
Juniors	Children between 1 and 5 years	0.491	0.032	0.458	0.028
Children	Children between 6 and 15 years	1.567	0.0716	2.012	0.073
seniors	Beyond the age of 65	0.239	0.226	0.192	0.025
Femcomp	Female household composition	0.502	0.017	0.482	0.011
depratio	Consumer-worker ratio	2.155	0.047	2.593	0.077
Specific characteristics of the household head/spouse					
hhsex	Sex of household head (1= female)	0.176	0.018	0.137	0.017
hhage	Age of household head	49.49	0.785	52.17	0.755
eduhh	Educational dummy of the head (literate=1)	0.10	0.015	0.390	0.024
edusp	Educational dummy of spouse (literate=1)	0.016	0.006	0.241	0.022
skillhh	Household heads with any kind of acquired skill (yes=1)	0.030	0.008	0.242	0.021
skillspp	Spouses with any kind of acquired skill (yes=1)	0.022	0.007	0.069	0.012
soldrdy	Whether a household member is conscripted into the army (yes=1)	-	-	0.147	0.018
Asset holding /human capital					
adufem	Female adult household members	1.143	0.031	1.291	0.039
adumale	Male adult household members	1.166	0.047	1.344	0.051
secondar	Members with secondary education	0.027	0.1093	0.211	0.030
primary	Members with primary education	0.232	0.0347	1.149	0.060
pcfarm	Farm size per adult equivalent	0.344	0.018	0.350	0.017
pcoxen	oxen holding per adult equivalent	0.245	0.014	0.188	0.015
pctlu	Livestock holding per adult equivalent	0.377	0.028	0.414	0.026
pcexp	Consumption expenditure in adult eqvl.	525.28	28.350	647.429	26.399
Access to services					
credit2	Households with access to credit (yes=1))	0.567	0.247	0.324	0.023
extensi2	A dummy to represent access to extension related training (yes=1)	-	-	0.312	0.023
irrland	Household located in villages with irrigation projects (yes=1)	0.251	0.000	0.229	0.007
offarm2	Households with access to off-farm employment (yes= 1)	0.347	0.022	0.553	0.024
aid2	Households with access to food aid (yes= 1)	0.183	0.017	0.581	0.022
ffw2	Households with access to food-for-work projects (yes= 1)	0.561	0.022	0.573	0.023
Village characteristics					
market1	Distance to market < 10 km	0.501	0.023	0.501	0.000
market2	Distance to market > 10 km	0.498	0.0235	0.498	0.000
popn1	Population density of < 200 persons/ km^2	0.375	0.023	0.374	0.002
popn2	Population density of > 200 persons/ km^2	0.624	0.023	0.625	0.002
rainind	Rainfall index calculated as the year's means divided to the mean of many years	0.986	0.000	1.014	0.000
wardy	War dummy to indicate villages affected directly by war (yes= 1)	-	-	0.311	0.000

Table 6.2: Regression results on correlates of poverty and changes in poverty between 1997 and 2000

	1997		2000		Changes in poverty	
Variables	**Coef.**	**Std. err±**	**Coef.**	**Std. err±**	**Coef.**	**Std. err±**
Household Characteristics						
babies	-0.110	0.074	0.533	0.091	-.006	.113
juniors	-0.010	0.038	-0.041	0.051	-.048	.055
seniors	-0.217	0.070***	0.103	0.070	-.107	.096
femcomp	0.175	0.058***	0.255	0.163	-.024	.060
depratio	-0.131	0.034***	-0.047.	0.027*	.106	.044**
Specific characteristics of the household head/spouse						
hhsex	-0.071	0.077	-0.004	0.113	.092	.112
hhage	-0.030	0.008***	0.004	0.012	.0002	.014
hhage^2	0.0002	0.000***	-0.000	0.000	-0.000	0.000
eduhh	0.116	0.068*	0.102	0.061*	.053	.121
edusp	0.134	0.067	0.074	0.065	-	-
skillhh	-0.154	0.181	0.104	0.063*	-.838	.535
skillspp	-0.280	0.204	-0.018	0.107	-.037	.185
soldrdy	-	-	0.137	0.076*	-.161	.102
Asset holding / human capital						
adufem	-0.112	0.040***	-0.058	0.049	.041	.046
adumale	-0.127	0.027***	-0.095	0.035***	.056	.039
primary	0.096	0.027***	-0.034	0.026	-.051	.063
secondar	0.076	0.061	0.086	0.041**	.168	.096*
pcfarm	0.334	0.118***	0.340	0.100***	.158	.082**
pcoxen	0.323	0.126***	-0.220	0.126*	-.219	.183
pctlu	0.211	0.058***	0.439	0.083***	.143	.108
Access to services						
credit2	0.031	0.045	0.010	0.060	-.078	.065
irrland	0.028	0.060	-0.049	0.073	.124	.143
extensi2	-	-	0.103	0.046	-.033	.063
offarm2	-0.017	0.086	-0.023	0.057	.188	.114*
aid2	-0.085	0.063	0.041	0.056	-.195	.101**
ffw2	-0.030	0.053	0.005	0.057	.041	.081
Village characteristics						
market2	-0.067	0.051	-0.243	0.058***	.158	.077**
popn2	0.011	0.059	-0.056	0.069	-.087	.076
rainind	0.337	0.105***	1.35	0.764*	-.004[a]	.006
wardy	-	-	-0.401	0.073***	.044	.068
Zonal dummies						
Zone 1	-0.052	0.286	-1.789	0.843**	-.724	.386*
Zone 2	-0.434	0.309	-2.194	0.843***	-.253	.424
Zone 3	-0.352	0.301	-1.891	0.760**	-.343	.392
Zone 4	-0.296	0.271	-2.185	0.784***	-.356	.372
		N= 355		N= 373		N= 305
		Strata= 16		Strata= 16		Strata= 16
		Psu= 355		Psu= 373		Psu= 305
		F(30, 310)= 97.01		F(32, 326)= 41.84		F(33, 257) = 2.32
		Prob > F= 0.000		Prob > F =0.000		Prob > F = 0.000
		R-squared= 0.869		R-squared = 0.774		R-squared = 0.298

*, **, *** significant at 10, 5 and 1 percent levels of significance. ± We adjusted the standard errors to both stratification and clustering effects

[a] We used c.v. of rainfall instead of the rainfall index used earlier.

Figure 1.1: First order stochastic dominance test to compare the incidence of poverty between 1997 and 2000

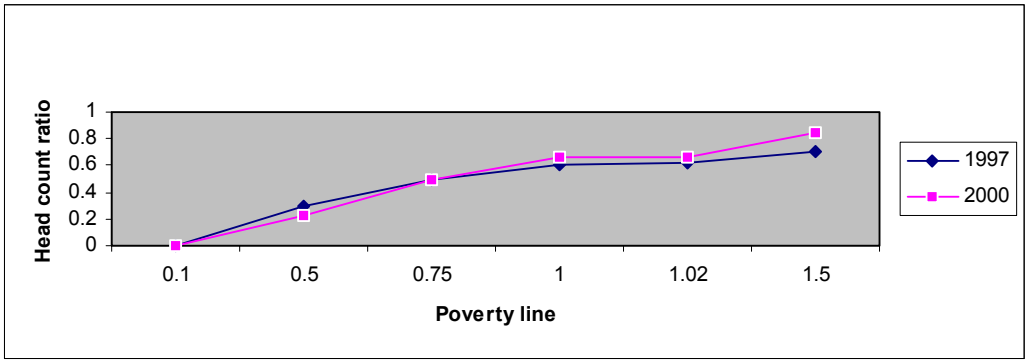


Figure 1.2: Second order stochastic dominance test to compare the depth of poverty between 1997 and 2000

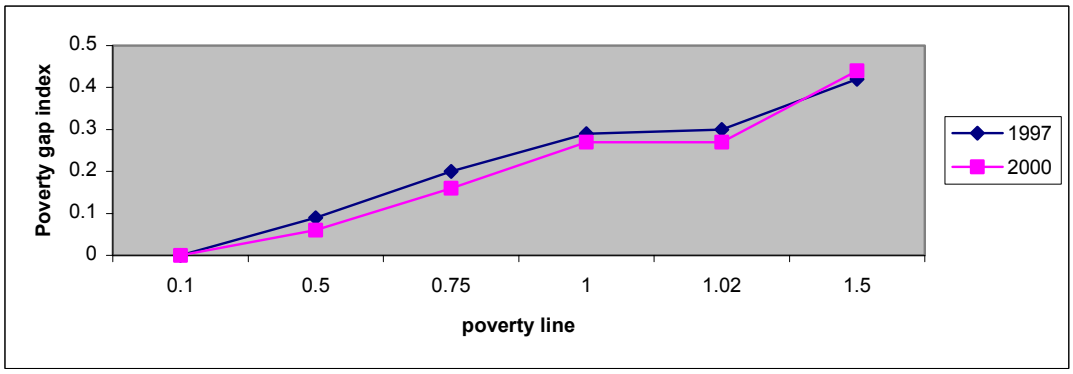


Figure 1.3: Third order stochastic dominance test to compare the severity of poverty between 1997 and 2000

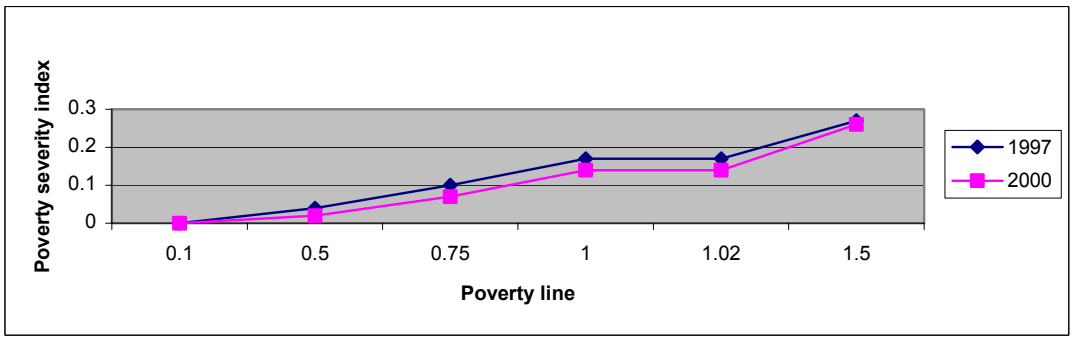


Figure 2.1: First order stochastic dominance test to compare the incidence of poverty among zones in 1997

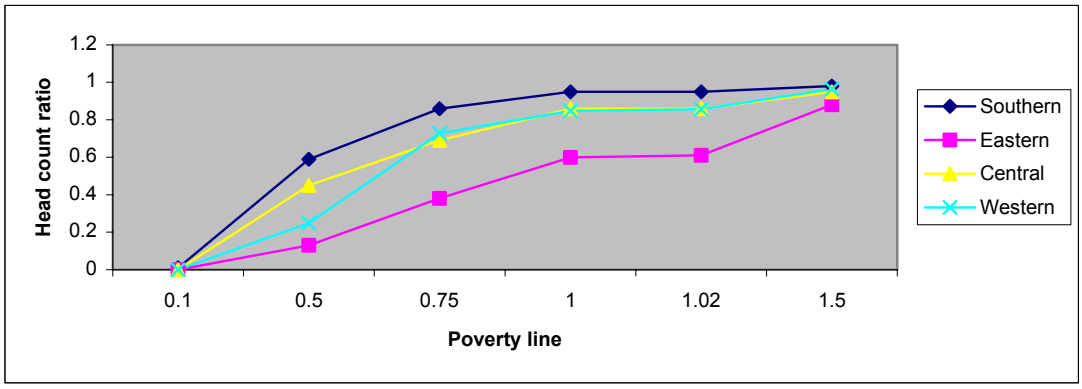


Figure 2.2: Second order stochastic dominance test to compare the depth of poverty among zones in 1997

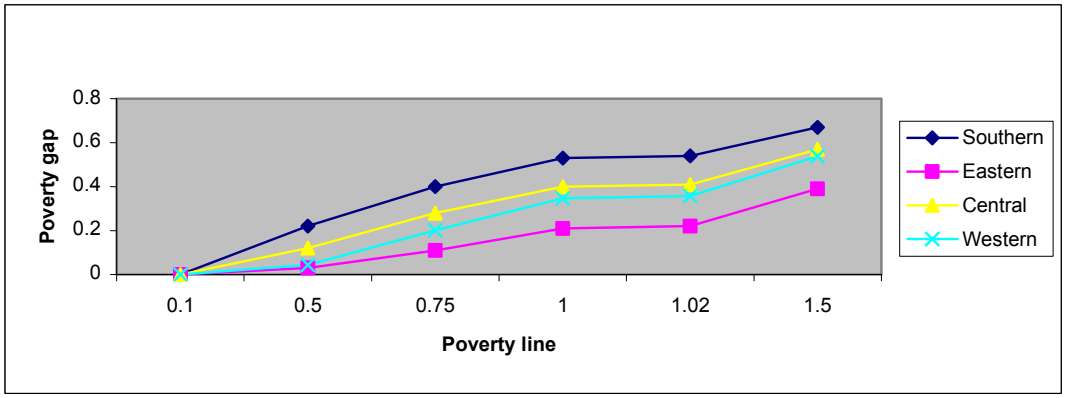


Figure 2.3: Third order stochastic dominance test to compare the severity of poverty among zones in 1997

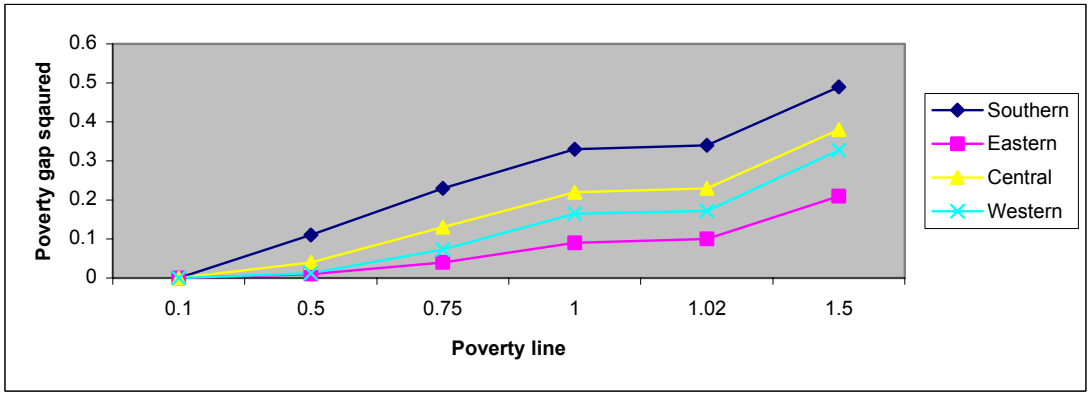


Figure 3.1: First order stochastic dominance test to compare the incidence of poverty among zones in 2000

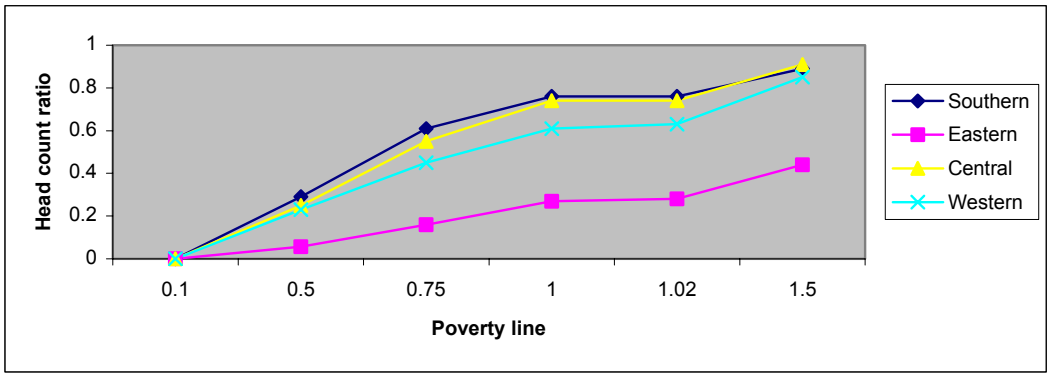


Figure 3.2: Second order stochastic dominance test to compare the depth of poverty among zones in 2000

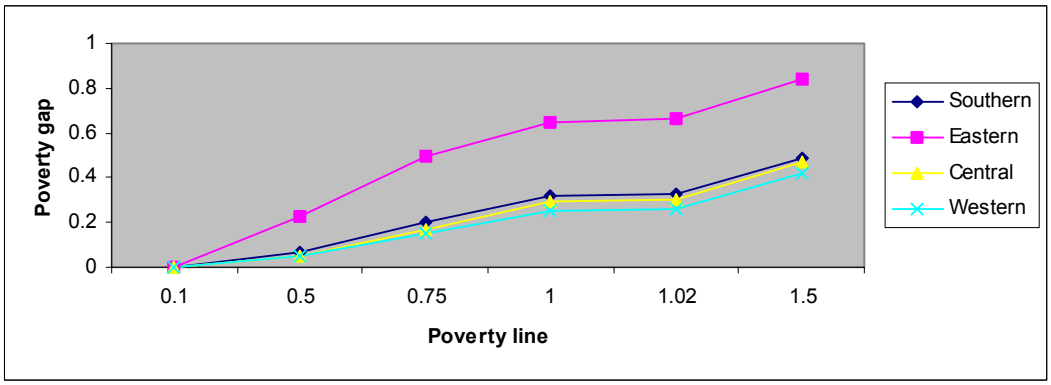
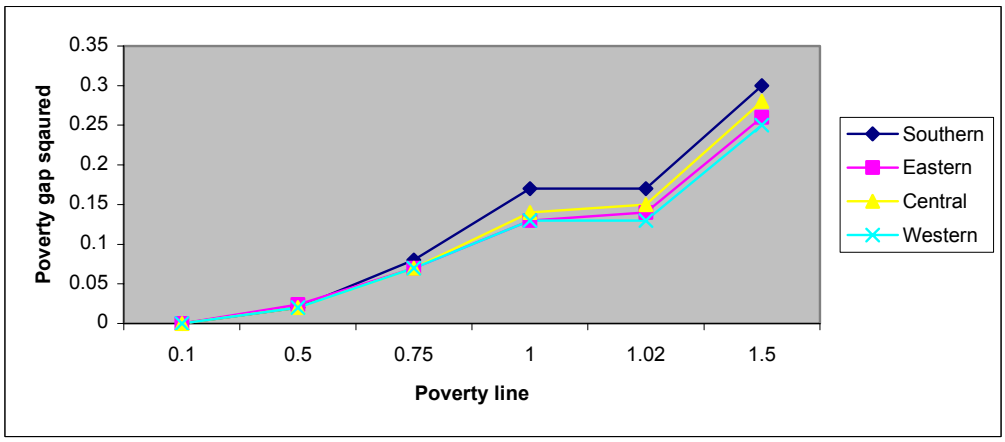


Figure 3.3: Third order stochastic dominance test to compare the severity of poverty among zones in 2000



Appendix 1

Table 1A: List of Tabias and their location with few key village level variables

Tabia	Location		Population density (persons/km^2)	Distance to market (in km) †	Mean rainfall**	Affected by conflict (Yes =1)	Irrigation project (Yes =1)
	Wereda	Zone					
Hintalo (tabia1)	Hintalo Wajerat	Southern	80.2	14	503.7 (183.5)	0	1
Samre (tabia2)	Seharti Samre	Southern	248.9	1.25	557.5 (175.7)	0	0
Mahbere Genet (tabia3)	Enderta	Southern	441.5	8*	552.1 (93.83)	0	1
Mai Alem (tabia4)	Enderta	Southern	429.6	6*	552.1 (93.83)	0	0
Kihen (tabia6)	Wukro	Eastern	160.6	23	420.4 (205)	0	0
Genfel (tabia7)	Wukro	Eastern	166.5	4	420.4 (205)	0	1
Emba Asmena (tabia8)	Tsaeda Emba	Eastern	631.10	7	596.8 (123.9)	0	0
Hagere Selam (tabia9)	Gulo Mekada	Eastern	749.4	39	419.05 (190.2)	1	0
Seret (tabia5)	Degua Tembien	Central	707	12.5	761.4 (178.9)	0	0
Debdebo (tabia10)	Ahferom	Central	161	6	668.52 (232.9)	1	0
Mai Keyahti (tabia11)	Ahferom	Central	636.6	16	736.6 (109.53)	0	0
Adi Selam (tabia12)	Mereb Leke	Central	206.8	29	579.32 (109.99)	1	0
Hadegti (tabia13)	Laelay Adiabo	Western	130.8	9	832 (156.7)	1	0
Tsaeda Ambera (tabia14)	Laelay Adiabo	Western	41.8	20	596.55 (152.63)	1	0
Mai Adrasha (tabia15)	Tahtay Koraro	Western	440	5.2	893.55 (152.63)	0	1
Adi Menabir (tabia16)	Tahtay Koraro	Western	236	21	783.4 (158.2)	0	0

* Even though the wereda market is about 20 km away, the Mekelle market is close (5-10 km).
** It is calculated based on rainfall data gathered in 1991 to 2001 at the wereda level by the regional Bureau of Agriculture. Standard deviations are given in brackets.
† We categorized tabias into distant from market for those greater than or equal to 10 kms away from a major market and population density on a benchmark of greater than or equal to 200 persons/km2.

Table 2A: Equivalence scales

Years of age	Men	Women
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.70
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-16	1.06	0.86
16-18	1.14	0.86
18-30	1.04	0.80
30-60	1.00	0.82
60 plus	0.84	0.74

Source: Adopted from Dercon and Krishnan (1998).

Table 3A: Regional food basket and average consumption (per year)

Item	Mean	Type	kcal	Real price (Southern 2000 price= 100)
111	26.68	Teff	341	2.5
112	31.09	Barley	354	1.75
113	7.190	Maize	362	2.0
114	36.39	Sorghum	347	1.75
115	3.64	Millet	329	2.25
116	4.58	Fava Bean	104	2.5
117	0.61	Lathyrus	348	2.0
118	1.29	Pepper	312	10.0
119	0.91	Beef	235	5.0
120	0.55	Mutton	255	5.0
121	0.29	Goat meat	170	4.2
122	0.43	Chicken	140	10.0
123	0.57	Milk	39	2.0
124	1.23	Butter	885	10.0
125	0.633	Sugar	400	6.0
126	0.70	Edible oil	884	9.0
127	2.75	Salt	0	2.5
128	3.27	Coffee	2	10.0
129	17.34	Wheat	351	2.5

Table 4A: Lespeyres price index deflated by 2000 southern price

Zones	2000	1997	Relative change	Change
Central	49.41	56.71	-14.78	Decrease
Eastern	56.56	64.88	-14.75	Decrease
Southern	100	112.36	-12.37	Held constant
Western	50.88	55.43	-8.9	Increase

Table 5A: Poverty profiles from similar studies

	Dercon and Krishnan (1998)			Woldehanna and Alemu (2002)		Bigsten et al. (2003)†		
Measures	**1994a**	**1994b**	**1995**	**1995\96**	**1999\00**	**1994**	**1995**	**1997**
P_0	0.39	0.32	0.41	0.455	0.442	41.9	37.6	35.5
P_1	0.16	0.10	0.17	0.129	0.119	16.8	16.2	12.7
P_2	0.08	0.05	0.09	0.051	0.045	8.8	9.1	6.2
	Regional poverty profile							
P_0	-	-	-	0.579	0.616	-	-	-
P_1	-	-	-	-	0.185	-	-	-
P_2	-	-	-	-	0.072	-	-	-

† We report only poverty profiles of rural communities.

The effect of program credit on participation in off-farm employment and welfare of rural households in northern Ethiopia

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Abstract

Households' participation and loan demanded were found to be positively related to the household being owner-operated but negatively related to the household being female-headed and being rich in livestock holding. Other household characteristics that determined participation and loan demand include the number of people with primary and secondary education, age of the household head and absence of female adult labor. Moreover, communities with higher population density were found to have higher rate of participation and demanded higher loans.

The effect of program on the change in the level of income derived from self-employment was positive and statistically significant while program credit has an insignificant effect on income derived from wage employment underlining the importance of access (capital) constraints to self-employment. The impact of participation in program credit and observed credit demand on changes in per capita consumption is positive and highly significant. A 10 percent increase in borrowing was found to have increased consumption expenditure by 0.35 percent. This reflects the long-term effects of borrowing on changes in consumption expenditure.

Key terms: Poverty alleviation, micro finance, off-farm income, consumption expenditure; Ethiopia

1. Introduction

Poverty reduction strategies generally aim to improve the asset holding of the poor, either by endowing them with additional financial, fixed, human, natural, or social assets, by increasing the productivity of assets they already hold or both (Barrett et al, 2001). Provision of micro credit is, hence, regarded as one of the most important policy tools in alleviating poverty (Micro Credit Summit, 1997; Morduch, 1999; Khandaker, 2003**).** Credit also provides an important tool for household consumption smoothing (Deaton, 1997). During the last three decades there was a micro-credit revolution triggered by institutional innovations in reducing the risk and cost of providing financial services to the poor. This experience, which started in Asia, is now replicated all over the globe (Morduch, 1999).

There is a growing empirical evidence, based on studies in Asia, that credit access by the poor, as measured by program participation and cumulative credit demanded,

increases per capita household expenditure (Pitt and Khandker, 1998) reduces vulnerability by strengthening crisis-coping mechanisms, diversifying income-earning processes and building-up of productive assets (Pitt and Khandker, 1998; Morduch, 1998; Zaman, 2000). Results from Africa are quite scanty, however.

While reliance on non-farm (off-farm) is widespread in Africa (Reardon, 1997), there is growing empirical evidence that household's access to off-farm income is closely related with their total income or wealth standing (Barrett et al. 2001). Poor households are unable to diversify their income because they cannot meet the investment requirements for entry into remunerative non-farm activities (Woldehana and Oskam 2001).

The objective of this paper is to assess the determinant of participation and the corresponding demand for loan in program credit in northern Ethiopia provided by Dedebit Rural Credit and Saving Institution (DCSI). By doing so we would like to assess whether the poor, those who lack physical and human capital, are targeted by the program. Moreover, it is to assess the role of credit in household's participation in non-farm employment, by distinguishing between self- and wage employment, and level of income derived from non-farm employment. Finally, we examined the impact of program credit on changes in household's consumption expenditure.

The availability of a panel data of 400 households in sixteen communities made it relatively easier to capture the direct benefits of the program on household welfare. The benefits of panel data over cross sectional data include: (i) cross-section results may not be robust as the measurement of program impact depends importantly on the methods used to treat program endogeneity (Lalonde, 1986); (ii) With panel data, the household fixed effects method is less reliant on the exact application of exogenous identification rule (Khandaker, 2003**)**. (iii) With panel data we could examine the long-term effects of program credit while with cross sectional data we could only examine short-term effects (Khandaker, 2003**)**.

Participation in credit program and the improvements thereof are identified with strictly and increasing credit limits. In this case, measuring the impact of credit reduces to measuring the effects of an increase in the corresponding credit limit on household behavioral and welfare outcomes (Diagne and Zeller 2001).

The program has reached all sixteen villages covered in the survey. As such, even if this reduces the problem of bias that could arise from non-random placement of program**,** it turns out to be difficult to control for the counter factual. We took

advantage of the availability of panel data to control for unobserved individual heterogeneity and measure the program effects (Khandker, 2003).

Part II describes the study site, sampling methodology and choice of data used in the analysis. Part III presents the theoretical framework followed by the outline of hypotheses formulated for testing. Part IV presents the econometric models and the choice of variables used in the various regressions. Section V presents results and discussions. Finally part VI concludes.

2. Setting and sampling methodology

Dedebit Rural Credit and Saving Institution (DCSI) provides formal rural credit in Tigray, northern Ethiopia. DCSI is in operation since 1994[17]. More than half of the disbursed loan of DCSI goes to the purchase of agricultural input loans such as fertilizer, improved seeds and farming oxen. It provides also regular loans to regular clients who are engaged in self–employment and other off-farm income generating schemes. However, DSCI offers no consumption loans. The loan ceiling is Ethiopian Birr 5000 (1 USD ≈ EB 8.56) for a loan period of maximum one year. DCSI's regular clients and clients of agricultural input loan has risen from 120 000 to 248,612 and from 220,000 to 637,143 between 1997 and 1999 (REST, 1997; DSCI, 2000; Amha, 2000).

Eligibility to credit is to 'all who are able to repay'. "In principle all productive loans that enable the borrower to generate income so that he/she can repay the loan are eligible" (REST, 1997; Gebremedhin et al, 1996; DCSI, 2000). For production credit, this is usually measured in terms of whether the household is male-headed or has a male adult family member, who is able and willing to cultivate the household's farmland. However, loans for self-employment are prioritized to female-headed households and unemployed youth that are able to undertake income generating ventures be it trade or production tasks. There are no material collateral requirements to credit. Security is in the form of peer group pressure and support. Five to seven members constitute a group who will take joint liability to credit and undertake peer-monitoring tasks. Group members are obliged to keep a saving for them to be able to get additional credit.

[17] DCSI started in 1994 as an affiliate of the Relief Society of Tigray (REST), a local NGO that stayed in operation since 1978. DCSI was established in 1997 as a rural microfinace institution following proclamation no. 40/1996, which defined the regulatory framework for micro finance institutions in Ethiopia.

In the survey, we gathered information related to household's perception of access to and participation in credit markets, both from formal and informal, their corresponding credit limit, the purpose for which the loan was used - farm investment, business, consumption and other family (social) events - and the repayment conditions in two rounds in 1998 and 2001 on a sample of 400 randomly selected households[18]. The study covered sixteen communities purposively stratified by population density, market access, (non) presence of an irrigation development project and their location in the four different zones in the region: central, eastern, southern and western. We gathered information on household income from various sources, consumption expenditure, and household assets alongside a host of other information related to household characteristics, demographic factors, access to market and other services, migration, agricultural (livestock and crop) production and related investments, sales of agricultural goods and purchases. Information related to location of villages (tabias) and other important village level variables are given in Table 1A of the first paper.

3. Theoretical framework

We develop a simple two-period consumption model. The consumer maximizes the discounted present value of consumption over the two-period horizon. Assuming that preferences are separable across periods, we represent a 'lifetime' utility as:

$$\sum_{t=0}^{t=1} \delta^t u(c_t) = u(c_0) + \delta u(c_1) \qquad (1)$$

where $\delta \in [0,1]$ is the discount factor.

We assume that the consumer is endowed with some initial wealth at the start of period 0 and earns income y_t in period $t = 0,1$. For the sake of simplicity we assume these income flows as exogenous[19]. Let's assume that the consumer can freely borrow and lend at a fixed interest rate between each of the two periods. Thus the consumer faces a pair of constraints, one for each period, given by:

$$A_1 = R_0(A_0 + y_0 - c_0)$$

and

[18] We had an attrition rate of 12 percent in the second round survey compared to the first one. We dropped three households with missing information from the analysis.

[19] This specification ignores the household's labor supply decision.

$$A_2 = R_1\left(A_1 + y_1 - c_1\right)$$

Where R_t represents the gross return on wealth between period t and $t+1$, and the consumer earns this interest on wealth plus income less consumption over the period. We restrict consumption to be non-negative. The stock of assets remaining at the end of the consumer's life must also be non-negative. The consumer's constraints that combine these two flows can be combined (by substituting the first in to the second), which after some rearrangement yields:

$$A_2 / R_1 + c_1 + R_0 c_0 = R_0\left(A_0 + y_0\right) + y_1 \qquad (2)$$

The left side of this expression represents the expenditures of the consumer on goods in both periods of life and the stock of assets held at the start of period two. The right side measures the total amount of resources available to the household for spending over its lifetime.

Maximization of (1) with respect to $\left(c_0, c_1\right)$subject to (2) yields:

$$u'\left(c_0\right) = \lambda = \delta R_0 u'\left(c_1\right) \qquad (3)$$

This consumer's Euler equation relates the marginal utility of consumption across two periods. The agent will consume those extra units of consumption in period one which leads to a discounted gain in utility given by the right hand side of (3). When this condition holds, lifetime utility cannot be increased.

The derivation with respect to A_2 is given by:

$$\lambda = \phi$$

where ϕ is the multiplier on the non-negativity constraints for A_2. So clearly, the non-negativity constraint binds $(\phi > 0)$ if and only if the marginal utility of consumption is positive $\left(\lambda > 0\right)$. It is sub-optimal to leave money when more consumption is desirable. This point has two important implications. First, in thinking about perturbations from a candidate solution, it is right to ignore the possibility of reducing c_0 to increase A_2, as this is not clearly desirable. Second, knowing that $A_2 = 0$ is a critical part of this problem.

With $A_2 = 0$, we can simplify the consumer's constraint to a more familiar expression

$$c_1 / R_0 + c_0 = A_0 + y_0 + y_1 / R_0 = W_0 \qquad (4)$$

in which all resources and expenditures are in terms of period 0 goods. Let W_0 denote the lifetime wealth for the consumer. Clearly, the optimal consumption choices depend on the measure of lifetime wealth (W_0) and the intertemporal terms of trade (R_0). In the absence of any capital market restrictions, the timing of income across the consumer's lifetime is irrelevant for their consumption decisions. Instead, variations in the timing of income, given W_0 are simply reflected in the level of savings between the two periods.

This assumes, of course, nonstochastic income in t_1 and the consumer does not face borrowing constraints. We need to extend the model to incorporate the stochastic nature of income and borrowing constraints. It will be easy to follow that the Euler equation when income in period 1 (y_1) is not known to the consumer in period zero is given by:

$$u'(c_0) = \delta R_0 E_{y1|y0} u'(R_0(A_0 + y_0 - c_0) + y_1) \qquad (5)$$

Note that the marginal utility of future consumption is stochastic, i.e. consumption decision depends on the persistence of income fluctuations. Thus the tradeoff given by the Euler equation reflects the loss of utility today from reducing consumption relative to the expected gain, which depends on the realization of income in period 1. This implies that variations in current income are spread overtime periods to satisfy the Euler equation condition that marginal utility today is equal to the discounted marginal utility of consumption tomorrow, given the return to R_0.

Let's move on to incorporate borrowing constraints and see its effect on consumption behavior. Suppose the household faced a constraint that its asset at the start of each period has to exceed $\underline{A}$, where $\underline{A} < 0$ is a limit on outstanding debt to the household. Given this constraint, period 0 consumption is bound from above by:

$$\bar{c} = A_0 + y_0 - \underline{A}/R_0$$

Let c_0^* be the optimal period 0 consumption in the absence of any debt limit. Then if $c_0^* \le \bar{c}$, the borrowing restriction does bind and the solution to the constrained and unconstrained problems are the same. Else, if $c_0^* > \bar{c}$, then the constraint does not bind. In that case, the Euler equation does not hold as an equality:

$$u'(\bar{c}) > \delta R_0 u'(c_1) \qquad (6)$$

where $c_1 = \underline{A} + y_1$. Clearly the consumer would prefer to borrow more to increase current consumption relative to the future consumption but is not able given the borrowing constraint. This model with borrowing restrictions implies that households care about the timing of their income flows. If a household is credit constrained, then rearranging the timing of permanent income by moving income forward will clearly increase the households welfare: consumption in the current period will rise and the borrowing constraint will slightly relax.

The main objective of this paper is, hence, to examine the empirical implication of the relaxation of borrowing constraints (narrowly defined as participation in program credit and realized loan demands) on changes in household consumption households' decisions to participate in non-farm employment and the level and type of income derived thereof.

Hypotheses

The probability of household's participation in program credit might be closely related to the eligibility criteria set by the credit institution. The usual eligibility criteria used for screening potential clients, especially for production loans, is whether the household is owner operator of its own land and the presence of adult labor (mainly male) in the household. By hypothesizing so, we intend to test whether the eligibility criteria is adhered to in the provision of program credit. This would also indicate whether the poor is targeted in the program. Households' participation in program credit might also be closely related to household factors such as age, sex, skill and education level of household head. Demographic factors such as the consumer–worker ratio may also influence household's participation in program credit partly because household with more dependent may face temporary cash shortages to meet their consumption requirements.

Household's asset holding (such as farm size, productive labor and livestock holding) may also increase its decision to participate partly because it is placed better than asset constrained households to join credit groups and vis-à-vis the lender's evaluation of household's credit worthiness. On the other hand, asset rich households may not face liquidity constraints as long as they could exchange easily their assets into cash. This may reduce their demand for cash and hence their decision to participate. Village level variables such as distance to market, rainfall variability and

population pressure will also affect household's decision whether to participate in program credit although the expected sign is ambiguous.

Household's extent of participation is measured by the maximum amount a household has actually borrowed. Factors that may influence the maximum amount of loan they could actually borrow include eligibility, age, skill, educational status and sex of household head. Experience of the farmer, as indicated by his age, is likely to have a positive effect on his credit limit. On the other hand, older people may have lower propensity to take-up risky ventures and thereby decrease their credit demand. The expected sign is, hence, ambiguous. Educated and skilled heads are expected to be innovative and hence have higher demand for credit. Educated and skilled household heads also are more likely to generate higher off-farm income implying increased initial loan demand. Male household heads are expected to have higher credit limits compared to their female counter parts.

Asset holdings such as farm size, livestock holding and the presence of adult labor (female or male) may increase intake of higher loan sizes given that there are no markets for these assets to enable easy exchange of cash and fixed assets. The size of land operated by the household may increase the household's credit limit by raising the household's capital requirement. Availability of productive labor implies higher income earning capacity of the household but also increased capital requirement to take-up other income generating activities. The expected sign of livestock holding is ambiguous just because one can transform livestock units into liquid asset as soon as the need arises. There could be differences in livestock types in this respect, however. Households may not like to easily dispose bigger animals (such as oxen) perhaps not only due to their economic importance (as a source of traction) but also the status symbol attached in keeping them. Finally, village communities differ in their agricultural potential and other opportunities they offer which might have a bearing on credit market participation and loan demand. We hence, add village level variables such as market access and variation in rainfall and village dummies to account for other excluded variables.

There is growing empirical evidence that households are growing more reliant on non-farm income in Africa (Reardon, 1997). It is also indicated that household's access to non-farm income is closely related with their total income or wealth standing (Barrett et al. 2001). Poor households are unable to diversify their income because they cannot meet the investment requirements for entry into remunerative

non-farm activities. Woldehana and Oskam (2001) showed that farm households diversify their income sources into off-farm wage employment motivated by low farm income and availability of surplus labor where as they enter into off-farm self-employment to earn an attractive return. Entry barriers, related to credit constraints or lack of entrepreneurial skills, render relatively wealthy farm households to dominate the most lucrative rural non-farm activities. Easing entry barriers, among others, through increased availability of loans to the poor may improve household poverty. Credit may improve access especially when such activities involve entry costs. Moreover, with the option of borrowing, households could do away with risk reducing but inefficient income diversification strategies (Eswaran and Kotwal, 1990) and precautionary savings with negative returns (Deaton, 1991). By testing the role of credit on changes in levels of off-farm income, we intend to see whether households´ participation in program credit facilitates household's participation in off-farm self- and/or wage employment and boosts household's income.

Consumption is the largest component of household expenditure in developing countries. Consumption of nondurables is not as volatile as income due consumption smoothing because households try to smooth their consumption when their 'life-cycle' income flow does not correspond their desired consumption pattern, or when income fluctuates with external shocks. We expect that credit access eases household consumption smoothing over time. On the other hand, when imperfect insurance or credit markets prevent perfect smoothing, separability between production and consumption breaks down as production decisions are affected by desired pattern of consumption (Besley, 1995; Deaton, 1992). In such a cases households may adopt other risk management strategies, which may not always be welfare enhancing.

4. Credit impact assessment: An econometric framework

The role of program credit on the household's decision to participate and level of income derived from non-farm employment and on household welfare (as measured by changes in consumption expenditure per adult equivalent) is estimated by the determination of (i) the households´ program participation and observed loan size, and (ii) the impact of cumulative loan intake on the households´ behavioral and welfare outcomes. We estimated the following reduced form borrowing equation:

$$b_{it}^{*} = X_{ijt}\beta_b + \eta_{ij}^{b} + \mu_{j}^{b} + \varepsilon_{ijt}^{b} \qquad (7)$$

where X is a vector of household characteristics, β is a vector of unknown parameters, η is an unmeasured determinant of the credit demand that is time invariant and fixed within the household, μ is an unmeasured determinant of the credit demand that is time invariant and fixed within a village, and ε is a non-systematic error term.

The level of income derived from non-farm employment (I_{ijt}) and conditional demand for consumption (C_{ijt}) in each period conditional on the level of borrowing for each period is given as:

$$I_{ijt} = X_{ijt}\beta_i + \beta_{ijt}\delta + \eta_{ij}^{i} + \mu_{ij}^{i} + \varepsilon_{ij}^{i} \qquad (8)$$

$$C_{ijt} = X_{ijt}\beta_c + \beta_{ijt}\delta + \eta_{ij}^{c} + \mu_{ij}^{c} + \varepsilon_{ij}^{c} \qquad (9)$$

where δ is the effect of credit intake on the respective outcome variables. The effect of credit intake on levels of income derived from non-farm employment and changes in consumption expenditure could be estimated using equations (8) and (9) respectively. However, the credit demand as given in equation (7) need to be estimated jointly with the respective outcome equations (8) and (9). Moreover, since equation (7) may not include any variables that were not included in equation (8) or (9), estimating equation (8) or (9) may not be distinguishable from equation (7). However, given the availability of panel data (t>1), identification is made possible through differencing out the unobserved village and household attributes, which are the source of correlation between credit demand and household outcome equation (Khandaker, 2003). Differencing equations (8) and (9) at two points in time yields the following outcome equations:

$$\Delta I_{ij} = \Delta X_{ij}\beta_i + \Delta B_{ij}\delta + \Delta\varepsilon_{ij}^{i} \qquad (10)$$

$$\Delta C_{ij} = \Delta X_{ij}\beta_c + \Delta B_{ij}\delta + \Delta\varepsilon_{ij}^{c} \qquad (11)$$

where ΔI_{ij} and ΔC_{ij} are levels of income derived from non-farm employment and the changes in consumption expenditure between 1997 and 2000, and ΔB_{ij} is the change in observed loan demand.

Consistent estimates of the credit effect on consumption can be obtained from equation (11) using household fixed effects method. This is based on the assumption that the error terms of the credit demand and outcome equations are uncorrelated. However, the error terms may be correlated for reasons other than the endogeneity of

program placement and participation. It is possible that socio-economic factors, which are assumed to be fixed at the household level[20], may change over time. Under such circumstances, equations (10) and (11) can be rewritten as:

$$\Delta C_{ij} = \Delta X_{ij}\beta_c + \Delta B_{ij}\delta + \Delta\eta_{ij}^{c} + \Delta\varepsilon_{ij}^{c} \qquad (12)$$

$$\Delta I_{ij} = \Delta X_{ij}\beta_i + \Delta B_{ij}\delta + \Delta\eta_{ij}^{i} + \Delta\varepsilon_{ij}^{i} \qquad (13)$$

In estimating the consumption expenditure equation (12), we introduced two-stage instrumental variable method in order to account for the endogeneity of program participation and loan demand. In the first stage we estimated a censored regression model given the censored nature of the loan demand variable, the predicted value of which is included into the second stage outcome equation. Since the standard errors estimated in the process are not correct, we estimated correct standard errors through bootstrapping technique.

The effect of participation in credit market on household's participation in non-farm employment, and, hence, the level of income from non-farm employment needs an estimation strategy that accounts for the censored but non-truncated type of the dependent variable. This could have been estimated using models such as Powel´s (Powel, 1984) censored absolute deviation model (CLAD) (Deaton, 1997). This model, however, has huge data requirement[21]. We estimated instead, the role of loan demanded, among other variables, on the participation in non-farm employment and level of income derived through a Heckman type two-stage estimation procedure as follows:

$$I_1 = x_1\beta_1 + u_1 \qquad (14)$$

where the dependent variable (I_1), level of income derived either from wage or self-employment, is determined by the regressors x_1, and an unobservable error term μ. The participation equation, signifying participation or non-participation in either wage or self-employment, is assumed to be determined by a vector of conditioning variables, x, through a binary choice model;

$$y_2 = 1[x\delta_2 + v_2 > 0] \qquad (15)$$

where $1[.]$ denotes an indicator function for the event of having participated in credit program, δ_2 is a vector of unknown coefficients, and v is the unknown error term.

[20] Running a household fixed effects model on the consumption expenditure model could not be implemented, however.

[21] We couldn't achieve convergence when we tried to use Powell's CLAD model (Powel, 1984).

where (x, y_2) are always observed where as I_1 is observed only when $y_2 = 1$. We assume that (u_1, v_2) is independent of x with mean zero implying that x is exogenous, and $v_2 \sim N(0,1)$. The last assumption is needed to derive conditional expectation given the selection sample. Furthermore, assume that $E(u_1 \mid v_2) = \gamma_1 v_2$, which requires the linearity of the population regression of u_1 on v_2. This implies that $(u_1, v_2)$is bivariate normal.

To derive an estimable equation, let (I_1, y_2, x, u_1, v_2) denote a random draw from the population. Since y_1 is observed only when $y_2 = 1$, what we can hope to estimate is $E(I_1 \mid x, y_2 = 1)$.

Under the assumptions we outlined above and equation (14)

$$E(I_1 \mid x, v_2) = x_1\beta_1 + E(u_1 \mid x, v_2)$$

$$= x_1\beta_1 + E(u_1 \mid v_2)$$

because (u_1, v_2) is independent of x by assumption.

$$= x_1\beta_1 + \gamma_1 v_2 \qquad (16)$$

If $\gamma_1 = 0 \Rightarrow u_1$ and v_2 are uncorrelated which, in turn, implies $E(I_1 \mid x, v_2)$ = $E(I_1 \mid x) = E(I_1 \mid x_1) = x_1\beta_1$. In this case, lease square estimation of β is consistent.

If $\gamma_1 \neq 0 \Rightarrow u_1$ and v_2 are correlated, then

$$E(I_1 \mid x, y_2) = x_1\beta_1 + \gamma_1 E(v_2 \mid x, y_2)$$

$$= x_1\beta_1 + \gamma_1 h(x, y_2)$$

If we knew $h(x, y_2)$, then, we could estimate β_1 and γ_1 from the regression of I_1 on x_1 and $h(x, y_2)$using only the selected sample. Because the selected sample has $y_2 = 1$, we need only to find $h(x,1)$. But $h(x,1) = E(v_2 \mid v_2 > -x\delta_2) = \lambda(x\delta_2)$, where $\lambda(.) \equiv \phi(.)/\Phi(.)$is the inverse Mills ratio, and so we can write:

$$E(I_1 \mid x, y_2 = 1) = x_1\beta_1 + \gamma_1\lambda(x\delta_2) \qquad (17)$$

Equation (15) can be estimated using Heckman's selection model (Heckman, 1979). The estimators obtained from (17) are consistent and $\sqrt{N}$ – asymptotically normal. Identification in this model requires that x_1 is not perfectly correlated with $\lambda(x\delta_2)$. Strictly speaking this could be assured as long as $\lambda(.)$ is a nonlinear function, though it helps for statistical power if x includes some variables not included in x_1. Thus, we

need to find for good instruments (exogenous exclusion restrictions) to make identification possible. In this paper, we defined a household choice variable, which determines whether a household has a choice to participate in a program. A household's choice in program participation depends on two factors: whether a credit program operates in the village where the household lives and whether the household itself qualifies to participate in the program. Even if, all communities are reached out by program credit there is a difference in the history of the program perhaps influencing household's participation behavior. A household will qualify for program credit provided that it has adult labor that could take care of the agricultural and/non-farm work. We generate a choice variable by interacting the number of adults in the household with the village dummies. This interaction terms were used as instruments for identification in both the outcome equations.

The Heckman model is sensitive to misspecification problems, especially violation of assumptions of normality and homoskedasticity of the error terms. In using the Heckman model, it is not possible to know whether these assumptions are violated because it is difficult to test for these misspecifications. This is because when there is self-selection problem $(\gamma_1 \neq 0)$, obtaining a consistent estimate for the asymptotic variance of β is complicated (Wooldridge, 2002).

Different models have been proposed as a solution to the problem by focusing on relaxing the distributional assumptions. Let's assume the distribution of (u_1, v_2) is unknown but still suppose that $\begin{pmatrix} u_1 \\ v_2 \end{pmatrix}$ is independent of $\begin{pmatrix} x \\ x_1 \end{pmatrix}$. We do not assume normality of (u_1, v_2). Given no distributional assumptions of (u_1, v_2), Newey (1988) and Andrews (1989) used a two-step procedure using a series of approximations to estimate $\lambda(.)$ using polynomial terms. Ahn and Powell (1993) followed a two-step procedure where in the first stage a nonparametric regression estimator for the selection variable and in the second step a weighted instrumental variables estimator is used. Deaton (1997), following a variety of the first one, estimated a polynomial form of the predicted probabilities to be used in the second stage.

We followed Deaton's selection models in our estimation strategy to check the robustness of our estimation results to different distributional assumptions. Furthermore, in the Deaton model, we could run different specification tests: normality tests using skewness and kurtosis as well as the Shapiro-Wilk and Shapiro-

Francia tests (Gould and Rogers, 1991; Gould, 1991) and homoskedasticity using the Cook and Weisberg (1983) test. The tests showed the presence of heteroskedasticity and violation of the normality assumption of the error term. We tried linear, log-linear and log-log functional forms in an attempt to eliminate the heteroskedasticity problem. Although it was not possible to eliminate the problem entirely, we selected the log-log functional form, which yielded the lowest χ^2 values. To handle zero values of variables in the data set we created dummy variables (1= for zero values) and used zeros in the log transformed data rather than setting arbitrarily small values that may bias the results. We corrected also for hetroskedasticity by estimating robust standard errors (White, 1980). In both estimation models we controlled for the endogeneity of program participation and, hence, of loan size. Furthermore, we could use the explanatory variables from 1998 to be able to test for time recursive causality in the non-farm income models. We also controlled for village fixed effects in the latter models.

5. Results and discussion

Descriptive statistics

Close to 57 and 32 percent of the households in 1997 and 2000 participated in program credit indicating a reduction in participation rates. The corresponding per capita loan demanded for the two periods, however, amounts to Birr 81 and 261 respectively. During the last five years, program participation rate reached to over 70 percent of the households. The cumulative per capita loan demanded during the last five years amount to Birr 230, the dominant form of which is production credit. A larger share of the loan disbursed is made for the purchase of agricultural inputs.

Close to 30 and 34 percent of the households participated in self-employment activities in contrast to 7 and 33 percent that took part in wage employment during the 1997 and 2000 period respectively. Mean consumption expenditure per adult equivalent has grown from 528 to 651 between 1997 and 2000. Statistical summary of other household and village related variables are also reported in Table 1.

Distribution of credit services

We tried to assess whether there is differences in the distribution of credit services across geographical locations (zones), household characteristics and village level variables. We reported calculated F- and t-statistics of differences in mean with regard to participation rates and loan demanded.

As can be seen from Table 2, there is significant variation in participation rates and the amount of loan demanded across zones. Both participation rates and observed average loan demand decreased with increase in per capita farm holding, but only the mean difference was significant with respect to participation. Likewise, participation and the corresponding credit limits seem to increase with livestock holdings. The mean differences were not statistically significant, however. Participation in credit market is markedly higher among male-headed households. Correspondingly, rate of participation and observed mean loan size was found to be statistically different between the gender of household heads.

As far as the distribution of credit services by specific village variables is concerned, population density and the presence of irrigation projects increased significantly the rate of household participation in program credit. On the other hand, communities that are located distant from market and affected by the recent conflict have significantly lower observed loan demands.

In the subsequent part of the paper, we run a rigorous statistical test whether these and other variables influence household's decision to participate and the amount of loan demanded from the program.

Participation in program credit

In line with our expectations**,** participation in program credit is closely related with the household being owner operator of its own land. Female-headed households were, hence, less likely to participate. Furthermore, households with no female adults, have lower participation rates in credit markets. These point to the fact that the eligibility criteria are strictly adhered to in targeting credit services to clients. This may lead to the exclusion of relatively poor sections of the society, especially those who lack the resources to operate their own land. The declared targeting of nonproduction credit to female-headed households by the program does not seem to have led to significant increase in participation of female-headed households. Participation seems to have

increased with age of the household head although at a decreasing rate as can be seem from the coefficient of the age squared. The presence of household members in primary and secondary education seem to have opposite effect on participation where the former led to an increase while the latter caused a fall in participation. This may be related to the latter's capacity to generate cash income given their higher educational attainment.

On the other hand, almost all asset holdings of households seem to have insignificant effect on participation. Livestock holding, on the other hand, was found to be significantly and negatively related to the household's participation in program credit perhaps implying that households may revert to selling their livestock units to solve their liquidity constraints. Finally, households in densely populated communities have significantly higher likelihood of taking part in the program. This could perhaps be related to population pressure induced increased intensification (e.g. fertilizer use) of production which increases demand for credit (see Hagos and Holden, 2002).

Loan demand

Households operating their own land have higher observed loan demand compared to those renting-out their land. This is also strengthened by the coefficient for oxen, which is positively related to the size of loan demanded. Households with oxen holding are likely to operate their own land. Female-headed households were also found to have lower observed credit demand. Number of household members with secondary education has led to a decline in loan demand.

As far as asset holding are concerned, households with no oxen holding are found to have significantly lower loan demand than those having one or more. Households without female adult labor were also found to have lower loan demands than with adult female members. On the other hand, households with more livestock holding have significantly lower loan demand. Finally, households in communities that are densely populated have also significantly higher loan demands.

Credit impact

Off-farm and credit

In Table 5, we report the determinants of wage- and self-employment. Participation in wage employment seems to be significantly explained by the age of the household head and the regime the household finds itself in food markets. Households, which are self-sufficient in food, seem to be less likely to take part in wage employment.

Moreover, the predicted wage rate influence the decision whether to participate positively pointing to the fact that with increasing wage rate households are likely to take part in labor markets. Households without female adult labor were also likely to take part although the coefficients for number of female and male adults are insignificant although they have positive signs.

On the other hand participation in self-employment activities, is significantly and positively explained by whether the head of the household has any kind of acquired skill or is educated, the number of male adults and the household's food situation. More educated and highly skilled households are likely to engage themselves in more paying self-employment activities. Like in the case of wage employment, net buying (selling) households are likely to take part in self-employment activities, and more so if they are net buying ones. Other variables such as the absence of female adults, livestock holding, the age of the household, rainfall variability and, contrary to our expectations, participation in program credit influence negatively (at 10 percent) the decision whether to participate in self-employment. This could perhaps be explained by the fact that a disproportionately high amount of program loan is granted for the purchase of agricultural inputs (e.g. fertilizer).

The impact of program credit on changes in the level of off-farm income is different with respect to the level of income derived from wage employment vis-à-vis the income derived from self-employment. The effect of program on the change in the level of income derived from wage employment was positive but statistically insignificant in all models considered (see Table 6). On the other hand, program credit has a positive and significant effect, albeit at 10 percent, on changes in level of income derived from self-employment[22]. This result was consistently reported in the Heckman and Deaton models. Moreover, village level variations seem to explain the changes in the level of income both in wage and self-employment. The tabias affected by the war have consistently negative coefficients in the three models perhaps pointing to the negative effect of the conflict on labor mobility and wage employment. On the other hand, in the income changes due to self-employment, tabias close to major markets have consistently positive coefficients. This may point to an interesting link between market access, choice of off-farm activities and the returns to credit.

[22] These results are consistent even when we consider instead the impact of credit on absolute levels of off-farm income derived from wage and self-employment for 1997 and 2000 separately.

Credit and consumption expenditure

Regression results on the effect program credit on changes in consumption expenditure are reported in Table 8.

The impact of participation in program credit and observed credit demand on changes in per capita consumption is positive and highly significant. Since the expenditure equation is in logarithmic form, the coefficients of the credit measures the response elasticity. A 10 percent increase in borrowing increases consumption expenditure by 0.35 percent. This reflects the long-term effects of borrowing on changes in consumption expenditure.

A few other factors seem to have explained the change in consumption expenditure. The difference in number of members with primary education was found to be positively correlated with changes in consumption expenditure. Access to non-farm income was also positively related to change in consumption expenditure perhaps pointing to the effect of program credit on consumption expenditure through household's increased participation in off-farm employment. This effect seems to decrease with distance to market. Furthermore, difference in male labor endowment seem also to contribute negatively to changes in consumption expenditure perhaps underlining the negative marginal returns to labor given the imperfections in labor market in the region.

6. Conclusion

Participation in program credit and observed loan demand was closely related to the household being owner operator of its own land. Female-headed households were, hence, found to be less likely to take part in program credit and demand lower loan. These point to the fact that the eligibility criteria are strictly adhered to in targeting credit to clients. It may also imply that the program excludes relatively poor sections of the society, especially those who lack the resources to operate their own land. The declared targeting of non-production credit to female-headed households and unemployed youth by the program does not seem to have led to significant increase in participation of female-headed households. Number of household members with primary education seem to increase participation while those with secondary education has led to a decline in participation and loan demand. Livestock holding was found to be negatively related to the household's participation in program credit and amount of loan demanded perhaps implying that asset rich households may rely

on their assets to solve their liquidity constraints which, in turn may point towards good functioning of livestock markets or to reluctance of asset rich farmers to join peer group monitored credit market. Finally, households in densely populated communities have significantly higher likelihood of taking part in the program and demand significantly higher loans, which may underline the increased loan demand linked to population density-induced intensification.

The effect of program on the change in the level of income derived from self-employment was positive and statistically significant while program credit has an insignificant effect on income derived from wage employment underlining the importance of access (capital) constraints to self-employment. The impact of participation in program credit and observed credit demand on changes in per capita consumption is positive and highly significant. A 10 percent increase in borrowing was found to have led to 0.35 percent increase consumption expenditure. This reflects the long-term effects of borrowing on changes in consumption expenditure. The evidence points to the fact that micro credit plays an important role in poverty reduction either through consumption growth or increased diversification of household income. It must be noted, however, that it may not necessarily be the poorest of the poor who benefits from it.

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Table 1: Descriptive statistics

	1997		2000	
Variable	**Mean**	**St. Dev.**	**Mean†**	**St. Dev.**
Households that participated in program credit during the last five years	-	-	0.711	0.023
Per capita credit demanded in the last five years	-	-	230.63	21.15
Households that participated in program credit	0.570	0.024	0.324	0.468
Per capita credit demanded	81.82	161.825	261	574.16
Per capita credit demanded for the purchase of agricultural inputs	-	-	232.34	596.098
Consumption expenditure per adult equivalent	528.50	576.45	651.27	603.346
Participation in self-employment	0.304	0.460	0.339	0.474
Income from self-employment per adult equivalent	133.16	361.80	52.439	133.68
Participation in wage-employment	0.065	0.247	0.329	0.470
Income from wage-employment per adult equivalent	12.773	76.405	64.771	180.444
Sex of household head (female=1;0= otherwise)	0.142	0.018	0.137	0.345
Age of household head	49.50	15.79	52.177	15.206
Educational standing of head (read and write or higher =1;0= otherwise)	0.176	0.516	0.349	0.477
Heads with any kind of skill (yes= 1; 0= otherwise)	0.030	0.171	0.242	0.429
Adult female household members	1.143	0.629	1.291	0.784
Adult male household members	1.166	0.954	1.344	1.018
Consumer-worker ratio	1.204	0.050	2.840	1.748
Household size (adult equivalent)	4.69 (3.98)	2.305 (1.93)	5.46 (4.55)	2.33 (2.03)
farm size per adult equivalent (in ha)	0.344	0.371	0.351	0.383
Owner operated	0.947	0.224	0.874	0.331
oxen holding per adult equivalent	0.245	0.296	0.186	0.323
livestock holding per adult equivalent (in tropical livestock units)	0.377	0.566	0.413	0.543
Children in elementary schools	0.321	0.690	1.149	1.252
Children in secondary schools	0.027	0.217	0.212	0.638
Distance to major (wereda) market in hours	2.47	0.055	2.47	0.055
Access to irrigation projects (yes=1; otherwise=0)	0.073	0.260	0.172	0.377

Table 2: Program distribution by selected socio-economic variables

By	Participation (n= 351)	Loan demand (n= 351)
Zones		
Southern zone	0.705	1567.30
Eastern zone	0.600	1141.49
Central zone	0.814	728.08
Western zone	0.711	494.65
F-test	4.12 (0.006)	8.92 (0.000)
Per capita farm holding (in tsimid ≈ 0.25 ha)		
Less than or equal to 1	0.745	951.49
Greater than 1	0.67	932.90
t-test	-2.225 (0.026)	-1.192 (0.234)
Per capita oxen holding		
Less than or equal to 0.1	0.67	925.68
Greater than 0.1	0.76	963.162
t-test	2.598 (0.009)	1.464 (0.144)
Per capita livestock holding excluding oxen (in tropical livestock unit)		
Less than or equal to 0.214	0.68	860.84
Greater than 0.214	0.75	1025.34
t-test	1.401 (0.162)	1.219 (0.223)
Sex of household head		
Male	0.774	1024.8
Female	0.34	459.70
t-test	6.765 (0.000)	2.758 (0.006)
Conflict affected areas		
Not affected	0.70	1093.62
Affected	0.74	585.55
t-test	-0.894 (0.371)	2.698 (0.007)
Population density		
Sparse	0.587	807.98
Dense	0.791	878.17
t-test*	-4.211 (0.000)	-0.873 (0.383)
Irrigation project		
With	0.806	864.17
Without	0.689	847.36
t-test	-1.839 (0.066)	-0.370 (0.711)
Distance to market		
Close	0.681	1252.213
Far	0.737	698.41
t-test	-1.171 (0.242)	3.43 (0.000)

* P-values are given in the parenthesis.

Table 3: Determinants of participation in the credit program (probit)

Dependent variable: Participation (0/1)		
Variable	**Coef.**	**Robust St. error**
Household characteristics		
Age of head	0.064	0.031**
Age squared	-0.006	0.0002**
Sex of head (female)	-0.689	0.337**
Educational standing (literate)	0.061	0.254
Head with skill	0.067	0.186
Ln (consumer–worker ratio)	-0.010	0.152
Physical and human capital		
Ln (no. of household members with primary education)	1.112	0.660*
Ln (no. of household members with secondary education)	-1.762	0.940*
Without female adult	-1.117	0.356***
Ln (female adult labor)	-0.007	0.301
Without male adult	0.152	0.334
Ln (male adult)	0.051	0.258
Ln (farm holding per adult equivalent)	0.001	0.131
Whether land is owner operated	0.318	0.176*
Without livestock holding	-0.104	0.223
Ln (tropical livestock unit per adult equivalent sub oxen)	-0.283	0.127**
Without oxen holding	-0.246	0.309
Ln(oxen per adult equivalent)	-0.037	0.230
Village characteristics		
Access to irrigation project dummy	0.491	0.381
Access to off-farm income dummy	-0.011	0179
Population density dummy	0.791	0181***
Conflict dummy	0.247	0.217
Ln (distance to major market)	0.014	0.089
_cons	-1.627	0.812**
		Number of obs = 341
		Wald chi2 (23) = 90.93
		Prob > chi2 = 0.000
		Log likelihood = -155.368
		Pseudo R2 = 0.244
		Percentage of correct prediction = 0.93

*, **, *** Are levels of significance at 10, 5 and 1 percent respectively.

Table 4: Regression on observed credit demand (Interval regression)

Dependent variable: ln (loan size)		
	Coef.	**Robust Std. Err.**
Household characteristics		
Age of head	0.054	0.064
Age squared	-0.001	0.001
Sex of head (female)	-1.182	0.674*
Educational standing (literate)	0.001	0.360
Head with skill	0.193	0.346
Ln (consumer–worker ratio)	0.197	0.268
Physical and human capital		
Ln (no. of members with primary education)	0.872	0.527
Ln (no. of members with secondary education)	-4.095	2.231 *
Without female adult	-2.075	0.820**
Ln (female adult labor)	0.438	0.423
Without male adult	-0.496	0.653
Ln (male adult)	0.161	0.412
Ln (farm holding per adult equivalent)	- 0.001	0.245
Whether land is owner operated	0.632	0.334 **
Without livestock holding	0.083	0.437
Ln (tropical livestock unit per adult equivalent sub oxen)	-0.597	0.221 ***
Without oxen holding	-1.305	0.571 **
Ln(oxen per adult equivalent)	0.679	0.376*
Village characteristics		
Access to irrigation project dummy	-0.012	0.535
Access to off-farm income dummy	-0.127	0.316
Population density dummy	1.252	0.345***
Conflict dummy	-0.108	0.351
Ln (distance to major market)	-0.154	0.183
_cons	2.183	1.662
/sigma	2.530	0.133 ***
		obs = 341
		Wald chi2 (24) = 94.64
		Log likelihood = -698.109
		Prob > chi2 = 0.000
		265 uncensored observations
		76 left-censored observations

*, **, *** are levels of significance at 10, 5 and 1 percent respectively.

Table 5: Participation in wage and self-employment

	Wage employment		Self-employment	
Variables	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
Household characteristics				
Age of head	0.078	0.032**	0.001	0.028**
Age squared	-0.001	0.0001**	-0.0001	0.0002
Sex of head (female)	-0.196	0.317	-0.222	0.416
Educational standing	-0.001	0.190	-0.396	0.214 **
Consumer-worker ratio	0.026	0.104	0.074	0.076
Head with skill	0.079	0.246	0.771	0.262***
Physical and human capital				
Members with primary	0.049	0.139	-0.255	0.073 ***
Members with secondary	0.354	0.471	0.0183	0.343 **
Predicted wage	0.408	0.243*	0.199	0.249
Without female adult	1.903	1.068*	-1.48	0.749 **
Female adult labor	0.220	0.168	-0.118	0.152
Without male adult labor	0 .172	0.337	-0.113	0.443
Male adult labor	-0.029	0.107	0.297	0.134**
Farm holding per adult eqv.	0 .107	0.360	0.720	0.512
Owner operated	0.370	0.110	-0.037	0.228
Without oxen	-0.227	0.269	-0.099	0.258
Oxen holding per adult eqv.	-0.483	0.435	-0.077	0.444
Without livestock holding	-0.237	0.212	-0.133	0.121
Livestock holding per adult eqv.	-0.194	0.244	-0.426	0.155***
Transferred income	-0.001	0.001	-0.001	0.0004
Net buyer in food	6.356	1.068***	4.589	1.242***
Net seller in food	6.257	1.175 ***	3.085	1.220 **
Village characteristics				
c.v. in rainfall	0.238	0.221	-0.5129	0.269**
Distance to major market	-0.067	0.068	-0.191	0.176
Access to credit				
Predicted loan size	-0.236	0.180	-0.315	0.191*
	Number of obs = 322		Number of obs = 322	
	Wald chi2 (15) = 341.54		Wald chi2 (15) = 418.28	
	Prob > chi2 = 0.000		Prob > chi2 = 0.000	
	Log likelihood = -170.589		Log likelihood = -169.987	
	Pseudo R2 = 0.110		Pseudo R2 = 0.175	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively. We run village fixed effects to account for village level heterogeneity.

Table 6: The effect of participation and amount of loan demanded on level of income earned from wage employment

	Heckman model		Deaton model	
Variable	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
Household Characteristics				
age of head	-0.007	2.141	-0.003	0.084
Sex of head (female)	0.122	0.012	0.331	0.720
Educational standing	-0.434	0.744	-0.398	0.345
Head with skill	0.152	0.389	-0.108	0.451
Ln (consumer–worker ratio)	-0.255	0.268	-0.282	0.267
Physical and human capital				
Members with primary edu.	0.060	0.201	-0.012	0.197
Members with secondary edu.	-0.628	0.472	-0.913	0.492 *
Without female adult	0.419	0.767	-0.796	1.170
Ln (female adult)	-0.188	0.554	-0.635	0.624
Without male adult	0.036	0.618	-0.039	0.627
Ln (male adult)	0.105	0.412	0.129	0.408
Ln(farm holding per adult eqv.)	0.153	0.264	0.108	0.266
Whether owner operated	-0.154	0.391	-0.372	0.446
Without oxen holding	-0.009	0.616	0.027	0.597
Ln (oxen holding per adult eqv.)	-0.131	0.475	-0.034	0.474
Without livestock holding	0.354	0.463	0.314	0.464
Ln(livestock holding per adult eqv.)	0.001	0.245	0.112	0.242
Ln(transferred income)	-0.059	0.084	-0.059	0.084
Ln(risk aversion coefficient)	0.007	0.159	0.023	0.161
Access to credit				
Predicted loan size	0.029	0.076	0.059	0.752
_cons	-0.104	1.441	0.567	1.271
imr	-9.006	2.879 ***	-6.025	3.349*
phat	-	-	10.68	7.797
Phat^2	-	-	-20.39	18.429
Phat^3	-	-	16.37	12.334
	Number of obs = 322		Number of obs = 322	
	F (36, 285) = 2.53		F (38, 283) = 3.32	
	Prob > F = 0.0000		Prob > F = 0.0000	
	R-squared = 0.1736		R-squared = 0.1825	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively. We run village fixed effects to account for village level heterogeneity.

Table 7: Impact of participation and amount of loan demanded on level of income earned from self-employment

Variable	Heckman model			Deaton model		
	Coef.	Robust Err.	Std.	Coef.	Robust Err.	Std.
Household characteristics						
age of head	-0.000		0.008	-0.001		0.007
Sex of head	0.065		.448	0.039		0.449
Educational standing	0.104		.311	0.090		0.311
Head with skill	0.018		.361	0.049		0.386
Ln(consumer-worker ratio)	-0.066		.204	-0.054		0.208
Physical and human capital endowments						
Members with primary education	0 .119		.173	0.116		0.171
Members with primary education	-0.031		.453	0.005		0.447
Without female labor	0.621		.734	0.579		0.735
Ln (female adult labor)	-0.225		.356	-0.201		0.357
Without male labor	0.265		.452	0.293		0.456
Ln (male adult)	0.085		.338	0.094		0.342
Ln (farm holding per adult eqv.)	-0.220		.211	-0.213		0.214
Whether land is owner operated	0.191		0.287	0.179		0.288
Without oxen holding	-0.346		0.445	- 0.387		0.446
Ln (oxen holding per adult eqv.)	0.206		0.322	0.228		0.325
Without livestock holding	0.202		0.331	0.244		0.330
Ln (livestock holding per adult eqv.)	-0.059		0.162	-0.080		0.161
Ln(transferred income)	-0.014		0.058	-0.011		0.059
Ln(risk aversion coefficient)	0.047		0.115	0.050		0.115
Access to credit						
Predicted loan	0.085		0.050*	0.092		0.051*
_cons	-1.225		0.865	-0.387		0.763
imr	-6.752		1.815 ***	-6.025		3.349*
phat	-		-	-		-
Phat^2	-		-	10.778		3.751***
Phat^3	-		-	-9.053		4.523**
	Number of obs = 322			Number of obs = 322		
	F (36, 285) = 5.74			F (37, 284) = 5.95		
	Prob > F = 0.000			Prob > F = 0.000		
	R-squared = 0.317			R-squared = 0.318		

*, **, *** are levels of significance at 10, 5 and 1 percent respectively. We run village fixed effects to account for village level heterogeneity.

Table 8: Impact of participation and level of credit obtained on changes in household expenditure per adult equivalent (2sls)

Variable	Coef.	Robust Std. Errors±
Household characteristics		
Age of head	0.090	0.070
Age squared	-0.001	0.001
Sex of head	1.152	0.689
Educational standing	0.424	0.408
Ln (consumer-worker ratio)	0.610	0.391
Physical and human capital endowments		
Ln (difference in members with primary education)	1.519	0.380***
Ln (difference in members with secondary education)	2.322	2.166
Without female adult labor	-0.627	0.437
Ln(difference in female adult labor)	1.014	1.322
Without male adult labor	-0.420	0.415
Ln(difference in male adult labor)	-0.082	0.951*
Ln(difference in farm holding per adult eqv.)	0.059	0.152
Whether land owner operated	-0.183	0.650
Ln(difference in livestock holding per adult eqv.)	0.165	0.183
Ln(difference in oxen holding per adult eqv.)	-0.398	0.352
Access to non-farm employment	1.170	0.434***
Non-farm*distance to major market	-1.599	0.472***
Migrant member	-0.611	0.496
Access to irrigation	-0.110	0.446
Access to credit		
Predicted loan size	0.353	0.139***
	n= 247	
	R^2 = 0.191	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively. ±The bootstrapped standard errors were also consistent with the results reported here confirming the significance of the coefficient for predicted loan demand and off-farm income.

Participation of rural households in food-for-work programs in northern Ethiopia: Application of selection models

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Abstract

The paper attempted to identify factors that most explained household's decision whether, and how much, to participate in food-for-work projects. We used econometric estimation techniques that accounted for selection bias under different distributional assumptions.

The probability of participation was found to be mainly related to the availability of adult labor and other factors related to household poverty. The degree of participation also depended overall on poverty and poverty related factors. However, livestock rich households were found to have supplied more labor units to FFW projects pointing to a leakage in targeting. This leakage might be caused by imperfections in factor markets, and hence, related as much to structural issues as to operational failures.

Key concepts: Food-for-work, poverty targeting, factor market imperfections, sample selection bias; Ethiopia

1. Introduction

Ensuring access to food for the poor constitutes a major challenge to policy makers and development practitioners. In many developing countries food assistance programs, which take mainly the forms of free food distribution (FA) and food-for-work (FFW), are used as means of transferring food to the poor. Free food assistance programs seek to target the needy not only for cost considerations but also to reduce the potential disincentive effects on food production and the disruptions it may cause to local markets (Maxwell et al, 1994; Webb et al, 1992; FDRE, 2000; Jayne et. al., 2001; Barrett et al., 2001). Nonetheless, there is growing empirical evidence that targeting error is common in free food assistance (see Barrett et al, 2001).

In response to these concerns, governments[23] have placed emphasis on alternative food transfer mechanisms such as 'food-for-work' (also known as workfare or employment generation scheme) in which a lower daily wage is predetermined to be paid to households that participate in labor-intensive public works such as road construction, land conservation, dam construction, etc. These schemes, besides targeting food to the poor, have the advantage of constructing public works, which

[23] The government of Ethiopia, for instance, commits itself to allocate more than 80 % of the food aid delivery to FFW programs (FDRE, 1996; Humphrey, 1999).

may have positive long-term effects on agricultural productivity and rural development (FDRE, 1996; Holden and Binswanger, 1998; Gebremedhin and Swinton, 2001; Barrett et al., 2001).

FFW funded programs target those that are physically able to work and are expected to effectively select the poor, because of the lower wage level and the nature of the work (Holden and Binswanger, 1998; Teklu and Asefa, 1999; Gebremedhin and Swinton, 2001). In spite of this, there are growing concerns that such programs may not target selectively the poor (Clay et al, 1999; Jayne et al. 2001; Gebremedhin and Swinton, 2001; Barrett and Clay, 2001).

Several explanations have been provided in the literature for errors of targeting in FFW programs. Teklu and Asefa (1999), in the case of in Botswana and Kenya, emphasized the operational and institutional issues related to FFW program implementation where FFW wage rates were set too high, inducing substitution of money wage work in the local market for FFW, and made rationing necessary. Gebremedhin and Swinton (2001) showed that the multiple objectives set for FFW programs – to deliver food to the poor, to build public works where necessary and project feasibility considerations – make perfect targeting difficult. Others have argued that limited resources available for FFW projects limit the geographic reach of the program and resulting, in some cases, uneven regional distribution of FFW programs (Jayne et al 2001).

At the heart of the self-selection hypothesis of FFW schemes lays the necessity of low wage determination to discourage non-poor households from participating. This hypothesis is based on the assumption of the existence of unconditional link between income and reservation FFW wages. In a standard farm household model, a household participates in off-farm work when the market wage is equal to the shadow value of its time (see, Singh et al, 1986; Gebremedhin and Swinton, 2001). Households with substantial endowments of productive assets (e.g. land, human capital and livestock) enjoy relatively high marginal returns to labor from self-employment and so have higher shadow wage rates than their less wealthy, lower income counterparts. So if one wants to make an unrestricted offer of employment but have only the poor to take up that offer, setting a low wage rate effectively induce self-selection into the program by the poor and out of the program by the wealthy. This argument is, however, challenged both on theoretical and empirical grounds.

First, factor markets in land, labor and capital in the developing world are often incomplete. Labor and cultivable land do not necessarily move freely between households to equalize land/labor ratios (see Sadoulet and De Janvry, 1995; Barrett and Clay, 2001; Barrett et al, 2001). Barrett and Clay (2001) showed that the inefficiency in FFW targeting might stem directly from the fact that higher income households are endowed with more labor per unit land or livestock holding, and factor markets in land, labor and livestock do not function well. These two phenomena break the unconditional link between income and reservation FFW wages on which the theory of self-targeting depends. Therefore, household's willingness to participate in FFW program need not be strongly inversely related to household pre-transfer income on unconditional basis. As well as being the reason why FFW programs are needed, market failures might be the underlying obstacles as to why the mechanism of self-targeting might not work as intended.

The main objective of this paper is, hence, to assess factors that explain household's decision whether to participate and the degree of participation in FFW using a cross section of 400 households in northern Ethiopia. By doing so, we want to see whether poverty issues played an overriding role in the targeting process or whether there is a significant leakage to asset rich households.

We assume that the household's decision with respect to involvement in FFW programs involves (a) the choice whether to participate, and (b) having decided positively the household chooses the amount of labor units it decides to supply given constraints it faces in labor endowments and home time demand and its food requirements. In contrast to earlier studies, (see Gebermedhin and Swinton, 2001; Clay et al, 1999; Jayne et al. 2001), we account for possible selection bias in our estimation strategy.

Part II presents the econometric model and hypotheses developed for testing followed by description of the study site, sampling procedure and variables used in the regression. Part IV presents summary statistics and results of mean separation tests. Part V presents econometric estimation results and discussions. Finally, VI concludes.

2. Econometric model specification

Let the household's decision to supply a given number of labor man days be given by:

$$y_1 = x_1\beta_1 + u_1 \qquad (1)$$

where y_1 will depend on the wage offer (which is constant in this case), the quantity and quality of labor units supplied, the availability of alternative employment opportunities, the household's demand for production and home time. The participation equation is given by:

$$y_2 = 1[x\delta_2 + v_2 > 0] \qquad (2)$$

where (x, y_2) are always observed whereas y_1 is observed only when $y_2 = 1$. We assume that (u_1, v_2) is independent of x with mean zero implying that x is exogenous, and $v_2 \sim N(0,1)$. The last assumption is needed to derive conditional expectation given the selection sample. Furthermore, assume that $E(u_1 \mid v_2) = \gamma_1 v_2$, which requires the linearity of the population regression of u_1 on v_2. This implies that (u_1, v_2) is bivariate normal.

To derive an estimable equation, let (y_1, y_2, x, u_1, v_2) denote a random draw from the population. Since y_1 is observed only when $y_2 = 1$, what we can hope to estimate is $E(y_1 \mid x, y_2 = 1)$.

Under the assumptions we outlined above and equation (1)

$$E(y_1 \mid x, v_2) = x_1\beta_1 + E(u_1 \mid x, v_2)$$

$$= x_1\beta_1 + E(u_1 \mid v_2)$$

because (u_1, v_2) is independent of x by assumption.

$$= x_1\beta_1 + \gamma_1 v_2 \qquad (3)$$

If $\gamma_1 = 0 \Rightarrow u_1$ and v_2 are uncorrelated which, in turn, implies $E(y_1 \mid x, v_2) = E(y_1 \mid x) = E(y_1 \mid x_1) = x_1\beta_1$. In this case, lease square estimation of β is consistent.

If $\gamma_1 \neq 0 \Rightarrow u_1$ and v_2 are correlated, then

$$E(y_1 \mid x, y_2) = x_1\beta_1 + \gamma_1 E(v_2 \mid x, y_2)$$

$$= x_1\beta_1 + \gamma_1 h(x, y_2)$$

If we knew $h(x, y_2)$, then, we could estimate β_1 and γ_1 from the regression of y_1 on x_1 and $h(x, y_2)$ using only the selected sample. Because the selected sample has $y_2 = 1$, we need only to find $h(x,1)$. But $h(x,1) = E(v_2 \mid v_2 > -x\delta_2) = \lambda(x\delta_2)$, where $\lambda(.) \equiv \phi(.)/\Phi(.)$ is the inverse Mills ratio, and so we can write:

$$E(y_1 \mid x, y_2 = 1) = x_1\beta_1 + \gamma_1\lambda(x\delta_2) \qquad (4)$$

Equation (4) can be estimated using Heckman's selection model (Heckman, 1979). The estimators obtained from (4) are consistent and $\sqrt{N}$ – asymptotically normal. Identification in this model requires that x_1 is not perfectly correlated with $\lambda(x\delta_2)$. Strictly speaking this could be assured as long as $\lambda(.)$ is a nonlinear function, though it helps for statistical power if x includes some variables not included in x_1. Thus, we to tried to ensure the nonlinearity of $\lambda(.)$ by using linear functional specification in the selection equation while the outcome equation has a log-linear specification.

The Heckman model is sensitive to misspecification problems, especially violation of assumptions of normality and homoskedasticity of the error terms. In using the Heckman model, it is not possible to know whether these assumptions are violated because it is difficult to test for these misspecifications. This is because when there is self-selection problem $(\gamma_1 \neq 0)$, obtaining a consistent estimate for the asymptotic variance of β is complicated (Wooldridge, 2002).

Different models have been proposed as a solution to the possible misspecification problems by focusing on relaxing the distributional assumptions. Let's assume the distribution of (u_1, v_2) is unknown with certainty but still suppose that $\begin{pmatrix} u_1 \\ v_2 \end{pmatrix}$ is independent of $\begin{pmatrix} x \\ x_1 \end{pmatrix}$. We do not assume normality of (u_1, v_2). Given no distributional assumptions of (u_1, v_2), Newey (1988) and Andrews (1989) used a two-step procedure using a series of approximation to estimate $\lambda(.)$ using polynomial terms. Ahn and Powell (1993) followed a two-step procedure where in the first stage a nonparametric regression estimator for the selection variable and in the second step a weighted instrumental variables estimator is used. Deaton (1997), following a variety of the first one, estimated a polynomial form of the predicted probabilities to be used in the second stage.

We followed Heckman and Deaton's selection models in our estimation strategy to check the robustness of our estimation results to different distributional assumptions. Furthermore, in the Deaton model, we could run different specification tests: normality tests using skewness and kurtosis as well as the Shapiro-Wilk and Shapiro-Francia tests (Gould and Rogers, 1991; Gould, 1991) and homoskedasticity using the Cook and Weisberg (1983) test. The tests showed the presence of heteroskedasticity

and violation of the normality assumption of the error term. We tried linear, log-linear and (reduced[24]) translog functional forms in an attempt to eliminate the heteroskedasticity problem. Although it was not possible to eliminate the problem entirely, we selected the log-log functional form, which yielded the lowest χ^2 values. We corrected also for heteroskedasticity by estimating robust standard errors (White, 1980).

Hypotheses

The household's optimal decision on the number of labor man days it allocates to FFW can be derived from a household modeling assuming imperfections in labor market (see e.g. De Janvary, Sadoulet and Benjamin, 1998; Barrett et al, 2000). For our task here, it suffices to say that, the household's shadow wage rate is not equal to the opportunity cost of labor (i.e. wage rate) due to imperfections in labor (factor) market(s). The implication of this is that asset (e.g. labor, livestock, land and labor) rich households may self-select themselves to work for FFW at wage rate that is even less than their reservation wage. This may cause leakage in targeting of FFW for the relatively poor households.

We used different variables in the regressions as measures of household wealth (farm, oxen and livestock holdings per adult equivalent, adult labor endowment (both female and male). Farm size, oxen and livestock holding may have negative effect on the household's decision to participate and the level of participation pointing to effective targeting. However, it is also possible to observe the opposite effect pointing to imperfections in factor markets and, hence, imperfections in targeting. Household's labor endowment is expected to positively influence decision and level of participation. Higher consumer-worker ratio is also expected to add pressure on the household to exert additional effort to take part in FFW programs given that it is not labor constrained.

Access to other, perhaps more paying, off-farm work (as wage- or/and self-employment), reduces the household's likelihood and level of participation. We did not use household's access to off-farm employment as a regressor in the equations because of the potential endogeneity as many of the explanatory variables we used to explain participation in FFW may well explain participation in other off-farm

[24] We did not include interaction terms in to the equation to minimize multicollinearity problem in the estimation.

employment opportunities. In stead, we used instruments such as educational status of the head and whether the head possesses any kind of acquired skill. We hypothesize that household heads with better educational standing and skills may choose not to take part in FFW programs. Withdrawal of potential labor from the household due to schooling or increased home and farm production is likely to influence the household's decision to participate as well as degree of participation.

Furthermore, a host of village-level variables like distance to major markets, population density and agricultural potential (access to irrigation project) and the recent conflict may have influenced households' decision. We expect that households in remote communities are more likely to take part in FFW schemes because of the absence of alternative employment opportunities locally. Moreover, households in densely populated communities are more likely to participate in FFW unless there are constraints to access. The conflict may have disrupted FFW activities in the communities and may have as a result reduced household access to FFW. We used village–level fixed effect model to control for these effects in the regression for participation.

3. Setting, sampling procedure and data used

Tigray is the northern most region of Ethiopia. Drought and famine are more frequent in the region. Severe environmental degradation problems, mainly soil erosion and nutrient depletion, constrain agricultural production in the region[25]. There has been a huge flow of food aid since early 1970's. FFW programs have been very common in Tigray as a way of improving household food security but also as an important means of undertaking environmental rehabilitation programs (e.g. soil and water conservation and reforestation) and infrastructure development projects (see Webb et al, 1992; Catterson et al., 1994).

Off-farm employment opportunities are limited in Tigray. There is seasonal variation in terms of labor use and off-farm work demand. Moreover, there are a series of entry barriers to the labor markets in nearby urban areas, especially for unskilled labor (Woldehanna and Oskam, 2001). Participation and extent of off-farm employment is highest during the slack season, January to April, and lowest in the peak agricultural season, May to December. The lowest wage rate is Birr 7/day (about USD 1), where

[25] The region was also plagued by persistent political instability and civil war during the last two-three decades. The region was directly affected by the recent border conflict between Ethiopia and Eritrea.

as the highest is Birr 12-15 for the unskilled daily laborers. The wage rate for skilled workers (e.g. masons and carpenters) is three times higher than for the non-skilled daily laborers (Ibid). The dominant type of off-farm employment available locally is FFW. The wage rate, mostly in kind, from a FFW program is 25 percent less than a prevailing market wage rate for an unskilled daily worker (Woldehanna, 2000).

Every year FFW project needs of communities[26] are assessed and forwarded to the national government. The government then pledges for donors based on project needs. The acquired food is then redistributed to communities depending on the amount received from international donors. Once, FFW deliveries are allocated to weredas, the local administration prepares a list of participant households based on the following criteria: a) asset holding (mainly oxen or livestock); b) access to off-farm income and c) remittances received from migrant household members and finally 'ability to work'. Only those who are able to work are eligible because of the work requirements of FFW programs. The usual wage is 3 kilograms of grain (usually wheat) and 120 grams of oil per day[27]. Eligible households could then decide for themselves whether the daily wage (in kind) is worth the effort. Furthermore, whether households' access to FFW is constrained depends mostly on the amount of food made available to communities. We use this setting to answer our research question, which factors most affected whether, and how much, households choose to participate in FFW projects.

A survey on 400 households was carried out during 2001 in Tigray, Northern Ethiopia. The survey covered 16 villages (tabias) with diverse agro-ecological, distance to market, population density and agricultural potential conditions. The sample communities included only those in the highland (above 1500 meters above sea level) in four zones - eastern, southern, central and western. We classified villages by population density based a benchmark of 200 persons/ km^2. Communities 10 or more kms away (with no all weather roads) from a major (wereda) market are classified as having poor access to market. We selected 25 households from each community from a list of all households using a simple random sampling technique. Multi-purpose questionnaire was administered to gather information on household income, access to public safety nets (FFW and FA), off-farm income, and household

[26] This is usually done at the *wereda* (district) level.

[27] This ration is supposed to cover a daily subsistence requirement for six people, offering some 1,800 kcal per head (Holt 1983; Admasie and Gebre, 1985; UNEPPG, 1987 cited in Webb et al, 1992).

asset holdings alongside a host of other information related to household characteristics, and village level variables such as presence of irrigation projects, population density and distance to market.

4. Results and discussion

Descriptive statistics

We split the sample into two based on y_2 to calculate descriptive statistics when y_2 =1 and y_2 =0. This will be more informative given the desire to analyze the sample selection issue. The descriptive statistics and definition of variables used in the regressions are reported in Table 1.

Around 60 percent of the households participated in FFW by supplying on average about 22 labor man-days in 2000. On average non-participating household heads seem to be older than participating heads. Sex of the household seems to play a role with male-headed households more likely to be participants in FFW. Proportionately more educated heads and those with specific skills seem to take part in FFW projects. Moreover, households with more adult labor endowment (both female and male), number of members with primary or secondary, oxen holding are on average more likely to be participants in FFW. On the other hand, households with larger farm and livestock holding and have access to irrigation are more likely to be nonparticipants in FFW. At the community level, households with better market access, higher population density and not affected by the recent conflict are more likely to be participants. These results highlight the possibility of a selection bias in the data, which we will rigorously test in the forthcoming parts.

We tested the significance of few key socio-economic variables listed in Table 1 and few others on the participation and level of participation of households in FFW. The results are reported in Table 2.

At the household level, male-headed households had significantly higher participation rates and supplied higher labor man units than female-headed households. Households with access to off-farm income have significantly lower participation rates but supplied more, though not statistically significant, labor units than those without access.

Moreover, we witness significant differences in terms of participation and levels of participation across the four zones. Household participation in FFW is highest in the

central zone with 77 percent of the households taking part while western zone has the lowest participation rate with 48 percent of the households taking part. Similarly, the degree of participation is also highest in central zone and lowest in western. Households in the other two remaining zones are placed in between in terms of participation and levels of participation. Both point towards geographical differences in terms of the distribution of food-for-work activities in northern Ethiopia. Households in remote communities have significantly higher participation rates than those close to market.

We also looked at the distribution of supply of labor for FFW as such and with respect to household asset holdings and expenditure per adult equivalent (see from the graphs in Figure 1- Figure 6 in Appendix I). The distribution of labor supplied to FFW is, is censored at zero and, as would be expected, right skewed. **T**he distribution of labor supplied to FFW did not seem to have increased with household per capita asset holdings (livestock, owned farm size, oxen holding) and consumption expenditure (all in per adult equivalent terms). However, It seems to have increased, although at a decreasing rate, with household's labor endowment.

In the subsequent parts, we run a rigorous statistical test whether these and other variables influenced household's decision to participate and the amount of labor man days supplied for FFW.

Participation in FFW

The regression results explaining the household's decision to participate in FFW programs are reported in Table 3 below.

A series of household related factors were found to be significant in explaining the household's participation in FFW programs. Participation was found to be a decreasing function of the household head's age. Compared to male-headed households, female-headed households were less likely to take part in such programs perhaps because such households lack adult (especially male) labor. Households with higher consumer-worker ratio were likely to participate perhaps due to the increased pressure to meet their subsistence requirements. Furthermore, the higher the number of children enrolled in secondary schools, the less likely it was for the household to take part in FFW because this implies a withdrawal of potential participants. Both education and skill of household heads did not significantly contribute to participation.

In line, with our expectations, the household's labor endowment (both female and male) increased the household's participation in FFW. Households with more livestock holding, an important measure of wealth in developing countries, were less likely to participate. The coefficients for oxen and farm holding are not significant either. This implies that poor, but labor rich, households are selected into the programs which points towards efficacy of program targeting.

Many of the coefficients for the village dummies we introduced turned out to be highly significant. These point to the fact that households living in communities close to market (e.g. tabia4, tabia7, and tabia8) are less likely to take part in FFW programs perhaps because of the availability of other employment opportunities in nearby urban centers compared to households in remote communities. Households located in the central zone (tabia5, tabia10, tabia11 and tabia12) have higher participation rates than the households located in other zones, especially the western zone (tabia13, tabia14, tabia15 and tabia16). For location and other village related variables see Table 1A (Paper I).

Levels of participation

The estimation results of the level of household labor supply conditional on the household's decision to participate in FFW are given in Tables 4 and 5.

Both the Heckman and Deaton's selection model show the presence of a significant selection bias. The coefficients for the inverse Mills ratio and coefficients for the predicted probability and its polynomial forms (phat, phat^2 and phat^3) are significant in the Heckman and Deaton model respectively. Moreover, estimation results in both models are highly robust in spite of the differences in distributional assumptions.

Once households have decided to participate in FFW programs, the intensity of participation, measured by the number of labor man units supplied, increased with the head's age but at a decreasing rate as can be seen from the coefficient for age squared. The latter is of negative sign and is highly significant in the Heckman model but turned out to be insignificant in the Deaton model. The amount of labor supplied is also negatively related to the household being female-headed. This result is in line with the result in the probability of participation. Furthermore, increased number of

children enrolled in elementary school negatively influenced the decision to supply more labor perhaps due to increased demand for home time.

Asset holding of rural households seems to influence the amount of labor supplied. The household's farm holding is negatively correlated to the number of labor units supplied to FFW. This inverse relationship may point to the increased labor demand for farm production with increased farm holding. It may also show that farm rich households may not find it attractive to work for low wage activities such as FFW pointing that farm poor households supply more labor to FFW in order to meet their consumption requirements. On the other hand, the coefficient for livestock holding is significant and positive pointing that livestock rich households supplied more labor to FFW program perhaps pointing to a leakage in targeting. It may also point to the imperfections in livestock markets where households may face transaction costs in transferring livestock wealth into cash income easily. This is especially important as the price of livestock plummets with fall in crop prices as drought steps in.

As far as village level variables are concerned, households located in densely populated village supplied significantly lower labor units compared to communities in lower density areas. This may point to constraints in access to FFW due to high population pressure. The coefficient for the war dummy is also negative and highly significant perhaps pointing to the negative effect of the conflict on FFW programs in general and households' level of participation in particular.

In the Heckman model, the availability of irrigation projects does seem to significantly, albeit at 10 percent, decrease the amount of labor units supplied while in the Deaton model it is insignificant although its sign is consistently negative.

5. Conclusion

The main objective of the paper was to identify factors that explained household's decision to participate in and the amount of labor units it supplied to FFW projects. By doing so, we want to see whether poverty issues played an overriding role in the targeting process or whether there was a significant leakage to relatively wealthy households undermining the efficacy of FFW programs in targeting the poor.

The efficacy of FFW in targeting has an important implication in terms of the role of FFW as a safety net, mitigating the adverse real income shocks on households, especially those living below the poverty line. The empirical evidence emerging here is that FFW plays an important role in alleviating the food security needs of the

majority of rural households in northern Ethiopia with around 60 percent of the households participating. There are significant differences in the geographical distribution of participation and level of participation in FFW in the villages within the four zones in the region explained by distance to market, population density and the presence of political risk (war).

At the household level, household and demographic related variables such as sex and age of the household head, and the household's consumer-worker ratio explained participation in FFW. The presence of dependents in school also decreased participation. Moreover, the households' decision to participate is determined by their labor endowments (in terms of female and male adult labor force) implying that poor, but labor rich, households are selected into the programs pointing towards efficient program targeting.

Once households have decided to participate in FFW programs, however, the intensity of participation, measured by the number of labor man units supplied, is not strongly determined by the labor endowment of households. On the contrary, besides few other variables such age of household head and number of children enrolled in elementary school, asset holding of rural households seems to have influenced the amount of labor supplied. Households rich in livestock were targeted by the FFW program supplying more labor man units to FFW compared to asset (livestock) poor households. This may involve a serious leakage in targeting. This problem of targeting the poor but labor rich could be related at least as much to structural issues as to operational failures. The accuracy of the self-targeting component of FFW schemes may be fundamentally limited by factor market failures, which are pervasive in rural settings of the developing world.

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Table 1: Descriptive summary

Variables	If y_2 =0 (n= 160)		If y_2 =1 (n=241)	
	Mean	**Std. Err.***	**Mean**	**Std. Err.***
Age of household head	54.975	1.077	50.319	0.885
Male-headed household	0.797	0.031	0.904	0.018
Female-headed household	0.202	0.031	0.095	0.031
Education status of head (illiterate)	0.698	0.037	0.550	0.035
Education status of head (literate)	0.301	0.037	0.451	0.035
Head with no specific skill	0.804	0.044	0.726	0.023
Head with specific skill	0.196	0.044	0.273	0.023
Female adult labor	1.196	0.069	1.354	0.049
Male adult labor	1.189	0.122	1.445	0.075
Consumer-worker ratio	1.281	0.104	1.633	0.094
Members with primary education	0.900	0.116	1.315	0.137
Members with secondary education	0.187	0.083	0.228	0.067
Per capita own farm holding	1.256	0.136	0.886	0.186
Per capita oxen holding	0.161	0.022	0.194	0.028
Per capita livestock holding	0.355	0.027	0.337	0.039
Community with no irrigation projects	0.762	0.118	0.775	0.098
Community with irrigation projects	0.237	0.118	0.224	0.098
Distance to market (in hrs)	2.429	0.378	2.360	0.339
Population density less than 200 persons/km^2	0.412	0.147	0.348	0.135
Population density ≥ 200 persons/km^2	0.587	0.147	0.651	0.135
Communities not affected by war	0.725	0.117	0.663	0.132
War affected communities	0.275	0.117	0.336	0.132
Rainfall variability	27.994	2.848	27.042	2.695

* The standard errors are adjusted to stratification and clustering effects.

Table 2: Mean participation rates and corresponding levels of labor man-days allocated by various socio-economic variables

By	Participation	Number of labor man days	No. of obs.
Sex of household head			
Male	0.633	23.827	344
Female	0.418	14.854	55
t-test	3.062(0.002)	1.605(0.109)	
Access to off-farm employment			
With access	0.525	24.50	229
With no access	0.662	20.846	172
t-test	-2.805(0.005)	0.944(0.345)	
Whether land is owner-operated			
Owner-operated	0.600	24.141	348
Rented-out	0.601	21.122	50
t-test	-0.036(0.970)	0.781(0.435)	
Zones			
Southern zone	0.520	24.48	100
Eastern zone	0.630	24.865	100
Central zone	0.772	28.059	101
Western zone	0.480	10.45	100
F-test**	7.51 (0.000)	4.61 (0.003)	
Population density			
Sparsely populated	0.560	25.29	150
Densely populated	0.625	20.79	251
t-test*	-1.295(0.195)	1.1316 (0.258)	
Irrigation project			
With access	0.605	20.815	92
Without access	0.586	28.059	309
t-test	0.058(0.768)	-1.587 (0.113)	
Distance to market			
Close	0.547	19.584	201
Far	0.655	25.383	200
t-test	-2.210(0.027)	-1.517(0.131)	
Conflict affected areas			
Not affected	0.579	23.048	276
Affected	0.648	21.216	125
t-test	0.293(0.196)	0.441(0.659)	

* We test for the difference in mean. P-values are given in the parenthesis.
**Multiple mean comparisons. P-values are given in the parenthesis.

Table 3: Probit estimates of factors explaining participation in FFW

Dependent variable: probffw (0/1)			
Variable	**Coef.**	**Robust Std. Err.**	
age of head	-0.017		0.005***
female-headed	-0.563		0.218*
education status	0 .081		0.111
skilled head	-0.094		0.181
ln (consumer-worker ratio)	0.216		0.079***
ln (female labor)	0 .973		0.288***
ln (male labor)	0 .325		0.174
ln(those with primary education)	0.087		0.187
ln(those with secondary education)	-0.817		0.283***
ln(own farm holding)	0.089		0.099
ln(oxen holding)	0.022		0.111
ln(tropical livestock unit)	-0.149		0.088*
ln(distance to market)	0.068		0.169
tabia2	-0.415		0.549
tabia3	-0.115		0.121
tabia4	-1.632		0.176***
tabia5	0 .390		0.085***
tabia6	0 .246		0.086***
tabia7	-0.703		0.235***
tabia8	-0.198		0.098**
tabia9	-0.138		0.184
tabia10	0.286		0.072***
tabia11	0 .107		0.113
tabia12	0.260		0.170
tabia13	-1.014		0.097***
tabia14	-0.418		0.143***
tabia15	-0.058		0.193
tabia16	-1.435		0.144***
_cons	1.047		.343
		Number of obs =	390
		Wald chi2(12) =	184.28
		Prob > chi2 =	0.0000
		Log likelihood =	-206.43763
		Pseudo R2 =	0.2221

Table 4: Factors explaining level of participation (Heckman model)

Dependent variable: ln(number of labor units allocated to FFW)		
Variable	**Coef.**	**Robust Std. Err.**
inverse Mill's ratio	-4.465	0.855***
age of head	0.013	0.007*
age squared	-0.000	0.000***
female headed	-0.413	0.165**
education status	-0.021	0.119
ln(members with primary education)	-0.294	0.134**
ln(members with secondary education)	0 .441	0.314
skilled head	0 .048	0.120
ln(consumer –worker ratio)	-0.053	0.095
ln(female labor)	-0.066	0.120
ln(male labor)	0.152	0.106
ln(own farm holding)	-0.151	0.073*
irrigated land	-0.293	0.176*
ln(rainfall variability)	-0.222	0.178
ln(oxen holding)	0.028	0.090
ln(tropical livestock unit)	0.203	0.070***
ln(distance)	-0.063	0.060
population density	-0.326	0.162**
war dummy	-0.422	0.161***
_cons	2.908	0.814***
		Number of obs = 317
		F(19, 297) = 3.17
		Prob > F = 0.0000
		R-squared = 0.1275

Table 5: Factors explaining level of participation (Deaton model)

Dependent variable: ln(number of labor units allocated to FFW)		
Variable	Coef.	Robust Std. Err.
phat	15.801	7.227**
phat^2	-28.244	13.237**
phat^3	17.85	7.738**
age of head	0.015	0.007**
age squared	-0.000	0.000
female headed	-0.438	0.165***
education status	-0.051	0.120
ln(members with primary education)	-0.375	0.138***
ln(members with secondary education)	0.574	0.368
skilled head	0.069	0.118
ln(consumer –worker ratio)	-0.030	0.093
ln(female labor)	-0.107	0.123
ln(male labor)	0.163	0.106
ln(own farm holding)	-0.174	0.076**
irrigated land	-0.271	0.177
ln(rainfall variability)	-0.199	0.178
ln(oxen holding)	0 .026	0.088
ln(tropical livestock unit)	0.222	0.070***
ln(distance)	-0.069	0.059
population density	-0.313	0.160**
war dummy	-0.479	0.158***
_cons	1.242	1.538
		Number of obs = 317
		F (21, 295) = 3.22
		Prob > F = 0.0000
		R-squared = 0.1497

Appendix I

Fig. 1- Fig. 6: Distribution of FFW by different socio-economic variables

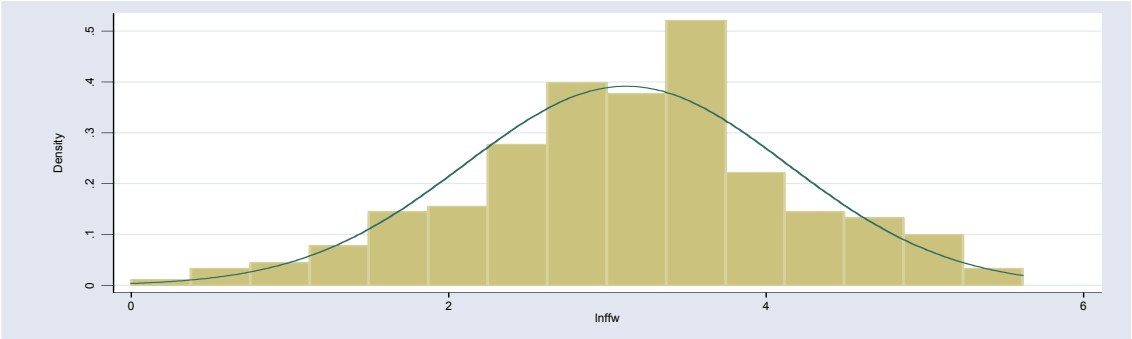

Figure 1: Distribution of ln(lmdffw)

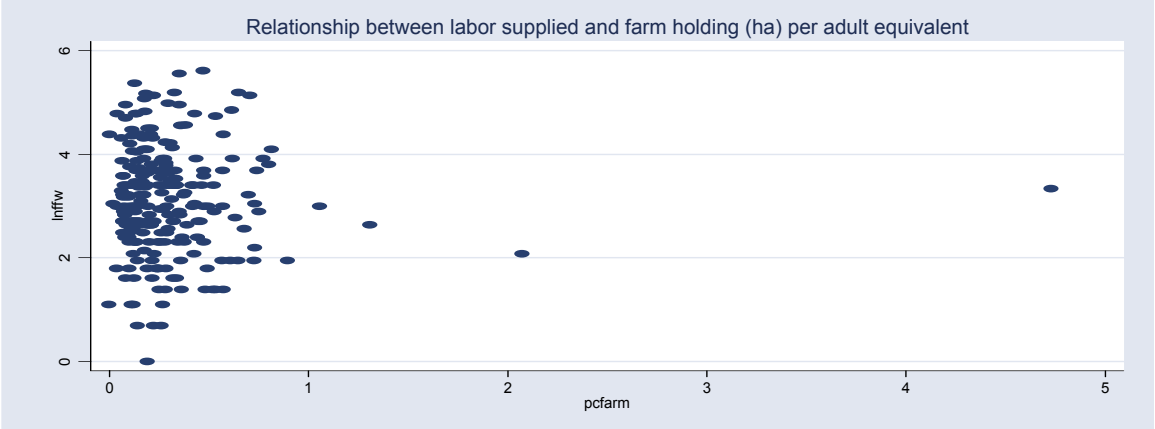

Figure 2: Relationship between labor supplied for FFW and farm holding

Figure 3: Relationship between labor supplied and oxen holding

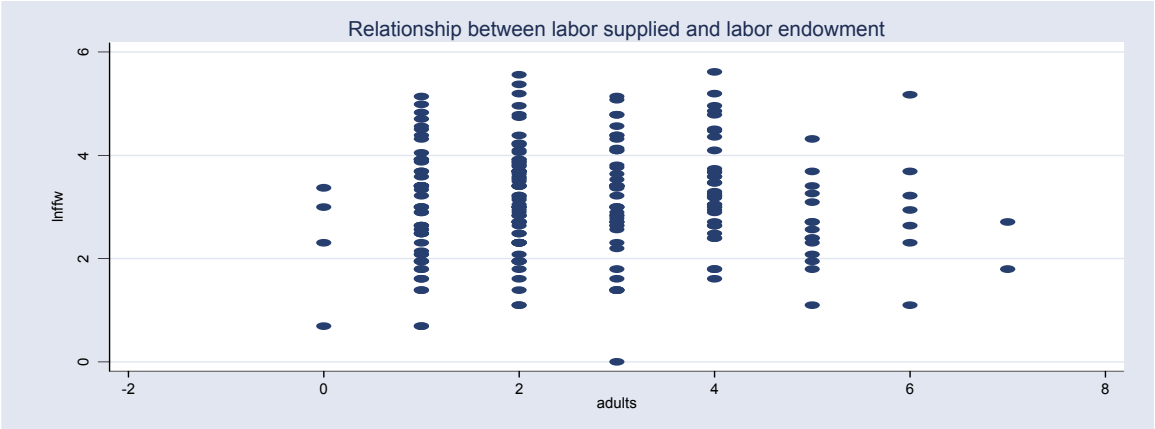

Figure 4: Relationship between labor supplied and labor endowment

Figure 5: Relationship between labor supplied and livestock holding

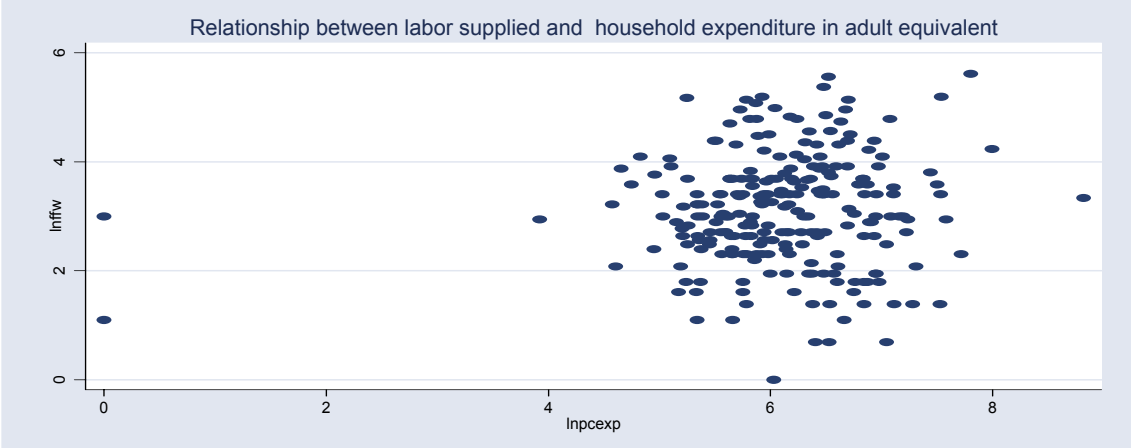

Figure 6: Relationship between labor supplied and household consumption expenditure

Fertilizer use decision of smallholder households in northern Ethiopia: Do risk preferences matter?

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Abstract

The paper examined the probability and level of fertilizer use and how these are affected by households' risk preferences while controlling for a host of biophysical factors, household level variables, institutional factors such as measures of tenure security and land tenure arrangements, market access conditions and village level effects. We controlled for possible selection bias in the estimation strategy.

Risk preferences seem not to adversely affect household's decision to use fertilizer. On the contrary, we found that the decision to use fertilizer increases with increases in household risk preferences. Fertilizer use intensity is not significantly affected by risk preferences, either. The results underscore that factors related to market access, liquidity constraints and asset poverty are crucial in determining the decision to use fertilizer among farm households in northern Ethiopia. This underlines the importance of alleviating household liquidity constraints, income poverty and the need for development of market infrastructure and marketing opportunities for households to reap the full potential of such innovations and thereby improve their well being.

Key terms: risk preferences, food security, market integration, fertilizer use, sample selection; Ethiopia

1. Introduction

Land degradation, mainly due to soil erosion and nutrient depletion, poses a serious problem on the livelihood of rural producers in the developing world. Ethiopia is one of the countries with the highest nutrient depletion rate in Sub-Saharan Africa (Stoorvogel and Smaling, 1990). This is no more evident than in the highlands of Tigray region, northern Ethiopia (Gebremedhin, 1998; Hagos et al., 1999), having serious implications on agricultural productivity and household food security.

Ensuring food security through increased crop productivity and reducing land degradation have become important tasks of development agents and policy makers in many developing countries. Various public led conservation programs have been going on in Ethiopia to avert soil erosion since the 1970s (see Gebremedhin, 1998; Hagos et al., 1999). Other efforts to address the problem of nutrient depletion and falling crop productivity have focused on increased use of chemical fertilizer. Since

recently, we see a shift in relative emphasis so that proportionately more resources are used to dealing with nutrient losses (World Bank, 1997; Pagiola, 1999).

In Ethiopia, the government initiated, with donor support, a green revolution type extension program, also known as Sasakawa Global 2000 (SG 2000), with the emphasis on increasing the productivity of food crops through a combined use of fertilizer and improved seed. The extension program reported some impressive results (Sasakawa-Global 2000, 1996; Mulat, et al. 1997). Pender et al., (2002) also showed that use of fertilizer increased predicted output in the region by 13 percent. In spite of these promising results, we still have problems attaining widespread adoption of fertilizer use in Tigray region. Fertilizer use in the region is estimated to be one of the lowest in the country (Hagos et al., 1999).

The literature has proposed several explanations for the low adoption of innovations, e.g. adoption of purchased inputs such as fertilizer, by smallholder households in developing countries. The most common explanation is the households' resistance to technological innovations that raise the mean and variability of income at the same time, i.e. raises income uncertainty. Sandmo (1971) showed that one effect of risk aversion on production choice of a profit-maximizing firm is to reduce effort. This implies that producers without perfect insurance will underproduce, and hence, underinvest in production and underpurchase inputs relative to what would be dictated by the maximization of expected profit. This explanation has received much attention among economists working on technology adoption, and resistance to risk taking has been used to explain many of the failures to induce poor villagers to adopt technologies developed for them (e.g. Feder et al., 1985; Eicher and Baker, 1982).

This view has recently been put under scrutiny. Poor rural households do not appear to systematically underproduce given their productive resources and the absorptive capacity of the market for agricultural products (Walker and Ryan, 1990). Besides, Sandmo's result seems to be counterintuitive: if people are poor and are concerned about their survival, the solution clearly is not to underproduce (Fafchamps, 1999).

Finkelshtain and Chalfant (1991) examining the effect of price risk on household behavior showed that faced with the same level of risk aversion households produce more than pure producers. Moreover, net-selling households use less and produce less under risk than under certainty, while risk averse net-buying households with severe risk aversion increase their production. Furthermore, Fafchamps (1992) pointed out that rural households facing thin and isolated food markets aim for food self-

sufficiency. In this case, poor households may apply a risky input if it brings them closer to the food self-sufficiency objective.

Regardless of these theoretical developments, there is scarcity of empirical evidence that establishes the link between risk aversion and technology adoption while also considering households' consumption preferences and food security objectives. Exceptions are Barrett (1996) and Fafchamps and Kurosaki (1997) where the former showed that small net buying households facing food price risk are induced to hyper-exploitation of household labor, and this leads to the inverse relationship between farm size and productivity, and the latter in testing the efficiency of insurance markets, by using panel data from Pakistan, found out that consumption preferences do affect crop production choices, providing an empirical support to the food security motive of households making investment decisions. Neither of these discussions, however, addressed the role of risk in using purchased farm inputs in the face of the household's desire to insure food security.

This paper attempts to find empirical evidence on the interaction between direct measures of risk preference, households' consumption preferences and strive for food self-sufficiency and households' decision to use fertilizer. The paper, hence, examines the probability and level of fertilizer use and how these are affected by households' elicited risk preferences while controlling for tenure insecurity, farm, household and village level factors. We test if the probability and intensity of input use is determined by different factors while at the same time testing and controlling for possible selection bias.

Section 2 specifies a theoretical framework that incorporates risk in the household's decision to invest on land quality enhancing measures, through purchase and use of farm input, accounting for consumption preferences and households' strive for food self-sufficiency followed by presentation of hypotheses. The next section presents the econometric model followed by description of the study area, survey methods and data chosen for analysis. Part 5 presents regression results and discussion followed by the final part that concludes.

2. Model specification

The model used here draws on theoretical models developed by Finkelshtain and Chalfant (1991), Fafchamps (1992; 1999) and Sadoulet and de Janvry (1995). Studies on behavior under risk assume that a producer maximizes the expected value of a

utility function defined only over income or final wealth. Aversion to risk in this single argument is measured by the curvature of the utility function, the Arrow-Pratt measure of risk aversion (Arrow, K., 1970; Pratt, J., 1964). However, to model households facing risks in other arguments of the utility function requires a more general objective function and an alternative definition of aversion to risk (Finkelshtain and Chalfant, 1991).

We assume a household is engaged in the production of a food crop (m) that it also consumes. Output is chosen prior to the realization of prices, while consumption related choice is made after the harvest period when prices are known. The prices of output and input (x) are denoted by p, q and the wage rate is w. The household is assumed to make production and consumption decisions to maximize the expected value of a utility function. The objective function is given by:

(1) $$\max_{m,l} \; E[U(m,l)]$$

subject to

(2) $$y(x) = pf(x) + wl - qx + T$$

where y denotes full income. Because the optimal consumption plans may be revised ex-post, the ex-ante decision involves only leisure (l) and x. Substituting the ex-post optimal plans for m into U leads to the variable indirect utility function $V(y, p, q, l)$. The utility function $V(y, p, q, l)$ can be understood as the result of a two-step optimization process: in the first period the producer chooses how much to work (and thus how much leisure l to consume); and in the second period the producer chooses how to spend earned and unearned income (T) on consumption. Epstein (1978; 1980) established that $V(y, p, q, l)$ is a dual to equation (1).

We consider here the case of output price fluctuations only (see Finkelshtain and Chalfant, 1991, and Sadoulet and de Janvry (1995)). Abstracting from the prices of all other commodities that the household purchases, the input level x that maximizes the expected utility of the household is given by:

(3) $$\underset{x}{Max}\, E[V(y, p)]$$

subject to

(4) $$y(x) = pf(x) - qx + T$$

The first order condition of the optimization problem is:

(5) $$Ev_y^{'}\left[pf'(x)-q\right]=Ev'_y\ pf'(x)-Ev'_y\,q$$
$$=\ Ev'_y\ \bar{p}\left[1+\sigma_{v'y}\sigma_p corr\left(v'_y,p\right)\right]f'(x)-Ev'_y\,q=0$$

The impact of risk on production behavior relies on the sign of the correlation between v'_y and p from equation (5). If p and y are uncorrelated, input use would be determined by $\bar{p}\ f'(x)=q$, independent of risk, where $\bar{p}$ is the mean price. On the other hand, if p and y are correlated, then input use and supply response are affected by risk. There are two elements on the influence of p on v'_y. On the one hand, we have the production effect, where an increase in the price p induces an increase in income y and, hence, decreases marginal utility of income; and, on the other hand, a consumption effect where an increase in price p reduces the real income thereby leading to a decrease in marginal utility of income.

The net effect of these two effects is shown in the following approximation obtained by a Taylor expansion (Sadoulet and de Janvry, 1995: 125):

(6) $$corr\left(v'_y,p\right)\approx-\sigma_p^2\left(R\left(s_p-s_c\right)+\eta s_c\right)$$

(7) $$=-\sigma_p^2\left(Rs_p-s_c\left(R-\eta\right)\right),$$

where R is the coefficient of relative risk aversion, η the income elasticity of consumption c of the food item, $s_c=pc/y$ the share of food consumption in total expenditure, and $s_p=pf(x)/y$ the share of the risky income in total income. These expressions show the determination of the degree of food self-sufficiency of the household as critical in the impact of uncertainty on production. For net selling households $\left[i.e.f(x)>c;s_p>s_c\right]$, expression (6) is always negative. Hence, the marginal utility of income is negatively correlated with price, and input use and production under risk are lower than under certainty. For net buyers, expression (6) is negative for low values of R and positive for large values of R. Hence, net buying households with mild risk aversion behave as producers in reducing their production. Very risk averse households increase their production in response to increase in risk. Moreover, the negative effect of risk on production is lower for households than for pure producers. This is seen in expression (7), as the income elasticity (η) is usually lower than R. A positive $R-\eta$ indicates that a household produces more than a pure producer does faced with same risk aversion. This is because consumption of its own

production in years of low prices ensures a certain level of utility to some of its product, which is not marketed at the low prices.

Fafchamps (1992; 1999) extended this discussion into the role of market risk. High transport cost and low agricultural productivity renders rural food markets to be thin and isolated. Consequently, households are confronted with food prices that are volatile and negatively correlated with their own agricultural output. Since basic staples constitute a large share of total consumption and have low-income elasticity, households are adamant to protect themselves against food price risk. In most cases, this is optimally achieved by emphasizing food self-sufficiency**.** Moreover, the effect of consumption preferences on technology choice implies that growing a crop whose revenue is positively correlated with consumption prices involves a form of insurance. Consequently, more risk averse households will seek to insure themselves against consumption price risk by increasing the production of staple crops if the covariance condition holds and the direct portfolio effect is not strong enough to induce a reverse behavior.

Finally, the addition of liquidity or credit constraints into the model is important because when households are presented with new technologies, such as fertilizer, for which up front cash outlays are required, credit constraint is likely to bind for poor households. In this case, an alternative hypothesis could be that credit constraints rather than risk aversion prevent households from adoption of fertilizer use. These insights will be incorporated in our econometric model in section 3 for statistical testing.

Hypotheses

Many of the farm households in the study area are poor and net buyers of food (see Table 1). Production is mainly for own consumption and, hence, households strive to be food self-sufficient in the face of adverse risk and poor market integration. In this case, both risk and risk aversion may encourage farm households to use fertilizer, even if fertilizer were considered a risky input, as doing so may bring them closer to their food security objective. That is, greater degree of food insecurity calls farm households to exert more effort to use resources to produce sufficient food.

Poverty is expected, generally, to reduce the household's willingness and ability to invest in purchased farm inputs. We expect relatively wealthy households (measured by their asset holdings) to apply more fertilizer than poor households, as they are less

cash constrained. Livestock holding will influence the decision to use fertilizer depending on the relative importance of livestock as a source of cash. Most importantly, livestock may contribute to a relaxation of the household liquidity constraints. Moreover, increased asset holding may enhance household's access to formal credit which, in turn, may increase the household's propensity to use and ability to intensify production. The availability of productive labor (both adult female and male labor) may increase the likelihood of using fertilizer as labor could be used to generate additional cash income, which could be used to purchase inputs. On the other hand, labor could be used to introduce alternative land management practices, such as constructing soil conservation measures, composting and manuring, which are as such labor-intensive tasks but may decrease the household's demand for fertilizer.

Poor households, on the other hand, may be cash constrained to use fertilize even though their subsistence requirements pull them in the opposite direction. Whether poor households will choose to use fertilizer or not will depend very much on how cash constrained they are. In this case, poor farm households' access to credit becomes crucial. Poor households' access to food aid and food-for-work may provide an insurance, and perhaps cash income, to apply risky but productive inputs such as fertilizer (Barret et al., 2001). On the other hand, it could also mean a disincentive to use fertilizer as they are not risk prone as before, i.e. the degree of food self-sufficiency may have improved. The expected sign is, hence, ambiguous. The poor may be endowed with labor but access to off-farm income may be constrained mainly because labor markets are underdeveloped or segmented. Increased access to labor markets may, hence, encourage the poor to use purchased inputs as long as agriculture remains the single most important source of household livelihood.

Household factors such as age, education level and sex of household head are expected to have a bearing on the decision to and on the level of fertilizer used. Experience of the household, as indicated by the age of the household head, is likely to have a range of influences on adoption. The household's previous experience with other innovations may have been either negative or positive, and this will likely influence his/her attitude on using fertilizer. Besides, his/her capacity to earn additional cash income, which may increase or decrease with age, may have a bearing on investment. The expected sign is, thus, ambiguous. Educated household heads are expected to be more innovative. Male-headed households are also expected to have lower willingness to invest in fertilizer compared to female-headed households partly

because male-headed households may use alternative labor-intensive land enhancing technologies. The opposite effect is not rule out entirely, however. Moreover, the presence of more dependents in the household may positively influence the household's decision to use fertilizer due to the household's increased subsistence requirement.

Tenure insecurity or the land rental arrangement could be another reason for lack of incentive to invest in land enhancing inputs. However, tenure insecurity is likely to be less important with respect to the decision to invest in fertilizer because the benefits accrue in the short term (Holden and Yohannes, 2002). To test for this hypothesis, we use duration of tenure holding, the presence of planted trees on the plot and tenure dummies to represent types of arrangement (owner-operated, rented-in and temporary transfer). We expected the likelihood of households using fertilizer to be higher on owner-operated plots than sharecropped or temporarily transferred plots for incentive (e.g. due to Marshallian inefficiency) reasons. We also added distance of plot from homestead not only to account for transaction costs involved with managing distant plots but also control for differences in the sense of security associated with closeness of plot to homestead. Both effects are expected to pull in the same direction; namely, households will less likely use fertilizer on distant plots. If security of tenure is binding, plots with planted trees on are likely to be selected for fertilizer use. On the other hand, trees may be planted, given scarce cultivable land, on relatively poor soils that are not suitable for crop production pointing to lower fertilizer use in such plots. The expected sign is, thus, ambiguous.

Fertilizer use decisions certainly are influenced by a host of biophysical factors such as plot characteristics, household crop choice and agro-ecological factors. To test this we included dummies representing altitude and degree of rainfall variability, as measured by the coefficient of variation of rainfall from a 10 years data, into the regressions. Variations in altitude are also associated with variations in cropping pattern, which may have a bearing on the decisions to use fertilizer. Moreover, plot characteristics such as soil type, susceptibility to erosion, soil depth, access to irrigation water and the presence of conservation structures on the plot may play a role in the decision. We adopted a locally used four-tier soil classification system: Hutsa (sandy soils), Baekel (cambisols), Walka (vertisols) and Mekih (luvisols) (Haile, 1996). We also used a three-scale category for soil depth: shallow, medium and deep. Generally, we expect households to use fertilizer on moderately fertile and

moderately deep soils because of possible higher return. Similarly, we expect households to use more fertilizer on plots relatively less susceptible to erosion, or on conserved plots. Irrigation is expected to increase fertilizer demand because of expected yield increase due to the complementarity of fertilizer and irrigation water. Furthermore, farmers selectively decide on whether to use and amount of fertilizer they apply depending on the type of crop they choose to grow on a specific plot. Hence, if the type of crop grown were excluded from the regression explaining households' decision to use fertilizer, it would cause an omitted variable bias problem. Instead of using many dummies (increasing loss in degrees of freedom) for the different crop types grown in the regression, and partly also due to fear of endogeneity problem, we choose to use the number of plowing days used to prepare land for planting as a proxy for the different crop types. We found that farmers (as a matter of cultural practice) invest different amounts of labor days for land preparation on different crops. For instance, farmers use more labor days on teff plots than on maize, wheat or barley. Similarly, they use more time on maize plots compared to wheat or barley plots. They use more time on wheat and barley plots than on plots for pulses or legumes and so on. The interest here is not to specifically examine which crop type gets the highest fertilizer per given land area but to account for differences in crop choice in the decision whether to and the level of fertilizer used.

Finally, village level variables such as distance to market and population density will influence the decision to use purchased fertilizer. Better access to market, as measured by distance to major (wereda) markets, is likely to encourage use of purchased inputs. We may also, however, expect households in remote communities to use more fertilizer due to the need to be food self-sufficient. The expected sign is, hence, ambiguous. Population density may induce input use intensification; we expected households in high population density environments to use more fertilizer pointing to Boserupian effect (Boserup, 1965).

3. Econometric model

Based on the theoretical framework developed in part II, we specify the following estimable model for the fertilizer adoption equation:

(8) $$I_i = f\left(h^z, R, W, Market, Tenure, Crop, P_{cha}, V\right)$$

where the dependent variable, I_i, is fertilizer in kg used on plot i. h^z includes household characteristics such as age, education and sex of the household head and other demographic characteristics (e.g. consumer-worker ratio) to control for the household's subsistence requirements. W is also a vector of household's asset holdings, which include farm size (in per capita terms) and livestock holding (in tropical livestock unit (tlu)) and male and female adult labor units per farm size (in ha) are incorporated into the model to control for the effect of these factors in the household's decision to use fertilizer. We used the estimated average constant partial risk aversion coefficient (R) as a measure of the household's risk preferences. We also included variables related to access to the credit market and safety nets ($Market$) such as food aid and food-for-work. We wanted to test if access to the formal credit market increases households' use of fertilizer, both its decision to and amount of fertilizer used per land area. Besides, we test if access to food aid and food-for-work serves as an insurance to households to use inputs such as fertilizer (Barrett et al., 2001).

Use of such purchased inputs may also be closely related to the prevailing land tenure arrangements and household's perception of tenure security. The tenure status of each plot and duration of tenure holding (number of years operated), and the presence of planted trees on plot, as a measure of relative security, are incorporated into the model to test whether any of these variables $(Tenure)$ influence the decision to use such inputs.

Furthermore, P_{cha} is a vector of variables related to farm level characteristics such as soil depth, soil type, susceptibility to erosion, access to irrigation water, whether the plot is conserved or not, and the distance from home stead. A household's decision to use fertilizer may also differ by crop types chosen for growing by the household. We include type of crops $(Crop)$ grown, proxied by the number of plowing days, into the model.

Finally, village level variables (V) as agro-climatic factors (rainfall and altitude), market access (proxied by distance to the major markets), and population density are included to control for village fixed effects.

Unlike usual approaches of modeling fertilizer demand using a Tobit model (e.g., (Croppenstedt et al., 1999), we model the adoption process as a two stage process: households first decide whether to use fertilizer and then, having decided positively

they decide how much fertilizer to apply on each plot. We test whether the probability and intensity of input use is determined by different factors. Households do not randomly use fertilizer on their plots, and may self-select themselves to use/from using any. The dependent variable is, hence, censored, with many zero values. To account for the two stage decision process, censoring of the dependent variable and to test and control for selection bias, we specify a selection model like:

(9) $$\pi = d\left[x'\beta + u\right]$$

where the dependent variable is determined by the regressors x, and an unobservable error term u, and the indicator variable d, which shows whether the dependent variable is censored or not. This indicator variable is assumed to be determined by a vector of conditioning variables, z, through a binary choice model:

(10) $$d = 1\left[z'\gamma + v \succ 0\right]$$

where $1[.]$ denotes an indicator function for the event of applying fertilizer, γ is a vector of unknown coefficients, and v is the unknown error term. If the two error terms in equations (9) and (10) are uncorrelated, a separate estimation of the two equations yields consistent results. If this assumption is violated, however, joint estimation of the model is necessary.

The model given in equations (9) and (10) can be estimated in several ways. Given that $v \sim N(0,1)$, i.e. v is normally distributed with zero mean and unit variance and $E(u \mid v) = \gamma_1 v$, which simply requires linearity in the population regression of u on v (Wooldridge, 2002), which, in turn, implies that $(u_1, v_2)$is bivariate normal, this model could be estimated by Heckman's selection model (Heckman, 1979). Heckman's model involves a two-step estimation procedure, where we derive the inverse Mills ratio, which is used in the second stage, from a probit model in the first stage using all observations and then estimate $\hat{\beta}$ and $\hat{\gamma}_1$ by least squares in the second stage on the selected sample. The estimators obtained from this procedure are consistent and $\sqrt{N}-$asymptotically normal.

Identification in this model requires that x_1 is not perfectly correlated with $\lambda(x\delta_2)$. Strictly speaking this could be assured as long as $\lambda(.)$ is a nonlinear function, though it helps for statistical power if x includes some variables not included in x_1. Thus, we

tried to ensure the nonlinearity of $\lambda(.)$ by using linear functional specification in the selection equation while the outcome equation has a log-linear specification.

The Heckman model is sensitive to misspecification problems, especially violation of assumptions of normality and homoskedasticity of the error terms. In using the Heckman model, it is not possible to know whether these assumptions are violated because it is difficult to test for these misspecifications. This is because when there is self-selection problem $(\gamma_1 \neq 0)$, obtaining a consistent estimate for the asymptotic variance of β is complicated (Wooldridge, 2002).

Different models have been proposed as a solution to the problem by focusing on relaxing the distributional assumptions (Newey, 1988; Andrews, 1989 and Ahn and Powell, 1993). Deaton (1997), following a variety of the procedure similar to Newey, (1988) and Andrews (1989) uses a polynomial form of the predicted probabilities of the binary choice model as an approximation to the inverse Mills ratio. In this paper, we used Deaton's selection model, along side Heckman's selection model, to test the robustness of the results to different distributional assumptions (For a similar econometric approach refer Holden et al., 2001).

Using, the Deaton model for the intensity equation, we estimated robust standard errors to correct for heteroskedasticty (White, 1980)**.** We tested for heteroskedasticity using the Cook and Weisberg (1983) and normality using skewness and kurtosis as well as the Shapiro-Wilk and Shapiro-Francia (Gould and Rogers, 1991; Gould, 1991) normality tests. The tests showed the presence of heteroskedasticity and violation of the normality assumption of the error term. We tried linear, log-linear and (reduced) translog functional forms in an attempt to eliminate the heteroskedasticity problem. Although it was not possible to eliminate the problem, we selected the log-log functional form, which yielded the lowest χ^2 values. We tested also for possible multicollinearity problem. In this regard, using the second and third degree polynomials of the predicted probabilities caused serious multicollinearity problem. We had to eliminate the polynomials, which proved to be highly collinear with a variance inflation factor (VIF) that exceeded 10 (Montgomery and Peck, 1992) from the regression and relied on the third degree polynomial only.

4. Study site and sample data description

Northern Ethiopia has been a scene of major drought, famine and social conflict for the last three or more decades (Webb et al., 1992). It has also relatively poor market access condition in terms of limited market development (roads, marketing and storage facilities, etc.) and most farmers are subsistence producers (Hagos et al, 1999). The food security situation can be understood from Table 1. The majority of the households are food deficit (net buying) households. Only 2.5 and 26.7 and 0.5 and 5.5 percent of the households are self-sufficient (non-participating in food markets) or net sellers during 1998 and 2000 respectively. The mainstay of the economy is agriculture, which is mainly rain-fed.

The data used for analysis here include a cross sectional data of 400 randomly selected households, operating 1753 plots, in Tigray region, Northern Ethiopia. In the 2001 survey we collected data on, as part of a comprehensive household and plot survey, household consumption and production, market access conditions, farmers' risk preferences and perceptions on soil erosion, measures taken to ameliorate erosion (e.g. investments made on farm) and their impacts, and a host of plot, household and village level information. We purposively stratified communities on the basis of their agricultural potential, market access, population density and the presence of irrigation projects. In this study we used only 1507 plots in stead because we dropped all rented-out plots from the analysis as the preferences, other household related characteristics and asset holdings of those currently renting-in those particular plots were not observed in our sample.

In the same survey, we tried to elicit households' subjective risk preferences using hypothetical questions. The approach used here has similarities with earlier approaches (Binswanger, 1980; Sillers, 1980; Wik and Holden, 1998) of eliciting risk preferences based on gambling games with real payments. In our case, however, we used hypothetical questions without gambling and real payments. In stead, the questions were framed to reflect farmers' real life production decisions. We expect that farmers could understand such questions more easily than the gambling approach[28]. The questionnaire presented six prospects with different expected yield levels and associated levels of risk from which household heads and spouses were

[28] A weakness of the gambling approach is that it allows subjective (unobservable) probabilities related to coin tosses. Another weakness may be that the game is far from a real world situation and may therefore not reflect real world response.

asked to choose (See Appendix I). The fact that the outcomes are distinguishable and the probabilities are explicit and constant may help farmers to respond consistently so that it can minimize one of the possible violations witnessed in expected utility theory (see Bar-Shira et al, 1997).

A unique risk aversion coefficient for the question was derived using a utility function with constant partial risk aversion based on which the mean of the constant partial risk aversion (R) is calculated to serve as a measure of households' level of risk aversion. Based on the elicited risk preferences, the majority of the farmers show intermediate to extreme risk aversion (Table 2). Only 11 percent of the households have moderate to risk neutral reflecting increasing partial risk aversion behavior.

We also run a separate regression to identify the correlates of risk preferences, which serve as a validation test to the data. Regression results (see Table 1A) show that most of the estimated coefficients of the respective equations were in line with economic theory. Partial relative risk aversion was negatively correlated with household consumption expenditure and oxen holding, a measure of household income wealth and important asset wealth respectively, pointing to decreasing absolute risk aversion (DARA) as was found by Binswanger (1980) and Wik and Holden (1998). Moreover, the coefficient for the expected gain was negatively correlated with households' risk aversion coefficient underlining increasing partial risk aversion hypothesis. In the subsequent parts of the paper, we used the calculated partial risk aversion coefficient directly as one of the explanatory variables in the fertilizer investment equations as an endogeneity test performed using Durbin-Wu-Hausman test (Davidson and Mackinnon, 1993) showed that the hypothesis of endogenous risk preferences was rejected.

5. Results and discussion

Descriptive summary

Description and statistical summary of the variables used in the various regressions are reported in Table 3. The reported standard errors are adjusted for stratification and cluster effects.

The average land holding in the region is 0.3 hectare. Nearly 84 percent of the plots are owner-operated the remaining being rented-in or temporarily transferred. The average fertilizer use is very low, i.e. around 9.7 kg/ha. Fertilizer was used on 571 plots out of the total 1507 accounting for about 38 percent.

Around 32 percent of the households have access to formal credit from a micro credit institution. The share of migrant household members is relatively small. Only 18 percent of the households had migrant household members, which supplied them with remittances. Food transfers, in the form of food-for-work schemes, play an important role in Tigray region. Around 80 percent of the households have access to food transfers either from direct food aid or food-for-work programs, the later reaching about 57 percent of the households. Most of the households are located far from major markets. The average distance to the major (wereda) markets is about 138 minutes of walking time. Close to 61 percent of the households live in tabias having a population density of more than 200 persons/ km^2.

As far as the biophysical factors are concerned, the majority of the plots (with the exception of 12 percent) were located in higher altitudes, i.e. beyond 1500 meters above sea level. The four soil types discussed in part IV seem to be evenly distributed across locations. Most of the plots are shallow to medium in terms of their soil depth. Only 9 percent of the plots are classified as highly susceptible to erosion. Finally, on average a household has to walk 26 minutes to get to the most distant plot. Rainfall is highly variable in the region with average coefficient of variation of 29 percent showing strong inter-village variations. Irrigation plays an insignificant role with only 6 percent of the plots having access to irrigation water.

Probability of fertilizer use

Probit results on the probability of fertilizer use are given in Table 4 below. The coefficient of the elicited risk preference rates is highly significant and positive. It implies that households' likelihood of using fertilizer increases with increased households' risk aversion. This is in line with the behavior of poor households that strive to survive in the face of adverse risk (e.g. due to weather shock) in remote areas where markets are not fully developed.

Ownership of assets also affects the decision to use fertilizer. Livestock holding significantly influences, in a positive way, the decision to use fertilizer. This could perhaps be because such assets could be used to relax the household's liquidity constraint (through sell of livestock units or their products) in case cash needs for loan repayment or for purchasing farm inputs arise. Oxen holding, on the other hand, turned out to be statistically insignificant though it has a positive sign. Farm size influences the probability of fertilizer use negatively implying households with

smaller plots are likely to use fertilizer pointing to possible Boserupian effects. Not surprisingly, access to formal credit market is also highly significant and positive in explaining the probability of fertilizer use. Cash constraints, hence, are binding in the household's decision to use fertilizer. Better access to market, as proxied by distance to the major markets, influences the probability of fertilizer use positively. Furthermore, households in densely populated areas have higher probability of using fertilizer pointing to possible Boserupian effects, implying higher population density induces agricultural intensification.

Other household related variables were found also to influence the probability of fertilizer use. Households with more female adult labor have higher probability of fertilizer use compared to households with more male adult labor endowment. This points perhaps to a possible substitutability between male adult labor and fertilizer use. The rationale could lie in the fact that the availability of more male adult labor in the household may encourage households to practice other labor-intensive land quality enhancing management practices, which may reduce the need for fertilizer. The positive influence of female labor on the probability of fertilizer use could be explained by a similar line of reasoning; namely, the female adult labor's low level of involvement, partly culturally conditioned, in labor-intensive land management practices rendering the likelihood of using fertilizer to be higher.

As far as the influence of the forms of tenure arrangements is concerned, both rented-in and transferred plots seem to have lower probability of being selected for fertilizer use compared to owner-operated plots pointing to the presence of Marshallian inefficiency. However, the results are not statistically significant. The coefficient for trees is not significant either and it has a negative sign. Contrary to our expectation, however, the length of tenure holding is positive and significant, albeit at 10 percent level of significance. Distance from homestead seems to significantly discourage households' decision to use fertilizer.

Looking at the influence of biophysical factors on the decision to use fertilizer, households have higher probability of using fertilizer on conserved plots. This is perhaps related with the increased return to fertilizer from moisture conservation. The decision to use fertilizer also varies by crop type planted. Households are likely to use fertilizer, in a decreasing way, on crops such as teff, wheat, maize, sorghum and barley which are found also to be labor demanding, in terms of land preparation time, compared to other cereals (e.g. legumes). Compared to sandy soil, which are very

poor in fertility, households are likely to use fertilizer on relatively fertile soils. The coefficients for the three soil types have positive sign although only the coefficient for Mekih is statistically significant. Finally, the probability of fertilizer use in extreme highlands (Degua) is lower than middle altitude (Hausi Kola). This is perhaps related to differences in cropping pattern at different altitudes. Teff and maize, for instance, are grown in middle altitude compared to wheat and barley, which are typically high altitude crops. Rainfall variability does not significantly affect the decision to use although the sign is, as expected, negative.

We will see below whether the factors that explained the probability also explain the intensity of fertilizer use.

Fertilizer use intensity

The results of the models used to estimate the intensity of fertilizer are reported in Table 5. Both the Heckman and Deaton selection models indicated that there is a significant selection bias. Test results on the Deaton model also show that the assumptions of normality and homoskedasticity of the error terms are violated. We estimated robust standard errors using White's heteroskedasticity consistent standard errors.

The two models produced highly significant and robust results with respect to four variables. Access to the formal credit market determined the intensity of fertilizer use, as it did the decision to use, underlining the importance of capacity to invest and liquidity constraints in the decision to use and the amount of fertilizer applied. Poor access to market, as measured by distance to major markets, negatively influenced the intensity of fertilizer use, as it did with respect to the probability. Access to market influences the returns to investment by providing households with marketing opportunities for their products and may reduce volatility of prices due to better market integration. Better market access also reduces the transaction costs of fertilizer use. In the face of shallow and undeveloped markets, households in remote areas are expected to focus on self-sufficiency in staple food. Meeting the food security objective may induce increased use of purchased inputs by households if doing so does not expose them to increased income shortfall. The evidence here points to the fact that households in remote communities use lower amounts of fertilizer perhaps implying the negative portfolio effect of using fertilizer. Livestock holding, a measure of household wealth, has a positive and significant effect on intensity. The coefficient

for oxen holding has also a positive sign but it turns out to be statistically insignificant. Finally, the intensity of fertilizer use was strongly determined by the type of crops grown.

In both models, fertilizer use intensity is not significantly related to risk preferences underlining that factors related to liquidity constraint, market access and asset holding are crucial in the decision to increase fertilizer use among poor farm households.

In the Deaton model, human capital related factors seem to influence the intensity of fertilizer use as both the age and sex of the household head were found to be negatively correlated with input intensity. In this case, female–headed households use lower fertilizer units per operated land area. This could be perhaps be related to differences in wealth status between male-headed and female-headed households. Quite interestingly, the number of dependents in the household was found to increase the intensity of fertilizer use underlining the food security motive of households using fertilizer. Again, in line with the result obtained earlier in relation to the probability of fertilizer use, fertilizer intensity was found to be an increasing function of female adult labor.

In line with our expectations, fertilizer intensity was found, in the Heckman model, to be significantly lower on rented-in plots compared to owner operated plots reinforcing the presence of Marshallian inefficiency with respect to fertilizer use. Irrigated plots indicated to have lower input use intensity in the Deaton model which seems counter intuitive. Casual observation, however, shows that households are quite often inclined to use manure on irrigated plots perhaps because fertilizer availability outside the main season is limited. Fertilizer use intensity was not significantly higher in conserved plots although the signs, in both models, are consistently positive. Access to food transfers was consistently negative in both models but not statistically significant. Finally, both farm size and population density proved to be insignificant failing to confirm the Boserupian effect pointed to earlier.

6. Conclusion

Risk preferences, as measured by the average constant partial risk aversion coefficient, seem not to adversely affect household's decision to use fertilizer. On the contrary, we found that the decision to used fertilizer increases with increasing household risk aversion. Fertilizer use intensity is not significantly affected by risk preferences, however. On the other hand, access to formal credit market affected the

probability and intensity of fertilizer use, underlining the importance of income poverty and liquidity constraints in the decision whether to use and the level of fertilizer used. Poor market access negatively influenced the decision whether to and the intensity of fertilizer use. Access to market determines the returns to investment by providing households marketing opportunities for their products and may reduce volatility of prices owing to better market integration. Better market access also reduces the transaction costs of fertilizer use. In the face of shallow and undeveloped markets, households in remote areas are expected to focus on self-sufficiency in staple food. Meeting the food security objective may induce increased use of purchased inputs by households if doing so does not expose them to increased income shortfall. The evidence here implies that the negative portfolio effect of using fertilizer weighs more than its insurance effect. This points to the need for development of market infrastructure and marketing opportunities if households' are to reap the full potential of such innovations and thereby improve the well being of poor households. Furthermore, asset wealth (in the form of livestock holding) also had a positive influence on the households' decision to use and amount of fertilizer used mainly because it may help relax the household's liquidity constraints.

Human capital related factors influence the intensity of fertilizer use as both the age and sex of the household head were found to be negatively correlated with input intensity. The probability and intensity of fertilizer use was found to be an increasing function of female adult labor. Moreover, the number of dependents in the household was found to increase the intensity of fertilizer use perhaps reinforcing the food security motive of households using fertilizer.

Land conservation seems to encourage the probability and, if not significantly, the intensity of fertilizer use. This points to possible complementarities between land conservation investment and fertilizer use. One way of promoting fertilizer use could be for the public sector to help households undertaking long-term conservation structures, which as an immediate effect will help increase moisture availability.

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Table 1: Participation in food markets of farm households in Tigray region

Participation status of households	1997	2000
Self-sufficient (non-participating)	2.5	0.5
Net seller	26.7	5.5
Net buyers	70.7	94
Total	100	100

Table 2: Risk aversion coefficient and households classification

Good year	Bad year	Partial relative risk aversion coefficient	Bounds of the CPRA function	Risk aversion class	Proportion of the sample
20	0	0	< = 0	Neutral to preferring	4.7
19.5	2	0.5897	0.5897-0.999	Slight to neutral	1.99
18	4	0.999	0.999-2.4414	Moderate	4.24
16	6	2.4414	2.4414-5	Intermediate	9.5
13	8	5.975	5 - 14.62	Severe	16.96
9	9	14.62	> = 14.62	Extreme	62.6

Table 3: Description of variables and summary statistics

Variable	Description	Mean	St. error♣
intense	Fertilizer use in kg per ha	9.71	0.52
conserve	A dummy for conserved land (yes=1)	0.74	
Plough	Number of labor man days used in land preparation per ha	10.77	22.29
pcfarm	Average land area (in ha)	0.33	0.02
tree2	Presence of planted trees on plot (yes=1)	0.11	
soiltype	Dummy for soil type (hutsa= 0, Baekel= 1, Mekih= 2, Walka= 3)		
baekel		0.25	
mekih		0.26	
walka		0.24	
soildp	Dummy for soil depth (shallow=0; medium=1 and deep=2)		
medium		0.39	
deep		0.38	
suseros	Plot's susceptibility to erosion (None=0; low=1; moderate=2 and high=3)		
low		0.29	
moderate		0.14	
high		0.09	
distance	Distance of plot from homestead (in minutes)	25.89	2.28
rainvar	Rainfall variability	29.07	2.74
ecosys	Dummy for altitude (hausi kola=0, hausi degua=1, Degua= 2)		
hausi degua		0.45	
degua		0.43	
tenure	Dummy for tenure arrangement (owner-operated= 0 and rented-in= 1, temporary transfer=2)		
rented-in		0.15	
transfered		0.02	
ownsince	Tenure holding (in number of years)	11.09	0.44
irrig	Access to irrigation (yes=1)	0.06	0.02
hhage	Age of household head	53.24	1.13
sex	Sex of household head (female=1)	0.09	0.02
edu	Education of household head (literate=1)	0.39	0.03
malelab	Number of male adults per ha	1.41	0.07
femlab	Number of female adults per ha	1.33	0.06
depdratio	Consumer-worker ratio	3.14	0.11
pcoxen	oxen holding per ha	0.18	0.01
pctlu	livestock holding (in tropical livestock units) per ha	0.40	0.04
access	Access to formal credit market (yes= 1)	0.32	0.023
insure	Access to formal food transfers (yes=1)	0.79	0.04
remit	A dummy for the presence of migrant in the household (yes=1)	0.18	0.02
popn	A dummy for population density (dense=1)	0.61	0.13
dismarkt	Distance to major (wereda) market in minutes	138.68	19.89

♣ Standard errors are adjusted to stratification and cluster effects.

Table 4: Probability of fertilizer use

Dependent variable: Binary (0/1)		
Variables	**Coef.**	**Robust Std. Err.**
Risk preference		
ln(R)	0.081	0.035**
Tenure status		
rented-in	-0.041	0.121
transfer	-0.135	0.327
trees	-0.027	0.114
Ln(tenure duration)	0.093	0.052*
Household characteristics and asset holding		
ln(age)	-0.072	0.137
female-headed	0.042	0.155
education status	0.083	0.078
ln(female adult labor per ha)	0.149	0.072**
ln(male adult labor per ha)	-0.119	0.068*
ln(dependency ratio)	-0.027	0.083
ln(tropical livestock unit per ha)	0.083	0.043**
ln(oxen adult labor per ha)	0.049	0.047
ln(mean farm size)	-0.207	0.098**
Market access related and village level variables		
access to credit	0.317	0.084***
remittances	0.189	0.093**
insurance (access to food aid)	0.063	0.093
population density	0.103	0.083**
ln(distance to market)	-0.318	0.042***
Plot level variables		
conserved plot	0.381	0.091**
ln(frequency of plowing)	0.261	0.039***
soildepth2	0.030	0.085
soildepth3	0.027	0.096
soiltype2	0.032	0.103
soiltype3	0.222	0.103**
soiltype4	0.143	0.115
mid highland	-0.178	0.126
extreme highland	-0.249	0.125**
ln(rain variability)	-0.146	0.120
ln(distance of plot from home stead)	-0.054	0.029**
irrigated plot	0.213	0.159
susceptible to erosion2	0.069	0.087
susceptible to erosion3	0.124	0.112
susceptible to erosion4	-0.037	0.134
_cons	0.453	0.660
		Number of obs = 1483
		Wald chi2 (31) = 217.32
		Prob > chi2 = 0.0000
		Log likelihood = -867.14
		Pseudo R2 = 0.123

*, **, *** are levels of significance at 10, 5 and 1 percent respectively.

Table 5: Intensity of fertilizer use

	Heckman model		Deaton's model	
Variables	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
Risk preferences				
ln(R)	0.037	0.046	-0.033	0.039
Tenure status				
rented-in	- 0.083	0.166***	0.392	0.172
transfer	0.040	0.358	0.166	0.335
tree	-0.015	0.139	0.095	0.112
ln(tenure duration)	-0.045	0.079	-0.049	0.082
Household characteristics and asset holding				
ln(age)	-0.212	0.181	-0.386	0.167 **
female-headed	- 0.313	0.279	-0.423	0.228*
education status	0.007	0.095	0.055	0.086
ln(dependency ratio)	0.349	0.286**	0.020	0.095
ln(female adult labor per ha)	0.118	0.132	0.169	0.074**
ln(male adult labor per ha)	0.296	0.310	0.123	0.080
ln(livestock unit per ha)	0.112	0.052**	0.092	0.049**
ln(oxen adult labor per ha)	0.078	0.055	0.027	0.051
ln(mean farm size)	0.252	0.341	0.002	0.125
Market access related and village level variables				
access to credit	0.177	0.106*	0.221	0.107**
remittances	0.066	0.113	-0.041	0.097
insurance (access to food aid)	-0.000	0.109	-0.065	0.096
population density	0.139	0.110	0.091	0.090
ln(distance to market)	- 0.241	0.062***	-0.125	0.051***
Plot level variables				
conserved plot	0.083	0.114	0.025	0.118
ln(frequency of plowing)	0.352	0.036***	0.624	0.054***
soildepth2	-0.036	0.102	0.041	0.091
soildepth3	-0.071	0.117	-0.142	0.093
soiltype2	0.071	0.1123	0.189	0.111*
soiltype3	0.183	0.129	0.142	0.107
soiltype4	0.095	0.132	0.195	0.106*
mid highland	-0.040	0.139	0.282	0.150*
extreme highland	-0.043	0.141	0.329	0.148**
ln(rain variability)	-0.493	0.608	-0.094	0.087
ln(distance of plot)	0.004	0.037	0.037	0.036
susceptible to erosion2	0.010	0.106	0.044	0.086
susceptible to erosion3	-0.070	0.136	0.046	0.127
susceptible to erosion4	-0.076	0.159	-0.044	0.147
irrigated plot	-0.323	0.217	-0.779	0.230***
_cons	2.116	0.944**	4.156	0.800***
mills	1.774	0.463***	-	-
phat^3	-	-	-1.099	0.377***
	Number of obs = 1177		Number of obs =1484	
	F(34, 1142) =11.67		R-squared = 0.229	
	Prob > F= 0.000		F (34, 350)= 10.79	
	R-squared = 0.234		Prob > F = 0.000	
			Cook-Weisberg test:	
			Chi2(1) = 25.4	
			Prob > chi2= 0.000	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively.

Appendix I

Approach used to elicit risk preferences

The questionnaire presented six prospects with different expected yield and associated levels of risk in the following manner: If you have the choice between a crop which gives X quintals in a good year but no yield in a bad year, and a crop variety which gives Y quintals in a good year and Z quintals in a bad year, which crop variety would you prefer to plant? We assumed that a bad year occurs one out of five years. The yield outcome X > Y > Z > 0. The choices are indicated in Table 2.

Table 1A: Correlates of risk preferences

Dependent variable: Partial risk aversion coefficient (*R*)		
Variables	**Coef.**	**Robust Std. Err.**
age of head	0.005	0.012
female-headed	0.016	0.496**
literate head	0.702	0.397*
dependency ratio	-0.381	0.175**
per capita expenditure	-0.0001	0.0001*
female adult labor	-0.347	0.206*
adult male labor	-0.168	0.231
per capita farm holding	-0.094	0.246
per capita oxen holding	-1.734	0.890 **
per capita livestock holding	0.998	0.629
expected return	-2.846	0.055***
cogito2	-1.808	0.513***
cogito3	-1.517	0.615**
enudmy2	-1.515	0.900*
enudmy3	-1.442	0.932
enudmy4	-2.313	0.880***
enudmy5	-1.625	0.932*
_cons	47.790	1.630***
/sigma	1.590	0.06
	Number of obs = 386	
	Wald chi2(17) = 6406.55	
	Log likelihood = -154.32	
	Prob > chi2 = 0.000	
	right-censored observations= 257	
	interval observations = 129	

Tenure security, resource poverty, risk aversion, public programs and household plot level conservation investment in the highlands of northern Ethiopia

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Abstract

The paper examined the role of tenure security, resource poverty, risk and time preferences and community-led conservation programs on differentiated patterns of soil conservation adoption by smallholders by controlling for biophysical, household characteristics, market access conditions and village level factors. It focused on medium and long-term conservation measures such as built soil bunds and stone terraces because of the need to capture the link between the various factors and the durability of the conservation investments. We introduced the distinction between determinants of the decision to and how much to invest in conservation.

Regression results show that public led conservation programs seem to significantly stimulate private investment. A host of plot level variables and households' perceptions of returns from conservation investments, in terms of improved land quality and increased crop yield, were found to be crucial in the decision to invest and intensify of soil conservation. The evidence on the significance of households' attitudes to risk aversion points to the role of risk and household capacity to bear risk in the decision to intensity conservation measures. On the other hand, tenure security indicators and households' resource endowments (poverty/wealth) had weaker effects in increasing the households' willingness to invest and the level of investment made.

Key terms: Resource poverty, tenure security, risk aversion, time preference rates, long- and medium-term conservation investments; Ethiopia.

1. Introduction

Land degradation, mainly due to soil erosion and nutrient depletion, poses a serious problem on the livelihood of rural producers in the developing world. Land degradation, in fact, is regarded as a source of poverty trap (Dasgupta and Mäler, 1991; Barbier and López, 1999) for farmers in many developing countries. In light of the problems posed by soil erosion on the livelihood of rural producers in the developing world, soil conservation investments have become an important task of development agents and policy makers alike. Various public led measures have been going on to avert soil erosion in northern Ethiopia (see Hagos et al, 1999; Gebremedhin, 1998). Nonetheless, there is hardly enough private investment by land users taking place commensurate to the problem at hand, in terms of both instantaneous adoption and/or maintenance of land conservation structures.

In the literature, several explanations have been proposed for this inadequate private response to land degradation. The reasons forwarded are manifold: lack of private property and tenure insecurity (Feder et al., 1988; Alemu, 1999; Gebremedhin and Swinton, 2000), poverty and high discount rates (Holden et al., 1998; Holden and Shiferaw, 2002), long payback periods of conservation structures, and low short-term returns to household income (Shiferaw and Holden, 1998; Gebremedhin, 1998; Shiferaw and Holden, 2001; Gebremedhin and Swinton, 2000), differences in transaction costs among communities, agro-ecological factors and factor market imperfections (Pender and Kerr 1998), labor shortages and credit market imperfections which may induce households to underinvest and mine their natural resource base (Anderson and Thampapillai, 1990; Lutz et al., 1994; Binswanger and Rozenzweig, 1986; Holden and Binswanger, 1998).

The question of the link between conservation and tenure security, withstanding the differences in context[29] and measurement of security (see Place and Swallow, 2000), has attracted researchers' attention. The evidence so far is mixed, however. On the one hand, there are findings from Ethiopia and elsewhere that support tenure security as an important variable influencing investments on land (Feder et al., 1988; Alemu 1999; Gebremedhin and Swinton, 2000). On the other hand, a growing number of studies show that tenure security in the form of land titling alone or insecurity from redistribution might bear a weak or an unclear link to conservation investment[30] or improvements in productivity (Place and Migot-Adholla, 1998; Feder and Nishio, 1999; Wood and Walker, 2000; Holden and Yohannes, 2002; Brasselle, et al., 2002). These results inclined researchers to argue that basic use rights are apparently sufficient to induce farmers to make land-specific investments (Brasselle, et al., 2002), and endogenous tenure systems are flexible enough to adjust to internal developments (Platteau, 1995), and are able to provide rather long term entitlements to users (Brasselle, et al., 2002). While these arguments should not be entirely discounted, there are reasons to believe that the situations in settings where state ownership of land prevails could be different. In such a context, land tenure arrangements could be precarious to guarantee security to the user (Dessalegn, 1992;

[29] Okbaselassie and Holden (2002) showed that the discussion of the link between tenure security and investment need to be context specific.

[30] Besley (1995), Sjaastad and Bromley (1997) and Brasselle, et al. (2002) argued that the apparent link between tenure security and investment is due to the endogeneity of tenure security. Once this is controlled for in the empirical estimation, the link is, at best, weak.

Admassie, 2000), and any endogenous change in property rights could be blocked by the state (Joireman, 2001).

Others emphasized the relative role of expected profits to the farm level adoption and maintenance of soil conservation practices (Place and Swallow, 2000). And this, they argue, may overcome the negative incentives that result from insecure property rights. In this case, poverty and poverty related constraints to investment might play a crucial role. It is argued that poverty and liquidity constraints, rather than tenure security, tend to increase rates of time preference and may thereby reduce incentives for investment and sustainable management of natural resources (Pender and Walker, 1990; Deaton, 1991; Holden et al., 1998; Deacon, 1999; Godoy et al., 2001; Holden and Shiferaw, 2002). There are also theoretical arguments that show a link between household's perception of security and its RTPs (see Panayotou, 1993), which may point to the issue of poverty and tenure insecurity reinforcing each other and impeding investment.

Incentives to invest in new agricultural technologies or inputs may also be reduced substantially when technologies have stochastic properties (Just and Zilberman, 1983; Hennesy, 1997). This is especially so when the time horizon and magnitude of net benefits associated with such technologies differ. Hence, the interplay of risk and household capacity to bear risk emerges as an important conditioning factor in the adoption decision (Feder and O'Mara, 1981; Rozenzweig and Binswanger, 1993; Shively, 1997; 1999; 2001; Just and Zilberman, 1988). This paper attempts to systematically extrapolate results of attitude measures (household time and risk preferences) to long-term conservation decisions[31].

Furthermore, while few studies documented the empirical evidence of the role of public programs on collective action (Gebremedhin at al., 2002; Pender and Scherr, 2002), showing public action crowding-out collective action, there is hardly any evidence on the role of public-led conservation programs in stimulating or displacing individual investment. The only exception, to the best of our knowledge, is a study by Gebremedhin and Swinton (2000) that provided evidence of public programs 'crowding-out' individual conservation in central Tigray (northern Ethiopia). While

[31] Only few studies used results from attitude measures of risk and time preference studies in explaining household decisions in conservation (see Shiferaw and Holden, 1999, and Holden and Shiferaw, 2002).

this seems to be a plausible result, there are no compelling theoretical arguments against a complementary relationship between such public programs and private investment. This is especially so when households face imperfect factor and capital markets.

The objectives of the paper are, therefore, to assess whether the following factors: a) tenure insecurity, b) poverty (resource poverty and high discount rates, c) risk and risk preferences, and d) public investment in conservation cause less private investment in land conservation. We focus on investments in soil bunds (medium term) and stone terraces (long-term) just because we want to capture the effect of the degree of tenure security, risk preferences and poverty-induced myopic behavior on conservation investments whose benefits, while perhaps causing short-term costs, accrue in the medium to long-tem[32] (Hayes et al., 1997; Gebremedhin and Swinton, 2000). We also introduced the distinction between determinants of the decision to invest and how much to invest in conservation, the latter measured by the length of conservation structures per hectare done by the household.

Section II presents the study area, survey methods and data choice. Part III specifies a theoretical framework of household decision to invest on soil conservation measures that incorporates tenure security, intertemporal and risk considerations as well as poverty and the role of public investment followed by hypotheses formulated for testing. Part IV presents the econometric model, variables chosen followed in part V by presentation of regression results and discussions. The final part concludes.

2. **Study site and sample data description**

Soil erosion, gully formation and loss in soil fertility are considered the three major land degradation problems facing the Tigray region, northern Ethiopia (Hagos and Holden, 2002a). To reverse the land degradation problem, concerted efforts have been going on in the region in terms of soil and water conservation activities (Geberemedhin, 1998; Hagos et al. 1999; Hagos and Holden, 2002a). Land conservation strategies focused mainly on the construction of technologies of physical structures depending on the land use pattern, through strategies that combine community–led mass mobilization and food/cash-for-work schemes (hereafter called

[32] On the role of risk preferences on the use of purchased inputs with short-term effects see Hagos and Holden (2002).

public investments)[33] and private investment (See Tables 4A and 5A). Additional incentives are devised to encourage individual households to undertake conservation measures on their holdings through increased provision of extension advice and incentives related to tenure security.

The land tenure system in Ethiopia has been substantially affected by past and current government policies (Rahmato, 1992; Joireman, 2001). Land is declared the property of the state; hence, it may not be sold or mortgaged. Peasants and pastoralists have only user rights. Equity concerns and problems of landlessness in the past have been addressed by recurrent process of government sponsored land redistribution.

A new land policy issued in Regional State of Tigray in 1997 prohibited further redistribution, except in cases where major public-led infrastructure development (e.g. irrigation) investments are made, hoping that this will stop further land fragmentation. It also formalized land-lease practices between farmers. Furthermore, it undertook land inventory surveys and issued use-right certificates to current users (Hagos et al., 1999). By doing so the regional government hoped to boost farmers' sense of security, which, in turn, may encourage to invest on erosion reducing and land quality enhancing technologies without the state losing its right of ownership to land. In spite of these measures, survey results still show that farmers are apprehensive, owing to the increasing problem of landlessness, to further land redistribution[34]. The study is partly an attempt to understand how recent changes in land policy have affected farmers' conservation investment behavior.

The study is based on a panel data covering 400 randomly selected households, operating 1752 plots[35] gathered in 1998 and 2001 in Tigray, northern Ethiopia. The survey covered 16 villages (tabias), four tabias strategically selected from each of the four zones (central, eastern, southern and western) based on differences in distance to market, agricultural potential conditions (due to variations in altitude and rainfall variability), population density and presence of irrigation projects. The study assessed farmers' perception of land degradation, the measures taken to ameliorate it and its impacts, and the magnitude and quality of conservation investments made on farm

[33] In the region, every adult household is required to provide free labor for 20 days annually for the construction of new and maintenance of existing conservation works both on private and communal lands.

[34] More than half of the surveyed households in 1998 fear future land redistributions in Tigray (Hagos and Holden, 2002a)

[35] We used only 1524 plots in this analysis because we had to drop the remaining due to sample attrition of about 12% between the two years.

through private initiative and/or public-led programs between 1998 and 2001. The data gathered a host of household related variables as well as plot level data on the plots' biophysical features, production history and input use.

The two major types of physical conservation structures used on farm plots are soil bunds and stone terraces. Grass strips, check dams, bench terraces, and fences (categorized as others in the paper) are also implemented either to complement stone terraces or soil bunds or as an independent measure to halt erosion. Soil bunds are embankments made by ridging soil on the lower side of a ditch along a slope contour. They can be constructed by hand digging or plowing. Stone terraces are constructed walls that retain embankments of soil. Their construction involves preparing a base for the wall, transporting construction rocks, and carefully layering the stones. Stone terraces are more effective than soil bunds in preventing soil erosion on steep slopes prone to runoff. Of course, building stone terraces requires considerably more investment of time and inputs than does building soil bunds. A capital budgeting analysis of conservation investments in northern Ethiopia by Gebremedhin et al. (1999) showed that the higher initial cost of stone terraces takes longer to pay off in form of crop yield gains than do soil bunds. However, the study showed that larger cumulative, discounted revenue from stone terraces after five or more years made it to be a more beneficial choice for longer planning horizons (Ibid.). In the 2001 survey, we gathered data on whether households have invested on these measures since 1998 and if they did, measured the length of these structures and the labor man-days invested on them.

In the same survey, we tried to elicit households' subjective risk preferences using hypothetical questions. For a discussion of the approach and outcome of the elicitation exercise (see Hagos and Holden, 2002b). We derived a unique risk aversion coefficient using a utility function with constant partial risk aversion based on which the mean of the constant partial risk aversion is calculated to serve as a measure of households' level of risk aversion. Based on the elicited risk preferences, the majority of the farmers show intermediate to extreme risk aversion. Only 11 percent of the households are moderate to risk neutral reflecting increasing partial risk aversion behavior.

We also run a separate regression to identify the correlates of risk preferences, which serve as a validation test to the data. Regression results (see Hagos and Holden, 2002b) show that most of the estimated coefficients were in line with economic

theory. Partial relative risk aversion was negatively correlated with household consumption expenditure and oxen holding, a measure of household income wealth and important asset wealth respectively, pointing to decreasing absolute risk aversion (DARA) as was found by Binswanger (1980) and Wik and Holden (1998). Moreover, the coefficient for the expected gain was negatively correlated with households' risk aversion coefficient underlining increasing partial risk aversion hypothesis.

Likewise, we elicited households' discount rates (rates of time preferences) using hypothetical questions (see Appendix I). We calculated the RTP for individual i as $\delta_i = \left[\ln\left(FV_t / PV_0\right) \Big/ (t) \right]$, where the future value (FV) is the certain income at future time t while present value (PV) is income that the household could receive now at $t = 0$.

From these hypothetical questions we calculated the mean RTPs for different time frames for both spouses in the household. As can be seen from Table 2, the mean RTPs, calculated for different categories depending on the future values, increased with the timeframes in consideration, which implies that households become impatient as time horizon extends into the future. We also run a separate regression on the pooled data (i.e. including all experiments), calculated discount rates as the dependent variable, to identify the correlates of time preference rates[36], which serves as a validation test to the data. Regression results show that most of the estimated coefficients were also in tune with economic theory (see Table 1A). RTPs were found to be negatively correlated to households' access to credit, liquid assets and farm size, results that are consistent with other earlier studies (Pender 1996, Holden et al., 1998; Holden and Shiferaw, 2002). Moreover, RTPs were found to be negatively correlated with households' expectations about future income and internal rate of return from investment in business if such a business were to take place. RTPs were found to be increasing with the future value of the games (magnitude effect) and decreasing with the timeframe involved (time effect). Moreover, RTPs were positively related to household risk preferences, which indicate that risk-averse households have higher discount rates, which supports the hypothesis that risk averse households are more pessimistic about the future (Munasinghe, 1993**;** Holden et al., 1998). We refrain from

[36] Holden et al. (1998) argued that PV may give a better fit econometrically than the RTPs when people are very poor and have very high RTPs. We used both interchangeably in this paper and both seem to do well.

a detailed discussion of the regression results here in this paper. In the subsequent parts of the paper, we used the predicted value of present value equivalent as an explanatory variable in the investment equations.

3. Theoretical framework

In the literature three principal mechanisms have been identified through which land rights influence resource use efficiency and land investment; namely, the security effect, the credit supply effect and the transaction effect (see, Place and Hazell, 1993; Feder and Feeny, 1993; Belsey, 1995; Gavian and Fafchamps, 1996; Hayes et al., 1997; Pender and Kerr, 1999). The threat to tenure security is not only justified by presence of expropriation risk but also the increasing pressure (due to high population growth) for land redistribution and missing formal land markets. Moreover, credit markets, both formal and informal, are very thin, and credit constraint[37] could be binding in the household's production and/or land investment decisions. This is typically the case in the study site.

Our model draws on a model developed by Gebremedhin and Swinton (2000). Gebremedhin and Swinton's model identified the condition for optimal soil conservation investment under conditions of perfect factor markets, and given public investment in conservation and household desire to maintain social image. While we maintain the role of public investments in our model, we model household conservation investment operating under imperfect factor markets. Factor markets in developing countries' settings could be missing, thin or imperfect. Comparative statics for different scenarios of market imperfections were developed by Pender and Kerr (1998). The implications of market imperfections is that production and consumption decisions are inseparable which, in turn, implies that household's production and investment decisions are not dictated by profit considerations alone but consumption choices as well. In such settings, households' asset endowments play a crucial role in influencing the decision and level of conservation investments made (de Janvry et al. 1991; Udry, 1996; Holden et al., 2001). For instance, labor rich households are expected to invest relatively more than labor poor households.

[37] Credit constraints in formal markets may be caused by adverse selection and moral hazard (Stiglitz and Weiss, 1981), interest rate restrictions (Gonzalez-Vega, 1984), and enforcement considerations (Bell, 1988; Pender, 1996). Moreover, in a risky environment farmers may choose to avoid credit if the penalties for default are sufficiently severe (Fafchamps, 1999; Holden and Shiferaw, 2002).

Similarly, farm households with larger farm holdings and other assets such as oxen and livestock holding per hectare may also invest relatively more on land conservation technologies than asset poor households. Public conservation investment is expected to influence individual conservation investment through different mechanisms. By taking part in public conservation programs, households may see the benefits of such programs without directly benefiting from it. On the other hand, households may also benefit directly from such programs by having one or more of their plots conserved. This is expected to reduce the labor and other resource requirements to conserve their own land. On the other hand, public investments on private holdings may also influence households' decision to undertake private investment negatively by changing households' expectations.

The household's utility is assumed to be increasing in present value of future income stream (π), and household characteristics and asset wealth (H^z) as indicated in equation (1):

$$\underset{I_i}{Max}\ U\left(E[\pi_t]; H_t^z\right)$$

subject to

$$(1)\qquad E(\pi_t) = \sum_{t=1}^{T} \delta^t \left(H_t^z\right)\left(pq_t A_t E[\tau_t] - cI_i(L_e) I_{it}\right)$$

$$q_t = y(s_t, z_t)$$

$$s_t = s_0\left(1 - er\left(\Psi, \sum_{\tau=1}^{t} I_{i\tau}, \sum_{\tau=1}^{t} I_{p\tau-1}\right)\right)$$

This equation defined the present value of future income stream (π_T) at the end of the household's planning horizon (T) as accumulated annual crop revenues minus the unit cost (cI_i) of conservation investment (I_i) as discounted by factor δ, which, in turn, is a function of household asset wealth and household characteristics (H^z). It is assumed that the unit cost of conservation investments is decreasing in level of worker experience $(cI_i'(L_e) < 0)$. Price (P_t) variability is captured by distance from farm to the nearest market. Expected crop revenues are the product of the crop price (p_t), yield (q_t), land area (A_t) and a binary expectation whether land tenure will be retained in period t $(E(\tau_t))$. Yield in season t, in turn is concavely increasing in

current soil depth $(q'(s_t) > 0)$ and depends also upon other conditioning factors (z_t) such as weather, pest attacks and soil fertility.

Soil depth increases linearly with initial soil depth $(s'(s_t) > 0)$ and decreases concavely with erosion $(s'(er) < 0)$. The erosion function, in turn, is assumed to be bounded to the interval $[0,1]$ and increasing in factors (Ψ) that govern soil propensity to erode $(er'(\Psi) > 0)$ such as slope, the presence of conservation structures and management practice. Erosion is further assumed to be concavely decreasing in cumulative soil conservation investments, both private $(er'(\sum I_{i\tau-1}\Psi) < 0)$ and public programs to build soil conservation structures on the household's farm $(er'(\sum I_{p\tau-1}\Psi) < 0)$. The cross partial derivatives of $er(.)$ with respect to Ψ and I_i or I_p are assumed negative. Because the erosion function is bound to the $[0,1]$ interval, the interaction effect of the public and private conservation investment $(\partial^2 er / \partial I_i \partial I_p)$ is indeterminate in sign. There is a potential substitutability between private and public soil conservation investments, but there is also potential complementarity if farmers either learn from experience with public programs or gain directly from it lowering the households resource requirements to conserve/maintain its land holding and therefore opt to make private investments. Which effect dominates is an empirical question.

We assume a condition of land scarcity where new land of comparable quality are not available, so cropped land (A_t) equals the initial land endowments (A_0) times the expectation of retaining land tenure in season t $(E[\tau_t])$. This expectation is assumed to be a binary and non-switching, such that the household either expects $(E[\tau_t] = 1)$ or does not expect $(E[\tau_t] = 0)$ to retain tenure in season t; once tenure is lost, it cannot be regained in a later period.

Substituting the definitions in equation (1) into the utility function yields the unconstrained, undiscounted Hamiltonian:

(2)

$$H = U\left(E\left\{ \sum_t \delta^t (H^z) pq_t \left(s_0 \left[1 - er\left(\Psi, \sum_\tau I_{i\tau-1}, \sum_\tau I_{p\tau-1} \right) \right], z_t \right) A_0 E[\tau_t] - cI_i I_i \right\}; H^z \right)$$

By differentiating equation (2) with respect to the choice variable I_i, we can identify the factors expected to influence the optimal rate of soil conservation under conditions of imperfect factor markets:

$$(3) \qquad \frac{\partial H}{\partial I_i} = \frac{\partial U}{\partial \pi}\frac{\partial \pi}{\partial q}\frac{\partial q}{\partial s}\frac{\partial s}{\partial er}\frac{\partial er}{\partial I_i}\left(A_0 E[\tau_t]\right) + \frac{\partial U}{\partial H^z}\frac{\partial H^z}{\partial s}\frac{\partial s}{\partial H^z} - \sum_{t=1}^{T}\delta^t(w)cI_i = 0$$

These conditions specify that optimal soil conservation investments take place where the marginal utility of the cumulative added yield equals the marginal cumulative discounted cost of the conservation investment required to achieve the added yield. This marginality condition also depends on household characteristics and asset wealth if markets do not fully function or are entirely missing. If markets are fully functioning, the effect of the second term in equation (3) becomes negligible. Given the household characteristics and asset endowments do not matter, the sign of the marginal utility term is positive; hence, households who maximize accumulated present value of future income stream will find it optimal to invest in more soil conservation.

This optimality condition also highlights the importance of the subjective expectation of enjoying land tenure in time period t $\left(E[\tau_t]\right)$. Because this term appears multiplicatively in the wealth term, the expectation of land tenure dictates the length of the planning horizon, thereby largely determining whether soil conservation appears desirable at all and if so, the type of conservation measure chosen.

Following the theoretical model and empirical literature (see Feder et al., 1992 and Clay et al. 1998; Clay et al., 2002), we specify an estimable land conservation investment model, which is given by:

$$(4) \qquad \sum_{t=1}^{T} I_i = f\left(tenure, wealth_{T-1}, H^z_{T-1}, plot, return, market, I_p, V\right)$$

$\sum I_i$ represents the level of conservation investment made by the household on plot i as measured by the length of soil bunds and stone terraces per hectare between 1998 and 2000. The vector *tenure* represents variables such as perceived degree of tenure security (τ), tenure arrangements, whether plot is owner-operated, rented-in/out or temporarily transferred, and the length of tenure holding or duration of contract. The

vector $wealth_{T-1}$ includes household's asset holdings such as relative farm size in hectares, livestock, labor holdings, both relative to the farm holding and exogenous income (e.g. access to food aid) in 1998. We classify adult labor into female and male labor units because female and male labor may represent different asset types. The vector h^z_{T-1} includes the household and demographic related characteristics in 1998 and households' attitudes of risk aversion and time preference rates. We assumed that initial wealth conditions, household, and demographic characteristics would matter in the household's decision to invest on land conservation. This will enable us to test for time recursive causality of initial wealth, household and demographic characteristics on conservation investments in land.

The vector *plot* includes farm characteristics such as soil type, slope, agro-ecology, degree of fragmentation (as measured by the ratio of total number of parcels to the total farm size (see Bellon and Taylor, 1993), access to irrigation, susceptibility to and degrees of erosion and distance from homestead, quality of conservation structures in place. We also included plot size, along side relative farm size in relation to the zonal average, into the model, the former to control for plot level unobservables (e.g. measurement error) and the relative farm size to test for farm size effects (see Udry, 1996; Holden et al., 2001). *return* is a vector of households' perceptions on the perceived impacts of conservation investments on improvements in land quality and crop yield. These variables could be regarded as proxy for the profitability of conservation structures. I_p is a binary variable indicating whether any of the plots operated by the household were conserved/maintained by public programs. The vector *market* is related to market access variable, which include access to credit, off-farm employment, and food-for-work projects. To control for the effect of village level fixed effects, we included village (V) level characteristics such as distance to a major market (far vs. close), population density, and rainfall variability into the model.

Hypotheses

Based on the theoretical and estimable model specified, we developed below the key hypotheses related to the important variables and the household's decision to invest in land conservation.

Tenure insecurity could be an important factor for lack of or lower incentive to invest in land conservation. We measured tenure security by using multiple indices such as perceptions of degree of security, duration of tenure holding (years operated),

differences in land rental arrangements, and farm characteristics such as distance from homestead and fragmentation of plots.

H1a: We hypothesize that investments in land conservation will increase with the perception of degree of tenure security.

H1b: The longer the number of years the household has operated a specific plot, the higher will be the incentive to conserve that plot because we believe that overtime households will develop a strong sense of security over holding, and this will encourage households to invest on it (Alemu, 1998). On the other hand, duration of tenure holding may not only measure stability of tenure but also capture the household's internal pressure for land redistribution as the number of landless people increase over time from the last land redistribution. The sign is, hence, ambiguous.

H1c: Own-operated plots are expected to be more likely be conserved compared to rented- in/out or temporarily transferred plots due to the usually short duration of tenure holding or rental/transfer contracts and other incentive problems.

H1d: Plots close to homestead are more likely to be conserved than far away plots not only due to the transaction costs involved but also the relative degree of security attached to homestead farms compared to distant plots. High fragmentation of plots may also involve higher transaction costs rendering investment to be unattractive. Maintaining fragmented plots may, however, also be used as households' risk spreading strategy. Its effect on conservation may, hence, be ambiguous.

H2: Poverty reduces the household's willingness and ability to invest (Pagiola and Holden, 2001and Holden and Shiferaw, 2002). Poverty in assets and cash income constraints lead to high RTPs and this may lead to a myopic behavior of farm households leading to low on-farm investment. This may be especially true of long-term investments whose benefits accrue long-term into the future.

H3: Households' risk preferences may negatively influence households' decision to invest on soil conservation especially if the investment exposes the household to further risk (e.g. short-term yield reduction). Besides, more risk averse people tend to have higher RTPs both pointing to lower willingness to invest. On the other hand, risk aversion may also enhance technology adoption if the technology reduces the risk to household income (e.g. moisture conservation). Furthermore, risk aversion may also lead to more investment as highly risk averse food deficit households may find

conservation as important food security strategy (see Finkelshtain and Chalfont, 1991; Fafchamps, 1992; Hagos and Holden, 2002). The expect sign is, hence, ambiguous.

H4: Public investment in conservation reduces private investment (Gebremedhin and Swinton, 2000). Given that there are public conservation measures to conserve private holdings, households may have less incentive to conserve their own land expecting that the public will take care of it

H5: Public investment may substitute for perfect markets and eliminates the negative effects of imperfect markets (H1-H3). If resource constrained households gain directly from public investments on their plots, this may reduce the resource burden of households to conserve the remaining plots or maintain already established structures. We conjecture that given imperfection in markets, such public action may compensate for imperfections in factor markets thereby reducing the role of resource endowments in conservation decision. Moreover, a positive outcome of communal conservation efforts on land quality improvement may encourage households by example to undertake such measures.

Finally, village level effects such as variations in agricultural potential (rainfall and altitude), distance to market and population density will determine the profitability of conservation investment. We hypothesize that households located in villages close to market and higher agricultural potential will have better incentives to invest on land conservation. On the other hand, households' located in remote communities may also invest more on land conservation because opportunities for off-farm labor may be fewer reducing the opportunity cost of conservation investment. Similarly, higher population density may induce intensification and, hence, trigger more investment in conservation as was hypothesized by Boserup (1965). The importance of conservation investments may increase with altitude because the rainier upper highlands are more exposed to erosion than the middle altitude.

4. Econometric model specification

Let the amount of conservation made on farm plot by a household i be given by:

$$y_1 = x_1\beta_1 + \mu_1 \quad (5)$$

where y_1 is the length of conservation structures per hectare that is expected to depend on the vector x_1 regressors outlined in equation (4). The participation equation, whether the household decides to invest or not, is given by:

$$y_2 = 1[x\delta_2 + v_2 > 0] \quad (6)$$

where (x, y_2) are always observed whereas y_1 is observed only when $y_2 = 1$. We assume that (u_1, v_2) is independent of x with mean zero implying that x is exogenous, and $v_2 \sim N(0,1)$.

Given such a model, if the error terms in equations (5) and (6) are related, we have to estimate them jointly where first the household chooses whether the household decides to invest and then having decided positively chooses the level of conservation investment to make on a specific farm plot. This needs testing for the presence of sample selection problem. In the absence of such a bias, however, the two equations could be estimated separately. In our case, the presence of selection bias was not confirmed using Heckman's selection model (Heckman, 1979). The Likelihood Ratio test of the independence of the two equations could not be rejected using regular test procedures, implying that there is no selection bias both in the soil bund and stone terrace equations. The lack of significant selection bias could be related to the distributional assumptions of the Heckman model. Hence, we tried to test the robustness of the results by relaxing the distributional assumption. We tested for selection bias using Deaton's selection model (Deaton, 1997). The results likewise could not reject the null hypothesis of no selection bias. Hence, we run separately a binary choice (Probit) model and censored regression model (Tobit) to estimate the decision to invest and level of conservation investment, respectively. Standard Probit and Tobit models can be formulated as:

$$\begin{aligned} y_i^* &= x_i'\beta + \varepsilon_i \\ y_i &= 1 \text{ if } y_i^* = 1 \\ &= 0 \text{ otherwise} \\ y_i^* &= x_i'\beta + \varepsilon_i, \\ y_i &= y_i^* \text{ if } y_i^* > 0 \\ &= 0 \text{ if } y_i^* \le 0 \end{aligned} \quad (7)$$

where i=1,2,…,N, and ε_i is assumed to be NID (0, σ^2) and independent of x_i [38]. This model is a censored regression model where observations may be censored from below.

The estimation procedure could be troublesome due to the presence of endogenous variables in the model. These may include variables such as household's elicited subjective risk and time preferences. This requires testing for endogeniety, and, in case we fail to reject endogeneity, we have to account for it in our estimation. Test results performed using Durbin-Wu-Hausman test (Davidson and Mackinnon, 1993) show that endogeneity of risk preferences is rejected while we fail to reject the endogeneity of time preferences, a result consistent with theory when markets are imperfect (Holden et al., 1998; Holden and Shiferaw, 2002). In order to deal with the endogeneity problem of the time preference rates, we used the predicted value from an OLS regression. To correct for possible heteroskedasticity, we estimated White-Sandwitch-robust standard errors (White, 1980) and estimated standard errors that adjust for within-cluster correlation (Rogers, 1993) both on the probit and censored (interval) regression models.

5. Results and discussion

5.1. Descriptive statistics

Table 4 presents description and summary statistics on a wide range of variables used in the regressions. The standard errors are adjusted to take account of stratification and clustering effects.

The majority of the households perceive that they have moderate to highly secure tenure holding. Only 20 % of the households perceive their tenure status to be either highly or moderately insecure. In this case, it seems that the recent change in land policy has brought a change on farmers' attitude of tenure security. Close to 80% percent of the plots are owner-operated. The bulk of the remaining plots are either rented-in or out, the exception one percent being temporarily transferred from parents to landless adult family members. The average duration of tenure holding in the region is 11 years ranging between close 12 years among owner-operated and 7 years among rented-in plots.

[38] We tried to use Powell's (Powell, 1984) censored least absolute deviation (CLAD) model to test the robustness of the results to non-normality distributional assumption but our sample was too small for the model to converge.

Close to 46 % of the plots were conserved through public programs where as 22 and 11 percent of the plots were conserved by stone terraces and soil bunds from private initiative with an average length of 14.7 and 15.20 meters per hectare. Other alternative conservation structures such as grass strip, check dams, bench terraces, and fences made by private households cover about 29 percent of the plots.

The perceived benefits of such conservation measures include improvements in the quality of the conservation structures, land quality and increased crop yield. About 32 percent of the plots are perceived to have shown improvements in land quality compared to 28 percent of the plots that are said to have shown improvements in crop yield. In the subsequent parts, we will rigorously analyze the role of tenure security regimes, attitude factors, public investment other factors on the decision to undertake and level of investment made by individual households.

5.2. Determinants of the probability of investment

Table 6 lists regression results on the determinants of private investment on land conservation, separately for investment decisions on soil bunds and stone terraces.

Degree of security or differences in tenure arrangements, although all with the expected sign, do not seem to significantly explain differences in investment behavior among farm households. Rented-in plots were found to have marginally lower probability, at significance level of 10 percent, of being conserved with stone terraces relative to owner-operated plots. The coefficient for the duration of tenure holding or tenure contract was not statistically significant in explaining investment behavior either.

Resource poverty does not seem to have significantly explained investment behavior. That is oxen, livestock and adult labor (both female and male) were not significant. Only relative wealth in farm holding was found to be statistically significant in explaining households' decision to invest both stone terrace and soil bund. The signs are, however, different in the two equations where increased relative farm holding seems to have increased the probability of investment on stone terraces while it is negatively related with the probability of investing on soil bunds. This is perhaps closely related with the nature of the conservation technologies because stone terraces need more space to be established while soil bunds do not take up much space implying that households with large farm holding are likely to invest on stone terraces as the probability of investment in soil bunds decreases with farm size. Attitude

measures such as endogenous RTPs and household risk preference do not significantly explain the probability of investment with respect to both soil bunds and stone terraces.

Access to factor and capital markets do not seem to influence the probability of investment implying that credit constraints and access to food-for-work do not contribute to increased probability of investment in land conservation. Households access to off-farm income seems to influence the probability of investment in soil bunds negatively, however.

Similarly, none of the household/individual characteristics was found to significantly affect the decision to invest. The coefficient of the dependency ratio was found to be marginally significant in explaining the probability of private investment in stone terraces. These results, together with the insignificant role of household asset endowments, point to household behavior under perfect markets. These results sound counter-intuitive at first perception. Nevertheless, they make more sense if we follow up closely the role of public programs in the investment decision of households.

Community-led investment on land conservation seems to have stimulated private conservation investment. The coefficient of whether the household benefited from public conservation programs, in terms of establishment of conservation structures on any of its plots, was found to be consistently positive and highly significant. What seems in play is that public intervention in conservation seems to have compensated for the imperfections in markets thus rendering household characteristics and asset holdings to be less important in determining the households' decision to invest on land conservation.

Similar to situations under perfect markets, plot level factors and the profitability of conservation structures seem to have significantly influenced the probability of private level investment. The probability of conserving on stone terraces is a decreasing function of plot distance from homestead. Land fragmentation was also found to have influenced positively the probability of investment on terraces and negatively soil bunds implying that households invest on technologies that economize on land space the more fragmented farms they operate. Other plot level characteristics such as soil types, susceptibility to erosion, state of the conservation structures and agro ecology were found to be highly related to the probability of investing in stone terraces. Note that plots that are highly susceptible to erosion and those with poor conservation structures are more likely to be picked for investment pointing that

households invest more on susceptible and marginal lands than on well conserved plots. On the other hand, the larger the share of non-conserved plots relative to the total farm holding, households are less likely to invest. Irrigated plots are less likely to be conserved with stone terraces because of irrigated plots are generally too small to allow the establishment of stone terraces.

In deciding to undertake conservation investments, households seem to take due consideration of the possible costs and returns linked to the investment. Households set certain expectations about the possible benefits of undertaking investments. Households' likelihood of investing in stone terraces increased significantly with the perception that land quality has improved due to conservation.

Finally, out of the few variables we used to control for village level fixed effects, distance to market, rainfall variability and population density were found highly significant. With respect to both stone terraces and soil bunds, households in communities that are relatively remote were less likely to conserve their land compared to households with better access to market. This decision could perhaps be related to the profitability of the conservation structures if done in communities close to markets. Contrary, to our expectations, communities with high rainfall variability were found less likely to invest on stone terraces. Furthermore, households in densely populated communities are more likely to invest more on labor-intensive technologies, i.e. stone terraces, pointing to Boserupian effects.

5.3. Intensity of conservation structures

The intensity of conservation investment as measured by the length of conservation structures (in meters) of soil bunds and stone terraces per hectare was also explained by a host of variables as depicted in Table 7.

Similar to the results we had on the probability of investment, differences in intensity of conservation investments made are hardly explained by perceived degree of tenure security, differences in types of land rental arrangements or the duration of tenure holding/ rental contract. Only severely insecure plots were found to have marginally lower, at 10 percent level of significance, level of intensity compared to highly secure plots.

With respect to households' asset holdings, oxen holding and relative farm holding were found significant in explaining the intensity of both stone terraces and soil bunds. Oxen holding were found to be positively related with the intensity of soil

bunds, which is not surprising given that soil bunds are made mainly with the help of plow oxen, and negatively related with intensity of stone terraces. The coefficient of the relative farm holding was also significant and negative in explaining the intensity of conservation with respect to both soil bunds and stone bunds pointing to an inverse relationship between farm size and conservation intensity. Households' labor endowment and livestock holding were found, however, insignificant. Similarly, the coefficient for the endogenous time preference rates was also insignificant underlining the weaker role of asset poverty in conservation investment. This is further strengthened by insignificant effect of liquidity constraints and access to non-farm employment on such investments.

Unlike the result with the probability of adoption, households' risk preference rates were found to be negative and significant in explaining the intensity of soil bunds and stone terraces pointing that risk and risk preferences may play a role in determining the level of investment made. In this line, more risk averse households, which were found to have higher discount rates, were found to invest less in medium- and long-term conservation measures.

Few household and demographic factors seem to have significantly influenced the levels of investment made on conservation. The age of the household head is negatively correlated with the intensity of soil bunds. Educated households seem to invest more on soil bunds but less on stone terraces. This may generally point to the higher opportunity costs of skilled/educated household labor thus rendering lower investment on labor-intensive conservation activities unless the expected return from these activities is not higher enough. Increased dependency ratio seems to have discouraged intensity of soil bunds but has no significant effect on the intensity of stone terraces.

Consistent with the results on the probability of conservation investments, the intensity of conservation investments was stimulated by community-led conservation investments. To see what is going on, we categorized investments done on private holdings, both stone terraces and soil bunds, into those done by public programs or through private initiatives and those done jointly by the two to see their relative importance in terms of the number of plots conserved through each program, share of area conserved to total farm size and the intensity of conservation. The results are reported in Table 2A.

Out of the total 874 plots conserved, 527 (60%) were conserved through public-led conservation measures while 173 (20%) were conserved through individual initiative. 173 (20%) plots benefited from both public and private investments in stone terraces. Likewise, Out of 768 plots conserved by soil bunds, 594 (77%) were conserved through public led programs whereas 68 (8%) were conserved by private initiative. 106 (14%) plots benefited from both public and private investments in stone terraces. The intensity of conservation is higher on plots that were jointly conserved through public and private programs in contrast to those made either through private or public programs only. This is true with respect to both stone terraces and soil bunds. On the other hand, conservation intensity, in stone terraces and soil bund, is far higher on plots conserved through private investment in contrast to those plots where conservation investment was made through public programs alone. These figures demonstrate that households having gained from public programs directly, they may have more resources to devote to conserving other non-conserved plots or maintain already conserved ones. This may strengthen our conjecture on the role of public programs in reducing the effect of market imperfections on household behavior and thereby encouraging investment across household categories regardless of their wealth standing and household characteristics[39]. It is imaginable that public led conservation programs gave a sort of kick-off effect on individual initiative by lowering the significance of household level variations in resource endowments.

One could not also rule out the possibility that households have learned by example by taking part in public conservation programs whose major focus was conserving community lands (see Tables 4A-6A).

These results gain weight given other empirical evidences related to households' perceptions pertaining to the importance of public programs. From the results in Table 3A, one could see that the majority of the respondents expected for increased community support to help them solve land degradation problems on their private land by drawing on technical assistance and labor mobilization. The evidence clearly illustrates that technical assistance was in highest demand but the large majority indicate also that technical assistance alone is not sufficient (see Hagos and Holden, 2002a).

[39] We run reduced models (excluding *public2*) for the probability and intensity of investments, and some of the asset variables, especially the coefficients for adult labor, turned out to be significant.

Plot level factors and the profitability of conservation structures, like under the theory of perfect markets, came out also strongly in explaining the intensity of conservation investment. Plot level variables such as soil type, susceptibility to erosion and altitude have influenced the level of investment made, the first variable in soil bunds and the other two in stone terraces. Degree of fragmentation and whether the plot is irrigated or not determined the intensity of soil bunds. The households' perceptions of possible impacts of conservation measures on changes in land quality and crop yield, which we used as a proxy for the profitability of structures, significantly determined the intensity of stone terraces. The coefficients for these variables in the soil bund equation were not statistically significant although the signs are consistently the same. This underlines the importance of the perceived positive marginal benefits received from undertaking investments in terms of land quality improvement and increased yield in influencing households' behavior towards investments in those measures.

From among the village level variables, population density and rainfall variability also influenced the level of investments made with respect to soil bunds. The intensity of soil bunds was positively determined by population density pointing to possible Boserupian effect. Increased rainfall variability has also led to increased intensity of soil bunds pointing to the importance of structures to conserve moisture. It may be pointed out that conservation structures are perhaps used as risk reducing mechanisms. Finally, intensity of stone terraces increased in communities far from market pointing to the absence of employment opportunities of labor in communities far from market and thereby perhaps encouraging labor-intensive conservation investments in land.

6. Conclusion

The empirical results point to the importance of public led conservation programs in significantly stimulating private investment on land conservation. This evidence is explained given the households' expectations on the importance of public programs in solving the land degradation problem on their private land by drawing perhaps on technical assistance and labor mobilization. The gains from such public programs to individual households may not only be in terms of the direct benefits driven from getting part of their plots conserved but also gains in technical knowledge from taking part in such programs. It is imaginable that public led conservation programs gave a

sort of kick-off effect on individual initiatives by lowering the significance of household level constraints in resources such as labor, inputs and capital.

In this line, labor mobilization for conservation work, which seems to work very well in the region (see Hagos and Holden, 2002a) as a system of taxing labor rich households in favor of labor poor households, may underline the usefulness and perhaps relevance of Pigovian taxes or subsidies (taking a form of taxation in labor) in addressing environmental problems in developing countries. Such public programs are usually justified by the presence of spatial and intertemporal externalities associated with the problem of land degradation underlining the need for coordination across farms, technical inputs and resources (labor) mobilization. If coordination issues to exploit labor resource, one of the most abundantly available resources in rural economies, for a common good (e.g. undertake conservation investments) and the delivery of technical inputs are properly devised, it may stimulate private conservation of land. Public intervention in conservation work may also be broadly justified by market imperfections, and prevalence of poverty and food insecurity. Given such 'crowding-in' effect of public programs on private investment in conservation, and the positive returns from conservation in terms of reduced erosion, improvements in land quality and yield, may demonstrate a sort of win-win-win situation of internalizing externalities, stimulating individual investment and contributing to poverty alleviation.

Plot level variables and households' perceptions on returns from conservation investments, in terms of improved land quality and increased crop yield, were found to be crucial in the decision to invest and intensify soil conservation. This points to the importance of making readily available of attractive (profitable) conservation technologies to households through the research and extension establishment if households are to be stimulated to invest on their holdings. This gains additional weight given the risky nature production in the region and the associated short and medium term costs and long-term pay-offs of these conservation technologies. The evidence on the importance of risk considerations in the decision to invest on land conservation calls for policy measures that focus on the provision of technologies that reduce household risk and poverty to enable sustainable investment on conservation measures by individual households.

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Table 2: Calculated continuous time discount rates

Future value	EB 10		EB 100		EB 1000	
Time frame	Husband	Wife	Husband	Wife	Husband	Wife
Two weeks	0.038	0.037	-	-	-	-
One month	0.109	0.112	-	-	-	-
Six months	-	-	0.733	0.728	-	-
1 year	-	-	1.942	1.940	-	-
2 years	-	-	3.608	3.648	-	-
5 years	-	-	-	-	14.946	15.310
Ten years	-	-	-	-	25.181	25.922

Table 4: Descriptive summary (n= 1524)

Variable	Description	Estimate	Std. Err.
Tenure arrangements and security related variables			
secure1	Severe insecure	0.088	
secure2	Moderately insecure	0.101	
secure3	Moderately secure	0.588	
secure4	Highly secure	0.222	
tenure1	Owner-operated	0.799	
tenure2	Rented-out	0.097	
tenure3	Rented-in	0.095	
tenure4	Transfer	0.014	
ownsince	Years operated	11.390	0.237
Conservation investment			
sterrace	Length of stone terraces per hectare	14.70	1.557
sbund	Length of soil bund per hectare	15.20	12.847
altcons	Other conservation structure per hectare	5.41	1.188
terrace	Whether terraces have been made on any of the household's plots privately (yes=1; 0 otherwise)	0.227	
bund	Whether bunds have been made on any of the household's plots privately (yes=1; 0 otherwise)	0.114	
public	Whether the household has benefited from community-led conservation on any of its farm plots (yes=1; 0 otherwise)	0.459	
Plot and soil characteristics			
ecosy	A dummy representing agroecology (hausi kola=1, hausi degua=2, degua=3)		
sotype	A dummy for soil type (Husta=1, Mekih=2, Baekel=3, Walka=4)		
soildp	A dummy for soil depth (Shallow=1, medium=2, deep=3)		
sslope	A dummy for slope (plain=1, foothill=2, mid hill=3, steep hill=4)		
distance	Distance of plot from homestead (in walking time)	24.675	0.774
fragmt	Index for land fragmentation (no. of parcels/ farm size)	3.696	0.126
qualit	A dummy for soil quality (poor=1, medium=2, good=3)		
suseros	Susceptibility to soil erosion (none=1, low=2, medium=3, high=4)		
erosio	Degree of soil erosion (none=1, low=2, medium=3, high=4)		
chacons1	Changes in conservation structures (worse=1, remained the same=2, improved=3)	0.057	
chacons2		0.116	
chacons3		0.825	
qltcons1	Quality of conservation structures (poor=1, medium=2, good=3)	0.315	

qltcons2		0.328	
qltcons3		0.356	
lqimp1	Impact of conservation investment on land quality (worse=1, remained the same=2, improved=3)	0.144	
lqimp2		0.539	
lqimp3		0.316	
yield1	Impact of conservation investment on yield (worse=1, remained the same=2, improved=2)	0.310	
yield2		0.411	
yield3		0.278	
irrig	A dummy for access to irrigation water (yes=1; 0 otherwise)	0.064	
Household characteristics			
hhage	Age of household head	49.193	0.798
sex1	A dummy for sex of household head (male=1; female=2)	0.887	
sex2		0.112	
edu1	A dummy for education of household head (illiterate=1; literate=2)	0.882	
edu2		0.117	
depratio	Ratio of dependent members to adults	2.618	0.110
Market access related variables			
foodaid	A dummy for having access to food aid (yes=1; 0 otherwise)	0.156	
ffwm	A dummy for having access to food-for-work (yes=1; 0 otherwise)	0.599	
access	A dummy for having access to credit (yes=1; 0 otherwise)	0.636	
laborm	A dummy for having access to other off-farm employment (yes=1; 0 otherwise)	0.355	
Asset holding and household wealth			
femlab	Number of female adults/farm size	0.267	0.011
malelab	Number of male adults/farm size	0.240	0.009
shrncons	Share of nonconserved land to total farm size	2.049	0.509
relfarm	Ratio of household to zonal average farm size	1.000	0.059
landarea	Farm plot in hectare	1.280	0.202
pcoxen	Oxen holding/ farm size	0.212	0.014
pctlu	Livestock holding/ farm size	0.303	0.021
Village-level variables			
market	Access to a major market (close=0; distant=1)	0.513	
rainvar	A coefficient of variation of rainfall for the last ten years	29.305	0.293
popn	A dummy for population density (Dense=1)	0.393	

Table 6: Factors explaining private initiative to conserve

Dependent variable	Probability of investing on terraces (n= 1346)		Probability of investing on soil bunds (n= 1346)	
Variables	**Coef.**	**Robust Std. Err.**	**Coef.**	**Robust Std. Err.**
Security and tenure arrangement related variables				
Severely insecure	-0.441	0.234	-0.157	0.301
Moderately insecure	- 0.212	0.245	-0.152	0.257
Moderately secure	-0.154	0.157	-0.182	0.185
Rented-out	-0.141	0.198	-0.014	0.177
Rented-in	-0.317	0.191*	-0.049	0.233
Temporarily transferred	-0.309	0.385	-0.404	0.497
Years of operation	-0.001	0.004	0.006	0.004
Alternative conservation investment and community action				
Benefited from public conservation	0.749	0.115***	0.723	0.120***
Presence of alternative conservation	-0.001	0.001*	0.001	0.001
Household characteristics				
age of head	-0.000	0.004	-0.004	0.004
Female-headed household	-0.203	0.188	0.143	0.174
Educational status	-0.144	0.157	0.113	0.190
Dependency ratio	0.049	0.028*		
Household asset and wealth variables				
Oxen holding per ha	-0.092	0.049*	0.069	0.054
Livestock holding per ha	0.023	0.027	-0.005	0.023
Relative farm holding	0.109	0.040***	-0.096	0.057*
Female adult labor per ha	0.027	0.058	-0.007	0.059
Male adult labor per ha	-0.001	0.047	0.053	0.051
Elicited variables				
Predicted present value equivalent	0.001	0.002	0.0003	0.002
Mean relative partial risk aversion coef.	-0.009	0.009	0.005	0.011
Market access related variables				
Access to food aid	0.187	0.159	-0.027	0.142
Access to food for work	-0.152	0.120	0.121	0.136
Access to credit	-0.083	0.125	-0.174	0.145
Access to off-farm work	0.054	0.114	-0.293	0.131**
Village-level variables				
Rainfall variability index	-0.018	0.005***	0.011	0.006
Distance to market	-0.116	0.126	-0.340	0.140**
Population density	0.365	0.113***	0.137	0.153
Plot and soil characteristics				
Plot area (in ha)	-0.000	0.006	0.008	0.007
Share of nonconserved area to plot area	-0.646	0.127***	-0.330	0.180
Plot distance from homestead	-0.005	0.002***	-0.002	0.002
Fragmentation index	0 .061	0.026**	-0.117	0.029***
Irrigated plot	-0.525	0.234**	0.070	0.224
Medium soil depth	-0.079	0.126	-0.013	0.128
Deep soil	-0.138	0.159	0.004	0.166
Baekel	0.738	0.138***	-0.637	0.142
Mekih	0.541	0.164***	-0.421	0.165
Walka	0.453	0.147***	-0.439	0.144***
Low susceptibility to erosion	0.283	0.190	-0.028	0.175
Moderately susceptible to erosion	0.182	0.273	-0.019	0.238
Highly susceptible to erosion	1.027	0.398***	-0.147	0.384
Hausi degua	0.498	0.176***	-0.267	0.211
Degua	0.545	0.190***	-0.631	0.217
Medium quality soil	0.060	0.148	-0.089	0.146

Good quality soil	-0.295	0.179*	0.219	0.177
Low levels of erosion	0.207	0.192	0.187	0.175
Moderate levels of erosion	0.326	0.295	-0.168	0.283
High levels of erosion	-0.113	0.421	-0.373	0.412
Medium quality conservation structures	-0.241	0.132*	-0.075	0.135
Good quality conservation structures	-0.771	0.167***	-0.516	0.175
No changes in conservation structures	-1.827	0.320	-0.385	0.384
Improved conservation structures	-0.437	0.207**	0.275	0.240
Expected returns from conservation				
No improvement in land quality	0.236	0.168	-0.392	0.212
Good improvement in land quality	0.588	0.186***	-0.274	0.212
No improvement in yield	-0.167	0.159	0.019	0.199
Good improvement in yield	0.144	0.162	0.019	0.165
_cons	-0.182	0.537	0.277	0.599
	Log likelihood = -518.687		Log likelihood = -515.19	
	Wald chi2 (55) = 484.21		Wald chi2 (55) = -248.19	
	Prob > chi2 = 0.000		Prob > chi2 = 0.000	
	Pseudo R2 = 0.442		Pseudo R2 = 0.245	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively.

Table 7: Intensity of conservation (soil bund and stone terrace)

Dependent variable	Length soil bunds in meters per hectare		Length stone terraces in meters per hectare	
Variables	**Coef.**	**Robust Std. Err†.**	**Coef.**	**Robust Std. Err†.**
Security and tenure arrangement related variables				
Severely insecure	0.346	45.142	-66.947	40.343*
Moderately insecure	3.922	38.843	3.511	32.251
Moderately secure	2.407	30.617	1.332	19.410
Rented-out	27.116	29.113	37.497	18.690
Rented-in	-5.737	46.796	13.305	23.602
Temporarily transferred	-162.543	181.601	-18.587	104.979
Years of operation	0.332	0.632	-0.567	0.646
Alternative conservation investment and community action				
Presence of alternative	0.673	0.128***	0.760	0.134***
Benefit from public prog.	90.495	21.874***	47.502	13.477***
Household characteristics				
age of head	-1.491	0.617***	-0.014	0.473
Female-headed	24.244	28.765	-13.278	20.373
Educational status	45.379	23.922**	-8.057	17.709**
Dependency ratio	-11.217	5.278**	4.679	3.452
Household asset and wealth related variables				
Oxen holding per ha	16.609	8.275 **	-14.903	7.281**
Livestock holding per ha	-4.146	4.187	5.768	3.708
Relative farm holding	-23.491	8.990***	-14.966	7.376**
Female adult labor per ha	7.271	8.415	-4.539	7.305
Male adult labor per ha	3.449	6.583	-4.442	5.493
Elicited variables				
Predicted present value	-0.184	0.288	0.357	0.207
Mean relative partial risk.	-3.378	1.809*	-2.264	1.194**
Market access related variables				
Access to credit	-16.763	21.258	-25.560	15.572
Access to off-farm income	-31.099	19.235	-3.891	15.450
Access to food aid	5.961	22.241	11.238	19.603
Access to food for work	11.388	18.276	-10.177	14.374
Village-level variables				
Rainfall variability index	25.877	20.744	54.317	14.514***
Distance to market	51.838	24.09**	20.067	19.118
Population density	4.396	.926***	1.053	0.672
Plot and soil characteristics				
Plot area	-0.080	1.021	-1.321	0.816
Plot distance from home	-0.122	0.367	0.012	0.223
Fragmentation index	-15.412	5.264***	4.396	3.278
Irrigated plot	65.238	34.404**	-16.882	29.988
Medium soil depth	0.735	19.879	-6.639	15.703
Deep soil	3.739	26.557	-3.309	20.470

Baekel	-112.535	23.641***	-3.302	15.985
Mekih	-58.662	23.771***	25.438	20.408
Walka	-85.059	21.589***	-21.033	16.045
Low susceptibility	-8.880	33.013	27.129	21.682
Moderately susceptible	0.305	38.739	78.163	35.508**
Highly susceptible	14.579	61.350	96.002	41.658**
Hausi degua	-4.111	31.269	84.284	30.665***
Degua	-38.642	30.382	66.928	31.398**
Medium quality soil	-32.183	21.218	-9.204	18.229
Good quality soil	-3.217	28.406	-36.102	24.063
Low levels of erosion	62.665	32.626**	2.151	21.707
Moderate levels of erosion	3.637	46.003	-49.812	36.568
High levels of erosion	-13.316	71.088	-29.459	41.837
Medium quality cons.	-12.121	20.986	-30.316	15.293**
Good quality cons	-80.825	30.106***	-84.625	21.918***
No change in conservation	-13.789	59.983	-143.949	41.588***
Improved conservation	42.072	42.839	19.784	28.862
Expected returns from conservation				
No improvement in land	-36.839	32.035	60.968	24.454***
Good improvement in land	34.616	34.930	100.927	19.132***
No improvement in yield	34.354	27.426	7.908	19.690
Good improvement in	27.940	23.414	60.216	13.762***
_cons	-6241.34	3357.887*	-365.317	83.360***
_se	1599.104	737.530**	134.977	9.32
	Number of obs = 1346		Number of obs = 1346	
	Wald chi2(55) = 353.62		Wald chi2(55) = 257.90	
	Log likelihood = -1215.48		Log likelihood = -2296.4185	
	Prob > chi2 = 0.000		Prob > chi2 = 0.0000	
	uncensored observations= 158		uncensored observations= 316	
	left-censored observations= 1188		left-censored observations= 1030	

*, **, *** are levels of significance at 10, 5 and 1 percent respectively.
† We adjusted the standard errors by accounting for household clustering effects.

Appendix I

Approach used to elicit Rates of time preferences

We presented respondent with a question which goes as follows: "If you have the choice between receiving an amount (FV_t) in t years into the future (with certainty) and another amount today (PV), how large would that amount (PV_0) have to be for you to prefer that amount today $(t=0)$ or to prefer to wait for FV[40] in t years?" We offered different bids, with a view of testing for time, magnitude and other framing effects, from which the household head (or any adult) was asked to choose iteratively. The cut-off point was then identified and interpreted as the point of indifference.

Time preferences:

If you have the choice between receiving 10 Birr one month into the future (with certainty) and another amount today, how large would that amount today have to be for you to prefer that amount today or prefer to wait for the 10 Birr in a month?

Husband
Where start?

Birr amount Preferred Tick		Birr amount preferred in a month	
0.20		10	
0.50		10	
1.00		10	
1.50		10	
2.00		10	
2.50		10	
3.00		10	
3.50		10	
4.00		10	
4.50		10	
5.00		10	
5.50		10	
6.00		10	
6.50		10	
7.00		10	
7.50		10	
8.00		10	
8.50		10	
9.00		10	
10		10	

Wife
Where start?

Birr amount Preferred Tick		Birr amount preferred in a month	
0.20		10	
0.50		10	
1.00		10	
1.50		10	
2.00		10	
2.50		10	
3.00		10	
3.50		10	
4.00		10	
4.50		10	
5.00		10	
5.50		10	
6.00		10	
6.50		10	
7.00		10	
7.50		10	
8.00		10	
8.50		10	
9.00		10	
10		10	

We run different experiments by varying both the PV , FV and timeframe to test for magnitude or timeframe effects.

[40] The fact that we asked the households to adjust a present value equivalent to a fixed future value may point in direction of an upward bias (Pender, 1996).

Table 1A:Factors explaining household time preference rates

Dependent variable: Discount rate		
Variables	**Coef.**	**Robust Std. Err.**
mean partial risk aversion coefficient	0.288	0.058***
same expected future income	-22.022	13.699
higher expected future income	-26.339	13.655**
internal rate of return	-0.002	0.0003***
future value	0.005	0.001***
time frame	-1.257	0.138***
age of head	0.064	0.024***
female-headed	1.264	1.196**
literate head	-0.413	0.721
hhsize	-0.030	0.144
female adult labor	2.607	2.597
adult male labor	4.595	2.170**
per capita farm holding	-0.251	0.414***
per capita oxen holding	-0.945	2.114
per capita livestock holding	0.668	1.679
access to credit	-2.256	0.804***
per capita expenditure	0.001	0.001
per capita saving	-0.001	0.0003**
start point	-0.001	0.001
_cons	31.078	13.520 **
/sigma	15.262	0.817
		Number of obs = 2629
		Wald chi2(19) = 228.84
		Log likelihood = -11400.85
		Prob > chi2 = 0.000
		Uncensored observations= 7
		Left-censored observations= 77
		Right-censored observations= 568
		Interval observations= 2052

Table 2A: Role of public and private conservation investments

	Public-led conservation investment	
Private	Yes	No
Number plots with stone terraces		
Yes	173	174
No	527	650
Number plots with soil bunds		
Yes	106	68
No	594	756
Intensity of stone terraces		
Yes	71.540	70.953
No	5.393	0.000
Intensity of soil bunds		
Yes	111.308	93.844
No	17.799	0.000

Table 3A: Types of assistance needed from the baito/kushet to reduce the land degradation problem

Type of Assistance	Zone				Average (%)
	Central	Eastern	Southern	Western	
Technical assistance and labor mobilization	60	58	45	59	56
Technical assistance	23	28	46	8	26
Technical assistance and conflict resolution	14	10	4	31	15
Technical assistance and other assistance	0	1	1	0	1
Conflict resolution and labor mobilization	1	0	0	1	1
Conflict resolution and other assistance	1	0	0	0	0
Labor mobilization	1	1	2	1	1
Other assistance	0	0	1	0	0
No assistance	0	2	1	0	1

Table 4A: Types of mass mobilization activities during last year (1997)

Types of Activities (%	Zone				Average (%)
	Central	Eastern	Southern	Western	
Conservation on communal land	62	51	48	27	47
Conservation on private land	28	17	41	14	25
Road construction	0	0	4	1	1
Other work	3	19	14	2	10
All activities	93	87	107	44	83

Table 5A: Ranking of benefits on private land from mass mobilization activities

Mass Mobilization Activities	Zone				Average
	Central	Eastern	Southern	Western	
Building of stone terraces	6.5	4.5	5.5	4.9	5.4
Building of soil bunds	2.5	3.9	5.1	2.6	3.5
Building of terraces	1.0	1.1	2.2	1.2	1.4
Protection against floods	1.9	1.5	1.5	1.9	1.7
Gully control	4.1	3.0	2.7	5.0	3.7
Tree seedlings/planting	1.8	1.6	1.3	1.7	1.6

Table 5A:Types of food-for-work activities that households have participated in

FFW activities that households have participate in (% of households)	Zone				All
	Central	Eastern	Southern	Western	
Stone terrace construction	35	8	20	6	18
Soil bund construction	4	4	15	0	6
Bench terraces construction	1	0	0	7	2
Check dam construction	6	5	0	1	3
Dam construction	14	12	48	15	22
Gully control	6	4	0	0	3
River diversion	0	2	0	0	1
Tree planting	2	5	3	4	4
Other soil and water conservation	18	8	3	7	9
Road construction	8	14	7	6	9
School construction	1	4	1	0	2
house construction	3	0	0	0	1

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Fitsum Hagos was born in Gulo Mekada (Tigray), Ethiopia, in 1966. He has a BA degree in Philosophy from Addis Ababa University, Ethiopia, (1988) and MA degree in Development Studies from the University of Leipzig, Germany, (1993).

The thesis is econometric analyses of various aspects of the rural economy in Northern Ethiopia using a panel data of 400 households from 16 communities. The thesis consists of five papers. The first paper provides an in-depth analysis of poverty, its distribution, dynamics and its correlates by applying up-to-date tools of poverty analysis. The paper places the discussion within the framework of the role of economic reforms on poverty reduction in a remote, unstable and environmentally troubled region. The second paper addresses the issue of the efficacy of a micro-finance program in reaching out to the poor and measures the impact of program participation on households' participation in and level of income generated from non-farm employment, and its overall impact on changes in household welfare. The third paper examines the efficacy of food-for-work (FFW) programs in targeting the poor by emphasizing the role of FFW programs as means to provide safety nets to the poor. The fourth paper examines farm households' decision to use purchased land quality enhancing inputs (e.g. fertilizer) and how this is affected by households' elicited risk preferences while controlling for institutional, plot, household and village level factors. The final paper analyzes the role of tenure insecurity, resource poverty, risk and time preferences, and public conservation programs on private investment by focusing on medium and long-term land conservation measures. The thrust of the last two papers is to add to the discourse on factors affecting farm households' investment behavior on land conservation by bringing in the role of behavioral responses of farm households facing chronic poverty and risk of livelihood collapse due to persistent exposure to external shocks. By doing so, this dissertation aims to contribute to an improved understanding of the relationship between poverty, institutions, peasant behavior and sustainability of resource use.

Professor Stein Holden was the dissertation advisor.

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