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Land Tenure in the Highlands of Eritrea: Economic Theory and Empirical Evidence

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CHAPTER ONE
Land Tenure Issues in Eritrea - Introductory and Overview

1. Introduction

In most developing countries agricultural land is still the main source of livelihood, investment, and wealth for the large majority of the population. As the result, the way land is instituted and distributed and ownership conflicts are resolved has a far-reaching consequence beyond the sphere of agricultural production (Deininger and Binswanger 1999). Land tenure systems[1] affect not only the ability of rural households to produce for their subsistence and for the markets (Shipton 1990; Rahmato 1993; Drèze and Sen 1989; Platteau 1992) but also their social and economic status, their incentive to work and use land resources sustainably, and their ability to self-insure or to obtain access to financial markets (Deininger and Binswanger 1999). As a result, issues of land tenure have been the subjects of hot debate in the theoretical and policy analysis on how to foster economic, social, and environmental goals in the developing world.

This PhD study focuses on the land tenure systems in the highlands of Eritrea with a particular emphasis on land rental markets, land contract choice, and on the implications of land tenure systems for farm household's resource allocation behaviour and efficiency outcomes. The objective is to look at the rationale for the existence of land rental markets and their role in compensating for imperfections in other factor markets, analyse the choice of land contracts in the presence of wealth/poverty differentials and imperfect markets for other factors, analyse the effects of tenure security on household investment behaviour and land productivity, and analyse the effects of land contracts on production efficiency. Apart from academic purposes, we hope that theoretical and empirical analysis of these issues would also contribute to the debate on land tenure and economic development in general and the land policy issue in Eritrea in particular. The analyses are made in chapters two-five of this dissertation, respectively. This dissertation has attempted to provide new insights on several of these issues.

The theoretical insights for analysing the different topics in this study comes from perspectives where individual households' behaviour is assumed to be conditioned by household objectives and a set of market and non-market institutional set ups and government policies and the bio-physical conditions that are external to the household. In particular we draw a lot from the imperfect factor market and information paradigms (De Janvry *et al*. 1991; Hoff and Stiglitz, 1993) and behavioral and material determinants of production relations in agriculture (Binswanger and Rosenzweig 1986 and Binswanger *et al*. 1989).

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[1] We refer to land tenure as the system of rights and institutions governing access to and use of land and other resources (Bruce 1993 and 1998); tenure defines who can use what land and how (Lastarria-Cornhiel 1995).

The data used for empirical analysis in this study comes from a household[2] survey (Appendix 1) carried out in the months of March-October, 2001 on 319 randomly selected households covering 32 villages[3] across five sub-regions in the highlands of Eritrea. The sub-regions selected represent contrasting features in terms of rainfall condition, land availability, population, access to irrigation, and integration into input and output markets. For each household in the sample, farm plot level and household characteristics data were collected for the rain-fed production season of year 2000. In addition, data on village characteristics such as distance to market towns, access to major roads, household population, water resources, and others were collected using a separate questioner (Appendix 2). We used econometric methods on the sample data to test relationships derived from theoretical analysis of the respective topics of interest. Except in chapter two where household level data is used, all the other chapters have used household plot level data for empirical analysis.

The rest of this introductory chapter is organized as follows. Section two provides some historical background on Eritrea, production constraint, and policy focus of the government. Section three discusses the issue of land tenure in the economic development literature by particularly focusing on the outstanding issues of controversy in the subject. Section four describes and discusses the land tenure system in the highlands of Eritrea from historical perspective and the reforms proposed in the new land policy of Eritrea. Section five provides a summary of research findings on the selected topics of interest, while section six lists the main conclusion of the dissertation.

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[2] In this dissertation we follow Sadoulet and De Janvry (1995) definition of households as a group that shares the same abode or hearth; those who reside and eat in one house and worked in the same group constitute a household unit.

[3] This figure does not include two villages that were included in the survey but dropped in the analysis because farm production in these villages was organized along collective type of agriculture in which case farm decisions were outside the control of the household.

2. The Challenges of Agricultural Development in Eritrea

With over 70 percent of the population working on agriculture (Table 1), Eritrea can be described as an agrarian society. Although Eritrea's endowment in land resources[4] is adequate relative to its population, the contribution of the agricultural sector to GDP is very low (about 20 percent) relative to the size of the agricultural work force (World Bank 1996 and 2002). The country's domestic grain balance is in most cases short of consumption requirements. For instance, output data for 1992-1998 for the Central and Southern regions indicated that overall yield (grain, pulses, and oil crops combined) ranges from one tone/ha in good years to 0.3 tone/ha in bad years (Figure 1). On average, this represents 30 percent lower than the minimum consumption requirement (Figure 2) for the population in the two regions. This is also consistent with the results obtained from a survey conducted in 1995 by Adugna *et al.* (1995) on 210 farm households in parts of the highland regions. In the survey, 67 % of the respondents indicated that, in good years, production is sufficient to satisfy household food requirement, and in bad years, 90 percent of them said it covers only a quarter of their food demand. At household level, production shortfalls create serious food insecurity problems.[5]

Decades of war, concurrent drought, poor agricultural technology and land management practices, and wrong policies pursued by previous administrations are some of the commonly cited reasons for the dismal records of the sector (FAO 1994; World Bank 1996).[6] Like the rest of Sahlian Africa, most of Eritrea receives its rainfall from Southwestern monsoon in the summer months, from April to October: *small rains* fall in April and May, and the *main rains* follow in July with the heaviest precipitation in July and August. The patterns of the rains in most of the country are, however, irregular in both quantity and distribution over the growing season. Irregular precipitations constrain efficient use of agricultural inputs, leading to either sub optimal or excessive use of some resources. In most cases, farmers are forced to adopt defensive low productivity production systems, such as sequential planting (FAO 1994), and low application of chemical fertilizer, particularly on soils with low moisture retention capacity (Adugna *et al*. 1995; FAO 1994) and preference for low value but low-risk crops - drought resistant - such as barley (Araya 2001). In expectation of low rainfall, farmers till their plots excessively in order to

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[4] The total land area of the country is 121676.97 km^2 (FAO 1994) of which about 12 percent is cultivable under rain-fed conditions, but only 4 percent is currently under cultivation (Table 2). It is also estimated that a further of 5 percent is potentially irrigable land, but very little of it is exploited. See Appendix 3 for administrative map of the country.

[5] As insurance against climatic risks and the ensuing production shortfalls, farm households combine different activities such as small-scale irrigation, off-farm work, animal sales, and remittances from migrant family members (Adugna *et al*. 1995; World Bank 1996).

[6] See ERD (1988 and 1992) for the effects of historical factors in general and war in particular on agricultural performance and environmental degradation in Eritrea.

allow percolation for ease of plant growth. This coupled with the rugged nature of the topography and highly erosive rainfall patterns that is typical of tropical rains, creates severe soil erosion and cause considerable loses of soil every year.[7] Furthermore, insecure land rights and population growth[8] (Abraham 1990; NEMP-E 1995; GOE 1994) have also contributed to the process of environmental degradation. Insecure land rights create the condition for low investment in land improving inputs and encourage inefficient cropping patterns. Given the scale of poverty in Eritrea[9], it may not also be ruled out that poverty, through its negative effect on investment, may have contributed to the process of environmental degradation. The 1994 FAO sector review noted that with appropriate incentive systems, improved technology, and prudent land and water resource management, a significant increase in production and yield could be achieved without major changes in the patterns of rainfall.

To redress the problem and make agriculture play its proper role in the economy, the government has put agriculture on top of the reconstruction and development agenda of the country.[10] While the overall policy objective has been agricultural rehabilitation and development, poverty alleviation and food security at both national and household level is also given high priority (GSE 1994). Environmental recovery and conservation was adopted as a strategy, among others, to rehabilitate agriculture and in particular to assist the medium to long-term food security objectives of the country. In *the Southwestern Barka* region, where the agricultural potential is high and population density is low, the focus is mainly in contributing towards national food security and economic growth objectives. In the relatively resource poor rain fed areas of the highly populated *Central* and *Southern* regions, the focus of government agricultural development policy is primarily on rehabilitating agriculture and improving household food security. In these regions, extensive works of soil and water conservation through dam and check-dam construction[11], catchments treatment through terracing and forestation of hillsides, and expansion

[7] In fact, soil erosion and depletion in the highlands of Eritrea are among the highest in the African continent. In 1984, it was estimated that 2,242,380 hectares of the central highland zone, which forms 19 percent of the total area of the country, had already been degraded through water erosion (NEMP-E 1995). Eritrea is also one of the Sahlian countries that experienced tremendous environmental damages in this century. At the turn of the century, Eritrea's forest cover was 30 percent of its total land area, but it had been reduced to mere 11 % in 1952, 5 % in 1960, and to less than 1 % in late 1980s (NEMP-E 1995).

[8] The Eritrean population was estimated to be 4.2 million in 2001and growing at 2.5 percent a year (World Bank 2002).

[9] According to the 1996 World Bank Poverty assessment study, 50 percent of the population in Eritrea is categorized as poor.

[10] Some people contest this view by saying that agriculture in the highlands of Eritrea did not receive adequate attention from the new government of Eritrea. The liberal bilateral trade agreements made between Ethiopia and Eritrea (enshrined in the principles of comparative advantage) and the new government's technocratic approach to development were some of the hypothesized reasons for the relative neglect of agriculture. The bilateral free-trade agreement made with Ethiopia had created a flood of relatively cheap food to the urban sector in Eritrea causing serious disincentive to increase domestic production and productivity.

[11] The construction of check-dams on riverbeds has proved to be effective in regenerating natural indigenous vegetation.

of stock exclusion areas have been vigorously pursued by the government. The techniques in use are largely mechanical, involving paid labour from rural households and student summer programs. However, it is reported that farmers are more interested on their own fields than on government-assisted conservation works (FAO 1994; Adugna *et al*. 1995), which may, at best, result in increased yield only in medium to long-term.[12] This could be due to uncertainty about future entitlement to the stream of benefits arising from forestation projects.[13]

Since 1997, the government has been running a program called Integrated Farming Schemes (IFS) where participating farmers would obtain chemical fertilizer, seed, and in some cases tractor services on credit basis. In some places this took the form of organizing farmers into what appears to be collective farming where participating farmers pool their land and labour resources and obtain most of input required for farming from the Ministry of Agriculture (MOA) on credit basis. However, in the highlands of Eritrea, the latter experimentation appeared to be confined in few villages around the capital, Asmara. The focus of the program in the highlands has been mainly on provision of chemical fertilizer and to a limited extent provision of seed, extension and tractor services. While farmers are in general positive about the program, loan repayment rate has been very low, putting the sustainability of the program in danger.[14]

The government has also been critical of the land tenure systems in the country, saying that they do to reflect the current challenge of agricultural development and environmental rehabilitation in the face of growing population. Accordingly, it has introduced a new land law (to be discussed later in this chapter) designed to standardize and reform the prevailing land right systems in the country. As we shall discuss soon, the new law has profound implication for the land right systems in the highlands of Eritrea.

[12] In relation to this, the 1994 FAO sector review observed that although government assisted soil conservation, forestation, and hill-side treatment projects are essential for sustainable long term environmental recovery and agricultural development, in the short to medium term it looks more productive to focus more on innovations that boost agricultural productivity without requiring major investment in soil conservation at household level (FAO 1994). The report further argued that the strategy to enhance environmental stability must be premised on enhanced productivity and profitability of the small farmer's production systems including rain-fed and irrigated crop production, livestock husbandry and forestry. The theory here is that increased profitability in agriculture will induce farmers to invest on soil and water conservation works, including dam construction and catchments treatment and their maintenance.

[13] It is, however, paradoxical to see that the survival rate of the trees planted through public forestation programs have been high. Many argue that this was made possible due to farmer willingness and participation, while others attribute the success to the effective follow up and maintenance works regularly conducted (every summer) by students through summer work programs.

[14] For the Southern Zone, for instance, of the total loan disbursed in 1998-1999, only 16 percent was repaid (MOA 2000)

3. Theories of Land Tenure and Economic Development

Land tenure research agendas vary across regions and continents. In Africa, where land has been perceived as a relatively abundant factor of production, much of the interest has been on the relationship between tenure security and productivity.[15] In Asia and Latin America, where land is relatively scarce and unequally distributed, the focus has been largely on equitable distribution of land (Maxwell and Wiebe 1998) and agricultural tenancy and their implications for efficiency (Lastarria-Cornhiel and Melmed-Sanjak 1999).[16] More recently, the focus has shifted on the effects of land tenure on environmental conservation and sustainability of resource use (Ostrom 1992; Bromley 1992; Thiesenhusen 1991). Recommendations from research results include redistribution of land among rural population (Latin American case), abolishment of tenancy relations (East Asian cases), and evolutionary or legal changes of the customary tenure systems in Africa. However, there appears to be more agreement in terms of the desirability of tenure security, creation of incentives and improved access to land than on what specific changes are needed, how they should be designed, introduced and made to work. Moreover, discussions on land policy are rarely free from ideological bias or they suffer from lack of understanding of the situation on the ground.

Binswanger and Rosenzweig (1986) and Binswanger *et al.* (1989) analyzed the behavioral and material determinants of production relations[17] in agriculture in which they understood institutions and institutional changes as responses to individual behaviour, risk, informational constraint, transaction cost, and material attributes of agriculture and of agricultural production factors. Their approach may be used to explain the absence of certain markets (e.g. formal land and future markets) and the presence of different kinds of informal institutions observed in many developing countries such as sharecropping, interlinking of credit, land, and labour contracts, and the prevalence of small farms. In their analysis, a distinction is made between land-scarce and land-abundant settings in which it is predicted that the development of private land markets would be more likely in the former than in the latter, which is also in line with Boserup's (1965) and Hayami and Ruttan (1985) hypothesis that linked the emergence of land markets to rising labour-land ratio. More importantly, however, the approach provides some clue into why certain exogenous changes did not work as intended, but instead resulted in some undesirable consequences (Platteau 1996). Although institutional changes are not entirely endogenously driven (as they are also affected by external intervention such as

[15] See Chapter two of this dissertation for review of empirical literature on this relationship.
[16] An exception to this was Feder *et al*. (1988) study of tenure security in Thailand.
[17] They referred to production relations as the relations of people to factors of production in terms of their rights of ownership and use in production.

government policies), exogenously introduced changes are unlikely to be efficient if they do not fit within the context or are not accompanied by complementary factors that are conducive for their operation. Below, we use this approach as a general framework to highlight and discuss outstanding issues of land tenure in the economic and development literature.

3.1: Tenure security

Economic theory suggests that secure and marketable land rights increase land improving investment through their effect on investment demand, credit supply, and land transferability by sale (Dorner 1972; Feder *et al*. 1988; Feder and Feeney 1991; Besley 1994; Harrison 1987; and Hayes *et al*. 1997). None of these effects are possible when land is communally held, which implies that customary tenure systems in much of Africa are perceived as constraint to economic development. This was the basis for the 1975 World Bank land policy, which called for the introduction of private land rights in Africa. However, results from extensive research on tenure systems have challenged the conceptual appeal of secure and marketable land rights. There is now an emerging consensus that communal tenure systems that were previously seen as sources of tenure insecurity can increase tenure security and provide a basis for land transactions in ways that are more cost-effective than freehold titles (Bruce 1988; Noronha 1985; Platteau 1992 and 1996; Bruce and Migot-Adholla 1994; Heath 1992; and Deininger and Binswanger 1999). Besides, it is argued that efficiency loses from communal tenure systems might be limited because (1) individuals in communal tenure systems enjoy inheritable rights over arable land (Deininger and Binswanger 1999) and (2) communal tenure systems provide public goods, such as common grazing and investment in community-level infrastructure (Boserup 1965; Dong 1996) allow diversification (McCloskey 1991) [18] and economies of scale to help with seasonal labour bottlenecks (Mearns 1996).

Efficiency loses in communal tenure systems might get larger with population density, since population growth creates tenure insecurity by threatening individuals' right over plots. Building on Boserup's (1965) theory, Sjaastad and Bromley (1997) counter argued that when land becomes increasingly scarce, many communal tenure systems either recognize a user's property rights if the land has been improved or compensate the user for improvements when the land is redistributed. Whether this is typical is, however, an empirical question. When communal tenure systems fail to respond appropriately to changing labour land ratios, there may be a need for external intervention to introduce the incentive structures compatible with the requirements

[18] Diversification includes mixed farming of crop and animal, multiple cropping, and having different plots in different areas, which is beneficial when risk is not covariate across plots.

of agricultural development and resource conservation in a context of population growth (Lele and Stone 1989; Platteau 1996). The form of intervention needed might be context-specific, but experience shows that success depends on how well tenure interventions are integrated into the overall development process, particularly the development of markets for labour, credit, insurance, and output. Furthermore, it is emphasised that tenure reforms need to be designed and initiated with full cooperation and participation of local communities as tenure rights are embedded in socio-cultural systems that are not easily bypassed (Atwood 1990; Platteau 1996). There may also be special cases where land titling through direct state intervention may be worthwhile.

3.2: Land transactions in the presence of imperfect markets

Well-functioning land markets can promote efficiency-enhancing land transfers, but individual titling is doomed to fail if it is not introduced as an integral element of a broader development process (Deininger and Binswanger 1999). For instance, the potential benefits of land transfers by sale may not be realized when high covariation in incomes (e.g. due to drought) combined with missing or imperfect capital and insurance markets lead to unfavorable condition for participation in the land sales market [19] (Sadoulet *et al.* 2001; Zimmerman and Carter 2001). Furthermore, imperfections in other markets gives land a value higher than the capitalized value of the stream of farm profit (Binswanger *et al.* 1995), with the implication that potential buyers, particularly the poor, are not able to buy land due to the lack of resources to purchase land at high prices. The reality in much of the rural third world is that factor markets are highly imperfect if not missing at all (De Janvry *et al.* 1991; Hoff et al. 1993). In particular, missing insurance markets and imperfect capital markets caused by moral hazard and adverse selection resulting from information asymmetry are typical (Stiglitz and Weiss 1981 and Hoff and Stiglitz 1993).

Unsatisfactory performance of the land sales market in a context of missing or imperfect markets meant that land rental markets and other informal transactions that were previously seen as sources of inefficiency and perhaps exploitation (World Bank 1975) are now considered as

[19] When households share covariate risk, the prices of productive assets such as land tend to move with household income so that when incomes are low, asset prices also fall and when incomes are high and households wish to buy land, there tend to be large number of buyers and few sellers, resulting in high land price. This leads to either non-participation in the land sales market or to a situation where some farmers may sell land in distress. Poor agents who are exposed to subsistence risk adopt costly and inefficient insurance substitutes, such as by adjusting their crop and asset portfolio to low return and low-risk combination (Deininger and Binswanger (1999) or sell land to buy more liquid assets such as grain that reduces their vulnerability (Zimmerman and Carter 2001). Such market constrained asset transactions lead to increase in inequality and decrease in long-term productivity.

cost-effective and more equitable alternatives to land transfers via private land markets. It is argued that land rental markets are less affected by credit market imperfections and have lower transaction costs than private land markets (Deininger and Binswanger 1999) and generate positive externalities by facilitating the acquisition of agricultural knowledge by the tenant (Reid 1977). Households may prefer land rentals to purchases if the former entails resource sharing by which both the landlord and the tenant can overcome factor market imperfections (Sadoulet *et al*. 2001). Furthermore, adjustment of land holdings via the land rental market provide greater flexibility by temporarily transferring land from land-rich to land poor households without the former risking loss of land (ibid.)

It should be noted, however, land rental markets are superior to land sales markets only when the conditions for the efficient working of the latter are not in place (Deininger and Binswanger, 2001). The message in the above is not that land ownership is not desirable and that it does not provide a set of extra benefits that the rental market cannot, such as the collateral value of land and the privilege of wealth.

3.3: Incentives and transaction costs in land rental markets

The efficiency and equity advantages of land rental markets might be questioned if transaction costs incurred in the land rental market are sufficiently high (Coase 1960) Transaction cost of entering the land rental market might be high that adjustment to the desired farm size via the land rental market might be incomplete (Bliss and Stern 1982; Srivastava 1989; Skoufias 1995). Similarly, transaction costs of preventing incentive problems possibly associated with output sharing (Marshall 1890) or asset abuse (resource mining) by the renter (Datta *et al*. 1986; Allen and Lueck 1992; Roumasset 1995; Dubois 1999 and 2002) might prove to be high. Furthermore, rental contracts may not provide sufficient duration for tenants to reap the benefits of their investment (Deininger and Binswanger 2001).

There are conditions where transaction costs associated with land rental markets can be reduced considerably, however. Where tenants and landlords live in the same community in which land rental transaction is part of a wider and repeated social interaction, there is little information asymmetry about the behaviour of the contracting parties (Otsuka and Hayami 1992; Sadoulet *et al*. 1997). This implies that entry barriers into the land rental market might be low within a community, but high outside a community. Similarly, the need to maintain land contracts in the long-term creates an incentive on both the contracting parties to avoid opportunistic behaviour that may damage their reputation and future relationship (Otsuka and Hayami 1992), regardless of the type of contract. The overall effect is that while transactions costs are low within a community, they can be high for transactions across communities, since the latter involves high information asymmetry.

Contracts could be chosen so as to minimize transaction costs of preventing incentive problems. For instance, landlords could choose fixed-rent contract to insure maximum effort by the tenant while at the same time reducing monitoring cost, although the dangers of asset abuse are more likely in fixed rent than in sharecropping contracts. There are, however, several reasons why sharecropping may be preferred to fixed-rent and other contract types by the contracting parties (more on this in chapter three of this dissertation)

Another interesting issue is the debate on efficiency differentials across farm sizes, which may have important implications for land reform measures. It is argued that small family-owned farms have efficiency advantages over large farms (Sen 1975; Berry and Cline 1979; Bhalla 1979; Cornia 1985), since the latter faces transaction costs in managing wage labour (Eswaran and Kotwal 1985; Feder 1985). However, controlling for quality and other plot characteristics, the negative relationship might get weaker (Bhalla and Roy 1988; Udry 1996), although inverse relationship was still observed even after controlling for household- or plot-specific effects (Burgess 1997; Heltberg 1998). In this respect, land redistribution in favour of small farms or land transfers either through land sales or land rental markets from large to small farms might lead to efficiency gains, besides to the obvious equity advantages it would have.

The above conclusion may, however, be reversed when economies of scale and imperfections in other markets work in favour of large farms as to outweigh the cost advantages of small farm. This might be particularly true for farms that are too small to be efficient. Deolalikar (1981), using data set from India, have shown that the inverse relationship is true for poorly developed areas but not for well-developed regions. Similarly, Kevane (1996) using data from the Sudan reported that capital market imperfection led to positive relationship between farm size and productivity. The implication for tenure reforms is that, where this is the case, it may just be sufficient to correct market imperfections to improve productivity rather than embark on tenure reforms.

4. Land Tenure in the Highlands of Eritrea

4.1: Description

The traditional land right systems in the highlands of Eritrea are diverse and very complex to understand. For our purpose here, however, we can broadly categorize them into two, namely, the family or *Risti* and the village or *Deissa* forms of land rights.[20] *Risti* land is owned by extended family group, called *enda*, which traces its rights to a common founding father who first settled the area (Tesfay 1976). A rightful claimant under *Risti* is entitled for his lifetime to a share of land in the land allocation process. He/she can also claim land in different areas simultaneously by virtues of descent. *Risti* land can be leased out or transferred to children through inheritance. However, individual ownership of *Risti* land was not absolute when it comes to selling or mortgaging to individuals outside the *enda*. Only after an offer to other member of the *enda*, can *risti* land be sold to others, becoming *Meriet-Werki*, literally meaning land of gold or land purchased with money (Gebremedhin 1989; Castelani 1998). Yet, sale to outsiders was very difficult due to the *enda's* pride in keeping foreigners excluded from owning land. As the result, landlessness among non-descendants was common. It was also characterized by endless conflicts over access to land arising mainly from multiple *enda* claimants.

Deissa landholding system, on the other hand, refers to collective ownership of land by a village community whose members are not necessarily related to each other by blood. In *Deissa* system, not only descent but also residence in a village for a specified period of time can qualify a person to a plot of land.[21] Under the system, a village council called *Baito-adi* classifies the village land into three categories: residential, forest and grazing, and farmland. Village farmland is classified on the basis of fertility and proximity of the land to the homestead. Thus, distribution of land among member households is carried out in such a way that every eligible member has equal access to a farmland of the same aggregate fertility. That is, a household, called *Gebar* gets a share of land called *Gibri,* which has in it all categories of

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[20] In addition to *Risti* and *Deissa* rights, there is a system called Kuah-Mahtse in a small part of the highlands of Eritrea. The system provides quasi-private rights, such as permanent use right and the right to transfer to and exclude others from use, but we have no information if it provides transferable right by sale, as well. Literally, the term Kuah-*Mahtse* means where the axe falls, to imply that ownership claim over a particular land comes from working and developing the land for cultivation. This may provide some evidence for the reverse relationship between security and investment discussed earlier. Furthermore, the fact that perennial fruit crops are widely grown under this form of land right, in contrast to *Deissa* and *Risti* systems, may also indicate that tenure security might be better in *Kuah-Mahtse*. A family member can make a claim on *Kuah-Mahtse* land if it is left fallow for two or more years.

[21] It is not clear how residence rights are established. Some writers say that foreigners would have to wait for 40 years to be recognized as village members and obtain their right to a plot of land (Pateman 1990). Others say that an outsider who had made the village his home by building a hut at the turn of the 20th century was entitled to a share of land (Gebremedhin 1989).

village farmland. Thus, a typical *Gebar* holds many parcels that are scattered in different parts of the village farmland. The average tenure over ones share of land is five to seven years after which the village's farmland is again put back under the control of the *Baito*-a*di* for fresh redistribution, called *Wareida*. Thus, plots change hands after every *Wareida.* This implies that a right holder under *Deissa* system is entitled to a lifetime usufructuaries right over land but not over a particular plot. It also implies that *Deissa* land cannot be alienated and/or inherited. It can, however, be leased or sharecropped on temporary basis.

The purposes of *Wareida* in *Deissa* are (1) to maintain the egalitarian distribution of land within a village in light of demographic changes within household and the village; land redistribution accommodates newly formed families and would be families and revises the eligibility status of members in accordance their current conditions, and (2) given that land quality is heterogeneous, land redistribution insures quantitative and qualitative equality in holdings through rotation of plots among holders of *Deissa* rights. People who were disadvantage in previous redistribution would be compensated in fresh redistributions.

4.2: Replacement and adaptation of land rights

There have been various interventions by different administrations to change the indigenous land right systems in Eritrea. The Italian colonial administration (1890-1945) was the first state intervention in the indigenous land right systems in Eritrea. Italian land policy in Eritrea was first aimed at securing productive land and a place to settle for poor Italian farmers. Towards this end, disregarding customary rights, large tracts of land were declared public property. All grazing land was declared state land. Land previously owned by chiefs and the church was also expropriated and distributed to new local chiefs and missionary institutions in exchange for political support (Castelani 2000). State land was given to Italian settlers and investors on grant basis and some to Eritrean cultivators on concession basis. And, except for the indigenous customary rights of ancient origin and property rights issued or acknowledged by the Italian government, the royal decree of the 1926 declared all land in the Eritrean colony belong to the state, creating the *domeniale* land (Ibid.).

The densely populated highland area was the most affected of this expropriation process, as its temperate climate and its fertile soil were considered favourable to Italian settlers (Leonardo 1980).[22] The immediate effect of the expropriation was that customary right holders were confined to small and marginally suited areas. Traditional systems of shifting cultivation

[22] Due to serious peasant resistance and armed revolt against the colonial administration, it is said that the process of expropriation in the highlands had slowed down later.

were largely abandoned due to growing shortage of land. Together with population growth, this had set a process of serious land degradation, as agricultural land, and particularly grazing land grew scarcer overtime (Gebremedhin 1989). Conflict over access to land had grown, partly due to uneven distribution of land within and among *endas* (ibid.) and partly due to scarcity of land created through Italian expropriation policy (Trevaskis 1960).[23] Consequently, in some places, at the request of local peasants, *Risti* land was converted into *Deissa* in order to redress the uneven distribution of land among the *enda*s (ibid.).

The British Military Administration (BMA) that replaced the Italian colonial rule after the defeat of the latter in world war II did very little to change the status qua created by the Italians. In fact, the BMA aggravated the situation by alienating an additional land and distributing them to Italian fruit and vegetable growers. Like its Italian counterpart, there was no agricultural or land policy aimed at developing peasant production systems.

In 1952, the new Eritrean government under federal arrangement with Imperial Ethiopia had introduced a new law that extends the *Wareida* period under *Deissa* to 25 years. This had, however, failed to materialize for lack of popularity among the peasantry; the perceived equity and security impacts were not acceptable to the peasantry. The formal annexation of Eritrea into imperial Ethiopia in 1962 created a favourable situation for the restoration of the old feudal ideals and practices, particularly in areas where the family system of land ownership has survived previous interventions by the Italian colonial land policies. Thus, what was Italian state land became Ethiopian Crown land and the crown had favoured its functionaries – the nobility, the chiefs, and the church – in bestowing land grants (Cliffe 1989).[24] In previously *Deissa* villages, redistribution of land was either halted or conducted with the ruling class and the church being the most favoured in getting the best land (ibid.). Some argue that the new chiefs who replaced the old village council abused the *Deissa* principles by allocating themselves the best land and delaying the redistribution process (Gebremedhin 1989). Others, however, attribute the delay in land redistribution to land scarcity and the infiltration of commercial values (Cliffe 1989). In any case, the result was that a serious conflict over access to land was created in many rural communities. Landlessness had become prevalent, particularly among newly formed families.

[23] Trevaskis (1960) argues, besides land expropriation, colonial agricultural policy was also to blame for marginalizing peasant production. Italian investment in agriculture was aimed at developing crop production in the Italian settlement areas while peasant production remained largely backward: there was little long-term investment in land improvement, human capital, and crop and animal husbandry

[24] Rights over land granted by the Ethiopian crown was known as *Gulti* rights; such rights are granted to individuals and religious institutions by the Ethiopian emperor in return to services rendered (taxes collected and military support).

The land reforms started by the two liberation fronts of ELF (Eritrean Liberation Front) and EPLF (Eritrean Peoples Liberation Front) since 1974 in the then liberated parts of Eritrea were strongly socialist oriented; the stated aim was to make the existing tenures more equitable. We could not find any written record of the reforms carried out by the former organization, but in the period 1976-81, EPLF-driven land redistribution had taken place in 162 villages. In the southern territories, EPLF land distributions included the abolition of privileged groups and introduced wider entitlement of women to land (Castellani 2000). The distribution programs have also included the definition of boundaries between villages where some peasants had *Risti* rights over land belonging to neighbouring villages. It is claimed that, in order to create more clarity and efficiency, such land was redistributed with the 'consent' of the concerned villages. More Interestingly, EPLF reforms were said to have included a program of compensation for improvements made between *Wareida* periods, but there is no documented evidence on how far this was implemented and how it affected investment and production outcomes. Many agree, however, although innovative in their equity impacts, the reforms have created land fragmentation, particularly, in areas previously under *Risti* form of land holding. It may not be ruled out also that EPLF land reforms were also meant to organize and mobilize the peasantry for a social and political change in line with the formation of an independent Eritrea. Whatever the motives were, the result in terms tenure reform was that more and more areas have come under more like *Deissa* system of land ownership.

The 1974 attempt by Ethiopia to reform the land tenure system in the areas under its control was also socialist oriented. Distribution of land was carried out on the basis of family size as opposed to household or *Gebar* based that characterized *Deissa* systems. Like that of EPLF's, it is said that the reform resulted in serious land fragmentation and decline in productivity, particularly in the *Risti* dominated areas. Moreover, an attempt to insure equality in access to land by redefining existing village boundaries among villages had created more conflicts. The problem was compounded by the challenges the Ethiopian authorities were facing from the peasantry, due to corruption and favouritism in the allocation process.[25] Given the complexities of the political realities related to the war in Eritrea, it cannot be said that the reform process was not also meant to serve the interest of the state in crushing the independence movements. Yet, there is no documented study that would help us have some idea on the social and economic

[25] For instance the regime replaced the old village council with newly formed farmer associations that were instrumental in implementing its policies in Eritrea, particularly mobilizing political and resource (labour and financial) support for its war against the Eritrean liberation fronts.

impacts of the reform. No doubt, however, a more *Deissa* like system of land ownership replaced *Risti* systems.

In summary, past interventions did not result in tangible and genuine measures to reform the existing tenure systems in a way that is compatible with population growth and economic development. Within the villages, however, there have been some interesting developments. In some of the villages that we visited, individuals who develop water by digging well beneath their plot are rewarded with complete ownership of the well, regardless of *Wareida*. In many of the villages that we visited to conduct the survey, therefore, ground wells are owned privately. The land adjacent to the well my be allotted to another farmer in a fresh *Wareida*, but by virtue of proximity to the well, the investor has high probability of continuing to operate the land by entering into some contractual agreement with the new holder of the land. This might be taken as evidence for the reverse causal relationship between investment and security proposed by Sjaastad and Bromley (1997) and Bromley (1998) or in line with Boserup (1965) Ruttan and Hayami (1985), Binswanger and Rosenzweig (1986) Binswanger *et al*. (1989), this may be considered as a response of the *Deissa* system to the increasing scarcity in land and commercialisation of agriculture (since irrigation is commercial oriented). However, such incentive are limited to irrigation water only, it does not cover structural works, tree planting, and other types of investment. By contrast, it may also lead to over investment in well digging which may lead to overexploitation of ground water unless appropriate control measures are applied; there are already symptoms of this problem in some of the villages that we visited.

Another positive feature of the *Deissa* is the existence of land rental markets through which land is temporarily transferred to relatively land poor and more enterprising households. Whether land transfers via the land rental market lead to complete adjustment of farm size or whether efficiency is enhanced through their working is an empirical question to which we come soon. But land rental markets provide a comparison base for analysis of investment and efficiency differentials across private and rented plots.

We noted among some *Deissa* villages that there has been a lot of community-based and state-sponsored structural conservation works achieved, particularly in areas of steep slopes. It would be difficult to imagine that such activities could be initiated and achieved individually, but in light of the new development in the country's new land policy, the mechanism for follow up and maintenance of such initiatives remain to be uncertain.

4.3: Critique of the Deissa

We have seen that various interventions, one way or the other, have resulted in the expansion of the *Deissa* system to areas previously under different systems, although replacements are not strictly made according to traditional *Deissa* principles. The *Deissa* system has been improved to make it more equitable. Despite increasing population pressure and serious land degradation, however, the *Deissa* system has not evolved further. To a large extent, increased population density did not result in technological and institutional innovation and agricultural intensification. This situation is in contrast to what happened in the Machakos district of Kenya or in South-east Asia where increased population together with appropriate policy responses has provided the incentive for technological and institutional innovation (Pingali *et al*. 1987; Tiffen 1994). The pattern in the highlands of Eritrea has been more like Malthusian scenario where increased population accompanied by unfavourable external conditions is also characterized by decreasing food production and increasing poverty.

It is fair to say that the traditional *Deissa* system does well in insuring not only equity among its right holders but also provide livelihood insurance for its current and future right holders. The latter aspect is particularly important in an environment characterized with limited and uncertain labour market opportunities outside the farming sector. However, with increasing population density, the efficiency cost of maintaining the equity and insurance advantages of the *Deissa* system might be questionable. The effects of the *Deissa* system on production efficiency and the environmental quality are not systematically studied yet. The specific ways through which the system is hypothesized to affect production negatively are as follows.

Firstly, through *Wareida*, a typical farm household holds 3-8 plots that are scattered in the village's farmland. In a situation where the average farm size is just below one hectare already, one can clearly see how tinier a given plot can get with further redistribution in the context of growing population. Some argue that running such tiny plots located here and there involves high cost of production and it may not be economical for the household to introduce modern inputs that are economical only with larger holdings. In many areas of the highland regions there is little room left for area expansion; scarcity of land has reached its peak that cultivation has already pushed into grazing and marginally suited lands. In some localities, increased pressure for cultivable land has also resulted in short or total abandonment of fallowing as a way of maintaining soil fertility.

Secondly, the average tenure over ones share of plots is too short to commit the landholder to long-term investment in land improvement and to respond to changing market opportunities efficiently. The farmers planning horizon is limited to the *Wareida* period, five to seven years. So only short-seasoned crops are grown. Investment in conservation is insignificant. Instead, farmer behaviour might tend to be more degrading as the *Wareida* time approaches.

4.4: The new land policy

The independence of Eritrea in 1993 has created conducive forum for a serious discussion and concern over number of outstanding development issues that includes the land tenure systems in the country. A major policy action in relation to land tenure after independence is the Eritrean Land proclamation (Proclamation No. 58/1994) that declared all land to be the property of the state, the Eritrean government. According the law any right over land is then given by the state. This implies that the village now has no collective claim to its former farmland, although it is allowed to continuous use and control of its pastureland, woodland, and water resources. Every Eritrean citizen is entitled to land usufruct with regard to agricultural and/or residential land regardless of sex, belief, or origin. The law refers to the endogenous land tenure systems as obsolete, progress impeding, and incompatible with the contemporary demands of the country.

The provisions of the law that we think have important implications for rural farmland, particularly those under endogenous tenure systems, are listed as follows. (1) A land administration body (LAB) consisting of a representative of the government's Land Commission (LC), members from a village assembly and various government bodies of localities is responsible for classifying land and distributing it to eligible by virtue of the proclamation and to those who make a living by farming, (2) the LAB, being a subordinate executive body with respect to land distribution, carries out its functions in accordance with orders and directives of the LC, (3) in distributing rural land for residence, agricultural, and farming purposes, the LAB provides priority to permanent village residents, (4) taking into account the differences between fertile and poor land, the LAB distributes land in an equitable and balanced manner to the eligible, (5) usufructuaries who intend to farm collectively or who intend to utilize their farm equipment collectively, upon prior notice to the LAB, may be allotted land in the same area, (6) land allotted according to the proclamation shall be registered and granted in the name of the recipient usufructuary; the usufructuary shall use the land for his/her lifetime and shall have the right to fence it, (7) a usufructuary may, in exchange for a fixed quantity of agricultural products, grant the right to use part or all of his/her land to any person who would contribute labour or oxen, or both or other farming implements, (8) a usufructuary may lease his/her usufruct right over land in whole or in part and duration of contracts shall be determined by an agreement to be made between the parties, (9) to prevent farms from being reduced to economically non-viable sizes, the law prohibits further parcelization of land through inheritance, (10) the government or appropriate government body shall have the right and power to expropriate land that people have been settling on or land that has been used by others, for purposes of various development and capital investment projects aimed at national reconstruction or other similar purposes. A government body that expropriates land in accordance to this provision shall pay compensation as allowed by this proclamation to the holder of the right who leaves the land.

It is clear from the above provisions that the law calls for a fundamental reform into the working of the endogenous tenure systems. In particular, by assigning permanent title to the holder, the law effectively calls for the elimination of periodic redistribution, *Wareida*. This is expected to provide strong economic incentive for the landholder to commit himself/herself to long-term investment in land improvement activities. The law is, however, not clear about possible scattering of land in the process of land redistribution. It does not provide specific provisions to address the current problem of fragmentation. While it encourages consolidation of land through resource-pooling, it at the same time calls for equal distribution of farming land in both quality and quantity terms, which, in the context of the highlands of Eritrea, is difficult to implement without having to produce land fragmentation (due to diversity in the qualities of land). This will certainly pose serious dilemma in the process of land redistribution. The call for equal distribution of land may also discourage more efficient producers from expanding their holdings. Of course, the provisions on share-cropping and lease may enhances the possibility of land transaction, although it may not provide sufficient security in relation to tenure security that may be obtained through absolute ownership of land.

Although much of its provisions are important milestones in providing tenure security, the law seems to have given too much power to the government at the expense of the village assembly in land allocation and administration. This power shift might create new source of tenure insecurity. Besides, the government might be venturing in what could be an extremely expensive and uneconomical in comparison to alternative and decentralized ways of land allocation and administration. The cost of defining, ascertaining, and administering individual land rights might be a lot cheaper and potentially less corrupt if implemented by village communities themselves rather than by the state bureaucracy.

The survey we conducted in selected villages in the highlands of Eritrea has shown that, in accordance to government orders, there has been fresh redistribution of land in most of the Southern (*Debub*) and Central (*Maekel*) highland regions of the country since 1998. However, the redistribution was not carried out in strict adherence of the new law; it appeared that a combination of rules from both the *Deissa* and the new law have been used to conduct it. In fact, with many of the elements of *Deissa* intact and with villages having some power in the distribution process, it appears that the redistribution was carried out as a short-term transitional measure to allow access to a number of landless people accumulated since last redistributions. Many villages have reported that the last redistribution they had before this was at least a decade ago. In the new land redistribution, previously disadvantaged groups like women and newly established families who have been landless for a long-time are allocated with land. Every eligible member of a village is thus allocated with land so that no eligible person is left landless. Moreover, the system of land redistribution based on family size that was introduced in some parts of highlands by the Socialist Ethiopia is abandoned in favour of redistribution on household, called *Gebar*, basis regardless of family size.[26] The fragmentation problem is still intact and in fact many agree that it is worse than it was before.

Now that redistribution have been carried out under government orders, most farmers are uncertain whether there will be further redistribution of land in the future or not, and if so how soon. Traditionally, many expect that it should be held in five-seven years according to the norms of their respective villages. The response to a question whether they will need another *Wareida* in the future or not was mixed, with a sizable majority demanding further redistribution. Some of the reasons given are that they do not think that redistribution was carried out fairly and many, especially the elderly, are concerned about their off springs that they will be landless. Asked how they would have changed their farming behaviour if there was no *Wareida* at all, most of them indicated that they would have invested more in their land and changed their cropping pattern in favour of more profitable crops. These might show that farmers are perfectly aware of the disincentive effects of periodic redistribution of land and they might be willing to accept the termination of *Wareida* provided that land is distributed equitably.

[26] However, land allocated to a household (called *Gibri*) could be full or half. A full *Gibri* is allocated to households that meet the criteria for a full household. A full household is one that shares a house under the institution of marriage, with or without children. Half *Gibri* is allotted to people who are not considered as full households because they do not meet these criteria. An example of such cases is divorced households with or without children and households that are survived either by the man or woman.

The current land tenure system in the highlands of Eritrea is then one that is more like *Deissa*, although greatly reformed and improved to make it more equitable. In the spirit of the new land law (consider, for example, the land-titling aspect of the law), however, it seems that the long-term direction of *Deissa* is towards more like private ownership of land. Of course, only time will tell us whether the *Deissa* will evolve to private land tenure system or not.

5. Summary of Research Findings

We have identified four issues of land tenure in the highlands of Eritrea for detailed empirical analysis. The empirical findings on these issues are summarized below.

5.1: Chapter 2 - Analysis of factor market imperfections and the land rental market

Under this topic we investigated the role of factor market imperfections on participation in the land rental market and the performance of the land rental market in terms of reducing the negative effects of factor market imperfections. Empirical analysis was made by distinguishing between the decision to take part in the land rental market and how much to participate, having decided to participate. This was done for land buyers and land sellers separately. We also did an analysis of net land leased in by pooling all types of households together in a single-equation setting.

The results have shown that participation in the land rental market was an attempt to adjust area cultivated to endowments in semi- or non-traded factors, such as oxen, human capital (in both quantity and quality terms), and access to working capital. It appeared that the role of the land rental market was to allocate land from households that are rich in land but poor in other factors to households that are poor in land but rich in other factors, indicating that the land rental market improves resource allocation by compensating for imperfections in other factor markets. This may also support the potential of land rental markets in providing alterative avenues in the debate for reforming the communal tenure systems in many African countries. Land rental markets also helped reduce land fragmentations considerably.

We also found that while land buyers and land sellers[27] faced insignificant transaction costs in the land rental market, indicting smooth resource adjustment, substantial non-participation in the land rental market indicated that there were considerable transaction cost

[27] We use the terms seller and buyer not in the strict sense of buying and selling land. We label households who rent in land in net terms as buyers of land and households who rent out land in net terms as sellers of land. The intermediate group is labeled as land self-sufficient households to indicate their non-participation in the rental market either as buyers or sellers. Analytically, the shadow price for these households is such that the market rate is unattractive.

in this market and thus non-participant households had problems adjusting land and other factors to an optimal mix. This raises the question whether resource allocation using land rental markets is superior to other forms of land transfers such as by sale. We also found that land buyers faced more transaction cost than land seller, suggesting that the land rental market was supply constrained.

5.2: Chapter 3 - Analyses of contract choice

Under this topic we reviewed the theoretical and empirical works on land contract choice. We argued that the assumptions of the principal-agent model are restrictive in situations where the tenant can also influence contract choice because he/she might possess non-tradable or imperfectly traded factors with positive marginal productivity and where the landlord may lack or be poor in these same factors. We theorized that contract choice is a function of the characteristics of both the landlord and the tenant. In particular, we hypothesize that contract choice is determined by the landlord's and the tenant's relative access to capital, wealth (poverty) and factors of production. Econometric results show that contract choice was affected by risk aversion, capital market imperfection and risk. In particular, poor landlords with less off-farm income, less business income, less irrigated land, less farm experience were more likely to go for fixed rent contracts and less likely to go for cost sharing contracts. Similarly, wealthy tenants with access to incomes from off-farm wage labour and dry-season irrigation, and with more livestock assets, and better access to credit were more likely to choose fixed rent contracts and less likely to choose cost-sharing contracts over pure sharecropping contracts. This implies that poor landlords and wealthy tenants are attracted to each other through a preference for fixed rent contracts. Likewise, less poor landlords and less wealthy tenants are attracted to each other through a preference for cost sharing contracts. The intermediate wealth stage on both sides provides a preference for pure sharecropping contracts. Contract choice was also affected by variation in weather risk in such a way that cost sharing is a more likely choice the higher is the coefficient of variation of rainfall.

5.3: Chapter 4 - Analysis of land tenure security, resource allocation and land productivity

The main objective of this chapter was to investigate the relationship between land tenure security and household investment behaviour in terms of application of animal manure and chemical fertilizer. The results showed that the decision to apply animal manure was more likely on plots with longer duration such as own plots and plots under medium-term contract than on plots contracted for one production season only. Intensity of manure application was not affected by tenure security, however. This implies that tenure security is an important consideration for the decision to apply manure but not to the decision of how much to apply once the decision to apply is made. On the other hand, there was no significant effect of tenure length on the probability of chemical fertilizer application, but short length plots have received more chemical fertilizer than long- and medium-length plots. The higher use of chemical fertilizer on short length plots might be the result of, given that chemical fertilizer is a substitute for animal manure, tenure insecurity itself. Tenure insecure farmers might apply more chemical fertilizer to prevent output on short length plots from falling due to low application of animal manure.

The analysis of land productivity has shown that animal manure and chemical fertilizer were important yield increasing inputs. Moreover, productivity was in general higher on rented plots than on own plots. The positive effect of animal manure on land productivity might provide an indirect evidence for the role of tenure security on agricultural performance. However, to the extent that tenure insecurity also causes increased use of chemical fertilizer (through substitution effect), which has positive effect on land productivity, it becomes difficult to see if it is tenure security or insecurity that benefits land productivity most. Tenure insecurity resulting from short duration of contracts might be limiting agricultural performance as far as manure application is concerned. On the other hand, tenure insecurity might also be enhancing agricultural performance, as short-length plots have received more chemical fertilizer and land productivity was higher on rented plots than on own plots. Comparison of marginal productivities was not possible since animal manure was largely non-traded.

The negative effect of tenure insecurity on investment in animal manure indicates that investment on more durable inputs (structural conservation, planting tree crops, and etc.) and hence land productivity would even suffer more if the *Wareida* system of land redistribution in *Deissa* continues. This prediction is consistent with the views of many farmers in the study areas that they refrain from investing on land saving inputs during the year preceding *Wareida* time. To the extent that short-term inputs can substitute long-term inputs, there is no reason to worry about tenure insecurity. However, perfect substitution may not be a realistic scenario, suggesting that there is a benefit from tenure security.

We found no evidence of direct effect of land fragmentation on land productivity, but animal manure application was observed to be less likely on distant plots. Furthermore, controlling for plot characteristics including land fragmentation, we found that input application and land productivity was higher on larger farms than on smaller farms. Thus, there may be a need for area consolidation in some situations.

5.4: Chapter 5 - Analyses of production efficiency across land contract types

The debate on efficiency differentials across contract types in general and on efficiency of share tenancy in particular centers around whether contracts are enforceable or not. Review of empirical literature on this subject suggest that there is high possibility of cooperative behaviour among contracting parties living in the same community and having broader mutual interactions than land contracts. People living in agrarian communities sharing common cultural values, having kin relationship, and interact on continuous basis are not driven by shortsighted economic interests that may jeopardize their long-term relationships. In agricultural land contract, this kind of setting provides the condition for self-enforcement of contracts leading to optimal use of inputs with negligible supervision from either of the contracting parties. We argued such conditions exist in the highlands of Eritrea where people are organized in village communities and land transactions are made between people who have either kin relationship or know each other's characteristic relatively well. We claim that reputation and consideration of broader and long-term relationships create the incentive to behave in a way that is socially optimal. As a result, we hypothesized that share tenancy need not result in sub-optimal use of input and output when the value attached to future utility by the contracting parties, particularly by the tenant, is sufficiently high.

Econometric results show no evidence supporting Marshallian inefficiency. We found no systematic downward bias in input use and land productivity on sharecropping contracts relative to owner-operated plots or plots under fixed rent contract. Sharecropping is found to be as efficient as the other contract types. Although we found that plots under cost-sharing contract received significantly lower amount of four of the five inputs analyzed, land productivity was not found to be lower on cost shared plots than on other contract types. Cost-shared plots were found to be as productive as plots under alternative contrat types including owner-cultivation. We think that the negative input bias on cost shared plots might be due to greater possibility of input substitution that cost sharing contracts may entail as compared to alternative contractual arrangements. The pooling of resources in a cost sharing contract creates a favorable condition for the contracting parties to exploit their comparative advantage in order to achieve a better and more efficient mix of resources. One possible result in terms of input combination is that contracting parties relied more on their combined labour and management inputs than on purchased inputs. An indication of this possibility was that labour hiring decreased significantly with family labour resources.

We also found that owner tenants are more productive than owner-operators. We attribute this not just to higher capacity of the former, but also to higher transaction cost that the latter face in the land rental market. Higher transaction cost imply that owner-operators (non-participant) had problems adjusting land and other factors to an optimal mix, resulting in lower land productivity

6. Overall Conclusion

Having reviewed the major findings of the empirical studies, we make the following conclusions.

1. By transferring land from less able to the more able households, land rental markets improve resource allocation, help reduce land fragmentation, and increase land productivity. Thus, policies that improve the working of the land rental markets should be encouraged. At the same time a way should be found to minimize transaction costs to allow greater participation in the land rental market. Poor landlords may also benefit from better functioning of the land rental markets. Such markets may, therefore, contribute to poverty reduction.
2. Tenure security is found to affect investment and land productivity positively. Thus, policies that enhance tenure security by extending duration of tenure are likely to result in higher investment in medium and long-term land improving inputs and hence increased land productivity. In particular, there is a need to reform the *Wareida* (land redistribution) system to allow sufficient duration of tenure and to introduce land tenure laws that allow and encourage long-term leasing. It may be useful to consider using land redistribution as a carrot and stick measure. The right to use land permanently should be based on positive long-term investment and its proper maintenance. Land redistribution should focus on poorly managed land and access should be allowed to landless people who are willing to invest. Extension of the *Wareida* period is a positive move to improved tenure security and will lead to investment in new cropping patterns and perhaps more durable investments than those considered in this dissertation. But whether land registration (also proposed in the new land law) that may eventually lead to private ownership of land would lead to even higher efficiency gains is an empirical question that needs further research.

3. There is a possibility that the elimination of *Wareida* or the extension of *Wareida* period would produce an army of landless unemployed people in the rural areas. A legitimate concern as it may be, this possibility may not be a realistic scenario in light of the evidences indicating labour market imperfections that we noted. Yet, since land availability varies across villages, it may be necessary to approach the issue more cautiously. Some villages are so poorly endowed in land that there is a need to develop alternative employment activities alongside land reform measures.
4. The proposal calling for consolidation of holdings in the new land policy is a step in the right direction, but area consolidation through integrated farming schemes need to be reconsidered in light of the potential incentive problems they may create. An extension of the *Wareida* period together with policies that enhance better working of the land rental market might be a better way of achieving area consolidation. However, more research is required on this area before practical steps are taken.
5. Our analysis of land productivity suggests that there is room to increase land productivity by improving the working of the labour market and enhancing access to credit without even having to change the existing tenure system considerably. However, diminishing returns to land and labour may call for increased investment in more durable investments of long-term in nature. This in turn may call for improved access to capital and perhaps increased tenure security. An example of investment area is irrigation, which, according to our results above, is more productive and yields higher return to labour than the alternative off-farm activities. If capital continues to be scarce, which is reasonable to assume, there may be a need for adopting combined strategy of enhancing tenure security and access to credit. To the extent that credit can be channeled through some kind of non-formal arrangement, without having to use land as collateral, however, there may not be a need to develop title-based land market that provides the right of sale and mortgage, which is what potential suppliers of formal credit may demand.
6. Share tenancy appears not to lead to Marshallian inefficiency and should therefore be considered as an acceptable contract form in the land market as it allows the sharing of risk and a way out of imperfection in the labour and capital markets. Further research is needed, however, on cost sharing contracts, particularly in terms of the effect of resource pooling on reducing factor market imperfection and on substitution possibilities between inputs.

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Table 1: Estimated total and rural population within Eritrea and population pressures (end of 1993) by province

Province*	Total Population. '000	Rural Population '000		Cultivated land ('000)**	People/ha
		Total	%		
Asmara	444	0	0.0	0	0.0
Akeleguzay	310	274	0.9	47.8	5.7
Barka	170.5	156.5	0.9	32.6	4.8
Denkel	137.5	73	0.5	1	73.0
Gash-Setit	271.5	249.5	0.9	71.6	3.5
Hamasien	256	257	1.0	41.1	6.3
Sahel	179.5	158.5	0.9	15	10.6
semhar	121	87.5	0.7	10.9	8.0
Senhit	277	207.5	0.7	42.3	4.9
Seraye	421.5	372.5	0.9	133.3	2.8
	2588.5	1836	0.709291	395.6	4.641052

Source: FAO, 1994.
*The provincial names here are according to the old administrative structure of the country.
** This is cultivated land 1993

Table 2: land Use Categories

Land Use	Hectares (000)	Percentage of Total
Cultivated land: Rain-fed*	417	3.01
Irrigated land	22	0.16
Disturbed forest	53	0.38
Forest Plantations	10	0.07
Woodland and Scrubland	673	4.86
Browsing and grazing land	6,967	50.34
Barren land **	4047	29.24
Potential Irrigable land***	(600)	4.34
Potential rain-fed land****	(1050)	7.59
Total	121189	100

Source: FAO 1994.
*Cultivated land: 1993 cropped land plus 12.5% for bare fallow.
** Barren lands: desert areas and unusable steep slopes
***Government estimates based on reconnaissance type surveys with no hard data on water resources or irrigability of the land commanded, possibly optimistic.
**** FAO mission estimated of under-utilised land in the southwest suitable for rain fed development. Figures are derived from Satellite imagery, and are highly tentative pending field surveys.

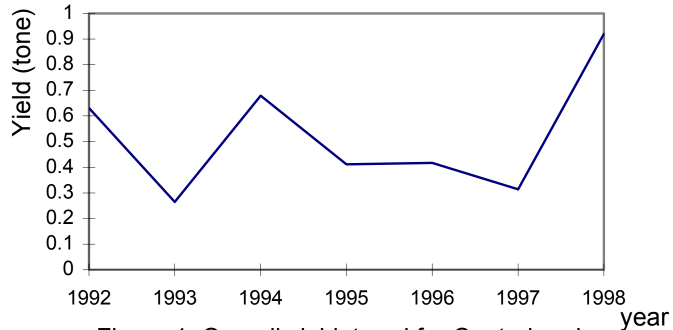

Figure 1: Overall yield trend for Central and Southern regions:1992-98

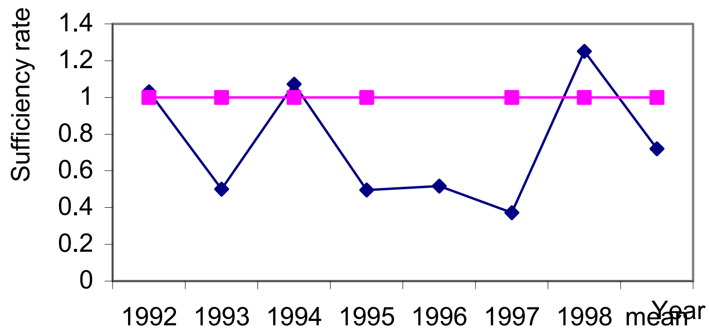

Figure 2: Food self-sufficiency rate over time

Source: Figures 1 and 2 are author's calculation based on production and cultivated area data for 1992-1998 from MOA, FAO sector review 1994, and regional total and household population data from MOA 1995. The minimum grain requirement is 435g/day/person according to FAO and 400g according to the Eritrean Relief and Rehabilitation Agency (ERRA).

CHAPTER TWO

Factor Market Imperfections and the Land Rental Market in the Highlands of Eritrea: Theory and evidence

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Abstract

In this paper we set out to analyze the relationship between market imperfections in non-land factors and land leasing behaviour and the role of the land rental market in compensating for imperfection in non-land factors. We theorized that participation in the land rental market is an attempt by farm households to adjust area cultivated to endowments in non-traded or imperfectly traded factors with positive marginal productivity. A perfectly operating land rental market would compensate for market imperfections in the non-land factors. We distinguished between the decision to take part in the land rental market and how much to participate, having decided to participate. We tested our hypotheses on sample data from the highlands of Eritrea using (1) single step estimation of net land leased-in and area cultivated equations proposed by Bliss and Stern, and (2) two-step estimation of net land leased in using Heckman's selection model and Deaton's alternative model. Results show that the markets for non-land factors such as labour, oxen and farm skill were highly imperfect and that households' participation in the land rental market was an attempt to adjust area cultivated to their endowment in these factors. The results from OLS regression of the net land leased in equation using the full sample showed that adjustment of area cultivated was not complete due to high transaction cost in the land rental market. Disaggregating the analysis by household types showed that land buyers (tenants) and sellers (landlords) have faced insignificant transaction costs and thus they were able to better meet their desired area of cultivation than non participants who were either rationed out or faced considerable transaction costs in relation to entering the land rental market.

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1. Introduction

Theoretical and empirical interests in tenancy markets are dominated by analysis of factor demand and efficiency differentials across land contracts. Explanations for efficiency differentials are sought in the differential arrangement in land tenancy types. Indeed, efficiency issues are at the core of the debate on the subject of tenancy markets. However, reasoning on efficiency differentials among plots under different rental contracts would be advanced if due attention is also given to the questions of why land rental markets exist and how they perform. Except for the few studies based on sample data from Asia that we are going to review later in this paper, we feel that this subject has received little attention, particularly in an African setting.

Empirical evidence on tenancy markets, mainly drawn from studies in Asia, attribute the presence of land rental markets to imperfections in the markets for other factors of production (Bell 1976; Pant 1983; Jodha 1981; Bliss and Stern 1982; Binswanger and Rosenzweig 1984; Nabi 1985; Eswaran and Kotwal 1985; Srivastava 1989; Skoufias 1991; Taslim and Ahmed 1992; Kochar 1997; Kevane 1997; Lastarria-Cornhiel 1999; Pender and Fafchamps 2002). The implication is that it is not easy for households to adjust the use of such factors through hiring-in or out, causing considerable resource allocation problems. The land rental market is then sought as an alternative resource adjustment mechanism by which households may adjust cultivated area to their access to the semi- or non-tradable factors. This seems to be the case also in the highlands of Eritrea where factors such as labour and oxen are either non-tradable or imperfectly tradable.

Adjustment of cultivated area through the land rental market is characterized by transaction costs, implying that the benefits of buying land are not the same as the benefits of selling land, creating a price band. Thus, depending on resource balance and the transaction cost of the land rental markets, a given household might have a choice to belong to a class of tenants or buyers of land, landlords or seller of land, or owner-operators (neither tenant nor landlord).[1] The possibility that market imperfection may not be symmetric across households and that leasing behaviour might be different for households on either side of the tenancy market is not recognized or not well treated in the empirical literature of tenancy outcomes. Yet overall adjustment may not be complete due to transaction costs, leading to the interesting

[1] We use the terms seller and buyer not in the strict sense of buying and selling land. We label households who rent in land in net terms as buyers of land and households who rent out land in net terms as sellers of land. The intermediate group is labeled as land self-sufficient households to indicate their non-participation in the rental market either as buyers or sellers. Analytically, the shadow price for these households is such that the market rate is unattractive.

question of the ability of rental markets to compensate for the imperfections in the markets for the non-land factors.

In this study we try to contribute to the discussion on the role of market imperfections in explaining leasing behaviour of households using sample data from the Highlands of Eritrea. In the sense of the ability to transfer land by sale, there is no land market in the highlands of Eritrea. As is the case in many rural areas of the developing world, however, there is temporary land transfer through land rental market, which appeared to be rather active. Participation in the land rental market is not even across all households, while some participate as sellers or buyers of land, others are non-participants, as they cultivate only their land. Why does the tenancy market exist? Why do households assume different positions (land sellers, land buyers, and non-participants) in the tenancy market? How perfect is adjustment via the land rental market? These are some of the interesting questions the answers to which may contribute to the understanding of the tenancy markets and their role in explaining efficiency differentials across farms. In order to address these questions, a study of the tenancy market and leasing behaviour of households is necessary.

Our specific objectives are (1) to analyze the rationale for household participation/non-participation in the land rental market, (2) to conduct a test of market imperfections in the land rental market and in other factor markets through the analysis of net land leased in and land area cultivated by distinguishing between land buyers, land sellers of land and non-participants.

In addition to rationalizing efficiency differentials across contract types, we believe that an analysis of leasing behaviour can also give insight into the kinds of tenancy reforms that may be required to deal with the land tenure systems in Sub-Saharan Africa where land markets are claimed to be full of imperfections. In particular, an analysis of the tenancy market based on household position in the land rental market is important for designing appropriate strategies for particular problems.

The rest of the chapter is organized as follows. In section two, we present literature survey, the tenancy situation in the highlands of Eritrea, and discuss the data from the study areas. In section three, we constructs a theoretical model of household land leasing behaviour. Section four outlines the econometric models, discusses estimation methods, and states specific hypotheses. Section five presents and discusses the results of regression analysis while section six concludes.

2. Literature Review and Tenancy Markets in the Highlands Eritrea

2.1: Literature review

The absence of private markets in land is not necessarily a cause of inefficiency in production. Given perfect marketability of all non-land factors of production, constant returns to scale in production across all farms, and perfect markets for produce, the household could adjust the use of the non-land factors to the size of the land without having to adjust the size of his/her cultivated area (Bliss and Stern 1982; and Binswanger and Rosenzweig 1984).[2] It is only when there are market imperfections in one or more of the non-land factors that tenancy markets may be needed as alternative adjustment mechanisms. Thus, tenancy markets may come in response to market imperfections in other factor markets, but their existence does not necessarily guarantee efficiency unless they and perhaps the other markets work perfectly. To the extent that there are efficiency advantages from transfer of land to more productive farmers, tenancy markets may have the advantage of minimizing efficiency losses that may be created due to the absence of private land markets. In this respect land-rental markets may play the role of private land market to some extent.

The subject of land rental markets in the context of imperfect markets for factors was first observed by Bell (1976) in his study of the Purnea district of Bihar, India. He argued that the non-existence of a market for bullock hire services provides the rationale for land leasing markets with the result that households having surplus bullocks relative to their land assets would choose to rent in land, while those with more land relative to their bullock capacity would rent out their surplus land. Bliss and Stern (1982) later developed this into a model (referred as the BS model, hereafter) in the context of imperfect markets for bullock and labour services. In their study of the Indian village of Palanapur, they argued that the market for bullock and labour services were highly imperfect due to high transaction costs[3] and thus adjustment in these factors was not possible. This, they argued, motivates households to resort to the land rental market to adjust area cultivated to their endowment of the semi- or non-tradable factors. To test their model, they postulated that households have a 'Desired Cultivated area (DCA)' that is determined by their endowment in labour, $\overline{L}$, and bullock capacity, $\overline{O}$.

$$DCA = f(\overline{L}, \overline{O}) \qquad (1)$$

---

[2] If we have constant returns to scale, identical production functions and n factors, only (n-1) efficient markets are necessary to have efficiency in production (Bliss and Stern, 1982). Perfect markets, by equalizing marginal productivities across individual farmers, result in production efficiency

[3] Bliss and Stern, 1982) did not use the term transaction costs specifically. But their reference to costs related to search for suitable landlord or tenant and negotiation could be termed as transaction costs.

Participation in the land rental market is an attempt to make up the difference between DCA and land owned, $\overline{A}$. Bliss and Stern referred to this difference as net land leased-in (NLI) expressed as

$$NLI = h(f(\overline{L},\overline{O}) - \overline{A}), \qquad (2)$$

Where *h* is a function of the imperfection in the land rental market. If households do not face transaction costs and adjustment of land owned to DCA is done smoothly, we have actual area cultivated (ACA) equaling DCA and thus

$$NLI = DCA - \overline{A} \qquad (3)$$

This implies that h=1. A linear approximation of (2) yields

$$NLI = c + h' f_1 \overline{L} + h' f_2 \overline{O} - h' \overline{A} \qquad (4)$$

where; c=constant term, $h' = \dfrac{\partial h}{\partial (DCA - \overline{A})}$ and $f_1 = \dfrac{\partial f}{\partial \overline{O}}$, and $f_2 = \dfrac{\partial f}{\partial \overline{L}}$

In Econometric terms (4) can be expressed as

$$NLI = \beta_0 + \beta_1 \overline{L} + \beta_2 \overline{O} - \beta_3 \overline{A} + e \qquad (5)$$

where $\beta_0 = c$, $\beta_1 = h' f_1$ and $\beta_2 = h' f_2$ and $\beta_3 = h'$, and e is the error term. Since with perfect adjustment *h=1*, Bliss and Stern argued that a statistically significant $\beta_3 = -1$ is evidence of a well functioning land rental market. Using sample data from Palanapur, estimation of (5) by Bliss and Stern revealed that both labour and bullock capacity affect rental behaviour significantly, suggesting that the markets for such services are highly imperfect. They found that $\beta_3 = -.78$, which was significantly different from –1, suggesting that the rental market was not working perfectly and that adjustment through the land rental market could not compensate fully for the imperfections in labour and bullock factor markets.

The BS theory was tested in other parts of India and Asia, as well. Pant (1983) and Nabi (1985), using sample data from six villages in Maharashtra and Andhra Pradesh of India, and from Semi-arid Pakistan, respectively, found evidence supporting the hypotheses of imperfect labour, bullock, and land rental markets. Srivastava (1989), in a study of three villages in Uttar Pradesh state in India, showed that bullock capacity affected rental behaviour significantly in two of the villages and labour affected rental behaviour significantly in the third village. The effect of land was significantly different from –1 in all the villages, showing that the land rental market was imperfect. The magnitude of the effect of bullock capacity is, however, very low when compared with the effect of land owned on rental behaviour.

Nabi (1985) argued that the BS model is basically a short run model in which possible long term adjustment in bullock capacity and other non-land factors are not addressed. Short-run difficulties in achieving desired leasing might be overcome in the long-term. The implication is that observed rental patterns could be the result of both short and long term adjustments in factor inputs in which case it may be useful to consider changes in household assets and cultivation over time.[4] Taslim and Ahmed (1992) built on Nabi's critique and postulated that the achievement of the desired leasing is gradual as opposed to the instantaneous adjustment in the BS model. They included a partial adjustment mechanism in the above model as follows

$$\Delta NLI_t = NLI_t - NLI_{t-1} = H(NLI_t^* - NLI_{t-1}) \qquad (6)$$

where; t and t-1 are period subscripts and $NLI_t^* = DCA - \overline{A}$ the desired leasing. After substitution, rearrangement, and taking linear approximation, they arrived at

$$NLI = c_1 + H' f_1 \overline{L} + H' f_2 \overline{O} - H' \overline{A} + (1 - H') NLI_{t-1} \quad ,$$

where $H' = \dfrac{\partial H}{\partial (NLI_t^* - NLI_{t-1})}$. In econometric terms,

$$NLI_t = \beta_0 + \beta_1 \overline{L} + \beta_2 \overline{O} - \beta_3 \overline{A} + \beta_4 NLI_{t-1} \qquad (7)$$

The implication is that the household in this model gradually adjusts its actual leased area to the desired leased area. The writers argued that if equation (7) is the true model of the leasing behaviour of the household, then regression estimates of the coefficients of equation 5 suffer from specification error and it may not have the properties of OLS estimators. If, however, the lease market is in instantaneous equilibrium or if households attained their desired leasing, then $NLI_t = NLI_{t-1} = NLI_t^*$ in which case model 5 is the true specification. Accordingly, they estimated equation 7 using data from two villages in Bangladesh. They reported that adjustment is complete in one village but the lease market in the other village appeared to be in disequilibrium, showing that a model of gradual adjustment is more appropriate for the latter village than the former village. The study also provided evidence of the role of bullock and labour endowment in explaining rental patterns in the area.

In Africa the only application of the BS model that we are aware of is that of Kevane (1997) on sample data from western Sudan. Kevane reported that rental behaviour is explained by household non-marketed factors, but the land rental market appeared to function

[4] This may, however, be context specific as in some cases, institutional limitations may limit leasing to be a short-run phenomenon. In the context of our study area, for instance, the duration of contracts for most land contracts is one year. So the argument for short-term adjustment may not be a wrong assumption to make.

well, suggesting that the imperfections in the market for non-land factors were partly compensated by the land rental market. This has important implications for the debate on the inefficiency of endogenous land tenure systems in many African countries. That is, if the rental market is efficient, there may not be a need for a land reform that is more in line of a private land holding system.

Pender and Fafchamps (2000) argued that the effect of land owned on area cultivated would be insignificant if the land rental market works perfectly. They tested their hypotheses using sample data from four villages in Ethiopia and found that area cultivated is positively and significantly affected by land owned, suggesting that the land rental market is characterized by considerable transaction costs. They also found evidence that area cultivated is significantly affected by household oxen endowment, suggesting that the service for oxen market is imperfect.

There, are, however, some weak points one can spot in the BS approach and its applications. First, empirical studies based on the BS approach run a single regression model of net land leased in (NLI) regardless of the position of the household in the land rental market. There may be substantial non-participants in the land rental market due to transaction costs. Variation in transaction costs in the land rental market across households might determine whether households participate or not in the land rental market. To the extent that this is true, an attempt to seek evidence of transaction costs in the land rental market through estimation of a pooled net land leased in equation may only tell part of the story; estimation of NLI using pooled sample may provide a way of testing for the presence\absence of transaction costs in the land rental market in general, but it does not explain how transaction costs vary across different households, or how costly adjustment is for land buyers as compared to land sellers and for non-participants relative to participants. Moreover, it may be possible that some of the independent variables used in the NLI affect the rental behaviour of households in different ways depending whether the household is a seller or a buyer of land or non-participant, since other factor and output market situations might be different for different types of households or since households on either side of the tenancy market may differ in production functions and /or utility functions (Skoufias 1995).

Secondly, the BS approach seems to consider households that neither rent in nor rent out as perfectly adjusted in the sense that they have an adequate mix of resources. As the result, the NLI equation was estimated using ordinary lease squares without correcting for the prevalence of zero values in the dependent variable. Empirical studies that tried to correct for this bias, for instance Skoufias (1995), have estimated Tobit models without considering the possibility that other factors may affect the participation decision than the decision on how much to participate. Furthermore, Tobit estimates are based on Maximum Likelihood estimation approach, which depend strongly on normality assumption of the distribution of the error terms.

In consideration of the above weaknesses, it may be useful to study the leasing behaviour of the land buyer and land seller households separately in which case two-stage sequential estimation methods of the land leased equation might provide a better insight than the BS model. This will require correction for selection bias that might be created due to consideration of only the land buyer or the land seller household.[5]

2.2: The tenancy market in the highlands of Eritrea

A defining feature of the land tenure system in the highlands of Eritrea is the collective ownership of land by village communities and the more or less equitable distribution of land among eligible village members. Landlessness is little known in the area. However, the distributions of the non-land productive assets are unequal and the markets for these services are imperfect at best. The implication is that it is not easy for households to adjust the use of these factors through hiring-in or out. The land rental market provides an alternative resource adjustment mechanism by which households may adjust cultivated area to their access to the non-tradeables, implying that land might be more mobile than the other factors. Non-tradability or market imperfections in non-land factors may not, however, be even across factors and households. Nor may access to the land rental market be smooth for all households, as some may face more transaction costs than others. Below, we try to provide a general description of the markets for labour and oxen, with the aim of setting a basis for developing a theoretical and empirical analysis of the rental patterns in the highlands of Eritrea.

Our observations in the highlands of Eritrea show that the land rental market plays an active mediating role in the adjustment of area cultivated to factors that are more or less fixed to the household. These factors include labour, farm skills, and draft power (oxen). The markets for services of these factors are imperfect and that adjustment of these factors through buying and selling is generally difficult, although it varies across factors and households.

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[5] In a study on the effect of formal credit on land tenancy, Kochar, (1997) applied Heckman's two-stage method on sample data from Northern Indian State of Uttar Pradesh to estimate tenancy outcomes. His results show an insignificant effect of land owned on land leased by tenant-cum households. However, since the purpose of the paper was on the effect of credit on tenancy outcomes, Kochar did not make any comments on the implication of this for the working of the lease market. His results, however, show that endowment in labour and draft animal affect area leased-in positively.

Some households are observed to participate in some markets while others do not (see table 7 for the study area, for instance). Access to farm labour and particularly to male labour is binding during peak seasons The traditional division of labour in agriculture in the highlands of Eritrea is that only men carry out the plowing and thus there is less substitutability between male and female labour. Access to off-farm work is generally uneven across households and gender. Better paying off-farm work opportunities are usually in relatively distant areas and, for cultural reasons, are generally accessible to men only. Therefore, adjustment of labour services is generally costly. Related to labour input is the market for farm skill. Agriculture is complex and requires entrepreneurial and managerial ability. Yet, as is the case in most developing country agriculture, the market for such services is thin and thus farm skill is non-tradable. The implication of non-tradability of labour and farm skill is that households that are deficit in these factors find it profitable to lease out land to those that have surplus of these factors.

The market for oxen power appeared to be nearly missing. One of the commonly cited reasons for this is the need to supervise the person using the bullocks on rental basis to prevent maltreatment of animals arising from moral hazard. Supervision takes scarce labour away from farming activities. However, there are some forms of transactions in bullock services that have little risk of moral hazard or that do not require much in terms of supervision. These are transactions conducted between labour scarce female-headed households and bullock scarce households whereby the former would allow the latter to use the bullocks in exchange for labour services. The opportunity cost of the labour supervising the use of the hired bullock in this type of transaction is low. Besides such transactions might also be confined among close relatives resulting in low supervision cost. The other possibility is sharing of oxen for households owning only one ox each, as a pair is required for plowing. This arrangement is called *Lifintee,* literally meaning collusion of draft animals for cultivation. In *Lifintee*, plowing is carried out in turns. As we shall see in our sample data later, however, these incidences are rare. The seasonal nature of agricultural activities dictates that plowing and other agricultural activities must be carried out during particular periods of the year. This limits transactions in oxen services during peak season.

One may argue for adjustment of oxen services to area cultivated through buying and selling of oxen. This is, however, difficult to achieve as the buying and selling of oxen involves transaction cost in terms of search cost and, more importantly, having (buying) oxen and maintaining its capacity is an expensive task, which perhaps requires access to capital. So short-term adjustment in oxen capacity is difficult to achieve. The implication is that oxen service is largely non-tradable and thus it is a major determinant of leasing outcomes.

2.3: The data and some preliminary observations

The data that we use in this study is from a sample of 319 households in 32 villages located in the highlands of Eritrea.[6] The sub-regions are *Mendefera, Dibarwa, Gala-Nefhi, Berik and Serejeka*. Administratively, the first two belong to the *Debub* region and the last three belong to *Maekel* region. *Dibarwa* and *Mendefera* are described as *Mid-highland* while *Gala-Nefhi, Berik* and *Serejeka* are described as *Highlands*. The distribution of sample villages by region and sub-region is shown in Table 3.

The land-rental market is active in the study area. Table 7 shows that 20 percent of the sampled households participated as land sellers (*type-1*, hereafter), 34 percent as land buyers (*type-3*, hereafter)) of land, while the remaining 46 percent have not participated at all (*type-2*, hereafter) in the land rental market.[7] It is shown in Table 7 that of the total land cultivated by *type-3* households, 41 percent was rented in and of the total land owned by *type-1* households, 63 percent was rented out. In an attempt to identify the rationale for household participation in and the working of the land rental market in the study area, we examined pre and post lease factor ratios for household types identified by participation in the land lease market. In Table 5 we see that the pre-lease land labour ratios were significantly different between *type-1* and *type–2* and between *type-1* and *type-3* households, but there was no significant difference between *type-2* and *type-3* households. The post-lease land to labour ratio has changed for all groups, but only to diverge further.

Decomposition of factor ratios by gender in Table 4 reveals that pre-lease land female labour ratios were not different between *type-1* and *type-3* households, and weakly different

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[6] The survey was conducted in the months March-Oct., 2001. The data collected is for the year 2000 rain-fed production season. The major types of crops grown are cereals that include barley, a mixture of barley and wheat (*MBW*, hereafter), and *Taff* (=*Teff*). *Taff* in *Mendefera*, *MBW* and *Taff* in *Dibarwa*, barley and *MBW* in *Gala-Nefhi*, and wheat and barley in *Berik* and *Serejeka* sub-regions dominate the cropping pattern. Production is dominantly subsistence oriented. However, *taff* and Potato are used as sources of cash in the sub-regions of *Mendefera* and *Serejeka*, respectively.

[7] The type of land contracts are G*irat-fereka,* literally meaning a land under fifty-fifty share; *Girat-Meseles*, meaning a contract that provides one-third of the total output to land owner: *Girat-ribae*, meaning a contract that provides a one-fourth of the total output to land owner, and *Girat-kiray*, meaning a contract where the tenant pays cash affront to the land owner. In first type of type of contract the tenant and landlord provide oxen and land, respectively, and costs of production are shared equally between them. There are, however, few cases where a landlord and a tenant who own one ox each entered into this type of contract. The second and third types of contracts are pure output sharing where the landlord contributes land only while the tenant provides oxen and bear all the production cost. The fourth type is fixed-rent contracts where the landlord provides land and receives cash payment up front as rent and the tenant provides oxen and bears all the cost of production. Cost and output sharing and pure output sharing contracts dominate, as the numbers of fixed rental contracts reported are very small when compared to the other type of contracts (See Okbasillassie and Holden, 2003d).

between *type-1* and *type-2* and between *type-3* and *type-2* households. Post lease factor ratios have shown significant divergences between all pairs of household types, but *type-1* household appeared to have made larger adjustment in comparison to both *type-2* and *type-3* household types. There was no difference in pre lease land male labour ratios between *type-2* and *type-3* household, and post lease ratios have diverged because of substantial adjustment by *type-3* households. It was not possible to conduct comparisons of this ratio between each of *type-2* and *type-3* with *type-1* households, as most *type-1* households were characterized by zero endowment of labour, which created computational difficulty.[8]

Given that *type-1* households are endowed with low levels of male labour and given that there was no marked difference in land female labour ratios, we can say that rental decisions were driven by access to male labour as opposed to female labour. Further, we can see that adjustment was larger for *type-1* households than for *type-2* and *type-3* households, suggesting that type-1 households might have faced less difficulty in adjusting than other household types. The pre-lease equality and the post-lease inequality between *type-2* and *type-3* households may also suggest that *type-2* households might have been prevented from entering the rental market due to transaction costs in the land rental market. In general, it seems that pre lease variation in land to labour ratio was a rationale for participation in the land rental market, but the fact that post-lease factor ratios have not converged across farms might indicate that the rental market did not operate smoothly.

Table 4 also shows that there were marked differences in pre and post lease oxen land ratios between each pair of household types, except for slight convergence in factor ratio between *type-2* and *type-3* households. Given that *type-1* households are oxen-poor, they appeared to have made substantial adjustment relative to *type-2* and *type-3* household.[9] We can say that rental behaviour was also determined by access to oxen.

In Table 5 we also tried to find out if there is a change in patterns of land use between labour rich and labour poor households with variation in oxen levels. The result shows that area cultivated increases with increase in oxen level for labour rich households more than for labour poor households, suggesting that for the former group labour played a complementary role to oxen. For the latter group, labour appeared to constrain production more. The role of oxen appeared to be stabilizing area cultivated around area owned, suggesting that that labour

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[8] The difficulty was that the denominator for the factor ratio becomes undefined. Changing the labour land ratio does not solve the problem, as many *type-1* households rented out all their land, reducing area cultivated to zero.

poor households with a pair of oxen might have resorted to the traditional mechanism of labour-oxen exchange to alleviate the shortage of labour, which in turn might indicate some degree of substitutability between oxen and labour.

Table 6 reports how leasing-in decisions affected land distribution and area consolidation. We see that pre-lease distribution of land was highly skewed in favor of *type-1* households as compared to *type-2* and *type-3* households, but there was not significant difference between *type-2* and *type-3* households.[10] Leasing decisions have reversed this order and resulted in more concentration of land by *types-3* households relative to *type-1* and *type-2* households. We also see that there was slight difference in pre-lease fragmentation levels between *type-1* and *type-3* and between *type-2* and *type-3* households, but not between *type-1* and *type-2* households. Post lease factor ratios have shown convergence between *type-1* and *type-3* households but not between *type-1* and *type-2* and between *type-2* and *type-3* households. *Type-1* and *type-3* households operate more consolidated holdings than *type-2* households, implying that participation in the leasing market reduces land fragmentation.

In Table 7, we report in and out hiring of labour by household participation in the land rental market, which showed that there was considerable participation in the labour market by all household types. This appears to suggest that the labour market is relatively active and that households faced less transaction costs in the labour market than in the land rental market, although this was not equally true for all household types. Non-participation in the labour market was the highest for type-1 households, indicating that they faced lower transaction cost in the latter market. Participation as a seller of labour was the highest for *type-2* households, suggesting that they faced lower transaction cost in the former. Labour buying was the highest for *type-3* households, indicating perhaps that transaction cost of accessing and managing (moral hazard) hired labour was lower for *type-3* than for the other households. This may suggest that leasing outcomes may depend less on household labour endowments for labour-hiring households than would be the case under a completely missing labour market. However, labour buying may also be necessitated by larger scale of production, regardless of transaction costs.

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[9] The analysis for *type-1* households was conducted using only 32 observations out of the total 64 type-1 households. This was because the denominator for the factor ratio becomes undefined, since renting-out of all plots results in zero area cultivated.

[10] This is the result of the household based (as opposed to family size based) system of land distribution of the *Deissa* system of land ownership in the Highlands of Eritrea. Per-capita land ownership tend to favour households with smaller family size. But this could also be a temporary situation created by the fact that many households have contributed at least one adult labour to the army due to the "border" war with neighboring Ethiopia.

Table 8 shows that 40 percent of the households have reported the use of tractor for plowing at least at one stage of the cultivation process[11]. There was significant difference in tractor use between household types, with *type-3* households being the most using followed by *type-2* households. Table 8 also shows the definition and summary statistics of all the variables used in regression analysis for the total sample and by household type

3. Participation in the Land Rental Market -Theoretical Model

In light of the above review of literature and the settings in the highlands of Eritrea, we postulate that participation in the land rental market is a result of imperfections in the services for labour, including management and draft power. The model below builds on Holden et al. (2001), which explicitly deals with and tests for imperfections in markets for land, oxen, and labour.[12]

Consider a farm household with initial endowments of land, $\overline{A}$, labour, $\overline{L}$, and some oxen power and other fixed farm assets, $\overline{O}$, for cultivation. Since the household has the possibility of adjusting its land and labour use through participation in the land rental and labour market, we have

(1) $A = \overline{A} + A_j$, $L = \overline{L} + L_j$

where A and L are area cultivated and labour used in production, respectively, and A_j and L_j are land rented-in or rented-out and labour hired-in or hired-out for household *j*, respectively. The household is a buyer of land if $A > \overline{A}$, and a seller if $A < \overline{A}$, and neither buyer nor seller if $A = \overline{A}$. The equilibrium condition for labour is the same as that for land. Further, we postulate that the household's crop output is given by

(2) $q(A, L, \overline{O})$,

where q is a twice-differentiable concave production function with positive and negative first and second derivatives, respectively. We assume complementarities between non-land fixed farm assets and land, $q_{AO} > \mathbf{0}$ and $q_{AL} > \mathbf{0}$. Assuming that farm output can be sold at a

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[11] For many households only the first stage of cultivation is done by tractor with the rest of the tillage, particularly sowing, is carried out using oxen power.

[12] Holden *et al.* (2001) also recognize that different factors may influence the participation or non-participation in these markets than those affecting the degree of participation. The functional relationships may also be different for the two-stages.

market price of P_q, land is rented on fixed-rent [13] basis at price P_j^r and labour at w_j, the household's income, y_j is given by

(3) $y_j = Pq(A, L, \overline{O}) - P_j^r A_j - wL_j$

Where $j = \begin{cases} \text{b = buyer of land / labour} \\ \text{s = seller of land / labour} \\ \text{* = self - sufficient in land / labour} \end{cases}$

Assuming that the household opts to maximize utility from income, his/her maximization problem is given by

(4) $\underset{A_j L_j}{L} = U(Pq(\overline{A} + A_j, \overline{L} + L_j, \overline{O}) - P_j^r(A - \overline{A}) - w_j(L - \overline{L}))$

where U is a twice-differentiable quasi-concave utility function with positive and negative first and second derivatives, respectively. Using the above model, one may derive nine combinations of equilibrium conditions for labour and land depending on the market status of the household in these factors (seller, non-participant, and buyer positions). These combinations, labeled C1-C9, are given in Table 1 below. Analogous to the land market, w_s, w_*, and w_b show the selling, the shadow, and the buying price of labour, respectively. These combinations are results of variations in non-land to land ratios and variations in transaction costs of resource adjustment in land and labour factor markets. According to these results a given household can assume different market positions in land and labour markets. For instance, C2, C5, and C8 show that the household has the possibilities of assuming a seller, a buyer, or a non-participant position in the labour market while remaining to be non-participant in the land market. For this particular case, it can be said that the household is facing less transaction costs (in C2 and C8) in the labour market if it participates in the labour market only. Similarly, households with C4 and C6 combinations face less transactions costs in the land market than in the labour market.

Non-participation in both markets simultaneously (C5) might be understood as a situation where, for given endowments in land and labour resources, the household faces

[13] In fixed-rent market, the price of land is the rental fee. In sharecropping context, the price of land is not clearly defined. It may be possible to consider the output share of the landlord, that is, the sharing rule, $1-\alpha$, where $0 < \alpha < 1$, as *de facto* price if all the costs of production are covered by the tenant. In reality, however, things are more complicated than this. To avoid such complications, we assume that there is some rental price, P_j^r, where the subscript j, indexing household type by market participation, indicates that the effective rental price might vary across household types.

transaction cost in both the labour and the land markets in such a way that efficiency (constrained Pareto efficiency) is achieved through non-participation in both markets.[14] Non-participation in the land rental market may also be due to perfect adjustment (Bliss and Stern, 1982; Nabi 1985), in which case non-participants contain

Table1. Household status in land and labour market

		1. Status in land rental market			Labour price
		Landlord: Seller	Non-participant	Tenant: Buyer	
2. Status in labour market	Seller	C1: 1. $P_q \frac{\partial q}{\partial A_s} = P_s^r$ 2. $P_q \frac{\partial q}{\partial L_s} = w_s$	C2: 1. $P_q \frac{\partial q}{\partial A} = P_*^r$ 2. $P_q \frac{\partial q}{\partial L_s} = w_s$	C3: 1. $P_q \frac{\partial q}{\partial A_b} = P_b^r$ 2. $P_q \frac{\partial q}{\partial L_s} = w_s$	w_s
	Non-participant	C4: 1. $P_q \frac{\partial q}{\partial A_s} = P_s^r$ 2. $P_q \frac{\partial q}{\partial L} = w_*$	C5: 1. $P_q \frac{\partial q}{\partial A} = P_*^r$ 2. $P_q \frac{\partial q}{\partial L} = w_*$	C6: 1. $P_q \frac{\partial q}{\partial A_b} = P_b^r$ 2. $P_q \frac{\partial q}{\partial L} = w_*$	w_*
	Buyer	C7: 1. $P_q \frac{\partial q}{\partial A_s} = P_s^r$ 2. $P_q \frac{\partial q}{\partial L_b} = w_b$	C8: 1. $P_q \frac{\partial q}{\partial A} = P_*^r$ 2. $P_q \frac{\partial q}{\partial L_b} = w_b$	C9: 1. $P_q \frac{\partial q}{\partial A_b} = P_b^r$ 2. $P_q \frac{\partial q}{\partial L_b} = w_b$	w_b
Land price		P_s^r	P_*^r	P_b^r	

not only those who are prevented from entering the rental market due to transaction costs but also those who have an adequate mix of land and labour resources. Non-participants may also include households that are completely rationed out of the tenancy market (Bell and Sussangkarn 1988; Skoufias 1995).

Combinations C1, C3, C7, and C9 show participation in both markets. C1 arises when the household faces low transaction costs in selling labour and land, which may indicate lack of or low level of a third resource, say oxen, that is costly to rent-in, or the household faces high opportunity cost of labour in off-far activity due to some particular skill or education. Similarly, C9 is a situation where the household has a sufficiently large amount of a third

[14] Non-participation in one or both markets does not, however, imply that there are no alternative resource adjustment mechanisms that may involve lower transaction cost than direct participation in factor markets. An example in this case is pooling of draft animals where two households combine their oxen power to do cultivation in turns, although this was not observed widely in our sample data.

resource, say oxen, for which there are high transaction costs in relation to selling and it faces sufficiently low transaction costs to participate in both markets as buyer. For C3 to arise the household should be rich in labour and other non-land assets, but poor in land, creating the adjustment situation that land is rented-in and labour is hired-out at the same time. C7 is a situation where the household rents-out part of its land and cultivates the rest with the help of hired labour (labour-poor but land-rich). Besides to low transaction cost in both markets, partial renting may also be due to difficulty in the ability to rent out all land.

To show the conditions under which the household adopts a particular status in the land rental market, we make the following simplifying assumptions that (1) transaction costs for oxen services is prohibitively high that we consider oxen, $\overline{O}$, as non-tradable, (2) further, we assume complementary relationship between oxen, land, and labour in production (implying also resource pooling is not permitted), (3) the labour market works perfectly and labour is of homogenous quality so that endowment of labour does not matter for household participation in the land rental market, and (4) the output market works perfectly. These assumptions imply that, the household's position in the land market is determined by his/her endowment of oxen relative to land assets and the transaction costs in the land rental market.

Given the above assumptions, the shadow value of land, P_*^r, and the equilibrium land allocation, A_*, for households that voluntarily do not participate in the land rental market, are determined by the following system of two equations

$$(6) \qquad P_*^r = P_q \frac{\partial q}{\partial A} \text{ and } y = P_q q(\overline{A}, w, \overline{O}),$$

The shadow value of land before renting in/out can then be expressed as a function of own land, non-land productive assets, and prices of output and labour as follows.

$$(7) \qquad P_*^r = P_*^r(\overline{A}, \overline{O}, P_q, w)$$

The shadow rental rate increases with output price, with household endowment in oxen, and decrease with household endowment in land asset and with the wage rate.[15] To decide on whether to remain non-participant or adopt a landlord or tenant position in the land rental market, the household compares the shadow value of land with the rental price of land. To illustrate this, let $\overline{O^1}$, the minimum level of oxen required to do some cultivation, be defined

[15] This result can be shown by placing the solutions for land and the shadow rental rate back in equations 6, totally differentiating the two system of equations in (6) and solving for $\frac{\partial P_*}{\partial I}$ where $I = \overline{A}, \overline{O}, w, P_q$.

by $P_q \frac{\partial q}{\partial A}(\overline{O^1}, A, w, P_q) = P_s^r$, where $A \geq 0$.[16] For given w and P_q and ignoring that oxen capacity is indivisible, one may think of five land allocation strategies or regimes, which are given in Table 2 below.

In table 2, the rationale for participating as land seller is that the household's endowment in oxen is so small that the marginal productivity of even one unit of land would be inferior to the rental income the household may get by renting out the land. Since by assumption $q_{AO} > 0$ and $q_{AA} < 0$, for $\overline{O} < \overline{O^1}$, it must be the case that $P_s^r > p_q \frac{\partial q}{\partial A}$. This implies that $A = 0$, the household rents-out all the land it has.

Table2: Household position in land-rental market under different levels of oxen and shadow value

Status in the land rental market	Levels (conditions) of		Quantity of			Price of land
	Oxen, $\overline{O}$,	Shadow rental value	A_s	A	A_b	
1. Pure landlord	$\overline{O} < \overline{O^1}$	$P_*^r < P_s^r$	+	0	0	P_s^r
2. Landlord-cum	$\overline{O} \geq \overline{O^1}$	$P_*^r < P_s^r$	+	+	0	P_s^r
3. Owner-operator	$\overline{O} > \overline{O^1}$,	$P_s^r \leq P_*^r \leq P_b^r$	0	+	0	P_*^r
4. Tenant-cum	$\overline{O} > \overline{O^1}$	$P_*^r \geq P_b^r$	0	+	+	P_b^r
5. Pure tenant[17]	$\overline{O} > \overline{O^1}$		0	0	+	P_b^r

Partial land selling arises (status 2 in Table 2) arises because it is profitable for the household to cultivate part of its land and rent out the rest. The allocation of land under own cultivation for this household is defined by $p \frac{\partial q}{\partial A}(A, \overline{O}) = P_s^r$. Here, the left-hand side term is equal to the shadow rental rate at $\overline{A} - A_s$, which is also greater than the shadow value at $\overline{A}$, since the shadow rental rate decreases in land asset relative to oxen. This implies that partial renting-out of land increases the return to land under own cultivation. It also implies that as

[16] This may not hold if the household can cultivate using hoe, but cultivation by hoe is non-existent our study area. It may, however, be possible for the household to cultivate using machinery instead of draft animals. Although this is a real possibility, in the context of our study area it is rare that access to tractor eliminates the need for draft animals, as some tillage, particularly the one for sowing is better and usually done by oxen. Thus, the use of tractor may reduce the importance but not completely replace the services of draft animals., we assume that the household has no access to machinery. Besides, to make our model simple and tractable, we choose to handle this in the empirical rather than the theoretical analysis of the problem.

[17] This category is an artificial case in the Eritrean context, as we do not have land less people.

oxen levels increase relative to land assets, selling land decreases until all land is put under own cultivation when $P_*^r(\overline{O}, \overline{A}, w, P) = P_*^r \geq P_s^r$.

Land buying (status 4 in Table 2) arises when $P_*^r \geq P_b^r$. That is, when non-land assets are sufficiently large relative to land assets, the household considers buying land. Since, by assumption, $q_{AA} < \mathbf{0}$, if the household is renting in land, it must be the case that $P_*^r > P_b^r$ before renting. The household will continue to rent in land until $P_*^r = P_b^r$. That is, when $P\frac{\partial q}{\partial A}(\overline{A} + A_b, \overline{O}) = P_b^r$.

Since $\frac{\partial q}{\partial A}(= p_b^r) > P_s^r$ for a land-buying household, there is a range of values for P_*^r in which the household neither rents in nor rents out land. This provides status 3 in table 2 for which allocation of land under own cultivation is defined by $P\frac{\partial q}{\partial A}(A, \overline{O}) = P_*^r$.

To show the above results graphically, we assume that all households are equally endowed with $\overline{A}$ quantity of land, but with different levels of oxen. Thus oxen land ratio, $\frac{\overline{O}}{\overline{A}}$, varies across households, leading to differences in marginal productivity curves, since $q_{AO} > 0$. We see in Figure 1 below that that quantity of land cultivated and with it the quantity of net land rented in varies across levels of oxen endowments. At $\frac{\overline{O}}{\overline{A}} = a$, the marginal productivity curve is given by *MPAa* where the household rents out its land entirely, since *MPAa* is less than the selling price of land. At $\frac{\overline{O}}{\overline{A}} = b$, where *b*>*a*, marginal productivity is given by *MPAb* and as the result the household adopts a land allocation strategy whereby it cultivates A_b amount of land and rents out $\overline{A} - A_b$ quantity of land at p_s^r. At $\frac{\overline{O}}{\overline{A}} = d$, where d>c, the household achieves *MPAd* and increases its the operational holding to A_d by renting-in $A_d - \overline{A}$ quantity of land at p_b^r. At $\frac{\overline{O}}{\overline{A}} = c$, where c>b, the household adopts a non-participant strategy by limiting its operational holding to $A_c = \overline{A}$ at a point where $MPc = p^*$.

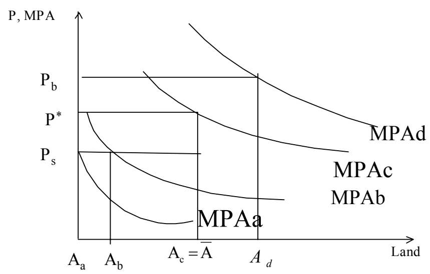

Figure1: Patterns of land use and lease under varying levels of oxen-land ratio

One can also see how changes in the wage rate and output price may affect land use and leasing decisions. The direction of the response to change in wages might depend on the net market position of the household in both the labour and land rental markets.[18] For net-buyers of land and labour (C9), the demand for land will decrease, as the increase in the price of labour reduces the profitability of land renting.[19] Similarly for net land and labour sellers (C1), more land might be available for renting out due to the incentive to hire out more labour for off-farm work. For households that are non-participants in the land rental market but hire in labour, the demand for land under own cultivation decreases and if transaction costs in the land rental market are sufficiently high to prevent the household from renting out land, then fallowing might be the only option available. The same response might also be expected if the household is non-participant in the land rental market but a net seller of labour in the labour market (C2), as the increase in wages, through its effect on reducing the shadow rental rate, might induce the household to increase the supply of labour to off-farm work by reducing its demand for land. For households that are non-participants in both the labour and the land rental markets (C5), the response of land use to changes in price is zero until they start to participate in one market or the other.

One can also analyze the effects of changes in output price on demand for land. The general expectation is demand for land to increase with output price regardless of the position

[19] The optimal land and labour allocations are $A^* = A^*(P_b^r, w, \overline{O}, P)$ and $L^* = L^*(w)$. Placing these solutions into the equations in C9 and doing total differentiation of the two equations wrt. w and solving for $\frac{\partial A}{\partial w}$, we get that $\frac{\partial A}{\partial w} = \frac{-pq_{AL}}{\mathrm{H}} < \mathbf{0}$, where H is the Hessian matrix, which is positive definite for maximization problems.

of the household in the land rental market. This is because the shadow land rental rate is a positive function of output price.

A partial equilibrium analysis similar to the above can also be made for labour and other non-land assets other than oxen that, by virtue of their non-tradability, may determine the position of the household in the land rental market. Assuming negligible substitutability between factors, household position in the land rental market may be expressed as a function of all the non-land non-tradable factors, with labour and oxen expressed relative to land assets. Similarly, given participation as a buyer or seller of land, area rented-out and area rented-in by the landlord and the tenant household, respectively, may be expressed as follows

$$A_j^r = A_j^r(P_j^r, NT_j^i) \qquad (8)$$

where $j = s, b$ and $i = \{\mathbf{1}, \mathbf{2}, \ldots\ldots n\}$ types of non-tradable factors that are essential for cultivation. Our theoretical analysis suggests that the demand (supply) of land increases (decreases) with the non-tradable and decreases (increases) with land price. This also suggests that if a household rents out all or part of its land due to shortage of some non-tradable factors, it is likely that it would choose to rent out to tenants with adequate capacity in those factors that it is short of. Having adequate capacity in labour and oxen capacity, for instance, may show the seriousness of the tenant in farming and the likelihood that the tenant would not face supply shortages during peak seasons when the market for such inputs is very tight (Taslim and Ahmed 1992). In general, by choosing tenants of high productive capacity due to their high endowment in labour, oxen, farm skills, and better access to working capital, landlords maximize the expected returns from rented out land.

Following the BS theory as outlined earlier, equation (8) may be expressed as the difference between the overall demand for land, A, and land owned, $\overline{A}$, as follows

$$A^r = A^r(A^*(\overline{L}, \overline{O}) - \overline{A}) \qquad (9)$$

Equations 8 and 9 will be the bases of our econometric estimation of land use and tenancy outcomes in the highlands of Eritrea.

4. Estimation Methods and Issues

Equations (8) and (9) are the basis of our econometric estimation. The BS model as outlined earlier is one way of estimating the models. However, the BS model estimates a single equation regardless of the market position of the household in the land rental market. By implication, it assumes that factor and output market conditions are the same whether the household is a land seller, land buyer, or non-participant in the land rental market. This assumption is, however, unrealistic at least in our context since participation in the land rental market is uneven across households; with a large middle group of non-participants in itself signifies considerable transaction costs in the land rental market. Accordingly, we shall analyse the leasing behaviour of buyers and sellers of land separately using sequential two-stage estimation methods. This method would give us insight into the rationale for household position in the land rental market and whether imperfections in the other markets vary across households. The BS model can, however, be useful for testing the presence of transaction cost in the land rental market as a whole.[20] Thus, both the BS and the separate two stage models are estimated. Estimation of the BS and the separate two stage models is preceded by analysis of the probability of participation in the land rental market using ordered probit models to explain the tenancy ladder[21] in our sample.

4.1: The BS model

Following the discussion of the BS model in our literature review section is we convert equation (9) into an econometric model as follows.

$$NLI = c_0 + \alpha' NT - \beta \overline{A} + u \qquad (10)$$

Where NLI is the desired net land leased-in derived as the difference between desired area cultivated and area owned for each household, c_0 is the constant term to be estimated, NT' is vector of non-land regressors affecting net land leased-in, $\overline{A}$ is area owned, α is a vector coefficients (to be estimated) associated with the non-land regressors, β is a coefficient on the land owned variable, and u is the unobserved error component of the model. Estimation of equation (10) using the total sample of households provides a test for the presence of transaction cost in the rental market as a whole. A value of β that is significantly larger than -1 is an indication of imperfection in the land-rental market that households are not able to achieve their desired area of cultivated. If the land rental market is perfect, actual area cultivated is independent of land owned. Otherwise, area operated is given by the sum of NLI and land owned and can be modelled econometrically as follows.

$$A = k_0 + \delta' NT + \lambda \overline{A} + e \qquad (11)$$

[20] By pooling all types of households in one regression, the BS model has an advantage of having a much larger sample than the separate analysis.

[21] The tenancy ladder theory, due Spillman (1919) and Reid (1977) hypothesizes that households first accumulate wealth and farming ability as hired labourers, progress to bear more risk while benefiting from landlord's cost sharing and managerial inputs as share croppers, and then become fixed rent tenant when they accumulate the needed capital and skills.

where A is area operated, k_0 is a constant term to be estimated, NT is a vector of non-land regressors affecting area cultivated, δ is coefficient associated with the non-land regressors to be estimated, λ is a coefficient of the land-owned variable, and e is the error term. Estimating area operated using the total sample provides an alternative test of imperfection of the land rental market. If adjustment through the land rental market is complete, area operated is independent of area owned and that the own-holding parameter is insignificant.

In line with our theoretical discussion, we expect net land leased in and area cultivated to increase with oxen and labour endowments. We distinguish between male and female labour because male and female labour may play different roles in production. Similarly, we distinguish between male-headed and female-headed household, as the former might have managerial and other advantages in the Eritrean context when particularly the labour market is imperfect.

Other regressors that are included in the estimation of (10) and (11) are gender (*hhsex*) age (*hhage*), education (*hhedu*) and farming experience (*hhfamex*) of the household head, use of machinery to cultivate land, incomes from off-farm (*offainc99*) and quantity of irrigated land the dry season (*irland*). We use education, farm experience, and gender of household head as proxies for farm skill, and since these inputs are non-tradable, we expect that more skilled farmers tend to be on the buying side while less skilled farmers tend to be on the selling side of the tenancy market. The effect of education may, however, be more of an empirical question, as it may have opposing effects on net land leased-in and area cultivated. To the extent that it enhances farm skills and household access to information, it may affect NLI and area cultivated positively. However, opportunity cost of farming might be higher for more educated household heads and both NLI and area cultivated might decrease with education.

Controlling for household farm experience, aged households are less likely to be on the buying side of the tenancy market, as age might reduce work effort. Access to tractor, to the extent that it is a substitute for oxen power, may have the effect of increasing area cultivated through a positive effect on land purchase and decreasing effect on land sales. Similarly, assuming an asymmetric access to credit markets, access to dry season irrigation may have the effect of expanding area cultivated by enhancing the farmer's ability to rent-in land.

Access to off-farm incomes may have two opposing effects. To the extent that it relaxes the cash constraint, it may increase area cultivated and the household may at least be saved from renting-out land. If the household is rich in labour, access to off-farm income[22] may induce the household to expand area cultivated by renting-in more land. On the other hand, a sufficiently high off-farm income may induce the household to rent-out land and specialize on off-farm activities only. For a labour poor household, however, participation in off-farm work may take labour away from farming activities and, therefore, the household may have to rent out some or all of its land. The net effect is an empirical issue.

Finally, considering the fragmented nature of the farms in the study area, leasing decisions might also be affected by distance of plots from homestead. To control for this, we derived an average measure of distance for land owned (*aavdist*) and used it as a regressor in models of net land leased-in and area cultivated. It is plausible to expect area cultivated to decrease with distance, but it is difficult to sign its effect on net land leased-in, as it may have opposing effects on leasing behaviour on either side of the tenancy market. Thus, it is easier to sign the effect of distance in a two-stage separate estimation procedure than in a single regression framework of the BS model.

Since land quality is heterogeneous even at household level in our setting, models (10) and (11) are estimated in two specifications each: one with total land owned and the other with land owned disaggregated into its three quality parts: good (*agland*), medium (*amland*) and poor (*apland*) quality land. This may provide some insight if rental behaviour is also affected by heterogeneity of land quality. We discuss the results for specification 2, while the results for specification 2 are given in the appendix to this chapter.

In terms of functional specification, equation (10) is estimated in linear form, as negative values of the dependent variable do not allow alternative specification. For equation (11), we have estimated a log-log specification, but off-farm incomes and area irrigated in the past dry-season are kept in linear form, as we do not know the functional form that relates these variables to the outcome variable.

We tested for heteroskedasticity using the Cook and Weisberg (1983) tests, which showed the presence of heteroskedasticity in model (10) but not in model (11). We also tested for normality of error terms in both models using the skewness and kurtosis tests as well as the Shapiro-Wilk and Shapiro-Francia tests (Gould and Rogers 1991; Gould 1991), which showed significant departure from normality in both models (10) and (11).[23] Thus, to test the robustness of the OLS results, we also estimated both models using quantile or median regression.[24] To

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[22] To avoid potential endogeneity of off-farm incomes, we have used a lagged off-farm incomes variable from the preceding year (1999), which is highly correlated with off-farm incomes in year 2000.

[23] The logarithmic transformation of model 11 helped reduce non-normality of the error terms but did not eliminate it.

[24] Quintile regression is considered to be desirable due to its robustness to conditional heteroskedasticity and distributional misspecification (Chen and Khan, 2000). Median regression is also known as least absolute value (LAV), minimum absolute deviation (MAD) model, and L1-norm models. Unlike least-squares regression where

control for heteroskedasticity and violation of the normality assumption in the least squares models in this approach, standard errors are estimated using the White Heteroskedasticity-Consistent Estimator of covariance matrix (Greene 1997).

4.2: Two-Stage Estimation

Converting equation 9 into econometric model along the ideas of the two-stage sequential estimation method, we have

$$A_j = I\left[X_i^{'}\beta + \varepsilon_1\right] \qquad (12)$$

where $j = seller, buyer$ and $X_i^{'}\beta$ and ε_o are the deterministic and random components of the model, respectively, and *I* is the indicator variable determined by whether the dependent variable is censored or not (whether the household sells land or not; or buys land or not in net terms). The indicator variable, I, is determined by a vector of conditioning variables, *Z*, using a binary choice model as follows

$$I_i = Z_i^{'}\eta + \varepsilon_0 \qquad (13)$$

Where $I_j = \begin{cases} 1 \text{ if } A_j > 0 \\ 0 \text{ if } A_j \leq 0 \end{cases}$ and ε_0 is an unobserved error term and η is a vector of unknown coefficients. Assuming $\varepsilon_1 \sim N(0,\sigma)$ and $\varepsilon_0 \sim N(0,1)$ and if $corr(\varepsilon_0, \varepsilon_1) = \rho \neq \mathbf{0}$ [25], which cannot be ruled out since process (13) depends on whether A_j is positive or zero, then

$$E(A_j \mid A_j > 0) = X^{'}\beta + \rho\sigma_{\mathbf{1}}\lambda(\alpha) + u\text{ ,} \qquad (14)$$ [26]

Where $\lambda = \phi(\alpha)/\Phi(\alpha)$, also called the *Inverse Mills Ratio*; ϕ and Φ are the density and cumulative standard normal, respectively; and α is the standard normal variable given by $\frac{a - X_i^{'}\beta}{\sigma}$ in which a is a point of censoring, which is zero in our case. The point is that if we estimate model (14) by OLS regression of *A* on *X*, we have omitted a variable, λ and that our estimates are biased (Heckman 1979). Much of the recent econometric work involving sample selectivity is done using the Heckit two-stage estimation procedure due to Heckman (1979).[27]

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the objective is to estimate the mean of the dependent variable, in median regression, the object is to estimate the median of the dependent variable conditional on the values of the independent variable; median regression finds the regression plane that minimizes the sum of the absolute residuals rather than the sum of the squared residuals (Rogers, 1992 and Gould, 1991).

[25] However, this correlation holds if the two error terms are jointly normal.

[26] See Green (1997) for derivation of these results.

[27] Other candidates for consistent (but inefficient) estimation are Non-linear least squares and Maximum likelihood estimation (MLE) methods. The attraction of Heckman two-stage procedure is that it requires a weaker assumption (than strict normality of the joint distribution of the error terms required in MLE) that $\varepsilon_1 = \rho\varepsilon_0 + v$ where v is independent of ε_1 (Cameroon, 2000, unpublished manuscript).

The Heckit approach obtains efficient estimation of $\lambda(\alpha)$ from a probit regression of model (13) and use the resulting estimate as an additional regressor in OLS estimation of (14).

The Heckit procedure relies on joint normality of the error terms and is sensitive to hetroscedastic distribution of the error terms (Greene 1997). To assess the sensitivity of the Heckit results to alternative specifications, we tried Deaton's two-stage regression model, which relaxes the assumption of joint normality of the error terms. Deaton's model uses the probability variables (obtained from the respective selection models) in polynomial form as an alternative approximation of the selection variable in the censored regression model (Deaton 1997). Mulitcolliniarity among the polynomial selection variables caused the need to eliminate some of them. We kept the first and the third degree polynomial elements in the land buyers' model and the second polynomial element in the land sellers' model. The elements with the highest VIF were eliminated when all were insignificant to assess whether the others become significant after elimination (to asses whether there was significant selection bias).

In the Deaton model we tested for heteroscedasticity using the Cook and Weisberg (1983) tests and rejected the null hypothesis of constant variance for both of the censored models. We also tested for normality of error terms using the skewness and kurtosis tests as well as the Shapiro-Wilk and Shapiro-Francia tests (Gould and Rogers 1991; Gould 1991) and we could not reject normality of the error terms for both of the censored models. To control for heteroskedasticity in the Deaton models, standard errors are estimated using the White Heteroskedasticity-Consistent Estimator of covariance matrix (Greene 1997).

Household endowment in labour and oxen and off farm incomes and irrigated area are normalized by land area owned in the first stage of estimation, whereas in the second stage these factors are used in absolute terms. In the second stage, it is necessary to use the endowments in absolute terms because we need to control for the effect of the land owned variable separately in order to test for transaction cost in the land rental market.

Identification of equation (13) is necessary to apply two-stage estimation procedures in this context. Since we had problems finding good variables for identification of the selection equations, we tried to use different functional form in the first and second step estimations. Thus, for land buyers, while the first stage was estimated using linear specification, we used log-log specification to estimate the second stage equation[28] except for the variables that may not have

[28] The choice of log-log format for the censored models might raise some questions in light of the mostly linear functions used in other empirical studies. It is difficult to argue for a specific functional form for the net land leased equation. Since the log-log specification is linear in parameter and the results can be interpreted in proportional terms, this should not be of major problem for testing our hypothesis of transaction cost. See Bliss

direct effect on the outcome variables.[29] For land sellers, identification of the selection equation was possible without resorting to a different functional form. In addition, the variable average distance of area owned from homestead (*aavdist*) was used to further identify the selection equations; average distance of area owned might affect the decision to rent-in or rent-out land, but not the extent of land rented in or rented-out. Area rented in or rented out might instead be affected by average distance of area rented in or rented out (*ravdist*).

Except for log-transformations, other variables that are used in the second stage are the same as those used in estimating equation (10).[30] However, since the number of uncensored observations is small, particularly for the land-seller category, some variables are dropped from the second step in order to enhance degrees of freedom in estimation.[31]

The second stage equations are also estimated using two specifications of the land owned variable: one with total land owned (Specification 1) and the other with land owned disaggregated into its quality (good, medium, and poor quality land) components (Specification 2). This enables us to test if leasing behaviour was driven by particular qualities of land and/or if transaction costs in the land rental market also vary across qualities of land. We discuss the results for specification 1, while the results for specification 2 are given in the appendix to this chapter.

We used four dummy variables for five sub-regions to control for spatial variation cropping, pricing, agro-climatic, and market integration that may affect leasing decisions.

The sign expectation for the land owned variable in the second stage is negative for land buyers and positive for land sellers. The effects of semi-and non-tradable factors such as labour, oxen, farm experience, access to irrigation in the dry season and tractor services on land leased in are positive, while the effect of the same variables on land leased out is negative in both the first

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and Stern (1982) and to a limited extent Skoufias (1995) for discussion on functional forms of the net land leased equation.

[29] The continuous variables that we think may not be directly related to the outcome variables are off farm incomes (*ofainc99*) and dry season irrigation (*irland*).

[30] In the two-stage estimation method, it is possible to consider such variables as rental rates that are not considered in the BS based studies. Most of the tenancy arrangements in our area are either pure output sharecropping or a combination of cost and output sharing. The are few cases of fixed-rent contracts Even though it is theoretically erroneous to treat rental or sharing rates in the land rental market as exogenous, it may equally be inappropriate to think that rental patterns are not affected by rental/sharing arrangements. We run a regression of the censored model for the land-buyers with dummy variables for the specific tenancy arrangements as regressors and found that area leased-in increases with pure sharecropping and fixed-rent as compared to fifty-fifty land contract. However, we do not know if these variables are controlling for variation in land price or the choice of particular contract over the other. Because of potential endogeneity, therefore, we choose not to include them in the censored models.

[31] The choice of variables to drop was, however, made carefully in order to avoid the problem of omitted variable bias. We found that male-headed households are more likely to be educated. Furthermore farm experience was highly correlated with age of the household head. Thus, for the land-seller category, we kept only household sex (*hhsex*) and farm experience in the second stage of estimation.

and second stage estimations. However, we distinguish between male and female labour, which may affect leasing decisions differently. We expect land leased-in (land leased out) to decrease (increase) with age of household head. As discussed earlier, the effects of education and off-farm work on the magnitude of land leased in and leased out are an empirical issue.

Finally, we expect the probability of leasing-out land to increase with average distance of land owned (*aavdist*), as it may be profitable for households to rent-out distant plots and focus only on nearby plots. The household may, however, face difficulties in renting-out distant plots, resulting in the possibility that area rented-out may decrease with distance. The probability of leasing-in might also increase with distance for a tenant household, as long as the tenant household can find land adjacent to his/her own land, as this may lead to a more consolidated holding that might help reduce production cost of cultivating distant plots. In the second stage estimation we used average distance of area leased-in for buyers and area leased-out for sellers (*ravdist*). The effect of *ravdist* distance on area leased-in or leased-out may not be the same under the two specifications in the second stage estimation, as differences in locations may also reflect differences in qualities of land. In this case, the effect of distance on area leased might be weaker under specification-2 than specification-1. In general, however, we expect area leased-out to decrease with average distance of areas leased-out, as landlord might face difficulties in finding a tenant for remotely located plots. Likewise, area leased-in might decrease average distance of areas leased-in, although this may not hold due to overall scarcity of land.

5. Results and Discussion

5.1: The probability of participation in the land rental market

Estimation of the probabilities of being seller, non-participant, and buyer in the land rental market using ordered probit is reported in Table 9. We see that the propensity to lease in was higher for male-headed households and increased with household endowment in male labour and oxen per unit of land owned. These results are consistent with our theoretical expectation that increasing endowment in semi—and non-tradeables is associated with improving position of the household in terms of achieving either a self-sufficient or a tenant position in the land rental market. Similarly, household heads with more farm experiences, and households with access to tractor services, and irrigation activities in the dry season are less likely to lease out land. These results show that male labour, oxen, farm experience, and access to tractor services are complementary inputs to land. Access to dry season irrigation provides the resources that may be needed to cultivate own land and perhaps expand area cultivated through leasing in. The results also show that older household heads are unlikely to be on the buying side of the tenancy market. Participation in the land rental market was also more likely in villages with relative abundance of land.

The ordered probit analysis does not, however, explain how these variables affect the decisions to lease in or not and to lease out or not separately, in which case one is not able to see the relative effects of the factors to leasing decisions on both sides of the tenancy market. To rectify this, Table 9 also reports probit estimates for the sellers and buyers of land, separately. We see that male-headed households and households with more male labour and oxen per unit of land owned, with access to tractor services, and more irrigated land in the dry season are more likely to rent-in land, while older household heads are less likely to rent-in land. By contrast, the probability of renting-out land increased for older household heads, but decreased for male-headed households and for households with more male labour and oxen endowments per unit of land, more farm experience and more land irrigated in the dry season. These results are consistent with our theoretical expectations. Household endowments in male labour and oxen per unit of land and gender of household head are the most important variables affecting the decision to participate in the land rental market, showing that the markets for these factors are highly imperfect and that adjustment in the land rental market is in response to these imperfections. The probability of renting in (renting out) increased (decreased) with relative land availability at village level, indicating the ease to rent in land compared to rent out land in areas with more land abundance. Consistent with our expectation distant plots are more likely to be rented out, indicating that it may be costly to self-cultivate distant plots than to rent out.

The fact that farm experience was significant in the ordered probit model and the decision to rent out model but not in the decision to rent in model is indicative that farm experience was not sufficient to help households rent-in land.

5.2: Testing for Transaction Costs using the BS Approach

Estimation of equations (10) and (11) using the full sample regardless of households' position in the land rental market is reported in Table 10. The results for NLI show that the OLS coefficient for the land-owned variable (*landow*) is -.63, which is significantly different from –1, showing that, overall, the land rental market is characterized by adjustment constraints of considerable magnitude.[32] A test for the normality of the error terms in the

[32] Estimation of equation (10) using specification 2 (Appendix Table 1A) has shown that only the medium quality land is significantly different from zero and –1, while the good and poor quality land showing are

OLS model was rejected and therefore we estimated a median regression and found that the coefficient for land owned is reduced to –0.46 while remaining significantly different from -1. The presence of imperfection in the land rental market is also evidenced by the positive and significant effect of the land owned variable on area cultivated in the area-cultivated model of Table 10.

Estimation of equation (10) in Table 10 also shows that net land leased in was higher for male headed households, increased with household endowments in male labour, oxen, farm experience and level of education of household head, area irrigated in the dry season and access to tractor services, and decreased with age of household head. These results are consistent with our theoretical analysis and the results from Table 10 that market imperfections in the oxen service, household male labour, farm skill, and working capital are the rationale for the presence of the land rental market in the highlands of Eritrea. However, only age of household head, oxen, and access to tractor, and land availability at village level were significant in median regression of equation 10, although the sign effect for the other variables are as expected.

Imperfections in the land rental market imply that some households are unable to fully utilize their productive capacity. That is, imperfect land rental market undermines the use of non-tradable factors. Since the estimates of equation (10) are composites of the effect of imperfection in the rental market and the corresponding independent variable, dividing the estimated coefficients of the non-tradable regressors by the coefficient of the land owned variable can show the effects of the respective non-tradable variables alone. For instance, the effect of a one-unit increase in oxen is to raise net land leased in by 1.61, almost sixty percent higher than the composite effect of oxen on net land leased in. This result is obtained by dividing the coefficient of the variable oxen by the coefficient of the land owned variable in Table 10, that is, 1.02/0. 63.

5.3: Testing for Transaction Costs using Two-Stage Estimation Approach

To test for factor market imperfections and transaction costs in both sides of the tenancy market separately, estimates of equation (14), using Heckman's selection model (H model, hereafter) and Deaton's alternative model (D model, hereafter) for land buyers and sellers, are given in Tables 11 and 12, respectively. In Table 11, we see the coefficient for the land owned variable for land buyers is -0.75 in the H model and -0.66 in the D model. A null

insignificantly different from zero, indicating that the BS model or the functioning of the land rental market might be sensitive to heterogeneity in land quality.

hypothesis that *landow = –1* could not be rejected in both models.[33] Similarly, in Table 12, the coefficient for landow variable in the model for land sellers is 0.94 in the H model and 0.90 in the D model; and a null of *landow=1* could not be rejected.[34] These results indicate that adjustment of area cultivated was smooth for both buyers and sellers of land. The difference in the size of coefficients may, however, suggest that adjustment was smoother for land sellers than for land buyers. Moreover, there is no significant effect of the land owned variable on area cultivated for both sellers and buyers of land, confirming the results of the net land leased in and leased out model that adjustment was perfect for both types of households. But the fact that the effect of land owned on area cultivated is stronger and positive for the land buyers than for land sellers may strengthen our argument that adjustment was smoother for land sellers and that buyers face supply constrains. Tables 11 and 12 also show that net land leased in and area cultivated increased with land availability at village level (*vlavland*) for land buyers, but the effect of *vlavland* on net land leased out was insignificant. Overall, these results may indicate that the land rental market was supply constrained. Holden and Shiferaw (2002) found indications of similar supply-side constraints in an area in the Ethiopian highlands.

Comparison of the *landow* coefficients in Tables 11 and 12 with the *landow* coefficient in table 10 might suggest that the overall inefficiency of the land rental market as shown by the coefficient in equation 10 is due to transaction costs faced by non-participant households. It could be argued that non-participant households were not able to achieve their desired area of cultivation. This is consistent with the informal observations we noted previously in our analysis of factor ratios in section 4.

Table 12 shows that area leased-in was higher for male-headed households and increased with household endowment in oxen, area irrigated in the dry season, farm experience (in D model) and level of education (in D model) of household head, decreased with household age, female labour (only in D model), and off farm incomes. These results are consistent with our hypotheses that the market for oxen, labour, farm skill, and capital are imperfect. The negative effect of female labour might be due to low substitutability between female and male labour in farming. Similarly, the negative effect of off farm income is

[33] Estimation of equation (14) using specification 2 for land buyers gave no significant pattern (Appendix Table 2B). But the fact that area cultivated increased with poor-medium quality land may indicate that adjustment may not have been sufficiently smooth for land buyers. Moreover the fact that net land leased in increased, although insignificantly, with poor quality land may indicate that decision to lease in was made in order to get access to good quality land, which might also why area cultivated is positively related to poor quality land in Table 14.

[34] Estimation of equation (14) using specification 2 for land sellers (Appendix Table 3C) indicated that adjustment was smoother for medium-good quality land than poor quality land.

indicative of labour market imperfection such that off-farm wage labour and leasing in of land are competing activities.

The results for area leased out in Table 12 confirm our hypotheses of imperfect factor markets and are consistent with the results in Table 11 for the land buyer household. Table 12 shows that land leased out decreased with farm experience use of tractor for cultivation, average distance of area leased out, female labour (only in the H model). Although the sign effect is consistent with our theoretical expectation, the effect of oxen on land leased out is not significant, in contrast to its effect on area leased in. This might indicate that oxen ownership is more important for the decision to lease out than how much to lease out, having decided to lease out. There is relatively low variation in oxen ownership among households that rent out land. We can, however, see in Table 12 that area cultivated increased with oxen. The sign effect of male labour is consistent with expectation, but the fact that the effect of female as opposed to male labour is significant requires some explanation. A possible reason for this is that, having decided to lease out land, it may become more profitable for male workers to devote more of their time working off-farm by keeping as little land as possible under the household's cultivation. This argument is strengthened by the positive effect of off-farm incomes (to which male labour has more access) on area leased out. Moreover, male labour in such households is composed of young adults with low farm experience but more education, which may induce them to seek employment outside the farm sector. For cultural reasons, the ability of women in terms of taking off-farm wage labour in relatively distant areas is constrained by lack of education/skill and cultural factors. This creates the incentive for households with more women to keep some land under household cultivation as a way of employment.

6. Summary and Conclusion

In this study we theorized that participation in the land rental market is an attempt by farm households to adjust area cultivated to endowments in imperfectly traded factors with positive marginal productivity. To test this, we investigated the role of other factor market imperfections on participation in the land rental market and the performance of the land rental market in terms of reducing the negative effects of other factor market imperfections. We distinguished between the decision to take part in the land rental market and how much to participate, having decided to participate. This was done for land buyers and land sellers separately. Controlling for selection bias due to censoring, this approach gave the advantage to test if there are differential effect of other factor markets and if the land rental market performed differently on the opposite sides of the tenancy market. This was done in addition to the BS approach, which used a single regression of the net land leased in equation to test for transaction costs in the land rental market and in other factor markets.

Results have shown that participation in the land rental market was an attempt to adjust area cultivated to endowments in imperfectly traded factors, such as oxen, human capital in both quantity and quality terms, and access to working capital. The results have also shown that the effects of these factors were more pronounced on the decision to participate than on the extent of participation, having decided to participate. The effects of endowments in male labour, oxen, and access to capital were more important for the decision to rent out than for the decision to rent in land, but the order of importance was reversed when it comes to extent of participation.

It appears that the role of the land rental market was to allocate land from households that are rich in land but are poorly endowed in non-land factors to households that are poor in land but rich in non-land factors, indicating that the land rental market improves resource allocation in the context of imperfections in other factor markets. As argued by Kevane (1997) and Sadoulet et al. (2001), this may also support the potential of land rental markets in providing alterative avenues in the debate for reforming African tenure systems.[35] But we also found that while land buyers and sellers faced insignificant transaction costs in the land rental market, indicting smooth adjustment process, substantial non-participation in the land rental market indicated that there were considerable transaction cost in this market and thus non-participant households had problems adjusting land and other factors to an optimal mix. This raises the question whether resource allocation using land rental markets is superior to other forms of land transfers such as by sale.

We conclude that rental transactions are motivated by need to adjust area cultivated to endowments in factors that are semi or non-tradable. Transaction costs vary across households for land and labour markets. Substantial non-participation in the land rental market indicated that there was considerable transaction costs in the land rental market and non-participants had problems adjusting their land and other factors to an optimal mix. While overall efficiency of the rental market is compromised by high transaction costs for non-participants, it may be argued that it worked better for land buyers and best for land sellers, indicating perhaps the market for land was supply constrained. It appears that unequal

[35] It is argued that indigenous tenure institutions (including land rental markets) in Africa are capable of guaranteeing security and thus encouraging investment and efficient allocation of land (Boserup 1981; Cohen 1980; Bruce 1988; Downs and Reyna 1988; Bassett and Crummey, 1993; Atwood 1990: Haugerud 1989; Noronha, 1985; Okoth-Ogendo 1989; Bruce 1985, Platteau 1991)

distribution of and imperfection in other factor market are necessary conditions for the existence of the land rental market, but efficiency in resource allocation might be improved if cross village transactions are also encouraged.

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Table 3. Distribution of villages by region and sub-region

Region	Sub-region	Sample size V*	H*	Distance & Location**	Elevation: asl. +	Rainfall++	Population Density++++
Debub	Mendefera	8	84	50-60 Km. South	1500-2000m	630 mm	95.79
Debub	Dibarwa	8	88	30-51 Km. South	1500-2000m	560 mm	62.68
Maekel	Berik	6	62	7-12 Km. N. West	>2000 m	486 mm	120
Maekel	Serejeka	8	69	11-29 Km. North	>2000 m	537 mm	107.23
Maekel	Gala-Nefhi	2	16	13-20 Km. North	>2000 m	387 mm	148.26
Total		32	319			515 mm	

v=villages and H=households.** Distance and location are from the capital, Asmara.
+ asl denotes above sea level. ++ Rainfall level is an eight year average in millimeter. +++ Average land size is in *Tsimdi*, which is equivalent to .25 hectares. ++++ Population density is as rreported in the sub- regional land use documents.

Table 4: Pre- and post-lease factor ratios***

Variable	Household type+ 1	2	3	P-value for t- test of means between type 1 & 2	1 & 3	2 & 3
Land owned per adult worker ++	3.10	1.76	1.53	0.00	.00	.12
Land operated* per adult worker	.87	1.76*	2.33	0.00	.00	0.00
Land-owned per male adult worker	•	2.91	2.72			.59
Land cultivated per male adult worker	•	2.91	4.13			0.001
Land owned per female adult worker	2.94	2.43	2.96	0.01	0.96	0.02
Land operated per female adult worker	.92	2.43	4.49	0.000	.0000	0.00
Oxen owned per unit of land owned	0.12**	0.47	0.59	0.00	.00	0.02
Oxen owned per unit of land cultivated	0.16**	0.47	0.40	0.00	.00	0.09
No of observations	64	147	108			

+ Household types 1,2, and 3 refer to land sellers, non-participants in the land rental market, and land buyers, respectively.
++ Household worker is derived by converting household adult female labour to male equivalent using conversion factor of .8 and adding the resulting figure to household male labour.
+++ Land area owned divided by worker and land area operated by worker gives pre and post lease factor ratios, respectively. Similarly oxen divided by land area owned and oxen divided by land area operated gives pre and post lease facto ratios, respectively. The oxen-land ratio was calculated
*Area operated is defined to include area fallowed in order to compare factor ratio results.
** Oxen-land ratio for *type*-1 households was calculated for 36 (out of 64) households since area cultivated was zero for the remaining households.
• Land male labour ratio for type-1 household was not calculated because of large number of observations with no adult male labour.

Table 5. Pattern of land use by variation in household oxen and labour capacity

Oxen	Labour poor households, < 2,28 * Obs.	Land owned Mean	St.dev.	Operated holding Mean	St.dev.	Labour rich and average households (>=2.28) Obs.	Land owned Mean	St.dev.	Operated holding Mean	St.dev.
0	75	2.98	1.30	1.25	2.01	14	2.87	1.36	2.25	1.39
1	46	2.86	1.38	2.36	1.53	48	3.07	1.38	2.87	1.52
2	51	3.58	1.31	3.78	1.95	73	3.41	1.51	4.14	2.45
3	0	.	.	.	.	6	4.68	1.06	6.92	3.31
4	1	5	.	13**	.	5	6.3	1.25	10.8	2.99
	173					146				

*The figure is average adult male equivalent based on the full sample.
**Cultivation is done mainly by tractor.

Table 6: Pre- and post lease levels of land distribution and farm fragmentation

Variables	Household type			P-value for t- test of means between type		
	1	2	3	1 & 2	1 & 3	2 & 3
Land owned per consumer unit **	1.82	0.95	0.86	0.00	.00	0.22
Land operated per consumer unit	0.47	0.95	1.32	0.00	.00	0.00
No of parcels per unit of land owned	1.79	1.82	1.55	0.47	.06	0.04
No. Of parcels per unit of land operated *	1.15	1.82	1.23	.0001	.62	0.00
No. Of observations	64	147	108			

* Converting household adult female labour and children to their adult male equivalents using conversion factor of 0.8 and 0.5, respectively, and adding the resulting figure to household male labour derives consumer units.
***Area operated is defined to include area fallowed in order to compare factor ratio results.

Table 7: Number of households by participation in land and labour market

Land / Labour	Sellers: *type-1*	Non-participants: *Type-2*	Buyers: *type-3*	Total
Sellers	64(=20%) / 18(=28%)	147(=46%) / 49(=33%)	108(=34%) / 25(=23%)	319(=100%) / 91(29%)
Non-Participants	64 / 39(=61%)	147 / 61(42%)	108 / 37(=34%)	319 / 137(43%)
Buyers	64 / 12(=18%)	147 / 51(=35%)	108 / 54(=50%)	319 / 118(=37%)
Sellers ∩ Buyers**	0 / 5(=8%)	0 / 14(10%)	0 / 9(=8%)	0 / 28(9%)

**These are households who participated in both the selling and buying side of the labour market. Participation in Land market is in net terms

Table 8: Summary statistics of household characteristics by household type

Variable			Household type							
Name	**T+**	**Definition**	**Type-1 (land seller)**		**Type-2 Land Self-sufficient**		**Type-3 (Land buyer)**		**All sample**	
			Mean	**s.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**	**Mean**	**S.d.**
netleas	C	Net land leased-in[36]	-2.12	1.56	0.00	0.00	2.09	2.04	0.28	2.05
landow	C	Land owned	3.28	1.38	3.00	1.39	3.47	1.40	3.22	1.40
agland	C	Good quality land	0.97	0.88	1.25	1.39	1.52	1.24	1.29	1.27
amland	C	Medium quality land	1.61	0.96	1.26	1.02	1.36	1.09	1.36	1.04
apland	C	Poor quality land	0.73	0.70	0.57	0.70	0.65	0.79	0.63	0.73
aavdist	C	Average distance of land owned	22.27	9.24	20.01	9.52	22.23	11.59	21.21	10.25
ravdist	C	Average distance of rented land	23.23	14.80	.	.	22.94	16.37	23.05	15.76
Fsize	C	Operated holding	0.95	1.35	2.47	1.30	5.11	3.00	3.06	2.58
hhsex	D	Male Household head	0.23	0.43	0.66	0.48	0.84	0.37	0.64	0.48
hhage	C	Age *	44.34	18.24	52.12	15.61	53.67	11.85	51.08	15.40
hhfamex	C	Farm experience *	21.11	17.83	30.77	17.41	33.82	14.06	29.87	17.02
hhedu	C	Education level *	1.59	2.27	2.34	2.89	2.70	3.12	2.31	2.88
madu00	C	Male t workers	0.27	0.51	1.09	0.92	1.64	0.83	1.11	0.95
madti	C	Male worker per unit of land owned	0.08	0.17	0.44	0.47	0.59	0.46	0.42	0.46
fadu00	C	Female workers	1.23	0.61	1.42	0.75	1.47	0.70	1.40	0.71
fadti	C	Female worker per unit of land owned	0.46	0.31	0.59	0.45	0.53	0.44	0.54	0.43
oxen	C	Bullocks	0.30	0.61	1.14	0.76	1.82	0.84	1.20	0.93
oxent	C	Bullocks per unit of land owned	0.09	0.20	0.47	0.46	0.61	0.36	0.44	0.43
Tractord	D	Tractor use	0.27	0.45	0.39	0.49	0.51	0.50	0.40	0.49
Ofainc99	C	Off-farm income, 000 Nakfa	0.53	1.52	1.13	2.51	0.65	1.70	0.85	2.10
Ofa99ti	C	Off-farm income/area owned	0.20	0.57	0.55	1.35	0.24	0.66	0.37	1.03
irland	C	Area irrigated in dry season	0.13	0.33	0.73	1.63	1.38	2.21	0.83	1.76
irlandti	C	Area irrigated/area owned	0.04	0.09	0.23	0.52	0.42	0.75	0.26	0.58
Vlavland	C.	Land availability+	1.06	0.38	0.92	0.39	1.08	0.42	1.00	0.41
marketd	C	Village distance from nearest town	7.88	4.69	7.17	4.87	7.52	4.58	7.43	4.73
sr	D	Four dummies for five sub-regions								
Observations			64		147		108		319	

+ T denotes variable type, C=Continuous, D=Dummy

* Age, education, and farm experience are that of household head and they are in years

++ Dividing average area owned at village level by total sample average yields a unit less measure of land availability.

36 Traditionally land area is measured in *Tsimdi*, which is equivalent to a quarter of a hectare.

Table 9: The probability of participation in the land rental market

Variables	Ordered probit		P (renting-in)		P (renting-out)	
	Coef. (Robust z-stat)+		Coef. (Robust z-stat)+		Coeff. (Robust z-stat)+	
Aavdist	-0.005	(0.64)	0.003	(0.30)	0.024	(1.71)*
HHsex	0.806	(3.50)***	0.726	(2.57)**	-0.623	(1.82)*
HHage	-0.025	(2.79)***	-0.027	(2.46)**	0.038	(2.93)***
Hhfamex	0.042	(1.44)	0.012	(1.34)	-0.030	(2.69)***
HHedu	0.018	(2.36)**	0.017	(0.51)	-0.085	(2.02)**
madti	0.706	(3.26)***	0.871	(2.78)***	-1.892	(2.72)***
fadti	-0.304	(1.43)	-0.270	(1.16)	0.680	(0.94)
oxent	1.207	(5.58)***	0.994	(3.03)***	-3.301	(5.04)***
Tractord	0.443	(2.53)**	0.244	(1.19)	-0.605	(2.33)**
Ofa99ti	0.006	(0.09)	-0.082	(0.79)	-0.164	(1.14)
Irlandti	0.345	(2.32)**	0.261	(1.76)*	-1.846	(2.18)**
Vlavland	1.122	(3.10)***	1.169	(2.76)***	-1.481	(2.23)**
Marketd	-0.010	(0.55)	-0.011	(0.58)	-0.015	(0.55)
Sr2	0.196	(0.94)	0.107	(0.46)	-0.339	(1.13)
Sr3	0.954	(2.43)**	0.492	(1.21)	-1.975	(2.32)**
Sr4	0.669	(2.21)**	0.181	(0.50)	-2.162	(4.00)***
Sr5	0.673	(1.91)*	0.098	(0.24)	-2.103	(3.52)***
Constant			-2.130	(3.06)***	2.168	(2.17)**
_Cut1	0.92					
_Cut2	2.74					
	Observations=318		Observations=318		Observations = 318	
	LR chi2(17) =161.04		Wald chi2(17)=62.88		Wald chi2(17)= 88.06	
	Prob > chi2 =0.0000		Prob > chi2 =0.0000		Prob > chi2 = 0.0000	
	Log likelihood= -251.53		Log likelihood = -156.19		Log likelihood = -72.30	
	Pseudo R2= 0.24		Pseudo R2 = 0.23		Pseudo R2= 0.54	

hhtype	Probability	Observed
Type-1	Pr(xb+u<cut1)	0.1981
Type-2	Pr(cut1<xb+u<cut2)	0.4623
Type3	Pr(cut2<xb+u)	0.3396

+Absolute value of z-statistics in parentheses

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

Table 10: Determinants of net land leased in and area cultivated using full sample: Specification1

Net land leased in (equation 10)								OLS estimation of area cultivated (Equation 11)		
Variables	**OLS**		**Median**		**Variables**	**Coef. (Robust t-stat)**	
	Coef. (Robust t-stat)		**Coef. (BS T-stat)**[++]				
landow	-0.633	(4.59)***	-0.465	(3.06)***	Ln(landow)	-0.003	(1.59)
Aavdist	-0.017	(1.84)*	-0.008	(0.81)	Aavdist	0.359	(2.36)**
Hhsex	0.821	(2.86)***	0.314	(1.28)	hhsex	0.138	(1.75)*
HHage	-0.028	(2.67)***	-0.019	(1.85)*	Ln(hhage)	-0.063	(0.53)
Hhfamex	0.023	(2.58)**	0.014	(1.57)	Ln(hhfamex)	0.052	(1.52)
HHedu	0.065	(2.09)**	0.050	(1.33)	Ln(hhedu)	0.054	(1.89)*
madu00	0.160	(1.45)	0.193	(1.78)*	Ln(madu00)	0.145	(2.28)**
Fadu00	-0.134	(1.16)	-0.020	(0.17)	Ln(Fadu00)	0.023	(0.31)
oxen	1.020	(6.89)***	0.697	(4.31)***	Ln(oxen)	0.559	(8.32)***
Tractord	0.757	(3.68)***	0.643	(3.09)***	Tractord	0.330	(5.51)***
Ofainc99	0.001	(0.02)	0.004	(0.10)	Ofainc99	-0.003	(0.30)
Irland	0.216	(2.01)**	0.108	(1.22)	irland	0.028	(1.73)*
Vlavland	2.338	(3.60)***	1.883	(2.88)***	Ln(vlavland)	0.261	(2.03)**
Marketd	-0.015	(0.84)	-0.014	(0.82)	marketd	-0.001	(0.25)
Sr2	-0.243	(1.00)	0.029	(0.11)	Sr3	-0.070	(1.04)
Sr3	0.755	(1.92)*	0.596	(1.54)	Sr3	0.157	(1.48)
Sr4	1.008	(2.48)**	0.528	(1.25)	Sr4	0.131	(1.40)
Sr5	0.841	(2.15)**	0.757	(1.80)*	Sr5	0.156	(1.44)
Constant	-1.549	(2.52)**	-1.318	(1.89)*	constant	0.068	(0.14)
Observations	318		318		Observations	318	
F(18, 299)= 11.83			bootstrap(500)SEs		F(18, 299) = 49.70		
Prob > F = 0.0000			.50 Pseudo R2 = 0.148834		Prob > F = 0.0000		
R-squared = 0.5184					R-squared = 0.67		
Cook-Weisberg test for heteroskedasticity Ho: Constant variance chi2(1)= 60.69 Prob > chi2 = 0.0000					**Cook-Weisberg test for heteroskedasticity** Ho: Constant variance chi2(1)=9.05;Prob > chi2 =0.0026		
Skewness/Kurtosis tests for Normality Pr(Skewness)= 0.00; Pr(Kurtosis)=0.000 Joint test: adj chi2(2)= 58.32; Prob>chi2=0.000					**Skewness/Kurtosis tests for Normality** Pr(Skewness)= 0.40; Pr(Kurtosis)=0.04; Joint test: adj chi2(2)= 5.03; Prob>chi2=0.0822		
Shapiro-Wilk W test for normal data W=0.94087;V= 13.27; z =6.085; Prob>z 0.00000					**Shapiro-Wilk W test for normal data:** W= .99117; V =1.981; z1.61; Prob>z 0.054		

[++] Absolute value of bootstrap t-statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 11: Determinants of net area rented in and area cultivated for land buyer household: Specification 1

Variables	Net area leased in by tenant household		Area cultivated
	Heckman Model Coefficients[+]	Deaton model Coefficients[+]	Coefficients (t-stat)
Ln(landow)	-.75 (2.25)***	-0.657 (1.92)*	0.305 (1.27)
ravdist	-.00 (0.17)	-0.001 (0.29)	-0.003 (1.62)
hhsex	.44 (2.74)***	0.432 (2.14)**	0.037 (0.40)
Ln(hhage)	-.51 (1.81)*	-0.550 (1.71)*	0.057 (0.38)
Ln(hhfamex)	.09 (1.06)	0.103 (2.08)**	0.017 (0.42)
Ln(hhedu)	.09 (1.61)*	0.147 (2.12)**	0.037 (1.32)
Ln(madu00)	.23 (1.48)	0.239 (1.19)	0.120 (1.35)
Ln(Fadu00)	-.19 (1.21)	-0.290 (1.80)*	-0.160 (1.43)
Ln(oxen)	.71 (4.80)***	0.665 (3.72)***	0.254 (2.56)**
Tractord	-.03 (0.28)	0.007 (0.06)	0.020 (0.29)
Ofainc99	-.04 (1.76)*	-0.041 (2.05)**	-0.025 (2.32)**
irland	.08 (3.74)***	0.073 (2.93)***	0.038 (2.53)**
Ln(vlavland)	.86 (3.14)***	0.802 (3.25)***	0.388 (2.07)**
marketd	-.01 (1.20)	-0.015 (1.60)	-0.010 (1.46)
Sr3	-.31 (2.56)***	-0.306 (3.22)***	-0.221 (3.22)***
Sr3	-.31 (1.25)	-0.275 (1.19)	-0.403 (3.17)***
Sr4	.25 (1.24)	0.277 (1.46)	0.098 (0.77)
Sr5	-.29 (0.82)	-0.209 (0.98)	-0.244 (1.73)*
P (rent in)		-1.446 (2.00)**	
P^3(rent in)		0.881 (1.32)	
_cons	2.36 (2.31)	3.243 (2.57)**	0.900 (1.52)
/athrho[++]	1.44		
lambda	.44		
Observations	318	318	108
Censored observations	210	210	
Wald chi2 (18)=113.32 Log likelihood= -195.93 Prob > chi2 = 0.00 LR test of (rho = 0): chi2(1)=6.51, Prob > chi2 = 0.0109		F(20,87) = 7.01; R-squared 0.54 **Cook-Weisberg test for heteroskedasticity** Ho: Constant variance chi2(1)= 3.48 Prob > chi2 =0.06 **Skewness/Kurtosis tests for Normality** Pr(Skewness) = 0.34 Pr(Kurtosis)=0.29 Joint test: adj chi2(2) = 2.04 Prob>chi2= 0.36 **Shapiro-Wilk W test for normal data** W = 0.98; V = 1.02; z= .05; prob>z=0.48	F(18,89) = 25.92 R-squared=0.76; Prob > F = 0.00 **Cook-Weisberg test for heteroskedasticity** Ho: Constant variance chi2 (1)= 0.06; Prob > chi2 = 0.8100 **Skewness/Kurtosis tests for Normality** Pr(Skewness)= 0.022 Pr(Kurtosis)= 0.086 Joint test: adj chi2(2)= 7.45 Prob>chi2=0.0241 **Shapiro-Wilk W test for normal data** W= 0.98; V= 2.20;z=1.75 Prob>z=0.04

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

[+] Robust t-statistics in parentheses

[++] athrho = 1/2*ln[(1+rho)]/(1-rho)]

Table 12: Determinants of net area rented out and area cultivated by land seller household: Specification 1

Variables	Net Area rented out		Area cultivated	
	Heckman model: MLE	**Deaton model**		
	Coef. (Z-stat)	**Coef. (Robust t-stat)**	**Variables**	**Coef. (t-stat)**
landow	0.944 (3.66)***	0.850 (2.99)***	Ln(landow)	-0.128 (0.31)
ravdist	-0.019 (2.00)**	-0.026 (1.71)*	aavdist	0.004 (0.63)
hhsex	0.333 (0.69)	0.532 (0.75)	hhsex	0.021 (0.08)
hhfamex	-0.016 (1.72)*	-0.018 (1.77)*	Ln(hhfamex)	0.016 (0.29)
madu00	-0.272 (0.70	-0.202 (0.39)	Ln(madu00)	0.189 (0.59)
fadu00	-0.392 (1.77)*	-0.463 (1.33)	Ln(fadu00)	0.269 (0.66)
oxen	-0.151 (0.53)	-0.130 (0.33)	Ln(oxen)	0.551 (3.00)***
Tractord	-1.055 (2.95)***	-0.958 (1.76)*	Tractord	0.629 (2.77)***
ofainc99	0.154 (1.42)	0.089 (0.68)	ofainc99	-0.027 (0.59)
irland	-0.072 (0.15)	-0.162 (0.26)	irland	-0.060 (0.21)
vlavland	-0.115 (0.11)	0.390 (0.34)	Ln(vlavland)	0.169 (0.46)
marketd	-0.021 (0.58)	-0.028 (0.63)	marketd	0.003 (0.21)
sr2	0.640 (1.84)**	0.614 (1.50)	sr2	-0.202 (1.16)
sr3	0.058 (0.07)	0.219 (0.33)	sr3	0.524 (2.17)**
sr4	0.261 (0.44)	0.446 (0.59)	sr4	-0.094 (0.41)
sr5	0.747 (1.08)	0.888 (1.11)	sr5	0.071 (0.20)
p^2(rent-out)		1.412 (1.78)*		
_cons	0.895 (1.07)	-0.268 (0.26)	_cons	0.050 (0.07)
/athrho	-0.965 (2.11)**			
lambda	-0.773			
Observations	318	318	Observations	63
Censored obs.	254	254		
Wald chi2(16) = 86.63		F(17, 45) = 12.83	F(16,46) = 35.85	
Log likelihood = -153.1503		Prob > F = 0.0000	Prob > F = 0.0000	
Prob > chi= 0.0000		R-squared = 0.68	R-squared = 0.5428	
LR test of rho = 0: chi2(1) = 3.44; Prob > chi2 = 0.0635		**Cook-Weisberg test for Heteroscedasticity** Ho: Constant variance chi2(1) = 5.18 Prob > chi2 = 0.0250	**Cook-Weisberg test for heteroskedasticity** Ho: Constant variance chi2(1) = 1.93 Prob > chi2= 0.164	
		Skewness/Kurtosis tests for Normality Pr(Skewness) = 0.22 Pr(Kurtosis) = 0.26 Joint test: adj chi2(2) = 2.93 Prob>chi2= 0.23	**Skewness/Kurtosis tests for Normality** Pr(Skewness)= 0.17 Pr(Kurtosis) =0.16 Joint test: adj chi2(2) =4.03 Prob>chi2=0.1331	
		Shapiro-Wilk W test for normal data W =0.98;V =1.34; z =0.63; Prob>z =0.26	**Shapiro-Wilk W test for normal data** W = 0.96;V= 1.75; z =1.21; Prob>z=0.11	

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

Appendix

Table 1A: Determinants of net land rented in and area cultivated using full sample: Specification 2

Net land leased-in			Area cultivated		
Variables	**Coef.**	**(Robust t-stat)**	**Variables**	**Coef.**	**(Robust t-stat)**
Agland	-0.151	(1.21)	Ln (agland)	0.158	(2.29)**
Amland	-0.301	(2.18)**	Ln(amland)	0.108	(1.58)
Apland	-0.080	(0.47)	Ln(apland)	0.126	(1.95)*
Aavdist	-0.016	(1.77)*	Aavdist	-0.003	(1.61)
HHsex	0.726	(2.54)**	hhsex	0.139	(1.81)*
Hhage	-0.028	(2.62)***	Ln(hhage)	-0.072	(0.62)
Hhfamex	0.023	(2.43)**	Ln(hhfamex)	0.058	(1.72)*
HHedu	0.061	(1.92)*	Ln(hhedu)	0.060	(2.06)**
madu00	0.161	(1.43)	Ln(madu00)	0.149	(2.30)**
Fadu00	-0.126	(1.07)	Ln(fadu00)	0.015	(0.19)
oxen	0.998	(6.66)***	Ln (oxen)	0.557	(8.33)***
Tractord	0.756	(3.74)***	Tractord	0.339	(5.83)***
Ofainc99	0.002	(0.06)	ofainc99	-0.000	(0.00)
Irland	0.184	(1.71)*	irland	0.030	(1.87)*
Vlavland	0.973	(1.68)*	Ln(vlavland)	0.349	(3.41)***
marketd	-0.014	(0.80)	marketd	-0.000	(0.08)
sr2	-0.234	(0.91)	sr2	-0.053	(0.78)
sr3	0.651	(1.66)*	sr3	0.171	(1.61)
sr4	1.042	(2.50)**	sr4	0.140	(1.47)
sr5	0.899	(2.18)**	sr5	0.159	(1.45)
Constant	-1.449	(2.26)**		0.323	(0.73)
Observations	318			318	

Net land leased-in	Area cultivated
F (20, 297) = 10.32	F(20, 297) = 41.14
Prob > F = 0.0000	Prob > F = 0.0000
R-squared = 0.5038	R-squared = 0.6720
Cook-Weisberg test for heteroskedasticity	**Cook-Weisberg test for heteroskedasticity**
Ho: Constant variance	Ho: Constant variance
Chi2 (1) = 55.70	chi2(1)=9.01; Prob > chi2= .0023
Prob > chi2 = 0.0000	**Skewness/Kurtosis tests for Normality**
Skewness/Kurtosis tests for Normality	Pr(Skewness)= 0.358
Pr(Skewness)=0.000 Pr(Kurtosis)=.00	Pr(Kurtosis)= 0.083
Joint test:	Joint test:
adj chi2(2)=55.9; Prob>chi2=.00	adj chi2(2) = 3.87; Prob>chi2=0.1448
Shapiro-Wilk W test for normal data	**Shapiro-Wilk W test for normal data**
W =.94; V=13.66; z=6.15;Prob>z=.00	W = 0.99; V=1.70;z=1.25; Prob>z=.11

+Robust t-statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 2B: Determinants of net land leased in and area cultivated for land buyer household: Specification 2

Variables	Log (Area leased-in)				Log (Area cultivated)	
	H Model: MLE		Deaton model			
	Coef.	(Z-stat)	Coef.	(Robust t-stat)	Coef.	(t-stat)
Ln (agland)	-0.154	(1.38)	-0.113	(1.03)	0.097	(1.32)
Ln(amland)	-0.082	(.75)	-0.062	(0.53)	0.120	(1.78)*
Ln(apland)	0.141	(1.3)	0.111	(0.94)	0.152	(2.13)**
ravdist	-0.001	(.38)	-0.001	(0.19)	-0.003	(1.35)
hhsex	0.408	(2.49)***	0.308	(1.51)	0.061	(0.63)
Ln(hhage)	-0.476	(1.70)*	-0.382	(1.15)	0.059	(0.39)
Ln(hhfamex)	0.084	(.96)	0.127	(1.64)	0.012	(0.30)
Ln(hhedu)	0.088	(1.58)	0.104	(2.18)**	0.042	(1.53)

Ln(madu00)	0.286	(1.84)*	0.168	(0.75)	0.118	(1.29)
Ln(fadu00)	-0.233	(1.51)	-0.285	(1.65)	-0.184	(1.56)
Ln (oxen)	0.639	(4.62)***	0.552	(2.86)***	0.259	(2.70)***
Tractord	0.044	(.34)	-0.029	(0.24)	0.046	(0.68)
ofainc99	-0.031	(1.21)	-0.032	(1.63)	-0.021	(1.72)*
irland	0.074	(3.31)***	0.062	(2.36)**	0.040	(2.72)***
Ln(vlavland)	0.386	(1.87)*	0.366	(1.80)*	0.440	(3.58)***
marketd	-0.017	(1.55)	-0.017	(1.84)*	-0.010	(1.44)
sr2	-0.278	(2.12)***	-0.295	(3.22)***	-0.197	(2.77)***
sr3	-0.288	(1.09)	-0.318	(1.44)	-0.389	(3.11)***
sr4	0.150	(.74)	0.237	(1.31)	0.106	(0.88)
sr5	-0.177	(.68)	-0.262	(1.27)	-0.240	(1.64)
P(rent-in)			-0.970	(1.66)*		
P^3			0.872	(1.44)		
_cons	1.327	(.966)	1.925	(1.77)*	1.074	(2.15)**
/athrho	1.65					
lambda	0.477					

Observations=318	Observations=108	Observations=108
Censored obs=210	R-squared 0.55	R-squared 0.77
Uncensored obs =108	F(22, 85) = 8.94	F(20, 87) = 21.54
wald chi2(20) = 115.97	Prob > F= 0.0000	Prob > F = 0.0000
Log likelihood = -194.695	**Cook-Weisberg test for heteroskedasticity**	**Cook-Weisberg test for heteroskedasticity**
prob > chi2 = 0.0000	Ho: Constant variance	Ho: Constant variance
LR test of (rho = 0):	chi2(1) = 2.62	chi2(1) = 0.01
chi2(1)=6.86	Prob > chi2 = 0.1053	Prob > chi2= 0.9122
Prob > chi2 = 0.0088	**Skewness/Kurtosis tests for Normality**	**Skewness/Kurtosis tests for Normality**
	Pr(Skewness)= 0.240	Pr(Skewness)= 0.051
	Pr(Kurtosis) =0.294	Pr(Kurtosis)= 0.100
	adj chi2(2) = 2.54	adj chi2(2) = 6.16
	Prob>chi2=0.2803	Prob>chi2=0.0460
	Shapiro-Wilk W test for normal data	**Shapiro-Wilk W test for normal data**
	W =0.98701; V = 1.144;z=0.299	W=0.98139;V =1.639
	Prob>z =0.38237	z=1.100;Prob>z=0.1356

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

Table 2C: Determinants of net land leased in and log of area cultivated by land seller household: Specification 2

	Net Area leased-in				**Area cultivated**		
Variables	**H model: Two-step**		**Deaton model**				
	Coef.	**(Robust t-stat)**	**Coef.**	**(Robust t-stat)**	**Variables**	**Coef.**	**(t-stat)**
Agland	1.100	(2.71)***	1.156	(3.03)***	Ln (agland)	-0.130	(0.39)
Amland	1.028	(2.34)**	1.051	(2.53)**	Ln(amland)	0.060	(0.16)
Apland	0.755	(2.27)**	0.756	(2.56)**	Ln(apland)	-0.061	(0.28)
ravdist	-0.026	(1.73)*	-0.037	(2.27)**	Aavdist	0.006	(0.85)
Hhsex	0.358	(0.48)	0.562	(0.73)	hhsex	0.111	(0.39)
Hhfamex	-0.015	(1.44)	-0.016	(1.56)	Ln(hhfamex)	0.014	(0.23)
madu00	-0.270	(0.53)	-0.239	(0.46)	Ln(madu00)	0.131	(0.40)
fadu00	-0.458	(1.34)	-0.657	(1.83)*	Ln(fadu00)	0.254	(0.53)
oxen	-0.065	(0.16)	0.105	(0.26)	Ln (oxen)	0.553	(2.92)***
Tractord	-1.159	(1.96)*	-1.043	(1.84)*	Tractord	0.623	(2.54)**
Ofainc99	0.197	(1.40)	0.222	(1.71)*	ofainc99	-0.042	(0.92)
Irland	0.067	(0.08)	0.086	(0.11)	irland	0.030	(0.09)

Vlavland	-0.027	(0.02)	0.159	(0.12)	Ln(vlavland)	0.095	(0.27)
marketd	-0.005	(0.10)	0.003	(0.07)	marketd	0.002	(0.16)
sr2	0.632	(1.31)	0.541	(1.19)	sr2	-0.244	(1.19)
sr3	0.293	(0.42)	0.404	(0.60)	sr3	0.533	(2.13)**
sr4	0.383	(0.50)	0.722	(0.99)	sr4	-0.093	(0.43)
sr5	0.911	(1.12)	1.193	(1.54)	sr5	0.041	(0.12)
Mills ratio	0.858	(1.83)*					
P^2(rent out)			2.002	(2.55)**			
Constant	0.716	(0.90)	-0.862	(0.91)	constant	-0.079	(0.16)
Observations	318		63			63	
Censored obs	254		254				
F(19, 43) = 14.39			F(19,43) = 14.7		F(17,45) = 25.16		
Prob > F = 0.0000R-squared = 0.6837			Prob > F = 0.0000		Prob > F = 0.0000		
			R-squared = 0.7021		R-squared = 0.5491		
			Cook-Weisberg test for Heteroscedasticity		Cook-Weisberg test for heteroskedasticity		
			Ho: Constant variance		Ho: Constant variance		
			chi2(1) = 4.71; Prob > chi2 = 0.0300		chi2(1) = 1.31; Prob > chi2 = 0.2573		
			Skewness/Kurtosis tests for Normality		**Skewness/Kurtosis tests for Normality**		
			Pr(Skewness) = 0.325 ;		Pr(Skewness) =0.089		
			Pr(Kurtosis) =0.206		Pr(Kurtosis) =0.109		
			Joint test:		Joint test:		
			adj chi2(2) =2.68 ;		adj chi2(2) =5.30		
			Prob>chi2 =0.2615		Prob>chi2=0. 0.0688		
			Shapiro-Wilk W test for normal data		**Shapiro-Wilk W test for normal data**		
			W = 0.97319;V =1.516;z =0.899 Prob>z=0.18440		W =0.964; V = 1.980; z =1.486 Prob>z=0.068		

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

CHAPTER THREE

Land Contract Choice: Poor Landlords and Rich Tenants - Evidence from the Highlands of Eritrea

Mahari Okbasillassie Tikabo & Prof. Stein T. Holden

Abstract

The persistence of share tenancy in many countries and Marshall's (1890) prediction of the inefficiency of share tenancy has made contract choice in land rental markets a point of much controversy among agricultural and development economists. Most commonly, contract choice has been assumed made by the landlord in a principal-agent model. Alternatively, the bargaining and screening models of contract choice have assumed that the tenant also may influence contract choice. The assumptions of the principal-agent model are restrictive in situations where the tenant can also influence contract choice because he/she might possess non-tradable or imperfectly tradable factors with positive marginal productivity and where the landlord may lack or be poor in these same factors. In this paper we combine perspectives from theories of bargaining, screening, and imperfect markets to explain contract choice in the highlands of Eritrea. In the highlands of Eritrea there is no formal land market. Access to land is based on membership to village communities and participation in the land rental market. Unlike the Asian setting where the landlord is typically richer than the tenant, the tenant in this context is typically richer than the landlord and thus participation in the land rental market is an attempt to adjust area cultivated to endowments in non- or semi-tradable inputs. Most land contracts are made between households living in the same community where everybody know and can monitor each other well. Land is generally scarce and most contracts are short-term, for one production season.

We theorize that contract choice is a function of the characteristics of both the landlord and the tenant. In particular, we hypothesize that contract choice is determined by the landlord's and the tenant's relative access to capital, wealth (poverty) and factors of production. We hypothesize that poor landlords prefer fixed rent contracts to share contracts and cost-sharing contracts due to the up-front payment in fixed rent contracts, and share contracts over cost-sharing contracts due to the up-front costs of cost-sharing. We also hypothesize that more wealthy tenants are more able and willing to go for fixed-rent contracts because they are more able to pay up-front. They may also prefer share contracts to cost sharing because they are more able to provide the inputs themselves. We tested our hypotheses using econometrics on household plot level data on both sides of the tenancy market from the highlands of Eritrea. The results show that poor landlords with less irrigated land, less farm experience, less off-farm income, and less business income, were more likely to go for fixed rent contracts and less likely to go for cost-sharing contracts. Similarly, wealthy tenants with access to incomes from off-farm wage labour and dry-season irrigation, and with more livestock assets, and better access to credit were more likely to choose fixed rent contracts and less likely to choose cost-sharing contracts over pure sharecropping contracts. This implies that poor landlords and wealthy tenants are attracted to each other through a preference for fixed rent contracts. Likewise, less poor landlords and less wealthy tenants are attracted to each other through a preference for cost-sharing contracts. The intermediate wealth stage on both sides provides a preference for pure sharecropping contracts.

1. Introduction

The persistence of share tenancy in many countries and Marshall's (1890) prediction of the inefficiency of share tenancy has made contract choice in land rental markets a point of much controversy among agricultural and development economists. There is a large and fascinating literature on contract choice and its effect on production efficiency. Most commonly, contract choice has been assumed made by the landlord in a principal-agent model, which was pioneered by Stiglitz (1974) and Newberry and Stiglitz (1979). This framework of analysis appeared to be widely accepted, as almost all empirical studies on contract choice are based on the assumption that the landlord has a greater power in stipulating contract terms, particularly the share to the tenant. Alternatively, the bargaining (Bell and Zusman 1976 and Bell 1989; Banerjee and Ghatak 1996) and screening (Hallagan 1978) models of contract choice have assumed that the tenant also may influence contract choice. The assumptions of the principal-agent model are restrictive in situations where that tenants can influence contract terms because he/she might possess non-tradable or imperfectly tradable factors with positive marginal productivity and where the landlord may lack or be poor in these same factors.

In the highlands of Eritrea, there is no formal land market. Access to land is based on membership to village communities and participation in the land rental market. Unlike the Asian setting where the landlord is typically richer than the tenant, the tenant in this context is typically richer than the landlord and thus participation in the land rental market is an attempt to adjust area cultivated to endowments in non- or semi-tradable inputs (examples are oxen, labour, farm skills, and working capital). The types of land tenancy contracts practiced in the highlands of Eritrea include pure sharecropping, a combination of crop and cost sharing, and fixed rent contracts. Most contracts are made between households living in the same community where everybody know and can monitor each other well. Land is generally scarce and most contracts are short-term, for one production season.

In this paper we combine perspectives from theories of bargaining (Bell and Zusman, 1976 and Bell, 1989), screening (Hallagan 1978) and imperfect market (Bliss and Stern 1982; Eswaran and Kotwal 1985; Sadoulet *et al.* 2001) to develop theoretical model explaining contract choice in the highlands of Eritrea. Our theoretical model focuses on the effects of wealth and risk aversion on contract choice. We test the theoretical predictions of the model using sample farm plot level data for landlords and tenants from the highlands of Eritrea.

In section two, we provide an overview of the theories and empirical evidences on tenancy contracts in order to get insight for modeling contract choice. Section three describes the setting pertinent to the issue of contracts in the highlands of Eritrea and presents and discusses the data from the study areas. In section four, we construct a theoretical model of contract choice. Section five outlines econometric models and estimation methods for testing the predictions of the theoretical model. Section six presents and discusses the results of our regression analysis while section seven concludes.

2. Literature Review

Marshall (1890) argued that in the absence of supervision, a profit maximizing tenant farmer would apply less labour input than what is optimal, resulting in the inefficiency of share tenancy. The spatial nature of agricultural production and the difficulty of identifying labour effort from observations of output and man-days due to production uncertainties may make it difficult to enforce labour inputs, although there might be some room for worthwhile monitoring. In this case, it is argued that first best results could be achieved if the landlord opts for fixed rent or wage contract. In reality, sharecropping is persistent and in many cases it is dominant. Much of the subsequent literature on tenancy markets has, therefore, focused on the rationale for and the conditions under which sharecropping might be preferred to fixed-rent and/or wage contract.

Assuming perfectly enforceable tenant labour, Cheung (1969) argued that sharecropping has a risk-sharing advantage over fixed-rent and wage contracts. This is so because under fixed-rent contract, the tenant bears all the risk while under wage contract the landlord bears all the risk associated with production, resulting in neither arrangement to be optimal in risk bearing. Thus, sharecropping comes as a compromise risk-sharing arrangement. However, under the same assumptions plus constant returns to scale and input divisibility, Reid (1976), Newbery and Stiglitz (1979), and Otsuka and Hayami (1988) have shown that, a mixture of wage and fixed-rent contracts can give the same pattern of return to the landlord and the tenant as does a share contract.[1] The point is that under the assumption of perfectly observable effort and risk-neutrality of both the landlord and the tenant, risk sharing is irrelevant for the existence of sharecropping.[2] Risk-neutrality is not a plausible assumption, though.

[1] Allen (1984) has shown that the same result can be obtained even with economies of scale, making the result more general.

[2] There are, however, sources of risk, other than output risk, that may provide a rationale for the existence of crop sharing as a risk-sharing arrangement. Newberry (1977) and Newberry and Stiglitz (1979) argued that if the agricultural labour market is subject to uncertainty, a combination of wage and fixed-rent contract might result in patterns of returns smaller than what can be achieved under share contract.

In the context of risk-neutrality (certainty) of the tenant farmer, non-enforcement of contracts cannot be a rational for share tenancy, as fixed rent contract can provide efficient incentive to eliminate the incentive problem. Assuming missing insurance market, risk averse tenant, and non-observability or costly monitoring of labour effort, Stiglitz (1974) argued that sharecropping might dominate wage contract because of its incentive advantage and dominate fixed rental because of its risk pooling advantages. In this theory, the landlord provides both land and insurance and the optimal contract from his perspective involves a trade-off between incentive provision and insurance provision to the tenant.

A limitation of the above analyses is that they cannot explain the co-existence of fixed rent and wage contracts with sharecropping unless one of the agents is assumed to be risk-neutral (Agrawal 1999). Otsuka and Hayami (1988) have argued that share tenancy may be chosen as risk sharing mechanism when both the landlord and the tenant are risk averse, regardless of the enforceability of contract, although this distorts work incentives as predicted by Marshal. However, they further argued that whether share tenancy would be inefficient might depend on technological conditions, as well; the more complex and less standardized farm operations are, the more difficult it is for the landlord to monitor tenants' work and thus share tenancy may result in inefficiency. Sadoulet *et al.* 2001 argued that landlords with a choice of tenants would prefer to rent land to those households that are less risk averse (that have more wealth) or that have access to sources of insurance such as secure off-farm incomes, in which case the trade-off between insurance and incentive might be minimized. They further argued that sharecropping induce higher level of labour use on-farm than fixed rent by reducing risk to the tenant who have to decide on the allocation of labour between risky, on-farm, and risk-less, labour market, activity.

Basu (1992) tried to explain the choice of share cropping as a response to limited liability and joint moral hazard in effort and risk associated with agricultural technology. He argued that fixed-rent contract in the presence of limited liability encouraged the tenant to adopt too much risk, because he is protected from downside risk, which is borne solely by the landlord. Sharecropping comes as an optimal contract to discourage the tenant from choosing too much risk. Sengupta (1997) and Ghatak and Pandey (2000) combined moral hazard in risk and effort to argue that joint moral hazard in risk and effort is needed for a share cropping to emerge as optimal solution. In this setting coexistence of wage contracts, sharecropping, and fixed rent tenancy is in response to relative importance of moral hazard in the choice of effort and risk.

Some alternative explanations of share cropping ignored risk aversion of agents and instead focused on labour shirking which is maximum under wage contract and asset abuse (tenant's lack of incentive to maintain future productivity of the landlord's land/capital), which is maximum under fixed rent tenancy, since the tenant manages the farm essentially on his own. In this approach, the optimal contract minimizes these two types of enforcement costs and that sharecropping is viewed as a compromise between these two types of agency costs, while co-existence of fixed rent and fixed wage contract is explained as emerging from variation in these two types of costs across various agents and land-types (Datta *et al.* 1986; Allen and Lueck 1992; Roumasset 1995, Dubois 1999 and 2002).

The screening perspective of Hallagan (1978)[3] was another attempt to incorporate tenants' condition into a model of contract choice. The screening theory assumes that the landlord does not have information on the characteristics of the tenant that affect productivity such as entrepreneurial or other ability. By offering a menu of contracts including share contracts, the landlord gets individuals of different ability to select different contracts. Tenants are thus self-selected in such a way that high ability ones select fixed-rent contract while the low ability ones get share contract or do not receive any contract at all, showing the coexistence of share tenancy with fixed rent.

The main shortcoming of Hallagan's model is that it considers the worker's (tenants') optimization alone, neglecting the landlord's (Otsuka and Hayami 1988) and failed to allow for heterogeneity of and competition among landlords (Basu 1982; Allen 1982). Basu considered monopolistic competition and Allen (1982) considered perfect competition among landlords to show that the resulting equilibrium is not the screening equilibrium as shown in Hallagan's model.[4] Assuming no information on the ability of workers and payment of rent upon realization of output, Allen (1985) developed a self-selection model similar to that of Hallagan, but incorporates the landlord's optimization behaviour, as well. He argued that self-selection among contractual options is used by a profit maximizing landlord as a device to prevent the tenant from default of rent payments in a situation where rent is not paid up-front.[5] In his model, workers whose abilities are below some defined minimum level would

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[3] This was in a way an attempt to formalize Spillman's (1919) theory of agricultural ladder in which he argued that farmers start their "agricultural ladder" from an agricultural labour, go through share-tenancy and finally reach fixed-rent tenancy.

[4] See Singh (1989) for details of the critique provided.

[5] A closely related theory is Shetty's (1988) explanation of contractual choice in the presence of wealth differences among potential tenants and limited liability. Assuming risk neutral landlords and tenants, variation in wealth among tenants, and payment of fixed-rent upon realization of output, Shetty predicted that wealthy tenants will get fixed rent contracts while poorer tenants will end up getting share contracts. The intuition is that

choose wage employment to fixed rent tenancy as long as rental payment is enforceable. If rental payments are not enforceable, to prevent potentially defaulting tenants from picking fixed-rent contract, the landlord limits the amount of land rented-out to people of unknown ability to a sufficiently small size. In essence, a landlord with no information on the ability of workers will propose the fixed-rent contract alone and let the worker choose either that or wage employment. In this respect, Hallagan's model fails to reason out for the existence of sharecropping under uncertainty. However, Newbery and Stiglitz (1979) extended Hallagan's model by allowing the landlord to vary the plot size and introducing monopolistic competition among landlords for high-ability tenants. They argued that the possibility to vary plot size enables the landlord to achieve a screening equilibrium even under competition.

Allen's (1985) work is further criticized for two reasons: (1) it provides no reason for the existence of sharecropping because at some level of tenant ability, it is possible for both fixed-rent and share contract to achieve the same patterns of resource allocation and income distributions in which case the tenant and the landlord are indifferent between the two forms of contracts (Otsuka and Hayami 1988), and (2) the assumption of non-observability of tenant quality might not fit into a real world situation where landlords and tenants live together in the same community and know each other's characteristics relatively better (Bardhan 1984; Bell 1988; Singh 1989; Hayami and Otsuka 1993). In the real world, it is possible to obtain knowledge on ability and land quality gradually through direct observation.

Eswaran and Kotwal (1985) build on the tenancy ladder theory[6] to explain contract choice in a double-sided moral hazard setting where the landlord shirks on his management effort and the tenant on his work effort or supervision of hired workers. In this setting increase in the tenant's share of output decreases his shirking while that of the landlord increases. Thus, sharecropping comes as a compromise contract to minimize efficiency loses from the two types of costs. Differentials in endowments of managerial and supervision inputs between the parties leads to the coexistence of various contracts. Hayami and Otsuka (1993) argued that in long-run optimization conditions, the landlord in the Eswaran-Kotwal model might be prevented from shirking in providing his managerial effort under a fixed rent in fear of loss of reputation.

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wealth can be used as collateral for amount due as rent and since richer tenants are more profitable and less likely to default on fixed-rent commitment, landlords offer fixed rent contracts to rich tenants and share contract to poor tenants. Although this explanation might be plausible in the context of imperfect capital market and where land-rentals are paid ex-post, the model did not go further to explain the resulting nature of optimal contract in such an environment. Besides, the validity of its prediction depends on the assumption that tenant quality is unobservable to the landlord, which is a flawed assumption in many agrarian contexts.

Numerical analysis of the Eswaran-Kotwal model predicts that the optimal share would be around 50:50, the tenant and the landlord sharing output and input costs in fifty-fifty fashion (Bell 1989). In principle, this should result in first best equilibrium, as this would restore the marginal condition for efficiency. However, cost sharing might be difficult to apply on landlords' managerial inputs and tenants' labour effort without having to incur some supervision and monitoring cost. Newbery (1975), Bliss and Stern (1982), Jaynes (1984) Braverman and Stiglitz (1986) argued that cost sharing can apply only to inputs that can be monitored and enforced by the landlord at low cost. When tenants' work effort cannot be monitored, it cannot be said that costs are shared on exactly equal proportion. In general, this may result in double-sided moral hazard leading to efficiency loses as predicted by Marshalian theory for the tenant. Eswaran and Kotwal (1985) and Copper and Ross (1985) modeled this by assuming risk-neutrality of the parties in a Nash non-cooperative behavioral setting in which they argued that both the tenant and landlord shirk as long as the share going to either party is between zero and one.

Johnson (1950), Rubinstein (1979) Rubinstein and Yaari, 1983, Radner (1981) and (1985), Newbery (1975) and Bardhan (1984) argue that in a in infinitely repeated contracts, an efficient insurance and incentive solution can be achieved by making contract renewal conditional on satisfactory overall performance or by punishing tenants for a period of time if aggregate output falls below expectations. The point is that in repeated contexts, tenant effort can be increased and thus share-contracts may not be inefficient at all.

The perspective of Eswaran and kotwal (1985) might be interpreted as an imperfect market perspective to contract choice in which resource and risk pooling might compensate for idiosyncratic market failure to which the parties in a contract might be subjected. In addition to entrepreneurial and supervision inputs considered in their model, we may think of access to working capital in the context of imperfect capital markets. A tenant with a cost and output sharing arrangement, for instance, requires less working capital than a tenant with fixed rent or pure sharecropping contracts that does not involve any cost sharing, as the landlord shares the costs of variable inputs such as fertilizer (Sadoulet *et al.* 2001). Moreover, in share contracts rental payments are differed out till the end of harvest season.

What came out of the critique of Marshal's and Cheung's predictions is that it is only when non-observability of labour is combined with market imperfections of some kind (e.g. risk and risk aversion and the lack of insurance market) that it may become a rational for

[6] It appears that the screening theory has drawn a lot from the agricultural ladder theory (Spillman, 1919 and Reid, 1977), as it focuses on variation in tenant ability and capacity, which also explains the latter theory.

sharecropping. With the exception Hallagan (1978) and Eswaran and Kotwal (1985) Copper and Ross (1985), and Sadoulet *et al.* (2001), a common feature of the above explanations of contract choice is that they are all based on a principal-agent setting where the choice of contract is made by the landlord (principal) and the agent (tenant) was typically assumed to have little influence over contract parameters. Landlords are assumed to be wealthier than tenants in the sense that they are landed and have more diversified income sources than the tenant; whereas tenants are assumed to be landless, infinite in number, and have identical opportunity cost equal to the wage rate in alternative employment. In this setting, the landlord as principal chooses the terms of contract subject to the tenant's reservation utility from alternative employment, implying that the market structure is such that the landlord has the power of stipulating contract terms.

Bell (1989) argued that the solution to models based on the principal-agent setting turn out to be that the landlord leaves no gain to the tenant over the utility from alternative employment. Bell (1989) and Banerjee and Ghatak (1996) argued that the solution to models based on principal-agent setting are unsatisfactory if there is a possibility that tenants can influence contract terms by virtue of their possession of factors with positive marginal productivity that are imperfectly tradable. Assuming a risk neutral landlord, a risk averse tenant, and enforceable contracts, Bell showed that the allocation of resources in production are identical in the bargaining and the principal-agent settings, but the distribution of the gain from the contract is better for the tenant (due to his/her power to influence contract terms) in the former than in the latter. When there is an incentive problem and costs of enforcing the contract are prohibitively high, however, the absence of a complete set of markets makes it unprofitable for the landlord to adopt wage contract and bear all the risks; the tenant will have no incentive to work unless he bears some risk. Bell argued that with constant absolute risk aversion (CARA) for the tenant, work incentives are affected by changes in the share to the tenant, but a side-payment to the tenant or a reduction in fixed payments to the landlord achieves a better distribution of the gains of the contract without affecting work incentives. To this extent, the principal-agent and the bargaining solutions would be identical. When there is decreasing absolute risk aversion (DARA), however, the landlord in a principal-agent setting is not free to vary fixed-payments without affecting work incentives, in which case the solutions for the two settings are not the same. Moreover, since work incentive varies with tenant share and fixed payments, Bell argued that the former (the share) will be lower and the latter (fixed payment) greater in the principal-agent setting than in the bargaining setting.

Empirical evidence from Medieval times suggest that imperfect capital market, risk (and risk aversion), and the fear of asset abuse by tenant favoured the spread of sharecropping over other forms of contracts in Western Europe (Ackeberg and Botticini 2000). [7] Specifically, in times of labour shortages landlords offered share contracts to poor (and therefore risk averse) tenants by offering them partial insurance against output risk. Similarly, the provision of loans and livestock by landlords to poor tenants lacking farm equipment and working capital (because they were rationed out from the capital market) was tied up to sharecropping contract. Sharecropping also served as a check to prevent the abuse of the landlord's assets such as perennial crops, livestock, and farm implements by fixed-rent tenant.

Evidence from contemporary developed and developing countries, although divergent in context, more or less corresponds to the above observations. In the Philippines, Dubois (2002) found that fixed rent contracts were preferred to sharecropping for most fertile plots, but the latter is preferred when crops inciting to land overuse, such as corn, are grown. A study in Tunisia by Laffont and Matoussi (1995) considered the role of ex-ante financial constraints contract choice and found that tenant's share of output is directly related to his/her working capital but inversely related to that of the landlord, showing that not only access to capital but also risk and risk aversion are important factors in contract choice. Similarly, Boadu (1992), in his study of Cocoa farms in Ghana, observed greater incidence of sharecropping compared to fixed rent and wage contracts in regions with a higher variation of coefficient of variation (risk) in Cocoa. Similarly, increasing off-farm employment opportunities are believed to be a cause for gradual shift to fixed rent contracts (Dowell 1977, cited in Hayami and Otsuka 1993). Evidence from Malaysia have also shown that sharecropping, by reducing the tenant's exposure to risk, has the advantage of creating the incentive to adopt risky but more productive technology (Shand and Khalirajan 1991)

Few studies documented coexistence of different contract types in a context of poverty, imperfect capital markets, and missing insurance market. In particular, the theoretical and empirical motivations have been the choice between sharecropping and fixed rent contracts, mostly within the principal-agent setting, while the choice between sharecropping contracts are largely ignored. In this paper we intend to contribute by modelling contract choice in the context of relative wealth differentiation between landlords and tenants, imperfect capital markets, and missing insurance market. We will show how a combination of

[7] See also Block 1966; Biagioli, 1987; Epstein, 1994; Galassi et al 1998 for more on this historical aspect.

wealth (poverty), risk, risk aversion, and credit market imperfection lead to the coexistence of different contracts.

3. The Setting in the Highlands of Eritrea and the Data

3.1: The setting

In the Eritrean context, there are three important aspects of the land rental market that have important implications for modeling contract choice. Firstly, tenants are members of a village community who, like other legitimate members, are entitled to an equal access to village farmland. A typical tenant owns excess non-land productive assets relative to what he requires to cultivate own land, creating the rationale for seeking additional land in the tenancy market. By contrast, landlords are those who have excess land relative to their endowment in non-land productive assets, creating a rationale for supplying land in the land rental market. Thus, a tenant farmer in the Eritrean context is one who operates a combination of own and rented land (owner-tenant) while a landlord is one who adopts either a mixed-landlord position by renting out part of his/her land or pure landlord by renting out his/her entire land. However, tenants are characterized by wealth differentials among themselves, as are landlords. Secondly, most land transactions are between individuals who live in the same village community and are either close relatives or know each other relatively well to the extent that their interaction extends to other aspects of life within the community on a continuous basis. Thirdly, land transactions happen in a context of a general scarcity of land where area expansion through clearing of new land or cross village land transactions is limited.

There are two implications of the above setting in Eritrea as far as contract choice is concerned. Firstly, in a context of imperfect credit market, differences in access to factors of production with positive marginal productivity and or overall difference in resource portfolio may result in the choice of different contracts, as these differences affect the relative expected returns of the different contracts for the two parties. Thus, in this setting, a model of contract choice based on a principal-agent setting may not provide satisfactory explanation of contract choice. The tenant in this setting has a stronger saying in contract choice than in principal-agent setting. Or, at least, it is reasonable to argue that the landlord's decision on contract terms is not done without considering the tenant's capacity. However, scarcity of land implies that the landlord may have the possibility of allocating land to other potential tenants in case of disagreement with a particular tenant. Moreover, given heterogeneity in landlord characteristics, some landlords may have access to some non-land factors that are essential for production.

Secondly, people in small communities with kin ties and same cultural values tend to care a lot about trust and reputation, which is also used as an indirect mechanism to enforce contracts. The implication is that contracting parties may spend negligible time monitoring each other's behaviour. Furthermore, the cost of monitoring might be low as fields are nearby and field activities (and timing) and crop stands are easily observable. Scarcity of land may imply that opportunistic short-term tenant behaviour might result in loss of reputation of the tenant; his/her ability to get new contracts not only with this landlord but also with others might be affected negatively. The combined effect of these factors is to provide self-enforcement mechanism, discounting the role of monitoring in contract choice.

3.2: The study area and the data

The sample data for this study is collected from a dominantly rain-fed agricultural system of 32 villages located in five adjacent sub-regions of the mid to highland regions of Eritrea. The distribution of sample villages by region and sub-region is shown in Table 3 of chapter two of this dissertation. The data is for the year 2000 rain-fed production season and the survey was conducted in the months of March-Oct., 2001. The villages selected represent the contrasting characteristics of the five sub-regions in terms of rainfall condition, per capita land availability, access to irrigation, and integration to input and output markets. The rains fall in the months of May-August, with the heaviest and longest being in July and August. However, the distribution is not usually even within and across villages and sub-regions. Plot level data was collected for 319 randomly selected households for 1899 plots that they own and\or operate.

There exists an active land-rental market in the study area. We distinguish among tenant-owners, those who operate both own and rented in lands; owner-operators, those who operate own land only; and landlords - those who rent out wholly are part of their land. As we can see in the Table 1, owner-cultivation dominates the tenure system in the study area, constituting 74 percent of the 1899 plots and 70 percent of the 1253.34 *Tsimdi*[8] of sampled agricultural land.

Since this paper is about contract choice, we focus only on owner-tenants and landlord households. Our data on contracts is not for tenant-landlord pairs (not matched) in the sense that characteristic of the other contract partner in a contract were not observed. Of the 590

Tsimdi of farmland and 796 plots operated by owner-tenant, 39 and 33 percent are rented-in, respectively. Similarly, 60 percent of the 237 *Tsimdi* owned by the landlord are rented out; this constitutes 60 percent of the 383 plots owned by landlord. Contract types include (1) fifty-fifty share of cost and output (C) where the tenant and the landlord provide oxen and land, respectively, and costs of production are shared equally between them[9]; (2) Pure output sharing contract (S) in which the landlord and the tenant contribute land and oxen, respectively, and the tenant bears all the production cost and gets either 2/3 or ¾ *of* the output; and (3) Fixed-rent contracts (F) where the landlord provides land and receives cash payment in advance as rent and the tenant provides oxen and bears all the cost of production. As we see in Table 1, fixed rent is highly dominated by sharecropping of which cost sharing constitutes 60 percent.

Table 1: Distribution of farmland and household types by contract type

Tenancy position	No of households	Owner cultivated area (number of plots)	Average plot size (number of plots) by contract type***				Total
			C	S	F	Total	
Owner-tenant	111	.69(530)**	.80(92)	.82(158)	1.54(16)	.86(266)	.74(796)
Owner-operator	145	.60(720)	0	0	0	0	.60(720)
Landlord	70	.61(157)	.61(92)	.64 (127)	.40(7)	.62(226)	.62(383)
Total	319*	.63(1407)	.71(184)	.74(285)	1.19(23)	.75(492)	.66(1899)

* The number of households at different tenancy position does not add up to the total because some households are observed to belong to both owner-tenant and landlord

** Area cultivated is in *Tsimdi*, which is ~ 0.25 ha.

The use of hired labour was reported for 403 plots (122 households) of which 83 are rented plots. However, hiring was for short-term activities such as weeding and harvesting tasks and therefore does not constitute a contract by itself.

A third of the total sampled households of whom 20 are land sellers and 21 are land buyers have indicated that they faced working capital/credit constraint to meet farm expenses, but only 9 percent of the total household sample is observed to have acquired credit in cash in 1999 and 2000 mainly from informal sources for different purposes including meeting household living expenses. Access to credit was higher for tenants operating pure sharecropping and fixed rent contracts (Table 3) and for landlords with cost sharing arrangement (Table 4). A large majority of the sample have acquired chemical fertilizer and

[8] *Tsimdi* is a traditional measure of land, which is equivalent to a quarter of a hectare.

[9] There are, however, 13 households who own an ox each reported to have entered into this type of contract. Of the non-cropped plots, six are shared-in and one rented-in.

to a limited extent tractor services under the government sponsored programme called Integrated Farming Schemes (IFS). We see that access to this was higher for tenants with fixed rent and pure share cropping than those with cost sharing contracts (Table 3).[10] However, this programme appeared to be an *adhoc* program rather than a sustainable policy intervention designed to transform agriculture. In general, the credit market is largely shallow, if not missing. In such a situation household wealth might play a role of financial intermediation.

We see in Table 3 that the average values of animal assets and off-farm incomes (proxy for wealth) are higher for tenants operating plots under pure sharecropping and fixed rent contracts than for those operating cost sharing contracts. Similarly, landlords who chose cost sharing contracts appear to have, on average, higher off-farm incomes and higher participation in non-farm self-employment activities than those who chose pure sharecropping contracts (Table 4). For tenants (landlords) plots under fixed rent and pure sharecropping contracts appear to be further (closer) in distance from homestead than plots under cost sharing contracts (Tables 3 and 4). Similarly, for landlords irrigated plots appear to be under cost sharing rather than under alternative arrangements. But these are only average observations. In section six, we will test if these average observations hold after controlling for a host of other variables shown in summary statistics (Table 3 and 4)

4. Theoretical Model

In the context of our study area, fixed-rent (F), pure sharecropping (S) and a combination of cost and output sharing (C) coexist. In this section we develop a theoretical model to explain the coexistence of these contracts.

4.1: Poverty, discount rates and contract choice

We start out with the following assumptions:

a) There is an imperfect credit market causing access to credit to be limited,
b) There is risk and imperfect access to insurance markets, both landlords and tenants are risk averse,
c) Both landlords and tenants are poor, that is, their income level is close to or below the poverty line,

[10] We do not look at access to IFS for landlords, because it is irrelevant for those who rented out their land completely.

d) There is no land sales market, only a market for land renting, land contracts are of short duration,
e) Landlords are well informed about each others' asset portfolios, land management abilities, and land quality in their village,
f) Land is scarce, creating competition for land in the land market,
g) Due to the spatial dispersion of land and its immobility there are significant transaction costs in the land market,
h) Factors of production other than land are imperfectly tradable (due to transaction costs) and largely complementary in production (low elasticity of substitution for most inputs),
i) Land rental contracts have to be made before the planting season. There is a time delay from contracts are made till harvesting time when output is harvested and eventually shared as part of the contract. Fixed rent payment is on the other hand made up front.

Based on the assumptions a), b), and c) above, we propose that individual households may have high subjective discount rates (Pender and Walker 1990; Holden *et al.* 1998; Holden and Shiferaw 2002; Hagos and Holden 2003; Yesuf 2003). Empirical studies show that the subjective discount rates are highly correlated with household wealth when credit and insurance markets do not work. We, therefore, introduce discount rate (δ) that can be stated as a function of household wealth or asset poverty (W) as follows

$$\delta^j = \delta^j(W^j),$$

where; j = tenant, landlord and

$$\frac{\partial \delta^j}{\partial W^j} < \mathbf{0} \text{ and}$$

$$\frac{\partial \rho^j}{\partial W^j} > \mathbf{0}, \text{ where } \rho \text{ is the discount factor given by } \rho = \frac{1}{1+\delta}$$

Holden *et al*. (1998), investigated the discount rates of poor rural households in Indonesia, Zambia, and Ethiopia and found that average discount rates are high and may range from 30 to 100 percent or even more at an annual basis. They also reported that wealthier households have lower discount rates than poorer household that is also consistent with the findings by Binswanger (1981) and Hagos and Holden (2002). With such high discount rates and large disparities in the subjective discount rates within communities it becomes clear that the discount factor on the output (share) matters for the valuation of it at the time the contract is made. Pender and Walker (1990) found that 1/3 of the households in their sample had discount rates above 100 percent. Holden *et al.* (1998) found large local variation in discount rates. With this in mind we develop a model of contract choice for the tenant and the landlord separately.

In pure sharecropping the tenant gets a share of output $\alpha_s : 0 < \alpha_s < 1$ and bears all production cost, while the landlord gets a share of output $1-\alpha_s : 0 < 1-\alpha_s < 1$; under cost sharing the tenant gets a share of output $\alpha_c : 0 < \alpha_c < \alpha_s < 1$ and bears cost of production proportional to output share, while the landlord gets a share of output $1-\alpha_c : 0 < 1-\alpha_c < 1$ and bears cost of production proportional to output share; In fixed-rent contract the tenant pays P_F amount of rent up-front per unit of land rented in, A_F, in which case $\alpha_F = 1$, the tenant is a full claimant of the residual output and bears all the costs of production.

The tenant's problem

For simplicity, we assume that the labour, oxen, and credit markets are missing. The tenant's income, y^t, comes from cultivating of own land, $\overline{A}^t$ and tenanted land, A_K, where $K = C, S, F$. Assuming risk neutrality, the tenant maximizes

$$y = \theta\rho^t P_q q_o^t(\overline{A}_o^t, L_o^t, m_o^t) - P_m m_o^t - w^t L_o^t +$$

$$F : \alpha_F \theta\rho^t P_q q_F^t(A_F^t, L_F^t, m_F^t) - P_F A_F^t - P_m m_F^t - w^t L_F^t$$

$$S : \alpha_S \theta\rho^t P_q q_s^t(A_s^t, L_s^t, m_s^t) - P_m m_s^t - w^t L_s^t$$

$$C : \alpha_c \theta\rho^t P_q q_c^t(A_c^l, L_c, m_c) - \alpha_c P_m m_c - \alpha_c w^t L_c$$

S.T.

$$L_o^t + L_F^t + L_s^t + \alpha_c L_c + L_e^t \le \overline{L}^t$$

$$0 < \alpha_c < \alpha_s < \alpha_F = 1$$

$$\rho^t(W^t) = \frac{\mathbf{1}}{\mathbf{1} + \delta(W)};$$

where, the superscript t indexes tenant; q^t is a twice differentiable concave production function for the tenant; θ is weather-related risk factor, which, following Stiglitz (1974) is treated as a multiplicative factor distributed with $E\theta = 1$ and positive finite variance, L_K^t and m_K^t ($K \in F, S,$ and C), are labour and purchased inputs used in production in each contract, respectively[11]; L_e^t is the leisure time, $\overline{L}^t$ is the labour endowment, and P_q and P_m are exogenously given prices of output and purchased inputs.

Because of an imperfect or missing credit market, household wealth serves as a source of liquidity (Binswanger and Rosenzweig 1986; Binswanger *et al*. 1989). However, wealth or assets are not perfectly tradable due to transaction costs. Lack of wealth or asset poverty may therefore limit the ability to mobilize liquidity, e.g. for fixed rent payment in relation to land contracts.

Given the above formulation, the household decides on which contract to go for by comparing the pay-off from each contract in response to its liquidity status defined by its wealth. Thus, we have the following pay-offs for the different contracts.

$$F : \pi(F(W^t)) = \theta\rho^t(W^t)P_q q_F^t(A_F^t, L_F^t, m_F^t) - P_F A_F^t - P_m m_F^t - w^t L_F^t$$
$$S : \pi(S(W^t)) = \alpha_s \theta\rho^t(W^t)P_q q_s^t(A_s^t, L_s^t, m_s^t) - P_m m_s^t - w^t L_S^t$$
$$C : \pi(C(W^t)) = \alpha_C \theta\rho^t(W^t)P_q q_c^t(A_c^t, L_c^t, m_c^t) - \alpha_c P_m m_c^t - \alpha_c w^t L_c$$

where w^t is the shadow wage rate of the tenant. Figure 1 below presents the expected pay-off as a function of the tenants' pay-off for each contract.

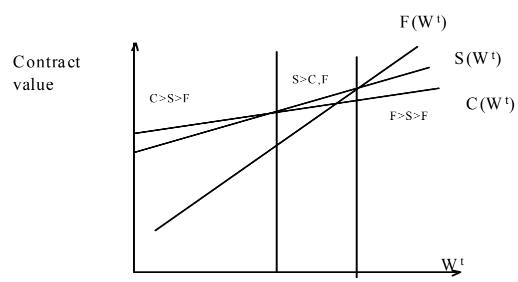

Figure 1: Optimal contract under varying levels of tenant's wealth

The difference in slope of the curves is due to difference in the share parameters. The height of the curves is determined by demand and supply (competition) in the local market. We see that at low level of wealth (high discount rates), cost sharing is more profitable than the pure sharecropping, which in turn is more profitable than the fixed-rent contract. This order is reversed when the wealth level is sufficiently high bring the discount rate down to allow the

[11] Note that in cost sharing not only purchased inputs but also labour and other variable inputs are shared equally between the parties, but for simplicity we consider only the purchased inputs as having shared the results of which can also be easily generalized to the others.

domination of fixed-rent contract over the other contract types. At intermediate wealth level (and discount rate), pure sharecropping is preferable to cost sharing and fixed-rent. This pattern is based on our theory of local variation in subjective discount rates.

The landlord's problem

The landlord's income, y^l, comes from rental income from tenanted land, A^r, and cultivating own land, $\overline{A}^l - A^r$, where $\overline{A}^l$ is landlord's land endowment. Assuming risk neutrality, the landlord maximizes

$$y^l = \theta\rho^l P_q q_o^l(\overline{A}^l - A^r, L_o^l, m_o^l) - P_m m_o^l - w^l L_o^l +$$

$$F : P_F A_F^r$$

$$S : (1-\alpha_s)\theta\rho^l P_s q_s^l(A_s^r, L_s^t, m_s^t)$$

$$C : (1-\alpha_C)\theta\rho^l P_c q_c^t(A_c^r, L_c, m_c) + w^l(1-\alpha_c)L_c - (1-\alpha_c)P_m m_c$$

S.T.

$$L_o^l + (\mathbf{1} - \alpha_c)L_c \le \overline{L}^l$$

$$0 < \alpha_c < \alpha_s < 1$$

$$\rho^l(W^l) = \frac{1}{1+\delta^l(W^l)};$$

where, the superscript l indexes landlord; q^l is a twice differentiable concave production function; $\overline{A}^l, \overline{L}^l$ denote landlord's endowment in land and labour, respectively; A_K^r, ($K \in F, S, \text{and C}$), denotes land under fixed-rent, pure sharecropping, and cost sharing contracts, respectively; L_o^l is the landlord's labour use on own land; $(1-\alpha_C)L_C$ and $(1-\alpha_C)m_C$ is landlord's share of labour and purchased inputs cost used on land under cost sharing contract; w^l is the shadow wage of the landlord, and the other variables are as defined for the tenet farmer.

Given the above formulation the landlord compares pay-off from the different contracts and chooses the ones that give the highest pay-off in response to its liquidity status defined by its wealth. Thus, we have the following pay-off functions for the different contracts

$$\pi(F) = \pi(F(W^l)) = P_F A_F^r$$

$$\pi(S) = \pi(S(W^l)) = (1-\alpha_s)\theta\rho^t(W^l)P_q q_s^l(A_s^r, L_s, m_s)$$
$$\pi(C) = \pi(C(W^l)) = (\mathbf{1}-\alpha_C)\theta\rho^l(W^l)P_q q_c(A_c^r, L_c, m_c) - (\mathbf{1}-\alpha_c)P_m m_c - (\mathbf{1}-\alpha_c)w^l L_c$$

Analogous to Figure 1, Figure 2 below presents the landlord's expected pay-off at different levels of wealth for each contract.

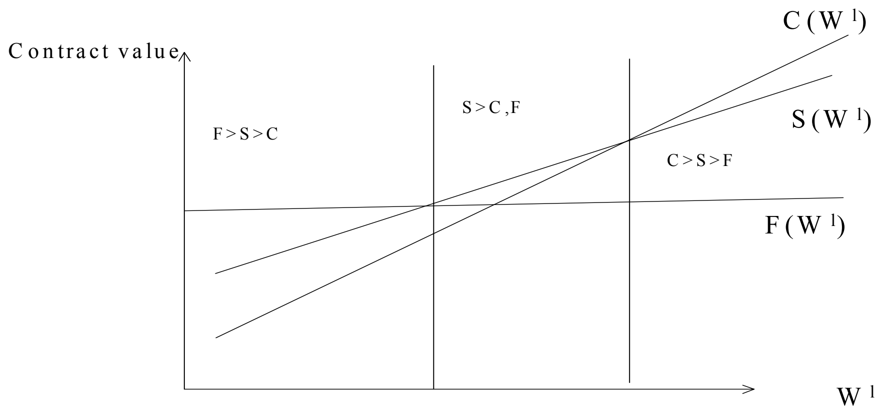

Figure 2: Optimal contract under varying level of landlords' wealth

We see that at low level of wealth the order of choice for the landlord is fixed-rent, sharecropping and cost sharing. This order is reversed at high levels of wealth the landlord choose cost sharing over share cropping, and sharecropping over fixed rent. At intermediate wealth level pure sharecropping dominates all fixed rent and cost sharing arrangements.

Looking at Figures 1 and 2 together, we see that our theory predicts fixed rent is a choice for rich tenants and poor landlords.

4.2: Risk and contract choice

As discussed in the literature review, risk is also known to affect contractual choice. The dominance of sharecropping in our study area may suggest that risk and risk aversion play a role in contract choice. Here in this section we use a risk premium, γ, approach to show how contract choice is affected risk and risk aversion in the context of credit and insurance market imperfections. Let the certainty equivalent income of the landlord, ψ, for each contract be as follows

$$F : \psi_F^l = P_F A_F^r$$
$$S : \psi_S^l = (1-\alpha_s)\rho^l P_q q_s^t - \gamma_S^l(\theta, R^l, \alpha_s)A_S^r$$
$$C : \psi_C^l = (1-\alpha_C)\rho^l P_q q_c^t - \psi_C^l(\theta, R^l, \alpha_C)A_C^r - (1-\alpha_c)P_m m_c - (1-\alpha_c)w^l L_e$$

Where R^l is the Arrow-Pratt measure of relative risk aversion given by $R^l = -\frac{\partial^2 U^l / \partial y^l}{\partial U^l / \partial y^l} y^l$ and

$$\frac{\partial \gamma_S^l}{\partial \theta} > 0; \quad \frac{\partial \gamma_S^l}{\partial R^l} > 0 \quad ; \frac{\partial \gamma_S^l}{\partial \alpha_S} < 0; \quad \frac{\partial \gamma_C^l}{\partial \alpha_C} < 0$$

Since $\alpha_C < \alpha_S$, we have $\frac{\partial \gamma_S^l}{\partial \alpha_S} < \frac{\partial \gamma_C^l}{\partial \alpha_C}$ and $\gamma_S^l < \gamma_C^l$

The implication of this model is that the more risk averse a landlord is, the more likely she is to go for a fixed rent contract. The less risk averse a landlord is, the more likely she is to go for cost sharing. Figure 3 below shows these relationships.

If relative risk aversion increases with poverty, $\frac{\partial R^l}{\partial W^l} < \mathbf{0}$, there are two reasons for poor

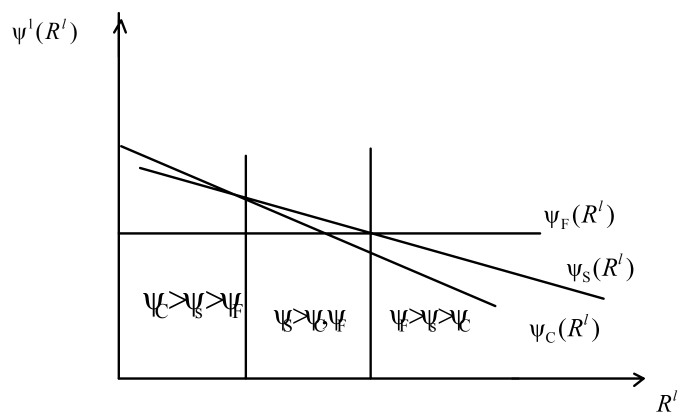

Figure 3: Contract choice under varying levels of landlord's risk aversion

landlords to prefer fixed-rent contracts, namely; (1) their high discount rate, and (2) their high level of relative risk aversion.

If we relax the assumption of competitive land rental markets, this opens the possibility for tenants to bargain down the fixed rent. Empirically, we should find (with imperfect competition)

- $\pi(C) > \pi(S) > \pi(F)\}$ due to risk aversion

- $\left.\begin{array}{l}\dfrac{\partial F}{\partial W^{l}} > 0 \\ \dfrac{\partial F}{\partial R^{l}} < 0\end{array}\right\}$ due to imperfect competition (lower bargaining power of poorer and more risk averse landlords).

For the tenant the certainty equivalent income, ψ^{t} from alternative contracts is given by

$$F : \psi_F^t = \rho^t P_q q_F - P_F A_F^r - \gamma_F^t(\theta, R^t, \alpha_F) A_F^R - w^t L_F^t - P_m m_F^t$$

$$S : \psi_S^t = \alpha_s \rho^t P_q q_s^t - \gamma_S^t(\theta, R^t, \alpha_s) A_S^r - w^t L_s^t - P_m m_s^t$$

$$C : \psi_C^t = \alpha_C \rho^t P_q q_c^t - \gamma_C^t(\theta, R^t, \alpha_C) A_C^r - \alpha_c P_m m_c^t - \alpha_c w^t L_e^t$$

Where R^t is the tenant's Arrow-Pratt measure of relative risk aversion given by

$$R^t = -\frac{\partial^2 U^t / \partial y^t}{\partial U^t / \partial y^t} y^t \quad \text{and}$$

$$\frac{\partial \gamma^t}{\partial \theta} > \mathbf{0}; \quad \frac{\partial \gamma^t}{\partial R^t} > \mathbf{0} \quad ; \frac{\partial \gamma^l}{\partial \alpha} > \mathbf{0}$$

Since $0 < \alpha_C < \alpha_S < \alpha_F = 1$, we have $\frac{\partial \gamma_C^t}{\partial R^t} < \frac{\partial \gamma_S^t}{\partial R^t} < \frac{\partial \gamma_F^t}{\partial R^t}$, which implies that $\gamma_F^t > \gamma_S^t > \gamma_C^t$. The implication is that, keeping other factors constant, the more risk averse the tenant is the more likely he is to prefer a cost-sharing contract. Similarly, keeping other factors constant, the less risk-averse he is, the more likely he is to prefer a fixed-rent contract. These results are shown in Figure 4.

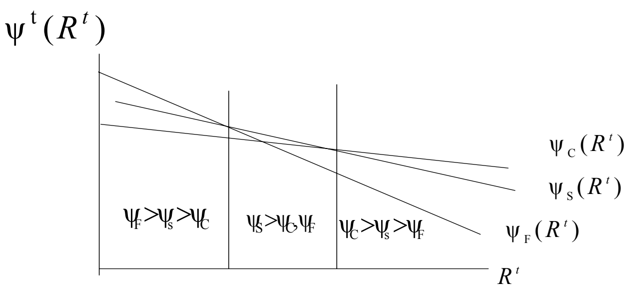

Figure 4: Contract choice under varying levels of tenant's risk and risk aversion

We see that the most risk-averse tenants will be more likely to prefer cost sharing. If risk aversion is related to poverty (increasing with poverty), there are two reasons for wealthier tenant's to prefer fixed-rent contracts, namely, (1) their low discount rate, and (2) their low level of relative risk aversion. Wealthier tenants are more able to pay upfront fixed rents and may in this way increase their expected profits. While poor landlords are more willing to trade-off their expected profit for their immediate cash and security needs.

Large variation in relative risk aversion also stimulates the coexistence of alternative contract types. Poverty reduces the chances of tenants being able to pay up-front fixed rent. Risk reduces the chances of tenants being willing to pay up-front fixed rent. Missing credit markets are likely to stimulate sharecropping, while well functioning credit/input markets are likely to stimulate fixed rent contracts.

4.3: Other relevant variables

The effect of land area and the characteristics of plots owned by both the landlord and the tenant on contract choice are not specifically addressed in the model above, but it is likely that contract choice also responds to these factors since these factors affect land value. The effects of these factors on contract choice may not be the same on both sides of the tenancy market. For instance, where land is scarce, one may expect the share going to the landlord to increase with land area owned, since land is more valued. However, since land area owned is typically fragmented and differs in quality, distance, and irrigation possibility, the landlord may achieve different contracts for different plots, with the better quality plots expecting to yield the landlord higher share of the output. On the other hand, the share to the landlord might decrease with land fragmentation when especially parcels are very small in size and are located in distant areas, as this might increase cost of production if the landlord decides to operate them.

Similarly, tenants might demand higher share of output for plots that are poorer in quality or distant from homestead in order to compensate them for the lower returns to labour and increased transportation. By the same logic, tenants may achieve lower share of output on good quality land, as it may be profitable for the landlord to go for cost sharing instead of fixed rent or pure sharecropping.

Variation in availability of land across villages is another factor, which may affect contract choice. Controlling for population differences across communities, it may be reasonable to expect that tenants' (landlords') share of output increases (decreases) with land availability. The intuition is that value of land is higher when it is scarce.

Many empirical studies in developing country agriculture consider larger holdings as sign of wealth. In light of our theoretical model, this would predict that tenant's with larger farms are less risk averse and, therefore, are more likely to shoulder higher risk in a contract. However, we noted in chapter Two of this dissertation that other assets also matter for wealth. So in absolute terms, increased holding might imply increased risk, in which case tenants might look for a partner to share the risk and cost of production, as their other resources may be more stretched (like labour). Accordingly, tenants with larger holdings relative to others might choose cost sharing over pure sharecropping or fixed rent contracts that have the effect of increasing the burden of risk on them.

Table 2: Summary of predictions (hypotheses)

Dependent Variable: Ordered probit models: Tenant model: 0=C (cost sharing), 1=S (share cropping), 2=F (fixed rent) Landlord model: 0=F, 1=S, 2=C	Expected sign on contract choice Tenant model	 Landlord model
Household Wealth indicators (risk aversion):		
Value of animal assets (*animalva*)	+	+
Number of oxen (*oxen*)	+	+
Risk:		
Coefficient of variation of rainfall (*cv*)	-	-
Average rainfall (*avrain*)	-	+
Access to working capital:		
- Irrigation in the dry season (*irland*)	+	+
- Access to credit		
- Cash loan (*creditd*)	+	+
- Integrated farming (*ifpartd*)	+	+
- Off farm incomes (ofainc99)	+	+
- Remittances (remitd)	+	+
- Self-employment (*bizd*)	+	+
Plot characteristics:		
- Distance (*plotdist*)	-	+
- Irrigation (*irigated*)	+	-
Land availability at household level		
Area owned relative to others (*relative*)	-	+
Number of parcels (*frag0*)	?	-
Land availability at village level (*vlavland*)	+	-

5. Econometric Models and Estimation Methods

The analysis of contract choice was carried out separately for owner-tenants and landlord households. The different types of contracts analyzed in the theoretical section can be modeled econometrically using ordered probit which is based on the following specification.

$z = \beta' X + \varepsilon$, with $\varepsilon \sim N[0,1]$ and Z unobserved latent variable determined by the value of the contract, CO, to the tenant such that

$$CO = \begin{cases} \mathbf{0} \text{ if } z \le \alpha_0 \\ \mathbf{1} \text{ if } \alpha_0 < z \le \alpha_\mathbf{1} \\ \mathbf{2} \text{ if } \alpha_1 < z \le \alpha_\mathbf{2} \\ \ldots\ldots \\ J \text{ if } z \le \alpha_{J-\mathbf{1}} \end{cases}$$

In our context J=3 since we have only three types of contracts four contract types. Thus, for the tenant farmer, we have

$$CO = \begin{cases} 0 \text{ if } \alpha_c = 1/2 \\ 1 \text{ if } \alpha_s = 2/3 - 3/4 \\ 2 \text{ if } \alpha_F = 1 \end{cases}$$

where the value of α indicates the value of output going to the tenant. For the landlord, the contract value increases in reverse order as follows.

$$CO = \begin{cases} 0 \text{ if } 1\text{-}\alpha_F = 0 = F \\ 1 \text{ if } 1 - \alpha_s = 1/4 - 1/3 = S \\ 2 \text{ if } 1\text{-}\alpha_c = 1/2 = \text{C} \end{cases}$$

We use plot level observations on contract type to estimate the models of contract choice for both the landlord and the tenant while controlling for possible non-independence of errors among observations within a household. The ordered probit model for the landlord is estimated using two specifications: one with plot characteristics variables such as plot quality, depth, slope, and, soil type included and the other without these variables. This was done because of missing data on these variables for some observations.

The basic hypotheses are outlined in the theory section. We do not observe risk aversion directly. But many empirical studies (Holden *et al*. 1998; Wik and Holden 1998; Binswanger 1981; Hagos and Holden 2003) have reported an indirect relationship between wealth and risk aversion. We exploit these results to use variation in wealth as proxy for variation in risk aversion. We use value of animal assets other than oxen (*aniamalva*), incomes from wage labour (*ofainc99*) and non-farm economic activity (*bizd*), irrigation in the dry season (*irland*), and remittance (*remitd*) as proxies for wealth.[12] The weakness of this approach, as also noted by Laffont and Matoussi (1995) and Ackeberg and Botticini (2000), is that household wealth might also be used to relax working capital constraint when the capital market is imperfect. Therefore, we may not know whether wealth as measured by the above factors might be picking the effect of risk aversion or capital market imperfection in the

[12] The 1996 World Bank Poverty study in Eritrea observed that ownership of oxen, animal assets, and access to non-farm incomes are main indicators of household wealth.

contract choice models. However, we believe that the effect of some wealth variable such as value of animal asset might be better indicators of risk aversion than, for instance, the effect of income from wage-labour, remittances, and self-employment, which are indicative of capital market imperfection more than risk aversion. We also use access to credit in 1999 (*creditd*) to further test the effect of capital market imperfection (high discount rates) on contract choice.

We control for household characteristics in terms of endowment in male (*madu00*) and female (*fadu00*) workers, gender (*hhsex*), education (*hhedu*), and farm experience (*hhfamex*) of household head; and a host of plot characteristics variables such as plot quality (*pqual*), plot slope (*slope*), plot depth (*depth*), and soil type (*soil*), and number of parcels (*frag0*) as rough measure of fragmentation. We also control for the effect of village characteristics on contract choice using village size in terms of number of households in each village relative to the sample average (*relpop*) and distance of village to the nearest market town (*marketd*). It is, however difficult to make sign expectation on these variables. We introduce sub-regional dummies in order to control for the effect of some unobserved characteristics across sub-regions such as differences in of market integration, culture, population density and others that may be systematically related to contract choice.

6. Results and Discussion

The results for contract choice for both the landlord and the tenant household are reported in Tables 5 to 8. The results of the ordered probit model for contract choice in Table 5 show that asset poverty and liquidity of tenants matter for contract choice**.** Higher incomes from off-farm activities (*ofainc99*) and dry season irrigation (*irland*), access to direct credit (*creditd*) and participation in integrated farming (*ifpartd*) increase the probability that tenants choose fixed rent and pure sharecropping to cost-sharing contracts. Similarly, the landlords' liquidity or wealth situation also affects contract choice significantly. We also see in Table 7 that the higher the landlords' income from off-farm and self-employment, the more they favour cost sharing to pure sharecropping and fixed rent contracts. In other words, poverty of the landlord increases the probability of him/her choosing fixed-rent in order to obtain up-front payment and to avoid risk. Contrary to what was found in Ethiopia by Pender and Fafchamps (2001) and in line with the findings of Laffont and Matoussi (1995) and Ackeberg and Botticini (2000) and our theoretical analysis, these results confirm that contract choice is affected by liquidity situation and asset poverty. To the extent that the above factors can also reflect variation in risk aversion across households, it can be said that the choice of fixed-rent and pure sharecropping over cost sharing contract is more likely the less risk-averse the tenant is.

Comparing the results in Tables 5 and 7, we see that the relative importance of these factors is different in the tenants' and landlords' model. For instance, the effect of income from off-farm wage work was bigger in the landlords' than in the tenants' model, while credit is more important for the latter than for the former. This may be partly because tenants have better access to credit than are landlords who might be forced to rely on off-farm wage labour to relax their working capital constraint.

In Table 5 we see that tenants with larger animal assets (*animalva*) have the tendency to choose fixed-rent contract as opposed to cost-sharing contract, but the effect of animal assets on landlord's choice is insignificant (Table 5), although positive as expected. To the extent animal assets are good proxies for risk aversion, this is evidence that contract choice, at least for tenants, is affected by risk aversion in such a way that more risk averse tenants are likely to choose cost sharing contracts as opposed to pure sharecropping and fixed rent contracts. This is in line of our prediction. For landlords, it may be said that working capital constraint rather than risk aversion might be more important in contract choice.

Contract choice is also affected by weather related risk considerations. Controlling for rainfall levels (*avrain*), we see in Table 5 that tenants are less likely to choose pure sharecropping and fixed-rent contract over cost sharing contracts, the riskier the weather is. But landlord's choice is not affected by risk, although the sign effect is negative as expected. For landlords, it is the amount of rainfall that appeared to matter; the likelihood of choosing cost sharing over pure sharecropping and fixed rent contract increased with level of rainfall. However, testing for weather effects resulted in the dropping of two sub-regional dummys because of colliniarity with the CV variable. Thus, we run a model without the sub-regional dummies and found that both CV and *avrain* are negative and significant in the tenant's model, while for landlords the effect of CV is still insignificant and the effect of *avrain* remained to be positive, but higher in significance. This latter result, while still confirming our hypothesis, appeared to be stronger than in the fixed-effect model. To avoid the problem of omitted variable, we choose to use the result from the fixed-effect models.

We see in Table 5 that increase in relative land availability at household level (*relative*) makes pure sharecropping and fixed rent contracts less likely as compared to cost sharing. This is in line with our prediction that tenants with more incentives to go to cost sharing due to their relative scarcity of other factors. Although insignificant, the positive sign effect of *relative* in the landlords' model (Table 5) is consistent with the negative result for the tenants' model. The level of dispersion or fragmentation as measured by the number of parcels (*frag0*) is shown to decrease the likelihood of cost sharing for the landlord, confirming the possibility that fragmentation might reduce the contract value of plots landlord.

Relative land availability across villages (*vlavland*) affects contract choice in such a way that pure sharecropping and fixed-rent are likely to be practiced in villages with relative land abundance than in villages with relative land scarcity. As predicted this is because of inverse relationship between the supply and value of land.

The choice of contract is also affected by plot quality. Table 5 shows that the choice of pure sharecropping and fixed-rent by tenants' is more likely the poorer the quality of the plot is (*pqual2* and *pqual3*) and the more distant the plot is from homestead. Similarly, Table 5 shows that cost sharing is a more likely choice for the landlord the further the plot is from homestead, confirming the result from the tenants' model. We also see in table 7 that cost sharing is more likely when the plot is irrigated (*irigated*) than when it is not. These results confirm our expectation that contract choice is affected by land quality in such a way that landlords choose value contract for good quality land while tenants choose high value for poor quality land to compensate them for the increased risk and cost of production.

We see in table 7 that cost sharing is a more likely choice for landlords the higher the farm experience of the head of household (*hhfamex*). Here farm experience might be picking the tenancy ladder effect due to Spillman (1919) and Reid (1977). In Table 5 we see that male tenant household heads are more likely to choose pure sharecropping and fixed rent as opposed to cost sharing. Assuming that male household heads have better managerial and farming skills than female household heads, this together with the farm experience effect in the landlords model, suggest that the farm skill is non-tradable. Better-educated landlord household heads are more likely to choose fixed rent and less likely to choose cost sharing. This might be because educated landlord household heads face a higher opportunity cost in the labour market and thus choose contracts that do not require their involvement in production in any way. Similarly, we see that landlord households with more male labour are more likely to choose pure sharecropping and fixed-rent contract. This could be because once the decision to rent-out is made, the returns to labour might be higher outside farming.

The numbers of fixed rent contracts in each of the models are small relative to the other contract types. Thus, we run the models without the fixed rent contract and we found that the basic results are maintained in both models, with the addition that the credit variable and the gender of the household head have become significant in the landlords' model.

The predictive power of the estimated models is quite high. Table 6 show that the estimated model for the tenant household is able to predict 81 percent of the observed contract types correctly. Disaggregating the figure by contract type, we see from the table that the model predicts correctly 72 and 91 percent of the observed cost sharing and pure sharecropping contracts, respectively, while only 38 percent of the observed fixed rent contract are predicted correctly. For the landlord model, Table 8 shows that the overall predictive power of the model is 85 percent. The percentage of correct prediction for cost sharing, pure sharecropping and fixed rent contracts are 84, 89, and 14, respectively. The low prediction of the fixed rent contract in both the tenant and the landlord models is due to small number of observations on this type of contract.

7. Summary and Conclusion

This paper reviews the theoretical and empirical works in contract choice and testes the effects of wealth (risk aversion), capital constraint, and risk on the choice of land contracts in a setting of imperfect capital market, poverty, and missing insurance market using sample farm plot level data of landlords and tenants from the highlands of Eritrea. The econometric results suggest that contract choice was affected by poverty, risk, risk aversion, and capital market imperfection. In particular, poor landlords with less off-farm income, less business income, less irrigated land, and less farm experience, were more likely to go for fixed rent contracts and less likely to go for cost sharing contracts. Similarly, wealthy tenants with access to incomes from off-farm wage labour and dry-season irrigation, and with more livestock assets, and better access to credit, were more likely to choose fixed rent contracts and less likely to choose cost-sharing contracts over pure output sharing. This implies that poor landlords and wealthy tenants are attracted to each other through a preference for fixed rent contracts. Likewise, less poor landlords and less wealthy tenants are attracted to each other through a preference for cost sharing contracts. The intermediate wealth stage on both sides provides a preference for pure output sharing. Contract choice was also affected by variation weather risk in such a way that cost sharing is a more likely choice the higher is the coefficient of variation of rainfall.

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Table 3: Summary statistics and variable definition by contract type for the tenant farmer

Variable			Mean and standard deviation by Contract type					
			C		S		F	
Name	**T***	**Definition**	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
landow	C	Total land area owned	3.81	1.24	3.57	1.60	4.05	2.03
relativ	C	Relative area owned**	1.07	0.25	1.07	0.23	0.92	0.25
frag0	C	Number of parcels	5.30	1.33	4.78	1.24	4.50	1.32
plotsize	C	Plot size	0.80	0.56	0.82	0.83	1.54	1.54
Pqual[+++]	D	Plot quality: 2 dummies for three categories						
depth[+++]	D	Plot depth: 2 dummies for three levels						
slope[+++]	D	Plot slope: 2 dummies for three levels						
soil	D	Soil type: 6 dummys for seven types						
plotdist	C	Distance from homestead	18.42	11.88	22.45	16.29	31.56	31.77
irigated	D	Plot is irigated	0.11	0.31	0.06	0.24	0.50	0.52
hhsex	D	Male head of household	0.87	0.34	0.86	0.35	0.81	0.40
hhedu	C	Level of education of household head	1.88	2.55	3.04	3.17	3.81	3.33
hhfamex	C	Farm experience of household head	36.16	13.28	32.80	13.72	32.00	12.53
madu00	C	Number of male workers	1.69	0.84	1.79	0.87	1.63	0.62
fadu00	C	Number of female workers	1.49	0.83	1.47	0.68	1.81	0.54
crconstr	D	Credit constrained	0.20	0.40	0.15	0.36	0.13	0.34
creditd	D	Access to credit	0.10	0.30	0.11	0.31	0.38	0.50
ofainc99	C	Off-farm income,000 NFA	0.41	1.35	0.50	1.30	0.80	1.69
bizd	D	Income from self-employment	0.07	0.25	0.11	0.32	0.06	0.25
remitd	D	Remittance income	0.03	0.18	0.16	0.37	0.31	0.48
oxen	C	Number of oxen	2.01	0.46	1.87	1.00	2.50	1.03
animale	C	Value of animals	7.13	7.24	15.66	15.93	21.99	23.87
irland	C	Irrigated land	1.63	2.16	1.74	2.82	2.76	2.66
ifpartd	D	Participation in Integrated farming	0.82	0.39	0.91	0.29	1.00	0.00
vlavland	C	Land availability ***	1.10	0.31	1.04	0.46	1.32	0.44
relapop	C	Relative household population****	0.93	0.39	1.24	0.95	0.79	0.51
marketd	C	Distance to nearest town in km.	8.17	4.58	8.69	3.04	6.31	2.55
cv	C	Coefficient of variation [++]	41.62	8.51	33.16	15.18	31.18	14.89
avrain	C	Average rainfall (7 year)	582.64	61.36	544.50	72.69	583.65	72.65
sr	D	Four dummies for five sub-regions						
Observations			92		158		16	

* T=variable type, D=dummy and C=Continuous. ** Relative area owned is a unit less measurement derived by dividing area owned (by individual household) by average area owned for a village. It measures relative land availability at household level.

*** Land availability is a unit less measurement derived by dividing average area owned for a village by average area owned for the total sample. It measures relative land availability at village level.

**** Relative household population is the number of households in a village divided by average number of households for the total sample

***** Distance is average of distance to sub-regional and regional capitals

[++] Coefficient of variation is derived from average rainfall for 1993-2000 at sub-regional level.

[+++] plot quality: 1= good, 2=medium, 3=poor; plot depth: 1=deep, 2=medium, 3=shallow; plot slope: 1=flat, 2=gentle, 3=steep

Table 4: Summary statistics and variable definition by contract type for the landlord farmer

Variable			Mean and standard deviation by Contract type					
			C		S		F	
Name	**T***	**Definition**	**mean**	**sd**	**mean**	**sd**	**mean**	**sd**
landow	C	Total land area owned	3.20	1.23	3.56	1.48	3.90	1.08
relativ	C	Relative area owned**	0.97	0.20	0.95	0.17	1.01	0.07
frag0	C	Number of parcels	5.28	1.28	5.50	1.93	5.57	0.98
plotsize	C	Plot size	0.61	0.38	0.64	0.35	0.40	0.33
Pqual+++	D	Plot quality: 2 dummies for three categories	1.89	0.70	1.91	0.73	1.57	0.79
depth+++	D	Plot depth: 2 dummies for three levels	1.96	0.71	2.07	0.67	1.29	0.76
slope+++	D	Plot slope: 2 dummies for three levels	1.26	0.57	1.39	0.63	1.14	0.38
soil	D	Soil type: 6 dummys for seven types	2.88	1.82	2.78	1.78	2.00	1.00
plotdist	C	Distance from homestead (minutes of walk)	17.12	11.51	24.94	17.45	30.71	22.63
irigated	D	Plot is irigated	0.10	0.30	0.05	0.21	0.00	0.00
hhsex	D	Male head of household	0.22	0.41	0.14	0.35	0.57	0.53
hhedu	C	Level of education of household head	1.01	2.16	1.84	2.40	2.57	1.90
hhfamex	C	Farm experience of household head	22.60	14.80	16.84	18.36	22.57	15.40
madu00	C	Number of male workers	0.21	0.47	0.22	0.43	0.71	0.95
fadu00	C	Number of female workers	1.14	0.35	1.13	0.33	2.00	1.41
crconstr	D	Credit constrained	0.24	0.43	0.35	0.48	0.29	0.49
creditd	D	Access to credit	0.17	0.38	0.01	0.09	0.14	0.38
ofainc99	C	Off-farm income, 000 NFA	0.74	1.81	0.18	0.40	1.31	1.72
bizd	D	Income from self-employment	0.14	0.35	0.07	0.26	0.00	0.00
remitd	D	Remittance income	0.10	0.30	0.20	0.40	0.29	0.49
oxen	C	Number of oxen	0.22	0.51	0.12	0.41	0.71	0.76
animalva	C	Value of animals	0.50	1.49	0.47	1.41	3.14	4.46
irland	C	Irrigated land	0.08	0.28	0.25	0.89	0.16	0.37
ifpartd	D		1.03	0.36	1.13	0.39	1.19	0.33
vlavland	C	Land availability ***	0.79	0.52	0.96	0.70	1.35	1.04
relapop	C	Relative household population****	8.27	5.03	8.70	3.43	8.43	2.51
marketd	C	Distance to nearest town in km.	37.92	15.99	36.90	13.46	41.06	4.06
cv	C	Coefficient of variation ++	572.07	35.83	568.62	66.59	546.00	90.16
avrain	C	Average rainfall (7 year)	2.35	1.38	2.31	1.47	2.43	1.51
sr	D	Four dummies for five sub-regions	3.20	1.23	3.56	1.48	3.90	1.08
Obs.			92		127		7	

* T=variable type, D=dummy and C=Continuous

** Relative area owned is a unit less measurement derived by dividing area owned individual household by village average of area owned

*** Land availability is a unit less measurement derived by dividing average area owned for a village by average area owned for the total sample.

**** Relative household population is the number of households in a village divided by average number of households for the total sample

++ Coefficient of variation is derived from average rainfall for 1993-2000 at sub-regional level.

+++ plot quality: 1= good, 2=medium, 3=poor; plot depth: 1=deep, 2=medium, 3=shallow; plot slope: 1=flat, 2=gentle, 3=steep

Table 5: Ordered probit: contract choice for owner-tenant (dependent variable: 0=C, 1=S, 2=F)

Variable	Coefficient (Robust Z-stat)
plotsize	0.095 (0.63)
Pqual2	0.476 (2.20)**
Pqual3	0.691 (1.65)*
depth2	-0.170 (0.70)
depth3	-0.689 (1.72)*
slope2	0.014 (0.06)
slope3	0.250 (0.52)
soil2	0.133 (0.54)
soil3	0.192 (0.44)
soil4	0.409 (1.00)
soil5	-0.766 (1.77)*
soil6	-0.006 (0.02)
Plotdist	0.016 (2.40)**
Irigated	0.155 (0.34)
Hhsex	0.604 (1.57)
Hhedu	0.056 (1.71)*
Hhfamex	0.018 (1.44)
madu00	-0.113 (0.77)
Fadu00	0.070 (0.33)
frag0	0.098 (0.94)
relativ	-1.890 (2.62)***
creditd	0.839 (2.44)**
Ofainc99	0.157 (1.75)*
bizd	0.060 (0.15)
remitd	0.232 (0.75)
oxen	0.048 (0.27)
Animalva	0.028 (3.02)***
Irland	0.112 (2.43)**
Ifpartd	0.589 (1.98)**
vlavland	1.579 (2.79)***
relapop	-0.532 (2.88)***
marketd	0.011 (0.30)
cv	-0.102 (4.36)***
avrain	-0.005 (1.35)
Sr2	0.984 (1.73)*
Sr4	2.597 (3.25)***
cut1	-3.53
cut2	-.51
Observations	266
Wald chi2(36)	151.30
Prob > chi2	0.0000
Pseudo R2	.37
Log Pseudo-Likelihood	-140.17546

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

Table 6: Observed and Predicted contracts (hit and miss table) for the tenant model

	Observed contract			
Predicted contract	C	S	F	Total
C	66	14	0	80
S	26	143	10	179
F	0	1	6	7
Total	92	158	16	266
Percentage of Correct prediction	72	91	38	81

Table 7: Ordered probit: Contract choice for landlord (Dependent variable: 0=F, 1=S, 2=C

Variables	Model 1 +++		Model 2 +++	
	Coefficient (Robust Z-stat)		Coefficient (Robust Z-stat)	
plotsize	0.723	(2.45)**	0.606	(2.47)**
Pqual2	-0.033	(0.14)		
Pqual3	0.313	(0.90)		
depth2	0.595	(2.21)**		
depth3	0.187	(0.48)		
slope2	-0.144	(0.48)		
slope3	-0.223	(0.70)		
soil2	-0.352	(1.27)		
soil3	0.498	(1.08)		
soil4	-0.628	(1.78)*		
soil5	-0.384	(1.12)		
soil6	-0.969	(2.23)**		
Soil7	-3.015	(2.93)***		
Plotdist	-0.022	(2.94)***	-0.022	(2.99)***
Irigated	1.557	(2.85)***	1.527	(3.04)***
Hhsex	0.147	(0.16)	0.183	(0.21)
Hhedu	-0.377	(3.88)***	-0.325	(3.34)***
Hhfamex	0.031	(2.11)**	0.024	(1.73)*
madu00	-1.477	(2.45)**	-1.335	(2.20)**
Fadu00	-0.489	(1.40)	-0.442	(1.30)
frag0	-0.264	(1.66)*	-0.392	(2.97)***
relativ	0.508	(0.48)	1.230	(1.21)
creditd	0.877	(1.02)	0.622	(0.77)
Ofainc99	0.665	(4.12)***	0.613	(3.73)***
bizd	2.585	(2.90)***	2.195	(2.39)**
remitd	0.010	(0.02)	0.106	(0.21)
oxen	0.127	(0.35)	0.071	(0.19)
Animalva	0.137	(1.21)	0.113	(1.06)
Irland	-0.234	(1.11)	-0.264	(1.20)
Vlavland	-2.173	(2.51)**	-1.354	(1.79)*
Relapop	-0.377	(1.42)	-0.312	(1.12)
Marketd	0.003	(0.06)	-0.004	(0.09)
cv	0.001	(0.03)	-0.002	(0.09)
avrain	0.013	(3.32)***	0.009	(2.74)***
Sr2	1.487	(2.53)**	1.558	(2.81)***
Sr4	-0.967	(1.66)*	-1.275	(2.20)**
cut1	.545		-.558	
cut2	4.365		3.035	
Observations	218		226	
Wald chi2(36)	194		114.38	
Prob > chi2	0.0000		0.0000	
Log Pseudo-likelihood	-89.61		-98.65	
Pseudo R2	0.50		0.45	

++ T-statistics are in parenthesis
* Significant at 10%; ** significant at 5%; *** significant at 1%
+++ Model 1 is with smaller observations than model 2, as data for plot characteristics was missing for some observations (8 observations).

Table 8: Observed and Predicted contracts for the landlord model

	Model 1				Model 2			
	Observed contract				Observed Contract			
Predicted Contract	F	S	C	Total	F	S	C	Total
F	1	1	0	2	1	2	0	3
S	6	105	12	123	6	113	15	134
C	0	13	80	93	0	12	77	89
Total	7	119	92	218	7	127	92	226
Percentage of correct Prediction	14	88	87	85	14	89	84	85

CHAPTER FOUR

Land Tenure Security, Resource Allocation, and Land Productivity: Theory and Evidence from the Highlands of Eritrea

Mahari Okbasillassie Tikabo and Prof. Stein T. Holden

Abstract

In this paper we set out to analyze the effect of tenure security /insecurity on input use and investment decisions and land productivity. We theorized that tenure security is an issue for the use of medium and long-term inputs as opposed to short-term inputs. However, tenure security may also be an issue for the use of short-term inputs indirectly if the short-term input can be used as a substitute for the medium/long term input. We also distinguish between the decisions to use and how much to use, given that the decision to use has been made, which opened the way for a possible differential effect of tenure security/insecurity on the two types of decisions. Empirically, we focus on the application of animal manure (organic fertilizer) as a medium-long term investment and chemical fertilizer as a short-term input. We made a general hypothesis that tenure insecurity affects the decision to apply manure negatively, but not the decision to apply fertilizer. Once the decision to apply the respective inputs is made, the effect of tenure security/insecurity on intensity of input use is more of an empirical issue. We used data from rain-fed agriculture in the highlands of Eritrea to analyze econometrically the direct effect of tenure security on decisions regarding the use of the respective inputs. We also investigated the effects of these inputs on land productivity to establish an indirect link between land tenure security/insecurity and land productivity. The analysis has shown that tenure security influences resource allocation behaviour of households and consequently land productivity. Particularly, we found that the probability of manure application increased with tenure security; manure application was more likely on own plots (long-term) and plots rented on medium-term basis than on plots rented on short-term basis. But the likelihood of chemical fertilizer application did not differ significantly between plots of different tenure duration. The intensity of animal manure use did not differ systematically across tenure durations, but chemical fertilizer was significantly higher on short-term plots relative to medium and long term plots. Land productivity increased with manure and chemical fertilizer applications, providing indirect evidence that tenure security has important implication for land productivity.

1. Introduction

While some perceive the traditional tenure systems in Africa as a constraint to economic development (Dorner 1972; Harrison 1987), others hold the view that indigenous land tenure systems in Africa are dynamic and evolve in response to factor price changes (Boserup 1965; Cohen 1980; Bruce 1988; Noronha 1985; Platteau 1992 and 1996; and Sjaastad and Bromley 1997). Thus, the former group argue for title-based privatisation of the indigenous tenure systems and the latter group question the need for title-based privatisation at the current stage of African economic development. To confine the debate to the presence or absence of title-based private ownership of land may not, however, be a useful way of understanding land tenure security/insecurity of African land tenure systems (Deininger and Binswanger 2001). The issue in Africa is much more complex. There are many socio-cultural, institutional, economic, and environmental factors that may go into the definition of land tenure security/insecurity in Africa than just the presence or absence of private property rights. In this respect, the title perspective of land tenure systems in Africa may not provide satisfactory answers to the question of the type of security that is compatible with the economic and environmental challenges. Yet, it cannot be denied that there are many problems of land rights and security in Africa for which a market perspective might be a useful framework for analysis. Therefore, for the benefit of appropriate formulation and implementation of land policy in Africa, there is a need for more empirical studies that assess the effectiveness of different land tenure arrangements in solving perceived land tenure problems. We review the few studies that exist and contribute with a new and unique study from Eritrea.

As part of the African continent, the issue of land tenure is also hot in Eritrea, especially after the advent of the country into the community of nations in 1993. While the indigenous land right systems in Eritrea are many and complex to understand, the dominant one in the highlands is the system of land holding called *Deissa* in local language. Access to *Deissa* land is restricted to *Deissa* village members, but there is a relatively active land rental transaction that, in most cases, is carried out among members of respective villages. Policy makers in Eritrea believe that the land distribution system under *Deissa* is not compatible with the requirements of agricultural intensification in the context of land scarcity. In particular, it is claimed that the system of periodic land redistribution, called *Wareida,* limits farmer's planning horizon in such a way that resource allocation behaviour is shaped by short-term cost and benefit considerations, neglecting long-term investment in land improving inputs and in more valuable cropping patterns. Similar views are also shared by many farmers in our study areas that as *Wareida* time approaches, farmer behaviour tends to be land degrading and opportunistic, causing considerable negative externalities on the common property resource.[1] Moreover, the land distribution mechanism in *Deissa* produces land fragmentation, which is believed to have prevented efficient use of land resources. A major policy response to the above perceived-inefficiency of the *Deissa* system of land ownership is the 1994 land law designed to reform the prevailing land right systems in the country. According to the new law, the state is the owner of all land in Eritrea and thus the government gives any right over land (Proclamation No. 58/1994). Regarding *Deissa* land, the new law calls for the extension of use right over plots to perpetuity. Fresh land redistributions have been carried out since 1998 in almost all of the highland villages, but the redistribution was more in line of the *Deissa* principles than on the new law. It appeared that the redistribution was a transitory policy aimed at primarily allowing access to land to previously deprived people. Most of the *Deissa* principles are intact and the possibility of a future redistribution is not ruled out. Apart from theoretical beliefs, however, to the best of our knowledge, there is no single empirical study made that associated the current low productivity of Eritrean Agriculture to the inefficiencies of the *Deissa* system.

The main objective of this paper is to seek empirical evidences on the relationship between land tenure security/insecurity and land productivity using cross-sectional data on investment and input use behavior of farm households in the *Deissa* system of the highlands of Eritrea. The presence of a land rental market in *Deissa* systems implies that a plot that is allocated to a *Deissa* member household (own-plot, hereafter) is either owner-operated or it is operated through some kind of tenancy arrangement between a landlord and a tenant farmer. Tenancy arrangements vary in terms of the contract duration and rental rates. A difference in ownership of plots and the associated contract duration provides a basis for comparing investment and input use behaviour across plots of varying tenure arrangement. Do differences in tenure duration lead to variations in resource allocation behavior of farmers in such a way that the less secured and hence more risky plots receive less investment in land improving inputs? The answer to this question may provide a clue to how the *Wareida* system in *Deissa* might affect resource allocation behaviour of households in the short and long terms.

The remaining part of the paper is organized as follows. The next section reviews empirical literature on the subject. Part three develops a theoretical model of the relationship between land tenure security and use of land improvement inputs. The purpose of part three is to derive testable hypotheses that are in line with the objectives of this paper. Part four develops an econometric model and discusses estimation methods and issues. Part five presents the data from the study

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[1] This result can be considered as similar to Hardin's theory of the tragedy of the commons (Hardin 1968), although not so much as the model for open-access resource system predicts.

areas. Part six presents results and discussion and the last part summarizes major findings of the study and concludes.

2. Literature Review and Land Tenure Insecurity in the Highlands of Eritrea

2.1: Literature review

Economic theory states that lack of secure ownership rights on land weakens farmer incentive to invest in yield-increasing inputs and to put land to its most productive use (Johnson 1972; Collier 1983; Feder *et al.* 1988; Besley 1995; Hayes *et al.* 1997; Roth and Dwight 1998).[2] This line of thinking has been the basis for advocating land reform that provides titling and private ownership of land to individual users (USAID 1986; World Bank 1993 and 1994). Through its effect on ownership security, land titling improves resource allocation and increases investment demand, and by creating the right of transferability, land titling allows the use of land as collateral to obtain credit from formal sources for investment and makes it possible to transfer land from less productive to more productive farmers (Feder *et al.* 1988; Green 1987; Bruce and Migot-Adholla 1994; Atwood 1990; Barrows and Roth 1989; Kille and Lyne 1993; Deininger and Binswanger 2001). For lenders, titling helps reduce the cost of information and the risk of default, which also results in the evolution of

Empirically, a study in Thailand has shown that titled lands are characterized by higher investment demand and input intensity and as the result yield was higher on titled lands than on lands without title (Feder 1988). In Lumakanda region of Kenya, Migot-Adholla *et al.* (1991 and 1994a) reported that more individualized rights were associated with greater land improvement activities that included continuous manuring. The same authors have also reported that in Butare and Gitaram regions of Rwanda, long-term improvements are positively related to land rights. This did not hold, however in Ruhengeri region of Rwanda. Similarly, in Kianjogu region in Kenya, Place and Hazell (1993) reported that *preferential transfer parcels* (parcels with the right to bequeath land rather than transfer it freely) have received more drainage or liming improvements than are *limited-transfer parcels* (no right of transferring parcels in anyway).[3] In

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[2] Private ownership over a resource provides the rights to exclude non-owners from use, the right to transfer the resource by sale or any other form, the right to ownership of income from the resource, and the right to enforce rights whenever others infringe them (Coase 1960; Demsetz 1967). Together with a full set of perfect markets, the provision of these rights are believed to result in socially optimum allocation of resources (Feeder and Feeny 1991)

[3] Place and Hazell (1993) have measured land rights in terms of the extent of use rights and transfer rights. Within use-rights, parcels were classified on the basis of the rights to grow annual crops for one or more years, to grow perennials, to make permanent improvements, collect fruits or firewood, cut trees, grazing livestock, and be buried on the land. Transfer rights are measured in degrees: the right to register the land, rent mortgage, pledge, bequeath, give or sell the land with and without approval from village leaders. They differentiated between complete, preferential, and limited transfer rights to define levels of tenure security. Complete transfer right refer to those parcels that can be sold by the current operator while preferential transfer parcels are those

Butare, Ruhengeri, Gitarma regions of Rwanda a positive correlation between the incidence of continuous manuring or mulching and land rights was reported (Ibid.). In Rujumbura, Uganda, land registration is positively and significantly related to continuous manuring and mulching, and positively but insignificantly related to all long-term investments (Roth *et al.* 1994a). In Gambia, Hayes *et al.* (1997) have found that within customary tenure system more individualized rights are associated with higher propensity to make investments, which in turn had a positive effect on yield. [4]

By contrast, in Madzu region of Kenya, Migot-Adholla *et al.* (1994a) and Place and Hazel (1993) reported no significant relationship between land title and investment. In the Shebelle region of Somalia, Roth *et al.* (1994a) found that agricultural investment is not significantly related to land title. In Burkina Faso, no investment differential was reported between owned and borrowed fields (Saul 1993).

A study on Ghana has mixed results. Migot-Adholla *et al.* (1994b) and Place and Hazel (1993) have found that land improvements are highly related with security of tenure in Anloga region, to a lesser extent in Wassa, and not at all in Ejuru. In Anloga the ability to freely transfer land was positively related to investment in drainage or excavation improvements. In Wassa tree crops were less likely to be planted on parcels with limited transfer rights, although the results were not significant. In Ejuru there was no relationship at all between land right category and investment in tree crop planting and destumping. However, Besley (1995), after controlling for endogeneity of land rights, has reached an opposite conclusion to that of Migot-Adholla *et al.* (1994b). That is, using the same data, he found that land rights facilitate investment in Wassa but not in Anloga.[5] Similarly, a study on 36 villages in central Uganda concludes that investment enhances tenure security, yet the converse relationship is not true (Balland *et al.* 1999). After controlling for such endogeneity, a recent study in Burkina Faso has found evidence that increased land right do not stimulate investment (Brasselle *et al.* 2002).

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parcels which can not be sold but can be given or bequeathed, usually to members of the same family or lineage. The remaining parcels that may not be permanently transferred are classified as limited transfer right parcels, which are also further sub-divided into short-term and long-term use rights.

[4] Land right categories are similar to that of Place and Hazell 1993.

[5] Some scholars are skeptic about the positive causal relationship between land tenure security and investment in the case of Sub-Saharan Africa where land rights are dominantly informal (Atwood, 1990; Platteau 1992, 1996, and 2000). In Sub-Saharan African countries, some land improvements, particularly planting trees, is a well recognized method of enhancing tenure security for holders of temporary or fragile claims (Bruce 1988; Place and Hazell 1993, Sjaastad and Bromley 1997), suggesting a reverse causal relationship between land rights and investment. The methodological implication of this for empirical study is that, in such contexts, it is important to control for endogeneity of land rights before drawing conclusions on security-investment relationships. As we discuss it later, the context of our study area does not indicate such a possibility

In Niger, Gavian and Fafchamps (1996) reported that tenure insecurity stimulates farmers to divert scarce manure resources from less secured land, *borrowed land*, to more secured land, *Hawajou* and *own-land*[6], whenever they can. The study further argued that the inability to transfer land by sale did not affect the allocation of these resources between *own-land* and *Hawajou* land. Accordingly, the study concluded that there is no basis for reforming the customary tenure system in Niger in favor of land titling. However, the finding does not appear to warrant this conclusion. The finding that *Hawajou* land were not less manured than own land can not be attributed to differences in land tenure in terms of ownership as long as the duration of use right for both the *own-land* and the *Hawajou* land was long enough to allow farmers to capture the benefits from manure application fully.

In another study of manure and fertilizer application at plot level in five villages in Burkina Faso, Matlon (1993) reported that inherited plots on lineage land received more manure than borrowed land in two of the villages, but he found no significant effect of tenure security defined by a hypothesized ordering of tenure status[7]. Fertilizer application on inherited plots on lineage land was higher than on borrowed plots in only one village, while it was positive on borrowed plots in another village.

A study of the effect of land tenure on production behaviour of farmers in rural china by Li *et al.*(1998) has shown that the right to use land for long (or indefinite) periods of time encourage the use of land-saving investments such as organic manure, but the use of short term inputs was not affected by such rights.[8] In a similar study in rural China, Jacoby *et al.* (2002) have reported evidence of negative effects tenure insecurity (land expropriation hazard) on investment in organic manure, but not on chemical fertilizer.

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[6] *Own land* is held permanently by individual families of a village where landowners are granted the right to use, modify, and the legitimate, but highly discouraged, right to sell. *Hawajou* land, on the other hand, is borrowed from a pool of community land entrusted to the village chief. Hawajou users have the same use right, as landowners except they are not allowed to sell or sublet land. Nor do they have the right to make medium-term modifications like fencing, wells, and plant trees. *Borrowed land* are held in security until the harvest but can be reclaimed by the owner afterwards. The writers considered the level of tenure security to diminish according to these characterization, with the least secured being *borrowed land*. The land improvement input considered animal manure, which is recorded as a binary variable, as in the context of their study area, it was applied by having livestock spend the night on the field.

[7] Matlon formed the following hypothesized ordering of tenure status according to use right security where 1 is most secured and 6 is least secured. (1) Inherited plot on lineage land from a lineage member, (2) Inherited plot on a non-lineage land from a lineage member, (3) Borrowed plot on lineage land from a lineage member (4) Borrowed plot on a lineage land from a non-lineage member (5) Borrowed plot on a non-lineage land from lineage member, and (6) Borrowed plot on a non-lineage land from non-lineage member. Moreover, within each of these situations, security was greater where current cropping is for meeting family subsistence needs rather than individual cash cropping.

[8] The authors also found that the effect of tenure insecurity varied across types of chemical fertilizer; tenure insecurity affected application of phosphate fertilizer negatively but not nitrogen fertilizer. The writers reasoned out that the former has the characteristic of being a more long-term investment.

In a study of the relationship between perception of tenure insecurity[9] and input use in Southern Ethiopia, Holden and Yohannes (2002) found that tenure insecurity had no direct effect on whether households purchased farm inputs or on how much they used. By contrast, in Hararge in eastern Ethiopia, Gavian and Ehui (1999) found that farmers on less secured lands applied more inputs than those holding more secured lands, although the less secured lands appeared to be farmed 10-16 % less efficiently than the more secured counterparts.[10] However, using the same data set and controlling for differences in village, household, and plot characteristics, Pender and Fafchamps (2001) reported no significant differences in input intensity or output value between own and sharecropped fields. In Zimbabwe, Harrison (1992) found that smallholders without having private title to their land have achieved rapidly increasing maize yields, and their productive performance was not inferior to that of the biggest farmers. Similarly, Place and Hazell (1993), in Ghana, Rwanda, and Kenya; Gavian and Ehui (1999) and Holden *et al.* (2001), both in Ethiopia, have reported an insignificant relationship between land rights and yield. [11]

On the effect of titling on credit allocation, the evidence is not conclusive either. Feder *et al.* (1988) reported major impact of titling on access to credit in two Thai regions and weak impact of titling on credit in a third Thai region where informal lending predominates. However, the evidence from Sub-Saharan Africa is that the use of credit was not related to land rights (Place and Hazell 1993; Roth *et al.* 1994a; and Roth *et al.* 1994b).

Having reviewed the empirical literature relevant to the subject of interest in this paper, two points are worth raising and discussing before we proceed to the next section to describe and discuss the setting in the highlands of Eritrea. Firstly, the above-reviewed studies are conducted in varying contexts of land rights (formal vs. informal), land availability (scarce vs. abundant), and investment types and characteristics. Such differences in contexts make it difficult to conclude on the pattern of relationship between land rights, investment, and land productivity. Common sense tells us that uncertainties about the future stream of benefits from current investment discourage investment, as investment of any form is always made in anticipation of benefits. Insecure land rights (formal or informal) create uncertainty about future benefits and thus limit investment. However, as argued earlier, investment could also enhance land tenure

[9] Tenure insecurity is measured by whether a farmer fears loss of land due to a policy of land redistribution or not.
[10] Less secured land refers to informally – contracted lands that include rented, shared, and borrowed lands.
[11] Gavian and Ehui (1999) have used total Factor Productivity (TFP) approach to measure production efficiency differentials among farms of different tenure arrangement. The arrangements considered are government allocated land, which is most secure, and informal arrangements that include rented, shared, and borrowed land.

security, although this might be truer in contexts of informal rights and relative land abundance than in contexts of formal land right and land scarcity. This highlights the importance of designing empirical studies to consider contextual differences in land rights and land availability. The results of studies based on this perspective may suggest increased security either through enhanced use-right or through title-based land rights. It may be possible to argue for either solution in particular contexts, but not for either solution as the best way (most efficient) to increase demand for investment and efficiency in resource allocation.[12] In particular, using an ideal land market or formal land rights as a benchmark to assess efficiency of African land tenure systems may not provide an insight into what can be done to improve security in order to achieve a more efficient resource allocation in Africa. The presence or absence of land title does not necessarily suggest tenure security\insecurity. Where there is no private ownership of land, as is the case in most Sub-Saharan African rural societies, for instance, absolute ownership security over the fruits of investment might be more important than the concept of absolute ownership security over land. [13] As noted by Gavian and Ehui (1996), sometimes, security is a mater of farmer's subjective assessment of the political and legal climate notwithstanding the existence of titled land rights.[14] Having said this, however, whether it is based on private ownership of land or other forms of land rights, as long as land is scarce, it is not unreasonable to argue *a priori* that tenure security is an important incentive shaping farmers' decision in resource use and investment behavior, particularly in medium to long-term yield increasing inputs.

Secondly, in most of the above-reviewed studies (Feder *et al.* 1988; Place and Hazell 1993; Besley 1995; Gavian and Fafchamps 1996; Hayes *et al.* 1997; Brasselle *et al.* 2002) the effect of tenure security on the use of land improvement inputs is limited to Probit or Logit analysis. The studies appeared to assume that the variables affecting the decision to apply the respective inputs

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Holden *et al.* 2001 differentiated between land allocated from peasant association and shared-in land. Private ownership of land does not exist in Ethiopia.

[12] Of course, title-based ownership rights and the ease with which land can be disposed (low risk and transaction cost), may make land acceptable as collateral to obtain scarce credit for investment from formal sources. Whether this will lead to efficiency gains as compared to alternative arrangements is, however, uncertain. In fact, under certain circumstances, alternative sources of credit that do not require land as collateral such as group lending might perform better in meeting the objectives of credit. There are many success stories on group lending, notable being the Grameen Bank of Bangladesh.

[13] One cannot think of private ownership security where sale and purchase of land is forbidden by law or by some social or custom.

[14] In some cases security might be understood in terms of household food security goals in the face of climatic uncertainties or other non-tenure source of risks. Small-scale farmers facing recurrent weather shocks may discount future benefits from investment considerably and may instead spread their investment on diversified activities (as a strategy to minimize fluctuation in income and household food balance) even with improved land tenure security (Maxwell and Wiebe 1998). Although improvements in land rights may create incentives to invest in risk minimizing activities such as water conservation, it may still pay the household to put some of its resources in alternative activities as insurance against some shocks and/or because returns are more stable in alternative activities.

are the same as those affecting the intensity of input use and thus failed to distinguish between the two types of decisions. Having decided on whether to use or not, the effect of tenure security on the intensity of input use was not given due emphasis. The effect of tenure security on intensity of input use might be different from that on the decision to use the respective input. Matlon (1993) and Li *et al.* (1998) and Jacoby *et al.* (2002) in China analyzed the effect of tenure insecurity on intensity of organic manure use using censored data, but without distinguishing between the two types of decisions. In this study, we distinguish between the two decisions and take the analysis beyond the traditional probit regression to carry out a test of the effect of tenure security on intensity of manure and chemical fertilizer inputs, as well. We do not form a direct link between tenure security and land productivity. However, we try to link tenure security to land productivity indirectly through its effect on chemical fertilizer and manure application. In addition, we test the effect of specific land contracts on land productivity in order to get an overall indication of efficiency differential across tenancy arrangements.

2.2: Land tenure insecurity in the Highlands of Eritrea

In the context of our study area there is no land market in the sense of actual buying and selling of land. Farmers do not hold legal titles over land. Instead we have the *Deissa* system, where members of a particular village collectively own and share land and water resources under the village's jurisdiction. *Deissa* farmland is distributed among eligible members according to the principles of *Deissa* where a right holder is entitled to a lifetime use-right over her/his share of village farmland. However, right holders under *Deissa* do not have lifetime use-right over particular plots, as land is periodically redistributed, every five-seven years, through a process called *Wareida*. Thus, plots change hand every *Wareida* time. Although it varies across village communities, land in general is scarce and that access to it is strictly limited to members of a village only. The purpose of *Wareida* in *Deissa* is (1) to maintain the egalitarian distribution of land within a village in light of demographic changes within household and the village; land redistribution accommodates newly formed families and would be families and revises the eligibility status of members in accordance their current conditions, and (2) given that land quality is heterogeneous, land redistribution insures quantitative and qualitative equality in holdings through rotation of plots among holders of *Deissa* rights. People who were disadvantage in previous redistribution would be compensated in fresh redistributions.

Despite its equalitarian advantages, the *Wareida* system in the highlands of Eritrea has been criticized for its disincentive effects on investment (see the review paper for more on this). This critique is popular among policy makers and the academia. However, we tried to gather farmer opinion on this by asking individual farmers how they would have changed their resource use behaviour if there were no land redistribution at all. The response was striking; 83 percent of the respondents replied that they would have taken a better care of their land through continuous application of land improving inputs such as application of organic manure and putting more durable structural works.[15] This might indicate that land redistribution causes tenure insecurity and limits the incentives to invest.

There is a relatively active land rental market in *Deissa* villages, although land rental transactions are usually limited to within communities. Thus, a plot that is allocated to a *Deissa* member household (own-plot, hereafter) is either owner-operated or it is operated through some kind of rental arrangement between a landlord and a tenant farmer.[16] For a cultivator who operates his/her own plot, the important source of tenure-risk is the risk of loosing his/her plot through village-wide redistribution. But for cultivator who operates shared\rented-in land, the primary source of tenure-risk is the risk of loosing that plot through termination of a contract with the plot owner. Although the source of risk, loss of plot, is similar in both cases, it is reasonable to argue that the latter source of risk is higher than the former, as the tenure length for land contracts are in general shorter than that for own plots. Other rights that do not apply to rented plots might also characterize own-plots. The implication is that benefits from investment on own plots are more secure than benefits from investment on shared\rented plots. Yet we can also distinguish between short-term and long-term rental contracts depending on the duration of the tenancy arrangement. Therefore, we may think of the level of tenure security to increase with duration on which the farmer expects to cultivate the land, putting own-plots as the most secure and plots rented under short-term contract as the most insecure plots.

Tenure security may be less of a concern if costs and benefits accrue in the short run than if the benefits accrue over a longer period of time (Knox McCulloch *et al.* (1998), Holden and Yohannes (2002), and Jacoby *et al.* (2002)). Accordingly, not only plot ownership but also the durability of the effects of respective investments matter for securing the benefits from particular

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[15] Paradoxically, when the farmers were asked if they would be interested to see land redistribution in the future, 60 percent of them replied yes, 30 percent replied no, while the rest were undecided. Some of the reasons given by those who expressed interest in further land redistribution were (1) they felt that the last redistribution was not fairly done, and (2) they believe that land redistribution is the only way to insure livelihood security.

[16] The forms of land contracts in our study area include (1) Fifty-fifty sharing of cost and output where the tenant and the landlord provide oxen and land, respectively, and costs of production are shared equally between them[16]; (2) Pure output sharing contract in which the landlord and the tenant contribute land and oxen, respectively, and the tenant bears all the production cost and gets 2/3 of the output; (3) Pure output sharing contract in which the landlord and the tenant contribute land and oxen, respectively, and the tenant bears all the production cost and gets a ¾ of the output ; and (4) Fixed-rent contracts where the landlord provides land and receives cash payment up front as rent and the tenant provides oxen and bears all the cost of production. The dominant contract types are pure sharecropping and cost sharing (see chapter Two).

investments. We believe that animal manure and fertilizer provide contrast in terms of duration of investment benefits. The contrast is also consistent with farmer's belief that manure is more durable than fertilizer in the sense that its productivity impacts last for two-three years while that of chemical fertilizer can be captured completely in one production season. Besides to enhancing crop nutrition, application of animal manure has an added advantage of enhancing moisture retention capacity of soils.[17] In this paper, we exploit this contrast to investigate if animal manure versus chemical fertilizer allocation behavior of farmers is systematically related to variation in land tenure security using sample data from 32 villages in the highlands of Eritrea. The results may provide some indication on the potential effects of the *Wareida* system on investment demand and on land productivity.

2.3: The study area and the data

The sample data for this study comes from a dominantly rain-fed agricultural system of 32 villages communities in five adjoining sub-regions of the mid-to-highland regions of Eritrea. The sub-regions are *Mendefera, Dibarwa, Gala-Nefhi, Berik and Serejeka*. The first two are described as Mid-highland while the last three are described as Highlands. The rains fall in the months of May-August, with the heaviest and longest being in July and August. However, the distribution of the rains across villages and sub-regions and sometimes within villages is typically uneven. The villages selected represent the contrasting features of the five sub-regions in terms of rainfall condition, per capita land availability, access to irrigation, and integration to input and output markets. The distribution of sample villages by sub-region together with some agro-climatic and location characteristics is given in Table 3 of chapter two.

The survey was conducted in the months of March-Oct., 2001 and the data collected is for the year 2000 rain-fed production season. Plot level data was collected for 319 randomly selected households for 1899 plots that they own and\or operate. Of this 1586 plots were grown to 18 different types of crops (see Table 1).[18] As can be seen in Table 1, the major types of crops grown are cereals that include barley, a mixture of barley and wheat (*MBW*, hereafter), and *taff* (local language for *Eragrostis=teff*). Taff in *Mendefera*, *MBW* and *taff* in *Dibarwa*, barley and *MBW* in *Gala-Nefhi*, and wheat and barley in *Berik* and *Serejeka* sub-regions dominate the cropping pattern. We can also see that, although much less important than cereals, legumes are important

[17] Jacoby *et al.* (2002) argue that a single application of organic fertilizer in most sub-tropical and temperate climatic zones can have an effect on the soil for four to five years.

[18] Of the 1899 plots 217 plots were not cultivated for many reasons that include fallowing. Another 89 plots were allocated for irrigation and thus were not put to rain-fed production in the period under study. Further,

part of the cropping system. Production is dominantly subsistent, but *taff* and *potato* are used as sources of cash for sub-regions of *Mendefera* and *Serejeka,* respectively. The numbers of observations used for estimating the input equations and land productivity are 1456 and 1429, respectively.[19]

Almost all of the villages in the sample have had land redistribution (*Wareida*) since 1998 as per government directions, but mainly according to *Deissa* principles. This implies that the use of past plot tenure as a proxy variable for tenure security may have little use in the analysis of the relationship between investment and tenure security, since there was no enough variation in the number of years elapsed after the last *wareida*. Similarly, the use of time period elapsed since last *Wareida* as risk indicator (assuming that land redistribution becomes more likely with the passage of time since last *Wareida*) is not useful either, since it is also likely that future *Wareida* might be held at about the same time for all villages. The only variation in duration one can count on in our data set is between own plots and plots that are under different contract duration. For the rented plots that we have complete input and output data (326 plots), 84 plots were contracted for at least two years, 193 plots were for one production season and the contract period for the remaining 49 plots was unspecified and uncertain for the respondent beyond the contract year.[20] However, most tenants expressed interest in renewing contracts. The duration for own plots was unspecified, as it depends on the timing of the next *Wareida* period, which is largely unknown; but it is expected to be longer than for all rented plots.

The sample data shows that chemical fertilizer (Urea and Dap) was used on 989 plots of which about 85 percent were grown with cereals. Of the total number of plots that were fertilized with chemical fertilizer, 203 were rented under different contract duration. The source of fertilizer was mainly participation in an integrated farming scheme (IFS) [21].

For many farmers in the study area, the use of animal manure on fields is an important method of enhancing soil quality in terms of crop nutrition and moisture retention capacity.

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landlords did not have information on input use and output on seven plots that were rented-out on fixed-rent basis.

[19] There is no input data for 115 plots that were shared\rented-out on con3-con5 basis by the landlord, as landlord households did not know the exact input level used by the tenant. Further, we have 12 plots (for six households) for which it was not possible to establish tenure status data by plot. A further 31 con2-con5 plots were not cropped. A plot grown with garlic was dropped from the analysis, as the crop is unique in many aspects and it was likely that it may cause bias in the estimations. This gives 1456 plots for which there is complete input data. Only 1429 observations are used for land productivity analysis, as 27 plots for which output data was found to be non-reliable were dropped from the analysis.

[20] The tenant was not certain of the contract duration beyond the study season.

[21] Integrated farming system (IFS) is a recently introduced method of farm support and production organization. It has different variants. In *Serejeka, Berik, and Gala-Nefhi* it is based on provision of fertilizer and seed. Whereas, in *Dibarwa* and *Mendefera*, it involves tractor in addition to fertilizer and seed provisions. The service

Farmers consider animal manure as a longer-term input than fertilizer, as they believe that the yield benefit from its application lasts for two-three years. There were 165 plots (99 households) on which animal manure was applied. Of this 30 plots were rented under different contract duration. The source of animal manure for most farmers was animal assets, but some have reported that they actually purchased animal manure from the market.[22] No uniform measure of animal manure was observed in the study areas. The measures are traditional that include animal-load (donkey), cartload (horse-drawn cart), truckload, sacks, and baskets. After thorough discussion with farmers we have converted those measurements to quintals as follows. A sack-load ≈ half quintal, a basket-load = 1/10 quintal, an animal-load = one quintal, a track-load=40 quintals, and one cartload≈10 quintals. Animal manure was transported to farmland by track (*mtranst1*), by horse-drown cart (*mtanst2*) and donkeys (*mtrans3*).

Looking at the average application of animal manure and chemical fertilizer in Table 2, it appears that there were considerable differences in the number of positive applications and intensity of application of the respective inputs across tenure durations. The incidence and intensity of application of animal manure was the least among short-term plots. This was not, however, the case with chemical fertilizer application, as three was little difference in both incidence and intensity of use across tenure durations. We need, however, to put this casual observation to more statistical scrutiny by controlling for a host of other variables, described in Table 3, which may have also influenced input use decisions and output results across plots. Estimation of the probabilities and intensity of applications of the respective inputs in section five will do this.

3. Theoretical Framework

3.1: Investment model

Following the above brief description of the land tenure system in the highlands of Eritrea, the model we develop here assumes no formal land market in the strict sense of buying and selling of agricultural land.[23] An important source of risk that we consider below is the fear of loosing a particular plot through village wide periodic redistribution of land (*Wareida*) or through a termination of a particular land tenure contract agreed with a landlord. Jacoby *et al.* (2002) used a standard investment model augmented to allow for risk of land expropriation to analyze the

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is said to be on credit basis. There are, however, villages in *Gala-Nefhi* and *Berik* (not included in this study), that practice a collective type of integrated farming scheme.

[22] The reported price for one-track load of animal manure including transportation varied between 250- 350 Nakfa (10 Nakfa≈1USD, in year 2000).

[23] This implies that the collateral value of land to obtain credit from formal banking institutions is zero. Yet households may get access to credit from various sources, which do not require land as collateral.

relationship between tenure security and investment in rural China. Because of the similarities of the redistribution systems they considered and that in the highlands of Eritrea, we find their model to be appropriate to motivate a theoretical analysis of tenure security and resource allocation behaviour. Thus, we adopt their model, but later we introduce some extensions to allow for factor market imperfections. The source of risk that we consider here is different from the expropriation risk we have in the Feder *et al.* (1988) model of land rights, as loss a particular plot through *Wareida*, for instance, does not result in complete landlessness or permanent lack of access to land in our context.

Consider a farm household that faces the risk of loosing a particular area of land, *A(t),* through village-wide land redistribution (*Wareida*) or termination of a land contract, both of which may happen at some random time, τ . The probability that the farmer retains control until at least time *t*, a period of time sufficient for recouping the returns from investment, is given by $\pi(t) = pr(\tau \geq t)$. The corresponding risk function of loosing a particular plot may then be defined by $risk(t) = \dot{\pi}(t) / \pi(t)$, where $\dot{\pi}(t)$ is the probability density function of plot tenure. The risk function represents the instantaneous probability of loosing a plot that has been held for some t years. The farm household maximizes the value of output from a plot of land obtained either from him/her being a member of *Deissa* village or through some kind of land contract.[24] The household decides on application of land improvement inputs at time t: organic manure, *M(t)* , and chemical fertilizer, *V(t)* at a price of P_m and P_v, per unit of each input, respectively. While chemical fertilizer is good to enhance the current period's production alone, application of organic manure has the effect of increasing the present and future stock of organic matter in the soil. The stock of organic matter in the soil at time t is *K(t).* The household's dynamic production function can be expressed as $Q\big(A(t), V(t), K(t); \varphi(t)\big)$[25], where; *Q(.)* is total output, and φ(t) is an index of plot characteristics. Normalizing equation (1) by *A(t) ,* we obtain the household's land productivity function at time *t* as follows

$$(1) \qquad q(t) = q\big(v(t), k(t); \varphi(t)\big)$$

[24] In reality the household might also be engaged in non-farm activities in addition to farming. As we discussed in the literature review, this may have implications for household resource allocation. However, we ignore this not only to make the theory simple, but also with the understanding that this possibility can be introduced later in our econometric analysis. We lose no generality by doing so.

[25] This specification assumes no production uncertainty in terms of weather risk, which quite a strong assumption in the context of highland agriculture in Eritrea. We prefer not to consider weather risk for the time being it in order to keep our model simple. We also consider a single crop and ignore other inputs in order to make things simple.

where; lower case letters denote per unit of land variables. We assume that $q_s > \mathbf{0}$, and $q_{ss} < \mathbf{0}$. The problem of the household is to maximize the expected present value of net returns by choosing the time path of manure and chemical fertilizer applications.[26] Normalizing output price to unity, the undiscounted net yield function is given by

$$(2) \qquad R(t) = y_t\big(v(t), k(t); \varphi(t)\big) - P_v v(t) - P_m m(t)$$

The household's problem is then

$$(3) \qquad \text{Max}\int_{0}^{\infty} e^{-rt}\pi(t)R(t)dt$$

Subject to

$$(4) \qquad \dot{k} = -\delta k(t) + v(t)$$

$$(5) \qquad m(t) \geq 0,\ v(t) \geq 0$$

where r is the discount rate. The objective function in (3) states household's period-t return adjusted by the probability $\pi(t)$. Equation (4) is the organic matter growth function in the soil, $\dot{k}(t)$, and expresses the net change of the stock of organic matter as a function of constant stock depletion rate, δ, and replenishment quantity, *m(t).* The constraints in (5) are non-negativity constraints. The Hamiltonian for the household's problem is

$$(6) \qquad \mathrm{H} = e^{-rt}\pi(t)R(t) + \chi(t)\big[-\delta k(t) + m(t)\big] + \mu(t)m(t) + \eta(t)v(t)$$

where $\chi(t), \mu(t),$ and $\eta(t)$ are multiplier functions, with $\mu(t) > 0$ when m(t)=0, $\mu(t) = 0$ otherwise, $\eta(t) > 0$ when *v(t)*=0, $\eta(t) = 0$ otherwise. The first order necessary conditions for maximum are

$$(7) \qquad -e^{-rt}\pi(t)P_m + \chi(t) + \mu(t) = 0$$

$$(8) \qquad e^{-rt}\pi(t)\big[q_v(t) - P_v\big] + \eta(t) = 0$$

$$(9) \qquad \dot{\chi}(t) = e^{-rt}\pi(t)q_m(t) - \delta\chi(t)$$

Using the result that $\eta(t) = \mu(t) = 0$ for positive application of manure and chemical fertilizer, differentiating (8) with respect to time and combining the result with (10) gives[27]

$$(10) \qquad q_k(t) = \big(r + \delta + \text{risk}(t)\big)P_m$$

Simplifying (9) we have

[26] Here we assume that the household is risk-neutral, which is not realistic, but risk aversion can be introduced later in the empirical analysis.

(11) $q_v(t) = P_v$

Differentiating (10) and (11) with respect to time and combining the result with (4) yields

(12) $$m(t) = \delta k(t) + \frac{p_m q_{vv}(t)}{q_{vv}q_{kk} - q_{vk}^2}\dot{risk}(t)$$

The denominator of the second term in the right hand side of equation (12) is positive by the concavity of the production function. Using equations (10) and (11) we solve for the unconditional demand for chemical fertilizer, $v^*(t)$, and stock of organic matter, $k^*(t)$ at time *t* as follows

(13) $v^*(t) = v^*(\text{risk}(t), r, \delta, P_v, P_m; \varphi)$

(14) $k^*(t) = k^*(\text{risk}(t), r, \delta, P_v, P_m; \varphi)$

Equation (13) states that the demand for chemical fertilizer depends on the risk function, discount rate, depletion rate of stock of animal manure, prices of chemical fertilizer and animal manure, and plot characteristics. Combining these results with equation (14), we solve for the demand for animal manure as follows

(15) $$m^* = m^*\left(\text{risk}(t), \dot{risk}(t), r, \delta, P_v, P_m; \varphi\right)$$

Equation (15) states that the demand for animal manure depends on all the arguments in (13) plus on how the risk function changes with plot tenure, $\dot{risk}(t)$. Note that $\dot{risk}(t) > 0$ means that the risk of loosing a plot increases with time while $\dot{risk}(t) < 0$ implies risk of loosing a plot decreases with time. In the context of our study area, this translates into how the risk function change as the *wareida* (land redistribution) time approaches. For $\dot{risk}(t) = 0$, that is, when risk does not vary with time, equation (12) implies that the household applies manure just enough to maintain the stock of manure in the soil. For $\dot{risk}(t) > 0$, it implies that farmers apply less manure than is required to replenish the stock of manure, since $\frac{p_m q_{vv}(t)}{q_{vv}q_{kk} - q_{vk}^2} < 0$. The intuition is that the right hand side of equation (10), the shadow value of manure, increases with the length of tenure on the plot and that an approaching *Wareida* should discourage investment in manure. The opposite results if $\dot{risk}(t) < 0$. Farmers apply more than is required to replenish the stock of manure, since its shadow value decreases with time.

[27] We also used the results that $\chi(t) = \pi(t)e^{-rt}P_m$ and $\dot{\pi}(t) = -\text{risk}(t).\pi(t)$ to simplify (11) further.

The demand for chemical fertilizer is not directly affected by changes in the risk function, since it is not considered as investment. Choice is made regardless of the future changes in the shadow value of chemical fertilizer. However, the demand for chemical fertilizer depends on the risk function indirectly through a cross-price effect, as we shall see soon.

The solutions for chemical fertilizer and organic manure are plugged in equation (2) to obtain the land productivity model as follows

$$(16) \qquad q^{*} = q^{*}(k^{*}, v^{*}, \varphi)$$

Equation (16) states the land productivity equation as a function of the endogenously determined demand for chemical fertilizer and the stock of manure, which is also enhanced by current application of manure, m^*.

The risk function can be viewed as having two arguments: time and exogenously determined frequency of land redistribution, ξ. The effect of the former on the choice variables is clear from the above discussion, but to see the effect of the latter, we define a proportional risk form $\text{risk}(\text{t}, \xi) = f(t)\,\xi$ and do total differentiation of equations 10-12 with respect to ξ, which yields

$$(17) \qquad \frac{\partial m^{*}(t)}{\partial \xi} = \frac{P_m q_{vv}}{q_{vv} q_{kk} - q_{vk}^{2}} \left[\ \delta f(t) + \dot{f}(t)\ \right]$$

$$(18) \qquad \frac{\partial v(t)}{\partial \xi} = -\frac{P_m q_{vk} f(t)}{q_{vv} q_{kk} - q_{vk}^{2}}$$

In equation (17) whether the sign effect is positive or negative depends on the sign of the term inside the square brackets. If $\frac{\dot{f}(t)}{f(t)} > -\delta$, that is if the rate of change in risk over time is faster than the depreciation rate, then investment on animal manure is negatively affected by change in ξ. For $\frac{\dot{f}(t)}{f(t)} < -\delta$, investment increases with ξ. We see from (18) that the demand for chemical fertilizer is affected indirectly through a cross-price effect. For $q_{vk} < 0$, the right-hand side term in (18) becomes positive, implying that application of chemical fertilizer increases with risk of loss of land. Conversely, it decreases when $q_{vk} > 0$.

3.2: Some extensions to the above model

In the above analysis, we tried to view the relationship between tenure security and input use as a single decision problem. In reality, it might be useful to distinguish between two decisions regarding input use: whether to use a particular input or not, and, having decided to use, how much to use. These two decisions might be affected differently by tenure security. The first decision is discrete where as the second decision is continuous in the outcome variable. Sometimes, tenure security might be relevant only to the decision whether to use or not, especially when the loss of land is highly probable due to say short-term nature of contracts. Conversely, farmers may decide to apply, although not necessarily in sufficient quantity, if the risk of loosing land is less probable in the near future and that they can at least reap part of the benefits of the investment. In the latter case the effect of tenure security is more on the intensity of application than on the decision to use.

Implicit in our investment model is the assumption of independence of production decisions from households' physical, human and financial characteristics. However, rural markets in developing countries are known to be imperfect (de Janvry *et al.* 1991; Hoff *et al.* 1993) and that input decisions and output are not independent of household characteristics and wealth, since production decisions are no longer recursively separable from consumption decisions (Singh *et al.* 1986). We address this by specifying the econometric models to test for factor market imperfection by including household fixed factors and farm characteristics, $H(t)$. We discuss the specific ways this may affect the outcome variables later when we formulate our hypotheses.

Finally, marginal productivity conditions may dictate that sharecropped plots may not receive as much investment as own-plot due to the potential disincentive effect of output sharing (Marshall 1890; Cheung 1969), regardless of the length of tenure. This complicates matters further. We do not intend to address this issue fully in this paper; a more complete treatment of share tenancy and its efficiency implication is made in Chapter five. Here in this paper, in the input models, we only control for cost-sharing contracts since the contracting parties make decisions regarding input use jointly. As will be clear soon, there is also a practical difficulty in trying to control for all the contract types in the input models. However, we are able to control for all types of contracts in the land productivity model; the purpose is to get some general indication about efficiency differentials between own and rented plots.

4. Estimation Methods, Issues, and Hypotheses

4.1: Regression models

Equations 13, 15, and 16 in the above are the basis for econometric estimation of the demand for chemical fertilizer and animal manure and the land productivity model, respectively. The dependent variables in the input models are value of chemical fertilizer per unit of land and quantity (quintals) of animal manure per unit of land. Among the arguments of the two demand functions, $\left(\text{risk}(t), \dot{risk}(t)\, ,\, r,\, \delta, P_v, P_m; \varphi, h\right)$, the discount and the depreciation rates and the price of manure are not observed directly. Animal manure is generally non-traded, but there is significant variation in its cost, which may be approximated using some household labour resources, distance, and mode of transporting manure. Similarly, to the extent that discount rate is inversely related to household wealth (Binswanger 1981; Holden *et al.* 1998; Hagos and Holden 2002), we may use household wealth indicators as proxies for discount rate. We do not have appropriate proxy for depreciation rate, but controlling for different plot characteristics may control for variation in depreciation rate, as well. The price of chemical fertilizer is given for all farmers.[28]

Land redistribution was carried out during 1998-2000 in all the sample villages from which our data was dawn. To the extent that the next redistribution takes place at about the same time for all the villages, the risk of loosing a plot arising from land redistribution can be assumed to be the same for all the farmers in all the villages.[29] As discussed earlier, the source of variation in risk in our setting comes from comparison of tenure length between plots allocated to the farmers as a member of a village and contracted plots. Thus, in our setting the two risk arguments, $\left(risk(t), \dot{r}isk(t)\right)$ in the demand function collapse to one that measures variation in length of tenure across plots. The relevant length of tenure varies between one year for short-term contracts (*length3*) and 2-3 years for medium-term contracts (*length3*) and the umber of years between *Wareida* periods for own plots (*length1*), which we expect to be longer than for contracted plots. Because *Wareida* periods are uncertain, we used dummy variable to indicate variation in tenure length across plots. Equations 13, 15, and 16 may then be specified as econometric models as follows.

(19) $$m_i = \alpha_o + \alpha_1 \pi_i + \alpha_2 C_{ij} + \alpha_3 \varphi_i + \alpha_4 h + \alpha_5 CC_i + \alpha_6 O + u$$

(20) $$v_i = \mu_o + \mu_1 \pi_i + \mu_2 C_{ij} + \mu_3 \varphi_i + \mu_4 h + \mu_5 CC_i + \mu_6 O + \varepsilon$$

(21) $$y_i = \beta_o + \beta_1 m_i + \beta_2 v_i + \beta_3 C_{ij} + \beta_4 \varphi_i + \beta_5 h + \beta_6 CC_i + \beta_7 O + e\,,$$

[28] The price was 1.47 Nakfa/kg of DAP and 1.10 Nakfa/kg of Urea. Nakfa is the national currency in Eritrea, equivalent to .10 USD during the period of Data collection.

[29] The redistribution was carried out as per government directions (see the overview chapter for more on this). However, most farmers expect the next redistribution to be not before 5-7 years, which is the traditional land redistribution period.

where m_i = the quantity of animal manure applied per unit of land (*manurp)*[30]; v_i = Value of fertilizer (*Urea* and *Dap*) applied per unit of land (*fertp*); y_i = Value of output achieved per unit of land (*yieldv)* [31] ; π_i is a future tenure length dummy variable for plot i, given by

$$\pi_i = \begin{cases} \text{length1} = \text{long tenure plot} = \text{all own plots} = 1, 0 \text{ otherwise} \\ \text{length2} = \text{plots rented on meduim - term basis} = 1, 0 \text{ otherwise} \\ \text{length3} = \text{plots rented on short - term basis} = 1, 0 \text{ otherwise} \end{cases};$$

where *length1* is the control variable; C_i = Rental contract dummy for the i[th] plot, given by

$$C_i = \begin{cases} \text{con1} = \text{owner - cultivated} = 1, 0 \text{ otherwise} \\ \text{con2} = \text{fifty} - \text{fifty cost and output sharing} = 1, 0 \text{ otherwise} \\ \text{con3} = \text{pure output sharing with tenant getting 2/3 of output} = 1, 0 \text{ otherwise} \\ \text{con4} = \text{pure output sharing with tenant getting 3/4 of output} = 1, 0 \text{ otherwise} \\ \text{con5} = \text{fixed} - \text{rent contract} = 1, 0 \text{ otherwise} \end{cases};$$

where *con1* is used as control variable; φ = plot characteristics; CC_i = cropping dummy indicating crop choice; *h* and *O* are household and unobserved factors, respectively; α, μand β are coefficients to be estimated for the three equations, respectively; u_i, ε_i, and e_i are error components for the three equations, respectively. Details and definitions of the specific variables included in the fixed factors are given in Table 3.

We see in the above that own-plot is common to the tenure length and contract variables. We cannot test for the effect of tenure security and contract types on input use simultaneously by using own-plot (long-tenure) as a control plot in both cases, since this would obviously result in dummy variable trap. Thus, given the objective of this paper, we test for the effect of tenure security on input use while controlling for whether the plot is cost shared (*con2*) or not. The rationale for choosing to control for cost-shared plots as opposed to other contract types in the input use models is that, the contracting parties jointly make input decisions on cost-shared plots;

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30 Unit of land in our setting is *Tsimdi,* a traditional measure of land area, which is equivalent to a quarter of a hectare according to national standards. We conducted an actual measurement of sample plots from selected villages to crosscheck the national equivalent. It seems that there is, generally no significant deviation between reported measures and their national hectare equivalent. However, we have made some adjustment of the reported sizes in some villages to harmonize local variation in what *Tsimdi* implies in terms of actual size. We have also scrutinized the reported area size in *Tsimdi* against the figures from village administration. Again, reported figures are usually consistent with those reported by the village administration.

31 Considering the diversity in cropping, we use the value of output per unit of land for each plot as our dependent variable in the land productivity regression. Output is measured at the market price during harvest time. There was no significant variation between the reported prices among sub-regions and thus the most frequently reported (mode price) is used to value output. The lack of significant variation in prices is probably due to the proximity of the sub-regions to each other and, more importantly, due to the similarity in cropping pattern among the sub-regions.

decision making under the other contract types is under one farmer. Testing for the effect of tenure security on individual decisions makes more sense than on joint decisions.

4.2: Estimation methods and issues

There are some econometric issues that appear to be relevant to our data set. These include data censoring and endogeneity issues. Censorship issue arises in both the fertilizer and animal manure equations, as we have many observations with zero application of either input. Failure to account for data censoring in both equations may results in inconsistent parameter estimates of the models. Consider, for instance, the following censored regression model for the fertilizer equation.

$$(22) \qquad v_i = I\left[X_i^{'}\beta + \varepsilon_o\right]$$

where $X_i^{'}\beta$ and ε_o are the deterministic and random components of the model, respectively, and I is the indicator variable determined by whether the dependent variable is censored or not. The indicator variable I is determined by a vector of conditioning variables, W, using a binary choice model as follows

$$(23) \qquad I_i = W_i^{'}\eta + \varepsilon_1$$

where $I_i = \begin{cases} 1 \ \ if \ \ v_i > 0 \\ 0 \ \ if \ \ v_i \leq 0 \end{cases}$ and ε_1 is an unobserved error term and η is a vector of unknown coefficients. By assumption, $\varepsilon_0 \sim N(0,\sigma)$ and $\varepsilon_1 \sim N(0,1)$. If $corr(\varepsilon_0, \varepsilon_1) = \rho \neq 0$, which may not be ruled out since process (22) depends on whether v is positive or zero, then

$$(24) \qquad E(v|v>0) = X_i^{'}\beta + \rho\sigma\lambda(\alpha)\,,$$ [32]

where; $\lambda = \phi(\alpha)/(1-\Phi(\alpha))$, also called the *Inverse Mills Ratio*; ϕ and Φ are the density and the cumulative standard normal functions, respectively; and α is the standard normal variable given by $\frac{a - X_i^{'}\beta}{\sigma}$. In this case, OLS estimation of (24), using only the reported regressors and without correcting for censoring, may lead to inconsistent estimates of the parameters (Heckman 1979).[33] Suitable candidates for efficient estimation are, among others, maximum-likelihood (MLE) and Heckman's two-stage procedures (Heckman 1979) and its adaptations (e.g. Deaton 1997)[34]. We

[32] See Green (1997) and Wooldridge (2002) for derivation of these results.
[33] The problem is actually analogous to omitted variable situation in model specification.
[34] Deaton's two-stage regression model relaxes the normality assumption for the error terms under Heckman's two step or MLE estimator, employs a polynomial approximation of the probability of input use, calculated from equation13, as an alternative selection variable in equation 14 (Deaton 1997).

are, however, unable to apply these methods due to lack of appropriate instruments to identify the first-stage models. Thus, we take the liberty to specify and analyze the first-stage and second stage models separately without having to worry about selection problem. The probit models are estimated using linear specification of the independent variables, while in the second-stage all the continuous variables are normalized by farm size and those that are directly linked to production decisions[35] are transformed to logarithmic form. A log-log specification is also assumed for the land productivity model in a similar fashion.

It is possible that observations within household clusters are correlated and thus reported standard errors may not be correct. The *cluster* option in *Stata*, which is a generalization of the Huber/White/Sandwich (HWS) estimate of variance (Rogers 1993; Williams 2000) obtains robust variance estimates that adjust for within-cluster correlation. Similarly, unobserved heterogeneity across households may also lead to inconsistency in parameter estimates. The random-effect (RE) estimator controls for unobserved household heterogeneity, which at the same time also adjusts for within-cluster correlation since it applies GLS.[36] We applied the RE estimator, which worked quite well for the first and second stage chemical fertilizer models, but not for the animal manure models. A model appropriateness test rejected random effect estimator for the first-stage animal manure model and that the probit model for the decision to apply animal manure was estimated by controlling for clustering effect using the HWS. Controlling for unobserved effects using the RE estimator or correcting for within-cluster correlation using HWS was not possible (perhaps not appropriate) for the second-stage manure model due to a large number of clusters with single observation. Thus, the second stage manure model was estimated using least squares estimator. We tested for heteroscedasticity using the Breusch & Pagan (1979) and Cook & Weisberg (1983) tests and found that homoscedasticity was rejected. Similarly, the null hypothesis for the normality of the error terms using Skewness and Kurtosis tests as well as the Shapiro-Wilk and Shapiro-Francia tests (Gould and Rogers 1991; Gould 1991) was also rejected. Thus, to test the robustness of the least squares estimator to alternative specifications, we estimated the second stage manure model using LAD estimator (median regression)[37], which relaxes the normality and homscedasticity assumptions.

For the first-stage chemical fertilizer model, a likelihood-ratio test for household random-effect estimator could not be rejected. Similarly, a test of model correctness using the Breusch

[35] The variables dependency ratio (*conswork*), value of oxen and non-oxen animal assets (*animac*), off-farm income (*ofa99c*), and area irrigated in the past dry-season (*irlandc*) are not direct materials in input and output decisions.

[36] See chapter five for model specification and application of the random effect estimator on censored models for manure, chemical fertilizer and other inputs.

and Pagan (1980) could not reject the null hypothesis in favour of the household random effects estimator for the second-stage chemical fertilizer model.[38] A test of heteroscedasticity after RE-estimator is difficult to obtain, but we tested for it using the above method on OLS residuals and we found that homscedasticity was rejected. [39] Thus, to check the robustness of the results from the RE estimator, we estimated the model using the LAD estimator.

Village level unobserved effects were controlled using village dummy variables. Alternatively, when the use of village dummy created estimation problems due to small sample size (for instance in the second stage manure model), we used sub-regional dummys (sr), which may also control for variations in agro-climatic, market integration, and other variables that may affect factor demand decisions and output. We also used observed village level peer variables as proxy variables for village level fixed effects. Such variables include village characteristics in terms of number of households in a village relative to total sample average (*relapop*), average village farm holding relative to total sample average farm holding (*vlavland*), and village distance from nearest market town (*marketd*). [40]

As we can see also from the formulation of the econometric models above, the variables natural manure and fertilizer are endogenous to the system. Disregarding this endogeneity is violating one of the basic assumptions for consistent and efficient estimates of the parameters. With endogeneity uncontrolled for in the land productivity model, we have $\mathrm{E}(m_i e_i) \neq 0$ and $\mathrm{E}(v_i e_i) \neq 0$. However, hausman test of endogeneity of the observed demand for chemical fertilizer and animal manure in the land productivity model was rejected.[41] We, therefore, used the observed values of chemical fertilizer and animal manure in the land productivity model.

We tested for heteroscedasticity and normality[42] of the error terms in the land productivity model using the methods that we used for the second-stage input models and we found significant

[37] See chapter four for specification of a LAD estimator.

[38] It is not necessary to test for normality of the error after random-effect estimation, since the random-effects estimator is justified on asymptotic grounds and thus the parameter estimates will be asymptotically normal regardless of whether the errors are normal.

[39] The test was on OLS results without adjusting for within-cluster correlation, since a test of heteroscedasticity is irrelevant after controlling for within –cluster correlation. Hetroskedasticity test was difficult after random effect estimator due to large number of households (panels)

[40] See Wooldridge (2002) for discussion on the use of cluster sample and peer variables in linear unobserved effects models.

[41] This result was further scrutinized by estimating the land productivity model with instrumental variable regression using the Two Stage Least Squares (2SLS). We found no significant difference between the OLS and 2SLS estimates of the coefficients and the standard errors. From all the possible linear combinations of instruments for the endogenous variable in the system, the method of 2SLS chooses that which is most highly correlated with the endogenous variable. This method is superior to carrying out the two-step explicitly because it produces correct standard errors (Wooldridge, 2002).

[42] A test of normality may not be needed after RE estimator, since parameter estimates are asymptotically normal regardless of whether the error terms are normal. Nevertheless, we conducted normality test and found that

departure from homscedasticity and normality. Thus, as in the input models, we estimated the land productivity model using LAD estimator to test the robustness of the results from the RE-estimator to alternative specification.

We argued in chapter four that the choice of contract for plots rented in or rented out is endogenous and that controlling for tenancy effects using the observed contract choices in the models to be estimated might lead to inconsistency of parameter estimates if we do not control for the implied simultaneity. However, there are some practical difficulties in trying to control for endogeneity in our case. Firstly, it is not appropriate to test for exogeneity of a particular contract type in a pooled plot-level data setting; the sample data for estimating the input demand and the land productivity functions includes households that are different in terms of their position in the land rental market. It may be possible to test for endogeneity of the contracted plots for the landlord and the tenant households, separately. But, obviously, we cannot use the predicted tenure values in the models using the full sample simply due to mismatch in the number of observations. Secondly, the tenure status of own plots can be considered as exogenous in all the models since access to these plots was predetermined based on membership to a village community, which is the same for all households, regardless of their position in the land rental market. In this particular context, therefore, it is impossible to control for potential endogeneity. One may, however, argue that decisions regarding contract choice are made prior to input decisions and, therefore, tenancy dummys might be considered exogenous in all the models.[43] In any case, it may be important to interpret results with this in mind. As also discussed in chapter five of this dissertation, we may, be able to minimize the problem by considering estimation methods that control for unobserved household effects such as household random and fixed effect estimators.

Although we did not introduce cropping choice in our theoretical model, our data set is for multiple crops. The response of input use and output might vary across crops and, therefore, it is important to introduce cropping dummies to control for this variation. We recognize that cropping decision might as well be potentially endogenous in all the models. However, there are some reasons that made us believe that this might not be the case in our setting. First, the general cropping pattern in the selected sub-regions have been stable for a long-time and seem to be

normality was rejected. Non-normality was reduced after log transformations and squaring of some of some variables, but it could not be eliminated. We suspected that the cropping dummys might be responsible for non-normality and perhaps heteroscedasticity and thus we run a model without the cropping dummys and found that normality was restored and homscedasticity (using OLS residuals) could not be rejected. However, we choose to keep the cropping dummys in the model in order to avoid the problem of bias in parameter estimate due to omission of variable

[43] It should also be noted that the instruments for predicting the potentially endogenous variables are already in the input and output models, which may imply that endogeneity is partly controlled.

dictated by agro-climatic conditions.[44] So having cropping dummies in the models is not a major problem as far as consistency is concerned; dropping them may, however, cause, model specifications problem that arise due to omitted variables bias.

4.3: Hypotheses (H)

Based on the theoretical model that we developed earlier, the following hypotheses are formulated.

H1: Since animal manure is considered an investment, we hypothesize that the probability of manure application decreases with the risk of loosing a particular plot, π_i, through contract termination. In particular, we hypothesize that short-term plots (*length3*) are less likely to be manured as compared to medium-term plots (*length2*) and even much less likely to be manured as compared to long-term (*length1*) plots.

H2: The probability of chemical fertilizer application is not affected by *length* of tenure. This comes out of the assumption that the costs and benefits of chemical fertilizer application occur in the short run. However, it is possible that both the probability and the intensity of chemical fertilizer application to increase on short-term plots if chemical fertilizer is a substitute for animal manure ($q_{vm} < 0$). [45]

H3: If long-term plots are more likely to be manured than short-term plots, we hypothesize that land productivity responds positively to tenure security. This hypothesis depends on the assumption that land productivity responds positively to manure application. However, the link between tenure security and land productivity in this respect would be indirect.

H4: When markets are imperfect, input decisions and output results are not independent of household human, physical, and financial characteristics. We control for a host of household characteristics, but it is difficult to hypothesize on how each of these factors affects household behaviour. However, few expectations can be argued for.

H4.1: To the extent that the capital market is imperfect and the household is capital constrained, factors that enhance household access to working capital function as financial intermediaries and thus may affect input applications positively. Such variables include value of animal assets (*animac*), incomes from off-farm wage labour (ofa99c)[46], self-employment (*bizd*)

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[44] The stability in cropping decisions may also be an indication of market imperfection to which households respond by trying to produce all the crops they need for consumption to reduce dependency on the market.

[45] Things might, however, get complicated if we consider the cross-price effect with each of the chemical fertilizer types: DAP and Urea, or more generally when there are multiple inputs.

[46] In our regression analysis, off-farm income in the year of study (*ofainc00*) was instrumented by off-farm income from 1999 (*ofainc99*) since the former is endogenous; The correlation between the two was found to

remittances (*remitd*), and irrigation in the dry season (*irlandc*)[47]. On the other hand, participation in off-farm wage work and self-employment might affect agricultural production negatively if it takes family labour away from farming activities (Stark 1991; Taylor *et. al*. 2000). For instance, participation in self-employment and off-farm wage labour may affect the use of animal manure negatively, since such activities are likely to compete with manure application for scarce labour, given that manure application is labour intensive. Similarly, remittance incomes may also create disincentive to work. The net effects of off-farm, self-employment, and remittance incomes may, therefore, be ambiguous, since they depend on the relative magnitude of these opposing effects.

H4.2: We may also expect both the probability and intensity of fertilizer use to increase with participation in integrated farming programs (*ifpartd*)[48], which makes fertilizer available on credit basis. Similarly, direct access to cash credit (*creditd*), although we observed very few cases in our study area, may also have the effect of increasing input use. Access to credit may have the effect of reducing the imperfections in the capital and risk markets and consequently the demand for fertilizer might be independent of household wealth and working capital relaxing inputs that we discussed earlier. The probability of chemical fertilizer application may also increase with the provision of extension services (*extseed*).

H4.3: Animal manure is an imperfectly traded input, as the market for it is not well developed. Thus, both the incidence and intensity of manure application might depend on availability, which in turn depends on ownership of animal assets such as oxen (*oxen*) and other non-oxen animals (*animalva*). Similarly, considering the bulkiness of animal manure, distance and access to transportation facilities might affect manure application. Thus, we might expect manure application to be less likely on distant plots (*plotdist*). By the same token, households employing trucks (*mtranst1*) and horse-drawn cart (*mtranst2*) might apply more manure than those who use less efficient modes of transporting animal manure such as donkeys (*mtranst3*).

H4.4: If the labour market is imperfect, input use decisions and land productivity outcomes may not be independent of household characteristics in terms of human capital. Given the labour intensive nature of manure application, we may expect both the incidence and intensity of manure application to increase with household endowment in labour. Similarly, land productivity may be expected to increase with household labour endowment in adult labour force However, since male (*madu00*) and female (*fadu00*) labour may not be perfect substitutes in an

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be high.

[47] Households who irrigate in the dry season might also be more efficient than non-irrigating households because of the better demand and supply information they may have by virtue of their higher participation in factor and output market than non-irrigating households.

agricultural setting, it is possible that their effect on input use and land productivity would also be different. In societies like Eritrea, where, for instance, certain agricultural activities are done only by male labour or where male heads of households have certain managerial advantages, we may expect manure application to be more likely (hence higher land productivity) in male-headed households (*hhsex*) and households with more male labour. The effect of male versus female labour on chemical fertilizer application is more complex. However, to the extent that chemical fertilizer is a substitute for animal manure and given that it requires less labour to apply than animal manure, female-headed households might be more likely to apply chemical fertilizer as opposed to animal manure.

H4.5: The most common finding on the relationship between farm size and land productivity is that it is inversely related (Sen 1975; Berry and Cline 1979; Bhalla 1979; Cornia 1985). Controlling for quality and other plot characteristics, the negative relationship might get weaker (Bhalla and Roy 1988 and Udry 1996), although inverse relationship was still observed even after controlling for household- or plot-specific effects (Burgess 1997; Heltberg 1998). Large farms (*relativ*[49]) might be more diversified than small farms or their bigger size might imply higher wealth, which may increase the probability and intensity of application of both chemical fertilizer and animal manure in a setting where the capital market is imperfect. Thus, input use and output may increase with relative farm size even after controlling for plot quality. However, it should be noted that farm size in our context is rarely a consolidated holding; the typical farm is fragmented into 3-5 plots (average for the sample). We try to control for fragmentation (*frag2*) [50] effect on the land productivity model, but the direction of effect of fragmentation is an empirical issue.

H4.6: Holden *et al.* (1998) investigated the discount rates of poor rural households in Indonesia, Zambia, and Ethiopia and reported that wealthier households have lower discount rates than poorer household, which was also consistent with the findings by Pender and Walker (1990) and Hagos and Holden (2002). The implication is that, variables such as animal assets (*animac*) and incomes from irrigation (*irlandc*) off-farm wage work (*offa99c*), self-employment (*bizd*), and remittances (*remitd*) might be used as proxies for the unobserved shadow discount rate. Thus to

[48] Participation is usually decided at village or sub-regional level and that this variable is exogenous to the demand models.

[49] Following Holden and Yohannes (2002), we define relative farm size (*relativ*) as the ratio of area owned (*landow*) to average area owned for the village.

[50] Following Bellon and Taylor, (1993), land fragmentation in our case is measured by the number of owned parcels per unit of land: we divided total number of owned parcels (*aparcels*) by total area owned (*landow*) area it shows the extent to which a unit of land is dispersed (*Tsimdi*).

the extent that wealth is inversely related to discount rate, we expect investment in animal manure and chemical fertilizer to increase with these variables.

H5: Input use decisions and output outcomes might also depend on whether plots are irrigated or not. Since land productivity is responsive to fertilizer application under conditions of good water supply (or rainfall), irrigated plots (*irigated*) might be more likely to be fertilized with chemical fertilizer and perhaps animal manure. Similarly, they may receive more chemical fertilizer and animal manure than non-irigated plots. A positive effect of irrigation on fertilizer use might be used as evidence on the general hypothesis that fertilizer application might be constrained by weather risk. We also control for the effects of other risk factors such as rainfall condition in year 2000 (*rain00d*) and occurrence of storm and/or flood **(***Stormfld*) at plot level in the land productivity model. [51] The expected effect of these risk factors on land productivity is positive for the former and negative for the latter.

5. Results and Discussion

5.1: The probabilities of animal manure and chemical fertilizer application

The regression results for the probabilities of animal manure and chemical fertilizer application are reported in Table 4. The table shows that application of animal manure was less likely on short-term plots (*length3*) as compared to medium term (*length2*) and long-term (*length1*) plots. The table (last column) also shows a change of tenure duration from long-tenure to a short-tenure reduces the probability of animal manure application by 4 percent. The probability of applying chemical fertilizer was not, however, affected significantly by tenure length. We found no significant downward bias in the probability of chemical fertilizer on *length2* or *length3 plots* as compared to *length1* plots, although the sign effect appeared to be negative. These results are consistent with our hypotheses that the shorter the tenure length the lower the probability of manure application **(H1)**, but tenure length does not affect the decision to apply chemical fertilizer **(H2)**. The negative but statistically weak effect of *length2* plots on manure application may also suggests that medium-tenure might provide sufficient time to recoup the benefits of investing in animal manure. Short-tenure imply that the farmer was uncertain whether he/she would continue to farm the land until the benefits of the investment in manure is captured completely. This uncertainty undermined the incentive to apply manure on short-tenure plots. These results not only validate our theoretical expectations but also they are consistent with previous empirical findings in other contexts (Gavian and Fafchamps 1996 in Niger; and Hayes *et*

[51] These risk variables are used only in the land productivity model since they are realized after input decisions are made.

al. 1997; Holden and Yohannes, 2002 in Ethiopia; Gavian and Ehuin 1999 in Ethiopia; Li *et al.* 1998 in China; Jacoby *et al*. 2002 in China).

Larger farms (*relative*) are more likely (less likely) to apply animal manure (chemical fertilizer), indicating perhaps the relative ability of large farms to accumulate animal manure and to use it as a substitute for chemical fertilizer **(H4.5).** To the extent that relative farm size can be used as proxy for wealth, relative farm size might also be capturing the effect of discount rate on investment, since wealth is inversely related to discount rate **(H4.6).** Farmers are more likely to apply chemical fertilizer and animal manure on larger plots (*plotsize*), although the result is significant only for the former.

Older household heads (*hhage*) are less likely to apply fertilizer, which might indicate lack of orientation to and information about modern technologies, as older people tend to be less educated. But controlling for age, household heads with longer farm experience (*hhfamex*) were more likely to use chemical fertilizer, highlighting perhaps the role of farm skills on fertilizer adoption. Household with more female labour (*fadu00*) were more likely to use chemical fertilizer, perhaps indicating that chemical fertilizer is a complementary input to female labour rather than a substitute.[52]

As expected **(H4.2),** households who participate in integrated farming systems (*Ifpartd*) and have received extension services (*extseed*) were more likely to use chemical fertilizer than those who do not. This may be taken as evidence for the role of credit programs and extension services on adoption of chemical fertilizer.

As expected **(H4.3),** the likelihood of manure application increased with ownership of oxen (*oxen*) and value of animal assets (*animalva*), indicating that the manure market is imperfect. Imperfection in the manure market implies that only households with animal assets are able to apply manure. Similarly, the probability of manure application decreased with plot distance from homestead. These results are cconsistent with the finding by Gavian and Fafchamps (1996) in Niger and Jacoby *et al.* (2002) in China.[53]

As expected **(H4.4)** Male-headed households (*hhsex*) are more likely to apply manure than female-headed households, perhaps indicating imperfection in the labour market. A related result is that the likelihood of manure application decreased with female workers, which, apart from labour market imperfection, could also arise due to the tendency for women to use animal manure

[52] Since fertilizer application leads to increased demand for weeding, harvesting, and other activities that are done mainly by women in our context, having more female workers might encourage the household to apply fertilizer more intensively.

[53] The positive effect of animal assets on manure application may also suggest some integration of crop and animal production.

as a substitute for fuel wood (to reduce female labour requirement for collecting firewood) instead of applying it on fields. Together with the gender result, it may also suggest that male labour is needed to deal with the hard work required to load to, transport to, and spread manure on fields.

The likelihood of manure application decreased with level of education of household head (*hhedu*), incomes form off-farm wage labour (*ofainc99),* self-employment *(bizd), and* remittances *(remitd).* This is consistent with our expectation **(H4.1)** that manure application is such a time consuming and hard work task that households faced with more rewarding use of their labour time are not willing to do it.

5.2: Intensity of Animal Manure and Chemical Fertilizer Use

Tables 5 and 6 report estimation results for the second stage animal manure and chemical fertilizer application. Both the OLS and the LAD estimators in Table 5 show no significant variation of manure application between short-term (*length3*) and long-term (*length1*) plots (with a positive sign effect for the former), but the LAD result show that medium term plots have received more animal manure than long-term plots. These results are in contrast to what we found above in terms of the probability of manure application. It suggests that once the decision to apply manure is taken, tenure insecurity might be a reason for higher application of animal manure on both short and medium-term plots. The farmer might hope to ensure the continuity of the land contract with the landlord by investing more, which gives the landlord both economic and moral reasons to allow the continuity of the contract. Or it may be because, although short-term plots are renewed annually, the expectation of the farmer, given his past experience or some other unobserved factors, might be that the contract was likely to be renewed. For instance, we found that more than half of the short-term plots on which manure was applied were irrigated. Irrigated plots are located close to irrigation water source, which is typically owned by the tenant farmer. Given that the landlord's choice of other tenant's is constrained by distance or by general scarcity of irrigation water, the probability of contract renewal for the tenant might be reasonably high as to create the incentive to invest. The implication is that the tenant is secured enough on such plots, strengthening our earlier results that manure application was more likely on more secured plots as opposed to less secured plots.

Regression results using the RE and LAD estimators in Table 6 show that short-term plots have received significantly higher amount of chemical fertilizer as compared to both medium and long-term plots. Using the result from the RE estimator, chemical fertilizer application on short-term plots was 20 percent higher than on log-term plots. There was no systematic difference in fertilizer application between long-term and short-term plots. The implied larger use of chemical fertilizer on short-term relative to medium-term plots may indicate that chemical fertilizer was used as a substitute for animal manure. That is, tenure insecure farmers may shift to more intensive application of short-term inputs like chemical fertilizer as a substitute for the long-term input, animal manure. The result is consistent with our theoretical prediction that application of chemical fertilizer might increase with tenure insecurity if it is a substitute for animal manure **(H2)**. Alternatively, higher use of fertilizer on short-length plots could be related to tenant's interest for contract renewal. Tenants who are interested about their future utility might use chemical fertilizer more intensively on plots with short-term contract than on plots with longer length contracts hopping that this would enhance their chance of having the contract renewed.

Large farms (*relativ*) have applied more animal manure (only in OLS) and chemical fertilizer.[54] As expected **(H4.5)**, this might be capturing the effect of wealth on input use and investment when there is imperfection in the capital market. Or it may also be capturing the effect of risk aversion on input use and investment when the market for risk is missing **(H4.6)**, assuming that risk aversion is inversely related with wealth. The LAD model shows that participation in integrated farming (*ifpartd*) was associated with increased use of chemical fertilizer, confirming again the role of public intervention in alleviating credit market imperfection (**H4.2**).[55]

In both the OLS and the LAD estimators, application of animal manure increased with ownership of animal assets (*animac)*, while it decreased with the use of pack animals (*mtranst3*) relative to the use of horse-drawn cart (*mtrans2*) and tracks (*mtranst1*) for transporting manure to the fields. These results confirm the hypothesis of imperfection in manure and perhaps in capital market **(H4.3)**, since only the wealthy farmers might afford to use carts and tracks to transport animal manure to fields. Households with access to carts and tracks were able to reduce transportation cost considerably that it was possible for them to obtain manure from sources other than own animal assets.

Both estimators show that plots with supplementary irrigation (*irigated*) have received more chemical fertilizer than those without. This may be taken as confirmation of the hypothesis **(H5)** that weather risk might be a constraint to chemical fertilizer application.

[54] Even though the dependent variable is on per unit of land basis, we controlled for plotsize and we found significant inverse relationship between plot size and intensity of use of both animal manure and chemical fertilizer. Since plot size is measured in traditional ways (*Tsimdi*), a possible mmeasurement error in plot size might result in systematic negative relationship between the dependent variable and the plotsize in which case the *plotsize* variable in our case might be capturing this effect.

[55] On the other hand, the LAD estimator shows that direct access to cash loan (creditd) was associated with decreased use of chemical fertilizer, although the result is weakly significant. We do not have an explanation for this, but nor do we have sufficient observations of cash credit to rely on the result.

Finally, application of chemical fertilizer increased with level of education of household head (*hhedu)* and dependency ratio (*conswork*). While the former might indicate the role of education in increasing the use of chemical fertilizer through its effect on orientation and know how, the latter might be capturing the effect subsistence orientation of farming that households with larger proportion of dependents use chemical fertilizer more intensively in order to produce enough to feed their family.

5.3: The land productivity model

Estimation results of the land productivity model using RE and LAD estimators are reported in Table 7. The results from both estimators show that land productivity responded positively and significantly to application of animal manure and chemical fertilizer, with results being more significant in the RE estimator. Similarly, results from both estimators show that land productivity increased with application of chemical fertilizer. These results are as expected **(H3).** The positive effect of animal manure provides indirect evidence that tenure security affects land productivity positively. At the same time to the extent that chemical fertilizer was a substitute for animal manure, tenure insecurity might cause increase in land productivity by increasing the use of chemical fertilizer. The net effect on productivity depends on comparison of the marginal productivities of the two inputs. Although we have the estimates of marginal effects of the two inputs, comparison is not possible because animal manure is largely non-traded while chemical fertilizer is expressed in value terms. Furthermore, animal manure is an investment with an effect of enhancing not only soil nutrition but also moisture retention capacity of soils, which may in turn induce more use of chemical fertilizer in the longer-term. So it is difficult to see whether security or insecurity is good for land productivity as far as the application of the two inputs are concerned.

In Table 7, we also see that rented plots were in general more productive than own plots. Both the RE and LAD estimators show significantly higher land productivity on plots under cost sharing (*con2*) and pure sharecropping contract (*con3)* than on own-plots (*con1*). Land productivity was also significantly higher (10 percent) on plots under pure sharecropping contract (*Con4*) than under own-plots (only in LAD), but it did not vary systematically between own plots and plots under fixed rent contract (*Con5).* These results indicate that efficiency was generally higher on rented plots than on own plots, but they do not necessarily provide evidence against Marshallian inefficiency. This is because the efficiency comparisons are between own land and rented land in general, regardless of the position of the household in the land rental market. What is referred to as own-plot here is general in the sense that the operator could be either owner-tenant or owner-operator[56]. A more informative approach would be to make efficiency comparisons across plots of different contract types (including own) that are run by owner-tenants. This is done in chapter five of this dissertation where we also discussed the potential endogeneity of the contract dummys.

After controlling for land quality, we find significant positive effect of farm size (*relatv)* on land productivity.[57] These results are consistent with the findings that the inverse relationship between farm size and land productivity gets weaker after controlling for plot characteristic variables (Bhalla and Roy 1988; Udry 1996). Similarly, land productivity increased with area irrigated in the dry season (*irlandc*). This may be due to the role of incomes from irrigation in relaxing the household's cash constraint, which may indicate capital market imperfections. But it may as well be capturing the effect of superior farm skills and information that irrigating households may have over other farmers due to their better access to information about factor and output markets.[58] In any case, these results are consistent with our hypotheses of capital market imperfections **(H4.5).**

Land productivity was higher for male-headed households, which may be indicative of existence of transaction costs in the labour market preventing the market from equating returns across labour inputs.[59] Land productivity also increased with dependency ratio (*conswork*) at least in the RE-Estimator, perhaps indicating that households with large number of dependents work harder to meet the food requirements of their families, but it may as well indicate the participation of small children in farm activities, contributing to land productivity. Together, these findings can be taken as evidences of labour market imperfection **(H4.4).**

As predicted **(H5)**, land productivity was higher on plots that received supplementary irrigation (*irigated*); land productivity was close to 50 percent higher on plots that received supplementary irrigation (*irigated*) than on plots that did not. Similarly, as expected, land productivity was higher for households that reported medium-good levels of rainfall condition in 2000 (*rain00d*) and it was lower for plots hit by storm/flood (*stormfld*). These two results

[56] Owner-tenant refers to a tenant farmer who also operates his/her own plot besides rented plots, while owner-operator refers to a farmer who operates his/her own plots only (see chapter three for more on this).
[57] It should be noted, however, that farm size in our context is not a consolidated holding.; it is sum of fragmented holdings, as the typical farm in our study area is fragmented.
[58] A separate regression for participation in off-farm wage work has revealed that dry season irrigation affects off-farm work negatively and significantly, suggesting that irrigating households are full-time employed and have higher return on labour on-farm than off-farm.
[59] There was no significant effect of household endowment in male (*madc*) and female (*fadc*) labour on land productivity in both the RE-Estimator1 and the LAD estimator, although the sign effect was positive. However, RE-estimation of the land productivity model without the cropping dummy variables has shown significant positive effect of household male and female labour on land productivity. Apart from labour market imperfection, this may indicate the labour-intensive nature of some crops, as well.

highlight the role of weather risk in explaining variation in land productivity across plots. There were significant differences in land productivity between different crop categories, as well.

6. Summary and Conclusion

The main objective of this paper was to investigate the relationship between tenure security and household resource allocation behaviour in terms of the use of animal manure and chemical fertilizer using sample data from the highlands of Eritrea. Moreover, we planned to analyze the effects of animal manure and chemical fertilizer application on land productivity in order to establish an indirect link between tenure security and land productivity.

Our study showed that the decision to apply manure was strongly affected by the length of tenure over plots; manure application was more likely on plots with longer duration such as own plots and plots under medium-term contracts than on plots contracted for one production season only. Intensity of manure application was not affected by tenure security, implying that that tenure security is an important consideration for the decision to apply manure but not the intensity of manure application, once the decision to apply is made.

There was no significant effect of tenure length on the probability chemical fertilizer application, but short tenure plots have received more chemical fertilizer than long- and medium-term plots. The higher use of chemical fertilizer on short length plots might be the result of, given that chemical fertilizer is a substitute for animal manure, tenure insecurity itself. Tenure insecure farmers might apply more chemical fertilizer to prevent output on short length plots from falling due to low application of animal manure.

The analysis of land productivity has shown that animal manure and chemical fertilizer were important yield increasing inputs. The positive effect of animal manure on land productivity might provide an indirect evidence for the role of tenure security on agricultural performance. However, to the extent that tenure insecurity causes increased use of chemical fertilizer on short length plots, it becomes difficult to see if it is tenure security or insecurity that benefits land productivity most. Tenure insecurity resulting from short duration of contracts might be limiting agricultural performance as far as manure application is concerned. On the other hand tenure insecurity might also be enhancing agricultural performance, as short-term plots have received more chemical fertilizer and productivity was higher on rented plots than on own plots. Comparison of marginal productivities was not possible since animal manure was largely non-traded.

If we depend on the negative effects of tenure insecurity on investment in animal manure to generalize on what might happen to investment on more durable inputs (e.g. structural conservation and planting of tree crops) if the *Wareida* system of land redistribution in *Deissa* continues, we can only predict negative consequences. This is also consistent with the views of the farmers in the study area that farmers refrain from applying manure and/or planting of legumes crops (to fix Nitrogen to the soil) during the year preceding *Wareida* time. The implication is that policies that enhance tenure security by extending duration of tenure are likely to result in increased investment in medium and long-term land improving inputs and hence increased land productivity. However, land productivity appeared to be responsive to short-term productive inputs the use of which was enhanced with tenure insecurity. So the question is to what extent can short-term inputs substitute more durable long-term inputs as far as increase in output is needed. Will there be a benefit from enhancing security by extending the *Wareida* period as proposed in the new Eritrean land policy? Extension of the *Wareida* period is a positive move to improved security that may lead to investment in new cropping patterns and perhaps more durable investments than those considered in this paper. But whether land registration under the new law that may eventually leads to private ownership of land would lead to even higher efficiency gains is an empirical question that needs further research. Our findings suggest that there is a need to reform the *Wareida* system to allow sufficient duration of tenure and to introduce land tenure laws that allow and encourage long-term leasing. It does not suggest that the *Deissa* system should be replaced by title based private ownership of land.

Our analysis has also highlighted the importance of non-tenure determinants of resource allocation and land productivity. There is room for increased land productivity by improving the working of the labour market and enhancing access to credit without even having to change the existing tenure system considerably. However, diminishing returns to these factors in the future may call for increased investment in more durable investments of long-term in nature, which in turn may call for improved access to capital and increased tenure security. An example of investment area is irrigation, which, according to our results above, is more productive (per unit of land and labour basis) than the alternative off-farm activities. If capital continues to be scarce, which is reasonable to assume, there may be a need for adopting a combined strategy of enhancing tenure security and access to credit. To the extent that credit can be supplied through some kind of non-formal arrangement, there may not be a need to develop title-based land market that provides the right of sale and mortgage at low transaction costs, which is what potential suppliers of formal credit may demand.

There is a possibility that the elimination of *Wareida* or the extension of *Wareida* period would produce an army of landless unemployed people in the rural areas. A legitimate concern as it may be, this may not be a realistic scenario in light of the evidences supporting labour market imperfections. Yet, since land availability varies across villages, it may be necessary to approach the issue more cautiously. Some villages are poorly endowed in land that there is a need to develop alternative employment activities alongside land reform measures.

We found no evidence of direct negative effect of land fragmentation on land productivity, but animal manure application was observed to be less likely on distant plots. Furthermore, controlling for plot characteristics including land fragmentation, we found that input application and land productivity is higher on larger farms than on smaller farms. Thus, there may be a need for area consolidation in some situations. The proposal calling for consolidation of holdings in the new land policy is a step in the right direction. But area consolidation through integrated farming schemes need to be reconsidered in light of the potential incentive problems they may create. An extension of *Wareida* period together with policies that enhance better working of the land rental market might be a better way of achieving area consolidation. However, more research is required on this area before practical steps are taken.

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Table 1: Area share of crops by sub-region

Crop type	Sub-region											
	Mendefera		Dibarwa		Gala-Nefhi		Berik		Serejeka		Total	
	Area	%	Area	%	Area	%	Area	%	Area	%	Area	%
Wheat	37.8	0.1	44.28	0.14	3.75	0.1	51.81	0.31	49.3	0.44	186.94	0.44
Barley	58.5	0.1	32.37	0.1	13.92	0.38	94.98	0.58	35.24	0.31	235.02	0.31
MBW	50.1	0.1	101.37	0.32	13.5	0.37	8.5	0.05	1.75	0.02	175.17	0.02
Taff	154	0.3	56.96	0.18	1	0.03	4	0.02	0	0	215.92	0
F.millet	18.5	0	9.75	0.03	0	0.04	2.5	0.02	0.75	0.01	31.5	0.01
Sorghum	19	0	4	0.01	0	0.03	0	0	0	0	23	0
Potato	0	0	0.5	0	0	0	0	0	9.35	0.08	9.85	0.08
Fababean	33.6	0.1	11.03	0.03	1.5	0.04	1.08	0.01	12.67	0.11	59.88	0.11
Chickpea	22	0	16.75	0.05	1.25	0.03	0	0	0.9	0.01	40.89	0.01
Field pea	4.5	0	3	0.01	0	0	0.75	0	0.12	0	8.37	0
G.pea	47	0.1	22.5	0.07	0.25	0.01	0	0	0	0	69.71	0
Lentil	3.2	0	7.5	0.02	0	0	0.25	0	0.13	0	11.12	0
Linseed	2.2	0	0.25	0	0.25	0.01	0.99	0.01	1.8	0.02	5.53	0.02
Fengruk	2.8	0	2.81	0.01	0	0	0	0	0	0	5.56	0
Maize	4	0	3.75	0.01	0	0	0.06	0	1.37	0.01	9.18	0.01
Tomato	0	0	1	0	0.85	0.02	0	0	0	0	1.85	0
Onion	0	0	0.75	0	0	0	0	0	0	0	0.75	0
Garlic	0	0	1	0	0	0	0	0	0	0	1	0
Total area	457.2	1	319.57	1	36.27	1	164.93	1	112.62	1	1090.63	1
Total plots	523		485		62		229		287		1586	

Table 2: Application of animal manure and chemical fertilizer by tenure length

Mean (standard deviation) use of inputs	Long-tenure plots	Medium-tenure plots	Short-tenure plots
Animal Manure (quintals/Tsimdi)			
On total sample	4.53(15.71)	13.42(28.13)	1.20(7.12)
On uncensored sample	38.23(28.28)	59.34(27.83)	26.30(22.20)
Percentage of observations uncensored*	12(32)	22(42)	4(21)
Chemical fertilizer (value/Tsimdi)			
On total sample	36.27(36.21)	34.86(40.14)	32.43(32.46)
On uncensored sample	51.91(32.62)	51.37(39.04)	53.53(32.61)
Percentage of observations uncensored	70(46)	67(46)	60(50)

Notes. Total sample size is 1456. The uncensored sample size refers to positive application of the respective input on each category of tenure length.

Table 3: Variable names, definition, and summary statistics[60]

Variable			Mean	Standard Dev
Name	**Type**	**Definition**		
Yieldv	Cont.	Land productivity: value/ Tsimdi [61]	1046.58	1230.27
fertp	Cont	Chemical fertilizer: Value/Tsimdi [62]	35.40	36.49
manurp	Cont	Animal Manure: quintals/ Tsimdi	4.49	15.87
plotsize	Cont.	Plot size in Tsimdi	0.68	0.51
pquality	Cate.	Plot quality: 1=good, 2=medium, 3=poor [63]	1.77	0.72
pslope	Cate.	Plot slope: 1=flat,2=medium,3=steep	1.28	0.56
psdepth	Cate.	Soil depth: 1=deep,2=medium,3=shallow	1.93	0.72
pstype	Cate.	Soil type: six dummies for seven soil types[64]	2.71	1.78
plotdist	Cont.	Plot distance from homestead, minutes walk	20.20	14.84
Frag2		Number of parcels per unit of area owned	1.68	0.92
irigated	Dum.	Plot received supplementary irrigation:1=yes, 0=n0	0.04	0.18
hhsex	Dum.	Sex of household head: 1=male 0=female	0.73	0.44
hhage	Cont.	Age of household head	52.83	13.98
hhedu	Cont.	Level of education of household head (years)	2.33	2.93
hhfamex	cont	Farm experience of household head (years)	32.33	16.05
Madu00[65]	Cont.	Male labour worker in year 2000	1.36	0.97
madc	Cont.	Ratio of male worker to cultivated land in 2000	0.44	0.52
fadu00	Cont.	Female worker in year 2000	1.47	0.74
fadc	Cont.	Ratio of female worker to cultivated land in 2000	0.53	0.51
conswork	Cont.	Ratio of dependents to workers	1.54	1.48
landow	Cont.	Area of land owned in Tsimdi	3.52	1.49
relativ	Cont.	Area owned relative to village average	1.03	0.20
ofainc99	Cont.	Income from off-farm work in 1999, ,000 Nakfa	0.75	1.91
ofa99c	Cont.	Income from Off-farm work in 1999, ,000 Nakfa/Tsimdi	0.36	1.14
bizd	Dum	Household engagement in non-farm business: 1=yes 0=no	0.10	0.30
Remitd[66]	Dum.	Household receives remittance: 1=yes 0=no	0.15	0.36

[60] The summary given in this table is for 1456 plots that include all plots cultivated by owner-tenants and owner-operators, but only cost-shared plots (*con2)* for landlord households, as we do not have input data for plots that the landlord households rented out on pure sharecropping (*con3-con4*) or fixed- rent (*con5*) basis.

[61] Considering the diversity in cropping, we use the value of output, instead of physical output, as our dependent variable in the land productivity regression. Total value of output is calculated by multiplying physical output for each plot by the market price of output at harvest time. There was no significant variation between the reported prices among sub-regions and thus the most frequently reported price (mode price) was used to value output for each crop. The lack of significant variation in prices is probably due to the proximity of the sub-regions to each other and, more importantly, due to overlapping cropping pattern among some of the sub-regions. The mode prices (per kg) used in valuing output are barley=2.00, wheat=3.00, barley and wheat mix = 2.5, taff=8.5, finger millet=7.00, sorghum=3.00, potato=3.00, fababean=5.00, chickpea=8.00, field pea=4.00, grass pea=4.5, lentils=5, linseed=5.00, Fengruk=9.00 maize=3.5 tomato=3.00, onion=3.00, and garlic=18.

[62] Monetary values of fertilizer is obtained by multiplying DAP and Urea applications in kilograms by their respective prices, which is the same for all farmers.

[63] This is based on traditional classification of land fertility into *Shiebet* (good), *maekelay* (medium), and *rekik* (poor) land.

[64] We have identified seven soil types: clay, loam, clay-loam, *Tsebaria* (kind of red soil which is hard to work), sandy-loam, sandy, and others, which are coded soil1-soil7, respectively.

[65] Male (*madu00*) and female (*fadu00*) workers in year 2000 are those between the age of 15-70 and the age of 15-65, respectively. The difference in eligibility age is due to our observation in the study area that women tend to retire earlier from the agricultural activities than men. Consumer worker ratio (*conswork*) is calculated as, number of dependents (sum of children below 15 and adults of over 70 for men and 65 for women), over the sum of *madu00* and *fadu00*.

[66] The use of dummy variable might be preferable to reported remittance incomes because of possible underestimation or non-reporting of remittance incomes by receiving households. Here, in addition to those

irland	Dum.	Area irrigated during dry season	1.07	1.99
irlandc	Cont.	Area irrigated in the dry season per unit of area operated in the rainy season.	0.26	0.55
creditd	D	Household obtained cash loan	0.11	0.31
ifpartd	Dum.	Participation in integrated farming systems: 1=yes 0=no	0.89	0.32
extseed	D	Household received extension services	0.17	0.38
oxen	cont	Number of oxen	1.48	0.92
oxenc	cont	Number of oxen per cultivated area	0.45	0.42
animalva	Cont.	Total value of animal assets, 000 Nakfa	7.39	11.35
animac	Cont.	Animal asset, 000 Nakfa/ Tsimdi	1.88	3.42
mtranst	Dum	Two dummies for three manure transporting technologies	2.16	0.84
stormfld	Dum.	Plot was hit by storm\flood: 1=yes 0=no	0.03	0.18
Rain00d[67]	Dum	Rainfall in year 2000: 1=good or medium, 0=otherwise	0.66	0.47
cropc	Dum.	Six dummies for seven crop categories[68]	2.65	1.61
Length1	Dum.	Long-term plots	0.78	0.42
Length2	D	Medium-term plots	0.06	0.23
Length3	D	Short-term plots	0.17	0.37
Contract	Dum.	Four dummy variables for five land contract types[69]	1.36	0.77
vlavland	Cont.	Land availability at village level[70]	1.06	0.41
relapop	Cont	Number of farm households in a village relative to sample average	0.99	0.70
marketd	Cont.	Village distance from nearest market town, in Km.	8.52	4.20
sr	Dum.	Four dummies for five sub-regions	2.56	1.51
V	Dum	31 dummys for 32 villages	15.11	9.35
Observations				

who received remittances in year 1999 or year 2000, our dummy variable presumes households who have their adult sons and daughters in Europe, Middle East, or Australia to have received remittance incomes.

[67] The rainfall dummy is household level variable; it is household's perception of the amount and distribution of rain during the season of study.

[68] The crop categories are *cropc1*=wheat, MBW, and barley; *cropc2*=Taff and finger millet; *cropc3*=potato, tomato, onion, and garlic; *cropc4*= sorghum and maize; *cropc5*=fababean, field pea, grass pea, and lentils; *cropc6*=linseed and Fengruk; and *cropc7*= chickpea.

69 The contract types con1-con5 as explained earlier.

[70] Relative farm size refers to average farm size at village level relative to total sample average.

Table 4: The Probabilities of Chemical Fertilizer and Animal Manure Applications

Chemical Fertilizer: RE-Probit Model		**Animal manure: Probit Model**		
Variables[+]	**Coef. (Z-stat)**	**Variables**	**Coef. (Robust Z-stat)**[++]	**DF/DX**[++++]
plotsize	0.291 (1.96)**	plotsize	0.163 (1.59)	0.014
pqual2	0.023 (0.16)	pqual2	0.128 (1.00)	0.011
pqual3	-0.181 (0.80)	pqual3	-0.352 (1.45)	-0.024
slope2	-0.203 (1.16)	slope2	-0.039 (0.19)	-0.003
slope3	-0.404 (1.50)	slope3	-0.241 (0.68)	-0.017
depth2	0.150 (1.06)	depth2	-0.163 (1.25)	-0.014
depth3	0.255 (1.20)	depth3	0.167 (0.80)	0.015
soil2	-0.019 (0.13)	soil2	0.264 (1.42)	0.024
soil3	-0.606 (1.35)	soil3	0.068 (0.10)	0.006
soil4	0.063 (0.29)	soil4	0.017 (0.06)	0.001
soil5	-0.227 (1.00)	soil5	0.516 (2.01)**	0.062
soil6	-0.520 (2.45)**	soil6	0.002 (0.01)	0.000
soil7	0.478 (0.73)	soil7	1.012 (2.05)**	0.186
plotdist	0.002 (0.49)	plotdist	-0.013 (2.30)**	-0.001
irigated	-0.186 (0.62)	irigated	0.618 (2.23)**	0.084
hhsex	0.354 (1.23)	hhsex	0.684 (3.04)***	0.045
hhage	-0.027 (2.13)**	hhage	0.001 (0.11)	0.000
hhedu	-0.016 (0.46)	hhedu	-0.055 (2.25)**	-0.005
hhfamex	0.017 (1.65)*	lnfamex	-0.120 (1.08)	-0.010
madu00	-0.115 (0.92)	madu00	0.047 (0.54)	0.004
fadu00	0.382 (2.76)***	fadu00	-0.236 (2.74)***	-0.020
conswork	0.017 (0.19)	conswork	-0.057 (0.92)	-0.005
relativ	-0.874 (1.93)*	relativ	0.531 (1.86)*	0.045
ofainc99	0.027 (0.55)	ofainc99	-0.088 (2.42)**	-0.007
bizd	-0.158 (0.54)	bizd	-0.624 (2.54)**	-0.035
remitd	0.080 (0.31)	remitd	-0.384 (1.88)*	-0.026
irland	0.032 (0.58)	irland	-0.036 (1.14)	-0.003
creditd	-0.145 (0.51)	creditd	-0.188 (0.84)	-0.014
ifpartd	0.686 (1.90)*			
extseed	0.552 (1.83)*			
oxen	0.112 (0.90)	oxen	0.169 (1.80)*	0.014
animalva	0.009 (0.94)	animalva	0.031 (4.77)***	0.003
cropc2	-0.057 (0.40)	cropc2	0.080 (0.50)	0.007
cropc3	-0.987 (2.58)***	cropc3	2.024 (6.26)***	0.544
cropc4	-1.504 (4.87)***			
cropc5	-1.889 (10.04)***	cropc5	-0.604 (2.51)**	-0.036
cropc6	-2.854 (6.14)***			
cropc7	-2.252 (8.10)***	cropc7	-0.861 (1.84)*	-0.037
Con2	-0.077 (0.32)	con2	-0.406 (1.20)	-0.026
length2	-0.318 (1.24)	length2	-0.313 (1.41)	-0.021
length3	-0.329 (1.64)	length3	-0.675 (2.88)***	-0.039
Constant	1.531 (1.66)*	constant	-1.889 (2.74)***	
Observations	1456	Observations	1363[+++]	
Number of households	297	Number of households	297	
		Pseudo R2	0.38	
Wald chi2(72)	248.69	Wald chi2(67)	674.15	
Prob > chi2	0.0000	Prob > chi2	0.0000	
Log likelihood	-587.04	Log pseudo-likelihood	-308.96	

Likelihood-ratio test of rho=0: chibar2(01) =97.10
Prob >= chibar2 = 0.000

[+] Variables estimated but not reported are 31 village dummys for 32 villages. [++] Standard errors adjusted for clustering on hhcode. [+++] In the animal manure model cropc4=0, cropc6 =0 and v27= predict failure perfectly and that they were dropped and 93 observations not used. [++++] DF/DX ifs for discrete change of dummy variable from 0 to 1. * Significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Determinants of the Intensity of Animal Manure use *(ln(manurp*

Variables[+]	OLS-Estimator Coef. (t-stat)[++]	LAD-Estimator Coef.(BS-stat)[+++]
Ln(plotsize)	-0.563 (6.53)***	-0.550 (4.01)***
soil2	0.021 (0.15)	0.060 (0.33)
soil3	0.230 (0.46)	0.357 (0.73)
soil4	-0.230 (0.94)	-0.577 (1.77)*
soil5	-0.195 (1.00)	-0.410 (1.37)
soil6	0.257 (1.26)	0.168 (0.70)
soil7	-0.649 (1.02)	-0.783 (1.60)
Ln(plotdist)	0.088 (0.91)	-0.007 (0.06)
irigated	0.031 (0.15)	0.039 (0.13)
hhsex	-0.245 (1.36)	-0.133 (0.50)
Ln(madc)	-0.336 (1.18)	-0.099 (0.19)
Ln(fadc)	-0.101 (0.29)	-0.177 (0.39)
relativ	0.494 (1.89)*	0.474 (1.39)
ofa99c	0.079 (1.16)	0.097 (0.90)
irlandc	-0.079 (0.99)	-0.078 (0.76)
oxenc	0.145 (0.78)	0.207 (0.60)
animac	0.021 (2.51)**	0.024 (1.85)*
mtranst2	-0.230 (1.59)	-0.150 (0.73)
mtranst3	-0.790 (5.45)***	-0.700 (2.68)***
length2	0.289 (1.64)	0.246 (1.96)*
length3	0.266 (1.12)	0.117 (0.36)
con2	0.076 (0.24)	-0.098 (0.23)
Constant	2.967 (4.19)***	2.574 (2.87)***
Observations	164	164
Adj R-squared= 0.5704		BS replications
F(29,134)=8.46		2000
Prob > F = 0.0000		
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity		
chi2(1) = 14.45; Prob > chi2 = 0.0001		
Skewness/Kurtosis tests for Normality:		
Pr(Skewness)=.97; Pr(Kurtosis)=.01;		
Joint test: adj chi2(2)=6.33;		
Prob>chi2 =.04		
Shapiro-Wilk W test for normal data		
W = .98; V = 2.52; z= 2.10; Prob>z=.02		

[+] Variables estimated but not reported are four dummys for five sub-regions and three village level peer variables (*vlavland*, *relapop*, and *marketd*). [++] Absolute value of t-statistics in parentheses. [+++]Bootstrap t-statistics in parentheses. * Significant at 10%; ** significant at 5%; *** significant at 1%

Table 6: Determinants of the Intensity of Chemical Fertilizer use (*ln* (*fertp*))

Variables[+]	RE-Estimator Coef. (z-stat)[++]	LAD-Estimator[+++] Coef. (BS-stat)
Ln(plotsize)	-0.485 (14.89)***	-0.484 (9.85)***
pqual2	0.072 (1.83)*	0.057 (1.06)
pqual3	0.050 (0.79)	0.090 (1.14)
slope2	-0.029 (0.63)	-0.032 (0.56)
slope3	-0.038 (0.55)	-0.141 (1.76)*
depth2	-0.039 (0.95)	-0.058 (0.95)
depth3	-0.011 (0.18)	-0.008 (0.12)
soil2	0.005 (0.11)	-0.000 (0.00)
soil3	0.025 (0.19)	0.049 (0.34)
soil4	-0.099 (1.52)	-0.110 (1.30)
soil5	0.013 (0.19)	0.104 (1.24)
soil6	0.054 (0.86)	0.069 (0.88)
soil7	-0.103 (0.53)	0.032 (0.13)
Ln(plotdist)	0.029 (1.05)	0.062 (1.68)*
irigated	0.378 (4.54)***	0.345 (2.75)***
hhsex	0.075 (0.73)	0.100 (0.88)
Ln(hhage)	0.063 (0.36)	0.105 (0.55)
Ln(hhedu)	0.039 (0.91)	0.041 (0.90)
Ln(hhfamex)	0.046 (0.88)	0.043 (0.71)
Ln(madc)	0.026 (0.19)	0.033 (0.23)
Ln(fadc)	0.184 (1.26)	0.327 (2.10)**
conswork	0.055 (1.98)**	0.072 (2.50)**
relativ	0.332 (2.07)**	0.432 (2.26)**
ofa99c	0.029 (1.19)	0.020 (0.71)
bizd	-0.024 (0.24)	-0.078 (0.71)
remitd	-0.075 (0.85)	-0.049 (0.53)
irlandc	0.003 (0.05)	0.015 (0.24)
creditd	-0.154 (1.48)	-0.214 (1.81)*
ifpartd	0.197 (1.45)	0.261 (1.65)*
extseed	0.062 (0.62)	0.089 (0.85)
oxenc	0.075 (0.85)	0.028 (0.27)
animac	-0.011 (0.92)	-0.011 (0.73)
cropc2	0.110 (2.73)***	0.065 (1.26)
cropc3	0.068 (0.76)	0.078 (0.70)
cropc4	-0.357 (3.18)***	-0.531 (2.65)***
cropc5	-0.218 (3.65)***	-0.254 (3.07)***
cropc6	-0.697 (4.41)***	-0.731 (3.02)***
cropc7	-0.542 (4.59)***	-0.510 (2.97)***
length2	0.044 (0.63)	0.052 (0.57)
length3	0.202 (3.52)***	0.289 (2.92)***
con2	-0.206 (2.78)***	-0.300 (2.61)***
Constant	2.511 (3.78)***	0.072 (2.50)**
Observations	989	989
Groups (Clusters)	269	269
	R-sq: overall = 0.4319	BS replications
	Wald chi2(72) = 494.43	2000
	Prob > chi2 = 0.0000	
Breusch and Pagan Lagrangian multiplier test for random effects:		
Test: Var(u) = 0: chi2(1) = 165.30; Prob > chi2 = 0.0000		

[+] Variables estimated but not reported are 31 village dummys for 32 villages
[++] Absolute value of z-statistics in parentheses. [+++] Bootstrap t-statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 7: Determinant of Land Productivity (*ln* (*yieldv*))

Variables	RE-Estimator1+	LAD-Estimator++
	Coef. (Z-stat)	Coef. (BS-stat)
Ln(manurp)	0.098 (6.73)***	0.099 (6.97)***
Ln(fertp)	0.045 (4.95)***	0.042 (4.22)***
Ln(plotsize)	-0.115 (2.82)***	-0.109 (2.39)**
Ln(plotsize)^2	0.088 (3.86)***	0.100 (4.62)***
pqual2	-0.038 (1.06)	-0.057 (1.39)
pqual3	-0.076 (1.33)	-0.085 (1.38)
slope2	-0.037 (0.91)	-0.023 (0.51)
slope3	-0.065 (1.02)	-0.067 (0.86)
depth2	-0.020 (0.54)	-0.015 (0.39)
depth3	0.013 (0.23)	0.001 (0.01)
soil2	0.015 (0.40)	0.034 (0.78)
soil3	0.117 (0.99)	0.093 (0.74)
soil4	-0.038 (0.65)	0.000 (0.01)
soil5	0.098 (1.72)*	0.090 (1.41)
soil6	0.004 (0.07)	0.017 (0.30)
soil7	0.205 (1.04)	-0.174 (0.84)
Ln(plotdist)	-0.013 (0.56)-	-0.005 (0.21)
Frag2	-0.008 (0.30)	-0.012 (0.35)
irigated	0.481 (5.82)***	0.489 (6.37)***
hhsex	0.130 (2.24)**	0.111 (1.80)*
Ln(hhage)	0.073 (0.72)	0.083 (0.78)
Ln(hhedu)	0.029 (1.20)	0.028 (1.06)
Ln(hhfamex)	0.037 (1.26)	0.040 (1.41)
Ln(madc)	0.134 (1.49)	0.127 (1.36)
(Ln(fadc))	0.321 (1.64)	0.351 (1.64)
Ln(fadc)^2	-0.215 (1.67)*	-0.227 (1.52)
conswork	0.027 (1.67)*	0.025 (1.18)
relatv	0.539 (2.65)***	0.571 (2.43)**
ofa99c	0.007 (0.45)	0.009 (0.62)
bizd	0.038 (0.67)	0.026 (0.38)
remitd	0.017 (0.34)	0.031 (0.58)
irlandc	0.154 (4.44)***	0.152 (4.00)***
oxenc	0.029 (0.54)	0.024 (0.42)
animac	0.007 (1.24)	0.008 (1.29)
stormfld	-0.455 (5.65)***	-0.427 (4.75)***
rain00d	0.136 (3.56)***	0.150 (3.55)***
cropc2	-0.643 (16.04)***	-0.638 (12.60)***
cropc3	0.365 (3.87)***	0.364 (3.38)***
cropc4	-0.876 (9.14)***	-0.884 (9.91)***
cropc5	-0.705 (13.96)***	-0.704 (10.86)***
cropc6	-1.034 (8.73)***	-1.066 (7.28)***
cropc7	-0.258 (3.38)***	-0.240 (2.54)**
con2	0.190 (4.03)***	0.182 (3.65)***
con3	0.126 (2.45)**	0.145 (2.91)***
con4	0.211 (1.55)	0.337 (1.76)*
con5	-0.138 (0.99)	-0.090 (0.68)
sr2	-0.029 (0.59)	-0.031 (0.59)
sr3	0.445 (4.83)***	0.439 (4.82)***
sr4	0.194 (2.83)***	0.194 (2.51)**
sr5	0.303 (3.74)***	0.296 (3.13)***

Constant	5.579 (13.75)***	0.025 (1.18)
Observations (clusters)	1429	1429
households	297	297
Overall R2	0.5577	
	Waldchi2(50)=1567.45 Prob > chi2= 0.00	Replications = 2000
Breusch and Pagan Lagrangian multiplier test for random effects: Test: Var(u) = 0; chi2(1) = 41.67; Prob > chi2 = 0.0000		

+Absolute value of z-statistics in parentheses. ++ Bootstrap t-statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

CHAPTER FIVE

Land Contracts and Production Efficiency: Empirical Evidence from the Highlands of Eritrea

Mahari Okbasillassie Tikabo & Prof. Stein T. Holden

Summary

In this paper we set out to investigate if input use and land productivity were systematically lower on rented plots under share tenancy than on own plots using sample data from the highlands of Eritrea. The setting in our study areas is such that land is scarce, people live in close village communities where there is little information asymmetry about the behaviour of contracting parties, most land contracts are short-term, and reputation plays an important role in social interaction. Accordingly, we theorized that this setting provides a condition of self-enforcement of contracts where the potential disincentive effects of output sharing might be counteracted by positive incentives arising from the need to maintain good reputation and continuity of the contract. We argued that reputation and consideration of broader and long-term relationships create the incentive to behave in a way that is socially optimal. As a result, we hypothesized that share tenancy need not result in sub-optimal use of input and sub-optimal output when the value attached to future utility by the contracting parties, particularly by the tenant, is sufficiently high.

Econometric results show that there is no evidence supporting Marshalian inefficiency. We found no systematic downward bias in input use and land productivity on sharecropped plots relative to own plots and plots under alternative contract types. Sharecropping is found to be as efficient as other contract types. Although we found that plots under cost sharing contract received significantly lower amount of four of the five inputs analyzed, land productivity on cost shared plots was found to be no lower than on other contract types. Cost shared plots were found to be as productive as plots under owner-cultivation and alternative contrat types. We also found that owner-operators were less efficient than owner-tenants, which might be due to not only differences in unobserved capacity and ability but also due to the higher transaction costs that the former faced in the land rental market.

1. Introduction

Marshall's (1890) prediction of the inefficiency of share tenancy has opened a door for a wide and unsettled controversy on the choice and efficiency of agricultural land contracts. The directions of theoretical and empirical approached pursued to resolve the controversy are various and are too many to review and grasp in this introduction. For the purpose of this introduction, however, two broad but interrelated lines of inquiry can be identified. The first one has been to directly test if there is input use and output differentials between different land contracts. Empirical evidences on this are mixed, with some polarization between evidences for and against the Marshallian thesis and others providing evidences of both (more on this in the next section). However, there has been little progress in this front in terms of exploring the conditions under which sharecropping can be efficient despite the potential disincentive effect of output sharing.

The second line of inquiry built on the weaknesses of the first and took an issue on why share tenancy prevailed and tended to dominate other contracts in developing agriculture. The focus is on identifying the rationale for share tenancy[1] and the conditions under which it might be efficient, regardless of the potential disincentive effect created by output sharing. Writers on this approach argue that share tenancy may not necessarily lead to inefficiency when (1) the tenant's work effort can be enforced at negligible cost, (2) individual non-cooperative behaviour is identical to the cooperative choice, (3) when contracts are repeated, and (4) when contracts are interlinked with other transactions such as credit, insurance, and marketing of produce (Otsuka *et al.* 1992; Sadoulet *et al.* 1994 and 1997). The last three conditions in particular create a situation where the contract might be self-enforced. By trying to characterize the settings in which land contracts are made, this approach represents a major milestone into explaining efficiency differentials across contract types. Putting studies into context lays the basis for objective comparison of empirical studies for drawing useful theoretical and policy conclusions. The specific ways the above conditions may arise will be discussed in the next section of this chapter.

In this paper, we study the land tenancy market in the highlands of Eritrea with a specific objective of investigating and explaining the effects of land contractual choice on input use intensity and output. Land contract types are of different types in the highland of Eritrea, but the dominant one is share cropping. Unlike the typical principal-agent setting, land rental transactions in the highlands of Eritrea are carried out between landed-households

[1] An excellent review of the literature on the rational for share tenancy is given in Singh (1989) and Otsuka *et al.* (1992). A brief summary of this literature is also given in chapter three of this dissertation.

who have kin and/or close cultural and social ties where trust and reputation play an important role in maintaining good relationships among households. Besides, land in general, and good land in particular, is scarce and that tenants would have to prove their ability and capacity in order to get access to the land rental market (chapter two of this dissertation). We claim that these and many other factors that will be introduced latter provide adequate incentive and indirect enforcement mechanism to insure the efficiency of share tenancy. The situation has a lot of similarities with some of the Asian contexts where agrarian communities with intense social interactions provide the basis for a relatively efficient mechanism of contract enforcement such as the role of reputation, which resulted in efficiency of share tenancy.

In section Two, we present a theoretical and empirical overview of the debate on the efficiency of share tenancy, describe the setting in the highlands of Eritrea, and introduce and discuss the sample data to be used for empirical analysis of the problem. In section three we construct a simple theoretical model based on the insights obtained from the literature review and the conditions defined by the study area. In section four we outline the econometric models, issues and methods, and state the specific hypotheses to be tested. Section five presents and discusses the results of our regression analysis while section six concludes.

2. Review of Literature and the Setting in the Highlands of Eritrea

2.1: Review of literature

The prediction that share-tenancy is inefficient as compared to owner operated and fixed-rent tenancy is based on the presumed incentive problem output sharing entails. Marshall's argument, framed in a principal (landlord) and agent (tenant) setting, was that the tenant gets a fraction of the residual output of his effort and this entails the incentive to supply input levels and work effort that is less than what is socially optimal. This results in sub-optimal output relative to what might be obtained under cooperative behaviour of the contracting parties. The tenet of this argument is that the landlord faces prohibitively high cost of monitoring the tenant's effort. No wonder, therefore, much of the debate that follows Marshall's prediction centered on enforceability of contracts.

Cheung (1969) assumed perfectly enforceable tenant labour. He argued that the landlord sets the contract terms including plot size, the share to the tenant, intensity of input use per unit of land and enforces it effectively with negligible cost. A requirement for enforcement is that the levels of effort and input use by the tenant are observable and verifiable by a third party. This results in the equality of input intensity (including effort) and marginal products across lands that are rented or owned, regardless of the type of contract.

However, Sadoulet *et al.* (2001) argued that if the share contract terms are set by the landlord, it is possible that the tenant might be bearing more risk than is socially optimal even if the contract is share tenancy, which may cause efficiency lose.[2] Moreover, the spatial nature of agricultural production and the difficulty of identifying labour effort from observations of output and man-days due to production uncertainties may make it difficult to enforce labour inputs, although there might be some room for worthwhile monitoring.

Other writers have argued that technological constraints might create a situation where share tenancy might be efficient, even more efficient than owner-operated or fixed-rent tenancy (Rao 1971; Otsuka and Hayami 1988); Hayami and Otsuka 1993). Otsuka and Hayami (1988) and Hayami and Otsuka (1993) argued that, under uncertainty and unenforceable contract, if elasticity of substitution between labour and land is less (greater) than one, sharecropping is less (more) efficient than fixed-rent and owner cultivation, while for elasticity of substitution equal to one, efficiency levels are even across own and rented plots, regardless of the contract type and whether the contract is enforceable or not. In the last condition, tenant's individual behaviour corresponds with what might be achieved under condition of no incentive problem. In general, the more complex and less standardized farm operations are, the more difficult it is for the landlord to monitor tenant's work effort.

In an infinitely repeated contract, an efficient insurance and incentive solution can also be achieved by offering short-term leases with renewal conditional on satisfactory overall performance (Johnson 1950; Rubinstein1979; Radner 1981; Newbery 1975; Bardhan 1984; Hayami & Otsuka 1993). Repeated contracts can also involve rewarding the tenant for efficient work and, in a wider interaction, they may also involve exchange of gifts and support between the landlord and the tenant, particularly in difficult times. The implication is that, in repeated contexts, tenant effort can be increased and thus share-contracts may achieve first best results. However, Sadoulet *et al.* (1997) argued that cooperation of the tenant in this respect is sustainable only when the benefits are sufficient and appropriately shared.

Heady (1947), Eswaran and Kotwal (1985), and Nabi (1986) argued that share tenancy could achieve first best results if input uses are shared between the landlord and the tenant on equal proportion, as this would restore the marginal condition for efficiency. However, cost sharing might be difficult to apply on landlord's managerial inputs and tenant labour effort without having to incur some supervision and monitoring cost. Newbery (1975), Bliss and

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[2] Cheung argued that share tenancy provides risk-sharing arrangement where neither fixed rent nor wage-contract is optimal in risk bearing. However, if contracts are enforceable, Otsuka and Hayami (1988) argued that share tenancy could exist as risk sharing mechanism only when both the landlord and the tenant are risk averse.

Stern (1982), and Jaynes (1984), all cited in Otsuka and Hayami (1992), argued that cost sharing can apply only to inputs that can be monitored and enforced by the landlord at low cost. Furthermore, Braverman and Stiglitz (1986) argued that when the tenants' work effort cannot be monitored, costs and output are not shared on exactly equal proportion. Since the input of either party is not enforceable, there may be a possibility of moral hazard on either side of the parties leading to inefficiency as predicted by Marshallian theory for the tenant. Eswaran and Kotwal (1985) modeled this in a Nash non-cooperative behavioral setting, in which they argued that both the tenant and landlord shirk as long as the share going to either party is between zero and one.

Another possibility, where share tenancy can be efficient, is when the tenant is highly risk averse and behaves according to the safety–first rather than the expected utility theory (Sadoulet *et al.* 1994). Here the tenant self-enforces the contract and thus his/her optimal choice corresponds to that of the social optimum without any monitoring from the landlord.

Finally, interlinking land and labour contracts with other markets such as marketing of output, credit, and insurance can result in efficient share contracts without any monitoring from the landlord (Hayami and Otsuka 1993). Interlinking works in different ways to achieve cooperative behaviour from the tenant. In some cases contracts are linked to land contracts complementarily (Ibid.), in other cases they are deliberately used to change the tenant's incentive structure by, for instance, reducing tenant's risk to mitigate Marshallian inefficiency (Subramanian 1995), and in other situations interlinking takes the form of punishment in other interactions for opportunistic behaviour or cheating on contract (Sadoulet *et al.* 1997).

Empirical evidences on efficiency differentials between contract types are mixed. Support for Marshallian prediction comes from studies conducted in Bangladesh by Zaman (1973), in Bihar, India, by Bell (1977) and in West Bengal, India, by Chattopadhyay (1979), and in India by Shaban (1987). Evidence in support of efficiency of share tenancy are given in studies conducted in different parts of India, Pakistan, and separately in Andhra Pradesh, India, by Rao (1971), in five Indian districts by Chakravarty and Rudra (1973), and in West Bengal and India by Dwivedi and Rudra (1973), in Malaysia by Huang (1975), in Pakistan by Nabi (1986). Studies by Hossain (1977) in Bangladesh and Bliss and Stern (1982) in Palanapur in India have shown mixed results with some supporting Marshallian and others supporting the opposing hypothesis. In Thailand share tenants operating under safety-first considerations and those in a long-term relation of gift exchange with the landlord are found to work at maximum efficiency and were more efficient than owner-operators and standard share tenants (Sadoulet *et al.* 1994). A recent study on the meaning of kinship in sharecropping contracts in the Philippines by Sadoulet *et al.* (1997) reported efficiency (inefficiency) of share tenancy for tenants that have kin (no kin) relationship with landlords.

Shaban (1987) argued that studies that did not find significant Marshallian inefficiency are conducted in contexts of either limited income opportunities where farmers have difficulties in meeting their subsistence needs (e.g. Dwivedi and Rudra 1973; Huang 1975; Nabi 1986; Hossain 1977; Bliss and Stern 1982) or they have not adequately controlled for other factors that may affect input use and productivity, such as land quality and differences in farmers' endowments or abilities. The implication of his argument is that the findings of these studies do not constitute a case against Marshallian inefficiency. Similarly, Otsuka and Hayami (1988) and Hayami and Otsuka (1993) have compared large number of studies including some of the above and concluded that there was no systematic downward bias in input intensity and yield of sharecropped plots. However, they argued that this does not constitute evidence against Marshallian inefficiency; instead it suggests that landlords who adopt share contract are those equipped with a relatively efficient mechanism of contract enforcement such as the role of reputation in agrarian communities where social interactions are intense. In particular, such studies include contracts that are made between family members and/or kin related (Cohen 1993; Sadoulet *et al.* 1997), in patron-client relationships (Hayami and Kikuchi 1990; Bardhan and Rudra 1982), and when contracts can be monitored easily (Nabi 1986). The studies that reported inefficiency of share tenancy (notably that of Bell 1977 and Shaban 1987) are conducted in contexts where the scope of contract choice was institutionally restricted; in India, for instance, landlords gave only short-term leases in order to avoid potential loss of land to the tillers due to the legislation of the land-to-the-tiller legislation and, in Bangladesh, fixed rent tenancy was outlawed and that landlords adopted share tenancy despite the obvious impossibility of monitoring tenants properly (Hayami and Otsuka 1993). Similarly, an analysis of evolution of yields in the Philippines by Otsuka *et al.* (1994) attributed lower yield on sharecropped land to the inability of landlords to evict tenants even if they shirk.

Similar empirical studies are scant in Africa. A study in Tunisia by Laffont and Matoussi (1995) found evidence supporting Marshallian inefficiency on sharecropped plots; efficiency increased with increase in the share of output to the tenant. Gavian and Ehui (1999) using Total Factor productivity (TFP) approach found that TFP was somewhat lower on informally contracted land than own lands.[3] However, the writers did not conduct

[3] The arrangements considered are government allocated land, which is most secure, and informal arrangements that include rented, shared, and borrowed land.

statistical tests of their result by controlling for household and plot level factors that may have caused differences in factor productivity. Using the same data and controlling for differences in village, household, and plot characteristics, Pender and Fafchamps (2000, unpublished), reported no significant differences in input intensity or output value between own and sharecropped fields. Similarly, Holden and Shiferaw (2000) and Holden and Yohannes (2002) reported no significant sign of Marshallian inefficiency between rented and own plots. However, they did not distinguish between different types of rental contracts (e.g. share vs. fixed-rent and cost sharing vs. pure sharecropping)

2.2: The setting in the highlands of Eritrea

Like in many Sub-Saharan African countries, the formal land market is illegal in Eritrea. However, temporary land transfer whereby households enter into tenancy contracts to adjust area cultivated to endowments in factors for which the market is imperfect (examples are oxen, labour, farm skills, and working capital) is widespread and legal (see chapter two). The types of land tenancy contracts practiced include (1) pure sharecropping called *Girat Bilae* whereby the landlord and the tenant contribute land and oxen, respectively, and the tenant bears all the production cost and gets 2/3 or ¾ of the output, (2) a combination of crop and cost sharing called *Girat Fereka* whereby the tenant and the landlord provide oxen and land, respectively, and costs of production are shared equally between them[4], and (3) fixed rent contracts called *Girat Kiray* whereby the landlord provides land and receives cash payment up front as rent and the tenant provides oxen and bears all the cost of production. The first two dominate the tenancy market, which might be due to risk, risk-aversion, and capital market imperfection (see chapter three).

In the context of highland agriculture in Eritrea, there are some aspects of the land rental market that have important implications for efficiency of sharer-tenancy. First, farmers are organized in village communities where every legitimate member has equal access to village farmland and other natural resources. Tenants are members of a village community who, like other members, are entitled to an equal access to the village's farmland. Typically, tenants own excess non-land productive assets as compared to pure owner operators and landlords, creating the rationale for seeking additional land in the tenancy market. By contrast, landlords are those who have excess land relative to their endowment in non-land productive assets, creating a rationale for supplying land in the land rental market. Thus, a

[4] There are cases where households who own an ox each enter this type of contract, although this is not widely observed in our sample.

typical tenant farmer in the Eritrean context is one that operates a combination of own and rented land (owner-tenant) while a landlord is one that rents out his share of land wholly or partly. Tenants are hardly landless and low capacity people to be treated as agents as in the principal-agent setting; they are richer and have higher productive capacity than other group of farmers, which, in the end may have implications for efficiency differentials across plots. At the same time, it is important for the tenant to maintain its productivity capacity in say oxen and animal assets, which are important determinants of access to land in the land rental market (chapter two). In any land contract, the tenant is a full claimant of crop residue, which is a major source of fodder for animals. This might provide the tenant with an added incentive to even work harder on tenanted land than on his/her own plots in order to enhance the likelihood of carrying the contract to the next production season.

The second aspect is that most land rental transactions are conducted between households living in the same community who might be either close relatives or know each other relatively better that the rental transaction is one among many other interactions that they make within the community. The interactions are based on trust and common interest that the costs of non-cooperation, say shirking in production, have far-reaching consequences in terms of jeopardizing other relationships (loss of reputation). As argued by Hayami and Otsuka (1993) and Sadoulet *et al.* (1997), such sense of trust and common interest helps internalize the costs of non-cooperation in production. Thus, in such communities, there is a good reason to believe that a built-in self-enforcing mechanism exists in tenancy contracts.

Thirdly, the agricultural system is basically subsistence oriented and is subject to considerable weather variation leading to instability of yield across seasons and villages. The household's primary concern in this setting is producing adequate supply of food for the household, which may create the incentive to make choices that correspond with the social optimum. This may, however, require an assumption of limited work opportunity for the tenant outside the farm sector (Shaban 1987), in which case it may even be possible for the tenant to achieve higher yield on share cropped plots than on own plots (Huang 1975). Furthermore, land and particularly good quality land is scarce and most rental arrangements are for short-term, subject to renewal conditional on, among others, good behaviour from the tenant. This may encourage the tenant to exert effort that corresponds to the socially optimal strategy.

Fourthly, the fact that agricultural activities are highly synchronic and routine makes shirking or non-cooperative behaviour on either side unlikely, as ones activities are observable and verifiable by farmers working on adjacent fields. Uncooperative behaviour in this setting endangers ones reputation.

The above conditions might lead to cooperative behaviour on both tenant and the landlord without the need to monitor each other's behaviour directly or without incurring major monitoring cost, regardless of the tenancy type. In short, contracts are self-enforced and consequently input use and land productivity differentials between tenanted and owner-cultivated plots might be negligible. In the next section we focus on the reputation element to show theoretically that the widely acclaimed incentive problems of share tenancy might be dominated by reputation effect in such a way that share tenancy is not necessarily inefficient.

2.3: The data

The sample data for this study is collected from a dominantly rain-fed agricultural system of 32 villages in five adjacent sub-regions of the mid-to-highland regions of Eritrea. The distribution of sample villages by region and sub-region is shown in Table 3 of chapter two. The villages selected represent the contrasting characteristics of the five sub-regions in terms of rainfall condition, per capita land availability, access to irrigation, and integration to input and output markets. The rains fall in the months of May-August, with the heaviest and longest being in July and August. However, the distribution is not usually even within and across villages and sub-regions, as was also noted in the sample data for the study area (see Table 1).

The survey was conducted in the months of March-October, 2001 and the data collected is for the year 2000 rain-fed production season. Plot level data was collected for 319 randomly selected households for 1899 plots that they own and\or operate. The numbers of observations used for estimating the input and land productivity equations are 1456 and 1429, respectively.[5]

[5] Of the total number of plots for which data was collected, 1586 were grown to 18 different types of cereal, legumes, vegetable, and other crops while the remaining 313 were not cropped for various reasons (see chapter four of this dissertation). Of the non-cropped plots, 217 were not cultivated for reasons that include fallowing and another 89 were irrigated plots were not put to rain-fed production in the period under study. Further, the landlord did not have information on input use and output on seven plots that were rented-out on fixed-rent basis. Of the cropped plots, there is no input data for 117 plots that were shared\rented out on pure sharecropping basis, as landlord households did not know the exact input level used by the tenant on these plots. Further, we have 12 plots (for six households) for which it was not possible to establish tenure status data by plot. A plot grown with garlic was dropped from the analysis, as the crop is unique in many aspects and it was likely that it may cause bias in the estimations. This gives 1456 plots for which there is complete input data and of this only 1429 observations are used for land productivity analysis, because the output data for 27 plots was found to be non-reliable and thus dropped from the analysis.

The land rental market is relatively active in the study area. Table 1 provides summary statistics by tenancy type for all the variables that are used in the estimation of our input and output models. For analysis purpose, we distinguish among tenant-owners: those who operate both own land (*TTO*) and rented lands under cost sharing (*TC*), pure sharecropping (*TTS*), and fixed rent (*TTF*) contracts; owner-operators: those who operate own land only (TOO); and landlords: those who cultivate own land (*TLO*) and rent out some under cost sharing (*TC*). Table 1 shows that owner cultivation (*TTO*, *TOO*, and *TLO* combined) dominates the tenure system in the study area, but we also have considerable number of cases for the other tenancy types.[6] The observations for rented plots are not by tenant-landlord pair basis and, therefore, characteristics of the other party in a contract are not observed in this sample.

There is not complete information on future duration of contract on plots shared out on pure sharecropping and fixed-rent basis.[7] For the contracts that we have complete input and output data, however, 84 plots were contracted for more than one year, 192 plots were contracted for one production season and the contract for the remaining 49 plots was unspecified and uncertain beyond the contract year for the respondent.[8] Most tenants, however, expressed interest in renewing contracts.

The use of animal draft (*oxen*) is the primary means of plowing land. However, there were 338 plots that were also partly or wholly plowing by tractor. Of this 76 are rented under different types of contracts. Tractor hire was available from private market and from MOA on credit basis (*IFT*) as part of an integrated farming scheme. However, in most cases, where tractor is used, particularly under integrated farming scheme, only the first stage of cultivation is done by tractor and the rest, particularly for sowing, is carried out using animal power.

The sample data shows that chemical fertilizer (Urea and Dap) was also used on 989 plots of which about 85 percent are grown with cereals (see chapter four of this dissertation). Of the total number of plots on which chemical fertilized was applied, 203 were rented under different contract types. The main source of chemical fertilizer is participation in an integrated farming scheme (*ifpartd*) where by farmers obtain Urea and DAP on credit basis.

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[6] The summary statistics given in Table 2 is for area cultivated under different contract types. The distribution of all farmland by contract type is given in Chapter Two.

[7] If land is rented out on pure sharecropping and fixed rent basis, the landlord does not know how much input is used by the tenant. It is only when the sharing arrangement is fifty-fifty for costs and output (other than land and oxen) that both the landlord and the tenant may have information on how much of the various inputs are used. And in both cases the duration of the contract as told by the landlord is either short term or uncertain.

[8] The tenant was not certain of the contract duration beyond the study season.

The sample data also shows that farmers in the study areas apply animal manure (organic fertilizer).[9] Animal manure was applied on 165 plots (99 households), of which 30 were rented under different types of contract. The source of animal manure for most farmers is animal assets, but some farmers have also reported that they actually purchased animal manure.[10] Manure application is time and labour intensive task and it appears that distant plots are not favoured for application.

The use of hired labour was reported for 402 plots (122 households) of which 83 were rented under different tenancy contracts. Hired labour is mainly used for weeding and harvesting tasks, which are short-term in nature hence it did not constitute a contract by itself. Furthermore, because hired labour worked alongside family labour in these types of activities, effort intensity from the worker is observable and that the possibility of moral hazard might be low. This implies that the observed amount spent on hired labour can be taken as a good proxy for effort intensity.

From Table 1, it appears that input intensity and land productivity vary considerably across contract and household types. However, we need to put the data through rigorous statistical analysis by controlling for a host of other variables that may have caused variation in input use and land productivity across contract and household types. Estimating the factor demand and land productivity equations will do this. Table 1 also describes the regressors that are used in our input and output models.

3. Land Contracts and Production Efficiency - Theoretical Model

The purpose of this section is to theorize on the relationship between land contract types and factor demand and land productivity. We will show that the setting in the highlands of Eritrea is such that factor demand and output of sharecropped land is not necessarily as predicted by the Marshalian thesis. From the earlier description of the context in which land transactions take place in the highlands of Eritrea, we shall take an issue in reputation effect to establish conditions under which solutions alternative to the Marshalian thesis might obtain. Loss of reputation due to uncooperative behaviour on the side of the tenant might lead to a situation where the tenant is not able to renew his/her contract in the future. The loss of

[9] Animal manure is applied to enhance soil quality in terms of crop nutrition, soil texture, and moisture retention capacity. Farmers consider animal manure as a longer-term input than fertilizer, as the yield benefit from its application lasts for more than two-three years. Jacoby *et al.* (2002) argue that a single application of organic fertilizer in most sub-tropical and temperate climatic zones can have an effect on the soil for four to five years.

future utility due to bad reputation is higher for a tenant who cares about his future utility than a tenant who does not care.

In the context of our study area, fixed-rent (F), pure sharecropping (S) and a combination of cost and output sharing (C) coexist, with the last two dominating the tenancy market. The domination of sharecropping is the result of risk, risk aversion, poverty, and imperfection in capital market (chapters three). In pure sharecropping the tenant gets a share of output $\alpha_s : 0 < \alpha_s < 1$ and bears all production cost, while the landlord gets a share of output $1-\alpha_s : 0 < 1-\alpha_s < 1$. Under cost sharing the tenant gets a share of output $\alpha_c : 0 < \alpha_c < \alpha_s < 1$ and bears cost of production proportional to output share, while the landlord gets a share of output $1-\alpha_c : 0 < 1-\alpha_c < \alpha_s < 1$ and bears cost of production proportional to output share. In fixed-rent contract the tenant pays P_r amount of rent up-front per unit of land rented in, A^r, in which case $\alpha = \mathbf{1}$, the tenant bears all the costs of production and becomes a full claimant of the residual output.

Below, we introduce maximization behaviour in a dynamic setting to show the effect of reputation on tenant's maximization behaviour. For simplicity we assume that the labour market functions but the oxen, capital, and insurance markets are missing. The tenant is risk averse and maximizes expected utility, U, of income *(Y)* from farm production *(Q)* on own land (A^o) and on rented land *(A^r)* and the probability (γ) of carrying the rental contract through period two to produce $Q^{r\mathbf{2}}$. We assume that $\gamma = \gamma(Q^{r1})$, and $\dfrac{\partial \gamma}{\partial Q^{r1}} > 0$, that is, the likelihood of having the rental contract renewed in period two increase with output from rented land in period one, Q^{r1}.

3.1: A sharecropping and/or a fixed rent tenant

Under the above assumptions, a pure sharecropping or a fixed rent tenant solves

$$\underset{l,m,L,M,O_o,O_r}{Max} \; EU = \mathrm{E}U^1 \left\{ \theta Q^{o1}(A^o, l, m, O^o) + \alpha_s \theta Q^{r1}(A^r, L, M, O^r) - P_r A_r - w(l+L) - P_m(m+M) \right\} +$$

$$\beta \mathrm{E}U^2 \left\{ \gamma(\theta Q^{r1}(A^r, L, M, O)) \alpha_s Q^{r2} \right\} \qquad (1)$$

S.T.

[10] The reported price for one-track load of animal manure is 350 Nakfa (10 Nakfa≈1USD, in year 2000). We would also expect the labour cost of spreading animal manure to be considerable the bulkiness of animal manure.

$$O^{o1} + O^{r1} = \overline{O^1} \qquad \text{and} \qquad O^{o2} + O^{r2} = \overline{O^2} \tag{2}$$

where Q^{o1} is production on own plot in period one, $\beta =$ discount factor given by $\frac{1}{1+\delta(W)}\frac{\partial U}{\partial Y}$ and δ is discount rate expressed as a function of wealth[11] of the tenant W^t; U^t and Q^{it} (with $i = own,\ rented$ and $t = period = 1,2$) are twice differentiable concave utility and production functions with $\frac{\partial U^t}{\partial Y} > 0$ $\frac{\partial^2 U^t}{\partial^2 Y} < 0$ $\frac{\partial Q^{it}}{\partial input} > 0$ and $\frac{\partial^2 Q^{it}}{\partial^2 input} < 0$; θ is weather-related risk factor, which, following Stiglitz (1974) is treated as a multiplicative factor distributed with $E\theta = 1$ and positive finite variance; l and m are labour effort and non-labour variable inputs used on tenant's own plot, $L,$ and M are labour effort and non-labour variable inputs used on rented plots, respectively; O^o and O^r are oxen power used on own and rented plots, respectively; and w and P_m are exogenously given wage and prices of non-labour inputs respectively. The price of output is normalized to one. The first order conditions (FOCs) for maximization for this problem are

$$\frac{EU_Y\theta}{EU_Y}\frac{\partial Q^{it}}{\partial I} = price, \tag{3}$$

where $i = o, r$; $t = 1,2$; $I = l, m, L, M, A^r, O^i$;

$price = w, P_m, P^r, o*$, where $o* =$ shadow price of oxen power

$$\frac{EU_Y^1\theta}{EU_Y^1}\alpha_s\frac{\partial Q^{r1}}{\partial I} + \beta\frac{\partial U_Y^2\theta}{\partial U_Y^2}\frac{\partial\gamma}{\partial Q^{r1}}\frac{\partial Q^{r1}}{\partial I}\alpha_s Q^{r2} = \Pr ice \tag{4}$$

where, $I = L, M, O^r$; $price = w, P_m, o*$

The FOC in equation (3) is with respect to input use (labour, non-labour variable inputs, and oxen) on tenant's own and fixed rent plots. It shows that the marginal conditions for optimal use of input is the same for own plots and plots under fixed-rent contract. That is, the tenant faces the same incentive condition for fixed rent plots as for own plots. Similarly, the FOC in equation (4) is with respect to input use (labour, non-labour variable inputs, and oxen) on sharecropped plots. The first term in equation (4) is familiar, but the second term is new and it is due to reputation effect. The sign of the new term is positive, implying that input and output use may not necessarily be as lower in sharecropped plots than own plots (or fixed-rent plots) as predicted by the Marshalian thesis. If the discount factor, β, is zero, implying that the

[11] In communal societies where non-economic factors are also given high importance, discount rate may depend on a host of variables other than wealth. Such factors might include kin relationships and moral values emanating from religious influences.

tenant does not care about his future utility, the new term disappears and that the Marshalian result $\frac{\partial Q^{r1}}{\partial I^{o}} > \alpha \frac{\partial Q^{r1}}{\partial I^{r}}$ holds. For positive discount factor, however, we have

$$\frac{\mathrm{E}U_Y^1\theta}{\mathrm{E}U_Y^1}\alpha_s \frac{\partial Q^{r1}}{\partial I} + \left(\beta \frac{\mathrm{E}\partial U_Y^2\theta}{\mathrm{E}\partial U_Y^2}\frac{\partial \gamma}{\partial Q^{r1}}\frac{\partial Q^{r1}}{\partial I}\alpha_s Q^{r2}\right) >< \frac{\mathrm{E}U_Y^1\theta}{\mathrm{E}U_Y^1}\frac{\partial Q^{it}}{\partial I^{o}} \tag{5}$$

That is, the larger β gets, the more the tenant is concerned about his future utility and that the more input and effort he puts on to the sharecropped land, compensating a potential loss in efficiency due to output sharing. For sufficiently large β, the tenant might even apply more input on sharecropped plot than on his own plot, making share tenancy more efficient. [12] The wealth dependent discount rate imply that wealthy tenants care more about their reputation as they have low discount rates and for this reason they may be chosen by landlords.

3.2: A cost sharing tenant

The problem of a cost-sharing tenant can be analyzed in more or less the same way as in the above. In the context of our study area, cost sharing is an arrangement where the landlord and the tenant contribute land and oxen, respectively, and they share the costs of labour and non-labour variable inputs and the resulting output equally between themselves. Unlike in the pure sharecropping contract, input decisions in cost sharing are made and implemented jointly. Assuming that variable inputs are perfectly contractible and enforceable, the solution to input use for cost sharing tenant would be $\frac{\mathrm{E}U_Y\theta}{\mathrm{E}U_Y}\frac{\partial Q^{r1}}{\partial I} = \mathrm{Pr}ice$, which is the same condition as for input use and output on own plots or fixed-rent plots. If inputs are not perfectible contractible, however, this result may not hold. [13] We argue that this is not necessarily the case when the reputation element applies both to the landlord and the tenant. The possibility that the tenant (or the landlord) applies inputs less than what he/she agrees to apply under the agreement might be offset by more application of inputs due to his/her concern for future utility. The results for cost sharing tenant apply also equally to the landlord.

[12] The possibility of asset abuse or unwise exploitation of land by the tenant might be more likely with pure sharecropping and fixed-rent contract (Datta et al. 1986; Allen and Lueck 1992; Hayami and Otsuka 1993; Roumasset 1995; Dubois 1999 and 2002). The reputation argument may also be applied in this case to show that asset abuse does not happen in our setting.

[13] Newbery (1975), Bliss and Stern (1982), Jaynes (1984) Braverman and Stiglitz (1986) argued that cost sharing can apply only to inputs that can be monitored and enforced by either agents at low cost. When the work effort of either party cannot be monitored, it cannot be said that costs are shared on exactly equal proportion. In

The satisfaction of the standard marginal conditions for efficiency under cost sharing does not necessarily imply that input levels under cost-sharing are comparable to input levels on owner-cultivated plots or plots that are under pure sharecropping or fixed-rent contracts. Note that in pure sharecropping, owner-cultivation, and fixed-rent contracts, the total cost of production is born by the cultivator. Whereas, cost sharing is a kind of resource pooling arrangement whereby, in addition to observable inputs, the landlord and the tenant may have access to more of each other's resource in which either side may have comparative advantage. Cost sharing may then result in a resource combination that is different from the other arrangements where the cultivator has access to his/her own resources only. A possible implication is that substitutability between inputs might be more possible in cost sharing than in the other contract types, leading to a possible increase or decrease in the use of some inputs. Nevertheless, decrease in the use of some input does not have to result in decrease in output, since it is being substituted by another input.

Cost sharing may lead to a situation where both the landlord and the tenant achieve higher output on the cost shared plot than on their respective plots if they were sufficiently constrained to carry-out own cultivation. On the other hand, it is possible for a landlord to relax his/her capital constraint sufficiently by renting out part of his/her land and do own-cultivation with the rest, implying that input use and productivity on own-cultivated land does not have to necessarily fall below that of rented out land. Yet, when cost sharing is between highly constrained tenant and landlord, cost sharing may not be efficient as compared to pure sharecropping and fixed rent contract.

3.3: Efficiency differentials across household types

In chapter two of this dissertation, we showed that differential access to productive assets coupled with factor market imperfection provided the rationale for the existence of the land rental market. We also postulated that this could lead to differences in efficiency results across household types. Since the productive capacity of owner-tenants is higher than owner-operators and landlords, this implies that they are more efficient than the latter types of households.

Pure owner-operators are also likely to be more productive at the margin since they posses higher production capacity. However, this may not be necessarily the case if, for instance, non-participation in the land rental market due to transaction costs in that and other

general, this may result in the possibility of moral hazard on either side of the parties (double-sided moral hazard) leading to efficiency loses as predicted by Marshalian theory for the tenant.

markets leads to inefficient input mix. Partial renting out of land may help landlords to improve their input mix and achieve a higher level of productivity (at the margin) than owner-operators who are unable to adjust area cultivated via the land rental market. This implies that landlords could be more efficient than owner-operators.

4. Estimation Issues, Methods, and Hypotheses

4.1: Model Specification

The theoretical discussions in section three suggest a reduced form of equation $y^* = y^*(P_m, w, risk,\ risk\ aversion, \delta, tenancy)$, where *y=input, output*, as a base for estimating the input and output equations. Many of the arguments for this equation are not directly observed, however. We do not have direct measures of risk, risk aversion, and discount rates, although, following the discussion on wealth, discount rate, and risk aversion in chapter three, these variables can be approximated using household wealth indicators.[14] The price of chemical fertilizer and tractor cultivation is given for all farmers.[15] The price of animal manure is not observed, since animal manure is generally non-traded, but there is significant variation in its cost, which may be approximated using distance from homestead, mode of transportation[16] and household endowments in terms of labour and animal assets. Unobserved risk and other factors can be controlled using village and sub-regional dummies. The primary concern of this paper is to test the effect of tenancy on input use intensity and land productivity. We do this by estimating five input intensity models and a land productivity model using the following econometric specification.

$$y_p = \beta_o + \beta_p T_p + \beta_p P_p + \beta_h H_h + \beta_f F + e_p$$

where y_p is a vector of dependent variables: ln(*yieldv*: value of output per *Tsimdi*), ln(*seedvp*: value of seed per *Tsimdi*), ln(*fertp*: value of chemical fertilizer per *Tsimdi*), ln(manurp: value of animal manure per *Tsimdi*), ln(hiredp: value of hired labour per *Tsimdi*), and ln(*tracthp*: hours of tractor use per *Tsimdi*) for household h and plot p; T_p is tenancy dummy for the

[14] To the extent that discount rate is inversely related to household wealth (Binswanger 1981; Holden et al. 1998; Holden and Shiferaw 2002; Hagos and Holden 2002), we may use household wealth indicators as proxies for discount rate. Similarly, if risk aversion is inversely related to wealth, household wealth indicators might also be used to approximate risk aversion.

[15] The price was 1.47 Nakfa/kg for DAP and 1.10 Nakfa/kg for Urea. Nakfa is the national currency in Eritrea, equivalent to .10 USD during the period of data collection. The rental rate for tractor service was 90 Nakfa/hour. These prices do not vary across farms. It must be noted that in a censored data setting, prices of these inputs are irrelevant to non-users. Wage rates vary across gender, but again the wage variable is irrelevant for plots on which haired labour was not used.

[16] We do not control for mode of transportation, as it does not apply for non-users in a single equation Tobit model, which we use to estimate our input equations. See chapter Four for the effect of mode of transportation on intensity of positive application of animal manure.

p^{th} plot. P_p and H_h are vectors of plot and household fixed factors, respectively; *F* is unobserved sub-regional or village level factors that may have influenced the dependent variables; $\beta_o, \beta_t, \beta_p, \beta_h, \beta_f$ are parameters to be estimated for the corresponding regressors; and e_p is a vector error component of the models. We have six tenancy dummies given by

- *TTO*= plot is owned and operated by owner-tenant = 1, zero otherwise
- *TC* = plot is operated under 50:50 cost and output sharing contract =1, zero otherwise[17]
- *TTS*= plot is operated by owner-tenant under pure sharecropping contract= 1, zero otherwise
- *TTF*= plot is operated by owner-tenant under fixed rent contract= 1, zero otherwise
- *TOO*= plot is operated by owner-operator = 1, zero otherwise
- *TLO*= plot is operated by landlord = 1, zero otherwise

The tests are carried out using *TTO* (owner-tenants' own plots) as a control variable. The effects of cost sharing (*TC*), pure sharecropping (*TTS*) and fixed rent (*TTF*) on the intensity of input and land productivity test for Marshalian inefficiency, since the tests are basically across plots run by different types of households in terms of their position in the land rental market. Thus, the theoretical discussion in section three will be used to make expectations (hypotheses) on input use and output differentials across these plots. The effect of *TOO* and *TLO* on input use intensity and land productivity test for efficiency differences across household types by participation in the land rental market.

4.2: Relevant estimation issues and methods

There are some econometric issues that arise in relation to our data set. These are. (1) Endogeneity of land rental contract, (2) censoring of input data at zero (seed is an exception), (3) potential correlation of plot level observations within household clusters, and (4) potential simultaneity of input decisions in the sense of Zellner's Seemingly unrelated equations

We argued in chapter three that the choice of contract for plots rented in or rented out is endogenous and, therefore, using the *T* dummies as regressors in all the models to be estimated might lead to inconsistency of parameter estimates if we do not control for the implied simultaneity. However, there are some practical difficulties in trying to control for endogeneity in our case. Firstly, it is not appropriate to test for exogeneity of a particular *T*

[17] The tenancy type TC is formed by combining all cost shared plots, regardless of whether they are reported from owner-tenants or landlords side. Similarly TTS is formed by combining pure sharecropping contracts with 67 and 75 percent share of output to the tenant.

using the full sample, which includes households that are different in terms of their position in the land rental market. Secondly, the *T* dummies for all owner-run plots (*TTO, TOO, and TLO*) can be considered as exogenous in all the models since access to these plots was predetermined based on membership to a village community, which is the same for all households, regardless of their position in the land rental market. Separately, it is possible to test for endogeneity of *TC*, *TTS*, and *TTF* plots for the owner-tenant and landlord households, but, we cannot use the predicted tenure values in the models using the full sample simply due to mismatch in the number of observations. More strongly, however, one may argue that decisions regarding contract choice are made prior to input decisions and, therefore, the tenancy dummies might be considered exogenous for all the models to be estimated.

It should also be noted that, the same instruments that would be used to predict the tenancy dummies (household wealth and plot characteristics variables, see chapter three) are also included as regressors in the estimation of the input and output models. Estimation of the input and output models by controlling for these variables should then reduce the endogeneity of the T dummies. If the *T* dummies are significant in a regression without household variables, but insignificant with household variables, we can say that endogeneity is not a problem after controlling for household fixed variables. If, however, the *T* dummies remain significant even after controlling for household variables, it might mean that there are some unspecified (unobserved) factors that are captured by the *T* dummies. We cannot be sure about the unspecified variables and their correlation with other variables in the model, which implies that caution is needed in the interpretation of results. We may, however, be able to minimize the problem by considering estimation methods that control for unobserved household effects such as random and fixed effect estimators (more on this soon).

Our data set is for multiple crops[18], although we did not introduce cropping choice in our theoretical model. The response of input use and output might vary across crops and, therefore, it is important to introduce cropping to control for this variation. We recognize that cropping decision might potentially be endogenous in all the models. However, there are some reasons that made us believe that this might not be the case in our setting. First, the general cropping pattern in the selected sub-regions have been stable for a long-time and seem to be dictated by agro-climatic conditions.[19] So having cropping in the models is not a major

[18] See chapter Four of this dissertation for details on cropping systems in the study areas.
[19] The stability in cropping decisions may also be an indication of market imperfection to which households respond by trying to produce all the crops they need for consumption to reduce dependency on the market.

problem as far as consistency is concerned; dropping them may, however, cause, model specification problem due to omitted variables bias.

Failure to account for the household-level clustering could lead to wrong standard errors of the estimated coefficients, since the error terms within-cluster could be correlated (Rogers 1993; Williams 2000; Wooldridge 2002). Estimation of our models using household random effects estimator controls for unobserved household level heterogeneity, while at the same time it controls, in part, for within household correlation of the error terms. As we shall discuss soon, random-effects (RE) estimator is based on the assumption that household unobservable factors are drawn from the same normal distribution. Alternatively, where the random effects estimator failed a model specification test, we try to correct for possible clustering effect by using robust cluster variance estimator, since the error terms within household may still be correlated (ibid.).

To control for censoring, we estimate all the censored input intensity equations using a single equation Tobit regression model. An alternative for estimating censored data is to apply Heckman's selection model due to Heckman (1979) or its variations (e.g. Deaton 1997) in order to control for possible selectivity bias that censored data may imply. Application of the Heckman method to our input models is constrained by lack of appropriate instruments to identify the first stage equation. One may also consider applying Zellner's (1962) seemingly unrelated regression model (SUR) assuming that the factor intensity equations are correlated to each other by their disturbance terms, which might be a realistic possibility to consider.[20] Direct estimation of censored system of equations using Maximum Likelihood is difficult due to multiple integrals in the likelihood function, but two stage estimation methods built on the ideals of the Heckman selection model were proposed by Heien and Wessells (1990) and a more consistent two-step method later by Shonkwiler and Yen (1999).[21] However, we could not apply this method on our sample here due to (1) difficulties in identifying appropriate instruments for estimating the criterion equation and (2) it was not possible to control for household level heterogeneity or clustering effect in a SUR setting.

[20] If there is a cross-equation correlation of the error terms, more efficient estimates of the parameters could be obtained by utilizing the information embedded in the correlation across the equations using SUR.

[21] Heien and Wessells (1990) proposed a two-step estimation procedure whereby a selectivity regressor (the standard inverse mills ratio) derived from first stage probit estimation of each equation is used in the estimation of the systems of equations using SUR in the second stage. Shonkwiler and Yen (1999) criticized this approach for lack of consistency in deriving the set of equations to be used for estimating the system of equations and they proposed a more consistent two-stage estimation procedure of censored systems of equations. Application of this procedure in our case was complicated not only because of computational difficulties using Stata, but also the lack of appropriate instruments to identify the criterion equation. Moreover, it was not possible to correct for clustering effect in this approach, as well.

Despite the above problems, SUR might be useful to get some indication on possible correlation of disturbances across input equations in order to decide whether some input decisions can be considered as exogenous to others.[22] In particular, we are interested to see if chemical fertilizer application is affected by use of animal manure and tractor inputs. We tested for independence of residuals obtained from SUR estimates of paired equations of animal manure and chemical fertilizer and tractor hours and chemical fertilizer using the Breusch-Pagan test of diagonallity of the residual matrix.[23] The test result showed that Independence of the residuals of the animal manure model from the residuals in the model for chemical fertilizer could not be rejected. Similarly, independence of the residuals of the tractor hour's model with the models for chemical fertilizer could not be rejected. This might be because the decisions regarding animal manure and tractor application are made well ahead of chemical fertilizer applications. The exogeneity of the observed values of the animal manure and tractor variables in the chemical fertilizer model was also confirmed by a two-step method of testing endogeneity proposed by Smith and Blundell (1986) cited in Wooldridge (2002).[24] We thus used the observed quantities of animal manure applied and tractor hours used as regressors in a Tobit regression of the chemical fertilizer model.

The formulation of censored regression models is generally given by an index function (Green, 1997),

$$y_p^* = \beta' X_p + e_p,$$

$$y_p = \begin{cases} 0 \text{ if } y_p^* \leq 0 \\ y_p^* \text{ if } y_p^* > 0 \end{cases}$$

[22] The fact that some input decisions are made recursively (for instance animal manure application and first stage cultivation using tractor are done long before decisions regarding chemical fertilizer, hired labour and seeding decisions are made) might eliminate cross-equation correlation of error terms arising from simultaneity of decisions, opening the way for separate estimation of the models. Yet error terms across equations might still be correlated due to some unobserved factors that may affect all input decisions simultaneously.

[23] It may not be appropriate to use the residuals from SUR to conduct the test without addressing censoring issue. However, this is not an ideal situation; we are just using it as an indication of possible correlation between residuals. Alternatively, we examined correlation between residuals obtained from separate regression of the models with and without household fixed effects. The indications we got are the same as those from the SUR model. Household fixed-effect using SUR (which might reduce the inconsistency problem due to censoring) was not possible due to matsize limitation in Stata.

[24] The test goes like this: let $u_1 = \beta_1 v_2 + e$, where u_1 and v_2 are jointly normally distributed error terms in chemical fertilizer and animal manure equation and e_1 is independent of v_2 and N $(0, \tau^2)$, $\beta_1 = \text{Cov}(u_1, v_2)$. We plug $\beta_1 v_2 + e$ into the chemical fertilizer equation, obtain estimate of v_2 from OLS estimation of the reduced animal manure equation and use it as regressor in a Tobit model of the chemical fertilizer model. Exogeneity of the observed animal manure variable in the household random effect Tobit chemical fertilizer model is not rejected if $\beta_1 = 0$.

where the subscript p denote observation at plot level, X is a vector of independent variables, β is vector of parameter to be estimated, and e_p the disturbance term. However, what we observe is not the latent variable but instead a censored value where the dependent variable, y_p: $y_p = y_p^*$ *if* y_p^* falls in some range and y_p = some limit value otherwise. For a randomly drawn observation y_p censored at zero, the standard Tobit model is given by

$$E(y_p | X_p, a=0) = \Phi\left(\frac{\beta' X_p}{\sigma}\right)(\beta' X_p + \sigma\lambda_p)$$

where Φ, ϕ are the standard normal cumulative and density functions, respectively; $\lambda = \frac{\phi(\beta' X_p / \sigma)}{\Phi(\beta' X_p / \sigma)}$, and $y_p \sim N[\beta' X_p, \sigma^2]$. Econometrically, we estimate

$$y_p^* = \beta' X_p + u_p$$

$$u_p \mid X_p \sim \text{Normal } (0, \sigma^2)$$

where u_p is the disturbance term and the other variables are as defined before. Estimation is based on maximum likelihood [25]. We control for household level observable factors (due to factor or output market imperfection) and plot and village characteristic that may have influenced input use and output (see below in this section). However, It is possible that there are some unobserved plot-constant heterogeneity, C_i, the effect of which could be looked at from an omitted variable perspective (Wooldridge 2002). In our application this could be some unobserved household characteristic the effect of which on the outcome variable is constant across plots within the household. However, for randomly drawn data, it is reasonable to assume that the effect of such unobserved household features as random draws from the population, along with the outcome and regressor variables (ibid.). The implication is that the unobserved effects are uncorrelated with the plot-constant observable, that is, $Cov(X_p, C_i) = 0$. Therefore, we estimate household random effect Tobit model in order to capture the effects of the unobserved household effects.[26] A random effect Tobit model is given by

[25] The log-likelihood function (L) generating the censored input use data is given by

$$\log L = \sum_{y>0} -\frac{1}{2}\left[\log(2\pi) + \log\sigma^2 + \frac{(y_p - \beta' X_p)^2}{\sigma^2}\right] + \sum_{y_p = o} \log\left[1 - \Phi(\frac{\beta' X_p}{\sigma})\right]$$, which is a mixture

of continuous , $y_p > 0$ and discrete, $y_p \leq 0$ distributions of the dependent variables.

[26] We believe that we have observed all the important X_i variables and the unobserved heterogeneity has no correlation with the observed X_i. Therefore, there is no need to estimate fixed effect model. Besides, estimation of fixed effects in probit and Tobit context is intractable (Green 2000).

$$y_{pi} = \max\left(0, \beta' X_{pi} + v_i + u_{pi}\right)$$, where *i=households*

$$u_{pi} \mid X_{pi} \sim \text{Normal}\,(0, \sigma_u^2)$$

$$v_i \mid X_i \sim \text{Normal}\,(0, \sigma_v^2)$$

$$Var(u_{pi} + v_i) = \sigma^2 = \sigma_u^2 + \sigma_v^2$$

$$Cor(u_{pi} + v_i, u_{pj} + v_i) = \rho = \sigma_u^2 / \sigma^2$$

Random effects Tobit puts the effects of the unobserved into the error term and accounts for the implied serial correlation in the composite error using GLS analysis. We carried a likelihood-ratio test for the null hypothesis that the contribution of the unobserved household level heterogeneity to the overall variance is zero and we rejected the null except for the animal manure and hired labour models. The models for animal manure and hired labour are thus estimated using interval regression, a Tobit variant, which also produces robust standard errors by controlling for household cluster effects directly.

The consistency of maximum likelihood estimator of Tobit model may, however, be questionable if the underlying disturbances are hetroscedastic and are not normally distributed, although there is no way to test for this in Tobit setting. We have no reason to suspect non-normality or heteroscedasticity. However, it may be necessary to test the robustness of the results in Tobit to alternative specifications of the distribution of the disturbance terms. Accordingly, we tried median estimation of the censored models using Powell's (1984) Censored Least Absolute Deviations estimator (CLAD)[27]. The CLAD model is considered to be desirable due to its robustness to conditional heteroskedasticity and distributional misspecification (Powell 1984; Deaton 1997; Chen and Khan 2000). For censored data, the model is given as follows.

$$y = max(0, x'\beta + u)$$

If the distribution of u given x is symmetric about zero, the median *(Med)* of y conditional on x is given by

$$Med(y|x) = max[0, Med(y^*|x)] = max(0, x\beta)$$

The parameter β is then estimated by solving

$$\min_{\beta} \sum_{p=1}^{N} | y_p - \max(0, x_p \beta) |$$

[27] Unlike least-squares regression where the objective is to estimate the mean of the dependent variable, the objective in Least-Absolute Deviation models is to estimate the median of the dependent variable conditional on the values of the independent variable; median regression finds the regression plane that minimizes the sum of the absolute residuals rather than the sum of the squared residuals (Rogers, 1992 and Gould, 1991).

CLAD application was, however, limited to the chemical fertilizer model, as model convergence was not achieved for the other censored models. Even on chemical fertilizer, application of CLAD was possible at some cost such as dropping of regressors with relatively small number of observations (*soil3, cropc4,* and *T5*) and use of sub-regional (of which the dummy for sub-region 3 was also dropped) instead of village dummy. We estimated two specifications of the CLAD model: one using households as primary sampling unit in bootstrapping (CLAD1) and the other using plot observations as primary sampling units in bootstrapping (CLAD2). The former might be more appropriate in our setting, but the latter enhances sampling possibility. So we considered a more stringent significance level (95 percent) for the later than for the former (90 percent).

The seed input and output equations are not censored. To control for unobserved heterogeneity across households, we estimated fixed and random effects models. We tested for the presence of household random effects using the Breusch and Pagan (1980) test for random effects and we could not reject the null hypothesis in favour of the household random effects model for both seed and land productivity. Furthermore, hausman test (hausman, 1978) for household fixed-effect estimator was also rejected for both models. Based on these two results, we conclude that the random effects model is a better choice than the fixed-effect model for estimating the two models.[28] A test of heteroscedasticity in a random-effects estimator is complicated. We, therefore, carried the test of heteroscedasticity using the Cook and Weisberg (1983) tests on OLS residuals just to get an indication of the extent of the problem. We found that heteroscedasticity could not be rejected in both models. Thus, in order to test the robustness of the results of household random-effect models to alternative specification, we estimated the models using Powell's (1984) LAD estimator (median regression), which relaxes the normality and heteroscedasticity assumptions.

We control for unobserved village level fixed effects by using village dummy variables. Village fixed effects could be variations in agro-climatic and risk conditions, resource endowment, market integration, and other variables that may also affect factor demand decisions and land productivity. Alternatively, where the use of village dummy gives no efficiency or consistency gains in parameter estimation, or where it created some estimation problems, we used sub-regional (sr) dummy, which may also control for variations in agro-climatic, market integration, and other variables that may affect factor demand

[28] It is not necessary to test for normality of the error terms in the seed and the land productivity since the random-effects estimator is justified on asymptotic grounds and thus the parameter estimates will be asymptotically normal regardless of whether the errors are normal.

decisions and output. In some cases, we also used observed village level peer variables as a proxy for village level fixed effects. Such variables include village characteristics in terms of number of households in a village relative to total sample average (*relapop*), average village farm holding relative to total sample average farm holding (*vlavland*), and village distance from nearest market town (*marketd*). [29]

4.3. Hypotheses (H)

The following hypotheses are based on the theoretical model in section three above and some of the theoretical and empirical finding in chapter two.

H1: Share tenancy might lead to lower input use land productivity on share cropped land than on owner-operated land or fixed rent land, but tenure insecurity related to contract renewal (reputation in repeated game) might provide tenants with positive incentive to increase land productivity on rented in land. Thus, the disincentive effects of output sharing in the Marshalian sense might be reduced or compensated by positive incentives due to tenant's concern about future utility

H2: We hypothesize further that tenants could apply more resources on rented in land than on own land if the stake involved in loosing a contract due to shirking is sufficiently large. This implies that land productivity is higher on rented in land than on tenant's own land.

H3: Owner-tenants are more efficient than both owner-operators and landlords. This applies to both own land and rented land. This is because owner-tenants posses higher production capacity (specified or unspecified) than landlords and owner-operators. If it is due to the observed capacity variables, the effect of the tenancy dummies on land productivity should become insignificant when these variables are included in estimation. If, however, the t dummies remain significant after controlling also for household variables, it might mean that there are some unspecified (unobserved) factors that are captured by the T dummies.

H4: Pure owner-operators are also likely to be more productive at the margin since they posses higher production capacity than landlords. However, landlords may achieve a more efficient input mix than owner-operators due to their participation in the land rental market. If the former is true, there should not be any efficiency differential after controlling for household fixed factors. If, however, landlords are found to be more efficient than owner-operators after controlling for household fixed factors, it shows that there are unspecified factors, which could be barriers to entry or transaction costs in the land rental market.

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[29] See Wooldridge (2002) for discussion on the use of cluster sample and peer variables in linear unobserved

5. Results and Discussion

Estimation results for all the input use and output models are given in Tables 2-5. First we present the results for the effects of tenancy types (*T*) on input use and later we discuss whether the results conform to our expectations by considering the estimation results from the land productivity model as well. We follow this approach because we think that a true test of Marshalian inefficiency hinges on whether input use behaviour of owner-tenant on his/her plot vis-à-vis the rented plots are also reflected in output results. Similarly, a test of efficiency differential across household types should be made in consideration of both input and output results.

5.1. The input models

Table 2, column 2, reports estimation results of the model for chemical fertilizer using household RE-Tobit and CLAD estimators. The results from the household RE Tobit estimator shows that application of chemical fertilizer was not systematically lower on plots under pure sharecropping (*TTS)* and fixed-rent contracts (*TTF*) than on tenant's own plots (*TTO).* The RE Tobit result for *TTS* is also confirmed in both CLAD1 and CALD2, where we see that there was no significant difference in the intensity of chemical fertilizer use between *TTS* and *TTO* plots. [30] Both the RE and the CLAD estimators show that use of chemical fertilizer was significantly lower on cost shared plots (*TC)* than on *TTO* plots. As we shall argue soon, however, this is not necessarily the result of Marshalian inefficiency. Similarly, owner operators *(TOO)* and landlords operating own-plots *(TLO)* have used significantly lower amount of chemical fertilizer than owner-tenants (*TTO*). We run the chemical fertilizer model without the observed household fixed variables using the RE Tobit estimator and found that the above results remained unchanged. Yet, the results for *TC*, TOO, and TLO could still be due to some other unobserved factors, which suggest that these results should be interpreted with caution.

Estimation results for the tractor use model using household RE Tobit estimator is given in Table 3, column 2. We see that there was no significant difference in intensity of tractor use between tenants' own plot (*TTO*) and plots under pure sharecropping contract and fixed rent contract, but cost shared plots (*TC)* have received significantly lower quantities of tractor inputs than *TTO* plots. Intensity of tractor use was not significantly lower on *TOO* and *TLO* plots. These results remained the same in estimation of the tractor use model without the household variables.

effects models.

Interval regression results for the animal manure model are given in Table 4, column 2. The results show that there was no significant difference in intensity of use of animal manure between tenants' own plot and plots under pure sharecropping contract and fixed-rent contract, but cost shared plots have received significantly lower animal manure than tenants' own plots. Furthermore, animal manure application was significantly lower on *TOO* and *TLO* plots relative to tenants' own plots. The effects of *TC*, *TOO*, and *TLO* became bigger and higher in level of significance in a model without the household variables. This may suggest that what is being captured by of *TC*, *TOO*, and *TLO* variables, after controlling for household variables, might still be the effect of some unobserved variables, such as cross-household differences in capacity or transaction costs faced in the land rental and other markets. Given the results for the RE Tobit estimators of the chemical fertilizer and tractor models with and without the household variables, this change in result may also indicate that RE estimators perform better in controlling unobserved household effects than interval regression models.

We see also from the interval regression results for hired labour in Table 4, column 3, that there was no systematic negative bias in use of hired labour on pure sharecropped plots, but cost shared and fixed rent plots received lower amount of hired labour than *TTO* plots. Use of hired labour on *TOO* and *TLO* plots were not different from *TTO*. These results remained more or less the same in estimation of the model without the household variables.

Table 3, columns 3 and 4, report estimation results for the seed model. Unlike the other input models, the results for the seed model show no mixed results in terms of seed intensity across contract and household types. Both the household RE and the LAD estimators show no systematic negative bias in seed application on all types of contracts. Similarly, there was no systematic negative bias in seed intensity on *TOO* and *TLO* plots.

We see from the above results that plots under pure sharecropping contract were not discriminated against in terms of intensity of use of all the inputs considered. Similarly, except for hired labour, intensity of input use was not systematically lower on fixed rent contract plots. In general, therefore, we can say that the hypotheses of no systematic difference in input use between own plot and plots under pure sharecropping and fixed-rent contract plots is confirmed, although we still have to look if these results also conform with the results for the land productivity model.

The above results also show that input use, except seed, was consistently lower on cost shared plots. But whether this constitutes sub-optimal use of input as predicted by Marshal or whether it is the result of some unobserved factors is something that has to be answered in

[30] The CLAD procedure dropped *TTF*, apparently because of small number of *TTF* observations.

consideration of the results for the land productivity model. That is, systematic decrease in input use on plots under cost sharing might not be taken as indicative of Marshallian inefficiency unless it is also followed by systematic decrease in output. We will pick on this soon when we present the results for the land productivity model.

5.2: The land productivity model

The results for a Cobb-Douglas estimation of the land productivity model using OLS, household RE, and LAD estimators is given in Table 5. The OLS estimates show that, compared to *TTO* plots, land productivity was significantly (10 percent) higher on pure sharecropped plots, but there was no systematic downward bias of land productivity on *TTC* and *TTF* plots. The household RE and the LAD estimators on the other hand, show no significant difference in land productivity between *TTO* and all rented plots. The result that there was no systematic difference in land productivity between *TTO*, *TTS*, and *TTF* plots is consistent with the results from the input models. [31] These results confirm that there is no evidence of Marshallian inefficiency associated with pure sharecropping. Despite the significant decreases in input use, land productivity on cost shared was not lower than tenants' own plots. Therefore, we say that there was no systematic downward bias in input use and land productivity on cost shared plots that could be attributed to Marshalian inefficiency. Our hypothesis that there is no input and output differentials between tenants' own plots and rented plots is generally confirmed. The potential disincentive effects of output sharing are counteracted by other factors that induce cooperative behaviour on both the landlord and the tenant. Besides reputation, such factors could also include the need to secure adequate supply of food in the face of limited opportunities outside the farm sector.

The significant negative bias in input use on cost shared plots could be due to some unobserved factors. Cost sharing is basically a resource pooling arrangement whereby the contracting parties may have the advantage of using their combined family labour and other non-observed inputs (effort and farm skill of either party) as a substitute for inputs like chemical fertilizer, hired labour, and tractor. Overstretched tenants my resort to more intensive use of chemical fertilizer and other inputs on plots they run fully than on cost shared plots as a substitute for other yield-increasing inputs that might be more available under cost-

[31] An exception to this is the significantly lower use of hired labour on *TF* plots. We do not have an explanation for this, but this should not be of much concern since we do not have sufficient observations of *TTF*, anyway. An apparent shortcoming of this study is Small sample size of *TTF* and data censoring, which created a highly uneven distribution of positive input application across tenancy types. The evidences on the effect of contract

sharing than under other contract types. Yet, it would not be unrealistic, for instance, to expect low use of hired labour by cost-sharing households, since pooling of their labour resource would relax the labour constraint. We see in Table 4, for instance, that use of hire labour decreased with household endowment in male and female labour, indicating that labour is hired to relax household labour constraint and that family labour and hired labour are not perfect substitutes. Similar, argument may also apply to tractor use and perhaps chemical fertilizer and animal manure applications. We have not observed the characteristics of the other party in cost-sharing arrangements. But even if we had managed to do so, it would still be difficult to observe the kind of input substitution possibility that this type of contract entails

OLS estimation of the land productivity model also shows that owner-operators (*TOO*) and landlords have achieved significantly lower land productivity than owner-tenants on all their plots. The significant effect observed in the OLS model is confirmed in the household RE and the LAD estimators for owner-operators, but not for landlords. These results are partly as expected. It appeared that the lower use of chemical fertilizer and animal manure by owner-operators and landlords is accompanied by a corresponding decrease in land productivity of owner-operators and landlords (only in OLS). This may be due to some unobserved differences between owner-tenants, owner-operators, and landlords. We run a model without household variables and found that land productivity on landlords' plots decreased significantly in all the estimators, while that of the owner-operators' remained the same. This may suggest that there are some unobserved factors at least for owner-operators. The downward bias in land productivity for owner-operators could be due to transaction costs in the land rental and other markets that they faced relative to owner-tenants and landlords. Transaction costs in the land rental market might cause efficiency loses, since it limits the ability to properly combine and utilize resources. By the same logic, the insignificant decrease in land productivity for landlords (in RE and LAD estimators), after controlling for household variables, might be due to participation in the land rental market, which may have helped them to combine their resources more efficiently than owner-operators.

From the tests that we conducted in the input and land productivity models, we can conclude that the setting in the highlands of Eritrea is such that variations in input use and output across plots are not due to differences in tenancy conditions. Reputation factors together with the need to produce adequate supply of food to the household and the other

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choice on input use and output are, therefore, applicable to tenancy types for which we have relatively sufficient number of observations to enable us draw a conclusion.

factors explained in section two of this paper provide adequate incentive to both the tenant and the landlord to overcome the potential incentive problem that output sharing may entail. This finding is consistent with the findings in some Asian countries that agrarian communities with intense social interactions provide the basis for a relatively efficient mechanism of contract enforcement, which resulted in efficiency of share tenancy (see the literature review section).

Efficiency differentials in our setting was attributed to differences in household characteristics in terms of physical and human resources and access to working capital, and cropping choice. The use of chemical fertilizer and tractor inputs was greatly enhanced by access to credit via integrated farming, highlighting the role of government support programs in reducing market imperfection. This also explains why the household wealth and working capital relaxing inputs were found to have little effect on chemical fertilizer and tractor use, but not in the other inputs. We found significant effect of working capital relaxing factors (*ofa99c* and *bizd*) on the use of hired labour and seed, suggesting imperfection in the market for capital. This was further confirmed in the land productivity model where all the estimators have shown positive and significant effect of relative farm size (*relativ*) animal assets (*animac*) and income from irrigation in the dry season (*irlandc*). It may also be possible that the household wealth factors are capturing the effect of risk aversion.

Plot characteristics in terms of quality, distance from homestead, slope, and irrigation were also found to be important determinants of variation in input use and land productivity. Similarly, risk factors such as variation in weather and incidences of flood and storm were also found to be important determinants of land productivity.

We found that application of chemical fertilizer decreased with animal manure application (only in the household RE estimator), indicating perhaps that these two inputs are substitutes (see chapter four for discussion on this). Both the random effect estimator and the two CLAD estimators have also shown that chemical fertilizer application increased with the intensity of tractor use, indicating perhaps complementary relationship between tillage and chemical fertilizer application; tractor cultivation increases tillage level, which, in turn may enhance the moisture retention capacity of soils that is essential for chemical fertilizer application. Animal manure application increased with household animal assets (*animac*) and relative farm size (*relativ*) and decreased with plot distance from homestead (see chapter four for more on this). Animal manure application decreased with off-farm incomes and self-employment opportunities, and level of education of household head, suggesting that animal manure application was not profitable for households with higher opportunity costs of labour.

Animal manure application was also lower on short-term contract plots than on medium- and long-term plots (see chapter four for more on this).

Finally, intensity of tractor use decreased with oxen ownership, suggesting that tractor was used as a technological alternative to cultivation by oxen-drawn plough. Similarly, intensity of hired labour use decreased with household family labour (male and female), suggesting imperfection in the labour markets. The intensities of hired labour and tractor inputs increased with plot size.

6. Summary and Conclusion

As highlighted in the first two sections of this paper, the debate on efficiency differentials across contract types in general and on efficiency of share tenancy in particular centers around, among others, whether contracts are enforceable or not. Empirical analyses of this subject have provided substantial evidences on the conditions under which share tenancy might be efficient. One such condition is the high possibility of cooperative behaviour among contracting parties living in the same community and having a lot of mutual interaction in addition to land contracts. People living in agrarian communities sharing common cultural values, having kin relationship, and interact on continuous basis are not driven by shortsighted economic interests that may jeopardize their long-term relationships. In agricultural land contract, this kind of setting provides the condition for self-enforcement of contracts, leading to optimal use of inputs with negligible supervision from either of the contracting parties. We theorized in this paper that such conditions exist in the highlands of Eritrea where people are organized in village communities and land transactions are made between people who have either kin relationship or know each other's characteristic relatively well. We argued that reputation and consideration of broader and long-term relationships create the incentive to behave in a way that is socially optimal. As a result, we hypothesized that share tenancy need not result in sub-optimal use of input and output when the value attached to future utility by the contracting parties, particularly by the tenant, is sufficiently high.

Econometric results show no evidence supporting Marshalian inefficiency. We found no systematic downward bias in input use and land productivity on sharecropping contracts relative to owner-operated plots or plots under fixed rent contract. Sharecropping is found to be as efficient as other contract types. Although we found that plots under cost-sharing contract received significantly lower amount of four of the five inputs analyzed, land productivity was not found to be lower on cost shared plots than on other contract types.

Cost-shared plots were found to be as productive as plots under alternative contrat types including owner-cultivation. We, therefore, think that the negative input bias on cost-shared plots might be due to greater possibility of input substitution, particularly labour effort and management, that cost-sharing contracts may entail as compared to alternative contractual arrangements. The pooling of resources in a cost-sharing contract creates a condition where the contracting parties may exploit their comparative advantage in order to achieve better and more efficient use of resources. One possible result in terms of input combination is that contracting parties relied more on their combined labour and management inputs than on purchased inputs. An indication of this possibility was that labour hiring decreased significantly with family labour resources.

We also found that owner tenants are more productive than owner-operators, which could be not only due to unobserved differences in capacity but also due to higher transaction cost that the latter faced in the land rental market. Higher transaction cost implies that owner-operators were not able to adjust area cultivated to non-land resources through participation in the land rental market.

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Table 1: Variable Names, Definition, and Summary Statistics by Tenancy (T) type

Variables			TTO	TC	TTS	TTF	TOO	TLO	Total
Name	**T***	**Definition**	**Mean s.d**	**Mean s.d**	**Mean s.d**	**Mean s.d**	**Mean s.d**	**Mean s.d**	**Mean s.d**
		Endogenous variables							
yieldv	C.	Value (in Nakfa[32]) of output	1126.08	942.58	1137.57	1235.24	1049.65	728.27	1046.58
		divided by plot size[33]	1400.07	841.13	726.96	798.41	1375.62	516.28	1230.57
seedvp	C	Value of seed divided by	176.59	135.69	172.05	116.94	181.74	133.39	169.44
		plotsize	191.45	148.81	135.52	75.14	201.88	93.72	180.51
fertp	C	Value of Urea and Dap	35.78	25.53	42.40	30.16	39.33	20.81	35.40
		divided by plotsize	33.35	31.52	42.42	29.74	39.21	26.00	36.49
manurp	C	Manure, in quintal, divided	6.42	0.72	8.97	2.00	3.87	0.53	4.49
		by plotsize [34]	16.49	4.71	23.59	4.55	16.28	5.62	15.87
tracthp	C	Tractor hours divided by	16.18	8.59	22.51	40.97	15.31	21.46	16.24
		plotsize in Tsimdi	36.02	22.27	40.92	54.52	35.69	64.26	38.51
hiredp	C	Value of hired labour divided	49.27	12.01	58.61	61.70	32.33	28.65	37.68
		by plotsize	101.59	42.78	110.03	115.97	69.57	89.82	85.77
		Exogenous variables							
Plot characteristics									
plotsize	C.	Plot size	0.69	0.73	0.84	1.61	0.62	0.58	0.68
			0.38	0.50	0.87	1.57	0.41	0.31	0.51
pqual	D	Plot quality: 1=good, 2=medium, 3=poor [35]							
slope	D	Plot slope: 1=flat,2=medium,3=steep							
depth	D	Soil depth: 1=deep,2=medium,3=shallow							
Soil	D	Soil type: six dummies for seven soil types [36]							
plotdist	C.	Plot distance from	20.63	17.75	21.50	27.67	19.85	21.27	20.20
		homestead, minutes walk	14.77	11.52	15.79	28.65	14.74	15.85	14.84
irigated	D	Plot received supplementary	0.02	0.08	0.07	0.53	0.01	0.01	0.04
		irrigation: 1=yes, 0=n0	0.16	0.27	0.26	0.52	0.12	0.09	0.18
Household Characteristics in labour									
hhsex	D	Sex of household head:	0.85	0.57	0.89	0.87	0.68	0.52	0.73
		1=male 0=female	0.36	0.50	0.32	0.35	0.47	0.50	0.44
hhage	C.	Age of household head	54.95	49.07	53.74	59.40	52.39	50.39	52.83
			11.86	14.56	10.81	6.00	15.34	15.96	13.98
hhedu	C.	Level of education of	2.62	1.45	2.88	3.93	2.31	1.67	2.33
		household head (years)	3.21	2.39	3.11	3.41	2.85	2.18	2.93
hhfamex	C	Farm experience of	35.23	29.64	33.74	32.87	31.39	28.01	32.33
		household head (years)	14.62	15.97	13.11	12.47	17.45	16.08	16.05
madc	C.	Ratio of male worker to	0.42	0.27	0.43	0.43	0.55	0.24	0.44
		cultivated land in 2000[37]	0.37	0.36	0.35	0.42	0.66	0.41	0.52

32 Total value of output is calculated by multiplying physical output for each plot by the market price of output at harvest time.

33 Plot size is measured in *Tsimdi*~ 0.25ha.

34 Traditionally animal manure is measured in animal-load (donkey), cartload (horse-drawn cart), truckload, sacks, and baskets. On the basis of the discussion with farmers we have established the following equivalents of these measurements. One sack-load ≈ half quintal, one basket-load=. 10 quintal, one animal-load=one quintal, one track-load=40 quintals, one cartload≈10 quintals.

35 This is based on traditional classification of land fertility into *Shiebet* (good), *Maekelay* (medium), and *Rekik* (poor) land. In the regression models estimation is done for medium and poor relative to good quality land. The same also holds for plot slope and depth

36 We have identified seven soil types: clay, loam, clay-loam, *Tsebaria* (kind of red soil which is hard to work), sandy-loam, sandy, and others, which are coded soil1-soil7, respectively. In the regression models the effect of soil type on input use and output is analysed for soil types 2 to seven relative to soil type one each.

fadc	C.	Ratio of female worker to	0.38	0.45	0.35	0.53	0.69	0.66	0.53
		cultivated land in 2000	0.33	0.35	0.27	0.69	0.52	1.00	0.51
conswork	C.	Ratio of dependents to	1.38	1.72	1.44	1.14	1.57	1.94	1.54
		workers	1.26	1.46	1.33	1.47	1.55	1.92	1.48
Farm size, non-farm Incomes, wealth, credit, and extension									
relativ	C.	Relative land availability at	1.05	1.02	1.09	0.92	1.01	1.00	1.03
		household level[38]	0.22	0.24	0.24	0.26	0.17	0.16	0.20
ofa99c	C.	Income from Off-farm work	0.19	0.21	0.12	0.24	0.62	0.28	0.36
		in 1999, ,000 Nakfa/Tsimdi	0.55	0.58	0.42	0.56	1.63	0.78	1.14
bizd	D	Household engagement in	0.09	0.09	0.12	0.07	0.10	0.17	0.10
		non-farm business: 1=yes 0=no	0.28	0.29	0.33	0.26	0.30	0.37	0.30
remitd	D	Household receives	0.13	0.07	0.12	0.33	0.19	0.15	0.15
		remittance: 1=yes 0=no	0.34	0.26	0.33	0.49	0.39	0.36	0.36
irlandc	C.	Area irrigated per unit of area	0.30	0.16	0.37	0.32	0.26	0.15	0.26
		operated	0.55	0.30	0.72	0.27	0.57	0.42	0.55
creditd		If household received credit	0.11	0.11	0.12	0.40	0.11	0.08	0.11
		in cash in year 1999	0.31	0.32	0.33	0.51	0.31	0.27	0.31
oxenc	C	Number of oxen per	0.43	0.29	0.39	0.50	0.56	0.28	0.45
		cultivated area	0.32	0.36	0.29	0.39	0.51	0.28	0.42
animac	C.	Animal asset, 000 Nakfa/	2.03	0.87	2.74	3.03	2.05	0.75	1.88
		Tsimdi	2.18	1.31	2.74	3.08	4.73	1.28	3.42
ifpartd	D	Participation in integrated	0.91	0.82	0.89	1.00	0.92	0.71	0.89
		farming systems (IFS): 1=yes 0=no	0.29	0.39	0.31	0.00	0.27	0.46	0.32
IFT	D	Tractor use from IFS	0.11	0.12	0.06	0.07	0.08	0.12	0.10
			0.32	0.32	0.23	0.26	0.27	0.33	0.29
extseed	D	Household received	0.19	0.17	0.23	0.13	0.12	0.33	0.17
		extension services	0.40	0.37	0.42	0.35	0.32	0.47	0.38
Risk , cropping, and tenure duration variables									
rain00d	D	Rainfall in year 2000:	0.70	0.62	0.80	0.67	0.65	0.44	0.66
		1=good or medium, 0=otherwise	0.46	0.49	0.40	0.49	0.48	0.50	0.47
stormfld	D	Plot is hit by	0.03	0.05	0.00	0.00	0.03	0.10	0.03
		storm\flood:1=yes 0=no	0.16	0.23	0.00	0.00	0.17	0.30	0.18
cgroup	D	Six dummys for seven crop	2.74	2.60	2.71	2.53	2.61	2.54	2.65
		categories[39]	1.73	1.57	1.60	1.88	1.51	1.65	1.61
length3	D	Duration of contract is Short	0.00	0.83	0.62	0.87	0.00	0.00	0.17
		(one year) [40]	0.00	0.38	0.49	0.35	0.00	0.00	0.37
Village and sub-regional fixed variables									
relative	C	Land availability at village					0.98		1.06
		level[41]	1.12	1.06	1.05	1.35	0.41	1.15	0.41
			0.43	0.33	0.46	0.44		0.32	

[37] Male and female workers in year 2000 are those between the age of 15-70 and the age of 15-65, respectively. The difference in eligibility age is due to our observation in the study area that women tend to retire earlier from the agricultural activities than men. Consumer worker ratio (*conswork*) is calculated as, number of dependents (sum of children below 15 and adults of over 70 for men and 65 for women), over the sum of male and female adult workers.

[38] Relative land availability at household level refers household farm size relative to village sample average.

[39] The crop categories are *cropc1*=wheat, HBW, and barley; *cropc2*=Taff and finger millet; *cropc3*=potato, tomato, onion, and garlic; *cropc4*= sorghum and maize; *cropc5*=fababean, field pea, grass pea, and lentils; *cropc6*=linseed and Fengruk; and *cropc7*= chickpea. HBW is a hybrid crop of wheat and barley

40 The tenure durations are 1=*length1* (own-plot) 2=*length2* (rented plot with tenure length over one year 3=*length3* (one season) or uncertain tenure. In the regression we use a dummy variable which takes the value of one tenure duration is length1 and zero otherwise.

[41] Relative farm size refers to average farm size at village level relative to total sample average.

relapop	C	Number of farm households in a village relative to sample average	1.01 0.72	 0.85 0.44	1.20 0.94	0.78 0.52	0.94 0.66	1.09 0.70	0.99 0.70
marketd	C.	Village distance from nearest market town, in Km.	8.23 3.74	 8.33 4.87	8.65 3.11	6.40 2.61	8.60 4.47	9.59 4.55	8.52 4.20
V	D	31 village dummys for 32 villages							
SR	D	Four dummies for five sub-regions							
Observations			443	169	141	15	114	574	1456

Notes: T= variable type, D=dummy, C=Continuous

Table 2: Determinants of Intensity of Chemical Fertilizer use, *ln (fertp)*

Variables[+]	RE Tobit Estimator Coef. (Z-stat)		Powell's CLAD (Coef.) CLAD1[++] Coef.	CLAD2 Coef.
Ln(manurp)	-0.171	(2.98)***	-0.022	-0.034
Ln(tracthp)	0.196	(4.35)***	0.126*	0.134**
Ln(plotsize)	-0.261	(2.21)**	-0.30*	-0.299**
pqual2	0.035	(0.24)	0.183	0.183
pqual3	-0.013	(0.05)	-0.027	-0.027
slope2	-0.249	(1.47)	-.237	-0.237
slope3	-0.665	(2.60)***	-.212	-0.212
depth2	0.110	(0.74)	0.024	0.025
depth3	0.123	(0.56)	0.072	0.072
soil2	0.040	(0.25)	-0.21	-0.211
soil3	-0.390	(0.81)		
soil4	0.170	(0.73)	-0.103	-0.104
soil5	-0.020	(0.08)	-0.013	0.013
soil6	-0.353	(1.57)	-0.180	-0.181
soil7	0.816	(1.12)		
Ln(plotdist)	0.036	(0.36)	0.056	0.057
irigated	-0.073	(0.23)	0.761*	0.761**
hhsex	0.529	(1.76)*	0.185	0.186
Ln(hhage)	-0.939	(1.87)*	-.737*	-0.737**
Ln(hhedu)	0.000	(0.00)	-0.021	-0.021
Ln(hhfamex)	0.350	(2.36)**	0.369*	0.369**
Ln(madc)	-0.275	(0.65)	-0.078	-0.078
Ln(fadc)	0.928	(2.07)**	0.442	0.442
conswork	0.069	(0.86)	0.056	0.056
relativ	0.024	(0.05)	0.064	0.064
ofa99c	0.023	(0.30)	0.064	0.064
bizd	-0.226	(0.77)	-0.012	-0.012
remitd	0.149	(0.58)	-0.042	-0.042
irlandc	0.046	(0.26)	0.047	0.047
creditd	-0.286	(0.97)	-0.360	-0.360
oxenc	0.205	(0.74)	-0.068	-0.068
animac	-0.016	(0.63)	-0.015	-0.015
ifpartd	1.005	(2.69)***	0.626*	0.626**
extseed	0.495	(1.67)*	0.490*	0.490**
cropc2	-0.111	(0.74)	0.530	0.530**
cropc3	-0.470	(1.32)	0.434	0.434
cropc4	-2.257	(6.12)***		
cropc5	-2.433	(12.48)***	-2.369*	-2.369**
cropc6	-3.811	(8.19)***		
cropc7	-3.460	(10.42)***		
length3	-0.066	(0.22)	-0.054	-0.054
TC	-0.764	(2.42)**	-0.635*	-0.635**
TTS	-0.263	(0.98)	-0.057	-0.057
TTF	-0.687	(1.14)		
TOO	-0.489	(2.35)**	-0.304*	-0.304**
TLO	-1.210	(3.78)***	-0.715*	-0.715**
Constant	3.880	(1.97)**	5.019*	5.019**
sigma_u	1.02	(12.77)***		
sigma_e	1.72	(37.59)***		

rho	.26		
	Observations (plots)=1456 Percentage of censored observations= 32	Initial sample size=1456 Final sample size= 1381	Initial sample size=1456 Final sample size = 1381
	Groups(households)= 297	297	297
	Wald chi2(79) = 626.43	Pseudo R2=.15	Pseudo R2=.15
	Prob > chi2 = 0.0000	BS replications=500	BS replications=500
	Log likelihood -2409.20		
	H_0: no household random effect, chibar2(01)=112.41 Prob>=chibar2 = 0.000		

[+] Parameters estimated but not reported for the random effect Tobit model are 31 village dummys for 32 villages.
* Significant at 10%; ** significant at 5%; *** significant at 1%.
[++] The sample drawn during each replication is a bootstrap sample from household clusters for CLAD1 and from plot observations for CLAD2.
[+++] The sample drawn during each replication is a bootstrap sample of plot observations.

Table 3: Determinants of Intensities of Tractor Hours (*ln (tracthp)*) and Value of Seed (*ln (seedvp))*

Variables[+]	Ln (tracthp)	Ln (seedvp)	
	RE-Tobit model Coef. (Z-stat)	RE model Coef. (Z-stat)	LAD Model Coef. (BS T-stat)
Ln(plotsize)	1.616 (5.99)***	-0.362 (12.12)***	-0.328 (7.46)***
pqual2	-0.684 (2.36)**	-0.015 (0.40)	0.032 (0.69)
pqual3	-0.794 (1.49)	0.102 (1.72)*	0.189 (2.57)**
slope2	-0.198 (0.54)	0.007 (0.16)	-0.021 (0.35)
slope3	-0.077 (0.13)	0.121 (1.84)*	-0.033 (0.35)
depth2	0.016 (0.06)	0.014 (0.37)	0.036 (0.77)
depth3	0.565 (1.19)	0.082 (1.45)	0.078 (1.16)
Soil2	-0.378 (1.27)	-0.007 (0.16)	-0.020 (0.42)
Soil3	0.192 (0.19)	-0.055 (0.46)	-0.037 (0.22)
Soil4	-0.862 (1.88)*	-0.131 (2.19)**	-0.217 (2.56)**
Soil5	-0.129 (0.25)	0.021 (0.36)	0.035 (0.42)
Soil6	-1.073 (2.23)**	-0.006 (0.11)	-0.018 (0.21)
Soil7	2.005 (1.27)	-0.103 (0.53)	-0.007 (0.03)
Ln(plotdist)	0.389 (1.77)*	-0.008 (0.31)	-0.033 (0.96)
Irigated	2.504 (4.73)***	-0.067 (0.81)	0.134 (0.97)
Hhsex	-0.816 (1.12)	0.055 (0.78)	0.010 (0.11)
Ln(hhage)	0.915 (0.66)	-0.016 (0.13)	0.016 (0.09)
Ln(hhedu)	0.726 (2.08)**	0.077 (2.62)***	0.081 (2.05)**
Ln(hhfamex)	-0.453 (1.77)*	0.049 (1.44)	0.009 (0.21)
Ln(madc)	1.235 (0.80)	-0.033 (0.33)	0.048 (0.28)
Ln(fadc)	0.176 (0.15)	-0.098 (0.91)	-0.075 (0.38)
Conswork	-0.120 (0.46)	-0.004 (0.23)	-0.006 (0.25)
Relativ	-0.266 (0.19)	0.059 (0.53)	-0.035 (0.23)
Ofa99c	-0.341 (1.25)	0.039 (2.09)**	0.035 (1.11)
Bizd	0.381 (0.61)	0.003 (0.05)	-0.003 (0.04)
Remitd	0.543 (0.82)	0.006 (0.10)	-0.014 (0.20)
Irlandc	1.034 (1.49)	0.075 (1.82)*	0.087 (1.31)
Creditd	-0.650 (1.10)	0.005 (0.07)	-0.010 (0.10)
Oxenc	-4.016 (4.01)***	0.125 (1.88)*	0.142 (1.32)
Animac	-0.069 (1.02)	0.006 (1.07)	-0.002 (0.28)
Ifpartd		0.065 (0.76)	0.108 (0.66)
Extseed		0.028 (0.40)	0.071 (0.69)
IFT	5.789 (14.02)***		
cropc2	-0.334 (1.18)	0.815 (20.28)***	0.807 (16.09)***

cropc3	-17.865 (0.00)	1.865 (20.41)***	1.993 (14.61)***
cropc4	-2.272 (2.54)**	-0.987 (11.03)***	-1.099 (5.18)***
cropc5	-0.682 (1.82)*	0.689 (14.22)***	0.750 (10.42)***
cropc6	-0.792 (0.69)	-0.049 (0.47)	-0.149 (1.17)
cropc7	-1.269 (2.11)**	1.466 (19.75)***	1.557 (16.64)***
Tlength3	1.613 (2.57)**	0.090 (1.18)	-0.202 (1.73)*
TC	-2.340 (3.06)***	-0.062 (0.76)	-0.115 (1.29)
TTS	-0.650 (1.25)	-0.045 (0.64)	0.028 (0.10)
TTF	-0.744 (0.68)	0.184 (1.17)	-0.036 (0.55)
TOO	0.199 (0.39)	-0.040 (0.81)	0.065 (0.65)
TLO	-0.835 (1.40)	-0.009 (0.12)	0.169 (1.45)
Constant	-3.626 (0.72)	3.516 (7.60)***	-0.006 (0.25)
sigma_u	2.50 (11.10)***	.217	
sigma_e	2.16 (20.53)***	.479	
rho	.57	.17	
Total Observations (plots)	1456	1456	1456
Percentage of censored Observations =	77	0	
Groups (households)	297	297	297
Wald chi2(50)	376.41	R-sq: within = 0.56 Between = 0.71 Overall = 0.63	BS replications=500
Prob > chi2	0.0000		
Log likelihood	-1043.46		
H_0: no household random effect[++]	chibar2(01)=163.41 Prob>=chibar2 = 0.000	chi2(1) = 48.01 Prob > chi2 =0.0000	

[+] Parameters estimated but not reported are 31 village dummys for the seed model and three village level peer variables and four sub-regional dummy for the tractor model.
[++] The test for household random effects for the tractor model is based on Log-Likelihood test, whereas for the seed model it is based on Breusch and Pagan Lagrangian multiplier test.
Absolute value of t-statistics in parentheses
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Determinants of Intensities of Animal manure, *ln (manurp)*, and hired labour, *ln (hiredp)*

Variables[+]	Interval regressions (Tobit)	
	Ln (manurp)	Ln (hiredp)
	Coef. (Robust Z-stat)	Coef. (Robust Z-stat)
Ln(plotsize)	0.204 (0.46)	1.102 (2.62)***
pqual2	0.348 (0.86)	-0.087 (0.19)
pqual3	-1.152 (1.36)	-0.382 (0.47)
slope2	-0.422 (0.64)	-0.305 (0.51)
slope3	-1.528 (1.21)	-0.169 (0.19)
depth2	-0.333 (0.85)	0.420 (0.88)
depth3	0.608 (0.89)	-0.038 (0.05)
soil2	0.716 (1.20)	0.310 (0.61)
soil3	0.072 (0.03)	0.654 (0.43)
soil4	0.013 (0.01)	0.371 (0.49)
soil5	1.495 (1.67)*	0.332 (0.43)
soil6	0.115 (0.14)	-0.273 (0.35)
soil7	3.139 (2.05)**	-0.783 (0.30)
Ln(plotdist)	-0.995 (2.71)***	0.240 (0.75)
irigated	1.822 (2.13)**	2.773 (2.80)***
HHsex	2.335 (3.71)***	-1.083 (0.98)
Ln(hhage)	1.553 (1.27)	2.965 (1.79)*
Ln(hhedu)	-0.898 (3.21)***	-0.048 (0.11)
Ln(hhfamex)	-0.399 (1.24)	-0.361 (0.81)

Ln(madc)	-0.544	(0.51)	-6.712	(3.68)***
Ln(fadc)	-1.610	(1.45)	-3.058	(1.67)*
conswork	0.072	(0.34)	-0.305	(1.14)
relativ	3.351	(3.53)***	-0.813	(0.45)
ofa99c	-0.405	(2.08)**	0.934	(2.81)***
bizd	-2.090	(2.81)***	2.686	(2.51)**
remitd	-0.674	(1.08)	0.569	(0.74)
irlandc	-0.533	(0.71)	1.254	(1.94)*
creditd	0.168	(0.53)	0.182	(0.21)
oxenc	0.985	(1.34)	1.696	(1.38)
animac	0.236	(4.05)***	0.101	(1.52)
cropc2	0.213	(0.36)	-1.765	(4.10)***
cropc3	6.560	(6.27)***	-0.651	(0.53)
cropc4	-18.055	(10.73)***	-5.159	(4.60)***
cropc5	-2.413	(2.82)***	-2.757	(5.18)***
cropc6	-16.365	(13.37)***	-8.252	(3.66)***
cropc7	-3.386	(2.20)**	-2.012	(2.76)***
Tlength3	-1.371	(1.68)*	-0.428	(0.49)
TC	-2.888	(2.35)**	-3.46	(3.53)***
TTS	-1.043	(1.44)	0.342	(0.47)
TTF	-0.055	(0.03)	-3.306	(2.18)**
TOO	-2.161	(4.49)***	-0.560	(0.75)
TLO	-5.364	(4.02)***	-1.319	(1.11)
Constant	-10.091	(1.98)**	-7.226	(1.09)
Sigma	3.59		4.52	
Observations (plots)	1456		1456	
Percentage of censored Observations =	89		72	
Household groups	297		297	
Wald chi2(73)	1523.57		1111.44	
Prob > chi2	0.00		0.0000	
Log pseudo-likelihood	-635.90		-1548.54	

+ Parameters estimated but not reported are 31 village dummys for 32 villages.
* Significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Determinants of land productivity *(ln (yieldv)*

Variables+	OLS		Random effects		LAD	
	Coef. (Robust T-stat)		Coef. (Z-stat)		Coef. (BS T-stat)	
Ln(plotsize)	-0.104	(2.39)**	-0.111	(2.68)***	-0.098	(1.95)*
$(\text{Ln(plotsize)})^2$	0.111	(4.89)***	0.100	(4.29)***	0.106	(3.44)***
pqual2	-0.064	(1.54)	-0.043	(1.17)	-0.062	(1.26)
pqual3	-0.111	(1.81)*	-0.099	(1.69)*	-0.120	(1.56)
slope2	-0.020	(0.45)	-0.037	(0.89)	-0.001	(0.01)
slope3	-0.098	(1.24)	-0.094	(1.46)	-0.160	(1.62)
depth2	-0.012	(0.30)	-0.017	(0.46)	-0.012	(0.25)
depth3	0.032	(0.58)	0.036	(0.65)	0.069	(1.03)
Ln(plotdist)	-0.020	(0.83)	-0.026	(1.06)	-0.018	(0.57)
soil2	0.027	(0.61)	0.013	(0.32)	0.025	(0.46)
soil3	0.068	(0.49)	0.095	(0.79)	0.117	(0.43)
soil4	0.005	(0.07)	-0.037	(0.61)	-0.003	(0.03)
soil5	0.101	(1.61)	0.112	(1.92)*	0.115	(1.47)
soil6	-0.011	(0.20)	-0.018	(0.33)	0.037	(0.53)
soil7	-0.174	(0.96)	-0.185	(0.92)	-0.088	(0.26)
irigated	0.551	(7.74)***	0.536	(6.33)***	0.624	(7.12)***

rain00d	0.171	(4.26)***	0.156	(4.01)***	0.181	(3.65)***
stormfld	-0.422	(4.93)***	-0.452	(5.49)***	-0.297	(2.25)**
hhsex	0.118	(2.14)**	0.133	(2.23)**	0.094	(1.17)
Ln(hhage)	0.073	(0.74)	0.066	(0.65)	0.076	(0.58)
Ln(hhedu)	0.006	(0.22)	0.010	(0.42)	-0.023	(0.71)
Ln(hhfamex)	0.037	(1.37)	0.036	(1.23)	0.038	(1.06)
Ln(madu00)	0.081	(0.92)	0.099	(1.08)	0.135	(1.28)
Ln(fadu00)	0.468	(2.32)**	0.469	(2.25)**	0.482	(1.56)
$(Lnfadu00)^2$	-0.268	(1.94)*	-0.273	(2.03)**	-0.320	(1.60)
conswork	0.025	(1.25)	0.027	(1.67)*	0.033	(1.28)
lnrelatv	0.694	(3.13)***	0.676	(3.26)***	0.828	(2.63)***
ofa99c	0.015	(1.06)	0.011	(0.69)	0.012	(0.64)
bizd	0.065	(0.93)	0.068	(1.13)	0.121	(1.44)
remitd	0.045	(0.85)	0.028	(0.55)	0.055	(0.85)
irlandc	0.134	(3.94)***	0.138	(3.78)***	0.112	(2.21)**
oxenc	0.032	(0.64)	0.042	(0.78)	0.001	(0.02)
animac	0.015	(3.19)***	0.013	(2.48)**	0.013	(1.79)*
ifpartd	0.024	(0.43)	0.032	(0.54)	0.006	(0.08)
cropc2	-0.640	(12.01)***	-0.644	(15.73)***	-0.640	(10.57)***
cropc3	0.470	(4.36)***	0.478	(5.10)***	0.423	(2.69)***
cropc4	-0.980	(11.50)***	-0.981	(10.14)***	-0.935	(8.13)***
cropc5	-0.777	(12.27)***	-0.787	(15.89)***	-0.819	(9.97)***
cropc6	-1.158	(8.07)***	-1.145	(9.61)***	-1.303	(8.89)***
cropc7	-0.355	(3.90)***	-0.379	(5.01)***	-0.327	(2.54)**
length3	-0.033	(0.48)	0.003	(0.04)	0.046	(0.55)
TC	0.099	(1.36)	0.091	(1.13)	-0.034	(0.36)
TTS	0.124	(1.93)*	0.081	(1.16)	0.071	(0.90)
TTF	-0.118	(0.82)	-0.205	(1.31)	0.053	(0.30)
TOO	-0.127	(2.96)***	-0.129	(2.98)***	-0.100	(1.93)*
TLO	-0.113	(1.66)*	-0.110	(1.59)	-0.150	(1.61)
Constant	5.544	(12.35)***	5.586	(12.73)***	0.033	(1.28)
			Sigma_u = .17			
			Sigma_u = .48			
			Rho = .11			
Observations (plots)	1429		1429		1429	
Clusters(households)	297		297		297	
	F (53, 296) =28.66 Prob > F = 0.00 R^2. =55		R-sq: within = 0.45 Between = 0.6478 Overall = 0.5431		BS Replications=500	
Test for household RE effect+++ H_0: no household random effect			Chi2 (1)=37.00 Prob>=chi2 (1)=0.00			

+ Parameters estimated but not reported are four sub-regional dummys and three village level peer variables.
+++ Breusch and Pagan Lagrangian multiplier test is used for the household RE estimator.
* Significant at 10%; ** significant at 5%; *** significant at 1%

APPENDIX 1: MAIN QUESTIONER FOR RURAL HOUSEHOLD SURVEY

A. Identification

Name of enumerator: ______________________________

First visit, date ______________________________

Second visit, date ______________________________

Region\Zoba ______________________________

Sub-region \Nius-Zoba ______________________________

Administration / *Mimihidar* ______________________________

Village*Addi* ______________________________

Name of Household head ______________________________

Household Number ______________________________

Data checked by	When	Status		Comment
		Ok	Return	

Data punched	**When**	Person responsible
Pages		
Pages		
Pages		

B. Household characteristics

1. Household size and composition, skill, and occupation

SN.	Name	RTHH	Sex	Age	Education	Occupation	Farm Experience	Skill	Present in		Remarks
									1999	2000	
1		Head									
2											
3											
4											
5											
6											
7											
8											
9											
10											

Codes & definitions

RTHH: relationship to household head
1=wife 2=child 3=Grand child
4=sister 5=brother 6=other
Education: 0=no education at all
RR= read and write only & grade in years if >RR
Skill: skill other than farming

Occupation:
0=dependent 1=student 2=watch animals
3=housewife 4=farming 5=hired labour
6=off-farm activity 7=village official
8=other, specify
Farming experience: number of farming years
Presence: months staying in the household.

2. Does any of the household members live outside the village? Yes\no If yes, give details of migration history in the table below

Name of migrant	Migrant Destination	Period of stay	Reason for migration	Return time	Remark

Codes & definitions
Period of stay: duration of stay as migrant
Migration destination:
1=inside the country 2=Middle East
3=Europe, USA, and Australia 4=other

C. Household Assets

1. Farm implements, equipments, and transport assets (year 2000)

Implements	Quantity	Purchase Price	Year In use	Need to be replaced
Plough				
Plow parts (in set)				
Spade				
Axe				
Sickle				
Hoe				
Water Pump				
Tractor				
cart				
Truck				
Bicycle				
Other, state				

2. Animal Assets

Animal category	Quantity beginning		Current Balance	
	1999	2000	Quantity	Value
Milking cow				
Other cows (dry)				
Ox				
Heifer				
Bulls				

Calves				
Sheep and goats				
Ewes				
Ram				
Lamb				
Does				
Bucks				
Kids				
Transport				
Horses				
Mules				
Donkeys				
Camel				

D. Household consumption (or use) of food and non-food items in year 2000

Commodity	Own produce				Purchased			Aid			Total	
	Q*	period	P	Total value	Q	P	Value	Q	P	Value	Q	Value
Cereals												
Wheat												
Barley												
Mixed (Wheat & barley)												
Taff												
Maize												
Sorghum												
Finger millet												
Pearl millet												
Other cereals												
Pulses												
Horse beans												
Field pea												
Fababean												
Chick pea												
Grass pea/vetch												
lentil												
Fenugreek												
Meat, egg, milk, and butter												
Beef												
Sheep												
Goat												
Chicken												

Eggs												
Milk												
Butter												
Vegetables and fruits												
Pepper												
Vegetables												
Fruits												
Other food and drinks												
sugar												
Cooking oil												
Salt												
Coffee												
Drinks												
Snacks												

***Note**: Q=quantity, P=price. Quantity is measured in quintal, kilogram, units, pieces, liters, kilos, or any other local measurement. It can be measured on per day, per week, per month, per season or per year basis. Own production is valued at the relevant market price

E. Land holding system, Farm size, and views on land reform

1. What is the land holding system in your village?
 a. Private (*Tsilmi*) b. Deissa c. Concession d. Lease from government
 e. Other, state

If *Deissa*, state the year of (a) Last *Wareida*: _______and (b) Next *Wareda*: ______
State the year of land acquisition, If the land holding system is not *Deissa*,? _________

2. Farm size (in *Tsimdi*) in year 2000?

Land	Size		
	Rain fed system	Irrigated system	Total
Allocated (or own) holding			
Own Land cultivated			
Own Land uncultivated (land fallowed)			
Land shared in			
Land shared out			
Land rented in			
Land rented-out			

3. Give details of land quality and location for each of the fields that your household operated in year 2000

Field number	Name of place	Field size (in *Tsimdi*)	Slope (F, G, S)	Depth (D, M, S)	Fertility (G, M, P)	Soil type (L, C, S, O)	Distance in minutes of walk
1							
2							
3							
4							

5							
6							
7. Rented in Field							
8. Shared in field							

Codes- Slope: 1=flat 2=gentle 3=steep; **depth:** D=deep M=medium S=shallow; G=good, M=medium, P=poor;
soil type: L=Loam, C=clay, S=sandy, O=other

4. If you shared in land, were you interested in sharing-in more land in either production systems than you actually got?
If yes, state your reasons for not doing it?
a. Could not get anymore land to share-in b. could not agree on the terms of sharing in
c. Lack of water for irrigation d. Other, state

5. If you shared-out land, state reasons for doing so?
a. Lack of oxen to cultivate b. Lack of labour to cultivate
e. Working off-farm f. Sharing risk

6. If you shared-in or shared-out, could you give details of the share contracts in the table below.

Terms of contract	Rain-fed		Irrigation	
	Shared in	Shared out	Shared in	Shared out
Input sharing rule				
Output sharing rule				
Year contract began				
Year contract ends				
Conservation responsibility				

Codes
Sharing rules: 1/2 = fifty-fifty share in input and output
1/3 = the landlord takes one-third of the crop harvest with out sharing input cost
1/4 = the landlord takes one-fourth of the crop harvest without sharing input cost
Other = state any arrangement outside the above three in the space given
Conservation responsibility: 1= if landlord's, 2=if tenant's
3= both 4=other state

7. If you rented-in or rented-out land, give details of contract in the table below.

Terms of contract	Rain-fed		Irrigation	
	Rented in	Rented out	Rented in	Rented out
Rental rate/year				
Year contract began				
Year contract ends				
Conservation responsibility				
Reasons for renting out				

Codes.
Conservation responsibility: 1= if owner, 2=if renter 3= both 4= other, state

Reasons for renting-out: 1=lack of oxen, 3=lack of water to irrigate 4= working off-farm 5=lack of water-pump 6=other, state in the given space

8. Were you interested in renting-in more land than you were able to get? Yes\No
If yes, give reasons for not doing it.
a. Shortage of land for rent b. High rental rate e
c. Lack of water to irrigate d. Lack of capital e. other, state _____

9. If the land holding system were *Deissa*, would you like to see another *Wareida* in five to seven years as before? Yes\No
If yes, why? a. to get a better quality and a larger size of land
b. To allow my married sons/daughters get their share of village land (livelihood security) c. Other, state _________________________
If no, how do you want to keep your share of land in the future?
a. the wareda time should be prolonged
b. Permanent use-right over the (no *wareida* at all)
c. Private ownership of land (the right to sell and buy land freely)
d. Other, state

10. If you say yes to the above question, what would you do if your village decides not to hold wareda anymore? Would you ask compensation? Yes\No
If yes, how would you like to be compensated?
1=in monetary terms 3=other, state
2=in land

If in monetary terms, how much would that be in Nakfa? _________

11. How would you change your farming behavior if there were no *wareida* at all?
a. I would plant tree crops in my field
b. I would invest in land improving technologies (better soil and water conservation techniques)
c. I would invest in better and more modern farm equipments
d. I would not change my farming behavior at all
e. Do not know

12. Do you support allotment of land in just one place? Yes\No\no opinion
If yes, why? b. It reduces production cost
c. It is easier to manage
d, It encourages investment and the use of modern inputs
e. Other, state
If no, Why?a. Fragmentation ensures equal share from all classes of land
b. Fragmented plots are subject to different weather risk
c. Fragmentation allows multi-cropping and crop rotation
d. Other, state

F. Integrated farming System

2. Have you been participating in integrated farming? Yes\No
If yes how much and which of your land has been under integrated farming ?

Land quality	Land size			
	1997	1998	1999	2000
Good				

Medium				
Poor				

3. Who makes the following decisions under integrated farming? (Tick in the appropriate cell)

Decision maker	Which Field to put under IF	Cropping
Farmers		
Village admin\council		
MOA		
village administrasjon & MOA		
Other, state		

4. Yield under integrated farming is higher than under traditional farming?
If you do agree, what do you think is/are the source/s of increase in yield under IFS?
a. Mechanization b. Fertilizer application
c. New crop variety d. More application of pesticide
e. Better plot management f. Other, state
If you disagree, state your reasons for disagreement
____
____
____

5. How has your household's welfare changed under IFS in comparison to traditional farming?
a. Better-off b. worse-off
c. No change d. No opinion. e. Do not know

6. Would you state your share of the returns in the table below? (for collective IF)

		1997	1998					2000	
Share for	crop type	Quantity	in Nakfa	Quantity	in Nakfa	Quantity	in Nakfa	Quantity	in Nakfa
Land									
labour									

7. How do you compare the labour requirement of IFS to traditional farming?
a. greater in IFS b. smaller in IFS
c. no difference d. do not know

8. Do you pay for inputs (mechanization, fertilizer, seed, and etc) provided under IFS?
If no, why?
a. It is paid by MOA c. cannot afford to pay e. Paid collectively
b. We are not supposed to pay d. Bad harvest f. Other, state ______

G. Crop Production activities in year 2000
1. Crop output in 2000 (rain-fed agriculture).

Input	Crop1	crop2	crop3	crop4	crop5	crop6	crop7	crop8	Remarks

Area in ha or *Tsimdi*									
Farming systems: IFS or TFS									
Field number									
Plowing and planting (man-days)									
Weeding (man-days)									
Harvest & threshing (man-days)									
Hired labour (man-days)									
Hired labour cost									
Seed variety: T or M									
Seed quantity									
Seed cost									
Fertilizer DAP									
Fertilizer urea									
Pesticide (liters or kg)									
Natural Manure (1999 & 2000)									
Tractor hours/days									
Tractor service (cost)									
Thresher cost									
Output (Qtl.)									
Value of output (Nakfa)									
Straw output (in Qtl. Or animal load)									
Value of straw output (price*quantity)									
Net value of output									
Crop output in 1999									

Note: value is quantity * price at harvest time. Value of straw is based on farmer assessment.
Codes and definitions: IFS= integrated farming system; One child labour = 1/2 adult labour
TFS=traditional farming system; One adult female labour = 3/4 of adult male labour. T=traditional, M=modern

2. Crop and vegetable production in year 2000 (irrigation)

Input	Crop1	crop2	crop3	crop4	crop5	crop6	crop7	crop8	Remarks
Area in ha or Tsimdi									
Field number									
Water source*									
Irrigation method**									
Water-pump ownership***									
Growing period in months									
Plowing and planting (man days)									
Weeding (man days)									
Harvest & threshing (man-days)									
Hired labour									

Hired labour cost									
Seed variety: T or M									
Seed quantity									
Seed cost									
Fertilizer DAP									
Fertilizer urea									
Fertilizer cost									
Natural Manure (1999 & 2000)									
Pesticide (liters or kg)									
Tractor hours/days									
Tractor service (cost)									
Land rent if land is rented									
Water Pump fuel expenses									
Water Pump maintenance expense									
Output (Qtl)									
Value of output (Nakfa)									
Straw output (Qtl)									
Value of straw output									

***Water source:** 1=groundwater, 2=Dam, 3= river/stream, 4=other, sate in the remarks section ****Irrigation method:** 1=gravity 2=Water-pump 3 = manual *(mesella* 4=other, state
Ownership of water pump: 1=own 2=rented 3=shared 4=communal 4=other, state

2. Did you apply any of the following soil/water (or moisture conserving) technologies to any of your fields since acquisition?

Conserve method**	Did you apply		Field No. **	Year of		Cost of (in Nakfa or labour days)	
	Yes	No		Construction	Maintenance	Construction	Maintenance
Terracing							
stone &/or soil bund							
Grass strip							
Tree-planting							
Contour plowing							
Tide ridges							
Micro-basin							
Mulching							
Other, state							

**Note: use the field numbers indicated in section E2.

3. If the household uses hired labour, give details on source, wages, & difficulty in hiring labour in the table below

Labour	Source	Wage	Difficulty in finding	Remarks
Male				
Female				
Child				

Source: 1=within village, 2=outside village,

3. = Other, state in the remarks section
Difficulty: 1=very difficult, 2=difficult, 3=ok 4=easy, 5=very easy

4. Show four of your major production constraints in the outgoing season from the list below? (Ranking: 1=constraint # 1)

Rain fed system		Irrigated system
Constraint	Rank	Constraint
Rainfall inadequacy		Water shortage (ground water depletion)
Rainfall distribution		Excess water
Lack of oxen		Ground water depletion
Lack of labour		Dam silt up
Land tenure system		Land tenure system
Pest attack & crop diseases		Lack of labour
Storm &/or flood		Lack of oxen
Lack of chemical inputs		Pest attack & crop diseases
Lack of cash to purchase inputs		Lack of water pump
Lack of good seed variety		Lack of chemical inputs
Land degradation		Lack of cash to purchase inputs
Poor quality land		Maintenance of water-pump
Lack of agricultural knowledge		Lack of good seed variety
Other, state		Poor quality land
		Lack of land
		Salinity
		Flood &/storm
		Frost
		Lack of agricultural knowledge
		Other, state

H. Credit

1. Have you obtained credit in the last two years to pay for your farm and/or household consumption expenditures? Yes\no
If yes , give details for 1999 and 2000 in the table below

						Repayment terms			
Year	Source	Amount	Interest rate	Collateral	Purpose	Maturity	Form of payment	Outstanding debt	Remark
1999									
2000									

Codes and definitions
Source: 1=village bank 2=credit coops 3=MOA 4=NGO 5=relatives and/or neighbors
6=traders or local money lenders 7=other, state in the remarks section
Collateral: 1=no collateral 2=group collateral 3= other, state in the remarks section
Form of payment: 1=lump sum in cash 2=installments in cash 3= when convenient 4=other, state
Maturity: The period in which the loan should be repaid.
Purpose: 1=purchase of farm inputs (fertilizer, pesticide, and etc.)
2=purchase of animals (state animal type in the remarks section)
3=soil and water conservation (structural works)
4= purchase of water pump and other farm capital

5=micro-business 6=animal feed and health 7=purchase of food, 8=other, state

2. If your answer to Q1 is yes, were you interested in getting more credit than you were able to obtain? Yes\No

If yes, where would you have spent it (use codes from the above table)

3. If your answer to H1 is no, were you interested in obtaining credit? Yes\No

If yes, if you had obtained credit, where would you have spent it? (Use codes from the table to answer the question)

I. Food security, risk management, and copping Strategies

1. What other methods (other than those stated in G2) do you use to prevent the effect of drought and related production risk?

Insurance system	Major priority (Rank: 1=priority 1)	Remarks
Choose crops &/or crop varieties which are drought resistant		
Choose short duration crops		
Diversify crop production		
Avoid use of risky inputs		
Other, state		

2. What income strategies do you use to prevent the negative effects of drought and other risks?

Income source	Tick	Amount received\earned	
		1999	2000
Vegetable production: irrigation			
Off-farm work			
Remittances			
Keep cattle, sheep, and goats			
Sale of milk and milk products			
Poultry products			
Hiring out land			
Hiring out oxen			
Petty trade			
Bee keeping			
Food aid			
Government transfer			
Assistance from relatives			
Gifts			
Other, state			

3. If a household member participates in off-farm work, give details for the last two years (1999 and 2000) of in the table below

Name	Year	Duration of employment	Work type	Location
	1999			

	1999			
	1999			
	2000			
	2000			
	2000			

Codes:
Work type: 1=farm, 2=non-farm
Employer: 1=relative, 2=friends, 3=other
Duration of employment: State the period of employment in months and year. If space is not enough go to the next line.

4. How difficult is it to find a gainful job?

Job category	Within village	Outside village	
		Asmara	Other places
Farm			
Non-farm			

Response codes: 1= very difficult, 2=difficult, 3=Ok, 4=easy , 5=very easy

5. Where does the working member live during employment period?
1. Stay with the household 2. Stay in the work place

If with the household, state the mode of transportation to and from work place
1. Walk 2. Bike 3.Bus, specify bus fare 4.Other, specify ________
If in the work place, give details of food and accommodation expenses in work place in the table below

Item	Provider	Expenses/day if own
Food		
Shelter		

Provider code: 1=own, 2=relatives, 3=employer, 4=other, state

6. Did the Househld wanted to take more off-farm works than it had taken? Yes\No
If yes, state the reason why the household could not take more off-farm work
a. Low wages
b. There was no more work opportunity
c. High transportation cost
d. Other, state

7. Do you use incomes from non-farm and/or off farm works to pay for your farm expenditures? Yes\No
If yes, give details of amount, purpose, and source of such expenditures in the last four years in the table below

Year	Amount	Use	Source	Remarks
1997				
1998				
1999				
2000				

Source: 1=off-arm work, 2=remittances, 3=trading, 4=other, state in the remarks section.

Use: 1=purchase of farm inputs (fertilizer, seed, herbicide, pesticide), 2= implements and oxen 3= purchase of water pumps; 4=soil and water conservation, 5= Purchase of animals (state animal type in the remarks section), 5=animal feed and health, 6=other, state in the remarks section.

8. Has the household sold cereals, pulses, or legume crop in the last four years? Yes\No
If yes, give accounts in the table below

Year	Crop type	Quantity	**Value**	Reason	Remarks

Code. Reason: 1= to purchase food for the household   3 = pay for farm expenses
2=pay for household non-food requirements   4=other, sate in the remarks section

9. What production do you expect in a good, medium, and bad year for your major crops?

Crop	Production in quintals/*Tsimdi*			Causes of bad year, rank for each crop (ranking: 1=cause #1)				
	Good	Medium	Bad	Drought	Pest attack	Disease	Excess rain	Other, specify
Crop1								
Crop2								
crop3								
crop4								
crop5								
crop6								
crop7								
crop8								
Crop9								

10. How many good, medium, and bad years have you had for the above crops in the last five years?

Crop	Number of years			Classification of years by type of year				Comment
	Good	Medium	Bad	Year	Good	Medium	Bad	
crop1				1996				
Crop2				1997				
crop3				1998				
crop4				1999				
crop5				2000				
crop6								
crop7								

11. What are your responses (coping strategies) when drought strikes?
How do you plan to meet the food and income needs up to the next harvesting period?

Strategy	Moderate drought	Severe drought	Remark
	Rank (1= strategy#1)	Rank (1=strategy# 1)	
Sell cattle (ox and cow)			

Sell goats and sheep			
Rely on existing off-farm income sources			
Rely on remittances from family Members or close relatives			
Rely on cash savings or food reserves			
Borrow food from relatives or neighbors			
Borrow money from neighbors and relatives			
Borrow money from other sources, state			
Migrate to food surplus areas			
Request food aid from government			
Other, specify			

12. For how many months in a year can the household count on its own output for food consumption?
Good year ___________ Medium year _______________ Bad year ____________

J. Links to Extension systems

Extension Type	Frequency of contact				Relevance of information		
	Never	Once	Twice	>2	Very relevant	Moderately relevant.	Not relevant.
Agronomic advice							
Soil and water conservation							
Animal production and health							
Home economics							
Input/output market information							
Other, state							

APPENDIX 2: VILLAGE QUESTIONER

A. Identification

Name/s of Enumerator\s ______________________________
First visit, date ______________________________
Second visit, date ______________________________
Region\Zoba ______________________________
Sub-region\ Nius-Zoba ______________________________
Admnistration/Mimihidar______________________________
Village\Addi ______________________________
Name of interviewee ______________________________

B. Distance and transportation infrastructure

Distance to (in Km.)

Sub-regional capital ____________
Regional capital ____________
Asmara ____________
Major produce market ____________
Major input and market goods town ____________
Distance to major road ____________

Transportation service

Is there access road to major road? Yes\ no
Is there bus service to regional &/or sub regional capital? Yes\ no

C. Village Human Population

	Population		
	Current	Before	
		10 years	20 years
Number of households			
Number of landholding households			
Number of people			

D. Power animals in the village

Animal	Stock	
	Beginning of year 2000	Current
Ox		
Cow		
Donkey		
Camel		
Mule		
Horse		

E. Water resources

1. Number of dams	
2. Capacity of dams (in Cubic meter)	
3. Condition of dams	
4. Is dam position suitable for gravity irrigation?	Yes\no
5. What are the dams used for?	
6. Number of ground-wells	
7. What are ground-wells used for?	
8. Level of ground wells	
9. Is there a river or stream?	Yes\no
10. What are rivers or streams used for?	

Codes.
Dam condition: 1=needs maintenance and silt clear up, 2=good condition
Use of dams, ground-wells, and rivers: 1=irrigation, 2=drinking water for people and animals, 3= both, and 4=other

Dam position: S=suitable for gravity irrigation, and NS=not suitable for gravity irrigation
Level of ground-wells: 1=high, 2=medium, 3=low, 4=all levels (high, medium, and low)

11. Is there some control/rule on the use of water for different purposes? Yes\No
If yes, state the type of control/rule applied?
1. Limiting extraction rate?
2. Banning extraction in particular seasons and/or for particular purposes.
3. Imposing quota and making sure that water for irrigation is equally shared
4. Others, state

If yes, is it respected and followed properly by water users? Yes\No
If no, why are water use rules violated?
____
____
____

12. Would you support the introduction of water charge (payment) for irrigation water?
Yes\No\No opinion
Why?

F. Integrated Farming Systems

1. Does your village participate in integrated farming (IF)? Yes\No
If yes, what type of integrated farming do you practice in your village?
a. Collective type farming c. Mechanization, fertilizer, and seed all on credit basis
b. SG and SP: fertilizer and seed on credit basis d. Combination of a, b, and c

2. Who makes the following decision in IF?

Decision area	Decision maker		
	Farmer	Collective	MOA
Farmer participation			
Which land to put into IF			
Cropping choice			

3.Are the following field characteristics considered (as criteria) in selecting fields for integrated farming?

Criteria	If it has a role?		Tick the admissible type		
	Yes	No			
Slope			Flat	Gentle	Steep
Soil depth			Deep	Medium	Shallow
Soil type			Loam	Clay	Sandy

4. If decision is made by MOA or by village-MOA jointly, how are groups for IF formed?
   1. Proximity of fields to one another 2. Willingness to participate in IF
   2. Other, state

5. Is labour participation in cooperative IF by landowning households obligatory? Yes\No
6. How is wage for workers determined?
   a. Market wage rate
   b. Based on harvest level
   c. Other, state
7. How are benefits or returns distributed among stakeholders in the collective type of IF?

8. Do you have an outstanding debt from previous production cycles? (Only for collective IF)Yes\No
   If yes, give details for the last four years.

Year	Labour	Tractor & harvester		Fertilizer	Pesticide	Herbicide	Other, specify	Total
1997								
1998								
1999								
2000								

9. Are you obliged to pay back your loan if production is not enough to cover expenses? Yes\No
10. Are you experiencing difficulties in convincing farmers to participate in IF? Yes\No
   If yes, what are the major difficulties?
   ____
   ____
   ____

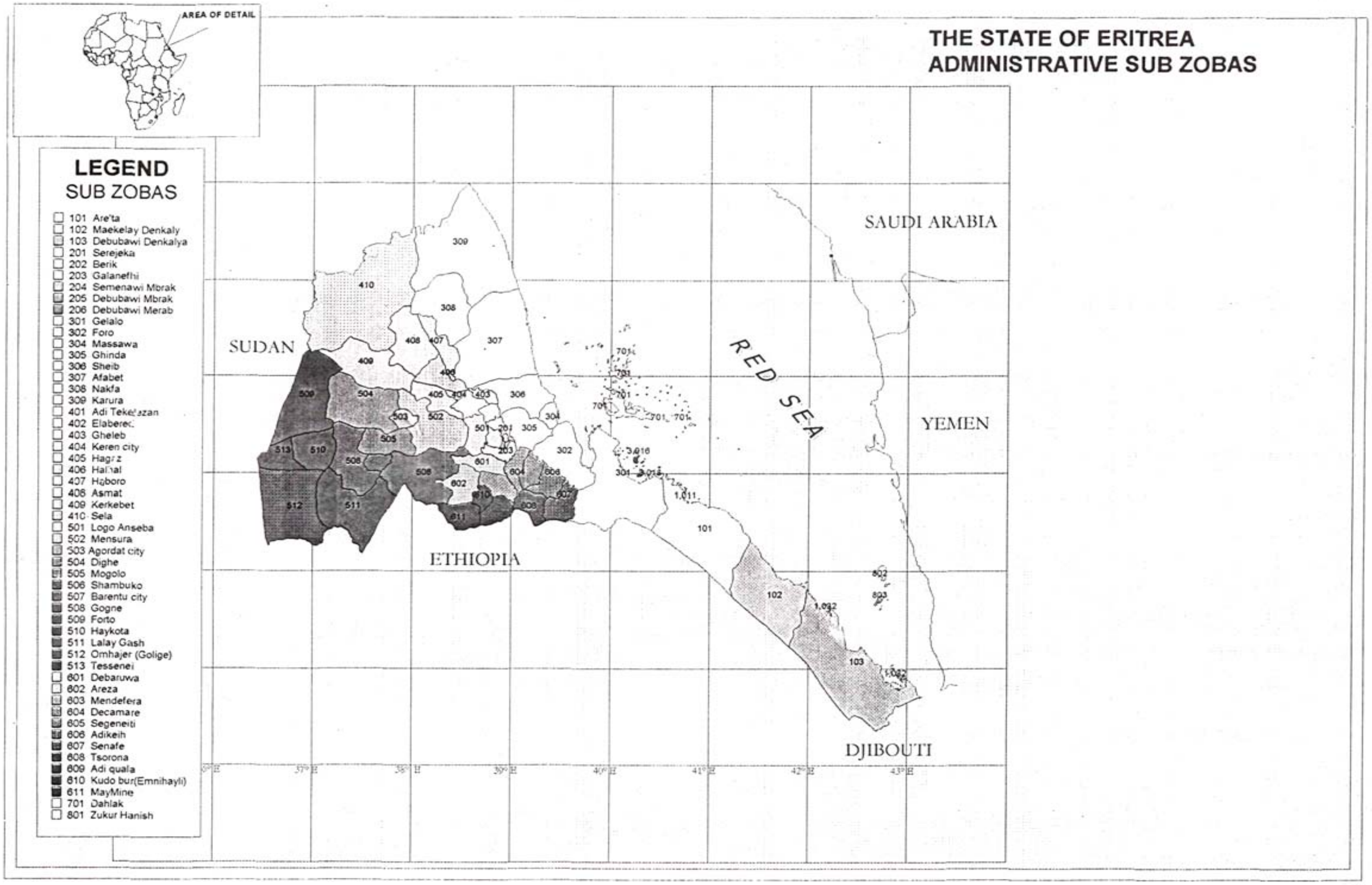
11. Crop production (1999-2000) of IF units in a village

Input	1999					2000					Price (cost)/given unit of Measurement)			
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	1999		2000	
											Price (cost)	Total	Price/cost	Total
IF group size														
IF plot size (ha.)														
Seed rate (in Qtl.)														
Cultivation labour														

Wedding Labour														
Harvesting Labour														
Mgt& extension														
Other Labour														
Fertilizer Urea (kg).)														
Fertilizer DAP (kg).)														
Pesticide														
Herbicide														
Tractor hour														
Oxen hour														
Comb-harvest hour														
Crop output (Qtl.)														
Straw output														
Net output														

Note: C1-C5 denotes crop1-crop5.

Appendix 3



The study villages are located in Sub-Zobas (=sub-regions) Serejeka (201), Berik (202), GalaNefhi (203), Dibarwa (601), and Mendefera (603)