Agriculture, Resource Management and Institutions

A socioeconomic analysis of households in Tigray, Ethiopia

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A socioeconomic analysis of households in Tigray, Ethiopia

Girmay Tesfay

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ABSTRACT

Empirical investigation of the impact of institutional and socioeconomic factors on agricultural productivity and natural resource conditions is important for an informed evaluation of current policies, and to identify areas for future improvements. In this line, the current study addresses three topics of relevance to the process of agricultural intensification and natural resource management in the context of the less-favoured Highlands of Tigray, Ethiopia.

The first topic assesses the impact of land contracting, in the form of sharecropping, on plot level crop and land management input use and intensity of use decisions, and the efficiency of resource use by tenants on their own and on sharecropped-in plots. Controlling for other socio-economic and biophysical factors, contrary to the predictions of the Marshallin theory of sharecropping, the study finds no statistically significant impact of tenancy status on input use and resource use efficiency at plot level.

The second topic focuses on understanding of farmers' perceptions of rainfall-related production risk and uncertainty in the study area, and investigates how that influences their decisions on the intensity of plot level farm management input use and investment in land management. The findings show that farmers differ highly in their production risk perceptions even they face similar external circumstances and their socioeconomic features are found to account for such differences. Farm management input use and labour investment in land management by farmers did not show statistically significant associations with the risk perception of farm decision-makers.

The third topic assesses the effectiveness of the household level labour quota system as a collective resource management institution employed in Tigray, and seeks to identify the household level factors that explain the degree of farmers' (non)-compliance with the system. The results from this assessment indicate the need for adapting the system to the changing socioeconomic circumstances of the households, and creating functional decentralized systems of resource management, considering the economic objectives of the human element.

Overall, farmers' decisions on plot level farm management and investment for land improvement, and compliance with collective action institutions are influenced by their socioeconomic and institutional circumstances that require policy consideration. Therefore, policy interventions are necessary to alleviate major constraints for efficient resource use, create production risk management services, and promote self-sustaining systems of communal resource management in the region.

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Girmay Tesfay
Wageningen, December 2006

Dedicated

to

My late father
Tesfay Belay

and

My late brother
Solomon Hagos

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CHAPTER 1

Introduction

1.1. Background

One of the main policy concerns of governments in low-income countries today is to achieve sustainable development that fulfils both economic and ecological objectives. In Sub-Saharan Africa (SSA), achieving food security, improving people's livelihoods and maintaining and improving the conditions of the natural resource base are central goals of policy reforms in the region (Kuyvenhoven *et al.,* 1998). In the region's densely populated countries, with a shortage of land, the challenge for policy-making is one of finding sustainable intensification paths that can cope with the expanding demand for food and biomass. Providing the appropriate technological and institutional inputs is a central and necessary aspect of achieving sustainable agricultural intensification and thereby supporting livelihoods in the region (Kuyvenhoven *et al.,* 1998; Ruben *et al.*, 2001; Kruseman *et al.*, 2005). In particular, development in the most neglected less-favoured drylands requires institutional and policy inputs that recognize the unique biophysical and socioeconomic features of these areas (Kuyvenhoven, 2004; Ruben and Pender, 2004; Ruben *et al.*, 2005).

Ethiopia is one of the SSA countries that face an almost overwhelming challenge in achieving food security and sustainable rehabilitation of the degraded natural resource base. Over time, unchecked population growth and poor technological progress in the agricultural sector have led a significant proportion of the country's population into extreme poverty. In such a situation, the role of appropriate policy support and an enabling institutional framework is indispensable for promoting local initiatives and technology adoption to achieve sustainable intensification. Dynamism in the institutional environment is also essential for innovative practices to flourish and for their wide scale dissemination in the country.

The limits of the land frontier in the highlands of Ethiopia has been reached, and increased current and future production is contingent upon proper maintenance of the productive capacity of existing farmlands and improvements in technology. Smallholders represent the majority of the producers in these areas and raising their productivity must form the basis for agricultural growth and food security. This entails increasing the productivity of both the land and the labour endowments of smallholders (Ruben and Pender, 2004; Pender, 2004). Besides such necessary interventions in the agricultural sector, there is also a great need to develop a non-farm sector in rural areas in order to create alternative livelihood sources (Hagos *et al.*, 1999; Woldehanna, 2000).

Better allocation of resources at individual farm and community level requires a suitable institutional framework and market development. For instance, allowing land transactions would facilitate the transfer of land to more efficient producers (Feder and Feeny, 1991; Hayami and Ostuka, 1993), while the development of labour and capital markets condition the ultimate impact on production efficiency (Pender and Fafchamps, 2001). It is important to empirically assess the effect of institutional and policy arrangements that promote factor and output markets on agricultural productivity and natural resource conditions.

One of the issues that this study investigates is the impact of land contracting, in the form of sharecropping, on the intensity of plot level management and resource use efficiency in the highlands of Tigray, Ethiopia. Land contract systems should lead to better efficiency in both the short- and long- term and contribute towards poverty reduction. However, when factor markets are poorly developed and tenants undersupply their effort, the efficiency gains may be low and their impact on food production limited. It is therefore necessary to evaluate such institutional arrangements to assess their impact on both economic gains and the sustainability of farmland use.

Besides socioeconomic and institutional limitations, agricultural development and resource management endeavours are also constrained by agro-ecological factors that affect the use of modern technologies and perpetuate risk-averse behaviour among farmers. The volume of food production in the dryland areas of Ethiopia is largely determined by the amount and distribution of rainfall during the rainy season. A late onset and/or an early end of rainfall, and unpredictable dry spells during the growing season affect the timing and intensity of major agronomic operations, use of inputs, and success of the production season. Recurrent occurrences of such climatic problems are likely to hinder the adoption of innovative farm management practices and compel farm households to follow more conservative risk-aversion strategies (McCann, 1990).

Spatial or temporal variations in yield between plots, farmers and regions are partly caused by differences in land management and agronomic practices (Ruben and Pender, 2004). These practices may be in turn be influenced by high uncertainty about production and risk perceptions of farmers that are associated with the unreliable rainfall conditions of dryland areas. In other words, farmers may not apply sufficient inputs and not adopt improved agronomic practices as means of reducing the cost of production and economic losses due to yield variability, in case rainfall falls below expected conditions. The process of decision-making in such highly variable and risky environments crucially depends on the information available to decision-makers and the presence of functioning institutional risk-management systems such as crop insurance. In the absence of such information support systems, farmers risk aversion behaviour may be an obstacle to the realization of sustainable intensification and food security in the drylands. Hence, there is a need for empirical research in identifying the determinants of variations in the risk perceptions of households, and on how these perceptions are linked to the level of input use in crop production and other land management activities. Research along these lines is also important for identifying ways of initiating appropriate institutional arrangements for managing the impact of production risk and uncertainty on farmers' incomes and livelihoods.

Agricultural production in Ethiopia is highly dependent on the natural resource base. Growing energy demand from the expanding population requires more biomass production, which increases the pressure on natural resources. Improving the performance of agriculture and coping with increased demand for biomass is therefore contingent upon the rehabilitation and enhancement of the natural resource base. In this regard collective action is being popularized as a viable means of achieving sustainable resource management and utilization in rural communities in Ethiopia. Soil and water conservation schemes and reforestation programmes are being conducted through collective resource management approaches. The implementation of such programmes is done in a decentralised manner, giving consideration to the regional resource endowments.

In Tigray, village level communal resource management through collective action is the dominant strategy, with villagers contributing unpaid labour and other physical resources to such programmes. As the incentives for private investment are low, resource management objectives are addressed through state and community investment, such as a labour quota system. This occurs in spite of problems in sustaining the contributions and the social profitability of such investments (Ruben and Pender, 2004). Ever since the initiation of such collective action in the region, almost two decades ago, economic changes have affected the opportunity cost and mobility of labour. The level of compliance of households with collective resource management institutions may therefore vary depending on the socioeconomic profile and comparative advantages of the households. Such investment activities also need to yield economic returns to farmers if they are to alleviate poverty (Pender, 1998). Hence, collective investment through mobilization of local resources must address the economic objectives of contributing households, besides enhancing natural resource conditions.

1.2. Research issues

This study addresses three issues of relevance to the process of agricultural intensification and natural resource management in the context of the Highlands of Tigray, Ethiopia.

The first issue relates to the *impact of land contract arrangements on farmland management and productivity*. The question is how does the nature of tenancy arrangements affect plot level crop and land management input use decisions and the efficiency achievement of tenant households in the highlands of Tigray? This is a prominent research topic in several developing countries and has policy relevance in Ethiopia in general and the Tigray region in particular. Tenancy arrangements have direct influence on the growth and sustainability of agriculture in the region. They also have wider implications on the welfare impact of land entitlement. With the policy adjustments in rural land laws of the mid 1990s that allow land contracting, and subsequent debates on the need for more liberalized land markets in Ethiopia, this study aims to contribute to the design of contextually appropriate institutional arrangements for sustainable land use.

In the absence of free land markets, land contract arrangements are important mechanisms for linking land and other factor inputs. Sharecropping is the dominant form of land contract systems in Tigray. This study evaluates the implication of the tenancy status of a plot on several variables: crop and land management input use, intensity of use decisions, and the efficiency of resource use at plot level by tenants on their own and on sharecropped-in plots.

The second socioeconomic issue this research addresses deals with the *impact of perceived rainfall-related production risk and uncertainty on the intensity of farm management inputs* that producers use at the plot level. An attempt is made to identify the impact of such attitudinal factors and how they condition farmers' decision-making regarding the level of use of crop management inputs. In addition, the research identifies implications of the results for designing extension messages and policy to manage production risk in such farming systems. The main research questions in this respect are: How can differences in risk perceptions among farmers in the study area be explained? And do farmers facing a higher production risk and greater uncertainty apply less-intensive management at plot level?

The third issue that this study addresses relates to the assessment of the *effectiveness of the household level labour quota system as a collective resource management institution* and seeks to identify the household level factors that explain the degree of farmers' (non)-compliance with the labour quota systems in Tigray. It aims to identify the major problems of these institutions of collective action, and the policy and institutional inputs required to promote successful and sustainable collective action in Tigray.

These three issues are intended as illustrative cases of the institutional elements that need to be addressed in order to promote sustainable agricultural development by small-holders in a less-favoured area. Several important institutional interventions are required in the development of such areas: these include the development of asset markets, the provision of weather insurance services, and community land rehabilitation programmes under decentralized management (Ruben and Pender, 2004; Ruben, 2005). The analyses in relation to the three issues dealt within this study provide insights into factors that influence the choice of crop and land management practices, productivity and the sustainability of collective action institutions.

1.3. Organization

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

Chapter 2 briefly provides the setting of the research area focusing on the natural, socioeconomic and institutional features, and the development and natural resource management strategies of Ethiopia, and the Tigray region in particular. It also provides a description of the research methodology, the conceptual background to household decision-making perspectives and the analytical approach. It provides a contextual setting for the issues investigated in subsequent chapters. Each of the core chapters (3 to 6) contains a more detailed statement of the research problem, literature background and hypotheses, data, analysis methodology, and results, discussion and conclusions.

Chapters 3 and ***4*** investigate the impact of farmland contract arrangements on crop and land management input use decisions, and on the efficiency of resource use at plot level of tenant households in Tigray. ***Chapter 3*** presents the results of a comparative analysis of the determinants of crop and land management input use and intensity of use decisions at plot level, and evaluates whether the tenancy status of the plot is a statistically significant determinant in the input use decision. The empirical findings show that, controlling for household, crop, plot, and agro-ecological factors, the use and intensity of use of fertilizer, labour and draft-power do not show statistically significant variation on owned and on sharecropped-in plots. The probability and intensity of manure use was marginally lower on plots that the tenants receive two-thirds of output share compared to their own plots and the likelihood of manure use is higher when tenants feel better security of tenure as measured by their expectation of longer duration of use of the plots. Furthermore, the findings indicate that the land contracting market in the region is poorly developed. Tenants sharecropping-in many plots are found likely to apply fewer inputs of labour, fertilizer and draft-power per unit land. In addition to the tenancy status of the plot, other physical features of the plot and socioeconomic characteristics of the household are found to be important factors influencing input use decisions at plot level.

Chapter 4 presents the results of a resource use efficiency analysis for comparison of the efficiency achievements on tenants' own and sharecropped-in plots, and identifies the major determinants of these efficiency differentials. Using a stochastic technical efficiency analysis, it shows significant technical inefficiency in the production systems. The technical efficiency levels were not found to vary by the tenancy status of the plot, *ceteris paribus*, contrary to the Marshallian expectations. Resource use efficiency shows significant positive association with livestock endowment of tenant households and population density of the area.

Chapter 5 focuses on the impact of farmers' perceptions of production risk and uncertainty on the intensity of crop and land management inputs applied at plot level. A simple method is developed to characterize the risk perception of decision-makers, based on their subjective expectations of crop yield variability. The risk perception of producers is found to be positively associated with the decision-maker's age, possession of marketable skills, livestock endowment and participation in agricultural training. The risk perception of a decision-maker is also found to vary by crop type. Farm management input use and labour investment in land management by farmers did not show statistically significant associations with the risk perception of farm decision-makers. Labour investment for land management is significantly positively associated with the resource capacity of the household in terms of farm assets, particularly endowments of livestock and cultivable land. Institutional support in the region therefore should focus on enhancing farmers' resource capacity.

Communities in Tigray conduct communal resource management based on a household labour quota system. One of the problems in such systems is maintaining the commitment of community members in terms of observing collective rules and fulfilling individual contributions. ***Chapter 6*** focuses on identifying the household level factors that influence the (non)-compliance of households with the labour quota system in two case study villages in Tigray. The empirical findings show that non-compliance is higher among households with older household heads and a better livestock endowment. A non-linear U-shaped relationship is found between household labour endowment and the level of non-compliance. These results reveal that, as an institution for collective action, the labour quota system needs to be adapted to the context of the villages and contributing households. Re-designing the existing approach of household level labour quota systems so that they become more self-sustaining systems of resource management could well be considered by policy makers. The conceptualization of decentralized resource management should go beyond the geographic or administrative criteria and identify and enrol those social groups that are most capable of efficiently organizing collective action.

Chapter 7 discusses the major findings and outlines the main conclusions from this study. It draws out major policy implications and discusses issues for future research.

The current study contributes in number of ways to the empirical literature. In relation to the subject of land contracting and land management, the comparative analysis of soil management inputs use as a proxy indicator for the sustainability concern is a new aspect. Previous studies are mainly focused only on economic indictors which only provide partial picture, given that output is influenced by a number of external factors. This study also uses data from 'owner-tenant' households which is not common in the existing literature and enables to control for some measurement errors and the effect of unobservable factor within a cluster. Furthermore, unlike the conventional use of the average production function, the use of stochastic frontier production function here is more appropriate for technical efficiency comparison by tenancy status. In line with the work of Pender and Fafchamps (2001, 2005), the findings of this study also support that where land is likely to be valued high, such as in densely populated and good rainfall areas, land productivity is not affected by tenancy status.

Another innovative element of the current study is the development of a simple approach to understand farmers' perceptions of risk and uncertainty in their production system which does not depend on the full knowledge of the probability distribution of potential outcomes. It is based on the assumption that farmers make decisions expecting range of outcomes for which they can only define the possible boundary levels of minimum and maximum values and a most-likely expectation in between rather than the entire distribution of outcomes. It also assumes, in practice, it is difficult to objectively measure outcomes and their probability of occurrence separately when recorded information is missing.

In relation to the subject of communal resource management, the study proposes a new way of conceptualization of a decentralized resource management which takes additional elements than the commonly considered administrative or geographic measures. Organizing collective resource management at the lowest administrative unit or small geographic area is not sufficient for functional decentralization. This study proposes a more functional and systemic conceptualization of decentralized resources management where by the economic objectives of the human element and the possible dynamism within the environment are fully considered.

CHAPTER 2

Study area and research approach

2.1. The setting of Northern Ethiopia

2.1.1. Location, demography and natural conditions

Tigray is the northernmost region of Ethiopia located at a latitude of 12^0 to 15^0 North and a longitude of 36^0 30" to 41^0 30" East and covers an area of 53,000 square kilometres (Hagos *et al*., 1999; Solomon, 2005). The region is bounded by Eritrea to the North, the Sudan to the West, and the Ethiopian regions of Amhara and Afar to the South and the East respectively. Figure 1 shows the location of Tigray region. The population of Tigray is over 4 million, with an average family size of five persons per household (Solomon, 2005). Population growth in Ethiopia is high; in the Tigray region the population is growing at 2.7% per year (BOPED, 2004). There is an estimated 825,678 rural households, of which 70% are male-headed and 30% female-headed (Solomon, 2005). According to the 1994 census the population density in the region is 63 persons per square kilometre (CSA, 1997). However, other studies indicate that in the highland areas the average density is 137 persons per square kilometre, showing that there is high population pressure in these areas (Pender and Gebremedhin, 2004).

Diverse soil types have been identified in Tigray, including *Cambisols, Rendzinas, Lithosols, Acrisols, Fluvisols, Luvisols, Regosols, Nitosols, Arenosols, Vertisols, Xerosols, Solonchacks and Andosols* (Hagos *et al.,* 1999). Two of the major constraints of agricultural production in the region are high level of erosion and poor fertility of the soils. Farmlands in the highland regions are deficient in critical macronutrients and organic carbon. According to Haile *et al*. (2002), the soil resources are extremely deficient in nitrogen, available phosphorus and organic matter. This has implications for farmers' willingness to adopt technologies, as low soil fertility reduces the benefits from productivity enhancing technologies and improved crop management practices.

Tigray is a semi-arid area characterised by a long dry season, with a main rainy season between June and September. Some parts of the southern and eastern zones of the region have a bimodal type of rainfall with short rains between February and April. Rainfall distribution in the region is characterized by high temporal and spatial variability, with annual precipitation ranging from 450 to 980 mm (Gebremedhin *et al*., 2004). According to Belay (1996) the coefficient of variation in annual rainfall in Tigray is about 28%, which is much higher than the 8% national average in Ethiopia (cited in Hagos *et al.*, 1999). According to Meijerink (2002), the annual average rainfall for the districts of Hawzen and Wukro in eastern Tigray for the years 1963 to 1997 ranges between 250 to 650 mm.

The region has a diverse topography, with peak highlands (8%), midlands (39%) and lowlands (53%), which together create diversified agroecological conditions and many niches for biodiversity (Hagos *et al.,* 1999). The wide range of altitude (200-3900 m) governs the temperature range and climatic conditions in the region. In the peak highlands and midlands of the region the annual average rainfall is about 650 mm (Pender and Gebremedhin, 2004; Solomon, 2005).

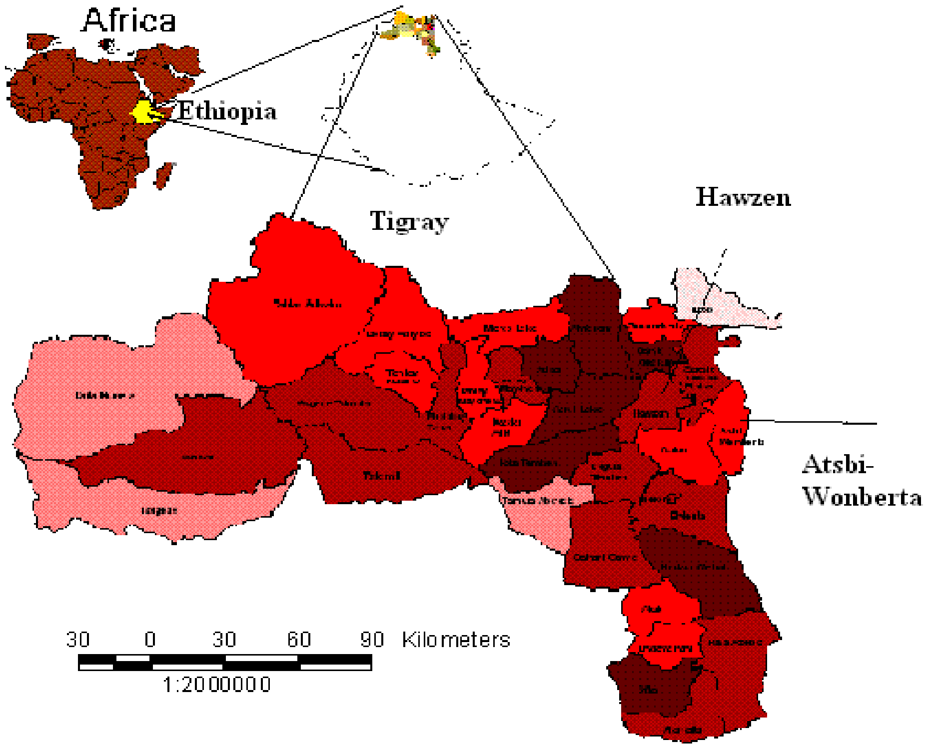

Figure 2.1 Location map of Tigray region and the Hawzen and the Atsbi-Wonberta Districts, Ethiopia (Not for official use)

The distribution of land use/land cover type in Tigray is given in Table 2.1. The major types of land use are bush and shrub land (36.20%), cultivated land (28.21%), and grass lands (22.78%). Other forms of land use account for 10.81% of the land mass. Cultivable land is the dominant land use in the highlands of Tigray, where there is high population density (Pender *et al.*, 2002b). The natural forest resource of the region is overexploited and covers only about

0.2% of the total land area. The decline in forest cover has a long history and is closely linked with human economic activities and population pressure (Nyssen *et al*., 2004). Rehabilitation activities are under way through area closures, afforestation and plantation programmes and community mobilization (Pender *et al.*, 2002b; Gebremedhin *et al.*, 2003).

Table 2.1 Land use/land cover type of Tigray region

Land use-land cover type	Area (hectares)	Proportion (%)
Cultivated land	1,434,792	28.21
Grassland	1,158,681	22.78
Bush and shrub land	1,840,918	36.20
Woodland and plantations	295,082	5.80
Natural forest	9,407	0.18
Afro alpine	670	0.02
Exposed rocks and soil	335,569	6.60
Water body and wetlands	8,053	0.16
Urban	2,610	0.05
Total*	**5,085,782**	**100,00**

* The total area for the land use/land cover study does not include about 2,142 square kilometres land which was excluded for security seasons during the time of survey. (Source: Ministry of Agriculture (2003))

2.1.2. Socioeconomic aspects

The Economy

Agriculture in Ethiopia is the dominant source of subsistence for the majority of the population. It accounts for about 45 percent of GDP, 90 percent of total exports, and 80 percent of employment (Abrar *et al*., 2004). Over 90 percent of the crop output is produced by the peasant sector, which is characterized by a low-level of technology and largely rainfed with a marketed surplus of less than 20% (*ibid*., 2004). Income from own-production accounts for about 73% of the total household income in rural areas (MOFED, 2002).

There has been an improvement in agricultural growth since 1992, especially compared to its level in 1980s (UN, 1999; MOFED, 2002). However, its overall impact in lifting the economy is not significant due to increases in population pressure and recurrent droughts that disrupt progress. For instance, in 1993/94 economic growth declined to 1.7% from the record 12.4% growth in 1992/93 and, in 1997/98 the rate declined to 2.8% although in the years in between the rate was 6 to 10% (UN, 1999). Severe recurrent drought is one reason for such fluctuations in the performance of the economy, which is largely dependent on agriculture. Overall, from 1992/93 to 2000/01, GDP grew on average by 5% with a sectoral growth of

2.5% for agriculture, 5.3% for industry, 6.3% for distributive services such as transport, trade, communication and tourism, and 8.2% for other service sectors (MOFED, 2002). Some case studies, based on panel data from 1989 to 1995, indicate that despite the economic growth that has occurred after the policy reforms in Ethiopia, its effect in alleviating rural poverty varies between different groups of households (Dercon, 2005). Recent reports show over 8% growth of the national economy for consecutive three years since 2003/04 (Ethiopian News Agency, April 2006), but the impact of this growth on rural poverty does need critically evaluating.

In Tigray, agriculture contributes around 57% to the regional GDP, of which 36% is from crop production and about 17 and 4% is from livestock and forestry respectively (BOPED, 2004). Rainfed crop production is the main economic activity for over 85 percent of the population, supplemented by livestock rearing under mixed-subsistence systems. The average land holding in the highlands of the region is less than a hectare (Pender *et al.*, 2002b; Pender and Gebremedhin, 2004). Major crops are sorghum, *Teff*, barley, finger millet, wheat and maize accounting for 26%, 16%, 12%, 11%, 9% and 7% of the total area (BOPED, 2004). Other crop types including pulses account for the remaining balance.

Average crop productivity in the Tigray region is about 0.8 tons per hectare (BOPED, 2004). This is low compared to the national average of 1.2 tons per hectare between 1980 and 1997 (Abrar *et al.*, 2004). The total land under cultivation in the region is about 10,000 square kilometres, of which 1,250 square kilometres is cultivated by private investors with the rest being under small farmers' holding (BOPED, 2004). Potentially cultivable land is about 14,840 square kilometres. Low productivity in the region is attributable to the low productivity of labour and fertilizer, and low levels of adoption of productivity-enhancing inputs (Woldehanna, 2000; Pender and Gebremedhin, 2004). This is directly related to the drought-prone nature of the area and the uncertainty about rainfall, which increases the risk associated with the use of external inputs.

Tigray has much livestock including 3.1 million cattle, 2.5 million sheep and goats, 0.4 million equines and 5 million poultry in 2004 (Gebremedhin *et al.*, 2004; Solomon, 2005). Although Tigray is one of the regions with the most livestock in Ethiopia, livestock production is mainly a secondary activity. The major economic role of cattle, particularly oxen, in mixed farming is supplying draft-power for crop production. The role of livestock in terms of food supply is limited to milk and related by-products. Equines are mainly used for transportation. Sale of small ruminants serves as a source of cash, although in general the livestock sector is less integrated to the market due to structural problems. Pender *et al.* (2002a) show that the gross rate of return from all livestock type in 1998/99 was about 16% and the rate was about 36% for cows.

Poverty situation

The incidence of poverty in Ethiopia is high, with about 45% of the rural population and 37% of the urban population living below the nationally defined poverty line (Woldehanna, 2004). In the Tigray region, poverty is extremely high (Hagos, 2003) and recent reports show nearly 75% of the population is living below the absolute poverty line (BOPED, 2004). According to BOPED (2004), the average household level production in the region (which is 6.59 quintal) covers about 38% of the annual food demand of the average household. Only about 17% of households are self-sufficient (Hagos *et al.*, 1999). Pender *et al.* (2002b) show that better availability of food in the highlands of the region is associated with better access to non-farm activities by households.

A Poverty Reduction Strategy Paper (PRSP) has been prepared at the national level, and Ethiopia is implementing sectoral programmes to achieve the Millennium Development Goals in relation to education, health, nutrition and other social services (MOFED, 2002; Woldehanna, 2004). Regional governments have also prepared similar documents based on the national framework. According to some country level projections, a sustained real growth of 5.7% is required until the year 2015 in order to halve the current level of poverty (MOFED, 2002). This will require significant increases in agricultural productivity and the development of non-agricultural sectors, which will have significant implications for land and labour allocation at household and community levels.

Access to social services and infrastructure

Since 1991, there has been a significant improvement in the provision of social services and access to infrastructure in Tigray, although these still fall far below the level needed to bring meaningful rural development (BOPED, 2004; Pender and Gebremedhin, 2004; Solomon, 2005). There has been a remarkable improvement in access to education, transport, credit and extension services compared to the pre-1991 situation. Local NGOs and communities play a significant role in contributing resources for infrastructure development in the region. However, the current level of literacy in the rural area is very low, with only about 15% of the households having some formal education for two years or more and only around 7% with basic literacy skills (Pender and Gebremedhin, 2004). There has been some improvement in road density in the region, although this is still below the national average (Solomon, 2005).

Another institutional intervention in the endeavour to foster rural development in Tigray, and other regions of Ethiopia, is the establishment of rural credit and saving institutions. These aim to facilitate the creation of capital in the rural sector and improve the availability of capital for investment in both rural and non-rural sectors. Since 1994 the Dedebit Credit and Saving Institution has provided institutional credit for households in Tigray (Hagos *et al.*, 1999). In 1998, about 60% of households in the region had access to institutional credit service (Pender and Gebremedhin, 2004). Credit is mainly provided for buying farm inputs such as seed, fertilizer and oxen. The extension service also provides institutional support for agricultural development. At least one extension agent with a background in general agriculture is assigned to each *Tabia*[2.1] in the region (Hagos *et al.*, 1999). However, only 11% of households have had direct contact with the extension agents seeking for advice (based on 1998 data; Pender and Gebremedhin, 2004). This low rate of utilization indicates the need for a critical investigation of demand side problems for such services in the region.

Land tenure

The traditional land tenure system in Tigray has been responsive to changes in population pressure and over time has evolved into more restrictive systems. The shift from open-ended, residence-based, claims to land to a more restrictive *rist*-based system in the region during the feudal era is evidence of such adaptation (Bauer, 1972; cited in McCann, 1990). In 1974 the traditional *Rist* and *Desa* systems were replaced by state ownership of land under the popular revolutionary motto of “Land to the Tiller.’’ The socialist regime nationalized all land through the Rural Land Proclamation (Number 31/1975), outlawed all forms of land transfers through lease, mortgage and sale, and abolished private, communal, church and other forms of ownerships of land in Ethiopia. Former tenants became usufruct holders of farmland in their respective community. With the promotion of cooperative systems in the country and the formation of peasant associations (PAs) most tenants were forced to join cooperatives by pooling their farm assets. This was most common in communities with potentially fertile lands and a good potential for irrigation development. Later on in 1989, the cooperative system was abandoned and the cooperatives were allowed to distribute the land and other farm assets if their members wanted to operate individually. Most producer cooperatives in the country did this.

The recent change in the land tenure system of Ethiopia came in the early 1990s following a change in government in 1991. According to the 1994 Constitution of the Federal Government, land is publicly owned, hence not freely tradable. In the Tigray region, the regional government improved the rural land policy in 1997. Unlike the land reform in 1975,

[2.1] Tabia in Tigray is the smallest administrative unit of the formal government structure, which is equivalent to *Kebele* in other regions of Ethiopia the current policy allows unlimited periods of use-rights for title holders as long as they maintain their residency in the village, and different temporary land transfer rights in a form of contract arrangement with restrictions on the duration of contract (*Negarit Gazeta* Number 23/1989 Eth. calendar, issued in March 1997). Farmers can sharecrop, lease and lend their individual parcels for a limited period, but can neither mortgage nor sell them. The policy allows a maximum contract period of two years for tenants using traditional technology and 10 years when the tenant uses 'modern technology.' Farmers are not allowed to construct a residence on field plots or plant non-agro-forestry trees. Farmers have the right for claiming compensation in the event of state taking land for their investment, and inheritance right is also recognized. Cutting down indigenous trees growing on individually allocated plots is not allowed. Individuals hold user titles, although some may not have received the certificate of title due to slow processes of issuing the certificates. Major land redistribution is not expected in Ethiopia in most regions, at least for the next 20 to 30 years (MOFED, 2002; Woldehanna, 2004).

One of the major problems with the current land tenure arrangement is land fragmentation. Because of the desire for equitable distribution of land of different quality and distance from place of residence, community members share a portion of each type. This, together with high population pressure in the region, is often claimed to have lead to a severe farmland fragmentation. The current land policy in Tigray prohibits further sub-division of small plots (0.25 ha.) of land beyond their current size during inheritance or other temporary land transactions.

Questions of land tenure within Tigary, and Ethiopia at large, are generally related to its impact on conservation investment, agricultural productivity, land transactions and the sustainability of land resource uses (Tesfay, 1995; Gebremedhin, 1998; Pender *et al.,* 2002; Gebremedhin and Swinton, 2003; Pender and Gebremedhin, 2004; Hagos, 2003; Gebremedhin *et al.*, 2003).

Markets and Marketing

Development of factor and product markets also has significant implications for the pattern of land use and management (Hagos *et al*., 1999). Subsistence economies are not fully integrated into product and factor markets (Holden *et al.*, 1998). Besides structural problems in the production and marketing process, the policies of the socialist pre-1991 period in Ethiopia are claimed to have been major impediments to the development of markets. Thus, liberalization of input and output markets became an integral part of the economic policy reform introduced in the early 1990s. Since then output quotas, price controls and input subsidies have been removed, and the participation of the private sector in marketing process has improved greatly.

The grain market in Ethiopia is poorly developed. According to Gabre-Madhin (2001), only 28% of the total cereal production reaches the grain market, with 18% of this passing through the formal marketing chain. Following the reform significant improvements have occurred in terms of competition and efficiency in wholesale grain trading in Ethiopia, although remote markets are still inefficient and the impact on welfare and equity may be negative (Osborne, 2005). Major problems in marketing development in Ethiopia are related to access to information, non-standardization of products, contract arrangement, and legal backing in the enforcement of contracts, all of which imply high transaction costs in marketing (Gabre-Madhin, 2001).

In Tigray local markets are poorly developed because of the dominance of subsistence production systems and a poorly developed infrastructure. According to Hagos *et al.* (1999), the proportion of agricultural output sold by producers is extremely low, as is the use of purchased inputs in production. The situation in livestock and livestock product marketing is similar to that of the grain market.

Non-farm activities in urban areas are increasing, as a result of the economic reforms in Ethiopia and are more non-farm employment opportunities for rural households in Tigray. Farm households participate to varying extent in the labour markets, although these markets are highly seasonal and involve high transaction costs (Woldehanna, 2000; Woldehanna and Oskam, 2001). Woldehanna (2000) found that public labour mobilization during non-farming season also involves opportunity costs for farm households.

Financial markets in the region are underdeveloped and are mainly restricted to major towns. In rural areas, the Dedebit Credit and Saving Institution is the sole provider of institutional credit for the purchase of agricultural inputs, with restrictions of the maximum loan size and repayment period (Hagos *et al*., 1999). Its services include provision of credit for productive purpose and collection of savings. Borrowers are required to take collective liability for loans, as no material collateral is required. Group members are also required to have saved a portion of the loan applied for in order to qualify for credit (Hagos, 2003).

2.1.3. Development and resource management strategies

Development Strategy

Since 1992 Ethiopia has followed a free-market oriented economic system to enable the country achieve rapid economic development, and reduce poverty and dependency on food aid (Hagos *et al*., 1999; MOFED, 2002; Woldehanna, 2004). As the economy is dependent on agriculture, increasing agricultural productivity through increased use of modern inputs such as inorganic fertilizer and improved seeds, and sustainable resource use is the main focus of Ethiopia's development strategy: since 1994, the country has followed an Agriculture Development-Led Industrialization (ADLI) strategy (MOFED, 2002). In line with this national framework, the Tigray region is following a Conservation-Based Agricultural Development-Led Industrialization (CBADLI) strategy to achieve food security and reduce poverty (BOPED, 1995). This strategy recognizes environmental rehabilitation as a prerequisite for sustainable development. Great emphasis is placed on community participation and the mobilization of local resources in environmental rehabilitation.

The ADLI focuses on introducing appropriate technological, market and institutional changes to enhance resource allocation and productivity in agriculture, and stimulate the development of industries that provide markets for, and inputs to, the sector. The agricultural sector development strategy includes the provision of technology packages through the extension systems; the enhancement of the capacity of the extension system through training and increasing its human resources; provision of extension support systems such as credit; enhancing input and output markets; initiating and facilitating the development of cooperatives to enhance their role in marketing and service provision; developing infrastructure for irrigation and water harvesting; and enhance agricultural research capacity (MOFED, 2002). The ADLI considers agricultural development as the driving force for economic development and promotes investment in agriculture to achieve economic growth and food self-sufficiency. It aims to promote integrated rural development to achieve agricultural growth in the smallholder sector which constitutes the majority of producers.

One element of the economic policy reform is liberalizing the input and output markets. Price controls, output quota systems, and input subsidies has been removed (Hagos *et al.*, 1999; MOFED, 2002). Following the reform, fertilizer prices have been increased, and despite this the use of fertilizer by smallholders at national level has doubled in the first half of the 1990s (Abrar *et al*., 2004). However, farm level application, which ranges between 10 to 50 kg per hectare among farmers who use fertilizer, is far below the recommended practice (ibid, 2004). The national average rate of fertilizer use falls far below that of other Sub-

Saharan countries, such as Kenya and Zimbabwe, where it is 48 and 60 kg per hectare, respectively (World Bank, 1995). At national level the proportion of farmers using improved varieties is less than 5%, and they account for about 1% of the cultivable land. Fertilizer is only used on about 28% of the cultivable land (CSA, 1995). The total quantity of national fertilizer use in 1999/2000 was 279,602 metric tons (Woldehanna, 2004).

In Tigray improved seed, mostly of wheat, *Teff*, and maize, is only used on about 1% of the cultivated land (BOPED, 2004). Fertilizer use in the region has increased from 3 to 13% of the total cultivated land between 1993 and 1998, and about 90% of fertilizer being applied for *Teff* and wheat. However, at a rate of less than 3 kg per hectare, chemical fertilizer use in Tigray is lower than the national average (Hagos *et al*., 1999). Pender *et al.* (2002b) claim that the proportion of households using fertilizer in the region has increased from 8% in 1991 to 65% in 1998, and that 27% of households used improved seed in 1998, compared to almost none in 1991. In practice the use of modern technology, such as fertilizer is intermittent and mostly well below the recommended level.

The budget allocation of the Federal government for food security, agriculture development and natural resource related activities is also increasing to meet the goals of the ADLI. For instance, in 2003/04 the Federal government allocated about 15% (19.3 billion Birr) of its total budget for this sector (Woldehanna, 2004). Regional governments also allocate additional budgets for such activities, although the amount may vary depending on the regional context.

Resource Degradation and Management Strategy

Environmental and natural resource degradation is a major concern in Ethiopia, because of its devastating consequences for economic growth and food security status of the people which are both highly dependent on natural resources. The problem of land degradation is most severe in the highlands, which account for 43% of the total land mass but are home to 88% and 75% of the human and livestock populations, respectively (Shiferaw and Holden, 2000; Sonneveld, 2002). In these highland areas human activity plays a pronounced role in the process of resource degradation (Sonneveld, 2002; Nyssen *et al*., 2004). A significant decline in the productive capacity of soil resources is related to nutrient losses caused by physical erosion and the breakdown of nutrient recycling processes. Over 68% of households in Ethiopia collect biomass from natural vegetations as a main source of energy (MOFED, 2002). At national level annual soil erosion is estimated at around 1.5 to 2 billion tons (UN, 1999) and removal of natural vegetation is increasing, further accelerating this process (Nyssen *et al*., 2004).

In Tigray the degradation of genetic resources and loss of natural forest and soils is excessive and related to a long history of human settlement and population pressure (Hagos *et al.*, 1999). Over 99% of regional energy consumption is met from biomass (BOPED, 2004), although access to fuel wood is declining in the region (Pender *et al.*, 2002b). Tillage practices are significant causes of soil erosion in the region (Nyssen *et al.*, 2000). Overall, decline of the natural resource endowment and continued severe degradation of the remaining resources is a major problem for the sustainable development of the economy. The regions' land resources need enormous investments for rehabilitation and conservation in order to recover their productive capacity.

Traditionally, the communities in Tigray, and Ethiopia at large, have used a variety of indigenous systems for common pool resource management. These systems are characterized by basic institutions of protection and regulated access that have been developed by the communities utilizing the resources. In the highlands of Tigray, indigenous systems for managing grazing lands, communal ponds and irrigation systems were very common, although much has changed over time. For instance, grazing lands are regulated through seasonal closures and grazing of selected livestock such as oxen during permitted periods (Gebremedhin *et al.*, 2003). Traditional irrigation systems are also sustained through indigenous institutions that govern access rights and oblige defined user groups to contribute to the maintenance of structures.

Over time, collective resource management institutions in Tigray has adapted to changing social, institutional and natural environments. Egalitarian access is the norm in most communities in Tigray and this may be a reason for overcrowding and degradation of communal resources in the region. Increased population pressure and changes in the land tenure systems of the 1970s have played a major role in the process. The revision of entitlements, and open admission systems to accommodate new claimants, reduced the regenerative capacity of those resources and aggravated the problem of degradation. Regular land redistribution at certain intervals to accommodate new claims has led to the fragmentation of farmland holdings. Grazing rights have also been subject to similar regular revision. However, there are new developments in some regions, including Tigray, which have officially halted land redistribution since 1991.

Conservation of communal lands and afforestation programs in Tigray began in 1970/1 with the support of USAID as a component of food aid distribution (Hagos *et al.*, 1999; Meijerink, 2002). However, this programme did not last long. Since the early 1980s the Relief Society of Tigray (ReST) and the Tigray Peoples Liberation Front (TPLF) promoted new collective action institutions, aimed at mobilizing local resources to rehabilitate the commons and enhance public infrastructure. Massive terracing work was done on farmlands and communal grazing and woodlands through mass mobilization as a component of food aid distribution in the areas occupied by the TPLF. ReST provided both technical and material support to facilitate these environmental rehabilitation activities and community participation. Since the change of government in 1991, this initiative was institutionalized at the lowest community unit in the region and is now implemented through a household level labour quota system.

This labour quota is a system of labour pooling peasant households for resource management in their respective *Tabias* or villages and is not compensated by external organizations. Every active adult household member is expected to contribute 20 to 27 adult-person-days per year. Labour is mobilized immediately after the harvest season in the month of *Tahsas* (December/January) and for plantation activities, contributions are made annually in the month of July. A minimum of 30% of the active adult labour in a village is mobilized every season. Every year an estimated 8 million[2.2] adult-labour days is expected to be mobilized provided that households fully comply with the collective decisions. These efforts are coordinated by the village councils and technical staff from the office of Agriculture and Natural Resources Development at the district level. Communities have bylaws approved by the respective village assembly and adopted by local social courts. The development committee, including members of village council and trained farmers, decides on sites for collective work, based on their own assessment and requests from community members. They identify farmlands, grazing lands, gullies, dam catchments and waste lands that need immediate attention. Participating households are organized in small work teams, locally called *Gujile*. Each work-team has twenty people, both women and men and an elected leader responsible or following up on the level of participation and work accomplishment by the team. Occasionally, for example, during severe drought periods and for households who are chronically food deficit, some compensation is provided in the form of food aid. This is made available through either governmental or non-governmental programmes.

Apart from physical soil and water conservation work, each village encloses degraded lands to allow natural regeneration and carries out afforestation and plantation activities, such as enrichment planting or woodlot establishment. Local resources are mobilized to establish and protect these assets (Gebremedhin *et al.*, 2003). While most village bylaws in Tigray emphasize self-discipline, plantations and area closures are guarded either by rotationally assigned community members or hired guards, who may be paid through programme assistance by the government or NGOs.

[2.2] This figure is estimated by the authors taking the average rural population statistics of Tigray based on the 1994 Census and 2000 projections, and a minimum 30% of adult labour participation.

These collective management institutions are incomplete in the sense that they lack use plans of the commons and do not take economic criteria into consideration in the allocation of mobilized resources or in rules governing the distribution of benefits. Generally at the household level the economic benefits realized from collective management of area closures and plantations are not significant, although there is a remarkable improvement in the natural capital endowment in each community (Gebremedhin *et al*., 2003).

Current arrangements regarding grazing land use differ between villages although broadly two types of grazing land management systems are practiced. The first is restricted access with pooled use right, whereby community members do not own a specific plot. The second type is restricted access with individually allotted specific plots. In the latter case beneficiaries abide by collective rules to protect the grazing land jointly, but each member owns a specific parcel. This is common in Eastern Tigray, including the villages of this study. The reason for such permanent allotment of individual plots is firstly meant to limit the number of users, and secondly to secure permanent claims, regardless of changes in livestock possession. Households with individually allotted grazing plots can either practice a cut-and-carry or controlled grazing system without encroaching into neighbouring pasture plots. However, free and unregulated grazing systems are also widespread within the region and degradation of such grazing lands is severe (Gebremedhin *et al*., 2004). Arable lands are also used as communal grazing areas during the dry season immediately after harvest.

In sum, the linkages between the regional resource management strategy, which aims at environmental rehabilitation, and the development strategy, which aims at improving social welfare, need to be well defined and integrated in order to achieve a ‘win-win’ situation. Therefore, the impacts of policy interventions and institutional arrangement need to be evaluated for potential ‘trade-offs’ so that appropriate changes can be introduced to enhance the synergy between these objectives.

2.2. Research methodology

2.2.1. Data sources and description

The data used for this study have been obtained from two sources. For the analysis in Chapters 3 and 4, data has been drawn from the database of the research project on ‘Policies for sustainable land management in the highlands of Tigray, Northern Ethiopia’ jointly implemented by the Mekelle University, the International Food Policy Research Institute and the International Livestock Research Institute. The database contains information on basic socioeconomic features, resource endowment, and the production and resource management activities of 500 households, with five randomly selected from each of 100 sample villages. Two villages were randomly selected from 50 *Tabias* and these *Tabias* were randomly selected from a stratified sample based on distance from district towns, agricultural potential, and availability of irrigation, with two each from 25 districts in the highlands of the region. The analysis covers a total of 115 households and the plots they were operating during the 1998 production season. These households were involved in sharecropping and operated 358 owned and 208 sharecropped plots during the production season. Detailed description of the data is given in Chapter 3.

For the issues addressed in Chapters 5 and 6, data have been obtained from key informant interviews and a formal household level survey in two villages selected among the 100 villages in the earlier survey. These two villages were selected for an intensive study of land degradation, production systems and resource management by the Wageningen University-Mekelle University-International Food Policy Research Institute project on 'Policies for sustainable land management in Tigray', in 2001-2003. The two villages are Tegahne, in Atsibi-Wonberta district, and Gobo Degaut, in Hawzen district in the eastern zone of Tigray. In total 155 households (78 from Gobo Deguat and 77 from Tegahne) were surveyed in 2002/03 and the detailed description of the sampling procedure and the dataset is given in Chapter 5.

2.2.2. Household decision-making

Economic theory stipulates that the efficient working of factor markets plays a major role in coordinating resource allocation. However, the reality in rural settings in developing countries is that many product and factor markets are either missing or far from perfect (de Janvry *et al.*, 1991; Sadoulet and de Janvry, 1995). Markets for land, labour, capital, agricultural outputs, and other inputs are usually either missing or not fully functioning (Kruseman, 2000; Woldehanna, 2000; Holden *et al.*, 2001). In this study the general conceptualization of the rural household as a unit of consumption, production and labour supply decision-making entity is assumed. Such conceptualization of the rural household in developing countries is widely assumed as a convenient framework for analyzing the response of farm households to policy changes and the impact of policies on the welfare of rural households and the condition of natural resources (Signh *et al.*, 1986b; Holden *et al.*, 1998; Kruseman, 2000; Taylor and Adelman, 2003). The basic framework is in contrast to the traditional assumption of separability, as rural households' decisions about production, consumption and labour supply are considered to be inseparable (Singh *et al.*, 1986a; de Janvry *et al*; Woldehanna, 2000). A number of reasons are cited as for this occurrence, which are related to information asymmetry, transaction costs and ill-defined property rights (de Janvry *et al*., 1991; Holden *et al.*, 1998; Kruseman, 2000; Taylor and Adelman, 2003). Under such conditions, resource mobility is restricted or localized, and the assumption of separability as a precondition for efficient resource allocation is impractical.

When markets are not operating efficiently, resource productivity is not solely determined by exogenous prices (Woldehanna, 2000; Holden *et al*., 2001; Taylor and Adelman, 2003). Resource allocation and efficiency in production is influenced by household characteristics such as physical and human capital endowments or in general by the distribution of factors (Holden *et al*., 2001).

In a household level analysis one of the issues is the treatment of intra-household interactions. When a household is modelled as a homogenous unit, the bargaining process and collective decision of household members are not captured (Bourguignon and Chiappori, 1992; Chiappori, 1992). However, this study accepts the conceptualization of a unitary household both because intra-household information was lacking and also because this assumption has been found to be valid in the context of Tigray (see Woldehanna, 2000).

At the village level some resources are collectively owned and village institutions define the access of individual households to these resources. These village institutions may lead to heterogeneity in resource endowments of farm households and thereby to differing opportunities in local markets and diversity in livelihood activities (Holden *et al.*, 1998; Ruben and Pender, 2004). Thus, where markets are imperfect, household level decisions are also conditioned by village institutions. In such settings non-price mechanisms also evolve to mediate resource exchange among households which may have implication for the efficiency of resource use and benefit distribution.

2.2.3. Analytical approaches

The econometric analysis employs mainly a reduced form approach. This approach helps to handle problems related to the cross-sectional nature of the data, which limits the availability of sufficient instruments to estimate a complete system of structural equations. The hypotheses in each of the topics studied are derived from a review of the theoretical and empirical literature on the respective subjects. However, reduced form equations only give information about the impact of the pre-determined or exogenous variables, and this limitation is acknowledged. However, appropriate instrumental variable models have been employed to deal with endogeneity problem. For the econometric analysis the choice of feasible techniques is dictated by the nature of the dependent variable. In each chapter an explanation is given for choice of the econometric model.

CHAPTER 3

Land contracts and land management under sharecropping

This chapter investigates the impact of land contract arrangements on plot level crop and farmland management decisions of tenants in Tigray, Northern Ethiopia. Input use and intensity of use decisions of 115 tenant households on 347 owned and 192 sharecropped-in plots are analysed to understand how tenancy factors affect plot level management and input use. Controlling for household, crop, plot, and agro-ecological factors, the use and intensity of use of critical soil fertility management inputs such as fertilizer and other farm management inputs such as labour and draft-power do not show statistically significant variation on owned and sharecropped-in plots. The probability and intensity of manure use was marginally lower on plots that the tenant receives two-thirds of output compared to their own plots and the likelihood of manure use is higher when tenants feel better security of tenure as measured by their expectation of longer duration of use of the plots. Another finding is that tenants who sharecrop-in many plots are likely to apply less labour and draft-power inputs per unit land and invest less of on land improvements. This may indicate that the land contract markets are poorly developed and information problems on the part of the landlord in screening potential tenants. Although, the extent of private long-term conservation investments in 1998 was limited to 8% of the sample plots, such investment occurred more frequently on sharecropped-in plots, which is unexpected. There is a need for further investigation, in a dynamic setting, in order to gain a thorough understanding of the implications of land contracting on land quality and productivity over time.

3.1. Introduction

Security of land tenure is one of the prominent topics in policy discussions on enhancing agricultural productivity and sustainable land management in developing countries (Feder and Feeny, 1991; Wacher and English, 1992; Place and Hazell, 1993; Ruben *et al*., 2001b). Land tenure security is considered important as it provides an assurance to farmers that they will be able to capture the long-term benefits from their investment (Wacher and English, 1992; Place and Hazell, 1993; Rahmato, 1994; Gebremedhin, 1998; Nega *et al*., 2003; Gebremedhin and Swinton, 2003), allows better access to credit markets where asset collateral is needed (Place and Hazell, 1993; Besley, 1995), and for the development of efficient land markets (Wacher and English, 1992; Besley, 1995; Pender and Kerr, 1999). Full rights on individually titled lands are thought to improve the efficiency of land markets and the productivity of land by transferring land from the less to the more efficient users (Wacher and English, 1992).

Recently there has been renewed research interest in Ethiopia on the effect of land tenure in general, and of land contracts in particular, on conservation investment, agricultural productivity, land transactions and the sustainability of land resource use (see Tesfay, 1995; Gebremedhin, 1998; Gavian and Ehui, 1999; Pender and Fafchamps, 2001 & 2005; Ahmed *et al.,* 2002; Deininger *et al.*, 2003; Hagos, 2003; Nega *et al*., 2003; Teklu and Lemi, 2004; Benin *et al*., 2005). The main focus of empirical research on land contracts has been on understanding the nature, development and economic impact of land contracting systems. However, insufficient attention has been given to the cumulative economic and environmental effects of land contracting practises. It appears that the short-term nature of land contracting arrangements has limited the discussion to the issue of efficiency *per se*. Issues related to its impact on soil fertility status and long-term productivity of contracted plots has been neglected in studies thus far, while the main concern of land rights reform has been related to its impact on the investment behaviour of farmers and land management. In Ethiopia, the question remains as to whether the improvements in user-rights, in land transactions, and of new regional policies will encourage sustainable production and land management. In-depth investigation of these issues in a dynamic setting will provide fruitful niche for theoretical and empirical research in the future. In the absence of feasible models and data for such a dynamic analysis, alternative methods need to be sought to gain preliminary insight into the management problems of contracted land, with its possible consequences for sustainability of production systems.

This chapter therefore focuses on the implication of agricultural contracts for sustainable land management and has two major objectives. First, it aims to assess whether plot tenancy status plays a role in the decisions of tenants regarding the use and intensity of soil fertility and productivity-enhancing inputs as well as private conservation investment. Comparative analysis of management systems and input intensities applied on owned and sharecropped-in plots by tenants will be used to reveal the potential problems with regard to sustaining quality of contracted land. Secondly, it aims to draw policy lessons and suggest possible interventions that will enhance the role of land contracts in improving sustainable production within the context of the highlands of Tigray.

The remainder of the chapter is organized as follows. Section 3.2 provides a brief background to land contracting systems in Tigray. In section 3.3 relevant literatures are reviewed and research hypotheses are formulated. Section 3.4 explains the data and method of analysis. In section 3.5 results are presented. Finally, in section 3.6 the main results are discussed and conclusions set out.

3.2. Land contracting systems in Tigray

A wide range of land contracts are practised world-wide in the form of wage labour, fixed rental, sharecropping, and exchange of draft power for labour or straw. Such land contracts are thought to evolve as a result of imperfections in resource markets created by institutional gaps and policy restrictions (Ellis, 1993:146-147; Bhaumik, 1993; Pender and Fafchamps, 2001; Teklu and Lemi, 2004). In Ethiopia, because of the state prohibitions on selling land, different forms of land contract arrangements are practiced, one of which is sharecropping.

Sharecropping is a long established form of land contract in Ethiopia (Robertson, 1987:6; Cohen and Weintraub, 1975:50) and became more informally practiced after the 1975 Land Reform that prohibited land transfer, sale and mortgaging. It is the dominant form of tenancy in Tigray, which is practised mainly as a form of resource pooling and factor proportion adjustment mechanism in farm production, and may also have a risk-pooling function. Earlier studies show that, compared to other developing countries, sharecropping in the northern Ethiopia is not based on dominance and dependency relations between tenants and landowners (Cohen and Weintraub, 1975:51). In Tigray, sharecropping has been observed as occurring between households with an excess ratio of land to labour or land to draft power, and those who are land deficit relative to their labour and draft power endowment.

Tables 3.1 and 3.2 use data from a survey of 500 households, undertaken by the ‘Policies for sustainable land management in the Highlandsof Tigray’ project (see section 3.4.1 for details on the data). A large majority of land is transferred through sharecropping, both from the demand and supply side, and this amount is increasing over time (Table 3.1). The average size, in *tsimdi*[3.1], of land imported through sharecropping was 0.36 in 1991 and 0.68 in 1999, with ranging from zero to 12 *tsimdi*. The average land size exported through sharecropping, in *tsimdi*, was 0.34 in 1991 and increased to 0.51 in 1999, with a range from zero to 7.5 *tsimdi*. In the 1998 production season, about 88% of the total temporary land transferred was through sharecropping, and sharecropped land accounted for 20% of the land operated by tenants in Tigray. Other studies also confirm the dominance of sharecropping in Tigray and show that female household heads sharecrop-out more often (Gebremedhin, 1998). The proportion of households participating in sharecropping arrangements during the years considered in this study ranges between 10% and 49%, and is showing an increasing trend in almost all zones of the region (Table 3.2).

Sharecropping contracts in Tigray are informally arranged without written agreement and are witnessed by third parties who are known and trusted by both those involved. Based on the 1998 data, in 95% of cases the agreement for sharecropping is for one season and two years for the rest 5%. However, in 46% of cases, the tenants expect to operate the plots for ten years duration, while for 36% of the plots tenants do not expect that long duration. For some 18% of plots the response is missing.

[3.1] *Tsimdi* is a local measurement unit of land size. One *tsimdi* is equivalent to circa 0.25 hectare.

Table 3.1 Descriptive information on average farmland acquisition and disposition of households in the Highlands of Tigray

Means of acquisition or disposition	**Mean size in *tsimdi****			
	1991	**1997**	**1998**	**1999**
Renting in	0.01(0.01)	0.01(0.01)	0.01(0.01)	0.01(0.01)
Sharecropped-in	0.36(0.06)	0.65(0.07)	0.66(0.07)	0.68(0.07)
Exchanged-in	0.01(0.00)	0.02(0.01)	0.02(0.01)	0.02(0.01)
Borrowed-in	0.01(0.01)	0.01(0.01)	0.01(0.01)	0.01(0.00)
Gift received	0.02(0.01)	0.05(0.02)	0.05(0.02)	0.07(0.02)
Mean total acquired	**0.36(0.05)**	**0.72(0.07)**	**0.75(0.07)**	**0.79(0.08)**
Rented out land	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.01(0.01)
Sharecropped-out	0.34(0.05)	0.50(0.07)	0.50(0.05)	0.51(0.05)
Exchanged-out	0.01(0.00)	0.01(0.00)	0.01(0.01)	0.02(0.01)
Loaned-out	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)
Given away land	0.00(0.00)	0.03(0.01)	0.03(0.01)	0.03(0.01)
Mean total disposed	**0.34 (0.04)**	**0.53 (0.07)**	**0.55 (0.05)**	**0.58 (0.05)**

Notes: * Standard errors in parenthesis and sample size (n) 500 households; source- author's computation

Table 3.2 Number and proportion of sample households participating in sharecropping by zone and year in the Highlands of Tigray

Zone and No. of households	**Number of households**				**Proportion of the surveyed household in percentages**			
	1991	**1997**	**1998**	**1999**	**1991**	**1997**	**1998**	**1999**
South (139) *	16	32	39	47	11.5	23.0	28.1	33.8
Central (170)	23	36	41	42	13.5	21.2	24.1	24.7
Eastern (120)	14	25	21	19	11.7	20.8	17.5	15.8
Western (71)	15	28	35	31	21.1	39.4	49.3	43.7

Notes: *Number of households included in the survey by zone used for computing the proportions; source- author's computation

3.3. Land contracts and land management

Land contracts enable farm households in developing countries to pool farm resources (Bardhan, 1980; Hayami and Otsuka, 1993) and may lead to higher productivity and equity if efficient factor combinations within and between farms are achieved (Otsuka and Place, 2001:29). Sharecropping is a widely practised form of tenancy, whereby a landowner and a tenant agree on input contributions and output sharing terms over a given production period or an agreed duration (Cheung, 1968; Otsuka *et al.*, 1992).

A number of studies have investigated the rationale for the existence and persistence of sharecropping and its economic and policy implications in different countries (e.g. Cheung, 1968; Stiglitz, 1974; Bell, 1977; Newbery, 1977; Bardhan and Rudra, 1980; Nabi, 1985; Braverman and Stiglitz, 1986; Otsuka and Hayami, 1988; Hayami and Otsuka, 1993;

Bhaumik, 1993; Sadoulet *et al.*, 1994; Agrawal, 1999; Pender and Fafchamps, 2005). These studies apply diverse economic concepts, such as moral hazard, transaction cost, risk-aversion, incentive provision, and imperfect and missing markets to explain the nature and economic implications of different forms of contracts (Otsuka and Hayamin, 1988; Singh, 1989; Ray, 1998). Otsuka and Hayami (1988), Singh (1989) and Ray (1998) give a comprehensive review of theories of sharecropping. Most frequently, sharecropping is considered to be a response to uncertainty and information asymmetries due to missing or imperfect markets (Nabi, 1985; Singh, 1989:68; Pender and Fafchamps, 2001).

The risk-aversion behaviour of tenants is another widely cited reason for sharecropping to exist (Stiglitz, 1974). Tenants enter into sharecropping arrangements in order to spread the risk that they are taking in production and marketing. The landlord may also be risk-averse and also prefer sharecropping arrangements (Ahmed *et al.*, 2002). Thus, sharecropping may be prevalent in dryland areas where production risk is an inherent feature. According to Eswaran and Kotwal (1985), sharecropping can also evolve as a result of differences in factor endowments of farm households. A study by Gavian and Ehui (1999) found sharecropping being practiced in Ethiopia even when the value of what the tenants pay as a share of the output to the land owner, after adjustment for the contribution of the land owner, is higher than what is paid as a rent under fixed cash rental arrangement. Such a situation may be explained in relation to the tenant's inability to access financial services and his/her risk aversion behaviour. Tenants with credit constraints and high risk aversion would prefer to enter into a sharecropping arrangement than a fixed rental because, in sharecropping contracts, payments are differed to the end of the season and risk is shared with the land owner.

Results from different studies tell mixed stories on the impact of sharecropping on input use and intensity of use decisions. Some studies show lower level of use of labour and other inputs on sharecropped plots compared to on tenant's own plots. Bell (1977), Chattopadhyay (1979) and Shaban (1987) provide evidence of greater intensity of use of farm inputs on owned plots than on sharecropped-in ones. Intensity of labour and draft-power use on owned plots has been found to be higher than on sharecropped-in plots (Shaban, 1987). However, Gavian and Ehui (1999) in Ethiopia show more input use on informally contracted plots than on plots owned by the tenant, and explain that such a pattern in terms of differences in farmers' endowments and experience. Other studies show that differences in the intensity of input use on owned and sharecropped plots are conditioned by crop type and village context (Nabi, 1986). Pender and Gebremedhin (2004) state that when land contract systems operate efficiently, plot tenancy status should not matter for land management. However, assuming uniform production technologies and functioning labour and capital markets, if it is costly to monitor a tenant's effort, intensity of labour and capital use will be less on sharecropped-in than on tenant's own plots (Pender and Fafchamps, 2005).

The generalizations made in theoretical studies of sharecropping are highly conditioned by the assumptions made about the conceptualization of the nature of other markets and the contexts in which contracting parties operate. For instance, in a pure tenancy form where the landlord owns a large amount of land and provides small sizes of plot per contract, and the tenant has limited income earning opportunities outside the farm, then the tenant will be forced to apply inputs such as family labour until earnings from the plot are sufficient to cover the subsistence needs of the tenant's family (Johnson, 1950). But, when sharecropping is considered as a form of partnership in which both the landlord and the tenant pool un(der)utilized resources and both have incentives to self-monitor (Reid, 1977), then the output from sharecropped plots may be higher than from other alternative systems, regardless of the inherent problem of moral hazard in sharecropping (Eswaran and Kotwal, 1985). The differences in findings thrown up from empirical studies are partly due to differences in methodological approaches and thus they cannot always be directly compared (Shaban, 1987; Otsuka *et al*., 1992).

The existence of moral hazard in sharecropping contracts has been explained in relation to its impact on economic efficiency differentials in comparison to alternative forms of contracts in a static framework. However, beyond the short-term implication for production efficiency, soil mining practices and poor management of contracted land have far-reaching consequences for the sustainability of agricultural land use that cannot adequately be captured by static models. Conceptually, higher exploitation during a production season affects future productivity because of its impact on the land's fertility (Dubois, 2002; Ray, 2005). Dubois (2002) suggests the need for a dynamic approach to capture this effect and using this information for formulating incentives for the tenant to use appropriate management.

However, the issue of the lack of incentives for maintaining the future productivity of land is only raised in relation to fixed rental or lease arrangements where the tenant manages the land on his own (Agrawal, 1999). It may also be relevant in a sharecropping tenancy where parties share the output, but input provision is the sole responsibility of the tenant. Eswaran and Kotwal (1985) show that as the output share of the tenant increases, the management effort also increases, although this may have a negative impact on the landlord's motivation. According to Bliss and Stern (1982), cited in Nabi (1986), landlords can ensure efficient resource allocation in sharecropping contracts by sharing costs with their tenants in the same proportion as the rental share. Braverman and Stiglitz (1986) also suggest output and cost sharing arrangements as efficient incentives for fertilizer input use and a non-monitorable labour effort. From a long-term perspective, sharecropping may also reduce the tenant's incentive to exploit the inherent fertility of the land in comparison to other forms of contract (Allen and Lueck, 1992).

The tenant's effort in terms of medium- and long-term investment on land management will have implications for current productivity, economic returns and the future sustainability of the sharecropping arrangements. Analysis of disparities in input use and land management practices are more informative than aggregate efficiency indicators in assessing the effect of tenancy contracts on land quality and the sustainability of land use. Under unstable production conditions, final output is affected by external factors.

Investment on land improvement practices depends on the level of tenure security that each contract provides to the tenants. According to Banerjee and Ghatak (2004) better security of tenure tends to lead tenants to invest more as current investment is linked with both current and future productivity. Tenants who invest during the initial periods of the contract will demonstrate more effort, so as to maintain their contract and benefit from their investment by avoiding eviction. However, if the duration of a contract is one season, the tenant will maximise his utility without concern for the depletion of soil fertility and other damage to the land that will adversely affect its future productivity (Otuska *et al.*, 1992). This implicitly assumes that contracts are non-renewable and any long-term investment by the tenant is not linked to contract extension. Earlier studies recognize that short contract duration reduces the expected returns to farmers from inputs whose effect lasts longer than the contract, unless compensation is provided for unutilized investments (Johnson, 1950). This applies to medium- and long-term land improvements, such as manuring and structural conservation structures. However, as far as contracts are not legally or formally recognized, a longer period of cultivation does not guaranty secure tenure (Nabi, 1986).

Undersupply of labour effort or variable input use in general is one of the prominent issues discussed in the literature relating to share contracts. This chapter aims to examine these issues by comparing plot level data about input use and intensity of use on tenants' own and sharecropped-in plots in the highlands of Tigray. Based on the preceding review of theoretical and empirical studies, the following hypotheses are developed for empirical testing:

Tenancy factors

Effects of tenancy contracts on plot level management are highlighted in the previous section, which takes into account different dimensions and conditioning factors involved. Their effect may vary according to the situation of the contracting parties, the nature of the contract terms, and other contextual factors. Within that in the study area assumptions about perfect market conditions in factor and output markets are far from realistic, the development of alternative contract systems is limited, the duration of the share contract period is short, and the input contribution of and possibilities of direct monitoring of tenant's effort by the landlord (due to lack of direct involvement of the landlord in the actual work) are low. Thus, it can be hypothesized that sharecropping leads to an undersupply of inputs by the tenant on sharecropped-in compared to their own plots.

However, other studies show that when a sharecropping arrangement is used to pool non-marketable resources such as land, family labour and draft-power (where markets for these factors are missing or imperfect) the lack of incentive for input use and management of plots may be corrected through mutual incentives and monitoring. In the same line of argument, because of the possible frequent informal contacts between the landlord and the tenant within a village and the existence of effective informally institutionalized social sanctions for dishonest behaviour in village communities, monitoring and enforcement costs may be negligible and problems of moral hazard may be low (Otsuka *et al*., 1992).

The effect of tenancy status may also depend on the type of land management practice under consideration. Tenants may apply less medium-term fertility management practices, such as manuring and structural and biological conservation investment, on sharecropped-in plots compared to their own plots when the duration of the contract is short. Even if the contract stipulates such requirements, when it is one-period agreement, sanction for not meeting such requirements may not be feasible (Otsuka *et al.*, 1992; Ray, 1998:441; Banerjee and Ghatak, 2004). However, this could be different when land contracts are arranged formally over a relatively longer period or when tenants expect contract extension where the supply of tenants is high. Application of inorganic fertilizer may not be influenced by contract duration or the tenure type, but rather by other household and biophysical conditions, as the value of fertilizer is recoverable in one production season. A related aspect is that the size of land or number of plots sharecropped-in or operated by the tenant household influence the capacity of the tenant household, although the ultimate impact of this factor is left for empirical determination.

Household and village factors

Empirical studies show that plot level input use intensities vary with a range of other household and village level factors, of both socio-economic and biophysical nature (Johnson, 1950; Nabi, 1986; Shaban, 1987; Pender *et al.*, 2002a; Pender and Gebremedhin, 2004; Pender and Fafchamps, 2005). Socio-economic features of the tenant households and their access to institutional services, physical characteristics of plots, and village factors may all condition decisions on input use and intensity of use. To control for the effect of such factors, a number of variables are included within the empirical testing. For instance, the application of manure may be influenced by availability (i.e. livestock endowment of households), labour endowment, and the household's dependency on dung for energy. The use of fertiliser may be influenced by the tenant household's level of education, participation in extension training, off-farm involvement, access to credit services and resource endowments.

Plot physical characteristics, such as soil type and slope, accessibility of the plot from the residence, and perception of tenants about the quality of the plot may all influence the plot level management applied. At the village level agro-ecological factors such as rainfall conditions, and demographic and market factors may further condition tenants' decisions. In villages where population density is high, land is scarce and labour availability relatively high, labour use intensity in farm production may be high (Pender, 1998). According to Pender and Gebremedhin (2004) population pressure may lead to intensive use of labour and draft-power per unit area and increase the probability of manure, compost and fertilizer use. Use of manure and fertilizer may also be conditioned by the impact of population pressure on the demand for biomass energy and economic stress, which reduces the commercial input purchasing capacity of households.

3.4. Data and methodology

3.4.1. Definition of variables

The data used in this study are obtained from the database of the research project 'Policies for Sustainable Land Management in the Highlands of Tigray, Northern Ethiopia' jointly implemented by Mekelle University, the International Food Policy Research Institute and the International Livestock Research Institute. The database contains information on the basic socioeconomic and resource conditions of 500 households, with five randomly selected each from a sample of 100 villages. Two villages were randomly selected from 50 *Tabias*, which were in turn randomly selected from a stratified sample of *Tabias*, based on their distance from district towns, their agricultural potential, and their availability of irrigation from 25 highland districts in the region. A total of 115 households and the plots that they operated during the 1998 production season were included for the analysis. These households were involved in sharecropping and operated 347 owned and 192 sharecropped-in plots during the production season. The location distribution of households is 37, 34, 15 and 29 in the Southern, Central, Eastern and Western zones of the region, respectively. The distribution of all plots is 182, 172, 55 and 130 in the Southern, Central, Eastern and Western zones respectively. The sharecropped-in plots are 69, 48, 26 and 55 in the Southern, Central, Eastern and Western zones, respectively. Looking at the distribution of plots by relative quality ranking, 21%, 40%, and 39% of sharecropped-in plots and 47%, 31%, and 22% of own plots are ranked as good, medium and poor quality, respectively. Thus, nearly 80% of sharecropped-in plots are of medium to poor quality. During the production season, 23%, 32%, 33% and 12% of sharecropped plots and 28%, 30%, 33% and 9% of own plots were used for growing *Teff*, small cereals, large cereals and pulses, respectively.

The dataset contains basic socio-economic profiles of the sample households, and their production activities, the physical features of plots operated, and the village conditions for 1998. This contains information on the sex, age, education, and secondary occupation of the household head; the active labour endowment in terms of female and male labour and dependency ratio; cultivable land size, number and area of plots owned and sharecropped-in; endowments of total livestock, draft power and transport animals; and access to credit, extension and training services. Educational status is defined as the household head’s exposure to formal or informal science education at all level. The secondary occupation variable is defined as whether the household’s secondary activity is non-farming. Whether the household uses dung as a primary source of energy is also included in the dataset.

Plot tenancy status is defined in three categories: owned plots, plots under equal (or less than half) grain output sharing, and plots with two-thirds or more of the share of grain output going to tenants. The distribution of sharecropped plots by the level of tenant’s grain output share is one-third for four plots (2%), one-half for 122 plots (64%), two-thirds for 51 plots (27%), and three-quarters for 15 plots (8%). The 50-50 sharing of grain output is the dominant one, similar to the findings of Gebremedhin *et al.* (2003) for the highlands of Tigray. Tenants get 100% of straw output in 90% of the cases and a one-half share in 10% of the cases. Input sharing between the tenant and the land owner is low. The land owner’s share of inputs is one-third to one-half in 2%, 9%, and 20% of the cases for fertilizer, labour and seed inputs respectively. These are comparable to the 5%, 10% and 16% contributions for each input, respectively, by Gebremedhin *et al.* (2003) from a community level survey in 1998 in the region. The tenant is fully responsible for providing draft power and farm equipment and almost solely responsible for supplying major inputs. There is little variation within this pattern and thus it could not be adopted as a factor. There is, however, greater variability in arrangements for sharing the output of grain and this was used as a proxy for the tenancy status of plots. Three dummy variables are thus defined representing a 50% share or less, a 66 to 75% share and plots that are owned by the tenant.

Another tenure related variable is the tenant's expectation of the duration of future operation of the sharecropped-in and the inheritance of own plots. This is taken as an indicator of perceived contract stability or tenure security. The expectation question for contract duration assumes the maximum allowed duration of ten years. Thus, when tenants respond positively to the question of whether they expected to operate the sharecropped-in plot for at least ten years or inherit own plots to their heirs, a dummy is defined with a value of one and otherwise zero. A third indicator of tenure impact on plot management is the number of plots sharecropped-in by each tenant household. Higher numbers will indicate a higher level of involvement of the tenant household in the land contract market.

Plot physical characteristics include area, soil type in local classifications, accessibility from residence, slope feature, and quality rank of each plot relative to all other plots owned or operated by the tenant. Five soil types were identified based on local names: *Hutsa*, *Walka*, *Keyih*, *Baekel*, and *Shashiher*. Based on the study by Corbeels *et al.* (2000), *Hutsa* soils (*Leptosols*) are coarse sandy soils; *Keyih* soils are reddish medium texture soils (*Luvisols*); *Baekel* soils are light coloured lightly texture known as *Cambisols*; *Shashiher* soils are fine sandy mixed with other soils and yellowish colour; and *Walka* soils are basically *Vertisols*. The slope position of the plot is defined in terms of whether the plot is on a slope, whether or it occupies a bottom or middle or top position. The distance of the plot from residence is measured in minutes of walking time from the tenants' residence. The physical features of the soil may influence the choice of management practice and the level of labour demand and other resources. Plot quality ranking is based on farmers' local knowledge. The ranking is a proxy measure of production performance of arable plots and it coincides reasonably well with the definition of the soil productivity adopted by International Soil Science Society (*ibid.* 2000). The ranking is taken as an indicator of the combined effects of physical and chemical characteristics for which information is absent.

The data includes information about the type of crop grown on each plot during the main rainy season, the management inputs applied in terms of labour, draft power, seed, and use and amount of fertilizer and manure, and whether the tenant carried out long-term land management investment during the 1998 production season and the stock of conservation work in 1997. The stock of conservation investment is referring mainly to the volume of investment in the form of soil bunds and stone terrace. Four categories of crop type are defined: *Teff* all varieties, small cereals all varieties, large cereals all varieties and pulses. Small cereals include varieties of wheat and barley, and the large cereals are varieties of sorghum and maize. The grouping is based on the similarity in management practices required for each crop type.

Village variables include population density (measured in persons per square kilometre and used as a proxy for population pressure) and rainfall conditions as agro-ecological indicator. Based on rainfall records, which ranges between 500 and 830 mm, the sample villages are categorized into relatively low, medium and high rainfall areas. The classification is normative based on cut-off points approximated at a range of 110-120 mm from the minimum level of 500 mm of rainfall recorded. For few villages where a rainfall record is lacking, the information for the nearby villages is assumed. Accordingly, the distribution of the plots is 137, 277, and 125 in low, medium and high rainfall areas respectively.

Long-term conservation investment by tenant households on own and sharecropped plots is defined in terms of whether tenant households carried out any structural conservation in 1998. Tenants carried out such investments on 43 plots in 1998 and the level of investment was measured in terms of quantities and values of the inputs invested. To control for the effect of stock of conservation investment on each plot on current investment, a measure of the amount of the stock in 1997 was considered. However, for both the 1998 flow and the 1997 stock, there were great variations in the amount and these figures have been converted to a binary variable, with a value of one for positive quantity and zero if no investment was carried out. Table 3.3 gives a list of the variables and descriptive information that will be used in the econometric analysis of this chapter.

Table 3.3 Descriptive statistics of variables used in the econometric analysis

List of variables	n	mean	SE mean	SD
Dependent variable				
Manure use (1 if yes)	533	0.25	0.018	0.433
Quantity of manure used (kg/*tsimdi*)$^{\psi}$	525	44.40	8.81	202
Fertiliser use (1 if yes, 0 otherwise)	534	0.363	0.020	0.481
Quantity of fertilizer use (kg/*tsimdi*)$^{\psi}$	534	5.1	0.427	9.86
Labour use (person-days /*tsimdi*)$^{\psi}$	524	20.5	0.484	10.70
Draft-power use (ox-day/*tsimdi*)$^{\psi}$	513	12.00	0.245	5.54
Private investment in 1998 (1 if yes)	536	0.080	0.011	0.272
Explanatory variables				
Tenure factor				
Own plots (1 if yes)	539	0.633	0.020	0.483
Half grain output share of tenant (1 if yes)	539	0.234	0.018	0.424
Two-third grain output share of tenant (1 if yes)	539	0.135	0.014	0.343
Tenure security indicator (1 if yes)	486	0.722	0.020	0.448
Number of plots sharecropped-in by tenants (count)$^{\psi}$	115	2.02	0.048	1.14
Agro-ecological indicator				
Plots in high rainfall areas (1 if yes)	539	0.232	0.018	0.422
Plots in medium rainfall areas (1 if yes)	539	0.514	0.021	0.500
Plots in low rainfall areas (1 if yes)	539	0.254	0.018	0.436
Plot quality ranking				
Plots with good quality (1 if yes)	538	0.372	0.020	0.484
Plots with medium quality (1 if yes)	538	0.342	0.020	0.475
Plots with low quality (1 if yes)	538	0.286	0.019	0.452
Soil type (base: *Hutsa* (*Leptisols*)				
Hutsa (*Leptisols*) or coarse sand soil (1 if yes)	538	0.260	0.018	0.439
Sheshiher (fine sandy) soils (1 if yes)	538	0.255	0.018	0.436
Baekel (*Cambisols*) soils (1 if yes)	538	0.219	0.017	0.414
Walka (*Vertisols*) soils (1 if yes)	538	0.130	0.014	0.337
Keyih (*Luvisols*) soils (1 if yes)	538	0.136	0.014	0.343
Slope position of plot (base: plot not on slope)				
Plot not on slope (1 if yes)	539	0.104	0.013	0.305
Plot on the bottom (1 if yes)	539	0.230	0.018	0.421
Plot on the middle (1 if yes)	539	0.202	0.017	0.402
Plot on the top (1 if yes)	539	0.464	0.021	0.499
Crop factors				
Teff all varieties (1 if yes)	529	0.27	0.019	0.44
Small cereals/ wheat & barley/ all variety (1 if yes)	529	0.31	0.020	0.45
Large cereals/sorghum & maize/ all variety (1 if yes)	529	0.33	0.020	0.46
Pulses all variety (1 if yes)	529	0.09	0.012	0.29

Table 3.3 (Cont.)

List of variables	n	mean	SE mean	SD
Household demographics				
Age of household head (years)	115	46.40	1.12	12.06
Household head education (formal/informal science) (1 if yes)	115	0.37	0.04	0.48
Secondary occupation (1 if non-farming)	115	0.27	0.04	0.44
Institutional credit (1 if received loan)	115	0.68	0.04	0.46
Participation in extension and training (1 if yes)	115	0.35	0.04	0.47
Dependency ratio (consumer/worker)	115	2.50	0.09	0.97
Primary source of energy (1 if dung)	115	0.33	0.02	0.47
Household resource endowment				
Male labour endowment (adult equivalent)[ψ]	115	2.33	0.08	0.87
Female labour endowment (adult equivalent)[ψ]	115	0.34	0.03	0.71
Cultivable land holding size (*Tsimdi*)[ψ]	115	5.0	0.27	2.90
Potential draft power endowment (TLU)[ψ]	115	2.60	0.13	1.36
Equine endowment (TLU)[ψ]	115	2.70	0.059	1.40
Other livestock – all but oxen and equine (TLU)[ψ]	115	4.5	0.15	3.5
Other livestock – all but oxen (TLU)[ψ]	115	5.36	0.18	4.2
Location factors				
Population density (persons per km square)[ψ]	115	118.12	5.63	60.38
Distance of plot from tenant's residence /minutes/[ψ]	509	23.2	1.11	25.1
Stock of conservation investment in 1997 (1 if yes)	529	0.416	0.021	0.493

Notes: n stands for number of observations, SE for the standard error of the mean and SD for standard deviation; [ψ] Included in their natural log forms for ease of interpretation and to minimize the effect of outliers and non-normality (to handle a zero cases of input quantities in the log transformation, a log of x+1 is employed); dummy variables are defined as 1 if yes or 0 otherwise for the analysis; and unless and otherwise stated all variables refer to 1998 production year.

3.4.2. Econometric model

This chapter investigates the factors that influence the likelihood and intensity of use of land fertility and productivity enhancing management practices by tenant households on owned and sharecropped-in plots. It specifically analyzes the determinants of use and intensity of use of manure and commercial fertilizer, the intensity of labour and draft-power, and the likelihood of tenant households investing in long-term land management on their own and sharecropped-in plots. Based on the preceding review of the theoretical and empirical literature, econometric relations of the factors that are hypothesized to influence the decision of tenant households are formulated as follows:

Use and level of use of organic fertility management practices, F_o,

$$F_o = f(T_i, H_i, P_i, C_i, Zi, R_i, Stock97) \quad (3.1)$$

Use and level of use of inorganic fertility management, F_{in},

$$F_{in}= f(T_i, H_i, P_i, C_i, Zi, R_i, Stock97) \tag{3.2}$$

Labour input for farm management, L

$$L= f(T_i, H_i, P_i, C_i, Zi, R_i, Stock97) \tag{3.3}$$

Draft-power input use, D

$$D= f(T_i, H_i, P_i, C_i, Zi, R_i, Stock97) \tag{3.4}$$

Whether the tenant household invested on long-term improvements in 1998

$$Inv98= f(T_i, H_i, P_i, Zi, R_i, Stock97) \tag{3.5}$$

Where, T_i stands for tenure status of the plot; H_i for the socioeconomic features of the tenant household; P_i for the plot characteristics; C_i for crop type grown; Z_i and R_i for population density and rainfall conditions respectively; and *Stock97* for plot level stock of long-term conservation investment at the end of 1997.

The econometric analyses involve both binary choice and continuous dependent variables. In the case of manure and inorganic fertilizer use and intensity of use decisions, sample selection bias is a potential problem (Maddala, 2003; Wooldridge, 2003). The decision of whether to use and the level of use for each input might be linked, and this should be accounted for to have consistent parameter estimates. The two-step Heckman selection model is used to estimate the determinants of use and intensity of use of manure to address the problem of selection bias. In this model, to handle the problem of identification, the variables assumed to affect only the awareness and managerial skill of decision-maker are excluded in the second stage. The excluded variables are the perceived tenure security indicator, household head's age, education level, secondary occupation, and participation in extension and agricultural training, and whether household's primary source of energy is dung. These are dummy variables, except household head age, that define mainly the capacity of the decision-makers to access information and do not show difference in the extent of actual information access and management skills. In the case of the household primary energy source, its effect in the second stage is possible to capture by the other included variables such dependency ratio and population density. Most of the household variables excluded are those not significant in the first stage. However, in the case of fertilizer, the test for selection bias is not significant and we apply a Probit model for the determinants of whether to use fertilizer and a Tobit model for the intensity of use which is a censored value. As dependent variables, the quantity of manure and fertilizer, measured in kilograms per *tsimdi*, are transformed into their natural log.

The intensity of labour and draft-power inputs are analysed using ordinary least squares (OLS), as the values for these inputs are strictly positive. For both labour and draft-power the natural log transformed values are the dependent variables. The determinants of the probability of tenant households carrying out long-term private investment on own and sharecropped-in plots is analysed using the standard Probit model. In the analyses all continuous explanatory variables are in the natural logarithm form and dummy variables are defined for discrete variables. For dummy variables, one group is dropped from the estimation as a reference for comparison. The coefficients of the dummy variables are interpreted as the percentage changes from the respective reference categories. Another econometric issue in the estimation of the regressions was the case of endogeneity of crop choice, where the crop variable is included as an explanatory factor. Given the cross-sectional nature of the data it was difficult to get strong instruments for the crop variable and the option followed is to test for whether the inclusion affects the impacts of the other variables using Hausman test for specification.

3.5. Results

3.5. 1. Descriptive results

The intensity of the use of manure and commercial fertilizer (measured in kilograms per *tsimdi*) and total labour and draft-power (measured in person-days and ox-days per *tsimdi*) respectively, was compared using standard T-tests of the mean differences of applications on the owned and sharecropped-in plots. Manure application is a medium-term land fertility management practice. The test of significance on the mean differences of input use on own and sharecropped-in plots was done controlling for crop type and aggregated by plot tenancy status. Results of the comparison of means are presented in Table 3.4.

Accordingly, the use of fertilizer is significantly higher on owned plots than on sharecropped-in ones, although the statistical significance varies by crop type. The mean difference in fertilizer use on plots used for growing *Teff* and small cereals such as barley and wheat is not significant. The total labour use is marginally higher on owned plots than on sharecropped-in ones but, as with the fertilizer varies by crop type. Labour use is marginally higher on owned plots than sharecropped ones for pulses. With the exception of plots under sorghum and maize, no significant differences between own and sharecropped plots were found in the intensity of manure use. Draft-power use did not show significant variation between own and sharecropped-in plots. The reported T-test results are based on the assumption of equal variance and show similar patterns as the results from the alternative assumption of unequal variance.

Although the results of the comparison of means provides some information on the patterns of input use on own and sharecropped-in plots, they are not sufficient to conclude that input use intensities are unaffected by the tenancy status of the plot. Thus, regression techniques are employed to identify the determinants of input use decisions and intensities at the plot level, taking into consideration other variables besides plot tenancy status.

Table 3.4 Comparison of means for input use intensity on owned and on sharecropped-in plots of tenants for four major inputs (assuming equal variance)

Input type	Own plots		Sharecropped plots		d.f.	t-value	p-value
	n*	Means (SE*)	n*	Means (SE*)			
Manure (Kg/*tsimdi*)							
Teff all varieties	101	45.2(14.9)	46	19.9(13.5)	145	1.05	0.146
Small cereals	100	42.5(14.4)	57	44.5(25.3)	155	-0.072	0.528
Large cereals	111	61.8(23.4)	60	6.1(5.1)	169	1.732	**0.043**
Pulses	29	26.1(17.9)	21	146.4(130)	48	-1.065	0.854
Combined	341	48.2(9.9)	184	37.4(17.2)	523	0.579	0.281
Fertilizer (Kg/*tsimdi*)							
Teff all varieties	101	8.32(1.2)	46	6.3(1.2)	145	0.988	0.162
Small cereals	100	5.7(1.1)	62	5.2(1.4)	160	0.248	0.402
Large cereals	111	4.3(0.8)	64	2.0(0.6)	173	1.913	**0.028**
Pulses	29	3.1(1.7)	21	0.0(0.0)	48	1.51	**0.068**
Combined	341	5.8(0.6)	193	3.8(0.6)	532	2.17	**0.014**
Labour (person-day/*tsimdi*)							
Teff all varieties	97	25.4(1.8)	46	24.6(2.0)	141	0.259	0.397
Small cereals	99	37.9(8.9)	62	25.7(3.2)	159	1.057	0.146
Large cereals	109	28.1(3.7)	63	23.4(2.5)	170	0.888	0.188
Pulses	28	34.8(9.8)	20	14.7(2.1)	46	1.709	**0.047**
Combined	333	30.8(3.1)	191	23.5(1.4)	522	1.725	**0.042**
Draft-power (ox-days/ *tsimdi*)							
Teff all varieties	96	12.5(0.6)	44	14.1(0.9)	138	-1.448	0.925
Small cereals	91	13.1(0.6)	62	13.9(0.8)	151	-0.791	0.784
Large cereals	110	9.8(0.4)	64	10.7(0.6)	172	-1.319	0.905
Pulses	26	11.5(0.9)	20	11.2(1.3)	44	0.207	0.418
Combined	323	11.6(0.3)	190	12.6(0.4)	511	-1.787	0.963

Notes: * n stands for number of observations and SE for the standard error of the mean is given in parenthesis. The hypothesis tested is that the mean(own) less mean (sharecropped-in) is equal to zero (H_0) against the alternative (H_a) of the difference being greater than zero; and T-values and p-values are for Ha: diff >0.

3.5.2. Determinants of tenant's decision on input use and level of use at plot level

Manure

To account for sample selection bias, equation (3.1) is estimated using a two-step Heckman selection model. The natural logarithm of the quantity of manure per *tsimdi* applied in the 1998 production season on each plot is used as a dependent variable for the intensity of use. The decision about manure use is modelled as a function of relevant explanatory variables including plot tenure status, together with characteristics of household, the crop, the agro-ecology, the plot, and the village. The coefficient of the Mills ratio in the two-step Heckman selection estimation is statistically significant, showing the potential problem of selection bias when the two decisions are estimated separately. The results are presented in Table 3.5.

The probability of use of manure is lower on sharecropped-in plots compared to tenant's own plots but it was statistically significant only under two-thirds of the grain share of the tenant compared to owned plots. Tenant households with positive expectations of contract extension for sharecropped plots and inheritance of owned plots (as indicator of perceived tenure security) are more likely to apply manure than those who expect otherwise. This is in line with the hypothesis that medium-term investment on soil fertility management will be affected by the tenure status of the plot and the perceived level of tenure security. The tenant households with more sharecropped-in plots are less likely to apply manure, although its coefficient is not significant.

Other factors that have a significant negative impact on the likelihood of manure use are rainfall, plot quality, the use of dung as a primary source of household fuel, the amount of cultivable land owned, and the distance of the plot from the residence. The likelihood of manure use declines with lower rainfall conditions and when the plot is perceived as poor quality. When households are dependent on dung as a source of energy, this competes for the available supply of manure and the competition is likely to be higher in high population density areas. This result has a wider implication highlighting the need for alternative energy source provision, through the development of other biomass sources of energy, such as household woodlots, to reduce dependency on dung. The lower probability of use with distance between the residence and the plot is likely to be associated with the bulky nature of manure and high transport costs involved. Households with more cultivable land may face shortages of manure and also high labour demands for transporting it.

Table 3.5 Heckman two-step estimation of determinants of manure use and intensity of use decisions by tenants in the Highlands of Tigray

Explanatory factors	**Use decision (Probit)**		**Intensify of use (OLS) in Kgs/*tsimdi***	
	Coeff.	**SE**	**Coeff.**	**SE**
Tenure factor (base: own plot)				
A half share of tenant (1 if yes)	-0.368	0.251	-0.146	0.750
A two-third share of tenant (1 if yes)	-0.792*	0.420	-3.485**	1.605
Tenure security indicator (1 if yes)	0.494**	0.219		
Number of plots sharecropped-in by tenants (count)ᵠ	-0.054	0.217	0.857	0.536
Agro-ecological (base high rainfall area)				
Plots in medium rainfall areas (1 if yes)	-0.813***	0.245	-3.534***	0.727
Plots in low rainfall areas (1 if yes)	-0.544**	0.255	-2.976***	0.659
Plot quality (base good plot quality)				
Plots with medium quality (1 if yes)	-0.428**	0.208	0.568	0.588
Plots with low quality (1 if yes)	-0.429	0.262	-0.101	0.786
Soil type (base: *Hutsa* (*Leptisols*)				
Sheshiher (fine sandy) soils (1 if yes)	0.393	0.265	1.900**	0.836
Baekel (*Cambisols*) soils (1 if yes)	0.559*	0.289	1.606*	0.943
Walka (*Vertisols*) soils (1 if yes)	0.361	0.302	1.578*	0.912
Keyih (*Luvisols*) soils (1 if yes)	0.745**	0.332	3.017***	1.038
Crop factors (base: *Teff* all variety)				
Small cereals all varieties (1 if yes)	-0.064	0.263	-0.493	0.711
Large cereals all varieties (1 if yes)	0.035	0.239	-0.024	0.659
Pulses all varieties (1 if yes)	0.406	0.371	1.533	1.013
Household (HH) demographics				
Age of HH head (years)	-0.011	0.011		
HH head education (formal/informal science) (1 if yes)	0.163	0.218		
Secondary occupation (1 if non-farming)	-0.127	0.249		
Institutional credit (1 if received loan)	-0.072	0.212	-0.569	0.532
Participation in ext. and training (1 if yes)	-0.192	0.218		
Dependency ratio	-0.065	0.129	0.244	0.350
Primary source of energy (1 if dung)	-0.737***	0.251		

Table 3.5 (Cont.)

Explanatory factors	Use decision (Probit)		Intensify of use (OLS) in Kgs/*tsimdi* ᵠ	
	Coeff.	SE	Coeff.	SE
Resource endowment				
Male labour endowment (adult equivalent) ᵠ	-0.231	0.304	0.196	0.859
Female labour endowment (adult equivalent) ᵠ	0.310	0.323	1.165	0.756
Cultivable land holding size (*Tsimdi*) ᵠ	-0.664***	0.221	-1.490***	0.572
Draft power endowment (ox-days) ᵠ	0.434	0.299	-0.389	0.883
Equine endowment (TLU) ᵠ	-0.292	0.229	1.076*	0.599
Other livestock excluding oxen & equines (TLU) ᵠ	0.419*	0.214	-0.481	0.665
Location factors				
Population density (persons per sq. km) ᵠ	-0.103	0.258	-1.472**	0.652
Distance of plot from residence /minutes/ ᵠ	-0.468***	0.065	-1.013**	0.417
Stock of SWC investment in 1997 (1 if yes)	0.523***	0.201	0.756	0.555
Constant	1.639	1.209	10.685***	3.727
Mills ratio/lambda/			2.285*	1.177
Rho(ρ)			0.903	
Sigma (σ)			2.529	
Number of observations	446		446	
LR chi2 (31)/Wald chi2(50)	220.12		199.06	
Prob > chi2	0.000		0.000	
Pseudo R square	0.4360			
Log likelihood	-142.376			

Notes: ᵠ indicates variables in their natural log form; SE stands for standard errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and dummy variables are defined as 1 if yes, otherwise 0. Test for multi-collinearity among included variables in the second stage show a mean variance inflation factor (VIF) of 1.6 which is very low; and inclusion of crop choice, which is a possible endogenous variable, did not affect the impact of other included variables as confirmed by the Hausman test (chi2(22) =18.59 with a p=0.6706).

The probability of manure use is significantly higher on non-sandy soils in general and more so on *Luvisols* (locally called *Keyih*) and *Cambisols* (locally called *Baekel*) compared to the coarse sandy soils (locally called *Hutsa*). *Husta* soils (*Leptosols*) are coarse sandy with poor moisture retention capacity which can be improved through such organic amendments, although this may not be economically attractive for farmers in comparison to the benefits they can get from other soil types. A higher livestock endowment increases the probability of manure application, as this directly influences availability. Showing the possibility of complementary relationship, the probability of manure use is higher on plots with a stock of conservation investment such as soil bunds and stone terrace.

The intensity of manure use is significantly lower on sharecropped-in plots under a two-thirds grain output sharing arrangement compared to on owned plots. It is also less on sharecropped-in plots with a half grain sharing arrangement than on owned plots, although statistically insignificant. The intensity of use of manure is less in lower rainfall areas and correlated negatively with households land endowment and the distance of the plot from the household's residence. This may be an indication of the lower economic worthiness of applying manure in low rainfall areas and on distant plots, and possibly of supply problems. In high population density areas the amount of use is significantly low which is related to the dependency of household on dung as a primary energy source explained earlier. The intensity of manure use is higher on less sandy soils and when the household's ownership of equines is higher in which the latter means a better transporting capacity.

These results confirm most of the hypothesised relationships. Controlling for other factors, although the statistical significance is marginal, the low likelihood and intensity of use of manure on sharecropped-in plots implies the risk of soil nutrient exploitation which will lead to a decline in long-term productivity. Manure application is higher on good quality plots and lower on plots that are perceived as poor quality. This is likely to have short-term economic advantages in terms of higher returns to manure application from good quality plots. However, if the medium and poor quality plots are given less attention, this could lead to loss of productive land which, in turn, would have a direct impact on future food production and food security. The higher probability of manure use on plots nearby to the residence may be economically rational in terms of reducing transport costs, but may also indicate an unfavourable pattern of transferring nutrients from distant fields to those close-by. Excessive nutrient mining from distant field plots may also lead to degradation in the long-term, unless other forms of nutrient management practices are used to compensate the loss.

The use of manure is lower in low rainfall areas than in the high rainfall areas. It is important to promote the use of manure in low rainfall areas because this can help to improve the moisture retention capacity of soils. There seems to be a need for intervention to promote better organic fertility management through developing alternative energy sources, such as household level woodlots and fuel efficient stoves which would save dung for manure.

Inorganic Fertilizer

The determinants of the decision to use fertilizer (both DAP and/or UREA) and the combined quantity applied in kilograms per *tsimdi* at plot level have been analysed using equation (3.2). A test for sample selection bias using the Heckman maximum likelihood model estimation shows that the two equations can be estimated independently[3.2]. These two decisions are modelled separately using a Probit and Tobit models, respectively. The Tobit is employed instead of OLS in the second stage as rejection of the sample selection bias in the above test may be due to identification problem. The general pattern of impact of the explanatory variables for both the Probit and Tobit models, presented in Table 3.6, are similar. The explanatory factors used here are the same as in the case of the previous analysis.

In the mean comparisons for fertilizer use by tenure status (Table 3.4), the results show a statistically significant higher use of fertilizer on own than sharecropped-in plots of tenants. However, controlling for other factors, the impact of the tenure status of plots is not statistically significant determinant of the probability and intensity of fertilizer use by tenant households. The variables for tenure security and the number of plots sharecropped-in by a tenant also show no significant impact on the probability and quantity of use of fertilizer at plot level.

Other significant positive predictors of fertiliser use and intensity of use are better access by tenant households to institutional forms of credit, and a higher age of the household head. Tenant household's participation in extension and training and better endowment of draft-power have a significant positive impact on the intensity of fertiliser use. The probability and intensity of fertilizer use are lower on plots perceived by tenants as being of poor quality and plots used on pulses and large cereals (sorghum and maize) compared to *Teff*, which is a high value cereal crop. The intensity of fertilizer use is also lower in low rainfall areas and on plots that are far from residence.

[3.2] The null hypothesis that the coefficient for the Mills ratio is statistically not different from zero, (H_0: rho=0), could not be rejected using the Wald test of independence on the Probit and OLS equations of the ML Heckman sample selection model. As the quantity of fertilizer is a censored variable we use the Tobit model in the separate estimation and this model also accounts for potential sample selection bias.

Table 3.6 Determinants of fertilizer use and intensity of use decisions by tenants in the Highlands of Tigray

Explanatory factors	**Probit estimation (1 if yes)**		**Tobit estimation (kilograms/*tsimdi*)**[ψ]	
	Coeff.	**RSE**	**Coeff.**	**SE**
Tenure factor (base: own plot)				
Half share of tenant (1 if yes)	-0.193	0.203	-0.477	0.428
Two-third share of tenant (1 if yes)	-0.050	0.228	-0.207	0.534
Tenure security indicator (1 if yes)	-0.252	0.167	-0.537	0.359
Number of plots sharecropped-in by tenants (count)[ψ]	0.218	0.163	0.319	0.338
Agro-ecological (base: high rainfall area)				
Plots in medium rainfall areas (1 if yes)	-0.181	0.194	-0.247	0.399
Plots in low rainfall areas (1 if yes)	-0.349	0.217	-0.845*	0.458
Plot quality (base: good plot quality)				
Plots with medium quality (1 if yes)	-0.594***	0.168	-1.126***	0.368
Plots with low quality (1 if yes)	-0.437**	0.193	-0.714*	0.426
Soil type (base: *Hutsa* (coarse sandy)				
Sheshiher (fine sandy) soils (1 if yes)	-0.233	0.200	-0.331	0.426
Baekel (*Cambisols*) soils (1 if yes)	-0.004	0.204	-0.071	0.433
Walka (*Vertisols*) soils (1 if yes)	0.277	0.232	0.408	0.471
Keyih (*Luvisols*) soils (1 if yes)	-0.332	0.252	-0.690	0.548
Crop factors (base: *Teff* all variety)				
Small cereals all varieties (1 if yes)	-0.318	0.202	-0.679	0.419
Large cereals all varieties (1 if yes)	-0.981***	0.185	-2.022***	0.399
Pulses all varieties (1 if yes)	-1.577***	0.353	-3.333***	0.738
Household (HH) demographics				
Age of HH head (years)	0.016**	0.008	0.036**	0.017
HH head education (formal/informal science) (1 if yes)	0.208	0.171	0.271	0.354
Secondary occupation (1 if non-farming)	0.143	0.178	0.175	0.380
Institutional credit (1 if received loan)	0.679***	0.187	1.240***	0.377
Participation in ext. and training (1 if yes)	0.221	0.161	0.598*	0.343
Dependency ratio	-0.115	0.099	-0.210	0.220
Primary source of energy (1 if dung)	-0.120	0.181	-0.135	0.392
Resource endowment				
Male labour endowment (adult equiv.)[ψ]	-0.192	0.234	-0.406	0.491
Female labour endowment (adult equiv.)[ψ]	-0.270	0.236	-0.422	0.520
Cultivable land holding size (*Tsimdi*)[ψ]	0.031	0.182	-0.390	0.374
Draft power endowment (ox-days)[ψ]	0.380	0.246	1.025**	0.506
Equine endowment (TLU)[ψ]	-0.166	0.178	-0.280	0.371
Other livestock excluding oxen & equines (TLU)[ψ]	-0.024	0.153	-0.107	0.325

Table 3.6 (Cont.)

Explanatory factors	**Whether fertiliser used (Probit)**		**Intensify of use (kilograms/*tsimdi*)** ψ	
	Coeff.	**RSE**	**Coeff.**	**SE**
Location factors				
Population density (persons per km square) ψ	-0.152	0.202	-0.236	0.432
Distance of plot from residence /minutes/ ψ	-0.082	0.051	-0.200*	0.115
Stock of SWC investment in 1997 (1 if yes)	0.240	0.157	0.526	0.333
Constant	0.382	0.972	0.753	2.150
Sigma			2.398***	0.156
Number of observations	444		447	
Wald chi2(31)/LR chi2(31)	98.15		118.00	
Prob > chi2	0.0000		0.000	
Pseudo R square	0.2157		0.1047	
Log pseudolikelihood	-228.06		-504.522	
Correctly classified (%)	72.97			

Notes: ψ indicates variables in their natural log form; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; dummy variables are defined as 1 if yes, otherwise 0; For the Probit model the Hosmer-Lemeshow test of goodness of fit statistics, chi2(8), is 13.59 (p=0.093); robust standard errors (RSE) for the Probit model are based on the White's heteroscedasticity consistent estimator of variance; alternative estimation of the Tobit model using robust specification of the interval regression gave similar pattern of relationship; and inclusion of crop choice, which is a possible endogenous variable, did not affect the impact of other included variables as confirmed by the Hausman test (chi2(31)=0.04 with a p=1.000).

In terms of soil fertility management input use and intensity of use, the findings of this analysis do not support strongly the Marshallian view of undersupply of variable inputs by tenants under sharecropping although in the case of manure there is limited evidence. Many other factors are found to explain the variations in fertility management inputs. One important factor is the perceived tenure security that shows better use of organic fertility management by tenants with positive expectation of contract extension. In the case of manure use, it is also low on sharecropped-in plots and it may be helpful to encourage long-term contract so as tenants may use medium term soil fertility management practice such as manuring. Currently, soil fertility management is more practiced on a relatively good plots than on lower quality ones, and although understandable on short-term economic grounds, it raises issues on the sustainability of farmland use and calls for intervention to address public interest in maintaining land resources.

Labour

Labour is a major input in the mixed-subsistence systems of the highlands of Ethiopia, which are highly labour-intensive. In sharecropping contracts, labour (together with draft-power) is one of the tenant's major contributions, and this takes the form of both casual and managerial services. The level of output depends greatly on the level of labour invested. A linear regression model of the level of labour use is estimated as a function of plot tenancy, and the characteristics of the household, plot, agro-ecology, and the village as stated in equation (3.3). In the estimation household variable is used as a clustering unit so as to account for non-independence of errors within households. The results are presented in Table 3.7. A diagnostic test for the problem of multicollinearity shows a mean variance inflation factor of 1.68 with a range of 1.27 and 2.28 for the lowest and the highest values respectively, indicating multicollinearity was not a serious concern.

The coefficients for the plot tenancy indicator variables, the share dummies, are statistically insignificant. Tenants who sharecrop many plots use significantly lower labour inputs per *tsimdi*. Tenants with a higher endowment of draft-power and those in high population density villages use significantly more labour per unit land. Labour intensity is also higher on medium rainfall areas compared to in areas with high rainfall. Intensity of labour use is significantly lower where the households have more cultivable land holdings, and when farmers produce pulses compared to *Teff*. Other variables included do not show statistically significant impact on the intensity of labour use.

Table 3.7 OLS estimation of determinants of labour use intensity in person-days per *tsimdi*

Explanatory factors	Coeff.	RSE
Tenure factor (base: own plot)		
Half grain output share of tenant (1 if yes)	0.013	0.069
Two-third grain output share of tenant (1 if yes)	-0.071	0.087
Number of plots sharecropped-in by tenants (count)	-0.126*	0.071
Agro-ecological (base high rainfall area)		
Plots in medium rainfall areas (1 if yes)	0.137*	0.071
Plots in low rainfall areas (1 if yes)	-0.030	0.098
Plot quality (base: good plot quality)		
Plots with medium quality (1 if yes)	0.016	0.065
Plots with low quality (1 if yes)	0.080	0.077
Soil type (base: *Hutsa* (coarse sandy)		
Sheshiher (fine sandy) soils (1 if yes)	0.112	0.072
Baekel (*Cambisols*) soils (1 if yes)	0.046	0.069
Walka (*Vertisols*) soils (1 if yes)	-0.008	0.094
Keyih (*Luvisols*) soils (1 if yes)	-0.028	0.086
Crop factors (base: *Teff* all varieties)		
Small cereals all varieties (1 if yes)	-0.025	0.076
Large cereals all varieties (1 if yes)	-0.083	0.061
Pulses all varieties (1 if yes)	-0.396***	0.097
Household (HH) demographics		
Age of HH head (years)	-0.002	0.003
HH head formal/informal science education (1 if yes)	0.040	0.074
Secondary occupation (1 if non-farming)	0.018	0.071
Institutional credit (1 if received loan)	-0.078	0.073
Participation in extension and training (1 if yes)	0.094	0.070
Dependency ratio	-0.055	0.043
Resource endowment		
Male labour endowment (adult equivalent) $^{\Psi}$	0.173	0.092
Female labour endowment (adult equivalent) $^{\Psi}$	0.064	0.109
Cultivable land holding size (*Tsimdi*) $^{\Psi}$	-0.164**	0.066
Draft power endowment (ox-days) $^{\Psi}$	0.207**	0.092
Other livestock (TLU) $^{\Psi}$	-0.039	0.061
Location factors		
Population density (persons per km square) $^{\Psi}$	0.249***	0.070
Distance of plot from residence /minutes/ $^{\Psi}$	-0.008	0.020
Stock of SWC investment in 1997 (1 if yes)	-0.069	0.056
Constant	1.922***	0.329
Number of observations	440	
F(28,113)	4.74	
Prob > chi2	0.000	
R square	0.2087	

Notes: $^{\Psi}$ indicates variables in their natural log form; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; dummy variables are defined as 1 if yes or 0 otherwise; RSE stands for robust standard errors; Ramsey RESET test using powers of the fitted values, H_0: model has no omitted variables that could not be rejected F(3,408)= 1.58 with a p-value 0.1933; Shapiro-Wilk W test for normal data show that W is 0.9965 and p-value is 0.4775; and exclusion of crop choice variable reduces the significance of the land and draft-power endowment of households variables to a 10% level and increases that of medium rainfall area dummy to 5% level with no other effects on the tenure status variables.

Draft-power use

Draft power is another critical input in the subsistence production systems in the highlands of Tigray. Ploughing, cultivation and threshing are mainly with oxen although equines and barren cows are also used to some extent. One of the policy interventions in the region is the provision of credit services to enable the purchase of oxen to meet the draft-power demand of the crop production system. Availability of draft-power is important for the timely preparation of seedbeds and other activities. Although minimum tillage practice is one of the technologies promoted by the extension systems in Ethiopia, frequent ploughing and fine seedbed preparation are common in most of the country's highland farming systems. The availability of draft-power is therefore critical for timely land preparation and sowing, particularly in rainfed-dependent farming areas, such as Tigray.

We estimate a linear regression model of the draft-power use as a function of plot tenancy status and the other variables considered earlier in the case of labour, as stated in equation (3.4). Similar to the case of labour use, robust standard errors are reported here controlling for non-independence of errors within households. The results are presented in Table 3.8. A diagnostic test for the problem of multicollinearity shows a mean variance inflation factor of 1.68 with the lowest and highest scores at 1.27 and 2.18, respectively.

As in the case of labour use, the impact of the tenancy indicators on draft-power use is statistically not significant and is inconclusive. The signs of the coefficients of the dummy variables for a half and two-thirds or three-quarters of grain output shares are opposite, and neither is statistically significant. However, with an increase in the number of sharecropped-in plots, the intensity of draft-power use shows a significant reduction.

Draft-power use is significantly lower when farmers have a larger endowment of cultivable land, better access to institutional credit, and are producing large cereals (such as sorghum and maize) and pulses rather than *Teff*. The intensity of draft-power use is also low on plots with a stock of conservation structures. Intensity of draft-power use is significantly higher in areas with a high population density and with medium rainfall. It is also significantly higher when tenant households have access to extension services and training, and on distant field plots. Draft-power endowment has a positive but a statistically insignificant impact on the intensity of use.

Table 3.8 OLS estimation of determinants of draft-power intensity in ox-days per *tsimdi*

Explanatory factors	Coeff.	RSE
Tenure factor (base: own plot)		
Half grain output share of tenant (1 if yes)	0.063	0.056
Two-third grain output share of tenant (1 if yes)	-0.066	0.063
Number of plots sharecropped-in by tenants (count)	-0.102*	0.052
Agro-ecological (base high rainfall area)		
Plots in medium rainfall areas (1 if yes)	0.113*	0.066
Plots in low rainfall areas (1 if yes)	-0.032	0.081
Plot quality (base: good plot quality)		
Plots with medium quality (1 if yes)	0.005	0.050
Plots with low quality (1 if yes)	0.060	0.061
Soil type (base: *Hutsa* (coarse sandy)		
Sheshiher (fine sandy) soils (1 if yes)	0.024	0.060
Baekel (*Cambisols*) soils (1 if yes)	0.017	0.056
Walka (*Vertisols*) soils (1 if yes)	-0.059	0.065
Keyih (*Luvisols*) soils (1 if yes)	-0.012	0.070
Crop factors (base: *Teff* all varieties)		
Small cereals all varieties (1 if yes)	-0.054	0.063
Large cereals all varieties (1 if yes)	-0.217***	0.055
Pulses all varieties (1 if yes)	-0.359***	0.084
Household (HH) demographics		
Age of HH head (years)	-0.002	0.003
HH head formal/informal science education (1 if yes)	0.016	0.055
Secondary occupation (1 if non-farming)	-0.013	0.060
Institutional credit (1 if received loan)	-0.184***	0.051
Participation in extension and training (1 if yes)	0.138**	0.055
Dependency ratio	-0.002	0.031
Resource endowment		
Male labour endowment (adult equivalent) $^{\psi}$	-0.031	0.081
Female labour endowment (adult equivalent) $^{\psi}$	-0.039	0.087
Cultivable land holding size (*Tsimdi*) $^{\psi}$	-0.172***	0.054
Draft power endowment (ox-days) $^{\psi}$	0.013	0.086
Other livestock (TLU) $^{\psi}$	0.068	0.050
Other factors		
Population density (persons per km square) $^{\psi}$	0.168**	0.066
Distance of plot from residence /minutes/ $^{\psi}$	0.040**	0.017
Stock of SWC investment in 1997 (1 if yes)	-0.075*	0.043
Constant	1.997***	0.356
Number of observations	455	
F(28,113)	7.09	
Prob > chi2	0.000	
R square	0.2724	

Notes: $^{\psi}$ indicates variables in their natural log form; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; dummy variables are defined as 1 if yes or 0 otherwise; RSE stands for robust standard errors; Ramsey RESET test using powers of the fitted values, H_0: model has no omitted variables that could not be rejected F(3,423)= 0.64 with p-value 0.5886; Shapiro-Wilk W test for normal data on the residuals: W = 0.9851, V=4.604 and p-value is 0.00013 indicating non-normality; and exclusion of crop choice variable lead to the loss of significance of the medium rainfall area dummy, reduced the significance of the dummy for the stock of conservation investment to 5% level and the significance of the population density and distance of plot variables to a 1% level with no change to the effect of the tenure variables.

Plot level private long-term conservation investments

To identify the determinants of the likelihood of private investment on land improvements and conservation practices, equation (3.5) was estimated using a Probit model. The probability of investing in long-term land management practices is modelled as a function of the tenure status of plots (T_i), household socioeconomics (H_i), crop (C_i), plot (P_i) and location (Z_i) features, and the stock of conservation investment in 1997 (Stock97). We assume public and collective investment in 1998 to be uniform for all plots, regardless of the tenancy status. The results of the Probit model are presented in Table 3.9.

The likelihood of tenants investing in conservation practices was significantly higher on plots sharecropped-in with a two-thirds share of grain output to tenants than owned ones in the 1998 production season, a result that was not expected. Although the effect of variation in plot quality did not show a statistically significant effect, most of the sharecropped-in plots receiving such investment were of poor- and medium- quality. Such result could be due to omitted variable problem such as the personal relationships of tenants and land owners. The probability of investing decreases in relation to the number of plots sharecropped-in by the tenant. Access to institutional credit is a negative predictor of private investment.

Better female labour endowment of the tenant household increases the likelihood of private investment at plot level. Conservation investment is more likely to occur when a plot is located halfway up a slope compared to plots not on the slope. Such investment occurs less frequently on plots located at the top of a slope compared to those on flat areas. There is a low probability of private investment on plots distantly located from the tenant's residence.

Although the model's goodness of fit test (i.e. its predictive power) is statistically acceptable, the results have limitations as investment was carried out only on 10% of the sample plots. The generally low levels of private investment may be due to the crowding-out effects of public investment, which is conducted at community level through labour mobilization. Other studies show mixed results on the crowding-out effect of public investment and programmes on private investment in soil conservation at the plot level. Hagos (2003) found a positive association, while Gebremedhin and Swinton (2003) and Holden *et al*. (2004) found negative associations.

Table 3.9 Probit estimation of determinants of private conservation investment decisions of tenants on owned and sharecropped-in plots in 1998

Explanatory factors	**Coeff.**	**RSE**
Tenure factor (base: own plot)		
Half grain output share of tenant (1 if yes)	0.300	0.319
Two-third grain output share of tenant (1 if yes)	1.314***	0.397
Tenure security indicator (1 if yes)	-0.173	0.262
Number of plots sharecropped-in by tenants (count)	-0.487**	0.235
Agro-ecological (base: high rainfall area)		
Plots in medium rainfall areas (1 if yes)	-0.287	0.288
Plots in low rainfall areas (1 if yes)	0.435	0.293
Plot quality (base: good plot quality)		
Plots with medium quality (1 if yes)	0.021	0.234
Plots with low quality (1 if yes)	-0.039	0.268
Soil type (base: *Hutsa* (coarse sandy)		
Sheshiher (fine sandy) soils (1 if yes)	-0.467	0.325
Baekel (*Cambisols*) soils (1 if yes)	0.034	0.295
Walka (*Vertisols*) soils (1 if yes)	-0.069	0.307
Keyih (*Luvisols*) soils (1 if yes)	-0.432	0.366
Slope position of plot (base: plot not on slope)		
Plot on the bottom (1 if yes)	0.297	0.269
Plot on the middle (1 if yes)	0.622**	0.271
Plot on the top (1 if yes)	-0.748**	0.332
Crop factors (base: *Teff* all varieties)		
Small cereals all varieties (1 if yes)	0.564	0.377
Large cereals all varieties (1 if yes)	0.788**	0.390
Pulses all varieties (1 if yes)	0.955**	0.469
Household (HH) demographics		
Age of HH head (years)	-0.010	0.013
HH head education (formal/informal science) (1 if yes)	-0.059	0.257
Secondary occupation (1 if non-farming)	0.257	0.263
Institutional credit (1 if received loan)	-0.440*	0.256
Participation in extension and training (1 if yes)	0.262	0.286
Dependency ratio	0.022	0.140
Resource endowment		
Male labour endowment (adult equivalent)$^{\psi}$	-0.220	0.305
Female labour endowment (adult equivalent)$^{\psi}$	0.437*	0.394
Cultivable land holding size (*Tsimdi*)$^{\psi}$	-0.076	0.242
Draft power endowment (ox-days)$^{\psi}$	-0.041	0.368
Equine endowment (TLU)$^{\psi}$	0.251	0.220
Other livestock (TLU)$^{\psi}$	-0.095	0.226

Table 3.9 (Cont.)

Explanatory factors	Coeff.	R.S.E.
Location factors		
Population density (persons per km square) $^{\psi}$	-0.256	0.323
Distance of plot from residence /minutes/ $^{\psi}$	-0.187**	0.077
Stock of SWC investment in 1997 (1 if yes)	0.051	0.251
Constant	0.473	1.527
Number of observations	445	
Wald chi2(30)	162.16	
Prob > chi2	0.000	
Pseudo R square	0.3056	
Log pseudolikelihood	-85.126	
Correctly classified (%)	93.26	
Goodness of fit test (Hosmer-Lemeshow chi2(8)) 4.58 (p=0.8012)		

Notes: $^{\psi}$ indicates variables in their natural log form; RSE stands for robust standard errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and dummy variables are defined as 1 if yes or 0 otherwise. Test for multi-collinearity among included variables show a mean variance inflation factor (VIF) of 1.42 which every low than 5 commonly considered as acceptable. Exclusion of the crop choice variable from the regression lead to gains in the statistical significance of the dummy for slope position on the top and the plot distance variables to a 1% level with no change to the effects of the tenure variables.

3.6. Discussion and conclusions

Given that there are methodological and data limitations to assess comprehensively the impact of tenancy arrangements on land quality, empirical works need to rely on partial assessment of systems through a comparative analysis of management practises. Comparison of tenant's management practises and use of inputs on owned and sharecropped-in plots gives reasonable insights into the incentive problems related to land contract arrangements. In this study we compare the use of important land quality enhancing and farm management inputs by tenant households namely, manure, chemical fertiliser, labour, draft-power and private investment for erosion control and conservation.

The results reveal that plot tenancy status has a mixed impact on tenants' decisions about input use and intensity of use depending on the type of input considered, output sharing arrangement and the level of tenure security it gives to the tenant. The probability and intensity of manure use by tenants are higher on plots that they own compared to the plots they operate receiving a two-thirds share of the grain output. Where tenants hold positive expectation of long-term use of a plot, the probability of manure use is found higher. Tenancy status of the plot is not found as statistically strong determinant of the probability and intensity of commercial fertiliser use by tenants. Fertilizer use is rather higher on good quality plots and high value crops, and when the tenant household has better access to credit.

The impact of tenancy status of a plot on the intensity of labour and draft-power use is not conclusive, as the results are statistically weak. However, the intensity of use of most inputs correlates negatively with the number of plots sharecropped-in and the size of cultivable land endowment of the tenant. This may imply a shortage of tenants and a poorly developed land contract market. Institutional interventions are required to support the development of land contract markets and to improve participation of tenants in the current practice.

In the case of private investment in plot level conservation, the results were puzzling and unexpected. The significantly higher level of private investment by tenant households on sharecropped-in plots compared to on owned ones was not expected, and this result may be due to omitted variable case such as the absence of variables that describe the personal relationship between tenants and land-owners. However, most of the investment on sharecropped-in plots occurs on poor- and medium- quality plots (nearly 80% of the sharecropped-in plots fall within these categories). The impact of tenants' perceptions about the possibilities of contract extension on sharecropped-in plots and inheritance rights on owned plots on their decisions about land management is inconclusive as the analysis does not provide any statistically significant evidence except in the case of manure use. Therefore, the results do not consistently support the Marshallian view of moral hazard in the supply of inputs by tenants.

The analysis identifies other significant determinants of the use, and level of use, of soil fertility and farm management inputs, besides tenancy status, that have implications for policy. Promoting alternative energy sources and credit services for fertilizer may both enhance soil fertility management at plot level. Tenants with relatively large holding of cultivable land use less manure, labour inputs and draft-power per *tsimdi*. By contrast, tenants with a better draft-power endowment apply more fertilizer and labour inputs per unit of land. These findings should interest land owners wishing to screen potential tenants based on their capacity to manage farm plots in a sustainable way. This also indicates the existence of an information problem on landowners' part and insufficient competition in land contract markets (Ray, 1998) and poor development of factor markets in general (Pender and Fafchamps, 2001, 2005).

Finally, there is a need for a policy framework governing land use in order to sustain the fertility and ultimately the usability of farmland in the region as current farm level practices of soil management of farmers are more focused on relatively good quality plots which could be due to economic reasons. There is also a recognizable need to further investigate the impacts of land contracts, within a dynamic setting, in order to identify the potential consequences on sustainable land use practices and design a way to deal with any negative externalities.

CHAPTER 4

Tenancy, resource use efficiency and sustainability

This chapter analyzes the level of resource use efficiency achieved by tenant households on their own and on sharecropped-in plots, and the determinants of the levels of efficiency achieved. Using plot level and location data from Tigray, it assesses whether tenancy status affects technical efficiency. Stochastic frontier production function analysis results show that a statistically significant level of technical inefficiency exists in the production system but this was not found significantly associated with the tenancy status of the plot, controlling for other factors. Technical efficiency was found to have significantly positive association with livestock endowments of the tenant household and the population density of the location.

4.1. Introduction

In the preceding chapter, we discussed the impact of land contracting on the use and intensity of use of farm inputs and conservation investment at plot level. The comparative analysis of input use and the intensity of input use decisions gives a partial picture of the impact of land contract arrangements on the sustainability of land use. In addition to the comparison of the farm management and conservation investment decisions at plot level, aggregate indicators of productivity are used to assess the resource use efficiency differentials for farmland operated under different tenancy arrangements. In empirical research, different indicators of resource use efficiency are employed, depending on the context of the study and the availability of data. Technical, allocative and economic indicators are commonly used to assess efficiency implication of institutional arrangements.

Recent studies in Ethiopia have analyzed the effect of different forms of tenancy arrangements on production efficiency (Gavian and Ehui, 1999; Pender and Fafchamps, 2001 & 2005; Ahmed *et al.,* 2002; Benin *et al*., 2005). Because of the short duration of tenancy arrangements, empirical analysis is limited assessing production efficiency solely in terms of production efficiency and economic viability *per se*. Little attention has been given to evaluating the cumulative economic and environmental effects of short-term tenancy arrangements. Investigation of this issue in a dynamic setting represents a future opportunity for theoretical and empirical research.

This chapter has three major objectives. First, it aims *to measure the efficiency of resource use on owned and on sharecropped-in plots* operated by tenant households in the highland farming systems of Tigray. Differences in the level of technical efficiency achieved by tenants will be used as an indicator of resource use efficiency and will then be used as a basis for an empirical assessment of the efficiency of tenancy arrangement in Tigray.

Secondly, it aims *to identify the determinants of any variations in achievements of technical efficiency*. Thirdly, it *considers the long-term implications of sharecropping arrangements* in the region in light of the available literature and draws policy lessons intended to enhance the contribution that land tenancy arrangements make towards productivity growth and sustainable use of farmland in the region.

The remainder of this chapter is organized as follows. Section 4.2 provides a brief review on the impact that agricultural contracts have on efficiency, from both theoretical and empirical research and states the research hypotheses. In section 4.3 the research problem and objectives are formulated. Section 4.4 explains the data and method of analysis. Results of the technical efficiency analysis and the determinants of differences in technical efficiency achievements are presented in section 4.5. Section 4.6 highlights the sustainability implications of sharecropping arrangements. Conclusions and policy implications are set out in 4.7.

4.2. Conceptual background and research hypotheses

The economics of sharecropping has been modelled from the tenant perspective since the time of Marshall (1890) and from the landlord side by Cheung (1968, 1969) and arrive at contrasting conclusions regarding its efficiency (cited in Ellis (1993), Bhaumik (1993), Pender and Fafchamps (2001)). In general, higher productivity is achieved in a share contract when the contracting agents fulfil their expected input contributions as stipulated in the contract (Eswaran and Kotwal, 1985). According to Marshall's tenant model, sharecropping is inefficient as the tenant is likely to undersupply effort as he or she will receive only a fraction of the marginal productivity of the effort supplied. However, Cheung challenged Marshall's view by assuming the possibility of monitoring the work effort of the tenant without cost. Inefficiency in contract arrangements is generally associated with lack of information and appropriate incentives, and problems in contractual enforcement (Ray, 1998: 404).

Understanding the implication of different forms of tenancy for efficiency and equity has great relevance for the land-tenure related policy discussion in Ethiopia, where the need for privatization of land is increasingly being raised in the political arena (Gavian and Ehui, 1999; Pender and Fafchamps, 2001 & 2005; Ahmed *et al.*, 2002; Gebremedhin *et al.*, 2003; Deininger *et al.*, 2003; Benin *et al.,* 2005). Studies in Ethiopia and elsewhere provide mixed evidence about the efficiency of sharecropping compared to alternative forms. Some empirical studies have found sharecropping to be inefficient compared to owner-operated farming, supporting the Marshallian view (Gavian and Ehui, 1999; Ahmed *et al*., 2002), while others report otherwise or find no difference (Nabi, 1986; Kalirajan, 1990; Pender and Fafchamps, 2001 & 2005).

Variations in efficiency achievement are of course associated with other socioeconomic characteristics of farmers and environmental circumstances as well tenancy factors. Some technical factors considered in empirical research include the knowledge of farmers about agronomic practices and timeliness of farming operations (Kalirajan, 1990), location factors (Abdulai and Eberlin, 2001), farm type such as crop or mixed enterprise, farm size, and access to irrigation (cited in Battese, 1992).

Socioeconomic factors influencing technical efficiency include operators' age (Audibert, 1997; Seyoum *et al.*, 1998; Abdulai and Eberlin, 2001; Ahmed *et al*., 2002; Gebreegziabher *et al.*, 2005), education level (Kalirajan, 1990; Seyoum *et al.*, 1998; Pender and Fafchamps, 2001; Ahmed *et al*., 2002), gender (Ahmed *et al*., 2002; Gebreegziabher *et al.*, 2005), household resource endowment (Abdulai and Eberlin, 2001; Ahmed *et al*., 2002), family size (Audibert, 1997) and composition in terms of dependency ratio and labour type (Abdulai and Eberlin, 2001; Ahmed *et al*., 2002), household members' health status (Audibert, 1997), land holding fragmentation (Shuhao, 2005), primary occupation and wealth status (Ahmed *et al*., 2002), involvement in off-farm work (Kalirajan, 1990; Gebreegziabher *et al.*, 2005), access to credit (Gebreegziabher *et al.*, 2005), and access to extension services (Seyoum *et al.*, 1998). The ethnic origin of operators has also been considered in some studies (Abdulai and Eberlin, 2001; Ahmed *et al*., 2002). Based on the conceptual review and the results of empirical work elsewhere, we aim to test the following hypotheses regarding sharecropping (in)efficiency:

Tenancy: The literature is not conclusive about the impact of tenancy status on production efficiency. We expect the possible impact to depend on the context of the area. It is assumed that there is mutual interest among the contracting parties to maintain social relations and a possibility of self-monitoring in the traditional communities of the study area. It is also possible to use social norms by the land owner to enforce contract agreements costlessly in such communities. It is therefore hypothesised that resource use efficiency on sharecropped plots will be comparable to own plots for the optimizing peasant.

Labour and draft-power endowment: Households with higher male labour and oxen endowments have been found to be more efficient in some empirical studies (Abdulai and Eberlin, 2001; Ahmed *et al*., 2002). A similar effect is expected in this study, as availability of these resources is associated with the timeliness of farming operations, especially during peak periods.

Education and labour market involvement: Better education is usually associated with efficient management of production systems (Kalirajan, 1990; Pender and Fafchamps, 2001; Abdulai and Eberlin, 2001; Ahmed *et al*., 2002). However, better education may also lead to better off-farm opportunities, reducing the availability of both physical and managerial functions of labour, and leading to lower efficiency in farm production. The impact of involvement in non-farm activities on productivity is not conclusive from empirical research results. Abdulai and Eberlin (2001) found lower efficiency of production when households were involved in non-farm activities, while Gebreegziabher *et al.* (2005) found the opposite effect. Thus, the effect of education and off-farm occupation on production efficiency is difficult to determine beforehand.

Access to credit and extension services: Access to credit reduces problems of liquidity and enhances the use of agricultural inputs in production, as often claimed in development theory (Feder *et al*., 1985). In Tigray credit is available for purchase of oxen and inputs. Better access to credit and to extension services may increase resource use efficiency.

Other exogenous factors: Two other exogenous factors are considered in this analysis: population pressure and rainfall conditions. In areas with good rainfall conditions there is positive incentive for tenants to show good effort due to better production opportunities and potential for risk reduction. Farmland is scarce in densely populated areas and tenants in these areas may make more efficient use of farmlands assuming the competition for land and market opportunities for produce are positively influenced by population pressure. Plot level management may also be better (timely and in the required quality) in high population density areas because of labour availability and resulting in higher resource use efficiency.

4.3. Research problem and objectives

In subsistence economies, efficient use of household resources such as labour, land and draft power is critical to increase agricultural production and food security. Different formal or informal forms of labour, land, draft power and/or financial resource exchange or contract systems play a role in mediating the efficient use of farm resources. The 1997 rural land administration and land use policy in Tigray recognizes temporary land transfer rights as a way to improve the institutional environment for agricultural production. However, the reviews of theoretical and empirical studies show that not all forms of resource contracting systems lead to more efficient resource use. Moreover, land contracts that are efficient in the short term may not be efficient and sustainable in the long term (Ray, 2005).

There is therefore a need to assess the productivity implications of formal and informal land contracting systems in Ethiopia, considering regional contexts. Sharecropping is one of the most widely used means of resource pooling and factor proportion balancing arrangements in the small-scale farming systems in the highlands of Tigray and elsewhere in Ethiopia (Pender and Fafchamps, 2002 & 2005; Gebermedhin *et al.*, 2003; Deininger *et al.*, 2003; Teklu and Lemi, 2004; Benin *et al.*, 2005). Thus far, there have been no comprehensive empirical studies on the implications of land contracting systems for production efficiency in Tigray which can serve as an input for policy making. Based on community level data, Gebermedhin *et al.* (2003) identified the determinants of the terms of share arrangements. Although not specifically focused on the effect of land contracting factors, Gebreegziabher *et al*. (2005) also analyzed technical efficiency achievements amongst subsistence producers in southern Tigray. Using household level survey data they were able to identify the determinant of such achievements and concluded that shortfalls in technical efficiency are not due to resource allocation problems. However, no comparative study on the implications of land contract systems on productivity has yet been carried out in the region. Indeed, the long-term effects of land contracting on production efficiency and the sustainability of production systems have not been addressed in any of the regional studies in Ethiopia. There are also very few studies on the long-term economic and sustainability implication of land contracting from other countries (Dubois, 2002; Ray, 2005). This chapter attempts to address the first gap using household and plot level data from Tigray and poses questions for future research about the long term dimensions of the issue. The specific research objectives are:

- to quantify and compare technical efficiency achievements on owned and on sharecropped-in plots operated by the same tenant household;
- to assess the impact of plot tenure status on technical efficiency achievement or inefficiency levels at plot level;
- to identify other household socioeconomic, institutional, and biophysical factors associated with the difference in technical efficiency achievement; and
- to identify areas where policy interventions can enhance productivity and sustainable land use in the Region.

4.4. Data and analysis methodology

Data

Details on the source and nature of the data are given in Chapter 3 (Table 3.3). Here an explanation is offered on the variables included specifically for the analysis in this chapter. Table 4.1 contains descriptive information about plot level inputs of labour, draft power, seed and fertilizer, plot area, and gross value of output in Birr[4.1] per plot. The gross value of grain and straw outputs and seed costs are computed based on average price information collected during the survey.

Table 4.1 Descriptive statistics of variables used in stochastic frontier production function estimation (tenant households)

Variables	n	mean	SE mean	SD
Dependent variable				
Gross value of grain and straw output in Birr $^{\Psi}$	518	441.13	18.52	421.63
Explanatory variables				
Production input variables				
Labour input (person-days) $^{\Psi}$	525	24.87	0.94	21.63
Area planted (square metres) $^{\Psi}$	538	3215.26	124.14	2879.60
Draft-power (ox-days) $^{\Psi}$	527	13.23	0.37	8.51
Seed cost (Birr) $^{\Psi}$	530	35.52	1.60	36.84
Fertilizer (kilograms) $^{\Psi}$	534	6.27	0.54	12.56
Household resource endowment				
Cultivable land holding size (hectare) $^{\Psi}$	115	1.25	0.028	0.66

Notes: $^{\Psi}$ Included in their natural log forms; dummy variables are defined as 1 if yes or 0 otherwise for the analysis; n stands for number of observations, SE for the standard error of the mean and SD for standard deviation; unless and otherwise stated all variables refer to 1998 production year and for descriptive information of other variables see Table 3.3.

Stochastic frontier production function method

A stochastic frontier production function approach is employed to compute the technical efficiency of resource use at plot level. This approach is widely employed in empirical studies that analyze technical efficiency analysis (e.g. Coelli *et al.,* 1998; Kumbhakar and Lovell, 2000; Abdulai and Eberlin, 2001; Ahmed *et al*., 2002). The frontier production function shows the maximum amount of output obtainable from given quantities of inputs, thus representing maximum efficiency (Hallam and Machado, 1996). Technical inefficiency is

[4.1] The Birr is the Ethiopian currency (in 1998 under the official exchange USD1 was equivalent to 7.00 Birr) measured in distance from this frontier and the composed error specification of the stochastic frontier production function enables separation of output shortfalls due to technical inefficiency from those caused by random disturbances. The general model of the stochastic frontier production function (Aigner, Lovell and Schmidt, 1977; Jondrow *et al.,* 1982; Stata, 2003; Kumbhakar and Lovell, 2000) is

$$Y_i = f(\beta^* X_i)\exp(v_i - u_i) \qquad i=1, 2, 3\ldots, N \qquad (4.1)$$

Where Y_i is the output for observation i; β stands for the vector of parameters to be estimated; X_i stands for the vector of input variables for the i^{th} observation; v_i stands for the disturbance term with a symmetric distribution ($N(0,\sigma_v^2)$); u_i stands for the disturbance term with a half-normal distribution ($N^+(0,\sigma_u^2)$) measuring the technical inefficiency component independently distributed of the v_i's; and i is the observation unit, in this case a plot. The technical inefficiency term u_i measures the shortfall of output from its maximum possible value given by the stochastic frontier (Jondrow *et al.,* 1982; Battese and Broca, 1997; Bravo-Ureta and Pinheiro, 1997). The half-normal distributional ($N^+(0,\sigma_u^2)$) assumption for u_i is widely used in empirical work and is adopted here. The technical inefficiency determinants may be expressed as:

$$u_i = \delta^* Z_i + w_i, \qquad i=1, 2, 3\ldots, n \qquad (4.2)$$

Where Z stands for the vector of factors that influence the technical inefficiency; δ stands for the vector of unknown parameters of the plot specific inefficiency variables; and w is a random disturbance term obtained by truncations of the normal distribution, with mean zero and variance σ^2. Given the specification of the stochastic frontier production function in equation (4.1), the technical efficiency scores of production for the i^{th} plot are predicted as

$$TE_i = \exp(-u_i) = \exp(-Z_i\delta - w_i) \qquad (4.3)$$

The Maximum Likelihood estimates of the model parameters are computed using the frontier models routine of the statistical package STATA 8SE, which assumes a Cobb-Douglas production technology (Stata, 2003). The determinants of inefficiency are identified by regressing the predicted scores over the Z variables as:

$$-\ln(TE_i) = \delta^* Z_i \qquad (4.4)$$

4.5. Technical efficiency achievement and determinants

Own and sharecropped plots

Before proceeding to a stochastic frontier production function analysis a T-test is conducted to assess the statistical significance of the differences in the mean gross value of output from tenants' own and sharecropped-in plots, controlling for plot area and crop type. The null hypothesis of equality of means is rejected under both equal and unequal variance assumptions and the results for unequal variance assumption are reported in Table 4.2. Controlling for crop type and area, mean gross value of output from own plots is significantly higher than on sharecropped-in plots.

Table 4.2 Comparison of mean gross values of output from owned and sharecropped-in plots of tenants by crop type per *tsimdi* (0.25 ha) assuming unequal variance

Crop type	Own plots		Sharecropped plots		d.f.@	T-value	p-value
	N	Means (SE)	N*	Means (SE)			
Teff all variety	96	1315 (185)	45	517(94.7)	131.7	3.841	0.000
Small cereals	97	616.8(125)	63	331.7(52)	126.4	2.103	0.018
Large cereals	110	1184.1(153)	65	571.5(78.0)	155.1	3.562	0.000
Pulses	24	495.2(205)	18	166.4(33.7)	24.2	1.582	0.063
All crops	327	1003(86)	191	441.4(39)	444.6	5.910	0.000

Notes: n stands for number of observations and SE for the standard error of the mean; d.f.@ Express Satterthwaite's degrees of freedom; and hypotheses tested is that the mean(own) less mean (sharecropped-in) is equal to zero (H_0) against the alternative (H_a) of the difference is greater than zero;

Efficiency analysis

The impact of the tenure status of a plot on resource use efficiency, as measured by technical efficiency, is analyzed using a stochastic frontier production function as stated in the previous section (4.4). The stochastic frontier production function is estimated using a Cobb-Douglas function, commonly used in technical efficiency studies (Coelli *et al.,* 1998; Kumbhakar and Lovell, 2000; Stata, 2003) and in Ethiopian studies (Seyoum *et al.,* 1998; Ahmed *et al*., 2002; Gebreegziabher *et al*., 2005). The same assumption is maintained here for reasons of comparability. This assumes constant returns to scale and a fixed elasticity of output with respect to production inputs. However, it is also important to know whether returns to scale are decreasing, because, if this is the case, an increase in population growth will have a negative impact on income and sustainability (Pender, 1998).

The plot level gross value of output is considered as a function of the inputs of total labour (in person-days), plot size (in square metres of area sown), draft power (in animal-days), seed inputs (in Birr), and inorganic fertilizer applied (in kilograms). Gross value of output and quantity of inputs are transformed into their natural logarithmic forms. To handle cases of zero fertilizer input, the method proposed by Battese (1997)[4.2] is employed. Apart from the conventional inputs dummy variables for rainfall conditions, plot quality indicators, crop type, manure use, and tenant's conservation investments in 1998 and the stock of conservation investment at the end of 1997 are also included, as described in the data section in Chapter 3. These factors are considered to have a direct impact on production by shifting the intercept of the production frontier. Coefficients of the dummy variables are interpreted as percentage changes from their respective base categories.

The estimated stochastic frontier production function is presented in Table 4.3. A Likelihood-ratio (LR) test on the statistical significance of the technical inefficiency within the data confirms that the null hypothesis of technical inefficiency (H_0: sigma μ=0) is to be rejected (p=0.007). The lambda (λ) value, commonly used as indicator of the significance of the inefficiency level is greater than one (1.347). The gamma (γ) value, a measure of the percentage variations in plot output due to technical inefficiency is 64%. Thus, use of Ordinary Least Squares (OLS) to estimate the frontier function is therefore inappropriate in the presence of inefficiency[4.3].

Output response for total labour, draft-power, seed and fertilizer inputs use is positive and statistically significant, except for plot area. Output elasticities for total labour, draft-power, seed and fertilizer inputs are 0.14, 0.35, 0.24, and 0.15, respectively. A Wald test for the constant returns assumption[4.4] is confirmed positively. The intercept for the stochastic frontier production function is significantly affected by crop type, plot quality and rainfall conditions. Gross revenue is 26% and 37% lower for small cereals and pulses respectively compared to *Teff*. Gross revenue is 29% and 19% lower for plots in low and medium rainfall areas, respectively, compared to the plots in high rainfall areas. Gross revenue from medium- and poor- quality plots is 20% and 28% lower, respectively, compared to good quality plots. Plots with stock of conservation investment in 1997 gave 13% higher gross revenue compared to those without prior conservation.

[4.2] A dummy variable is included in the analysis which takes a value one in the case of a zero-value of fertilizer input.
[4.3] The residuals from an OLS estimation show negative a skew (-0.288), which is a further indicator for the presence of technical inefficiency in a dataset (Kumbhakar and Lovell, 2000:73).
[4.4] The test for the assumption of constant returns to scale was done by imposing a linear restriction as the sum of the coefficients for the labor, land, draft power, seed and fertilizer is equal to unity. The Wald test did not reject the null hypothesis of constant returns to scale.

Table 4.3 Stochastic frontier estimation of plot level production efficiency in the Highlands of Tigray (1998 production season)

Dependent variable: Gross value of grain and straw outputs (in Birr) $^{\psi}$		
Explanatory variables		
Production inputs	**Coeff.**	**SE**
Labour input (person-days) $^{\psi}$	0.146***	0.051
Plot area (square metres) $^{\psi}$	0.089	0.059
Draft-power (ox-days) $^{\psi}$	0.359***	0.077
Seed cost (Birr) $^{\psi}$	0.244***	0.047
Dummy for fertilizer zero values[1]	0.411***	0.156
Fertilizer (kilograms) $^{\psi}$	0.152**	0.060
Agro-ecologic conditions (base high rainfall area)		
Plots in medium rainfall areas (1 if yes)	-0.196***	0.070
Plots in low rainfall areas (1 if yes)	-0.294***	0.081
Plot quality conditions (base good plot quality)		
Plots with medium quality (1 if yes)	-0.201***	0.067
Plots with low quality (1 if yes)	-0.289***	0.072
Crop factors (base *Teff* all varieties)		
Small cereals all varieties (1 if yes)	-0.269***	0.089
Large cereals all varieties (1 if yes)	-0.067	0.076
Pulses all varieties (1 if yes)	-0.375***	0.124
Other management practises		
Manure use (1 if yes)	0.007	0.069
Private investment in 1998 (1 if yes)	-0.066	0.100
Stock of SWC investment in 1997 (1 if yes)	0.133**	0.057
Constant	3.471***	0.349
/lnsig2v	-1.572***	0.186
/lnsig2u	-0.976***	0.302
Sigma v	0.455	0.042
Sigma u	0.614	0.092
Sigma square	0.584	0.084
lambda (δ_u / δ_v)	1.347	0.130
Gamma ($\gamma = \lambda^2 /(1+\lambda^2)$) or $\gamma = \delta_u^2 / (\delta_u^2 + \delta_v^2)$	0.644	
Number of observations	484	
Wald chi2(16)	569.39	
Prob > chi2	0.000	
Log likelihood	-426.13	
Likelihood-ratio test of sigma u=0 Chibar2(01)	6.01	
Prob>=chibar2	0.007	

Notes: ψ stands for natural log form; [1]Defined according to the Battese (1997) method for handling zero cases of input use in our case fertilizer; dummy variables are defined as 1 if yes or 0 otherwise for the analysis; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and gamma (γ) measures the percentage of total output variation due to technical inefficiency.

In order to investigate the determinants of technical efficiency differentials, the technical efficiency scores at plot level were generated using equation (4.3). The distribution of the predicted technical efficiency scores is presented in Table 4.4.

Table 4.4 Distribution of technical efficiency scores by plot tenancy in the Highlands of Tigray (1998 production season)

Efficiency	Own plots		Sharecropped-in plots		Combined	
score range*	Count	Percent	Count	Percent	Count	Percent
0 to 0.2	1	0.32	0	0.00	1	0.21
0.2 to 0.4	7	2.27	14	8.00	21	4.34
0.4 to 0.6	89	28.90	43	24.40	132	27.27
0.6 to 0.8	180	58.44	101	57.39	281	58.06
0.8 to 1.0	31	10.07	18	10.21	49	10.12
Total	308	100.00	176	100.00	484	100.00
Average score		65.77		64.12		65.17
Cases below the overall mean	135	43.83	79	44.88	214	44.21

Note: * Ranges exclude upper boundaries except for the final category

The overall mean of technical efficiency level is 65% ranging from 18% to 87%. Technical efficiency scores for a large proportion of sharecropped-in and owned plots are below the overall average. The wide range of variations in technical efficiency achievement reveals the challenge and potential for improving crop production in dryland areas of the highlands of Tigray through better allocation and management of external factors.

Table 4.5 presents a summary of the technical efficiency levels by crop type. The mean technical efficiency on tenant's own plots is marginally higher than from sharecropped-in plots (at 10% level of significance). However, when we disaggregate by crop type, plot quality and rainfall conditions, the statistical significance of the efficiency scores by plot tenancy status is variable (see Tables 4.6 and 4.7). The results in Table 4.6 show that the variations in technical efficiency scores on owned and sharecropped-in plots are not significantly different when we compare for each crop type.

Table 4.5 Mean technical efficiency levels for owned and sharecropped-in plots by crop type in the Highlands of Tigray (1998 production season)

Tenure status and crop type	No. of plots	Means (SD)	Min	Max
All plots aggregate	**484**	**0.651 (0.127)**	**0.178**	**0.871**
Own plots:				
Teff all varieties	87	0.665 (0.110)	0.327	0.854
Small cereals (Barley and wheat)	95	0.654 (0.122)	0.282	0.865
Large cereals (e.g. Sorghum, maize, millet)	104	0.652 (0.128)	0.178	0.865
Pulses	22	0.670 (0.106)	0.417	0.820
Sharecropped-in plots				
Teff all varieties	44	0.641 (0.122)	0.314	0.840
Small cereals (Barley and wheat)	58	0.648 (0.132)	0.303	0.871
Large cereals (e.g. Sorghum, maize, millet)	58	0.641 (0.144)	0.209	0.855
Pulses (e.g Beans, peas, vetch)	16	0.613 (0.196)	0.233	0.848

Notes: * SD stands for standard deviations in parenthesis

Table 4.6 Comparison of means for technical efficiency levels for owned and sharecropped-in plots by crop type (T-test assuming unequal variance)

Crop type	Own plots		Sharecropped-in plots		d.f.[@]	t-values	Sig. (p)
	n	Means (SE)	n	Means (SE)			
All crops aggregated technical efficiency	308	0. 658 (0.006)	176	0.641 (0.009)	320.721	1.308	0.095
Teff all varieties	87	0.665 (0.011)	44	0.641 (0.018)	79.158	1.096	0.138
Small cereals	95	0.653 (0.012)	58	0.648 (0.017)	113.375	0.223	0.411
Large cereals	104	0.652 (0.011)	58	0.641 (0.017)	107.02	0.487	0.313
Pulses	22	0.670 (0.022)	16	0.613 (0.049)	21.410	1.046	0.153

Notes: n stands for number of observations and SE for the standard error of the mean; d.f.[@] Satterthwaite's degrees of freedom; The hypothesis tested is that the mean(own) less mean (sharecropped-in) is equal to zero (H_0) against the alternative (H_a) that the differences is greater than zero; and T-values and p-values are for Ha: diff >0.

A different pattern emerges when comparing mean technical efficiency scores for owned and sharecropped-in plots controlling for land quality and rainfall conditions (see Table 4.7). In medium and low rainfall areas, the technical efficiency achieved by tenants is significantly higher on their own plots than on sharecropped-in plots, but in high rainfall areas the differences are not statistically significant. The mean technical efficiency scores are higher on tenant's own plots than on sharecropped-in ones when the plots are of good quality, but not significantly so on the medium and poor quality plots.

Table 4.7 Comparison of means of technical efficiency levels for owned and sharecropped-in plots of tenants by rainfall conditions and land quality (T-test assuming unequal variance)

Variable	Own plots		Sharecropped -in plots		d.f.@	T-values	Sig. (p)
	n	Means (SE)	n	Means (SE)			
High rainfall area	71	0.643 (0.013)	34	0.674 (0.019)	64.497	-1.305	0.901
Medium rainfall area	150	0.660 (0.01)	97	0.641 (0.015)	175.32	1.462	0.072
Low rainfall area	87	0.664 (0.012)	45	0.632 (0.019)	82.740	1.408	0.081
Good quality plots	144	0.660 (0.010)	37	0.614 (0.024)	48.819	1.747	0.043
Medium quality plots	101	0.655 (0.012)	70	0.643 (0.016)	134.107	0.573	0.283
Poor quality plots	63	0.653 (0.014)	69	0.653 (0.015)	129.49	0.008	0.496

Notes: n stands for number of observations and SE for the standard error of the mean; d.f.@ Satterthwaite's degrees of freedom; The hypothesis tested is that the mean(own) less mean (sharecropped-in) is equal to zero (H_0) against the alternative (H_a) that the difference is greater than zero; and T-values and p-values are for Ha: diff >0.

Determinants

Cross tabulations and mean comparisons are useful for comparing patterns of technical efficiency achievement between plots with different tenancy status, but they are of limited use in explaining the factors behind the differences. To identify the factors that explain the difference in technical efficiency achievements, regression techniques are used, with equation (4.4) estimated using an Ordinary Least Square model controlling for non-independence of errors within households. The predicted technical inefficiency scores are regressed over the factors hypothesized as influencing the level of efficiency (Z_i). These are drawn from the theoretical and empirical review, and include factors that directly or indirectly affect the management decisions of farmers and the technical efficiency levels that they achieve. Factors that are believed to have an effect on the managerial skills, timeliness of resource allocation decisions, and the implementation of farm operations by farmers are considered. These include the tenure status of the plot, perceived tenure security indicator, the number of plots sharecropped-in by the tenant, the tenant's age, education status, secondary occupation, access to institutional credit, participation in extension and training, resource endowment (in terms of male and female labour, cultivable land, and draft-power), distance of the plot from the residence, and the population density of the village. The variable of interest here is the land tenure status of plots, categorized as either: tenant's own plot, plots under a half sharing arrangement and plots where a two-thirds or three-quarters share of the grain output goes to tenants. Population density is considered as a proxy for population pressure. The regression results are presented in Table 4.8.

The findings show that tenancy factors were not statistically significant determinant of technical inefficiency, although the signs were positive for all the variables referring to the share tenancy. Technical inefficiency scores were higher for tenants operating large numbers of plots and lower when tenants expected long period of use of plots although both were not statistically significant.

Technical inefficiency levels are significantly lower in high-population density villages, in line with the Boserupian hypothesis (Pender, 1998). That greater efficiency of tenants in such villages may be due to greater competition for land, which requires tenants to operate at a relatively higher level of efficiency so as to maintain continuity of contracts. The level of technical inefficiency is significantly lower for livestock endowed households which could be related to the wealth status of the household and the dependence of the livestock system on crop residue for feed. Other socioeconomic and resource endowment factors of tenants show no significant impact on the level of technical efficiency achievements.

In sum, on both owned and sharecropped-in plots of tenants, there is a significant level of inefficiency in the production systems. However, the regression results do not show significant impact of tenancy status of a plot on technical efficiency. Technical efficiency was significantly positively associated with livestock endowments of households and population density. Previous studies confirmed the existence of other sources of inefficiency, which indicate the need for further empirical research. For example, Gavian and Ehui (1999) identify differences in quality and problems of proper application of inputs (rather than the intensity of application) as possible sources of inefficiency. The findings of the current study (Chapter 3) show some evidence of different level of application of manure on owned and sharecropped-in plots, but for fertilizer, labour and draft-power inputs, the intensity of use shows no statistically significant difference. Tenants sharecropping-in many plots apply fewer inputs of labour and draft-power per unit land. It is suspected that there may be a problem of timing of input applications on sharecropped-in plots, although it is not possible to support this from the analysis, due to lack of data on the specific timing of input use during the production year considered. It is therefore important in further research to control for the quantity, quality and timing aspect of input use to understand how these affect efficiency of production.

Table 4.8 Determinants of technical inefficiency

Dependent variable: predicted technical inefficiency scores		
Explanatory variables	**OLS**	
Tenure status of plot (Base: own plots)	Coeff.	RSE
Half grain output share to tenant (1 if yes)	0.0572	0.0364
Two-thirds/three quarters grain output share to tenant (1 if yes)	0.0454	0.0401
Number of plots sharecropped-in by tenants (count) $^{\psi}$	0.0153	0.0375
Tenure security indicator (1 if yes)	-0.0228	0.0288
Household demographics		
Age of household head (years)	0.0002	0.0014
Household head education (formal/informal science) (1 if yes)	-0.0156	0.0304
Secondary occupation (1 if non-farming)	0.0268	0.0442
Institutional credit (1 if received loan)	0.0078	0.0306
Participation in extension and training (1 if yes)	0.0244	0.0327
Household resource endowment		
Male labour endowment (adult equivalent) $^{\psi}$	0.0443	0.0331
Female labour endowment (adult equivalent) $^{\psi}$	-0.0472	0.0317
Cultivable land holding size (*Tsimdi*) $^{\psi}$	-0.0373	0.0360
Potential draft power endowment (TLU) $^{\psi}$	-0.0032	0.0580
Other livestock (TLU)	-0.0652**	0.0272
Location factors		
Population density (persons per km sq.) $^{\psi}$	-0.0687*	0.0394
Distance of plot from tenant's residence /minutes/ $^{\psi}$	0.0065	0.0074
Constant	0.8493	0.1938
Number of observations	421	
F(16,112)	1.33	
Prob > F	0.192	
R square	0.071	

Notes: $^{\psi}$ indicates variables in their natural log form; RSE stands for a Robust Standard Errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and dummy variables are defined as 1 if yes or 0 otherwise.

4.6. Long-term prospects of sharecropping arrangements

The conditions of sharecropping, in terms of output and input sharing, the duration of contracts and obligations regarding land management practises have impact on both the level of efficiency of production and on the sustainability of land use. Evaluation of the features of the sharecropping system in Tigray shows that major problems exist in these important aspects. Contract duration is mainly for one year and is not likely to give sufficient incentives for tenants to invest in land improvement practises. According to Gebremedhin *et al*. (2003), also tenants' investment on soil and water conservation practices and tree planting does not influence the likelihood of contract extensions in Tigray. Another study in the Arussi area of

Ethiopia shows one-season land contracts are a major concern to landless tenants as they give little incentive to invest in long lasting land-improvements (Tolossa, 2003). In the case of cash-rental contracts, it has been observed that land owners increase the rent in line with improvements in productivity that follow better land management practices from tenants (*ibid.* 2003). This is a clear disincentive for tenants to invest in land improvements even though it may motivate the land owner to invest more. The duration of share contracts is also short in the Amhara region where more than 70% of the communities practice one-year contracts (Benin *et al.*, 2005). Under such short contract durations, it is unlikely that land owners threatening to evict tenants will provide much motivation for tenant investing in and adopting sustainable production systems on sharecropped-in plots (Banerjee and Ghatak, 2004). Thus, the cumulative effects of short-term contracting could be the source of long-term inefficiency of production on continually sharecropped plots, even if the contracts are renewed season after season.

Short duration of contracts may also motivate tenants to focus on short-term objectives that can be achieved through exploitative production technologies (Ray, 2005). Preservation of soil quality and sustainable management could be achieved through other incentives that maintain or enhance plot quality (Dubois, 2002). For instance, land owners could provide incentives to tenants to manage the land sustainably or to plant less nutrient-mining crops.

Another important aspect of the sharecropping which needs attention is the terms of production input and cost sharing between tenants and landowners. In Tigray, the contribution of the landowner in terms of labour and other inputs is minimal. This minimal contribution of labour may limit the landowner's ability to monitor the work effort of the tenant as direct participation would lower the cost of supervision. The inability of the landlord to adequately monitor the tenant's input is one of the possible causes of inefficiency of sharecropping according to the Marshallian view. Likewise, it can be inferred that such a lack of monitoring of the use of fertility enhancing external inputs, coupled with the difficulty of detecting soil nutrient depletion in one-season arrangements, may lead to a decline in the long-term productivity of farmlands. It is therefore important that the terms of land contracts be designed comprehensively to minimize these problems and the long-term implication of land contract arrangements gain more attention in empirical research.

4.7. Conclusions and implications for policy

Efficiency analysis has an important role to play in generating information for policies aiming at enhancing productivity of farm resources. This study employs stochastic frontier production function analysis to evaluate the impact of tenancy arrangements on agricultural productivity. Unlike previous studies in the region (Gebreegziabher *et al.*, 2005), the findings of the current study show that there is a statistically significant level of inefficiency in the production systems of the study area. However, the tenancy status of the plot is not a significant cause of inefficiency when other factors are controlled for.

This study did not find strong evidence of the impact of contract duration on efficiency of production due to the non-significance of this variable in the regression results. About 95% of the plots in the sample are sharecropped for one production season. The regional rural land administration and land use policy also restricts contract duration to two years for tenants applying traditional technologies. As the limited information from other studies indicates, such a restriction is not beneficial in terms of sustaining long-term productivity. It is therefore important to consider this in further research and come up with a more empirical evidence of the impact of such restrictions in the region.

The input sharing arrangements indicate that the tenant is responsible for provision of almost all production inputs. This reduces the possibility for the land owner to monitor and enforce tenant's effort without a high cost. Other factors also contribute to the differences in technical efficiency achievement. It is therefore important to further empirically investigate the demand and supply side of the contract markets to come up with conclusive results as this study is based on the demand side information. A comprehensive study will be required to investigate the reasons for the dominance of sharecropping and lack of development in the other forms of land contracts.

CHAPTER 5

Risk perceptions, input use and land management

This chapter develops a simple way of characterizing farm decision-makers' perceptions of production risk based on subjective expectations of crop yield variability. It also identifies the factors that explain differences in farmers' risk perceptions and how these production risk perceptions are associated with their decisions about farm management input use and investment in land improvement. In the study villages, farmers perceive high level of downside risk in their production system. Farm management input use and labour investment in land management by farmers did not show significant association with the risk perception of farm decision-makers. Labour investment in land management increases with the resource endowment of the household. This may imply that households with a better risk-bearing capacity invest more on land management.

5.1. Introduction

The sustainability of production systems in the drylands depends, among many other factors, on farmers' decisions on input use and investment in land management. These decisions are strongly influenced by farmers' perceptions of climatic uncertainty, which is part of the very nature of the dryland agroecology. Moreover, due to poor availability of historical agro-meteorological and production data, it can be difficult to identify risk-efficient production and land management practices in these areas. Such conditions make the provision of technical advice through extension systems more difficult. In practice, decision-makers take risk and uncertainty into account by employing a subjective approach (Bacic *et al*., 2006). Farmers rely on experience-based assessment of their working environments to make their production and land management investment decisions. Simplified approaches can be developed to understand farmers' risk perceptions and how these impact on production and land management decisions.

Risk and uncertainty are among the many factors that have been identified through empirical research as determinants of technology adoption, production, marketing, and the investment decisions of farm households (e.g. Huijsman, 1986; Smidts, 1990; Mazid and Bailey, 1992; Paudel *et al.*, 2000). Through constraining farmers' motivation for technology adoption and land management investment, risk and uncertainty have negative implications for agricultural intensification and sustainable livelihoods.

In a risky and an uncertain environment, farm decisions made at the household level will differ, even if the households face similar external circumstances. Risk coping strategies of households, both *ex ante* and *ex post* (Fafchamps, 2003:12), may differ among households depending on their resource and managerial capacity. Farmers adjust their production and investment activities according to their own interpretation of changes in circumstances and their expectations of crop yield variations. For instance, in the drylands of Ethiopia, farmers commonly adjust their management intensity and even replant their fields after observing poor signs about rainfall conditions during a production season. In practice farmers use their subjective perceptions of the range of probability about beneficial or bad outcomes of a certain decision. Such expectations define their working boundary and may vary according to the socioeconomic differences between decision-makers. This chapter employs the subjective expectations of farmers to explain why their production risk perceptions differ and how this influences their crop and land management decisions.

The remainder of the chapter is organized as follows. Section 5.2 states the research problem and objectives. Section 5.3 presents a brief review of the relevant literature and sets out research hypotheses. Section 5.4 describes the setting of the study villages. Data and methodology are presented in section 5.5. Section 5.6 presents results and discussion. Finally, section 5.7 draws some conclusions and draws out policy implications.

5.2. Problem statement and objectives

Uncertainty about climatic factors and risk attitudes held by farm households are known to influence decisions on crop choice and resource allocation, use of institutional credit and marketing, and land management investment (Huijsman, 1986; Smidts, 1990; Mazid and Bailey, 1992; Paudel *et al.*, 2000). Risk therefore has a wider implication for rural development (Fafchamps, 2003:146). A number of approaches have been used to study farmers' attitudes to risk and how they deal with risk and uncertainty in decision-making (Dillon and Scandizzo, 1978). An objective measure of risk and uncertainty is required in order to assess how farmers' risk perception influences production and land management decisions. However, risk perception is not directly measurable and has to be inferred from decision-makers' behaviour and attitudinal responses.

In the absence of relevant historical data on climate, production, price and the financial markets, measuring the level of production, price and financial risks that farmers face is challenging. In this situation farmers' perceptions of risk and uncertainty are inferred from proxy indicators. One possibility is to use farmers' subjective expectations about yield variations under alternative scenarios with uncertain factors. Variations in farmers' decisions on input use and land management strategies may be explained by their differing expectations about crop yield. For practical reasons it is easier for farmers to give their expectation of the minimum, most likely and maximum yield levels from a given plot they operated for a relatively longer period, rather than seek estimates of the probabilities of uncertain events.

Farmers' socioeconomic characteristics differ and this could be the source of diversity in their risk perceptions. Feasible interventions aiming at sustainable intensification need to understand and take into account the link between risk perception and socioeconomic features of farm households. There is a need for empirical work that identifies the determinants of variations in risk perceptions and on how these risk perceptions are linked to the level of input use in crop production and land management activities. Heterogeneity in risk perceptions may be the cause of diversity in resource allocation decisions for crop and land management among farm households and their risk perceptions may be conditioned by their experience of the actual risk in the past seasons. Knowledge of the determinants of difference in risk perceptions is therefore useful when tailoring technical recommendations to particular categories of peasants (Moscardi and de Janvry, 1977). Therefore, this chapter aims to address two key research questions: What factors condition the production risk perceptions of farm decision-makers? And how do risk perceptions of decision-makers in the area influence their crop and land management investment decisions? To answer these questions the study aims

a) to develop a simple indicator for production risk perception of farm decision-makers based on their subjective estimate of expected crop yield variation under assumed rainfall scenarios;
b) to identify the socioeconomic and biophysical determinants of variations in risk perception of decision-makers; and
c) to assess how risk perception of the decision-maker influence the intensity of farm management input use and investment in land management.

5.3. Conceptual background and research hypotheses

Decision-making under uncertainty is required in many situations. Thus, the impact of risk and uncertainty on the behaviour of a decision-maker has been dealt with by a number of social scientists (Roumasset, 1976; Dillion, 1977; Hazell and Norton, 1986; Moschini and Hennessy, 2001; van den Berg, 2001). In agricultural economics, investigation of the impact of risk and uncertainty on farm decision-maker's choice of production activities and investment behaviour has been a major subject of research (Binswanger, 1981).

Differences in risk attitude lead to varied production decisions and diversity in production systems, especially in a risky environment (Feinerman and Finkelshtain, 1996; Paudel *et al.*, 2000; Bard and Barry, 2000; Bacic *et al.*, 2006). Risk considerations lead poor farm households to concentrate on activities and production systems that minimize variations in income and limit their willingness to adopt new systems that increase the mean and variability of income (Fafchamps, 2003:151). Land management is a medium- to long- term investment which is greatly influenced by the risk attitude of the decision-maker. Understanding the attitudes of decision-makers is therefore an essential part of a research and extension system for rural development (Bard and Barry, 2000). Strategies to help smallholders cope with the myriad of risks they face require understanding how risk affects their choice of farming practices. However, risk perceptions and attitudes are not easily directly measured and have to be inferred from measurable proxies (Krahnen *et al.,* 1997).

According to Huijsman (1986:24), risk perception is a subjective or personal judgment about the chances associated with the various outcomes that might arise from any decision. Risk perception theory focuses primarily on decision-makers' attitudes and personal characteristics that are associated with perceptions of increased risk (Tucker and Napier, 2001). Risk perceptions about an uncertain action can therefore be viewed as a necessary condition for the emergence of risk attitude of and choice by a decision-maker (Senkondo, 2000). In risk analysis that uses subjective assessment of probabilities, decision-makers' risk perceptions are considered to approximate objective probabilities though empirical work is lacking to confirm this assumption (Smith and Mandac, 1995).

Several alternative approaches can be used to empirically assess the risk attitude and/or preferences of individuals. One approach is the experimental method (Smidts, 1990; Bar-Shira *et al.*, 1997). This approach is mainly based on the hypothetical assessment of risk behaviour using questions that show different income opportunities associated with different degrees of risk levels (Dillion, 1977:129; Binswanger, 1981; Grisley and Kellogg, 1987). It deals mainly with risk perceptions as opposed to risk preferences (Smidts, 1990). Wärneryd (1996) raises three major issues about the reliability of the hypothetical elicitation of risk attitudes: 1) whether respondents are able to give a meaningful answer to hypothetical risky choices; 2) that the relationship between expected values and subjective expected utility and the factors influencing the relationship are not explicit; and 3) the correlation between risk attitudes and risky behaviour, such as actual portfolio choice is not linear. An additional reason could be that individuals plan or decide on the basis of expecting an acceptable range of outcomes rather than a specific level.

Another approach is based on the actual behaviour of individual decision-makers and considers the individual as having certain objectives, such as a utility maximization and safety-first (Smidts, 1990; Buschena and Zilberman, 1994). The expected utility maximization approach has been widely used since the 1960s in the analysis of choice under risk (Dillion, 1977:107; Buschena and Zilberman, 1994). This approach requires an explicit formulation of the utility function and the probability of occurrence of alternative outcomes (Hardaker *et al.,* 1997) and assumes agents to be rational decision makers (Dillion, 1977).

Mean-variance analysis is another approach used in risk analysis. In investment and portfolio decisions, risk is measured by the variance or the standard deviation of the uncertain returns (Breitmeyer *et al.,* 2004). According to this approach extreme gains or losses are undesirable (Rötter *et al.*, 1997) and this is commonly used in risk preference studies.

The stochastic dominance analysis is another approach that does not require the knowledge of the utility function of the decision-maker. It identifies risk-efficient operating conditions by comparing the entire probability distributions (Dillion, 1977:138). However, developing objective probabilities for possible outcomes is more of a hypothetical concept and it may not be so easy to define for an actual outcome (Roumasset, 1976:14).

When probabilities of the occurrence for an uncertain outcome are unknown, the mean and variance can be computed using the 'triangular distribution' assumption from decision-makers' subjective estimation of three outcome points, representing the minimum, maximum and most likely outcomes (Rider, 1963; Hardaker *et al.,* 1997: 44-45; Rae, 1994:288; Johnson and Kotz, 1999).

The choice of approach in risk modelling is subject to a trade-off between simplicity and theoretical appeal and these in turn have implications for the ease of use and cost (Da Cruz and Da Fonseca Porto, 1988). In this study a simple method is developed to characterize farmers' risk perceptions. It draws on lessons from both the experimental approach and the mean-variance analysis used in risk attitude and preference studies. The method is discussed in the methodology section.

Farmers' risk perceptions in terms of expected yield variation are specific to a particular technique, location and time, and change with the availability of new information (Senkondo, 2000). The actual yield level attained at any location is determined by both the agro-technical possibilities and constraints, and the socioeconomic conditions under which the farmer operates (Rötter *et al.*, 1997). Considerations of differences in both biophysical setting and management practices allow for spatially related variations in yields to be taken into account.

The socioeconomic features of the farm household and the decision-maker's experience condition his/her perception of, and attitude towards risk and uncertainty (Sitkin and Pablo, 1992; Moscardi and de Janvry, 1977; Dillon and Scandizzo, 1978; Feinerman and Finkelshtain, 1996; Wärneryd, 1996; Senkondo, 2000; Bacic *et al*., 2006). These features influence the decision-maker's ability to generate, process and store information and thereby his/her perception of risk and uncertainty (Tucker and Napier, 2001). According to Moscardi and de Janvry (1977), the nature of the household, its income-generating opportunities and its access to public infrastructure are important factors in shaping farmer's attitudes towards risk.

Based on a review of empirical studies, Feinerman and Finkelshtain (1996) identified the following factors as major determinants of the sign and magnitude of an individual's measure of risk attitudes and choice: household size and composition, wealth status and level of income from off-farm sources, education, origin and age of decision makers; and farm size and water availability. These socioeconomic factors influence the farmer's capacity to bear risk and his/her choice of a risk management strategy. For instance, in marginal agronomic areas where the level of production risk is high, households participate more in labour markets to supplement farm income (Moscardi and de Janvry, 1977). In empirical work, risk perception is considered as the initial stage in the formation of risk attitude. Therefore, the factors that influence the risk attitude and preferences of decision-makers may be taken as potential determinants of risk perceptions of decision-makers without assuming identical magnitude and direction of effects. According to Binswanger (1981) in addition to the socioeconomic features of the decision-maker, the nature of the external environment also influences the level of risk and uncertainty.

Based on the forgoing discussion of the general literature on risk attitude and preference studies, we formulate two sets of hypotheses in relation to risk perception which is the main focus of this study. The first set relates to the factors that condition production risk perception of decision-makers. The production risk perception of a decision-maker is hypothesized to be influenced by his/her age, gender, education status, the nature of his/her household in terms of resource endowment, income diversification, quality of plots owned and the crops he/she is growing. Low production risk perceptions of decision-makers may be associated with better experience in farming, resource endowments, and alternative income opportunities outside farming controlling for other variables. More resource endowments improve the capacity to cope with risk and uncertainty and may reduce the perceived risk of a decision-maker. The age of the decision-maker is used as a proxy for his/her experience and the average annual cash income of the household from other resources as a proxy for alternative income opportunities.

The second set of hypotheses is on the impact of the decision-makers' production risk perceptions and socioeconomic features, and their biophysical environment on farm input use and land management investment decisions. The effect of uncertainty on input use intensity may vary depending on the type of input and the relevant socioeconomic and biophysical factors. Decision-makers who perceive a high production risk may use low level of pre-harvest labour and draft-power inputs to minimize their loss. The use of other (non-labour) variable inputs, such as fertilizer, may be positively or negatively associated with the risk perceptions of decision-makers. Fertilizer use increases expected yield, but may have either risk reducing or risk increasing effects. Fertilizer improves nutrient status of soils which reduces production risk associated with poor soil fertility. But, in dryland farming, due to low moisture, fertilizer may increase the risk of crop failure and in this context it may be perceived risky. The impact of risk perceptions on labour investment in land management is also indeterminate. High production risk perceptions may reduce the motivation for long-term investment as the return may be low under perceived high crop production risk. However, it is also possible that investment in land management leads to increased and more stable production in the long-term and is practiced as a risk management strategy. Thus, the association between decision-makers' perceived production risk and land management investment decision is difficult to determine *a priori*.

5.4. Setting of the study villages

Chapter 2 provides a broad description of the situation in the Northern Highlands of Ethiopia in general and that of Tigray in particular. This section provides more specific information about the case study villages, *Tegahne* and *Gobo Degaut*.[5.1] These villages were selected on the basis of their contrasting features in terms of agricultural potential and market access.

Tegahne is located in Golgol Naele *Tabia* in the Atsbi-Wonberta district in the eastern Tigray, some 80 kilometres to the northeast of Mekelle, the regional capital. The village is located close to the district town of Atsibi. It is a typical highland village at an altitude of 2,500 metres. It has a relatively flat topography with good agricultural land. The village contains 463 households with an average family size of 4 persons. The average land holding is 0.45 hectares per household. Population density is 13 persons per hectare of cultivable land[5.2] and about 25% of the households are landless. About 67% of the village land is suitable for crop and pasture production and this is fully utilized. The rest is regenerating woodlands, community plantation and rocky wastelands communally used by villagers.

Gobo Deguat is located in the Debrebizen Tabia in the Hawzen district of eastern Tigray about 160 kilometres to the northwest of Mekelle. The altitude of the area varies between 2,100 and 2,800 metres and has a mountainous and rugged topography. The village is 25 km away from the district town and is linked by a poor seasonal road. The village has 200 households and the average family size is 5 persons. The average land holding is 0.30 hectares per household. Although, marginal lands are utilized for farming and grazing purposes, more

[5.1] The villages were selected for the Wageningen University-Mekelle University-IFPRI project on 'Policies for sustainable land management in Tigray' which was supported by the Netherlands Ministry of Foreign Affairs (DGIS).
[5.2] Population density per hectare of cultivable land is given here to illustrate the level of population pressure that is mostly not conveyed by the traditional indicator of persons per square kilometres of total land. In most cases the effective cultivable land is small proportion of the total land.

than half of the village land is not suitable for crop cultivation. The quality of soil resources is generally poor because of continual use and erosion problems.

In both study villages crop production is the dominant economic activity. Livestock production is also practiced as supplementary activity, although its contribution is low due to poor availability of feed and the subsistence nature of the system. Severe feed shortages are a cause of declines in livestock holding in the study villages. The villages are among the most drought affected areas in the region.

5.5. Data and Methodology

Data

A village census was conducted to prepare a sampling frame in August 2002. Cultivable land holding is used as the criterion for grouping households as this is the dominant variable that differentiates households. 'Small-holder' households are defined as those with 0.5 hectare or less in Tegahne and those with 0.375 hectare or less in Gobo Deguat. Households with holdings above these points in each village are defined as 'large-holders'. The grouping is based on land holding size is to help get a proportional representation of households owning land. In each village 44 households were randomly selected from the small-holding category and 36 households from the large-holding category, giving a total of 160 households, 80 from each village, included in the survey. A socioeconomic survey was conducted in 2002/03, covering household production and consumption activities for the season. Data from 77 households in Tegahne and 78 households in Gobo Deguat were used in the analysis; with five households being excluded because of data error and incompleteness.

The data include household socioeconomic features in terms of resource endowments (land, livestock, labour, and other assets), family composition (sex, age, educational status and skill), production and resource utilization activities, income sources and expenditure patterns, and involvement in community level activities such as communal resource management. Household head's educational status is defined as his/her exposure to formal or informal science education as the level of schooling was low. Household head's skills are considered marketable if such skills help earn additional pay in the labour market beyond what is paid for a causal labour or important for self-employment. These include skills such as metal and wood works, and masonry.

The expectations of the household head regarding yield levels for the crops being grown that season were collected under the alternative scenarios of 'poor', 'most likely', and 'good' rainfall conditions. In this study a 'poor' rainfall condition assumption excludes complete crop failure due to severe drought, which is a possibility in practice, but difficult to capture in cross-sectional analysis. Input data include farm management inputs for each crop type and labour allocated to private and collective land resource management as well as other production and maintenance activities. The household level data for the two villages was combined in the final analysis after testing for pooling using the Chow test.[5.3] A descriptive summary of the variables included for the analysis in this chapter is given in Table 5.1. The derivation of some of the variables is explained in subsequent section.

Table 5.1 Production and socioeconomic data for sample households in case study villages

Variables	n	mean	SE mean	SD
Dependent variable				
Variance-mean ratio of expected yield	401	0.122	0.01	0.112
Pre-harvest labour (person-days/tsimdi)	468	12.93	0.48	10.550
Draft-power use land preparation (ox-days/tsimdi)	466	2.60	0.04	0.969
Non-labour variable input (Birr/tsimdi)	468	76.95	1.87	40.637
Private labour investment for land management (person-days/year)	149	14.15	1.14	13.91
Explanatory variables				
Household demographics				
Age of household head (years)	155	54.78	1.13	14.14
Household head sex dummy (1 if male)	155	0.71	0.03	0.45
Household head education (formal or informal science) (1 if yes)	155	0.11	0.03	0.324
Proportion of household members with formal education	155	30.08	1.81	22.56
Whether the household head has marketable skill (1 if yes)	155	0.30	0.04	0.461
Whether the household has members with marketable skill (1 if yes)	155	0.55	0.04	0.49
Proportion of household members with marketable skill (%)	155	15.05	1.34	16.47
Family size (count)	155	5.61	0.20	2.54
Dependency ratio (consumer units/producer units)	155	1.92	0.06	0.68
Access to institutional credit (1 if received loan)	155	0.09	0.02	0.28
Participation in agriculture related training (1 if yes)	155	0.19	0.03	0.39
Resource endowment: labour				
Female labour endowment (adult equivalent)	155	1.29	0.06	0.68
Male labour endowment (adult equivalent)	155	1.01	0.07	0.88
Resource endowment: land				
Total cultivable land holding (in *Tsimdi*)	155	1.85	0.08	0.96

[5.3] Using the Chow test, conducted by taking the residual sum of squares of the regressions from the pooled data and for the separate villages, the computed statistics were smaller than the tabulated at 1% level of significance in all cases. That is, the test results were in favour of pooling the data.

Table 5.1 (Cont.)

Variables	n	mean	SE mean	SD
Resource endowment: livestock				
Total livestock endowment (in TLU)	155	2.90	0.20	2.50
Oxen ownership (head count)	155	0.70	0.05	0.66
Livestock endowment less oxen (in TLU)	155	2.23	0.17	2.11
Equine ownership (1 if yes)	155	0.59	0.06	0.79
Physical asset ownership				
Value of farm equipments (in Birr)	155	101.81	6.47	79.73
Value of total physical asset owned (in Birr)	155	175.92	13.37	164.93
Income variables				
Average annual cash income (in Birr)	155	358.01	60.33	743.83
Plot quality conditions				
Plots with good quality (1 if yes)	469	0.26	0.02	0.44
Plots with medium quality (1 if yes)	469	0.36	0.02	0.48
Plots with poor quality (1 if yes)	469	0.36	0.02	0.48
Proportion of cultivable land with poor and medium quality (%)	152	72.93	2.5	30.87
Crop factor				
Barley all variety (1 if yes)	475	0.50	0.02	0.50
Wheat all variety (1 if yes)	475	0.26	0.02	0.44
Pulses all variety (1 if yes)	475	0.23	0.02	0.42
Risk perception indicator				
Household level average variance-mean ratio	151	0.11	0.01	0.09
Location factor				
Village dummy (1 if Tegahne)	155	0.49	0.04	0.50

Note: Variables for 2002/03 unless otherwise stated; n stands for number of observations (plots or households), SE for the standard error of the mean and SD for standard deviation and dummy variables are defined as 1 if yes, otherwise 0.

Measuring risk perceptions or uncertainty in crop production

Farm production involves different sources of risk and uncertainty; decision-makers commonly consider climatic and price fluctuations to be among the most important. This analysis attempts to measure the impact of rainfall related production-risk perceptions of farm decision-makers on their crop production and land management decisions in the highland farming systems of Tigray. A simple methodology is developed to assess the level of uncertainty in crop yield that each producer assumes from a specific plot under different scenarios of rainfall variations. Production risk is assessed on the basis of farm household heads' experience of yield variations of major crops under assumed conditions of 'good', 'most common' and 'poor' rainfall scenarios. No reliable probability of occurrence can be quantified, objectively or subjectively, for the rainfall scenarios due to absence of meteorological data, which makes it difficult to compute expected levels of output on the basis of the probability of each scenario occurring. The scaling also excludes expectations of complete crop failures under disastrous conditions for which farmers would logically opt to do nothing if they had prior knowledge of such an occurrence.

Historical farm level data are often lacking in developing countries and probabilities for alternative events in decision-making may not be quantifiable. In this case, the individual decision maker's opinion on crop yield variations associated with rainfall fluctuation is taken as an indictor of the level of uncertainty that farmers assume. It is important to point out that this methodology relies on farmers' own judgments and experiences on the range of variation in their production activities, rather than on a hypothetical elicitation of preferences for uncertain opportunities. It is an appropriate approach for generating such information in farm communities with a low level of education (Huijsman, 1986). It is considered as a proxy for the level of uncertainty that decision-makers assume in their actual practices. A decision-maker's risk perception can be characterized by the pattern of the mean and variance of the expected yield variations.

The mean and variance for the expected yield estimates are computed using the triangular probability distribution based on a three-point yield estimate given by farmers (Hardaker *et al*., 1997). The mean, E(Y), is computed as follows:

$$E(Y) = \frac{(L + M + H)}{3}$$

Where, L stands for the lowest, M for the most-likely and H for the highest yield estimates given by farmers for 'poor', 'most-likely' and 'good' rainfall scenarios, respectively. The variance, V(Y), is computed as follows:

$$V(Y) = \frac{\{(H - L)^2 + (M - L)(M - H)\}}{18}.$$

Small mean and high variance values represent a high level of yield uncertainty or production risk. The ratio of the variance to the mean, {V(Y)/E(Y)}, is considered as an indicator of the decision-maker's perception of risk. Values close to zero indicate a low risk perception and close to one a high risk perception. This variable is then used as the dependent variable in the econometric analysis of the determinants of decision-makers' risk perceptions. In the econometric analysis, socioeconomic and biophysical factors are hypothesized to influence the disparities in risk perceptions among decision-makers and these are considered as explanatory factors. The hypotheses regarding the impact of socioeconomic factors on the risk perceptions of decision-makers, and the impact of risk perception on the choice of crop and land management practices will be tested.

Econometric model

The econometric relations are specified based on the knowledge of the possible associations derived from the theoretical and empirical literature presented in section 5.3.

Difference in risk perception, as measured by the variance-mean ratio of expected crop yield (VMR), is explained as

$$VMR = f(H_i, C_i, P_i, V_i) \quad (5.1)$$

Plot level crop management input use ($CPINPUT_i$) is explained as

$$CPINPUT_i = f(H_i, C_i, P_i, V_i, VMR) \quad (5.2)$$

Private land management investment in terms of labour ($LMINPUT_i$)[5.4] is explained as

$$LMINPUT_i = f(H_i, RD_i, AVMR) \quad (5.3)$$

Where, H_i stands for household characteristics, P_i for plot features, C_i for crop type and V_i for village features. The level of labour input for pre-harvest activities, intensity of draft-power use and the estimated cost of other non-labour farm management variable inputs such as seed and fertilizer are considered. RD_i is an indicator of the risk associated with farmland degradation faced by each household which is the proportion of cultivable land holding with grouped as medium- and poor- quality. AVMR is the average for the risk perception indicator from all plots that a household operates. Specific variables included in each regression are discussed in the next section.

The major econometric problem in relation to the analysis here is the issue of endogeneity. In theory, given that strong instruments are available for all endogenous variables, an instrumental variable model may be employed to handle this problem (Baum *et al.*, 2003). Excluding some variables from the analysis to handle identification problem also requires valid theoretical argument. In the absence of such theoretical justification an alternative approach is followed to identify potential instruments for the risk perception starting with a reduced model regression for input equations (5.2), estimated using a seemingly unrelated regression model. All exogenous variables in equation (5.2) which were jointly non-significant from the seemingly unrelated regression model were considered as potential instruments for the risk perception variable. In a separate second step regression, those with significant positive correlation with the risk perception variable were taken as

[5.4] The private land management investment is the total labour allocated by a household for land improvement activities for all plots owned by the household.

instruments in the instrumental variable estimation of the input use determinants (equation 5.2). The same procedure is followed to identify the determinants of private investment for land management (equation 5.3).

5.6. Results and Discussion

5.6.1. Expected mean yield and variability

Farmers' experience-based estimates of the lowest, most-likely and highest yield (in quintals/*tsimdi*) are used to quantify the mean and variance of the expected yield for the three major crops in the study villages, namely barley, wheat and pulses. The mean and variance levels for each crop type obtained by using the triangular distribution are summarized in Table 5.2. The overall expected mean yield, computed using the triangular distribution, is higher for barley than for the other two crops, although the variability in yield is also higher for this crop.

Table 5.2 Crop yield expectations and variability for three crops in quintals per *tsimdi* (0.25ha)

Items	Crop type (means/standard deviations)		
	Barley	Wheat	Pulses
Mean of lowest estimates (quintals)	0.92(0.59)	0.78(0.54)	0.58(0.41)
Mean of most-likely estimates (quintals)	2.15(1.22)	1.59 (0.91)	1.65(1.28)
Mean of highest estimates (quintals)	3.50(2.40)	2.55(1.38)	3.15(3.41)
Range in quintals (highest less lowest)	2.58(1.98)	1.80(1.14)	2.56(3.32)
Overall expected mean (quintals)	2.18(1.22)	1.65(0.88)	1.80(1.56)
Overall yield variance	0.38(0.58)	0.19(0.24)	0.29(0.49)

A high expected mean yield is associated with high variability (See Figure 5.1). That is, farmers associate high level of yield uncertainty with the production practices that give a high yield. A related finding is that, in Gobo Deguat, the expected mean yield by farmers was below the most likely yield for 22, 33 and 65% of the plots of barley, wheat and pulses, respectively. In Tegahne these figures were even higher for 40, 38 and 51% respectively. This implies a high level of downside risk in the production systems of the study villages. This needs closer investigation to understand the reasons for the difference in risk perceptions of farmers.

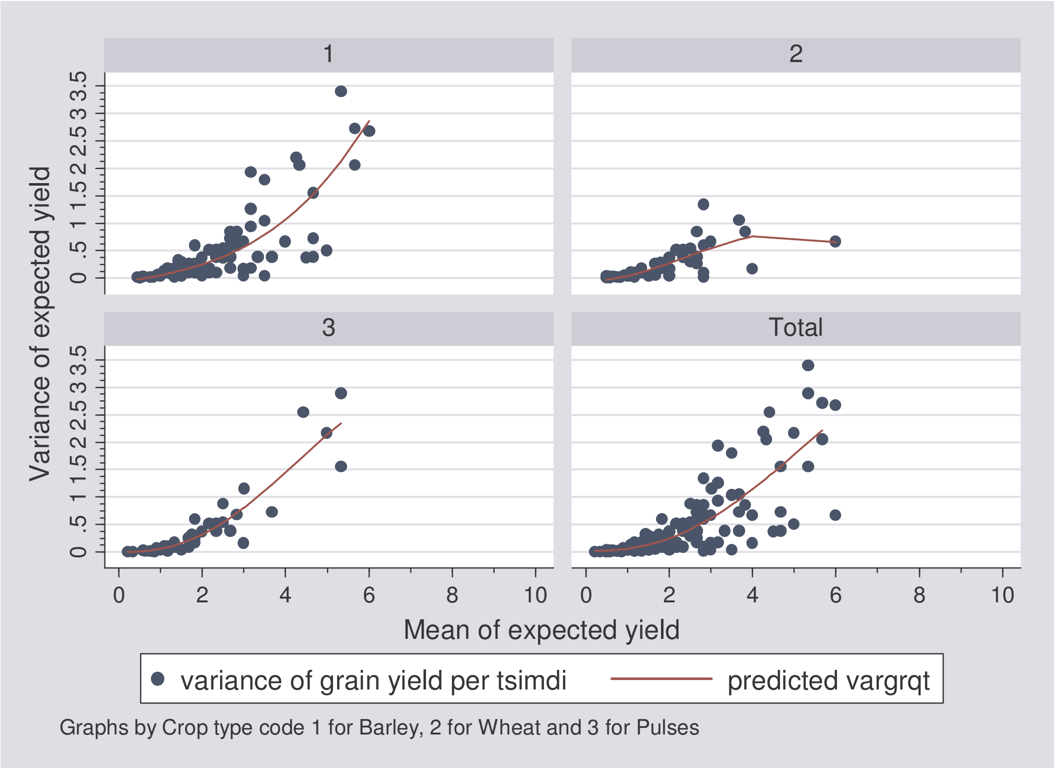

Figure 5.1 Relationship between mean and variance of expected grain yield estimates

5.6.2. Determinants of farmers' perceptions of production risk

Households in the study villages differ significantly in their perceptions of crop production risk. Variance ratio and mean comparison tests on the mean and variance of the risk perception indicator, controlling for crop type, confirm this. What, however, are the determinants of such differences in risk perceptions among households? Econometric techniques are used to identify the socioeconomic, biophysical and location factors to explain differences in risk perceptions among decision-makers.

Equation (5.1) regresses the production risk perception indicator over the explanatory factors of household characteristics including age, gender, education status, skill and participation in extension training of the household head, family composition, access to credit in the production year, resource endowment in terms of cultivable land, labour, livestock, and material farm assets, crop type, plot quality, and a village dummy. In addition, as a proxy for a regular annual cash income from other sources, an estimated amount is assumed based on the household head's evaluation of annual past earnings. An interval regression model is used to identify the determinants of risk perception because the dependent variable is censored and the model computes robust standard errors. The outcomes are presented in Table 5.3.

High risk perception of decision-makers is found positively associated with the household head's age, his/her possession of a marketable skill and livestock resource, income from other sources, participation in agricultural training and being located in Tegahne. As a proxy for the experience of the decision-maker, age was hypothesized to have a negative relationship with the level of perceived production risk. However, in dryland areas older household heads may have a better knowledge of the deteriorating agro-climatic conditions in their surroundings and associate this with an increase in production risk.

The positive association of production risk perceptions and the possession of marketable skills, livestock endowment and cash income from other sources could be taken as an indicator of coping mechanisms developed by farmers to diversify to other production activities because they perceive high risk in crop production. Household heads with diversified income sources associate high risk with crop production activities. The risk perceptions of farmers also differ by crop type, with farmers perceiving higher risk with barley varieties compared to wheat and pulses. These findings also indicate that households with better capacity show better risk-taking behaviour in the study villages.

Table 5.3 Determinants of the risk-perception of decision-makers

Dependent variable: variance to mean ratio of expected grain yield		
Explanatory variables	**Interval regression**	
Household demographics	Coeff.	RSE
Age of household head (years)	0.001**	0.0004
Sex of household head (1 if male)	0.000	0.016
Household head education (formal/informal science) (1 if yes)	0.014	0.020
Whether the household head has marketable skill (1 if yes)	0.023*	0.013
Dependency ratio (consumer/producer)	0.009	0.008
Participation in extension and training (1 if yes)	0.055***	0.020
Institutional credit (1 if received loan)	-0.004	0.030
Household resource endowment		
Female labour endowment (adult equivalent) $^{\psi}$	0.016	0.025
Male labour endowment (adult equivalent) $^{\psi}$	0.025	0.016
Cultivable land holding size (*Tsimdi*)$^{\psi}$	-0.016	0.014
Other livestock endowment (in TLU)$^{\psi}$	0.037***	0.011
Oxen endowment(count) $^{\psi}$	0.001	0.020
Value of total farm assets (in Birr)$^{\psi}$	0.005	0.007
Average annual cash income (in Birr) $^{\psi}$	0.005*	0.003
Crop factors (base: barley all varieties)		
Wheat all varieties (1 if yes)	-0.045***	0.010
Pulses all varieties (1 if yes)	-0.038***	0.012
Plot quality conditions (base: good quality)		
Plots of medium quality (1 if yes)	-0.009	0.012
Plots of low quality (1 if yes)	-0.005	0.011
Other variables		
Village dummy (1 is Tegahne)	0.089***	0.020
Constant	-0.101**	0.047
Number of observations	385	
LR chi2/Wald chi2 (16)	137.29	
Overall model fit (prob >chi2)	0.000	
R square	0.3730	
Log pseudolikelihood	390.744	

Notes: $^{\psi}$ indicates variables in their natural log form; RSE stands for Robust Standard Errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; dummy variables are defined as 1 if yes, otherwise 0; and R square for interval regression is computed from the correlation of the actual and predicted values of the dependent variable. Omitting the crop choice variable from the regression results in the loss of the statistical significance of the household head skill and the average annual cash income variables.

5.6.3. Risk perception and farm-management input use in crop production

Pre-harvest labour, draft-power, and non-labour variable input uses are explained as a function of household features, the production risk perception of decision-makers, and plot quality conditions to assess the impact of risk perception of decision-makers on farm management input use. The risk perception variable was found endogenous and equation (5.2) was estimated using instrumental variable techniques. The procedure followed in the identification of potential instruments for the risk perception variable is explained in the methodology section. The instruments selected based on the statistical procedure followed are the household's other livestock endowment and the household head's participation in agricultural extension and training. In general, although the statistical tests reported show support for the use of instrumental variable approach, the instruments identified were weak as indicated by the first stage F-statistic (8.17) which is lower than the minimum level recommended as a rule of thumb of a greater than 10 (Staiger and Stock, 1997). The results from the instrumental variable approach are presented in Table 5.4 and those from the OLS are given in Table 5.5. The discussion is based on the former as these are more reliable given the endogeneity problem.

The risk perception variable did not show statistically significant impact on the intensity of the use of the variable inputs considered. There were non-significant negative association with the intensity of labour use and positive associations with the use of draft-power and other non-labour variable inputs such as fertilizer and seed. The intensity of labour input is significantly lower on poor-quality plots and when the cultivable land endowment of households is large. Higher intensity of labour use is significantly associated with male-headship, better education of the household head and female labour endowment.

The intensity of draft-power use is directly associated with oxen endowment and it is lower for wheat and pulses compared to barley. Farmers in Tegahne use lower intensity of draft-power compared to those in Gobo Deguat. In the case of non-labour variable inputs, the intensity of use was negatively associated with the household head's age and his/her access to credit service. The same variables were found significant when estimated using OLS (Table 5.5). The changes in the sign and significance of the risk perception variable in the labour use determinants analysis may be due to the endogeneity problem.

Table 5.4 Determinants of pre-harvest labour, draft-power and non-labour variable input uses in crop production (Instrumental variable estimation)

Explanatory variables	Pre-harvest labour $^{\psi}$		Draft-power $^{\psi}$		Non-labour variable input $^{\psi}$	
	Coeff.	RSE	Coeff.	RSE	Coeff.	RSE
Household demographics						
Age of household head (years)	0.002	0.004	0.0004	0.002	-0.005*	0.003
Sex of household head (1 if male)	0.254*	0.142	0.071	0.080	-0.002	0.105
Household head education (1 if yes)	0.361***	0.172	0.047	0.078	-0.012	0.086
Whether household head has marketable skill (1 if yes)	0.144	0.108	-0.026	0.061	-0.008	0.070
Dependency ratio (consumer/producer)	0.048	0.065	0.002	0.040	-0.085	0.057
Institutional credit (1 if received loan)	-0.086	0.128	0.014	0.079	-0.190*	0.105
Household resource endowment						
Female labour endowment (adult equivalent) $^{\psi}$	0.391**	0.188	-0.036	0.079	0.044	0.117
Male labour endowment (adult equivalent) $^{\psi}$	-0.052	0.124	-0.081	0.082	0.055	0.099
Cultivable land holding (in *Tsimdi*) $^{\psi}$	-0.366***	0.101	-0.060	0.050	-0.016	0.074
Oxen endowment(count) $^{\psi}$	-0.086	0.155	0.196***	0.073	0.047	0.103
Value of total farm assets (in Birr) $^{\psi}$	0.063	0.039	-0.011	0.021	-0.006	0.026
Average annual cash income (in Birr) $^{\psi}$	0.0002	0.023	-0.006	0.010	0.008	0.013
Crop factors (base: barley all varieties)						
Wheat all varieties (1 if yes)	-0.161	0.135	-0.176***	0.056	-0.088	0.076
Pulses all varieties (1 if yes)	0.110	0.149	-0.569***	0.059	-0.026	0.081
Plot quality (base: good quality)						
Plots of medium quality (1 if yes)	0.060	0.109	0.027	0.048	0.002	0.077
Plots of low quality (1 if yes)	-0.278**	0.116	0.004	0.055	-0.051	0.066
Risk-perception indicator						
VMR of expected yield (risk perception)	-1.583	1.782	0.205	0.921	1.311	1.016
Village dummy (1 is Tegahne)	-0.134	0.225	-0.319***	0.115	0.010	0.133
Constant	1.823***	0.443	1.204***	0.219	4.469***	0.280
Number of observations	384		384		384	
First stage partial R square	0.0944		4.94		4.94	
First stage F(2,121)/	8.17		8.17		8.17	
First stage P-value	0.0005		0.0005		0.0005	
Hansen J statistic/Chi2(1) p-val	0.35/0.55		0.40/0.52		0.40/0.52	
C statistic (test for exogeneity of risk perception variable =2.67 p=0.1016						

Notes: $^{\psi}$ indicates variables in their natural log form; RSE stands for Robust Standard Errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and dummy variables are defined as 1 if yes, otherwise 0. Test for multicollinearity for variables included in the second stage shows no severe problem with mean VIF of 2.02, ranging from 1.18 and 5.65.

Table 5.5 Determinants of pre-harvest labour, draft-power and non-labour variable input uses in crop production (OLS estimation)

Explanatory variables	**Pre-harvest labour** $^{\psi}$		**Draft-power** $^{\psi}$		**Non-labour variable input** $^{\psi}$	
	Coeff.	RSE	Coeff.	RSE	Coeff.	RSE
Household demographics						
Age of household head (years)	0.001	0.004	0.0003	0.002	-0.006**	0.003
Sex of household head (1 if male)	0.257*	0.147	0.073	0.080	-0.006	0.111
Household head education (1 if yes)	0.328**	0.161	0.049	0.083	-0.027	0.084
Whether household head has marketable skill (1 if yes)	0.068	0.106	-0.036	0.057	-0.005	0.066
Dependency ratio (consumer/producer)	0.023	0.056	0.0002	0.037	-0.089	0.056
Institutional credit (1 if received loan)	-0.075	0.106	0.015	0.079	-0.189*	0.104
Participation in extension and training (1 if yes)	-0.226*	0.118	-0.049	0.066	0.063	0.075
Household resource endowment						
Female labour endowment (adult equivalent) $^{\psi}$	0.354**	0.151	-0.034	0.078	0.026	0.117
Male labour endowment (adult equivalent) $^{\psi}$	-0.126	0.109	-0.087	0.074	0.047	0.099
Cultivable land holding (in *Tsimdi*) $^{\psi}$	-0.319***	0.102	-0.056	0.046	-0.010	0.078
Oxen endowment(count) $^{\psi}$	-0.097	0.131	0.190**	0.074	0.061	0.108
Other livestock endowment (in TLU) $^{\psi}$	-0.081	0.084	0.008	0.049	-0.052	0.064
Value of total farm assets (in Birr) $^{\psi}$	0.043	0.042	-0.016	0.021	0.001	0.028
Average annual cash income (in Birr) $^{\psi}$	-0.019	0.018	-0.009	0.010	0.010	0.014
Crop factors (base: barley all varieties)						
Wheat all varieties (1 if yes)	-0.061	0.097	-0.158***	0.042	-0.089	0.064
Pulses all varieties (1 if yes)	0.233**	0.117	-0.554***	0.051	-0.028	0.073
Plot quality (base: good quality)						
Plots of medium quality (1 if yes)	0.080	0.105	0.030	0.047	0.003	0.077
Plots of low quality (1 if yes)	-0.297**	0.117	0.001	0.056	-0.049	0.067
Risk-perception indicator						
VMR of expected yield (risk perception)	1.597***	0.599	0.570	0.207	1.378	0.308
Village dummy (1 is Tegahne)	-0.409***	0.136	-0.346***	0.065	-0.006	0.086
Constant	2.105***	0.385	1.218***	0.191	4.528***	0.276
Number of observations	384		384		384	
F(20,140)	3.78		14.39		2.57	
Prob >F	0.000		0.000		0.000	
R-square	0.1437		0.4519		0.1354	

Notes: $^{\psi}$ indicates variables in their natural log form; RSE stands for Robust Standard Errors; ***, ** and * indicate 1%, 5% and 10% levels of significance respectively; and dummy variables are defined as 1 if yes, otherwise 0. Test for multicollinearity for variables included in the second stage shows no severe problem with mean VIF of 1.57, ranging from 1.19 and 2.17.

5.6.4. Risk perception and private investment for land management

Private investment for land management in the study villages mainly in a form of labour allocation for the construction and maintenance of soil and water conservation structures, transporting and spreading farmyard manure on field plots, and other improvement activities such as clearing weeds in the off-season and fencing. Investment decisions for land management are conditioned by different factors and this study also tests the association between farmers' perceptions of production risk and the level of investment on land management by the farm household. Equation (5.3) is estimated using a Tobit with instrumental variable model (Tobit IV) to account for the endogeneity of the risk perception and the left-censored nature of the dependent variable which is labour investment.

In addition to the production risk perception indicator, other household features and plot conditions are considered as explanatory factors. Household factors considered included age and gender of the household head, proportion of household members with formal education and marketable skill, dependency ratio, access to institutional credit and participation in agriculture related training, resource endowments in terms of female and male labour, cultivable land, and livestock and equines, value of farm assets owned and estimated annual cash income from other sources. The proportion of cultivable land of medium and poor quality and village dummy are also included. The results are presented in Table 5.6 including results from a standard Tobit model for comparison.

Based on the Tobit IV estimation, the level of private labour allocation for land management is not significantly associated with the production risk perception of farm decision makers, although there is a negative association. Households with large endowments of farm assets and livestock are found to invest more in land management, implying that better resource capacity is the major determinant of invest in land management. The other variables considered did not show statistically significant association with land management investment.

5.7. Discussion and Conclusions

In this chapter a simple method has been developed to characterize the production risk perceptions of farm decision-makers. This method is not dependent on the full knowledge of the distribution of the uncertain outcomes. It is developed on the basis of decision-makers' subjective estimation of crop yield variations under different assumed rainfall scenarios, while controlling for other factors. Farmers differ significantly in their perceptions of production risk, controlling for biophysical determinants of crop yield.

Table 5.6 Determinants of private labour investment for land management

Explanatory variables	**Tobit IV (MLE)**		**Tobit**	
	Coeff.	SE	Coeff.	SE
Household demographics				
Age of household head (years)	0.003	0.005	0.003	0.005
Sex of household head (1 if male)	0.125	0.189	0.112	0.182
Proportion of household members with formal education (%)	-0.004	0.003	-0.005	0.003
Proportion of household members with marketable skill (%)	0.001	0.004	-0.000	0.004
Dependency ratio (consumer/producer)	-0.038	0.092	-0.050	0.087
Institutional credit (1 if received loan)	0.272	0.214	0.243	0.203
Participation in agriculture related training (1 if yes)			-0.103	0.166
Household resource endowment				
Female labour endowment (adult equivalent) $^{\psi}$	0.817	0.875	1.122	0.786
Square adult female labour	-0.096	0.485	-0.275	0.419
Male labour endowment (adult equivalent) $^{\psi}$	0.440	0.561	0.516	0.536
Square adult male labour	-0.213	0.347	-0.287	0.315
Cultivable land holding (in *Tsimdi*)$^{\psi}$	0.147	0.126	0.179	0.114
Livestock endowment (TLU) $^{\psi}$	0.346**	0.156	0.318**	0.142
Equine ownership (1 if yes)	-0.196	0.167	-0.215	0.164
Value of total farm assets (in Birr)$^{\psi}$	0.159***	0.052	0.154***	0.052
Average annual cash income (in Birr) $^{\psi}$	0.001	0.025	-0.004	0.024
Proportion of cultivable land of poor and medium quality (%)	-0.000	0.002	-0.001	0.002
Risk-perception indicator				
VMR of expected yield (risk perception)	-0.644	2.748	1.096	0.781
Others				
Village dummy (1 is Tegahne)	-0.004	0.310	-0.153	0.167
Constant	0.669	0.532	0.685	0.519
Number of observations	140		140	
Wald chi2 (18)/ LR chi2(19)	114.78		89.12	
Overall model fit (prob >chi2)	0.000		0.000	
Pseudo R square			0.2405	
Log likelihood	31.642		-140.689	

Notes: $^{\psi}$ indicates variables in their natural log form; SE stands for Standard Errors; ***, ** and * indicate 1%, 5% and 10% levels of significance, respectively; and dummy variables are defined as 1 if yes, otherwise 0. Test for multicollinearity for variables include show no severe problem with mean VIF of 4.87. Risk perception variable is instrumented with the variable participation in agriculture related training as it was positively significantly correlated (p=0.000).

Some socioeconomic features of decision-makers are found to explain the difference in their production risk perceptions of farmers. A positive association is found between the level of perceived production risk of decision-makers and their age, possession of marketable skills, livestock endowment, and participation in agricultural training. Decision-makers' perceptions of production risk also differ by crop type. These findings are in line with results from empirical studies elsewhere that used the more conventional approaches to risk attitude analysis (Moscardi and de Janvry, 1977; Dillon and Scandizzo, 1978; Sitkin and Pablo, 1992; Feinerman and Finkelshtain, 1996).

The relationship between decision-maker's perceptions of production risk and their decisions on farm input use and investment in land management has also been analysed. Controlling for other factors, the decision-makers perception of production risk and the intensity of farm management input use at plot level did not show statistically significant association. Other factors related to resource capacity of the household were found to have significant association with the level of input use. The intensity of labour use is higher among household heads with better education and better endowment of female labour. Farmers use lower intensity of labour on poor quality plots which again confirms dominance of short-term economic interest in land use systems of the study area.

The level of private labour allocated for land management is not significantly associated with the production risk perception of the decision-maker, although the association was negative. Labour investment is more strongly associated with better endowments of livestock and farm assets. This implies that investment for land improvement is directly associated with the wealth status of the household. It also may imply that households with a better risk-bearing capacity invest more on land management.

In conclusion, appropriate extension messages and institutional inputs for risk management can greatly benefit from a better understanding the risk perceptions of farm decision-makers and the factors that condition these perceptions. Extension messages can also be designed to improve farmers' understanding of the production environment and associated risk so as to minimize the level of uncertainty and perceived production risk and thereby improve their risk management strategies. Intensity of farm management and private investment in land improvement show significant association with the human and material resource endowments of farm households, and policies that enhance the resource capacity of the poor may lead to greater investment in sustainable land management.

CHAPTER 6

Labour compliance for collective resource management

Communities in Tigray, northern Ethiopia, conduct resource management collectively based on a household level labour quota system. This chapter analyses the level of non-compliance of households with the system and its household level determinants in eastern Tigray based on a household level survey and key informant interviews conducted in two villages. The results show that there is a great deal of under-contributions by individual households and this poses a great challenge for the continuation of the system. The level of non-compliance is found to be variable among households within a village. The level of non-compliance is higher among households with older household heads and better livestock endowment. Fewer religious and cultural non-working days corresponds with a lower level of non-compliance in fulfilling labour quota. Differences in household labour endowment show a non-linear relationship with the level of non-compliance. The results reveal that the labour quota system as a collective resource management institution cannot be applied uniformly in all villages and for all households. This implies the need for more decentralized communal resources management systems within the region that take account of inter-household and inter-village differences.

6.1. Introduction

Common property resources play an essential role in the livelihood systems of the rural poor (Wade, 1994; Ostrom, 1994; Beck and Nesmith, 2001; Gebremedhin *et al.*, 2003). Different forms of common property resource management systems can, when properly designed, play an important role in broader national poverty reduction strategies designed to benefit the poor (Kumar, 2002). Development initiatives that use such institutions to try to create sustainable livelihood systems need to build on the communities' own capabilities and resources (Beck and Nesmith, 2001). However, lack of sufficient long-term investment by rural households is one of the major factors limiting the community's role in sustainable development (Barbier, 1997).

Communal resource management regimes and collective action institutions are widely advocated for decentralized, viable, and sustainable use and management of natural resources (Ostrom, 1990; Wade, 1994; Ostrom, 1994; Kumar, 2002; Gebremedhin *et al.*, 2003; Meinzen-Dick *et al.*, 2004). Collective management of natural resources is more relevant in drylands, as common pool resources are usually damaged by previous unregulated use and natural calamities. In dryland areas, collective management is, at least in the short term, mostly concerned with rehabilitation. It is generally appreciated that it takes some time to achieve any noticeable improvement in the productivity of degraded natural resources within dryland regions (Jodha, 1989) and that any immediate benefits tend to be limited. Poor people living in less favoured areas also face many other structural constraints that may prevent them from investing in sustainable resource management (Ruben and Pender, 2004).

Communal resource management in the Tigray region is conducted through labour based collective action at the lowest community unit or a village. Labour is mobilized through a household level labour quota system. Thus, it is implicitly assumed that labour is an abundant resource that rural households can readily contribute for managing communal resources. This approach also assumes that labour has low opportunity costs and can be utilized in such labour-intensive resource management activities with no loss to individual household's welfare. However, rural households face different socioeconomic circumstances and this assumption may not be taken for granted. Households may show variable levels of compliance with collective institutions, owing to their diverse and changing socioeconomic circumstances.

It is important to understand the reasons why households fail to comply, partially or fully, with the rules and conventions that they themselves have set up for communal resource management (Bromley, 1986:4). Knowledge of the factors that improve or weaken individuals' capabilities to organize and participate in collective action is important for effective policy making (Wade, 1994; Ostrom, 1994; Agrawal, 2001). In line with the principle of the 'creative use of conflict' (Ostrom, 1986: 611), a better understanding of the reasons for non-compliance may help us to identify the challenges of sustaining existing institutions and lead to the design of new ones that enhance collective management (Agrawal, 2001). In the context of Tigray, studies are required to identify factors that influence the effectiveness of labour mobilization institutions aimed at the sustainable management of communal resources.

This research aims to investigate the determinants of farmers' non-compliance with labour mobilization systems in two villages in Tigray. Previous studies (e.g. Gebremedhin et al., 2003; Gebremedhin et al., 2004; Benin and Pender, 2006) have assessed the impact of village features in terms of agricultural potential, population pressure, markets, and institutional access on organizing collective action. There is a gap, however, in our understanding of the household level factors that determine non-compliance with the labour quota institution for communal resource management. This chapter therefore aims to investigate this issue based on the study of households in two selected villages in Tigray. It aims to draw policy lessons for enhancing the role of collective resource management in the less-favoured highlands of northern Ethiopia.

The rest of the chapter is organized as follows. Section 6.2 states the research problem and objectives. Section 6.3 introduces the nature of communal resources management and collective action in the study villages. Section 6.4 briefly reviews relevant theoretical and empirical findings on the determinants of resource mobilization and set out the research hypotheses. The research methodology is described in section 6.5. In section 6.6 the empirical findings are presented and discussed and section 6.7 presents the main conclusions and policy implications.

6.2. Difficulties in resource mobilization

Land and unskilled labour are the primary resources of poor rural households in developing countries (Barbier, 1997). With increases in population pressure and land scarcity, the livelihood systems of rural households shift from land-extensive activities to intensive and labour-based diversification systems. In subsistence economies, diversity in livelihood systems has a clear relationship with the labour utilization decisions of households (Ruben and van den Berg, 2001). As labour is the most important resource of rural households in developing countries, policy-makers need to pay close attention to promoting its effective utilization.

Farm households allocate labour for both farm and non-farm production activities and the management of individually allocated resources. Collective labour-based institutions for resource management directly affect households' livelihood systems in terms of the level and timing of contributions to collective management and the derived returns. The effect varies according to the socioeconomic features of a household. Total labour requirement during the collective management season may exceed the availability at household level. Under such circumstances a re-design of labour mobilization institutions is required.

A number of factors influence households' voluntary resource contribution and collective action in common pool resources management (Murty, 1994). These include: households' perception about the fairness of benefit distribution rules and income improvements (Oakerson, 1986), inequalities in land and livestock holdings, the level of skills and education of household members, and changes in access to labour markets facilitated by infrastructural development such as roads. All these factors influence farmers' willingness to contribute their labour resource to collective action. For example, better access to labour markets increases the opportunity cost of labour and reduces farmers' willingness to participate in the collective management of resources that yield a lower marginal value than the wage income. Possessing skills that enhance entry to off-farm employment opportunities may reduce labour contributions to collective work. The size of farmland endowment affects households' motivation to contribute labour to collective soil and water conservation works on arable lands. Farmers with smaller land holdings may find it cheaper or more rewarding to undertake conservation individually than collectively. This is because the direct benefits in terms of collective investment on private farmlands are proportional to the size of land holding rather than the level of labour contribution by a household. Poor households may be less interested in long-term investment such as woodlots and community plantations. Household's willingness to contribute labour for grazing land management may depend on the number and type of livestock that they own, unless other benefit entitlement mechanisms are in place to reward those who do not own livestock.

Natural resource rehabilitation objectives should be complimentary to the production and livelihood diversification activities of households. For instance, irrigation development will reduce labour availability to manage common pool resources, such as woodlots and grazing lands, because irrigation is a labour-intensive activity and there is a great deal of overlap in the timing of collective work with the irrigation season. Area closures can be created by limiting a community's access to free grazing, fuel wood and other material needs from dwindling resources. An expansion of areas under closure may create a higher labour demand for livestock management. Interventions of this nature should therefore address these problems in tandem with the rehabilitation programme. For example, to reduce the conflict with livestock production activities, grass production can be incorporated with the rehabilitation activities by sowing beneficial grass seeds rather relying solely on natural regeneration, and fodder trees can be incorporated within community plantations.

With the village council (locally known as *Baito*) being responsible for coordination of collective works, the following questions can be raised: (1) how does the village council decide on the amount of labour contributed by each farm household, and does it take into consideration the characteristics of the households and common resources they manage? (2) how can benefit distribution rules be established that take into account cost-sharing norms and other relevant factors, such as natural conditions, that influence the amount of benefit received by households? and (3) how can the management of natural resources be improved by alternative collective management institutions. As a stepping stone in addressing these issues, this chapter addressed the following questions: First, what household level factors explain farmers' compliance or non-compliance with the labour quota for communal resource management? And, secondly, what institutional and policy innovations are needed to promote compliance levels and to sustain collective sustainable resource management and livelihood systems, through acknowledging household level economic objectives?

6.3. Communal resources and collective action in study villages

In Ethiopia, communal resources include all land resources that are administrated by the lowest level of administration in every community, excluding state forests and mineral deposits. Some communal resources are distributed to members of the community for individual use; others are collectively used as a common pool resource. In Tigray, farmlands are publicly owned but permanent use rights are guaranteed to individual households. In some communities grazing lands are individually allotted but in many others communal use is still practiced. Woodlots, area closures, community plantations, water sources and waste lands are common pool resources that can typically be found in a village in Tigray. Where they exist, irrigation systems, both traditional and small dams constructed through community mobilization and programme support, are collectively managed by group of water users. For instance, in *Tegahne* village, there is a small-scale irrigation dam and those who own irrigable plots are responsible for its management, although external organizations also provide technical support.

At the village level all communal resources are managed collectively through labour mobilization as described in Chapter 2. In the study villages labour quota systems were started in 1991 and each able-bodied household member is expected to annually contribute 22 person-days in *Tegahne* and 28 in *Gobo Deguat*. The mobilized labour is used for resource conservation and development of the economic and social infrastructure. In Gobo Deguat about 53% of the mobilized labour in 2003 was allocated for conservation works on cultivable land, 18% for conservation work on non-cultivable land, and 29% for maintenance of conservation structures and seasonal roads, gully stabilization, and water harvesting activities. The specific allocation of mobilized labour in the Tegahne village is not recorded; however, most of the labour is used for the construction and maintenance of structural conservation works on communal non-cultivable lands and farm plots with a problem of flooding. Some additional conservation activities are carried out with programme support in the form of food-for-work (FFW), food-for-recovery (FFR) or cash-for-work (CFW).[6.1] To qualify for these programmes, households are first required to meet the free contribution of labour unless exempted by the community. Screening the households that qualify for such compensated work is done with the involvement of community members. Household members who are aged, ill, full-time employees, or students are not obliged to participate.

[6.1] Food-for-work is an in-kind payment based on a fixed daily rate of grain (up to 3 kilograms) for participating individual but food-for-recovery is a fixed in-kind allowance of 12.5 kilograms grain per month for needy households participating in community work. Cash-for-work is a cash payment based on daily wage rate set by supporting organization for a participating individual.

Penalty systems for failures to comply with the labour quota are well established and documented in village bylaws, locally called *Sirit*. In Gobo Deguat a first time absentee gets a verbal warning, and on the second occasion a written one from the mobilizing committee. When reported for a third time, a cash fine equivalent to the daily wage rate for each day missed is imposed on the offender. For a fourth offence, the person gets a cash fine of 100 Birr plus the daily wage rate for each day missed. Besides the verbal or written warnings and cash penalties, the person is required to fulfil his/her quota within a specified period. Although, detailed information is lacking[6.2], comparable sanctioning systems are expected to exist in Tegahne village. However, in both villages the established penalty systems are not strictly enforced. According to the key informants, rule enforcement is irregular in both villages. Regular absentees may be punished, but irregular and nominal presence is usually ignored. The bylaws also lack clear rules on benefit sharing from investment on communal non-farm lands.

The physical benefits of such collective work include improving the potential of cultivable fields and other land use types through soil and water conservation structures, creation of communal woodlots and plantations, and public infrastructure such as rural roads. There are studies that show positive economic impacts of such collective activities through better farm productivity (Gebremedhin, 1998; Gebremedhin *et al*., 1999) and increased natural capital at community level (Gebremedhin *et al*., 2003).

6.4. Conceptual background and research hypotheses

In earlier studies of collective action the focus was on problems related to the provision of public goods (Olson, 1969). The major question was how could a group of people achieve a certain degree of commitment to make joint contributions and observe collective rules, so as to enjoy the benefits from a public good? Studies of group theory assume that individuals with a common interest would act voluntarily to try to promote those interests (Bentley 1949 and Truman 1958; cited in Ostrom, 1994:5). However, Olson (1969:3-4) challenged this assumption referring to the basic assumption of rationality and behaviour of self-interested individual. According to Olson individual rationality does not provide a sufficient basis for collective rationality. A number of models developed to explain this theory have shown that if all members of a group or community choose to free ride, no collective benefit can be

[6.2] In Gobo Geguat the village council has better documentation of the actual use of contributed labour. But, in Tegahne village the leaders were only able to qualitatively tell how the labour is used which makes it difficult to make parallel comparison for the two villages in terms of labour allocation.

realized, and if only some are contributing, the outcome will be Pareto inferior (Dresher and Flood, 1950; cited in Roth, 1995:8; Hardin, 1968; Olson, 1969). Hence there is a need for an external body to ensure individuals act in their common interest (Olson, 1969; Hardin, 1968).

Recent theories, however, show the ineffectiveness of external intervention in collective action and posit common property resource management as a viable and sustainable alternative to private or state property rights systems in developing countries (Bromley, 1990; Ostrom, 1994; Wade, 1994; Baland and Platteau, 1996; Agrawal, 2001; Gebremedhin et al., 2003). Nevertheless, the question of why individual members within a communal resource management system violate the rules of the collective institution still needs thorough investigation.

The literature shows that successful management of commons is associated with factors related to the nature of the resource, the actors' characteristics, the institutional arrangement and the broad external environment (Agrawal, 2001; Sekher, 2001; Ostrom, 1994; Gibson et al., 2005). These factors all affect the motivation of individuals to conform (or not) with institutional solutions for management of the commons. The following section summarises current thinking about the most important household level determinants of such decisions, which are used as the basis for developing hypotheses to inform the subsequent empirical investigation.

6. 4.1. Determinants of non-compliance with collective resource management institutions

A number of demographic and socioeconomic features have been identified as important in determining the likelihood of households' involvement in collective action (Theesfeld, 2004). For instance, households with more education are more aware of opportunities outside their community and may make fewer contributions to collective action (Pender and Scherr, 2002). Users of common resources do not have the asset endowments and access to markets and institutions (Ruben and Pender, 2004) and this can also contribute to different levels of participation in collective resource management (Wade, 1988:191; Ostrom, 1990). However, studies from Japanese villages (McKean, 1986) and other places (Baland and Platteau, 1996) show inequality in private landholdings to be less important in influencing participation in collective action.

In addition to the assumptions made in theoretical analysis about the effects that more endowments and stronger social capacity may have on the willingness of households to participate in collective action, other households may be constrained by insufficient resource capacity (Ostrom *et al.*, 1994:35). The features of households also change over time and may lead to changes in their motivation and capacity to contribute to collective action. For example, Theesfeld (2004) found older heads of households and widows were less interested in joining a system of collective management in irrigation systems in Bulgaria.

The motivation of households to contribute to collective resource management and the level of contribution that they are prepared to contribute is also associated with the degree of dependence on the resource (Gibson *et al.*, 2005). Households benefiting more from the communal resource are more willing to contribute to the management of these resources than those who are less dependent. This is in line with the main assumption of Community Based Natural Resource Management, that 'people who live close to communal resources and whose livelihoods directly depend on the services of these resources, have more interest in sustainable use and management than state authorities or distant corporations' (Li, 2002). Thus, those who benefit less from the services of the resources may not be prepared to make the same level of contribution as those who benefit more. As the experience of collective farming in Chinese cooperatives shows, using individual contributions as a basis for distribution of benefits may minimize such problems, although this may fail to generate the critical minimum total contributions for viable team work (Burkett and Putterman, 1993).

Rural households are engaged in a number of activities to diversify their livelihood systems, through their relationship with available markets (McCarthy *et al.*, 1998; Woldehanna, 2000; Romano, 2000; Ruben and van den Berg, 2001; Woldehanna and Oskam, 2001). Households with a better comparative advantage in the labour market are more likely to look for (and find) off-farm employment (Becker, 1990), increasing competition among other activities for labour (Kuiper *et al.,* 2001). Thus, households will consider the opportunity cost of their labour and will evaluate the utility they receive from collective action when deciding whether or not to comply with collective institutions (Hardin, 1968; Becker, 1990). Hence, communal resource management systems should yield benefits in the short-term (Ostrom *et al*., 1994:274; Place and Otsuka, 2002:76). Policies aiming at improved management of natural resources should therefore consider the private economic objectives of resource operators (Ruben and Castro, 1996).

With an increase in the number of exit options, organizing collective action becomes costly and the problem becomes significant when the group is large and heterogeneous (Baland and Platteau, 1998). A higher number of exit options may reduce cooperative capacity by weakening social cohesion, which increases the difficulty of reaching and enforcing collective decisions (Bardhan, 1993; Pender and Scherr, 2002; Gebremedhin *et al*., 2003). At the household level, exit options are created by better human capital endowments and marketable skill levels as well as proximity to markets and other social infrastructure.

Households with more exit options are therefore likely to contribute less to collective management of resources.

Free riding behaviour by some members may encourage others in the group to reduce their effort in collective action, leading to an over all decline in the future stream of benefits for all members (Ostrom, 1994:42). Hence, free riding may also create some degree of inequality in benefit distribution. As the experience of team work in collective farming in China shows, lower effort by some members may trigger retaliatory action by others (Dong and Dow, 1993). Uneven distribution of the costs of, and gains from, the collective development of watershed programmes in India was one of the reasons for them not being as successful as hoped (Kerr, 2002). Studies in Ethiopia show equitable sharing of costs and benefits is a fundamental feature of indigenous local resource management institutions (Ashenafi and Leader-Williams, 2005). Institutionally, established management plans should enable contributing households to get a faire share of the benefits from collectively managed resources (McCarty *et al.,* 2001). Otherwise, free riding and opportunistic tactics of some may lead to mistrust among community members and impede collective action (Olson, 1969; Schneider and Pommerehne, 1981; Theesfeld, 2004).

In principle, compliance with collective rules should be voluntary (Wade, 1988: 209) as is advocated in participatory development approaches. However, in practice, effective sanction systems are necessary determinants of success in collective resource management (Ostrom *et al*., 1994: 274; Baland and Platteau, 1996; Gibson *et al*., 2005). Impartial and effective adherence to established penalty systems plays an important role in the successful conduct of collective resource management (McKean, 1986:569). Punishment strategies that can be enforced by the community are found to increase cooperation (Baland and Platteau, 1996). Good benefit sharing approaches have been found to be more effective than administrative enforcement mechanisms in many cases (Murty, 1994). In addition the internal and the external environments that existed when the collective management institutions were designed can change over time and old rules may not be appropriate to new contexts (Jodha, 1989; Ostrom *et al*., 1994:40). Flexibility in rule design to accommodate changing situations is a further important factor of success in collective resource management (McKean, 1986:566). Constraints on the capacity of village officials to enforce rules can also undermine the effectiveness of such collective institutions (Ostrom *et al*., 1994:269).

Collective management can be successful if appropriate interventions are designed and implemented to motivate households to participate (Ostrom *et al*., 1994:326; Baland and Platteau, 1996). The rationale for external assistance in resource management stems from the very nature of the service provided by these resources, which are both private and public services. Food-for-work and other schemes are used as an incentive to motivate households' participation in community activities in developing countries (Pender and Scherr, 2002; Gebremedhin *et al.*, 2003). In drought seasons, such programmes are implemented in Tigray to carry out conservation and development activities. Participation in programme supported activities is tied in with fulfilment of the free labour contribution.

The above review highlights the factors that influence the costs and benefits to individual households of compliance with collective institutions. These factors are assumed to influence the level of (non)-compliance shown by households with the labour quota institutions.

6.4.2. Research Hypotheses

Based on the review of the theoretical and empirical work the following hypotheses about the labour quota system can be formulated:

1. The level of non-compliance with labour quota system may vary among households depending on their endowment of resources and the level of benefit that they enjoy from collective resource management. For instance, an individual household's benefit from collective investment on farmlands is proportional to its endowment of cultivable land. Thus, *ceteris paribus*, households with relatively larger cultivable land are more likely to meet their contributions more than those with smaller holdings. In addition, when households own plots which need or directly benefit from collective conservation work, their level of compliance will be higher.
2. The individual household's non-compliance level may vary with other household-level socioeconomic differences. The labour endowment and composition of a household are expected to influence the degree of compliance. For instance, when benefit distribution rules do not consider explicitly the amount of individual contributions, which is the case in the study area, then the labour-endowed households bear a higher cost of collective action when they comply fully. This is a disincentive for these households to contribute fully. In terms of composition, households with skilled and marketable labour are likely to contribute less because of higher labour opportunity costs.
3. The livestock endowment of households is also hypothesized to influence the level of compliance, with higher endowments expected to reduce the non-compliance level. However, the institutional systems regulating access to and benefit entitlement from communal grazing systems, and the implication of livestock production on the value of feed and the opportunity cost of labour, makes this relationship non-linear. Where institutional systems stipulate equitable access to or sharing of common pool pastures

differences in livestock endowment may not be relevant. But, even if equitable access is stipulated, the value of livestock feed, e.g. grass from the commons, is higher for households with more livestock than for those with less. Therefore, households who own less private pasture land are more likely to meet their obligations than those with alternative pasture sources. Engagement in livestock production also increases the opportunity cost of labour which may reduce compliance, *ceteris paribus*. Thus, the impact of livestock endowment on degree of compliance can not be known *a priori*.

4. Proximity to markets has been found to influence collective action in empirical studies. It is hypothesized that households with better access to off-farm employment comply less than those with lower opportunities, controlling for the effect of better markets on the value of products from common pool resources. Better off-farm opportunities increase the opportunity cost of labour contributions and this is likely where enforcement is weak and immediate benefits from collective investment are low.
5. Programme support, linked to resource management and supplementing household livelihoods, serves as a positive inducement for households to comply with labour quota systems. The effect is stronger when qualification to participate in such programmes requires full compliance with the free labour quota obligations, as is the case in Tigray.

6.5. Data and Methodology

As explained in Chapter 5, data used in this chapter was collected using key informant interviews and household surveys. Descriptive information on the labour quota system, community bylaws, and problems encountered was obtained from key informant discussions. The analysis in this chapter is based on the responses of 155 households (78 from Gobo Deguat, and 77 from Tegahne). Besides the household socioeconomic features described in Table 5.1, information on household labour allocation, participation in communal resource management, and benefits from programme supported activities are used for the analysis in this chapter. For both study villages, there is no recorded information on the benefit distribution from the commons that can be directly used for the analysis. According to the applicable norms in each of the study villages, community members are entitled to get a share of the benefits from such activities equitably. However, it is inappropriate to assume equitable access because the resource endowments that determine the distribution of benefits are unevenly distributed among households.

The dependent variable is the extent of non-compliance which is measured as the deviation of each household's actual contribution from the expected contribution in 2002/03.

For the econometric analysis, the deviation is normalized by the expected maximum for each household and the values range between zero and one. A maximum value unity indicates complete non-compliance and a zero value show full compliance.

Explanatory variables are household socioeconomic factors and a village dummy. The first group includes the age and sex of household heads, the proportion of household members with formal education, possession of marketable skill by some household members, and consumer-to-producer ratio within the household. Labour endowments are measured in terms of female and male labour endowments in adult equivalents and number of working days during the month of *Tahsas*/ December/[6.3]. The size of the household's cultivable- and pasture- land holdings, whether the household owns private woodlots, and plots that need conservation work, are also considered. The livestock holding is also taken into account.

The aggregate value[6.4] of the annual average receipts of the household from participation in programme supported activities and transfers such as food-for-work (FFW), food-for-recovery (FFR), food-aid (FA), and cash for work (CFW) are considered to as the impact of programme incentives on the level of non-compliance. The programme benefits are self-reported averages based on the households experience in programme participation for the years proceeding the survey year. These values are indicators of households' dependency on such programmes. A village dummy is specified to account for village level variation such as the differences in proximity to markets and agricultural potential. Descriptive statistics of the explanatory variables considered in the econometric analysis are presented in Table 6.1.

Table 6.1 Descriptive information of the variables used for econometric analysis

Variables	n	mean	SE mean	SD
Dependent variable				
Ratio of non-compliance (under contribution) to expected maximum contribution	151	0.37	0.02	0.34
Explanatory variables				
Number of working days during *Tahsas*/ December/	154	14.59	0.20	2.49
Private pasture land holding in *Tsimdi*	155	0.19	0.03	0.31
Private woodlot ownership (1 if yes)	155	0.48	0.04	0.50
Whether the household has one or more plots which need conservation structures (1 if yes)	154	0.46	0.04	0.50
Cash value of program transfers	155	284.61	17.05	211.7

Note: n stands for number of cases, SE stands for standard error of the mean and SD for standard deviation; and for descriptive information of other variables see Table 5.1.

[6.3] The number of working days is computed by excluding the number of days in the month which are observed by each household as religious and cultural holidays.

[6.4] Cash value of the in-kind receipts from program support is computed using average village prices for the grain type received.

Generally collective action in communal resource management can only be achieved when the benefits from collective management exceed the costs (Ostrom, 1990; McCarty *et al.,* 2001; Gebremedhin *et al*., 2003). The net benefits of collective action to participating households are influenced by the socioeconomic feature of the household and collective decisions that determine the cost and benefit sharing rules (Dayton-Johnson, 2000). Assuming that collective decisions apply uniformly to all participating households, the final decision of whether or not to comply will depend on the subjective evaluation of each household of the expected net gain from collective action, (considering also the probability of sanctions and their costs if the household fails to comply). Theoretical and empirical studies show the interrelationship of household socioeconomic features and the success of collective action. The analytical model for this study is formulated based on these conceptual constructs. Non-compliance level is stated as a function of household socioeconomic features given exogenous village factors. Functionally, it is stated as

$$NC_i = f(H_i \mid DV) \qquad (6.1)$$

Where NC_i stands for level of non-compliance of individual i, H_i for socioeconomic characteristics of individual i, and DV is a dummy for differences in village features. In line with the hypotheses relevant household socioeconomic features are included. The empirical model used for econometric analysis is stated as follows assuming linear relations in the parameters:

$$\begin{aligned} NC = {} & \beta_0 + \beta_1 DV + \beta_2 Ag + \beta_3 DHS + \beta_4 E + \beta_5 DS + \beta_6 DR + \beta_7 FL + \beta_8 FLS + \beta_9 ML + \\ & \beta_{10} MLS + \beta_{11} TW + \beta_{12} CL + \beta_{13} PP + \beta_{14} DW + \beta_{15} DSW + \beta_{16} LV + \beta_{17} CV + \mu \end{aligned} \qquad (6.2)$$

Where β_i are parameters to be estimated and μ is the random disturbance term with the usual properties. Other variables are defined below.

When estimating the empirical model in equation (6.2) a positive relationship is expected between the level of non-compliance and those household factors that increase the opportunity cost of labour contributions for the household and its share in the total cost of collective action. Households with better human capital (high proportion of educated family members (E) and marketable skill endowments (DS)) will have more exit options, and higher labour opportunity costs and thus are expected to show a high degree of non-compliance. Households less dependent on products from communal resources, for instance those who own private pasture (PP) and woodlots (DW), are also expected to show a higher degree of non-compliance.

The impact of labour endowment may be non-linear. Better endowment of female (FL)- and male (ML)- labour may initially reduce the non-compliance level. However, with an increase in labour contributions, a household's share in the total cost of collective action increases and this may lead to a higher level of non-compliance. To test for the hypothesized non-linear relations the square terms of female (FLS)- and male (MLS)- labour endowment are included.

Taking variations in endowments of farmland as a proxy for the distribution of benefits received from, or extra costs saved by, individual households due to collective investment on farmlands, non-compliance is expected to decline with an increase in land holding (CL). When the endowments of households' increase the benefits gained from collective management, non-compliance will be decreased.

Male headed households (DHS) may have better labour endowment than female headed households, hence non-compliance will be lower for the former. Households dependent on transfers and participation on program assisted employment schemes (CV), where selection for participation is contingent on fulfilling community labour quotas, will comply more than those less dependent on such schemes. Households with large families and higher dependency ratios (DR) can be assumed to show higher dependence on natural resources and will show greater compliance although the ultimate effect may be conditioned by the effect of high dependency ratio on labour demand for family maintenance. Non-compliance is expected to be less for households with more working days (TW) during the collective work month. Finally, households who own one or more private plots (DSW) which need conservation structures are expected to show lower non-compliance because they can expect to benefit from the collective labour investment on labour on these plots.

In line with the hypothesis the impact of livestock endowment (LV) cannot be determined *a priori*. The same is true of the age of household head as there is insufficient prior knowledge of the likely impact of this.

Standard statistical and econometric techniques are employed for the data analysis. Comparison of means of contributions and non-compliance levels by village and by household groups within a village is conducted using a standard T-test. Regression techniques are used to identify the household level factors that explain the varying extent of non-compliance.

6.6. Results

6.6.1. Qualitative and descriptive results

Qualitative and descriptive techniques are used to examine the level and pattern of compliance of households with the labour quota system and their opinion about its acceptability in the study villages. According to village key-informants, contributions for improving the availability of water for humans and livestock, religious purposes, helping elderly people, and grazing land management are traditionally initiated from within the community. Collective action for constructing soil and water conservation structures on farm- and non-farm- lands, use of organic and inorganic fertility management practices, and infrastructure development such as roads, schools, ponds and dams generally promoted by external organizations. The Regional Bureau of Agriculture and Natural Resources Development (BoNARD), local and foreign NGOs play roles in promoting these type of developments through provision of material and training support.

Labour mobilization for rehabilitating natural resources and developing of rural commons is promoted by local institutions such as the village council. In the study villages, the majority of households support such collective institutions for resource management. Of the total sample households, 96% in Gobo Deguat, and 62% in Tegahne were in favour of the labour quota system. Twelve per cent of households in Tegahne were against the system for two reasons: the timing of mobilization and a lack of compensation by the state. The high support for the system in Gobo Deguat may be related to the severity of resource degradation in the village and the recognized need for such a collective initiative. The majority of the sample households in both villages support the programme for its role in soil erosion control, moisture conservation and rehabilitation of degraded lands.

Household level contribution of labour is higher in Gobo Deguat than in Tegahne, with 51 and 35 person-days per household, respectively. Although the mean adult-labour endowment per household is comparable, 2.69 against 2.58, respectively, the total contribution is significantly higher in Gobo Deguat than in Tegahne. This is in line with earlier empirical findings that villages with more degraded resource and more remote from market areas contribute more to collective management (Gebremedhin et al., 2003). However, in both villages, the actual aggregate village level contribution is lower than expected at full compliance.

Per-adult labour contribution of ‘small’ holding households significantly exceeds ‘large’ holding ones in Tegahne, but was comparable in Gobo Deguat (Table 6.2). Per-adult non-compliance level of large holding household in Tegahne is in excess of their counterparts in

Gobo Deguat (10% level of significance), while that of small-holdings is comparable between the two villages. Key-informants in Tegahne believe that no more structural conservation is necessary, given that the village has a mainly flat topography and that enough has been done for over 15 years. Collective investment on privately operated plots is perceived as unnecessary in this village as this should be the individuals' responsibility. This suggests the need for revising the allocation of mobilized labour to more productive community activities that do not displace the private responsibilities of land owners. According to key-informants failure by the village council to enforce established penalty system is one of the reasons for increased non-compliance. Thus, the non-compliance is partly due to free-riding behaviour and retaliatory actions of other households, which occurs under a weak sanctioning system.

Table 6.2 Household level labour contribution for collective resource management (CRM) in two study villages in 2002/03 (in person-day equivalent)

Item	Gobo Deguat village (n=78)				Tegahne village (n=75)			
	Large (n=35)		Small (n=43)		Large (n=36)		Small (n=39)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Total labour contribution for CRM	66.5	27.1	37.5	27.7	34.9	26.9	34.4	27.3
Total female labour for CRM	35.3	15.7	24.4	16.6	15.3	16.2	20.9	17.7
Total male labour for CRM	31.1	18.1	13.1	14.9	18.7	16.3	13.4	16.6
Per adult labour contribution for CRM	17.8	6.7	15.7	10.6	9.3	7.8	15.3	13.5
Per adult non-compliance level	7.7	6.1	9.9	9.4	10.3	8.1	8.2	8.5

Note: n stands for number of cases and SD for standard deviation

In this study we find about 13% and 8% of the households in Gobo Deguat and Tegahne, respectively, engaged in off-farm employment outside their villages during the month of *Tahsas* (December). The amount of labour is 186 and 30 person-days, respectively. Although Tegahne is close to a district town market, the employment opportunities for households in Gobo Deguat was better, due to more construction activities during the 2002/03 season around the town of Hawzen. As Gobo Deguat is relatively resource-poor, off-farm employment is an important supplement to livelihood systems. During the peak agricultural period in the 2002/03 production season (June to September), 30 percent of the sample households in Gobo Deguat "exported" 1,030 person-days of labour, compared to 25 percent of households in Tegahne that "exported" 277 person-days of labour. Economic problems related to poor agricultural resource endowments and the windfall economic incentives of construction activities in the district town may have combined to create the incentive for households in Gobo Deguat to involve themselves to such an extent in off-farm employment opportunities. During the dry season, labour hired-out amounted to 1,113 and 248 person-days for Gobo Deguat and Tegahne, respectively, with similar proportion of households involved as in the peak farming period. The low level of labour hiring-out within Tegahne may be due to the availability of irrigation in the village, which provides on-farm employment for family labour during the dry period. The high degree of non-compliance among households in Tegahne may also be partly explained by access to irrigation.

Within the survey year (2002/03), the mean of household level labour availability and use balance in the two villages during the month for collective action and the entire dry season show deficit. However, the range is wide. Households with a better farmland endowment generally have a higher labour deficit. This indicates the need for a more careful analysis of the household context in designing labour-mobilization for collective resource management.

Analysis of the annual per adult contribution to collective programmes during the month of *Tahsas* (December) shows that nearly 50% of households in Gobo contribute less than half of the agreed quota of 28 person-days. In Tegahne 65% of households contribute less than half of the agreed quota of 22 person-days. During the same month, 14% and 24% respectively of sample households did not contribute at all. Looking at the entire dry period (December to May), the figures for households contributing less than half of the expected level fell back to about 40% and 51% in Gobo Deguat and Tegahne, respectively. This shows that over an extended duration some households can and are willing to make up the shortfall in their contribution, although they remain in violation of the collective decision on the timing of the mobilization. The contribution for tree planting is declining in Tegahne, due to a major shift in the natural resources extension system in which household level forestry packages are being promoted, where farmers can collect seedlings of their own choice at a nominal price from community nurseries, and plant these on their private woodlots.

In sum, in both villages the collectively agreed norms of labour contribution are not fulfilled. During 2002/03, only 13% of households in Gobo Deguat, and 26% in Tegahne fully complied with the quota system. This seems like a situation of ‘collective free-riding’ or non-compliance (Wade, 1988). In discussion with key informants, the decline in individual contribution was identified as a major problem. Thus, there is a need for investigation of the household-level or other factors that explain the wide range of non-compliance.

6.6.2. Econometric analysis

The variation in the level of non-compliance among households is statistically significant in the study villages. The dependent variable, the ratio of under-contribution to expected maximum contribution, is continuous and both left- and right- censored. Thus, interval regression model is employed for the econometric analysis. The explanatory variables explained in section 6.5 are included in the regression and results are presented in Table 6.3.

The household level of non-compliance is lower in Tegahne compared to in Gobo Deguat although this is only marginally significant. This may be due to the higher level of the labour quota in Gobo Deguat and the higher participation of households in the village in off-farm employment.

In line with the hypothesis, non-compliance is significantly affected by the level of *labour endowment* of households. The non-compliance level decreases with an increase in labour endowment, for both female and male labour, but not in a linear way. Households with higher levels of female and male labour endowments show a higher level of non-compliance, as these households carry the highest cost of collective action. In general, the pattern of relationship has a U-shape nature. This result suggests the need for an incentive or benefit-distribution system that takes into account the extent of labour contribution. Households with less number of religious and cultural holidays during the collective work month show a lower level of non-compliance. This shows that households vary in their degree of observance on cultural and religious restrictions on working days. There is an ongoing intensive awareness campaign at the community level to reduce the number of holidays in Tigray.

Non-compliance is significantly higher for households with a better *livestock endowment*. Livestock is the most labour-consuming production activity of households in the study villages. Collective decisions on the management of communal grazing lands, woodlots and plantations, and area closures usually limit the free roaming of livestock in open areas. This increases the labour demand for livestock management and the opportunity costs of labour in farm production.

The age of the household head is found to have influence with older ones showing high degree of non-compliance which may be related to their inherent short time preference. It is not also clear whether benefits from collective investment are inheritable as in the case of user-rights on farmlands. Theesfed (2004) found similar results in collective management of irrigation systems in Bulgaria.

Table 6.3 Determinants of non-compliance with labour quota systems for collective resource management

Variables (Dependent variable**:** Ratio of under-contribution to expected maximum contribution)	**Interval regression**	
	Coeff.	RSE
Explanatory variables		
Household demographics		
Age of household head (years)	0.0065**	0.003
Sex of household head (1 if male)	-0.1192	0.102
Proportion of household members with formal education (%)	0.0012	0.002
Household has members with marketable skill (1 if yes)	-0.0704	0.069
Dependency ratio (consumer units/producer units)	-0.0178	0.065
Resource endowment and use: labour		
Female labour endowment (adult equivalent unit)	-0.4995**	0.232
Square adult female labour	0.1629**	0.067
Male labour endowment (adult equivalent unit)	-0.2125*	0.118
Square adult male labour	0.0676**	0.032
Number of working days during the month of *Tahsas*/ December (days)	-0.0598***	0.019
Resource endowment and use: land		
Total cultivable land holding in *Tsimdi*	-0.0273	0.042
Private pasture land holding in *Tsimdi*	0.1644	0.149
Private woodlot ownership (1 if yes)	-0.0661	0.075
Whether the household has one or more plots which need conservation structures (1 if yes)	-0.1289	0.080
Resource endowment: Livestock		
Total livestock endowment in TLU	0.0377**	0.016
Program support		
Cash value of programme transfers in the form of FFW, FFR and FA in birr (square root)	-0.0055	0.005
Other variables		
Village dummy (1 if Tegahne)	-0.2062*	0.111
Constant	1.5955***	0.423
Number of Observations	146	
Wald chi2(18)	74.41	
Overall model fit (prob >F)	0.000	
R square	0.3574	
Log pseudolikelihood	-82.84	

Notes: dummy variables are defined as 1 if yes or 0 otherwise; *, ** and *** show statistically significant determinants at 10%, 5% and 1% levels of significance respectively; RSE stands for robust standard errors; and R square for interval regression is computed from the correlation of the actual and predicted values of the dependent variable.

Some of the hypothesized explanatory factors did not show any statistically significant impact. From the mean comparisons, the level of per adult non-compliance was relatively higher for households with small land holdings in Gobo Degauat and those with large land holdings in Tegahne. Graphic inspection of the pattern of relationship between the degree of non-compliance and household labour endowment show a non-linear (a U-shaped) relationship (Figure 6.1). There is also a non-linear relationship between the non-compliance level and the land to labour ratios of households (Figure 6.2).

Inter-village and inter-household heterogeneity in terms of resource endowments and opportunities influence the level of compliance with collective institutions. Hence, such heterogeneity should be considered in designing suitable institutions. In line with the 'development pathways' hypothesis (Pender *et al.*, 2001), collective institutions should be designed to take the comparative advantages of participating households and their circumstances into account. For instance, households with marketable labour may prefer to engage in off-farm activities during the labour mobilization period. According to key informants this was one reason for non-compliance of households although the regression results do not confirm this. Households who depend on temporary out-migration to areas with better employment opportunities should not be prevented from migrating in order to fulfil the quota requirement. The benefit entitlement rules from such collective management should also take into account the cumulative contributions of complying households as would be the case for any other long-term investment activities. Under the current system, households who contribute regularly over time do not benefit any more than those whose contributions are erratic or who only recently joined. This absence of basic economic principle about benefit appropriation may eventually lead to a decline in the sustainability of the labour quota system. If alternative modalities are included to capture the diversity of household circumstances, the collective resource management institutions will have better chances of survival.

6.7. Conclusions and policy implications

Rural households' participation and effort is well recognized as the critical input in sustainable management of communal resources on which their livelihoods directly depend. This was the reason for the initiation of the labour quota system for collective resource management in the northern Ethiopia region of Tigray. However, the system has faced many challenges since its start in 1991.

This chapter has investigated the level of non-compliance of households with this system in two study villages and found that there is a great deal of under-contribution, despite the fact that majority of households favour of the system. Around 14 and 24% of the sample households in Gobo Deguat and Tegahne, respectively, fail to contribute at all. On average, household contributions are 50% below the annually targeted quota in both villages. Non-compliance is partly explained by village-level differences. In the village with poor agricultural resources, the magnitude of contributions is much higher than in the village with good resource conditions, which is in line with the findings from community level studies in the region (e.g. Gebremedhin *et al.*, 2003). However, poor resource conditions also act as a push factor for households to involve themselves in off-farm activities to supplement their livelihoods. Thus, the degree of non-compliance is higher in the resource-poor village. The implication is that a uniform institutional approach should not be applied in all villages and to all households with diverse internal conditions.

The findings show that subsistence households have differing socioeconomic circumstances that determine their motivation and capacity to comply with collective action institutions. The collective mobilization of labour will have different implications depending on households' resource endowments and their comparative advantages. The actual level of contribution of households with a better labour endowment is higher than their counterparts with a lower labour endowment but the degree of non-compliance is higher among households with a good labour endowment. This implies the need for matching the distribution of the costs of collective action with the expected benefit distribution. Households with better comparative advantages in collective action should be encouraged with the right institutional incentives to organize, and benefit from, the sustainable development of communal resources, which is in line with the decentralized approach for resource management. In addition households with higher labour opportunity costs might substitute their contributions with hired labour or cash, which would enhance the functioning of labour markets and investment in public goods in the region.

A labour quota system is one way of mobilizing communities' capacity for sustainable resource management, although it should be organised considering inter-household and inter-village differences. Communities should be allowed to adapt the norms, timing and purpose of the labour contributions to their context. In its current form, the system lacks economic considerations and this is a likely reason for the high level of 'collective' non-compliance by households. Hence, it is necessary for policy makers to create an environment that is conducive for participating households and design new institutions that consider their comparative advantages. This may imply a need for a shift from the current geographic based organisation of collective action to alternative institutional setups with dual economic and ecological objectives. The conceptualization of decentralized resource management should go beyond the geographic or administrative criteria of spatial scale towards identifying social groups that are capable of organizing collective action efficiently. Examples could include cooperative resource management systems where households, who are willing and able to contribute resources, organize collective action.

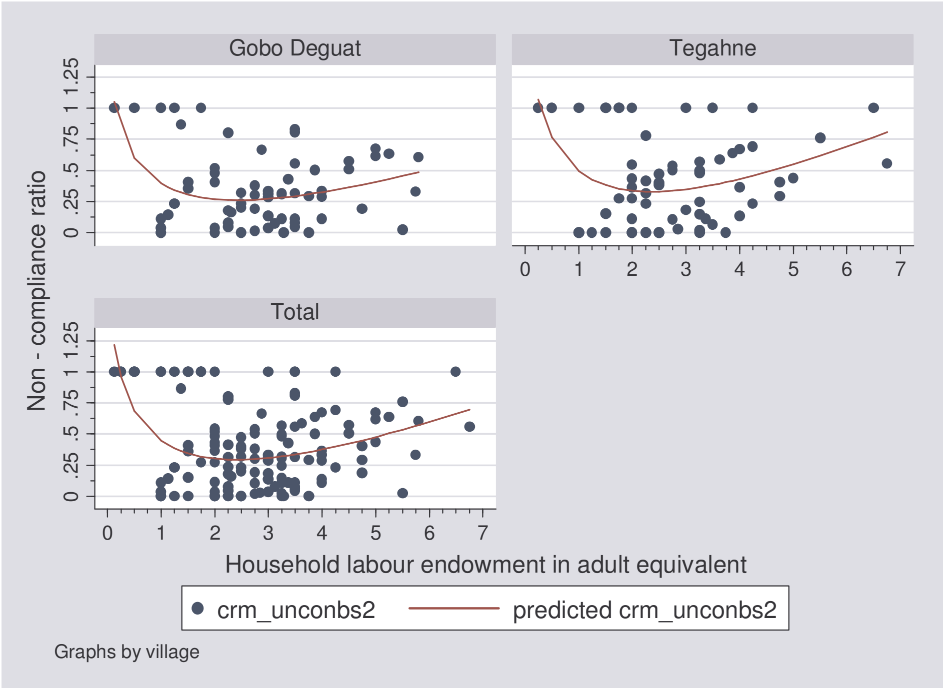

Figure 6.1 Distribution of non-compliance ratio by household adult labour endowment in person-day equivalent

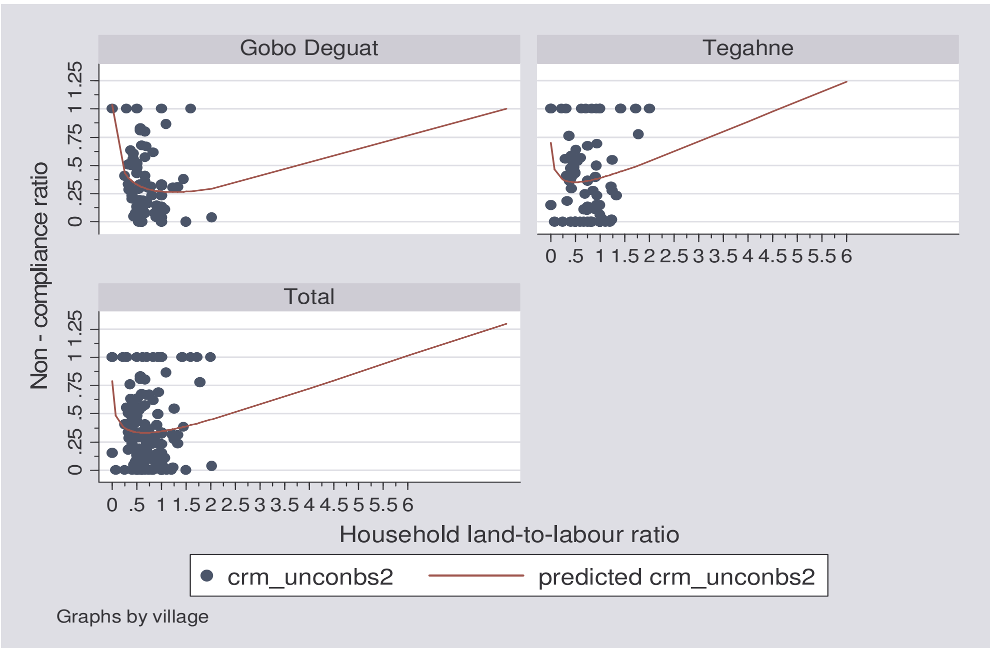

Figure 6.2 Distribution of non-compliance ratio by the relative land to labour endowment of households

CHAPTER 7

Discussion and conclusions

7.1. Agriculture, resource management and institutions

Creating an institutional environment that is conducive for promoting sustainable livelihood systems and economic development in low income-countries is at the centre of policy discussions these days. Ethiopia is one of the countries facing a huge challenge in achieving food security and sustainable rehabilitation of its degraded natural resources. This requires appropriate policy support and an enabling institutional framework that can promote local initiatives and technology adoption. Such a framework needs to be able to enhance property right institutions, credit, and insurance, and to support extension services, indigenous institutions for resource management and decentralized systems of administration.

This study has addressed three issues of relevance for sustainable resource management and agricultural development in the highlands of Tigray. *The first issue examined the impact of land contracting, in the form of sharecropping, on plot level management and productivity*. It evaluated the implication of the tenancy status of a plot on several variables: crop and land management input use, decisions over intensity of use, and the efficiency of resource use on owned and sharecropped-in plots of tenants.

Institutional intervention designed to assist farmers to cope with the risk and uncertainty they face in their production environment requires an understanding of farmers' risk perceptions and how these affect their choice of farming practices. Thus, *the second issue addressed in this research deals with the impact of perceived rainfall-related production risk and uncertainty on the intensity of farm management inputs used by producers at plot level and their investment in land management*. It tries to identify the factors that explain the differences in risk perceptions among farmers in the study areas and to understand how such differences in risk perceptions influence farm management intensity at plot level.

The success of collective institutions of resource management depends on compliance of members in respect of resource contributions and observing collective rules. In practice, individuals may violate such collective decisions, as seen with the problem of non-compliance at the household level with labour quota system that has been adopted as a collective resource management institution in Tigray. *The third issue that this study addressed examined the household level factors that influence the (non)-compliance of households with* *this labour quota system*. It identified some of the major problems faced by such a collective action institution and the policy and institutional inputs required to successfully promote sustainable collective action in the region.

Small holders often face resource constraints, operate in a risky environment, and share communal resources which require collective management. These three issues are therefore intended as illustrative cases of the institutional elements that need to be addressed in order to promote sustainable agricultural development by small-holders in a less-favoured area. The analyses results will provide insights into factors that influence the choice of crop and land management practices, productivity and the sustainability of collective action institutions under such context.

Discussion on the findings of each research issue and conclusions are presented in subsequent sections. Section 7.2 presents the findings and conclusions on the impact of sharecropping arrangements on the plot level management decisions of tenants and on productivity. The main findings and conclusions from the analysis of the determinants of farmers' perceptions of production risk and their impact on farm management decisions are presented in section 7.3. Section 7.4 presents a discussion of the findings and conclusions of the analysis of the determinants of household non-compliance with labour contributions for resource management. Finally, in section 7.5 the main policy implications and further research needs are set out.

7.2. Land contracts, farm management and productivity

The debate on the implications of tenancy arrangements on land management and productivity is one of the long-standing issues in both theoretical and empirical studies in economics and development economics (Otsuka and Hayami, 1988; Singh, 1989; Ray, 1998). In the absence of functioning land markets contract arrangements enable farm households to combine land with other complementary factors and can contribute to an increase in productivity and equity, provided that efficient factor combinations within and between farms are achieved (Bardhan, 1980; Hayami and Ostuka, 1993; Otsuka and Place, 2001; Pender and Fafchamps, 2005). Land tenancy systems should also lead to better land management practices in both the short and long term and thereby to contribute towards sustainable agricultural development (Dubois, 2002; Ray, 2005).

However, one of the prominent issues raised in the literature relating to sharecropping contracts is that of moral hazard in input supply by tenants (See for example Otsuka and Hayami, 1988; Singh, 1989; Ray, 1998). In this research the impact of sharecropping, a dominant form of land contracting in Tigray, on land management and productivity was investigated, both in the context of the region and in the light of the scholarly debate on the subject. Four important farm management inputs were considered in the analysis: manure, inorganic fertilizer, labour and draft-power.

Tenancy and farm management decisions

The empirical findings show that, controlling for household, crop, plot, and agro-ecological factors, the use and intensity of use of fertilizer, labour and draft-power did not show statistically significant variation on owned and on sharecropped-in plots. The probability and intensity of manure use was marginally lower on plots that the tenants receive two-thirds of output share compared to their own plots and the likelihood of manure use was higher when tenants feel better security of tenure as measured by their expectation of longer duration of use of the plots. Tenants who sharecrop-in many plots were found likely to apply fewer inputs of labour, fertilizer and draft-power per unit of land. This indicates that the land contract markets are poorly developed and information problem exists on the part of the landlord in screening potential tenants.

Controlling for other factors, the limited evidence of low probability and intensity of use of manure on sharecropped plots indicates the likelihood of soil nutrient depletion in the long-run that may lead to a decline in the production capacity of these plots. The findings also show that tenants' decisions on plot level management and agronomic practices were mainly guided by their short-term economic interests. Farmers apply good soil fertility management practices (manure and inorganic fertilizer use) on plots of relatively good quality, close to the residence and where rainfall conditions are relatively good. In the case of fertilizer, there was better application on high value crops such as *Teff*. A further indicator of such short-term economic orientation is that land owners currently make minimum input contribution (if any at all) under current sharecropping arrangements. Although this could be caused by their limited capacity to do so, it might be also due to rent-seeking behaviour by land owners. Either way it contributes to unsustainable land use. Thus, tenancy laws should address the negative externalities of land contract markets to protect public interest in sustaining land resources.

The tenancy factors therefore have mixed impacts on tenants' decisions over input use and intensity of use, depending on the type of input considered. When the value of the input can be recovered in one season, the tenancy status of the plot does not affect the intensity of their use. However, tenancy status does have some effect on the use of inputs, such as manure, whose effect last for more than one season although statistically not strong evidence.

Tenants that own large cultivable land holdings, apply less manure, labour and draft-power inputs per unit of land. This implies lack of competition in the land contract markets which may be caused by lack of information (Ray, 1998) and poor development of factor markets in general (Pender and Fafchamps, 2001). Institutional incentives to increase participation of farmers in land contract markets might help to increase competitive land use and land management.

Tenancy and resource use efficiency

A stochastic frontier production function analysis results show a significant level of technical inefficiency in the production systems of the study area. However, the technical inefficiency was not strongly associated with the tenancy status of the plot, *ceteris paribus*. There is a wide range of variation in resource use efficiency among households which are mainly associated with the tenants' endowment of livestock and the population density of the area. Greater efficiency in high population density areas could be due to higher competition for land and economic opportunities in output markets in these areas. This lends support to the view that with a better developed land market, the efficiency of resource use should not vary by plot tenancy status (Pender and Fafchamps, 2005).

Studies in Ethiopia and elsewhere provide mixed conclusions about the efficiency of sharecropping compared to alternative forms of tenure. Some empirical studies have found sharecropping to be inefficient compared to owner-operated plots (Gavian and Ehui, 1999; Ahmed *et al.,* 2002), others have reported otherwise or found no difference (Nabi, 1986; Kalirajan, 1990; Pender and Fafchamps, 2001 & 2005). The latter group argued that (in)efficiency may be explained by other non-tenure factors (Kalirajan, 1990) and the poor development of factor markets in general (Pender and Fafchamps, 2001 & 2005). Gavian and Ehui (1999) also acknowledge other possible causes of inefficiency related to input quality and application problems rather than differences in the intensity of input use. The results from the current study do not show statistically valid conclusion on the impact of plot tenancy on inefficiency of production.

Implication of tenancy arrangements for sustainability

Sharecropping contracts in Tigray mostly last for one growing season. There are also legal restrictions on the duration of contracts, contingent upon the type of technology used by the tenant. Both these arrangements give rise to concern over the sustainability of farmland use in the region. Land contracts are informal and are extended on a seasonal basis. Such an arrangement does not give security to the tenant, even if operating the plot for long period (Nabi, 1986). This provides little incentive for the tenant to invest in long-term improvements (Banerjee and Ghatak, 2004). It also encourages tenants to focus on short-term objectives which are achieved through exploitative production technologies which adversely affect the future productivity of land (Otsuska *et al.,* 1992; Ray, 2005). The current study also found better use of manure when tenants feel more security in terms of operating the plots for longer duration. Policy-makers should revisit the current law to alleviate the potential undesirable effects of such restrictions on the duration of contracts.

In terms of the relevance of this study to the empirical research, the findings show that the Marshallian view of undersupply of inputs by tenants do not consistently apply for all variable inputs, as this was not the case for fertilizer, pre-harvest labour and draft-power in this study. Besides we did not find a statistically strong evidence to support the the inefficient nature of sharecropping. The existence of tenants who sharecrop-in many plots, despite the fact that they are likely to manage the plots less intensively, shows an information problem on the part of the land owners and the generally poorly developed state of the land contract and other factor markets (Ray, 1998; Pender and Fafchamps, 2005). This requires further research, both on the demand and the supply side of the land contract market, to identify the reasons for weak development of the land contract markets and the dominance of sharecropping in the region.

7.3. Risk perception and farm management

Risk has wide implications for rural development (Fafchamps, 2003). Empirical research identifies concern about risk and uncertainty as major determinants of farmers' decisions on crop choice and resource allocation, use of institutional credit and marketing, and investment in land management (Huijsman, 1986; Smidts, 1990; Mazid and Bailey, 1992; Paudel *et al.*, 2000). Heterogeneity in perceptions of risk causes differences in crop and land management practices and production systems (Feinerman and Finkelshtain, 1996; Paudel *et al.*, 2000; Bacic *et al*., 2006). Risk considerations compel poor farm households to orientate on activities and production systems that minimize income variation, and limit their willingness to adopt new systems that will increase the mean and possible variability of income (Fafchamps, 2003). It is therefore essential that research and extension systems aiming at rural development understand the attitude of decision-makers (Bard and Barry, 2000; Moscardi and de Janvry, 1977).

An objective measure of risk and uncertainty is required in order to assess how farmers' risk perceptions influence their production and land management decisions. However, in practice, measuring risk and uncertainty is problematic and it has to be inferred from measurable proxy indicators (Dillon and Scandizzo, 1978; Krahnen *et al.*, 1997). Farmers use their subjective expectations of the range of the most probable good or bad outcomes of any given decision. This study developed an indicator of farmers' risk perception based on their subjective expectations of the range of yield variation for three crops, assuming different hypothetical rainfall conditions, during a production season. Farm household heads' experience of yield variation of major crops for assumed 'poor', 'most common' and 'good' rainfall scenarios were used to generate the corresponding yield scenarios. No reliable probability of occurrence could be quantified, objectively or subjectively, for the rainfall scenarios, which made it difficult to compute the expected levels of output on the basis of probability of each scenario occurring. Therefore, farm household heads' own estimation of yield levels as the 'lowest', 'most-likely', and 'highest', corresponding to the rainfall scenarios in the same order, were obtained directly.

The risk perception of a decision-maker can be illustrated by the pattern of the mean and the variance of the expected yield scenarios. Following Hardaker *et al*. (1997), the mean and variance of expected yield were computed using the triangular probability distribution based on the three-point yield estimates given by farmers. Small mean and large variance values represent a high level of yield uncertainty or production risk. The ratio of the variance to the mean of the expected yield is used to scale farmers' risk perceptions. In this scaling values close to zero indicate a low risk perception and those close to unity a high risk perception. This scaling, which shows how farmers differ in their risk perceptions, is also of value in explaining their choice of crop and land management practices.

The findings show that farmers associate a high degree of variability with a high expected mean yield for a specific crop. That is, farmers associate a high level of yield variance or uncertainty with production practices that give high yields. Low rates of adoption of improved practices in the study areas might be related with the high level of risk that farmers associate with these practices. This is in line with the empirical literature (Huijsman, 1986; Smidts, 1990; Mazid and Bailey, 1992; Paudel *et al*., 2000). In both study villages, farmers perceive high 'downside risk' in their production systems. The computed mean yield is lower than the most-likely yield expectation of farmers on a high proportion of plots under barley, wheat and pulses.

Farmers in the study villages differed widely in their risk perceptions even they face similar environmental constraints. Decision-maker's perception of production risk was strongly positively associated with his/her age, possession of a marketable skill, livestock endowment, and participation in agricultural training. The risk perceptions of decision-makers also differ by crop type. These findings are in line with results from empirical studies elsewhere that used the more conventional approaches to risk attitude analysis (Moscardi and de Janvry, 1977; Dillon and Scandizzo, 1978; Sitkin and Pablo, 1992; Feinerman and Finkelshtain, 1996).

Farm management input use and labour investment in land management by farmers did not show statistically significant associations with the risk perception of farm decision-makers. Labour investment for land management was significantly positively associated with the resource capacity of the household in terms of farm assets, particularly endowments of livestock and cultivable land.

7.4. Institutions of resource management

Rural households in developing countries are dependent on common pool resources (CPR) for their livelihoods. Collective investment by community members in CPR management is therefore necessary to sustain the role of these communal resources. However, some individuals fail to comply with the collective rules and conventions for CPR management and it is important for policy makers to understand why this occurs (Bromley, 1986; Wade, 1994; Ostrom, 1994; Agrawal, 2001).

In the literature the successful management of the commons is found to be associated with factors related to the nature of the resource, the actors' characteristics, the institutional arrangements and the broad external environment (Agrawal, 2001; Sekher, 2001; Ostrom, 1994; Gibson *et al.*, 2005). At the household level, individuals assess the opportunity costs of their contributions (Hardin, 1968; Becker, 1990), and evaluate the fairness of the distribution rules and the magnitude of benefits that they receive from CPRs (Murty, 1994; Ruben and Castro, 1996; McCarty *et al.*, 2001). Changes in the internal and external environments of households, which might arise as a result of policy interventions in other aspects, influence households' motivation and capacity to contribute to CPR management. Therefore flexibility in the design of collective rules is needed to accommodate such changes (McKean, 1986; Jodha, 1989; Ostrom *et al.*, 1994). For example, an increase in the participation of rural households in the labour markets in southern Tigray was found to increase the opportunity cost of labour contributions for resource management (Woldehanna, 2000; Woldehanna and Oskam, 2001).

In Tigray collective resource management is conducted through a household level labour quota system under which each able-bodied adult member of a household contributes

22 to 28 person-days annually during December/January. However, the system has faced major challenges due to a decline in these annual contributions. This study used household level data to identify the factors that explain farmers' non-compliance with the system. It also aimed to identify the institutional and policy innovations needed to enhance the role of collective institutions for resource management in the region.

Acceptance of the labour quota system by households varies depending on the resource conditions of the village. In Gobo Deguat, where resources are poor and degradation is high, 96% of households were in favour of labour mobilization while in Tegahne, where resource conditions are relatively better, only 62% of households were in favour of the system. Not surprisingly, the total per household labour contributions in Gobo Deguat is higher than in Tegahne. However, a significant proportion of households, nearly 50% in Gobo Deguat and 65% in Tegahne, contributed less than half of the quota during the agreed period during the survey year (2002/03). The degree of non-compliance varies between households within a village. In Tegahne, key informants were in favour of individually carrying out conservation works on farmlands allocated to households. This indicates the need for a different approach for mobilization and/or allocation of labour, depending on the context of villages.

The sanctioning system for non-compliance is weak in both villages. The village councils frequently do not enforce the established penalty system. From the literature, it can be inferred that, under such a weak sanctioning system, free-riding behaviour develops and in turn provides a disincentive for complying households (McKean, 1986; Dong and Dow, 1993; Ostrom, 1994; Baland and Platteau, 1996). It is therefore also important to identify the problems that the village councils have in effectively implementing the established bylaws.

The level of non-compliance is significantly affected by the labour endowment of the household, although in a non-linear way (U-shaped). Non-compliance initially declines with an increase in the household's labour endowment but then starts to increase as the labour endowment increases. A household with a larger labour endowment has more capacity to contribute, but with an increase in household contributions, a household's share of the total cost of collective action increases. A related finding is that households that celebrate fewer religious and cultural holidays during the collective work month show better compliance. Taking individual contributions as a basis for the distribution of benefits may minimize the problem of uniform contributions, although it may still fail to generate the critical minimum resources required for a viable team work (Burkett and Putterman, 1993).

Households with a larger livestock endowment show a higher level of non-compliance. Livestock management is the most labour-consuming production activity of households in the study villages. Communal resource management activities reduce the open areas for livestock grazing and increase the labour needed for looking after cattle. The effect of livestock endowment is thus twofold: in terms of competition for labour and its negative motivational impact as livestock owners have less open land for their livestock to roam freely on. This diminishes both the motivation and the capacity of households to contribute to collective action (Wade, 1994; Ostrom, 1994).

The age of the household head is found to have influence, with older ones showing a higher degree of non-compliance. This may be related to their inherent short time preference. It is not also clear whether the benefits from collective investment are inheritable, as is the case of user-rights on farmlands. Theesfed (2004) found similar results in a study of collective management of irrigation systems in Bulgaria.

Overall, the findings show that the differing socioeconomic circumstances of subsistence households determine their capacity and motivation to comply with collective action institutions. Collective mobilization of labour thus has different implications, depending on households' resource endowments and their comparative advantage. There is a need for careful analysis of the household context in designing labour-mobilization based institutions for resource management. Flexibility in the timing of the collective work, considering the suitability for various groups within a village, might help increase the level of contributions. Integrating community resource management with household level forestry package programmes, such as those in Tegahne village may help to optimize the use of labour at household level.

In conclusion, a labour quota system is one way of mobilizing local capacity for sustainable resource management. However, it has to be organized so that inter-household and inter-village differences are taken into account. In its current form, the system lacks economic considerations and this is one likely reason for the high level of non-compliance. Existing bylaws are not effectively complied with and lack completeness in defining the distribution of benefits. There is a need for matching the distribution of the costs of collective action with the expected benefit. Households with higher labour opportunity costs could contribute hired labour or cash, which would enhance the functioning of labour markets and investment in public goods. Hence, policy makers need to consider creating an environment conducive for cooperating households and design new institutions that take their comparative advantages into account. This may imply a need for a shift from the current geographic boundary based organization of collective action to alternative institutional setups with combined economic and ecological objectives. One such example would be cooperative resource management systems where households, who are willing and able to contribute resources, take responsibility for organizing collective action.

7.5. Policy implications and further research

Policy implications

The three issues addressed in this study are interrelated and can be addressed within the context of a rural household system. One of the reasons cited in the literature for the existence of sharecropping is the risk aversion behaviour of tenants (Stiglitz, 1974). In general this is caused by missing or imperfect markets (Nabi, 1985; Sign, 1989; Pender and Fafchamps, 2001). Sharecropping serves as insurance system for tenants with high perceptions of risk because tenants pay a share of the output at the end of the season and the level of risk sharing increases when land owners share the production inputs. However, in Tigray, the land owners partly shift some risk to the tenant households as land owners share inputs in limited cases. In the absence of an institutional risk management system and with a poorly developed capital market, land owners and tenants may continue to depend on limited forms of land contract arrangements. The non-compliance with labour quota system may also be related to farmers' income risk management strategies. Farmers engage in labour markets and self-employment during the off-season to smooth income fluctuations due to problems with their farming.

One important policy implication of this study is that policy-makers need to simultaneously address the issues of agricultural intensification and resource management, using harmonious policy measures. Resource rehabilitation through local resource mobilization, such as the household labour quota system, should not conflict with farmers' engagement in off-farm activities and the labour market, which are central elements of the poverty reduction strategy. Farmers sharecropping-in land face a higher demand for labour for land preparation, work which usually starts early in the dry season, and this may also reduce their labour contribution. Thus, policy-makers should work to harmonize different policy objectives in the region and allow flexible approaches to encourage household level contributions for resource management.

Illustrative policy proposal could be providing institutional risk management service (e.g. crop insurance) to farmers adopting recommended farm management practices and investing on their private plots, and introducing private or small group responsibility in CPR management. This policy proposal addresses the missing market for crop insurance, which would enable farmers to reduce their myopic risk perceptions and cope with the potential risk of adopting new crop management practices and technologies. This may be expected to increase input use and private investment for land management at plot level, since it will increase the liquidity status and risk coping capacity of households. If qualification for such an insurance service is contingent upon a household's participation in communal resource management, both production and resource management objectives could be better achieved in the region. A private or small-group responsibility for CPR management also addresses some of the main limitations of the current approach and promotes the innovative practice of communal land allocation for landless households for tree plantation in some villages. This approach addresses the problems over benefit distribution, rigidity in the timing of mobilization, and the enforcement cost of collective rules. Such a policy proposal also assumes the need for a governmental programme to support the local contributions made for agricultural development and resource conservation in less-favoured areas.

On another level there is also a need for clear policy framework governing land contracting in the region in order to formalize contracts and protect the public interest in sustaining farmland use. Revision of the restriction on contract duration is necessary to encourage long-term contracts which may lead to a smooth transfer of households that depend on sharecropping-out their land to other economic sectors.

In addition, extension messages should be designed to improve farmers' understanding of potential land contract markets, institutional risk management strategies, and the role that collective resource management plays in improving their livelihood systems. Lack of information on these aspects is likely to lead to high transaction costs and informal arrangements which are neither legally enforceable nor efficient.

Finally, there is a need for re-defining the current geographic-boundary based organization of collective action and establish alternative institutional setups with combined economic and ecological objectives. The concept of decentralized resource management should be re-defined to allow social groups to set up appropriate institutional arrangements to organize collective action, based on their comparative advantages. Policy should create an enabling legal environment for this process to occur.

Further research

Consideration needs to be paid to dynamic elements and nature of the issues addressed in this study. For instance, the impact of short-term land contracts on productivity extends beyond one season. Efficient land contracts in a cross-sectional analysis do not imply efficiency in the long-term. The intensity of exploitation during one production season has an effect on future productivity, because of the impact on soil fertility (Dubois, 2002; Ray, 2005). The issues of production risk and labour quota systems can be incorporated into a non-separable farm household model that takes into account the possibilities of land contracting and contains feasible assumptions about labour markets. Further research is therefore needed to address these aspects in a dynamic setting.

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SUMMARY

Ethiopia faces a huge challenge in achieving food security and in sustainable rehabilitation of its degraded natural resource base. Meeting this challenge requires an institutional environment that is conducive for promoting local initiatives and adoption of technology. As part of this process it is important to empirically assess the effects of current policy and institutional interventions on agricultural productivity and natural resource conditions.

This study addresses three issues relevant to sustainable resource management and agricultural development in the context of the highlands of Tigray. The first concerns the impact of land contract arrangements on farmland management and agricultural productivity in the region. This is treated in Chapters 3 and 4. The second issue, which is covered in Chapter 5, assesses the impact of perceived, rainfall-related, production risk and the uncertainty of producers on the intensity of farm management inputs at plot level and investment in land management. The third issue concerns the effectiveness of the household level labour quota system as a collective resource management institution and the identification of household level factors that explain the degree of farmers' (non)-compliance with such systems in Tigray. This is the subject of Chapter 6. The findings of the study provide insights into the factors that influence the choice of crop and land management practices, productivity and the sustainability of collective action institutions in the study area. These findings should be of relevance to inform future policy.

Chapter 2 briefly provides the setting of the research area focusing on the natural, socioeconomic and institutional features, and the development and natural resource management strategies of Ethiopia, and the Tigray region in particular. It also provides a description of the research methodology and the analytical approach. It is intended to serve as a context for the issues investigated in subsequent chapters.

Chapters 3 and ***4*** investigate the impact of land contract arrangements on crop and farmland management input use decisions, and on the efficiency of resource use at plot level by tenant households in Tigray, Ethiopia, where sharecropping is the dominant type of land contracting arrangement. The analyses in these chapters use data from a sample of 115 'owner-tenant' households, operating 347 own and 192 sharecropped-in plots.

Chapter 3 presents the results of comparative analyses of the determinants of crop and land management input use and intensity of use decisions at plot level, and evaluates whether plot tenancy status is a statistically significant determinant in tenants' input use decision. Four important farm management inputs are considered: manure, inorganic fertilizer (DAP and UREA), labour and draft-power. The probability of use of manure and its intensity are

analyzed using a two-step Heckman model which takes into account sample selection bias. In the case of inorganic fertilizer, the use and intensity of use decisions were analyzed using Probit and Tobit models, respectively, as the test for sample selection bias showed that these can be analyzed independently. In the case of pre-harvest labour and draft-power use, an ordinary least-squares model is used. The empirical findings show that, controlling for household, crop, plot, and agro-ecological factors, the use and intensity of use of fertilizer, labour and draft-power do not show statistically significant variation on owned and on sharecropped-in plots. The probability and intensity of manure use was marginally lower on plots for which tenants receive two-thirds of output compared to own plots, and the likelihood of manure use was higher when tenants felt better security of tenure as measured by their expectation of longer duration of use of the plots. Tenants who sharecrop-in many plots were found likely to apply fewer inputs of labour, fertilizer and draft-power per unit of land. This indicates that land contract markets are poorly developed and information problem exists on the part of the landlord in screening potential tenants.

Chapter 4 presents the results of a resource use efficiency analysis to compare the efficiency achieved by tenants' on their own and on sharecropped-in plots, and identifies the major determinants of efficiency differentials. A stochastic frontier production function analysis shows a significant technical inefficiency in the production systems assessed. The overall mean technical efficiency was 65%, ranging from 18% to 87%. *Ceteris paribus*, the technical efficiency levels were not found to vary by the tenancy status of the plot. Resource use efficiency was significantly positively associated with livestock endowment of the tenant household and with population density. One of the concerns over sharecropping arrangements in Tigray is the prevalence of one season contracts, which are likely to create an incentive for tenants to focus on short-term economic objectives. Moreover, current rural land policy restricts contract duration. Policy makers should reconsider this restrictions and allow parties to establish longer contract periods should they wish so.

Chapter 5 assesses the impact of farmers' perceptions of rainfall-related risk and uncertainty on the intensity of crop and land management that they apply at plot level. It uses data from a survey of 155 sample households in two villages in the highlands of Tigray carried out in the 2002/03 production season. This analysis firstly develops a simple indicator of production-risk perception of farm decision-makers, based on farmers' subjective expectations of the range of yield variations under different assumed rainfall scenarios. The method is based on the mean and variance of expected yield, computed using the triangular distribution for a three-point estimation of minimum, most-likely and maximum yield expectations, which correspond to poor, most-likely, and good rainfall scenarios, respectively. A small mean and a large variance represent a high level of yield uncertainty or production risk and the ratio of the variance of the expected yield to the mean is used to scale farmers' risk perceptions. In this scaling a value close to zero indicates low risk perception and close to unity a high risk perception.

The findings show that farmers associated production practices that give high yields with a high level of yield variance or uncertainty. In both study villages, farmers perceived significant downside risk in their production systems. The computed expected mean yield was lower than the most-likely yield expectation of farmers for a high proportion of plots under barley, wheat and pulses. Decision-makers' perception of risk is strongly positively associated with his/her age, possession of a marketable skill, livestock endowment, and participation in agricultural training. The risk perception of decision-makers was also found to vary by crop type. Farm management input use and labour investment in land management by farmers did not show statistically significant associations with the risk perception of farm decision-makers. Labour investment for land management was significantly positively associated with the resource capacity of the household in terms of farm assets, particularly endowments of livestock and cultivable land. Overall, the results imply the need for institutional risk management services to promote the use of technologies and optimal input levels by farmers in the study area.

Communities in Tigray conduct communal resource management, based on household labour quota system. One of the problems of this system is maintaining the commitment of members in terms of observing collective rules and fulfilling individual contributions. ***Chapter 6*** focuses on identifying the household level factors that influence the (non)-compliance of households with the labour quota system in two case study villages in Tigray. The data used in this analysis is obtained from the same sample of households as in Chapter 5. The empirical findings show that non-compliance with the labour quota was higher among households with older household heads and a better livestock endowment. A non-linear U-shaped relationship is found between household labour endowment and the level of non-compliance. These results reveal that, as an institution for collective action, the labour quota system needs to be adapted to the context of the villages and the contributing households. Policy makers could therefore give consideration to re-designing the existing approach of household level labour quota systems so that they become more self-sustaining system of resource management. The concept of decentralized resource management should be extended beyond geographic or administrative criteria and enrol those social groups that are most capable of efficiently organizing collective action.

Chapter 7 discusses the major findings and conclusions from each of the research issues addressed in this study. It draws relevant policy implications and identifies future research needs. In broader terms, the study asserts that sustainable rural development requires institutional inputs to enhance the mobilization of human and material resources, and their efficient utilization. Policy-makers also need to harmonize institutional interventions so that policy objectives do not conflict. For example, resource rehabilitation through local resource mobilization, such as the household labour quota system, should not conflict with farmers' involvement in off-farm activities and the labour market, which are the central elements of the national poverty reduction strategy. The chapter also outlines some points for policy consideration to enhance factor markets and the organization of collective resource management. It also suggests the need for policy interventions to create an institutional risk management system in the region. Furthermore, as the issues dealt in this study have a dynamic nature, further research on specific aspect of these topics is recommended.

SAMENVATTING (SUMMARY IN DUTCH)

Voor Ethiopië is het bereiken van voedselzekerheid en het duurzaam herstellen van de gedegradeerde natuurlijke hulpbronnen een enorme uitdaging. Dit vereist een institutionele omgeving die lokale initiatieven en technologische vooruitgang bevordert. Als deel van dit proces is het belangrijk om de effecten van het huidige beleid en de institutionele interventies op de landbouwproductiviteit en de toestand van de natuurlijke hulpbronnen empirisch te beoordelen.

Deze studie richt zich op drie onderwerpen die relevant zijn voor het duurzame beheer van hulpbronnen en landbouwontwikkeling in de hooglanden van Tigray. Het eerste onderwerp betreft het effect van pachtovereenkomsten op het beheer van landbouwgronden en de landbouwproductiviteit in de regio. Dit wordt behandeld in hoofdstukken 3 en 4. Het tweede onderwerp wordt behandeld in hoofdstuk 5 en betreft het bepalen van het effect van subjectieve, regenval-gerelateerde, productierisico's en onzekerheid van boeren, op de intensiteit waarmee landbouwproductiefactoren worden aangewend op perceelsniveau en investeringen in het beheer van landbouwgronden. Het derde onderwerp is de effectiviteit van het quotasysteem van familie-arbeid als een institutie voor het collectieve beheer van hulpbronnen en tracht de factoren op huishoudniveau te identificeren die de mate van medewerking van de boeren aan zulke systemen in Tigray verklaren. Dit is het onderwerp van hoofdstuk 6. De bevindingen van deze studie geven inzicht in de factoren die de keuze van gewassen en toepassingen in het beheer van landbouwgronden, productiviteit en duurzaamheid van de samenwerkingsovereenkomsten in het bestudeerde gebied beïnvloeden. De resultaten zouden relevant moeten zijn voor het toekomstige beleid.

Hoofdstuk 2 geeft een bondige beschrijving van het onderzoeksgebied met specifieke aandacht voor de natuurlijke, sociaal-economische en institutionele kenmerken, en de strategieën voor een economische ontwikkeling en het beheer van natuurlijke hulpbronnen in Ethiopië en de regio Tigray in het bijzonder. Er wordt eveneens een beschrijving gegeven van de onderzoeksmethodologie en de analytische benadering. Het is de bedoeling de context weer te geven van de onderwerpen die in de daaropvolgende hoofdstukken worden onderzocht.

Hoofdstukken 3 en 4 bestuderen de impact van pachtovereenkomsten op beslissingen van gewaskeuze en inputgebruik in het beheer van landbouwgronden evenals de impact op de efficiëntie van het gebruik van hulpbronnen op perceelsniveau door pachthuishoudens in Tigray, Ethiopië, waar deelpacht de meest voorkomende vorm van pachtovereenkomst is.

Voor de analyses in deze hoofdstukken wordt gebruik gemaakt van data van een steekproef van 115 boerenhuishoudens die 347 eigen en 192 gepachte percelen bewerken.

In hoofdstuk 3 worden de resultaten gepresenteerd van vergelijkende studies naar de determinanten van gewaskeuze en inputgebruik in het beheer van landbouwgronden en de beslissingen over intensiteit van het inputgebruik op perceelsniveau. Het evalueert of de pachtstatus een statistisch significante factor is in de beslissingen die de pachter neemt over het inputgebruik. Vier belangrijke inputs worden onderzocht: stalmest, kunstmest (DAP en UREUM), arbeid en trekkracht. De waarschijnlijkheid van het gebruik van stalmest en de intensiteit daarvan worden geanalyseerd in een *two step Heckman* model dat rekening houdt met de bias in de steekproefselectie. Het gebruik en de intensiteit waarmee kunststoffen worden gebruikt zijn geanalyseerd met respectievelijk *Probit* en *Tobit* modellen, aangezien de test op steekproefbias liet zien dat deze onafhankelijk konden worden beschouwd. Voor het bestuderen van de inzet van arbeid en trekkracht voor de oogst is een *Ordinary Least-Squares* model gebruikt. De empirische resultaten tonen aan dat het gebruik en de intensiteit waarmee kunstmeststof, arbeid en trekkracht worden gebruikt niet statistisch verschilden tussen de eigen en gepachte percelen. De waarschijnlijkheid en intensiteit van het gebuik van stalmest bleken slechts marginaal lager op percelen waarvan de pachter twee-derde van de opbrengst behoudt ten opzichte van zijn eigen percelen. De kans op het gebruik van stalmest is hoger wanneer de pachters zich beter beschermd voelen, wat gemeten werd door de duur van ingebruikname van deze percelen. Voor pachters die deelpachten op meerdere percelen is de waarschijnlijkheid groter dat ze minder arbeid, meststoffen en trekkracht per oppervlakte land gebruiken. Dit geeft aan dat de markten voor pachtovereenkomsten slecht ontwikkeld zijn en dat de eigenaar van het land stuit op problemen met het verkrijgen van informatie bij het screenen van potentiële pachters.

In hoofdstuk 4 worden de resultaten gegeven van een efficiëntie analyse waarbij de efficiëntie verkregen door de pachters op hun eigen land wordt vergeleken met die bereikt op hun deelpact percelen. Het identificeert de voornaamste oorzaken van de verschillen in efficiëntie. Een *stochastic frontier* analyse van de productiefunctie laat zien dat er binnen de productiesystemen significante technische inefficiëntie bestaat. De gemiddelde technische efficiëntie was 65%, met een spreiding tussen 18% en 87%. De technische efficiëntie blijkt, rekening houdend met alle andere factoren, onafhankelijk te zijn van de pachtstatus van het perceel. Er werd een significant positief verband gevonden tussen de efficiëntie in het gebruik van hulpbronnen en de veestapel die het gezin bezit en de bevolkingsdichtheid. Eén van de zorgpunten voor de pachtovereenkomsten in Tigray is de dominantie van contracten die van kracht zijn voor één seizoen. Dit is waarschijnlijk een aansporing voor pachters om korttermijn doelstellingen na te streven. Bovendien beperkt het huidige rurale grondbeleid de lengte van de contractduur. Beleidsmakers zouden deze beperkingen moeten heroverwegen en de partijen toestaan langere contractperioden overeen te komen als zij dat zouden willen.

Hoofdstuk 5 bestudeert het effect van subjectieve, regenval-gerelateerde, productierisico's en onzekerheid van de producenten op de intensiteit van het gewas- en landbeheer op perceelsniveau. Er wordt data gebruikt uit een enquête uitgevoerd in het groeiseizoen 2002/2003 bij een steekproef van 155 families in twee dorpen in de hooglanden van Tigray. De analyse begint met het ontwikkelen van een eenvoudige indicator voor de risicoperceptie van de boeren, gebaseerd op de subjectieve verwachtingen van de boeren van de hoogte van de opbrengstvariatie onder verschillende regenvalscenario's. De methode is gebaseerd op het gemiddelde en de spreiding van de verwachte opbrengst en berekent de minimum, meest waarschijnlijke en maximale verwachte opbrengst voor respectievelijke slechte, gemiddelde en goede regenvalscenario's onder de veronderstelling van een driehoeksverdeling. Een laag gemiddelde en een grote spreiding duiden op een hoog niveau van opbrengst onzekerheid of productierisico, en de verhouding tussen de spreiding van de verwachte opbrengst en het gemiddelde wordt gebruikt om de risicoperceptie van de boer in te schatten. In deze schaal wijst een waarde van bijna nul op een lage risicoperceptie en een waarde dichtbij één op een hoge risicoperceptie.

De resultaten geven aan dat landbouwers productiemethodes met een hoge opbrengst associeerden met een grotere spreiding van de opbrengst of onzekerheid. In beide dorpen ondervonden de producenten significant "*downside risk*" in hun productiesystemen. Voor een groot deel van de percelen met gerst, tarwe en peulvruchten was de verwachte gemiddelde opbrengst die werd berekend lager dan wat de boeren aangaven als de meest waarschijnlijke verwachte opbrengst. De risicoperceptie van de beslissingsnemers vertoonde een sterk positief verband met de leeftijd van het gezinshoofd, zijn/haar verkoopkwaliteiten en deelname aan een agrarische opleiding. De risicoperceptie van de beslissingsnemers varieerde ook per gewas. Er bleken geen statistisch significante verbanden te zijn tussen de risicoperceptie van de producenten en de investering van arbeid in het beheer van landbouwgronden. Er was een significant verband tussen het investeren van arbeid in het beheer van landbouwgronden en het vermogen van het huishouden in termen van agrarische bedrijfsmiddelen, in het bijzonder het aantal stuks vee en landbouwgrond. Over het geheel geven de resultaten de noodzaak aan van institutionele diensten voor het beheren van risico's ten einde het gebruik van technologieën en de optimale inzet van inputs door de boeren in het studiegebied te promoten.

Het gemeenschappelijke beheer van hulpbronnen is in Tigray gebaseerd op een quotasysteem van arbeid per huishouden. Eén van de problemen van dit systeem is het instandhouden van de verplichting van de leden om de collectieve regels na te leven en te voldoen aan de individuele bijdragen. De analyse in hoofdstuk 6 tracht de belangrijke factoren op huishoudniveau te identificeren die het al dan niet naleven van het arbeidsquota systeem in twee dorpen in Tigray beïnvloeden. De data voor deze analyse komen uit dezelfde steekproef die gebruikt is in hoofdstuk 5. De empirische resultaten tonen aan dat het niet-nakomen van de arbeidsquota hoger is bij huishoudens met een ouder gezinshoofd en meer vee. Een niet-lineair verband met een verloop gelijkend op een U is gevonden tussen de hoeveelheid familie-arbeid en de graad waarmee de gezinnen de afspraken niet nakomen. Deze resultaten geven aan dat het quotasysteem van familie-arbeid als institutie voor gemeenschappelijk landbeheer moet worden aangepast aan de context van de dorpen en aan de huishoudens die daaraan bijdragen. Beleidsmakers zouden daarom kunnen overwegen om het bestaande quotasysteem van familie-arbeid te herzien tot een systeem voor het beheer van hulpbronnen dat beter op zichzelf kan bestaan. Het concept van een gedecentraliseerd hulpbronnenbeheer zou moeten worden uitgebreid met verruimde geografische of administratieve criteria en deze sociale groepen aantrekken die het best in staat zijn om een collectief project efficiënt te organiseren.

In hoofdstuk 7 worden de belangrijkste resultaten en conclusies besproken van elk van de onderzoeksonderwerpen waarop deze studie zich heeft toegelegd. Het geeft relevante conclusies voor beleid en identificeert onderwerpen voor toekomstig onderzoek. In een breder perspectief beweert de studie dat duurzame agrarische ontwikkeling institutionele inzet vereist om de mobilisatie van menselijke en materiële hulpbronnen en de efficiëntie ervan te verbeteren. Beleidsmakers dienen ook institutionele interventies op elkaar af te stemmen zodat de doelstellingen ervan niet strijdig zijn. Het rehabiliteren van hulpbronnen door het mobiliseren van lokale middelen, zoals het quotasysteem van familie-arbeid, zou bijvoorbeeld niet moeten conflicteren met de betrokkenheid van boeren in activiteiten buiten het landbouwbedrijf en op de arbeidsmarkt, wat centrale elementen zijn van de nationale strategie ter bestrijding van armoede. Het hoofdstuk geeft tevens enkele punten aan die in het beleid van landeigendomsrechten en de organisatie van gemeenschappelijk beheer van hulpbronnen kunnen worden overwogen. Het suggereert eveneens de noodzaak voor beleidsinterventies om te komen tot een institutioneel systeem dat instaat voor het beheer van risico in de regio. Daar de onderwerpen die in deze studie worden behandeld een dynamisch karakter hebben, wordt toekomstig onderzoek op deze onderwerpen aangemoedigd

TRAINING AND SUPERVISION PLAN

Description	Institute / Department	Year	Credits
Courses			
Techniques for writing and presenting a scientific paper	Mansholt Graduate School	2001	1
Social Science Research Methods	Mansholt Graduate School	2001	1
Mansholt Introduction course	Mansholt Graduate School	2002	1
Multi-disciplinary seminar	Mansholt Graduate School	2006	1
Multi Agent System for Natural Resource Management	Mansholt Graduate School	2001	2
Pathways to Agricultural Intensification	Mansholt Graduate School	2001	2
Agroecological Approaches for Rural Development	Graduate School for Production Ecology and Resource Conservation	2002	1
Bioeconomic farm and village modelling	Mansholt Graduate School	2002	1
Macroeconomic Analysis and Policy	Wageningen University	2002	3
Advanced Household Economics	Wageningen University	2002	3
Quantitative Analysis of Development Policy	Wageningen University	2002	3
Agricultural Economic Models	Wageningen University	2002	5
Econometrics II	Wageningen University	2002	4
Regional Agricultural Development: Analysis & Policy	Wageningen University	2002	3
Resource Flow Mapping in Tropical Farming Systems	RESPONSE & TSBF, ICRAF	2003	1
Theoretical Topics in Ecological Economics	School of Ecological and Environmental Economics, ICTP, Italy	2003	2
Workshop on 'Policies Sustainable Land Management in the Highlands of Tigray, Ethiopia'	Mekelle University, Ethiopia	2003	1
Presentations at conferences and workshops			2
International workshop on 'Development strategies for less-favoured areas', RESPONSE July 12 & 13, Wageningen, The Netherlands		2002	
Conference on 'Theoretical topics in Ecological Economics', February 10-21, 2003 Trieste, Italy, Organized by the Beijer Institute of Ecological Economics and the School of Ecological and Environmental Economics, ICTP.		2003	
International workshop on **'**Sustainable Poverty Reduction in Less-Favoured Areas**',** December 8 & 9, 2005, Wageningen , The Netherlands, Organised by Wageningen University & International Food Policy Research Institute (IFPRI)		2005	
Total (minimum 20 credits)			**37**

*One credit is equivalent to 40 hours of coursework

CURRICULUM VITAE

Girmay Tesfay was born December 31, 1972 in Mekelle, Tigray, Ethiopia. He joined the Alemaya University of Agriculture in September 1989 and obtained B.Sc. degree in Agricultural Economics in August 1993. In September 1993 he was hired by the Mekelle College of Dryland Agriculture and Natural Resources. After working for a year, in October 1994, he joined the University of North Wales (Bangor College), UK for his M.Sc. studies in Rural Resource Management and graduated in March 1996. His M.Sc. thesis title was 'Methodological review for the economic assessment of soil conservation and water harvesting practices' with a case study from Tigray. From April 1996 to August 2001 he worked with Mekelle University as a teaching and research staff. During this period he has attended a number of short-courses in Ethiopia and abroad: A curriculum development course in February 1997 and a course on teaching methodology in August 1998 at the Larenstien International College of Agriculture, the Netherlands; a trainers training on 'Food Security Policy' in August/September 1999 in Addis Ababa organized by the Tigray Integrated Food Security Desk and the GTZ-Integrated Food Security Program (IFSP) in Tigray; and advanced courses on 'Property Rights Structure and Environmental Resource Management' in March 2001 in Luxor, Egypt and on 'Theoretical topics in Ecological Economics' in January/February 2003 in Trieste, Italy, both organized by the Beijer Institute of Ecological Economics.

Side by side to his academic duties, from 1998 to 2001, Tesfay has worked as a local project coordinator and team member for a research project on 'Policies for Sustainable Land Management in the highlands of Tigray, Ethiopia' implemented by the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI) and the Mekelle University. For his contributions as a research team member of the project, he received a certificate of the 'Neville Clarke Award for Outstanding Teamwork' from ILRI in 2001. Tesfay joined the Development Economics Group of Wageningen University in September 2001 as a Ph.D. researcher under the RESPONSE program. During the period of his appointment as a Ph.D. researcher, he has successfully completed the training program of the Mansholt Graduate School and was involved in teaching and research activities of Mekelle University during his stay in Ethiopia for two and half years (2003-2004/5).

Regional Food Security Policies for Natural Resource Management and Sustainable Economies

The research presented in this thesis was carried out within the framework of the RESPONSE (*Regional Food Security Policies for Natural Resource Management and Sustainable Economies*) programme, a joint initiative of Mansholt Graduate School for Social Sciences, C.T. de Wit-Graduate School for Production Ecology and Resource Conservation, and Wageningen Institute of Animal Sciences (WIAS) at Wageningen University and Research Centre (WUR), and the International Food Policy Research Institute (IFPRI) in Washington, D.C. The programme aims at supporting policy-makers in identifying alternatives for addressing poverty, food insecurity and natural resources degradation in less-favoured areas.

RESPONSE is one of the six multi-annual research programmes of the INterdisciplinary Research and Education Fund (INREF) of WUR, launched in 2000. INREF enables the cooperation of researchers from various Wageningen Graduate Schools, international and national research institutions in the South. The multi-annual research programmes focus on a variety of issues which cannot be tackled in a mono- or multi- disciplinary manner.

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