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# Effects of forest plantations on soil carbon sequestration and farmers' livelihoods
## – A case study in Ethiopia

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Cover: *Cupressus lusitanica* plantations in Ethiopia, 2011, photo by author

# Abstract

The establishment of monoculture forest plantations with exotic, fast-growing species is common in tropical countries. This study was conducted to determine both (1) the long-term effects of plantations on soil organic carbon (SOC) and (2) the social impact of the plantation on farmers' livelihoods in Ethiopia. Tree plantations of *Cupressus lusitanica* and *Eucalyptus saligna* were established on abandoned mechanized farmland nearly 30 years ago. SOC amounts under forest plantations were compared with SOC of mechanized farmland, traditional farmland and natural forest which was the reference site. The study had a retrospective design and differences in SOC contents were compared between the five land uses sampled at two different occasions with a 10-year interval. Moreover, 20 farmers in total, both male and female, living at different distances from the plantations, were interviewed in order to assess the difference in the social impact of the plantations on farmers' livelihoods.

The results showed that the amount of SOC sequestered under the five land uses in the 0-20 cm soil layer differed significantly and was highest under *C. lusitanica* followed by *E. saligna*, natural forest, and traditional and mechanized farmland. However, the forest plantations do not yet seem to be in a steady-state with respect to SOC. Due to the establishment of plantations, farmers' livelihoods have changed in different aspects. The impact of the plantations was stronger in households situated closer to the plantations than for those people who lived further away from the plantation area. Those farmers who lived near the plantations had easier access to collect firewood and graze their livestock. They had also more job opportunities and access to shelter and were inspired to start on-farm *Eucalyptus* plantings. On the other hand, they also had to face problems associated with the plantations such as loss of agricultural land due to the establishment of plantations, crop destruction by wildlife, and conflicts with the forest guards.


***Keywords:*** plantations, soil organic carbon, farmers, livelihood

# Popular science summary

In Ethiopia, large-scale plantations, mainly monocultures of *Eucalyptus*, *Cupressus* and *Pinus* species have been established with the aim to increase the supply of timber products, protect the remaining natural forest and achieve an ecological restoration of degraded sites.

At Munessa-Shashemene natural forest, tree plantations of *Cupressus lusitanica* and *Eucalyptus saligna* were established nearly 30 years ago on former mechanized farmland. In 2001, soil samples were collected from the 15-year-old *C. lusitanica* plantation and the 17 year-old *E. saligna* plantation. The soil samples were analyzed for total carbon and compared with soil samples from mechanized farmland, traditional farmland and the natural forest which was the reference site.

The aim of this study was to determine the current soil organic carbon sequestration rate under five types of land use. In 2011, soil samples were collected from the same pits and analyzed in the same way as in 2001. The study also aimed to assess the long-term effects of the plantations on farmers' livelihoods. In total, 20 small-holder farmers, male and female, living at different distances from the plantations, were interviewed to identify the differences in the social impacts of the plantations.

The results showed that in the 0-20 cm soil depth, soil carbon under *C. lusitanica* and *E. saligna* plantations was 70 % and 39 % respectively higher than in mechanized farmland. Within a decade, the amount of SOC was increased by 25 % under *C. lusitanica* and 20 % under *E. saligna* . Due to the establishment of plantations, farmers' livelihoods changed in different ways. The impact of the plantations was considerable in households situated closer to the plantations than those who lived further away from the plantation site. The main effects of the plantations that improved the farmers' livelihoods were the firewood collection, grazing, job opportunities and motivations to plant *Eucalyptus* around the farmers' homesteads. Nevertheless, negative impacts such as a loss of agricultural land due to the establishment, crop destruction by wildlife and conflicts with forest guards were also reported.

# Contents

# Introduction

## Ethiopia in brief

In 2010, the Ethiopian population was close to 85 million – almost 30 % more than in the year 2000 (FAO, 2010) and the population is expected to reach 114 million in 2020 (UNdata, 2011). A high population growth rate poses an extra burden on the already degraded environment resulting in further deterioration of the natural resources.

Eighty-two (82) % of the Ethiopian population lives in rural areas (FAO, 2010) making agriculture the cornerstone of the country's economy. The agricultural sector accounts for 51 % of the country's GDP (World Bank, 2009) and the agricultural exports make up 84.4 % of the country's total exports (FAO, 2010). Coffee, oil seeds, vegetables and flowers are the top export products (UN Comtrade, 2010). However, the traditional subsistence agriculture dominates in Ethiopia. The majority of the Ethiopian farmers practise both crop production and livestock husbandry. The average cropland area in the country is 0.85 hectares per farmer in which cereals, pulses, oilseeds, vegetables and root crops are cultivated. Other crops grown are coffee, enset, chat, fruits, and sugar cane (CSA, 2006).

Consequently, issues of soil health and maintenance of soil fertility are of vital importance for the Ethiopians and for the country's agricultural production and economy. Land degradation is a serious problem and is a key barrier to achieve sustainable yields. Berry (2003)
the costs that arise from degraded land in Ethiopia. In particular, he emphasizes the direct causes such as deforestation in combination with unfavourable climatic (prolonged drought, heavy rainfall) and topographic conditions (steep slopes) that induce erosion. Cereals have a significant role in the Ethiopian diet. However, they leave the soil bare for long periods of the growing season (Berry, 2003) and demand a very good tilled soil and monoculture. Such agricultural management practices make the soil more prone to erosion (Bishaw, 2001).

The use of biomass (crop residues, dung) for energy purposes contributes to the decline of soil fertility and nutrients losses. Due to the limited use of fertilizers, either being too costly or unavailable, the nutrients exported from the soil are not compensated for (Berry, 2003). An FAO project assessed the average nutrient balance of Ethiopia for the year 2000. The study estimated average net losses of 47 kg $ha^{-1}$ $yr^{-1}$ of N, 7 kg $ha^{-1}yr^{-1}$ of P and 32 kg $ha^{-1}yr^{-1}$ of K (FAO, 2003).

The high population growth accompanied by overgrazing and continuous cultivation with short fallow periods results in a decline of soil fertility (Berry, 2003). The agricultural production is unable to satisfy the increasing demands and the low agricultural imports are not enough to fill the nutrition gap (FAO, 2010). The persistence of high food prices at the current global market will negatively affect the Low-Income Food Deficit Countries (LIFDCs), including Ethiopia, since they must now pay approximately 30 % more for food imports than in 2010 (FAO, 2011). Malnutrition is common in Ethiopia. According to FAO's latest statistics 41 % of the population suffered from undernourishment, during the period 2005-2007 (FAO, 2010).

In order to cope with the problem of food insecurity Ethiopian farmers have expanded their agricultural fields at the expense of forest land (Tscopp, *et al*., 2010; Berry 2003). The agricultural extensification, the high domestic demand for firewood and overgrazing are key drivers of deforestation (Lemenih *et al.,* 2008). Firewood is the primary source of cooking fuel for the majority of the population (CSA, 2007). Selling firewood is the dominant activity carried out at a household level that generates income from the forest (Bekele, 2001). In Ethiopia it is usually women and girls who collect firewood and trade it on the local wood markets (Chiche *et al.*, 2003).

Forests and trees are still an integral part of many farm-household livelihoods and play a key role in reducing their vulnerability. In Ethiopia, natural forest is a state-owned asset and conflicts over the use of this resource are common (FRA, 2010). According to the Ethiopian Forestry Action Program (1994), 150 000 hectares of natural forest are deforested annually. The natural forest cover declined from 16 % in the 1950s to 2.2 % in the 2000s (Berry, 2003). The need to cover the increasing demand for timber products from other wood sources is a necessity for Ethiopia and the establishment of fast growing tree species appears to be the solution to address the problem of wood scarcity.

## Forest plantations and potential benefits

The shortage of wood is a problem that was diagnosed early in Ethiopia. In the end of the 19th century *Eucalyptus* species were introduced to satisfy the high demand of firewood (Bishaw, 2001). A more organized effort was made in the 1970s when large-scale plantations were established with the financial support of the international community (Yirdaw, 2002). In the year 2005, it was estimated that Ethiopia had 509 000 hectares of plantations, mainly monocultures, of *Eucalyptus*, *Cupressus* and *Pinus* species and 20 000 hectares more were expected to be established by the year 2010 (FRA, 2010). The purposes of the establishment are to increase the supply of timber products, to protect the natural forest and restore the degraded land (Lemma, 2006).

There are potential environmental benefits that can arise from the plantations. Ecological restoration of a degraded land can be achieved by establishing exotic tree species (Lemenih, 2006). Tree plantations have the potential to improve the soil fertility by accumulating biomass, increasing the amount of organic matter returned to the soil, enhancing plant nutrient availability and decreasing bulk density (Lugo, 1997). The maintenance of biodiversity is another potential benefit. The natural forest's patches can be connected with forest plantations and therefore wildlife can disperse seeds from a natural to a plantation forest (Brockerhoff, *et al*., 2008; Lememih, 2006). Hence, regeneration of native tree species under the canopy of exotic tree plantations can be achieved (Lugo, 1997)

Moreover, the establishment of large-scale plantations is considered an effective method to mitigate climate change (House *et al.,* 2002). Carbon (C) can potentially be sequestered in forest biomass and in soils which represent the largest C pool in the terrestrial ecosystem (Lal, 2004). Afforestation/reforestation projects are included in several climate change mitigation mechanisms such as Reduced Emissions from Deforestation and Forest Degradation (REDD). In Bali, December 2007 at COP 13, decisions were adopted by the Conference of the Parties. In The Bali Action Plan, Decision 1/COP 13, the Parties decided on *"Policies, approaches and positive incentives on issues relating to reducing emissions from deforestation and forest degradation in developing countries; including the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing counties".*

In 2008, in the Climate Change Conference that took place in Poland, the Parties decided that "*the role of conservation, sustainable management of forest and enhancement of forest carbon stocks" have* the same priority and importance *as "reduced emissions from deforestation and forest degradation".* Since 2008, a plus was added to REDD (Holloway and Giandomenico, 2009). The idea behind REDD+ is that financial incentives should be given to developing countries in order to reduce emissions from deforestation and forest degradation and enhance C stocks through afforestation/reforestation projects. The social benefits of REDD were discussed at COP 13 and the rights and benefits of indigenous people are also part of the agenda of REDD+ (Peskett *et al.,* 2008; Holloway and Giandomenico, 2009). Nevertheless, there are concerns whether or not the local community is benefitting by the implementation of carbon credit projects. REDD+ highlights the social benefits that could potentially be delivered to the local people. However, there is a lack and unclear information with regard to the social implications of REDD+.

Whether or not forest plantations succeed in delivering different benefits is a very context-specific issue and depends on various factors. The crucial issues which this paper examines are the specific impacts of forest plantations on soil organic C (SOC) sequestration and the long-term effects of the plantations on farmers' livelihoods.

## The impact of forest plantations on soil organic carbon pool (SOC) after afforestation/reforestation

Soil organic matter (SOM) is considered to be a key indicator of soil quality and productivity (Larson and Pierce, 1994). SOM influences physical, chemical and biological soil properties. In particular, SOM is contributing to soil aggregate stability, improves soil structure and hence also soil aeration and water infiltration which contribute to a higher water holding capacity of the soil. SOM also acts as a plant nutrient pool and provides energy and nutrients to soil microorganisms which facilitate the process of decomposition of organic matter and nutrient cycling (Brady, Weil, 2008; FAO, 2005). The enhancement of SOM is an important issue especially in countries where self-subsistence agriculture dominates, as SOM improves the soil fertility and contributes to a sustainable crop production (Lal, 2004). Apart from food security, mitigation of climate change by carbon sequestration is an important argument for better SOM management (Lal, 2004). This is also one of the aims in the REDD+ mechanism.

Land use activities and management practices can influence the amount of C sequestered in the soil (Lal, 2004; FAO, 2005). In Ethiopia, a land use change from a natural forest to agricultural land usually results in a significant loss of SOC in the top soil. SOC reductions in the range of 17 to 83 % have been observed as a result of conversions to plantations (Girmay *et al.,* 2008). Soil C sequestration as a result of afforestation/reforestation is a research field that has fuelled a scientific debate since afforestation/reforestation activities can both increase or decrease SOC depending on the local conditions (Laganiere *et al*., 2010).

In a field study carried out in the southwestern highlands of Ethiopia, Lemma *et al.* (2006) found out that plantations of *Cupressus lusitanica* and *Pinus patula* established on former arable land resulted in an increase of SOC over a 20-year period. A different study which also found an increase of SOC was conducted by Grunzweig, *et al.* (2007) in Israel. In this case where plantations of *Pinus halepensis were* established on semi-arid shrub land an increase of 75 % in SOC was reported after 35 years. Similarly, Del Galdo *et al.* (2003) assessed and compared the amount of C stored between three different land uses in Italy. In his study, soil samples were collected from farmland, grassland and mixed plantations of *Quercus robur* and *Tylia europea* established on a former agricultural land 20 years ago. The positive impact of plantations on SOC was reported to cause an increase of 23 % in the top soil and 6 % in the deeper soil layer. Garten (2002) went further and argued that an increase of SOC is possible to be achieved within a relatively short space of time. He reported a net C accumulation of 40-170 g C $m^{-2}$ $yr^{-1}$ over a 10-year period under plantations of *Pinus taeda* established on abandoned farmlands in the southeastern part of USA.

On the other hand, there are other cases of afforestation/reforestation projects which led to a loss of SOC. A study by Farley *et al.* (2004) showed that plantations of *Pinus radiata* established on grasslands in the highlands of Ecuador failed to create a new C sink. The study compared the soil C between grasslands and *Pinus radiata* plantations and concluded that grasslands proved to be the best C sequestration sites in comparison with the pine plantations. In Brazil, Neufeldt *et al.* (2002) compared the SOC of four treatments (cropland, pasture land, *Pinus caribaea* and *Eucalyptus citriodora*) with the native tropical savanna which was used as a reference site. In this study it was found that cropland and plantations of *Pinus caribaea*, led to a decline of SOC whereas reforestation with *Eucalyptus citriodora* did not cause any loss of SOC. Another study by Kirschbaum *et al.* (2008) indicated a SOC stock reduction of 5.5 t C $ha^{-1}$ over an 18-year period of *Pinus radiata* plantations established on a degraded pasture land in Australia.

Nevertheless, there are also studies which report neither a significant increase nor a loss of SOC. For instance, Smal and Olszewska (2008) carried out a field study in south-east Poland where SOC stock changes were compared between *Pinus silvestris* plantations established on former agricultural land, an adjacent farmland and a mature mixed coniferous forest. The study concluded that the amount of C stored in the topsoil under the afforestation site was similar to the one under the farmland although 30 years had passed since the establishment of the plantations. In New Zealand, the afforestation of degraded grassland with *Pinus nigra* did not impact the SOC during the first 5 years of the plantation and had a minor effect on SOC when the plantation was 10 years old (Davis *et al.,* 2007).

A meta-analysis study conducted by Laganiere, *et al*. (2010), showed that afforestation/reforestation activities can impact the SOC in various different ways depending on parameters such as land history, type of tree species, soil type, site preparation and climate. Hence, generalizations with respect to the real impact of tree plantations on soil C sequestration should be avoided and more research with different species that grow on a variety of soils over a long period of time is needed.

## The social impacts of forest plantations in rural communities – lessons learned from other countries

When assessing the impacts of forest plantations on SOC, the social perspective of an afforestation/reforestation project must not be neglected. It is important to look into the social implications of the plantations in order to fully assess the consequences of such large scale projects and their sustainability.

From a literature review by Gerber (2011) it appears that large-scale plantations especially when established on state-owned land impact negatively on rural communities which rely on the natural resources to meet their needs. Loss of land was the most common negative impact reported from several countries in Asia, Latin America and Africa .The establishment of plantations either on state or privately owned land usually resulted in migration to urban areas.

In South Africa, in the Tsolo district, 400 households were displaced at the end of 1950s as a result of an afforestation project with pine plantation and establishment of a sawmill. The eviction was accompanied by low compensation, health problems, poverty and a spiritual decline in farmers' life as the plantation was established on an ancestral burial site (Tropp, 2003). In some countries, like in Thailand the government used military force in 1991 to displace farmers from the forest and establish forest plantations. The afforestation project, planned to relocate 250 000 households during the period 1991-1996, was finally cancelled in 1992 when democracy returned once again to Thailand and instead small-scale farming with *Eucalyptus* was proposed as an alternative option (Hall, 2003).

Another example comes from Ecuador where the company bought land from the farmers with the aim to establish *Eucalyptus* plantations. The promised compensations were not given to all the farmers who sold their land. The amount of money was lower than the farmers were initially promised by the company. For those farmers who were unwilling to sell their land different methods were used in order to enforce them to do so. Those methods involved access prohibition to the plantation area, destruction of farmers' crop, theft or exposition to pesticides. Finally, several farmers sold their land, moved to urban areas where they failed to find a job and ended up landless and poor. Those farmers who remained in their households faced health problems associated with shortage of water or pollution due to increased exposure to pesticides (Gerber and Veuthey, 2010).

Another negative effect that many villagers had to deal with was the shortage of water. For example, in the case of Sri Lanka, pine and *Eucalyptus* plantations were established in the catchment of small watersheds and resulted in a lower water table and finally had a negative effect on the farmers' crop yield (Starkloff, 1998). In some cases, the establishment of plantations was followed by a decline in physical and/or cultural health. A study conducted by Montalba *et al.* (2005) in Chile, in Mapuche communitiy, showed that villagers developed health problems related to the pine plantations.

The argument that plantations offer employment opportunities is the most commonly referred to with regard to the social perspective of the plantations. However, in some cases, job opportunities are few and unskilled as well as low-paid and characterized by seasonality and hard working conditions (Cossalter and Pye-Smith, 2003). Local opposition to plantations has been reported and has in some cases resulted in violence (Gerber, 2011).

Contrary to large-scale plantations, small-scale plantation projects in the form of farm forestry or agroforestry managed by farmers proved to be beneficial for some local communities (Schirmer, 2007). These types of projects were aimed to promote equal distribution of benefits, improve income through employment opportunities, and maintain the population structure and the traditional land use patterns (Schirmer, 2007).

For instance, in Ghana 250 hectares of plantations mainly of native tree species were established with the aim to restore the degraded land. The project was based on the taungya system, a combination of food and tree crop production. Farmers being highly involved in the project were responsible for the labour works and were the main owners of the timber products. The land was provided by landowners, technical advice and training were given by the Forestry Commission while the forest communities were in charge of protecting the plantations. It was a community-based project which developed a feeling of trust and support and finally motivated farmers to be involved due to the number of benefits that they could get such as increased income, timber and non-timber products, food crops and fertile land (Blay, *et al.,* 2008).

In Vietnam, the shift in forest policies favoured the country's forestry sector, economy and rural community (Sam and Trung, 2001). The country adopted a social forest policy which resulted in enhancing the involvement of households, individuals and communities in the management of forest resources, giving owners a benefit and sharing rights to the households and individuals and also providing them with land in order to be used for forestry purposes with a long term perspective. According to Sam and Trung (2001), the new legislation promoted the establishment of small-scale plantations under the ownership and management of the local community who could increase their income by selling plantation products to the markets.

## Small-scale plantations of *Eucalyptus* established by smallholder farmers in Ethiopia

On-farm planted *Eucalyptus* grown by small-scale farmers is another form of forest plantations that has been evolved as a result of the problem of wood shortage. The expansion of small-scale plantations of *Eucalyptus* in the form of farm forestry is mainly observed in the highlands of Ethiopia due to the appropriate climatic conditions (Dessie and Erkossa, 2011). *Eucalyptus sp.* are most commonly planted in household ' yards, around agricultural fields as farm boundaries or in another piece of land (Lemenih, 2010). There are different drivers behind the trend of *Eucalyptus* tree plantings. Studies show that (1) the shortage of wood in combination with the high household demands for firewood and construction wood and (2) the income generation are the top two drivers (Lemenih, 2010).

A study made by Gemechu (2010) in the Mulo district of Oromia Region showed that most of the farmers preferred to plant *Eucalyptus globulus* rather than *Cupressus lusitanica* or *Juniperus procera. Eucalyptus* is more attractive to farmers and the reasons are its' high profitability, and its generation of quick return. It can be grown on degraded land, is easily cultivated and gives high amount of biomass suitable for construction and energy purposes. The same study made by Gemechu (2010) also reveals that the majority of the farmers have been inspired to plant *Eucalyptus* by observing other farmers doing so. The motivation is also driven by the personal interests of the farmers who took the initiative and started on-farm tree-plantings with the aim to improve their households' income and meet their needs in wood. The Government also advised and motivated farmers to start planting *Eucalyptus.*

The Farm Forest Policy in Ethiopia has encouraged and practically supported small-scale private plantations of *Eucalyptus* grown by farmers. Tax incentives that are related to the number of planted trees have been given to the farmers. Currently, the private sector is encouraged to invest in the forestry sector by stopping the control on pricing of wood in order to make the access to the markets easier. The private forest ownership and transfer rights of land where trees are planted have been recognized by the forest laws of Ethiopia (Nawir, *et al*., 2007). For instance, farmers can plant *Eucalyptus* and secure the private ownership of their rural land even though they may live in cities (Amare 2002).

**Figure 1.** Small-scale plantations of *Eucalyptus* close to farmer's household in Lepis Pesasant Association

## The framework of the study

This paper is partly based on the study made by Lemenih *et al*. (2004). In the paper *"*Comparison of soil attributes under *Cupressus lusitanica* and *Eucalyptus saligna* established on abandoned farmlands with continuously cropped farmland and natural forest in Ethiopia*"* they assessed and presented the difference in soil properties between two types of plantations (*C. lusitanica* and *E. saligna)*, two types of farmlands (traditional and mechanized) and a natural forest which was used as a reference site. The plantations were established by the financial support of the Swedish International Development Agency (Sida) on former agricultural land and are now under the management of the state owned Arsi Forest Enterprise (AFE). The objectives of the plantations were primarily to increase the supply of timber, relieve the pressure on Munessa-Shashemene natural forest and achieve an ecological restoration of the abandoned farmlands.

The Munessa-Shashemene forest is a state owned tropical Afromontane forest managed by AFE (Lemenih, 2004). The Ethiopian Government claims that the protection of the natural forest is an issue of high priority for the country and has recognized the forest as a National Forest Priority Area (NFPA) (Lemeni, 2004; FAO, 2002). The plantations are surrounding the natural forest and have a potential to act as a buffer zone so as to stop illegal cuttings which are still continuing (Lemenih*.,* 2004). Apart from the increased saw timber production, the plantations seem to benefit the soil fertility and are considered to be the most suitable method for land restoration for the country (Lemenih, 2004).

In 2001, soil samples were taken from the 15 year-old *C. lusitanica* plantation and the 17 year-old *E. saligna* plantation. The soil samples were analyzed in terms of total C and compared with soil samples from mechanized farmland (MF), traditional farmland (TF) and the natural forest (NF). Following the paper of Lemenih *et al.* (2004) it can be concluded that the concentration of C in 0-10 cm soil layer was in the order NF > *C. lusitanica* > TF > *E. saligna* > MF.

This paper is partly related to the experiments conducted in the referred paper of Lemenih *et al.* (2004) and will present the differences of total C sequestered at the same land uses over a 10-year period. Returning back to the same fields in 2011, soil samples were collected from the same pits and analyzed in the same way as Lemenih did in 2001 (Lemenih *et al.,* 2004). It is assumed that TF and MF as well as the *C. lusitanica* and *E. saligna* used to be natural forest before converted to other land uses. Therefore, the soil conditions are homogeneous, the topography of the different land uses is also the same and hence a fair comparison can be made.

Apart from that, this paper will give a social dimension to the study. Households are scattered almost everywhere in the study area and some of them are located adjacent to the plantations where the soil sampling took place. Therefore, it is necessary in order to fully assess the impacts of plantations to investigate whether or not the plantations have affected farmers' livelihoods.

Specifically, this paper will give answers to the following research questions:

1. What is the current SOC sequestration rate under the five land uses (NF, *E. saligna and C. lusitanica* plantations, TF and MF)?
2. What are the effects of the plantations and the operations of Arsi Forest Enterprise on farmers' livelihoods in the study area?
3. What is the natural forest's current role on farmers' livelihoods in the study area?

(A)

(B)

**(C)**

**(D)**

**Figure 2.** *Cupressus lusitanica* (A), *Eucalyptus saligna* (B) plantations, mechanized farmland (C) and traditional farmland (D) from where soil samples were collected

## The theoretical framework of the study

The study will be guided by the Sustainable Livelihoods Approach and A Theory of Access.

*"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for the means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks, maintain or enhance it capabilities and assets, while not undermining the natural resource base"* (Chamber and Conway, 1992).

The Sustainable Livelihoods Approach is a method of understanding poverty and the livelihoods of the poor people. According to Ashley and Carney (1999), it is *"a way of thinking of the objectives, scope and priorities for development activities"*. People are the core of the sustainable livelihoods approach. As people are complex and heterogeneous their livelihoods are also complex, dynamic and interdependent (Tadesse, 2010). The sustainable rural livelihood is a multi-level approach which can be applied from an individual up to a national level and can achieve sustainable livelihood outcomes (Scoones, 1998).

The framework of the sustainable livelihoods approach is composed by five elements: (1) the vulnerability context, (2) livelihood assets, (3) transforming structures and processes, (4) livelihood strategies, and (5) livelihood outcomes. The framework depicts the interaction and relationship between these elements and indentifies in which way the combination of different elements of the framework can influence people's decisions and therefore their livelihoods.

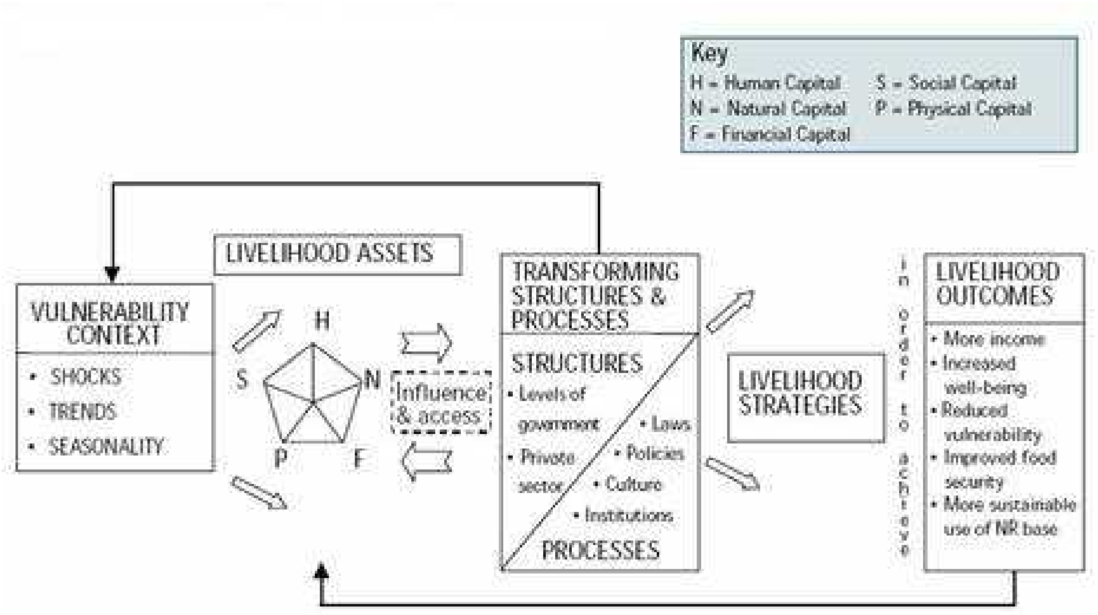


**Figure 3.** Sustainable Livelihood Framework (DFID, 2001).

The context of vulnerability refers to changes in the external environment which impact the availability of livelihood assets and the adoption of the livelihoods strategies. Livelihood assets named as "capital" are another key element of the framework. Scoones (1998) identifies the natural capital which includes natural resources (soil, water, forest, etc.) and environmental services, the financial capital (economic assets, infrastructure equipment, technologies), the human capital (skills, knowledge, health, physical capability, labor ability) and the social capital (social networks, relations, affiliations , associations).

Based on the context of vulnerability and the availability and combinations of assets different livelihood strategies are followed. Scoones (1998) recognizes the strategy of agricultural intensification/extensification, diversification and migration. According to Ellis (2000), the choice of the livelihood strategy is a complex and dynamic process which involves many activities in order to meet the needs and achieve a beneficial livelihood. Institutions and organizations are an important component of the framework and act as the binding link between the access to assets and the adoption of livelihood strategies. The achievements of the livelihood strategies are the sustainable livelihood outcomes which include: (1) increased employment in the form of income, production or recognition for being engaged in something that is worthwhile, (2) reduced poverty, (3) increased well-being and capability including both material and non-material such as self-esteem, happiness, security, (4) livelihood adaptation to stresses and shocks, reduced vulnerability, enhanced resilience and (5) sustainable use of natural resources and at the same time maintenance of productivity.

"A Theory of Access" is also the basis for the study. According to Ribot and Peluso (2003), access is defined as the "*ability to benefit from things"*. For this paper, "things" refers to land and its different land uses such as agricultural or forest. The access framework strongly links the ability of having access with power as the latter impacts the ability to benefit. The definition of access is more about a *"bundle of power"* which involves material, cultural and political-economic means rather than a *"bundle of rights"* as it is in the case of property. Individuals can get access and derive benefits from the land even though they do not have the land ownership. The most "powerful" person is the one that benefited the most from the land. Peoples' power differs between different groups and institutions, under different circumstances and over time periods.

Gaining access is a dynamic and complex process. The access framework involves the mechanisms of the rights-based access that can be either legal or illegal. Laws, customs or conventions are all means of gaining a direct and legal based access. In this case the person has a direct access to land and is able to gain benefits from it either by holding the user rights to the land (law-based property rights) or being socially accepted (customary or conventional access). Access can also be gained directly through illegal rights-based but not socially accepted such as theft or violence.

Apart from the law-based and the illegal mechanism of access, the theory identifies the structural and rational mechanism. The structural mechanism of access involves factors that can influence the ability of an individual to benefit. Technology, capital, market, labor and knowledge are such kind of factors. The individual who has more access to technology, capital, market, labor opportunities and knowledge is the one that has the potential to derive more benefits than others. The rational mechanism is another type of mechanism. In this case, a person can gain access and derive benefits by cultivating social relationships with those that control or maintain access. The rational mechanism of access involves the social relations and identities.

# Materials and Methods

## Site description

### Location

The soil sampling sites and interviewed households belong to Lepis Peasant Association (PA) in Arsi Negele district, Oromia National Regional state in Ethiopia. Peasant Association in Ethiopia indicates a specific locality in rural areas and encompasses the entire population in that area. Farmers belong to PAs and are responsible to implement the Governments' orders with regard to rural development projects within their PA. The Lepis PA is located at the latitude 7°32 N and longitude 38°79 E at an elevation of 2138 m.a.s.l. The PA is situated on the eastern escarpment of the Rift Valley and is located approximately 240 km south of Addis Ababa (Lemenih e*t al.,* 2004).

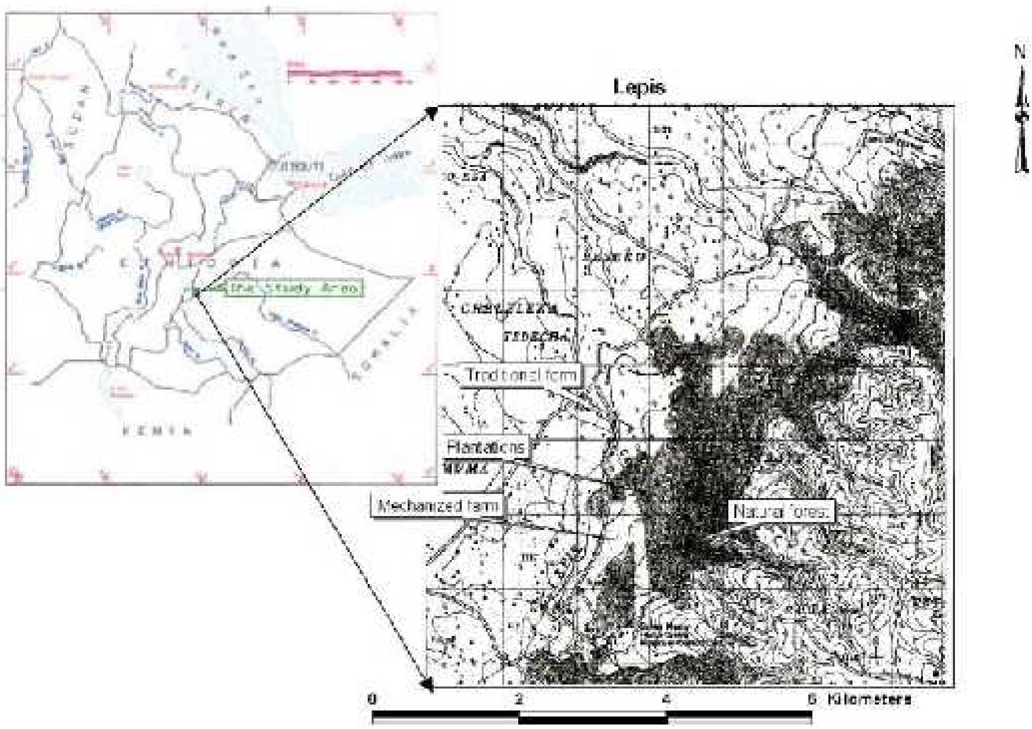


**Figure 4.** A map of the study area showing the different land uses where soil samples were collected (from Lemenih *et al.,* 2004).

## Climate

The climate is characterized as warm sub-humid with a bimodal rainfall with a main rainy season starting in July and extending to October, and a short rainy season from May to June. The mean annual rainfall is 1200 mm and the mean annual temperature is approximately 20 °C (Lemenih *et al.,* 2004).

## Vegetation

Munessa-Shashemene natural forest is a tropical dry Afromontane forest situated at the eastern escarpment of the Rift Valley (Lemenih *et al.,* 2004). The pressure on the remaining forest is high. Gaps, as well as illegal cuttings, intensive grazing, and cleared areas for agricultural cultivation can be observed. There is a steady decline in the quality and quantity of the forest (Lemenih *et al.,* 2004; Tolera *et al*., 2008). In areas where natural forest has been converted to agricultural land some indigenous tree species can be found scattered in the agricultural fields. The most common tree species include *Afrocarpus falcatus, Celtis africana, Olea hochstetteri, Prunus africana* and *Croton macrostachys* (Tolera *et al*. 2008).

## Soil

The soils are classified as Humic Haplustands (Soil Survey Staff, 1999) or Mollic Andosols (FAO, 1998) with their parent material originating from volcanic lavas, ashes and pumices (Mesfin, 1998). The soils in the study area are considered to be relatively fertile and have a potential to give high yields (Lemenih, *et al.,* 2008). However, the productivity is relatively low due to continuous cultivation without fallow periods and low inputs of nutrients.

**Figure 5.** Agricultural landscape in Lepis Peasant Association.

## The profile of the interviewed households

The total population registered at Lepis Peasant Association (PA) was 6.374 people. More than half of this population consisted of children aged 0-14 years (personal communication with the chairman of PA).

The average age of the interviewed male farmers was 43 years and the average age of the female farmers was 39 years. The family size of the interviewed households varied from 4 up to 18 family members and the average number of people per household was 9 individuals. The maximum size of the agricultural field which was reported through the interviews was 3 hectares and the minimum size was 0.25 hectares while the average size was 1.05 hectares. Some of the interviewed farmers got access to their farmlands by the government while others got a land to farm by their families or by their husbands' families in the case of female farmers. In any case, most of the interviewed farmers had a land certificate which provided them with user rights to their land and secured the land ownership. The rest of the interviewed farmers who did not have the land certificate were in the process of getting the document from Lepis PA (information gathered through interviews).

The small scale farmers of Lepis are engaged in mixed crop-livestock farming activities. It is a traditional self-subsistence agriculture which involves the ox plow and low inputs of manure coming from cattle (Lemenih *et al.,* 2004). The most common crops cultivated in the agricultural fields of Lepis PA are maize, wheat, potato, sorghum, barley and bean with maize being the main stable crop (Chiwona-Karltun *et al*. 2009).

In the typical gardens of the case study other crops are grown such as enset, spices, coffee, lettuce and some fruit trees like banana and avocado. Small private plantations of *Eucalyptus* are common in the study area. Often *Eucalyptus* is planted by farmers around their agricultural fields, in the households' yard or even in another piece of land close to their households (information gathered through interviews and field observations).

**Figure 6.** The backside of an interviewed household

## The profile of Arsi Forest Enterprise (AFE)

Arsi Forest Enterprise (AFE) was established in 1996 with the objectives (1) to sustainably manage the forest resources, (2) to ensure the sustainable management of biodiversity and (3) to contribute to the improvement of the socio-economic conditions of the local people who live around the forest area.

In total, AFE manages 15 000 hectares of plantation forests and around 187 000 hectares of natural forests. Forests plantations are mainly monocultures consisting of *Eucalyptus saligna, Eucalyptus globulus, Cupressus lusitanica, Pinus patula* and *Juniperus procera.* Approximately 6 000 hectares of plantations *of C. lusitanica* and

*Eucalyptus* species belong to the Munessa-Shashemene forest. Timber products such as saw logs, lumber, transmission poles, fuel wood and construction wood are produced and sold on the local market. Forest guards have been employed by AFE in order to protect the forest plantations from disturbing human activities such as illegal cuttings, theft of *Eucalyptus* saw logs and cattle grazing in the young plantations of *Eucalyptus*. The legal activities carried out in the plantations include the collection of branches during thinning and harvesting periods, livestock grazing in the mature plantations and collection of seeds and fallen branches.

With respect to Munessa-Shashemene natural forest, no management plan is followed. The primary objective of AFE is to protect the natural forest from illegal cuttings and wild fires. According to the law, collection and trading of firewood, grazing and keeping beehives in the natural forest are prohibited activities unless farmers get permission from AFE. However, it is difficult to enforce the prohibitions (personal communication with the manager of AFE, Didha, D.A,).

## Data collection and analysis

## Soil sampling

Following the method used by Lemenih *et al.* (2004), soil samples were collected from each land use category using the same 20 m x 20 m plot as was used in the previous study. From each plot, five samples were taken from the topsoil (0-10 cm) and five from the 10-20 cm depth. The collected samples were air-dried, mixed and passed through a 2 mm sieve for analysis. Total C and total N were analyzed with a LECO-1000 CHN analyzer and the results were reported on an oven-dry basis. To determine the dry bulk density, another set of soil samples was taken from the same pits using steel cylinders, which were dried in an oven at 105°C.

## Selection of households for a questionnaire survey

Data regarding farmers' perceptions towards the plantations and the natural forest and information which revealed the interactions with AFE were collected by making interviews. Semi-structured interviews with the farmers of the study area and the manager of AFE, field observations in the plantations and in farmers' households, formal discussions with the Chairman of the PA and a forest guard are the research methods used in this study. The data were collected during the period $4^{th}$ to $14^{th}$ of May 2011.

The selection of households was based on the criteria of gender and distance to the plantation area. A list of names given by the PA leadership was used as a basis to select households that satisfied the criteria of the survey. In total, 20 households were interviewed. A group of 10 households, located relatively close to the forest plantations and another group of 10 households located at a distance of 1 up to 3 km from the plantation area were selected. From each household either the male or the female farmer was interviewed. From each group of 10 households, an equal number of male and female farmers were interviewed. All the interviewed households were headed by a male, except for 4 households which were headed by females. Two (2) of the female-headed households belonged to the group of households which was interviewed near the plantations while the rest belonged to the distant households.

The questionnaire was first translated into the native language Oromiffa by the interpreter who also orally translated the farmers' answers to English during the interviews. All the interviews were digitally recorded and thereafter transcribed to written documents.


**Figure 7.** Map showing the location of the 10 households interviewed close to the plantation area (red) and the 10 households located in a distance of 1-3 km to plantations (yellow).

# Results

## Soil

In the following section the results of dry bulk density (g $cm^{-3}$), soil organic carbon (kg $m^{-2}$) and C:N ratios of soils from plantations, farmlands and the natural forest are presented.

## Dry bulk density

Dry bulk density at the depth of 0-10 cm showed the order NF < *C. lusitanica* < TF < *E. saligna* < MF **(Table 1)**. In the deeper soil layer (10-20 cm), dry bulk density increased in the order: NF < TF < *C. lusitanica* < MF < *E. saligna* **(Table 2)**.

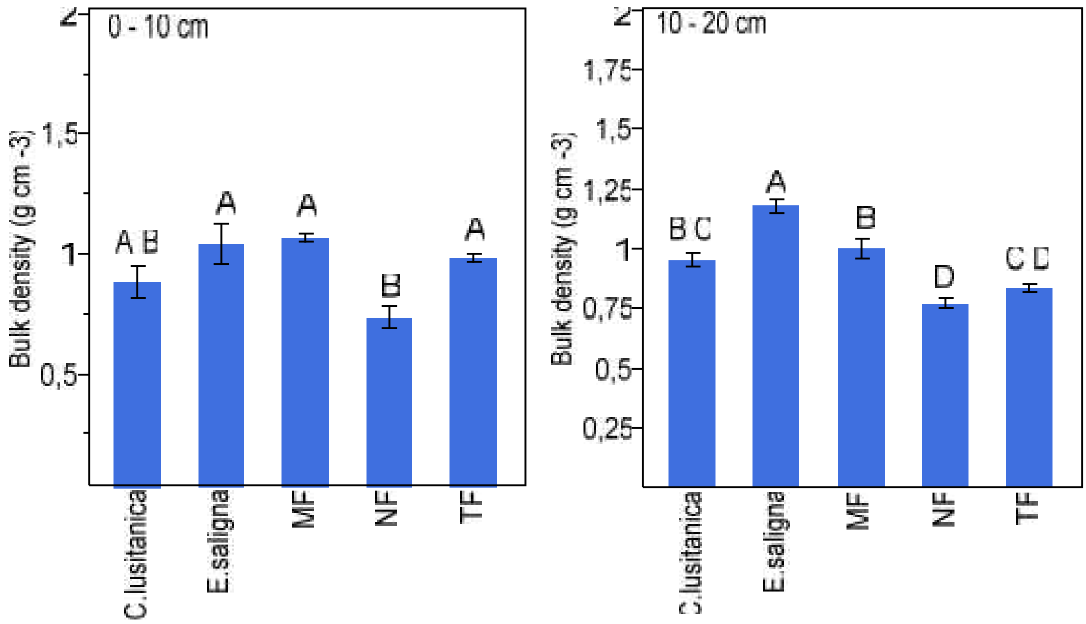


**Figure 8**. Mean dry bulk density at the depth of 0-10 (left) and 10-20 cm (right) for the different land uses. Bars which are not connected by the same letters are significantly different.

**Table 1.** Probability of significant differences in dry bulk density between the different land-use types at 0-10 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$

| | **MF** | ***E. saligna*** | **TF** | ***C. lusitanica*** | **NF** |
|---|---|---|---|---|---|
| **MF** | - | 0.99 | 0.78 | 0.15 | 0.0025** |
| ***E. saligna*** | | - | 0.93 | 0.28 | 0.0055** |
| **TF** | | | - | 0.71 | 0.031* |
| ***C. lusitanica*** | | | | - | 0.31 |
| **NF** | | | | | - |

**Table 2.** Probability of significant differences in dry bulk density between the different land-uses at 10-20 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$

| | ***E. saligna*** | **MF** | ***C. lusitanica*** | **TF** | **NF** |
|---|---|---|---|---|---|
| ***E. saligna*** | - | 0.0021** | 0.0002*** | <.0001*** | <.0001*** |
| **MF** | | - | 0.77 | 0.0062** | 0.0002*** |
| ***C. lusitanica*** | | | - | 0.07 | 0.0023** |
| **TF** | | | | - | 0.51 |
| **NF** | | | | | - |

## Soil organic carbon

The amount of soil organic carbon (SOC) (kg $m^{-2}$) stored in the soil under the natural forest, *E. saligna, C. lusitanica*, TF and MF at a depth of 0-20 cm differed significantly and decreased by soil depth **(Table 3)**. SOC at the depth of 0-20 cm showed the order: *C. lusitanica* > *E. saligna* > NF > TF > MF. At 0-10 cm, significant differences were found among the different types of land use and the order was *C. lusitanica* > NF > *E. saligna* > TF > MF **(Table 4)**. Likewise, significant differences were observed at the lower soil depth (10-20 cm) among the natural forests, the plantations and the farmlands **(Table 5)**. The amount of C stored in the soil under *C. lusitanica* plantations was still the highest while the natural forest had the lowest amount of C. Soil C at a depth of 10-20 cm decreased in the order: *C. lusitanica* > *E. saligna* > MF > TF > NF.

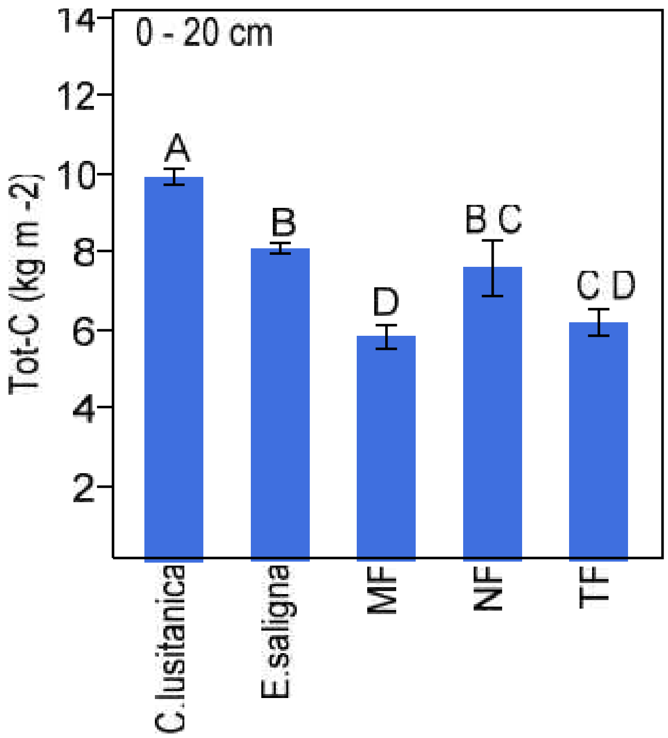


**Figure 9.** Mean Tot- C (kg $m^{-2}$) at 0-20 soil depth for the different types of land use. Bars not connected by the same letter are significantly different.

**Table 3.** Probability for significant differences in SOC between the different land-uses at 0-20 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$,

| | ***E. saligna*** | **MF** | ***C. lusitanica*** | **TF** | **NF** |
|---|---|---|---|---|---|
| ***C. lusitanica*** | - | 0.0021** | 0.0002*** | <.0001*** | <.0001*** |
| ***E. saligna*** | | - | 0.77 | 0.0062** | 0.0002*** |
| **NF a** | | | - | 0.07 | 0.0023** |
| **TF** | | | | - | 0.51 |
| **NF** | | | | | - |

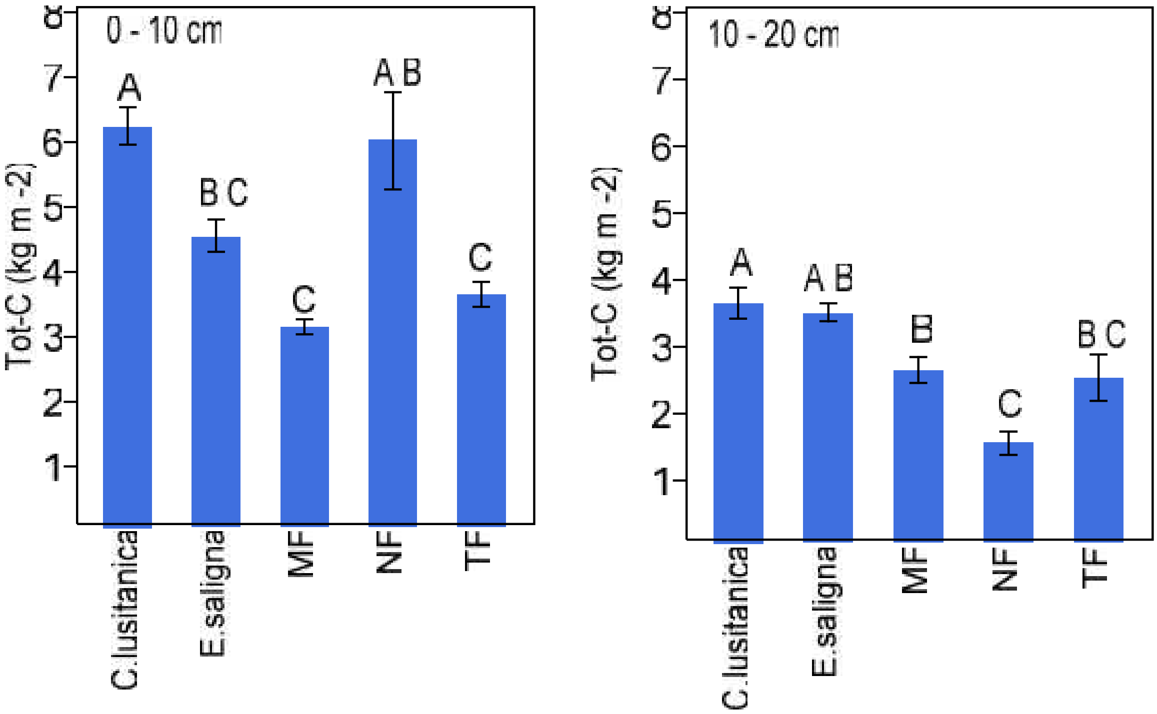


**Figure 10.** Mean Tot-C (kg $m^{-2}$) at 0-10 cm (left) and 10-20 cm (right) soil depth for different land use types. Bars not connected by the same letter are significantly different.

**Table 4.** Probability of significant differences in SOC between different land-use types at 0-10 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$

| | *C. lusitanica* | NF | *E. saligna* | TF | MF |
|---|---|---|---|---|---|
| *C.lusitanica* | - | 0.99 | 0.045* | 0.0012** | 0.0002*** |
| **NF** | | - | 0.1 | 0.003** | 0.0004*** |
| *E. saligna* | | | - | 0.49 | 0.12 |
| **TF** | | | | - | 0.89 |
| **MF** | | | | | - |

**Table 5.** Probability of significant differences in SOC between different land-use types at 10-20 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$

| | *C. lusitanica* | *E. saligna* | MF | TF | NF |
|---|---|---|---|---|---|
| *C.lusitanica* | - | 0.99 | 0.046* | 0.023* | <.0001*** |
| *E. saligna* | | - | 0.10 | 0.05* | <.0001*** |
| **MF** | | | - | 0.99 | 0.026* |
| **TF** | | | | - | 0.05* |
| **NF** | | | | | |

## C:N ratio

The mean C:N ratios at depth of 0-20 cm differed significantly between *E. saligna* and natural forest and decreased with depth **(Table 6)**. In the 0-20 cm soil layer, *E. saligna* had the highest C:N ratio followed by *C. lusitanica* while the natural forest had the lowest ratio ( *E. saligna* > *C .lusitanica* > TF > MF > NF).

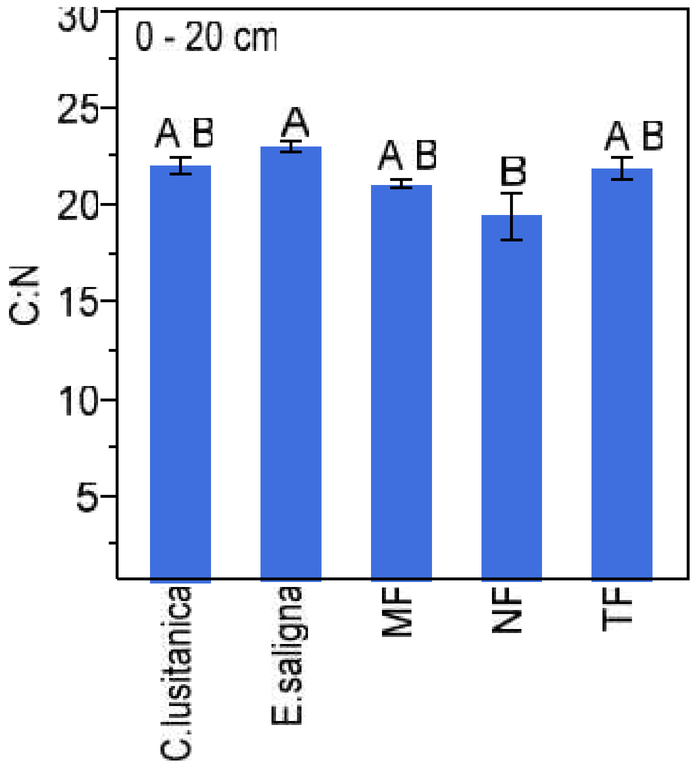


**Figure 11.** Mean C:N ratio at a depth of 0-20 cm for types of different land use. Bars not connected by the same letter are significantly different.

**Table 6.** Probability of significant differences in C:N ratio between different land-use types at 0-20 cm depth. using Tukey's test. * Significant differences at $p < 0.05$, ** significant differences at $p < 0.01$, *** significant differences at $p < 0.001$

| | ***E. saligna*** | ***C. lusitanica*** | **TF** | **MF** | **NF** |
|---|---|---|---|---|---|
| ***E. saligna*** | - | 0.86 | 0.78 | 0.30 | 0.0098 ** |
| ***C. lusitanica*** | | - | 0.99 | 0.83 | 0.07 |
| **TF** | | | - | 0.90 | 0.10 |
| **MF** | | | | - | 0.42 |
| **NF** | | | | | - |

## Changes in bulk density over a 10-year period

The comparison of the means of bulk density (g $cm^{-3}$) between 2001 and 2011 showed that bulk density changed over the years although the differences were not statistically significant for the majority of land use types. The bulk density at 0-10 cm soil depth, had increased in the plantations, natural forest (NF) and traditional farmland (TF) whereas a decrease in bulk density was observed in the mechanized farmland (MF). The increase in dry bulk density was only statistically significant in the TF case where it increased from 0.86 (g $cm^{-3}$) in 2001 to 0.98 (g $cm^{-3}$) in 2011. At the lower soil depth (10-20 cm) no clear pattern was observed during the 10-year period. A statistically significant increase of mean bulk density was observed for *C .lusitanica* and *E. saligna* while the mean bulk density of NF also increased but not in a significant way. The mean bulk density of MF decreased (not significantly) while the mean bulk density of TF remained stable and equal to 0.83

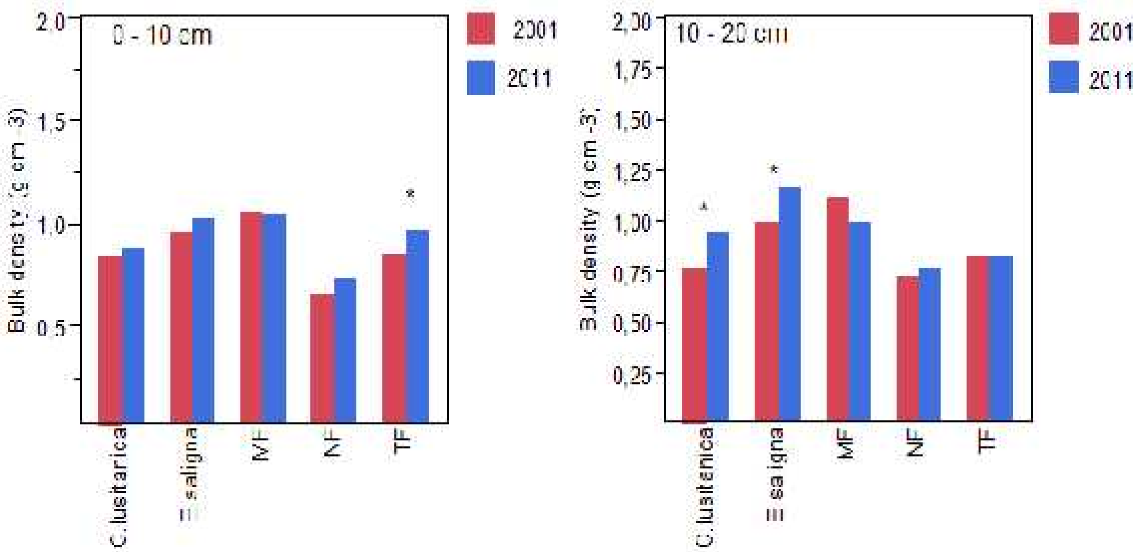


**Figure 12.** Comparison of the means of dry bulk density in 0-10 (left) and 10-20 cm (right) soil depth among the different land use types over a ten-year period. Bars with an asterisk (TF at 0-10 cm and *C. lusitanca, E .saligna* at 10-20 cm) indicate a significant increase between the means of 2001 and 2011.

## Changes in soil organic carbon over a 10-year period

The comparisons of SOC (kg $m^{-2}$) between 2001 and 2011 showed that the amount of C stored under the different land use types changed over the years. SOC at 0-10 cm increased under plantations and natural forest (NF). A statistically significant difference was observed for *E. saligna* which increased from 3.75 in 2001 to 4.55 in 2011**.** In contrast to plantations and natural forest (NF), the SOC of farmlands at 0-10 cm decreased although the change was not statistically significant. A statistically significant difference was observed for *C. lusitanica* at 10-20 cm soil layer as SOC increased from 2.56 in 2001 to 3.65 in 2011**.** SOC under *E. saligna* and NF increased (not significantly), and a decrease of SOC was observed over the years in farmlands (not statistically significant).

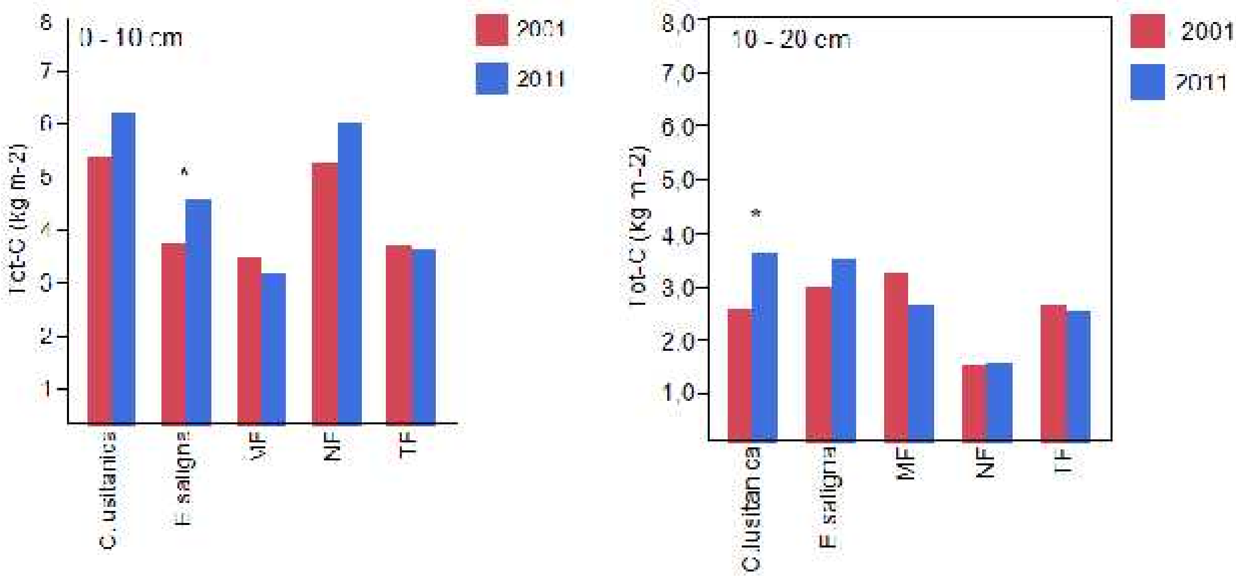


**Figure 13.** Comparison of the means of SOC in 0-10 (left) and 10-20 cm (right) soil depth among the different land uses over a ten-year period. Bars with an asterisk (*E. saligna* in 0-10 cm and *C. lusitanca* in 10-20 cm) indicate a significant increase between the means of 2001 and 2011.

## Interviews

## The effects of *C. lusitanica* and *E. saligna* plantations on farmers' livelihoods

The land use change from a farmland to plantations also had effects on farmers' activities and choices, influenced their strategies and changed their livelihoods in different ways. Variation in the effects was observed between households interviewed near and far from the plantations but also between male and female farmers. For the sake of a better understanding the effects of plantations on farmers' livelihoods three types of effects have been identified and described below.

### Effects related to the management of the plantations and operations of Arsi Forest Enterprise

The results from the interviews show that the plantations of *Cupressus* and *Eucalyptus were* considered as an additional source of firewood for the respondents. Most of the farmers (16 out of 20) and all the women who lived near the plantations stated that they collected branches from the plantations during pruning and thinning periods in order to use it as firewood or fencing materials. Farmers reported also to collect leaves, fallen branches, or even seeds which were used in order to establish a tree nursery site on their farm with the aim to increase the number of planted trees.

Except for firewood collection, grazing in the plantations was another type of activity commonly reported by those who lived relatively close to the plantations (8 out of 10). Similarly, all the women who lived near the plantations stated that they grazed their cattle in the forest plantations. On the contrary, most of the households interviewed far from the plantations (8 out of 10) indicated that they used other grazing sites such as their yard, the communal land and/or natural forest.

**Figure 14.** Collection of fallen branches in *C. lusitanica* plantations.

**Figure15.** Livestock grazing in *E. saligna* plantation.

The results also showed that households, mainly those interviewed nearby the plantations got inspired and motivated to start on-farm tree plantings by observing the plantations of *Cupressus* and *Eucalyptus.* In fact, the Enterprise actively supported their planting activities by providing tree seedlings, training and technical advice to the farmers with the aim to educate them regarding the successful establishment and management of their private plantations. As a 35 year-old farmer said,

*"I observed the plantations of the project and I got influenced to start planting my own trees. The Enterprise also gave me different kinds of tree seedlings. In the past, I used my land only for agricultural purposes but I have realized that plantations influenced me and changed my life*

Based on the discussion made with the manager of the Enterprise it was reported that one of the objectives of the company was to support and improve the living standards of the farmers who lived around the forested area. In order to fulfill this objective, the manager stated that the company provided wood to the rural community for communal purposes (construction of schools and bridges) or individually to farmers in different cases (for weddings, funerals or loss of husband). However, the majority of the interviewed farmers (15 out of 20) argued that the needs of the rural community such as clean water, employment, electric light, better infrastructure were not taken into consideration by the Enterprise. This argument was expressed by all the interviewed men. As one farmer said,

*"The enterprise does not follow the rules. There is a rule that says that whenever the community needs wood for communal purposes they should provide it. Although they promised to give wood for the construction of an elementary school, they did not keep their promise. I repeatedly asked them to help us and disagreed with them several times"*

The results from the interviews also indicate that conflicts usually emerged between forest guards and farmers. It concerned mainly those who lived closer to the plantation area (7 out of 10). Cutting trees from the forest plantations and grazing in the young *Eucalyptus* stands were the most common reasons for a conflict between farmers and guards. Forest guards protected the young *Eucalyptus* plantations from livestock grazing in order to secure the successful coppice regeneration of the stand. Guards also protected the young and dead native trees found in the plantations from illegal cuttings. In any case, whenever farmers acted illegally they were punished by fines or even imprisonment. For instance, in the case of illegal grazing farmers had to pay 2 up to 8 birr per cattle.

## Environmental effects

It was stated by farmers that there was an effect of plantations on their livelihoods as a result of the crop destruction by wildlife (wild pig, monkey and baboon). It was a common problem and mainly reported by those farmers who lived near the plantations (6 out of 10) as their agricultural fields were also located close to the plantations. The only two farmers who lived far from the plantations which experienced crop destruction by wild life had their croplands located more closely to the plantation area than other farmers in their group. The problem had become so serious for two of the interviewed farmers that they were forced to shift to other crops. A 25 year- old farmer said,

*"I used to cultivate maize and potato but they were destroyed by monkeys. Now I am cultivating beans and barley although I am not interested in those crops at all"*

A 59 year-old farmer gave his own explanation regarding the wildlife attack on farmers' crops,

"*In the past, when this site was covered by natural forest, Colobus monkeys did not eat our crops. Nowadays, there is plantation which does not have enough fruits and that's why monkeys eat our crops. We must stay awake during nights in order to protect the crops".*

Some farmers (8 out of 20) argued that the plantations created better climatic conditions in the area. This issue was raised by farmers regardless of their gender or their household location. Farmers expressed this argument with phrases such as *"attracts rain"*, *"creates better air", "prevent floods during rainy season".*

Some farmers (4 out of 20), especially women, recognized that plantations provided shelter for themselves and their livestock. The aesthetic value of the forest plantation was also reported by two male farmers who lived near the plantations. They particularly argued that observation of the scenery made them feel happy and mentioned "*mental satisfaction*".

According to some farmers (7 out of 20), the establishment of forest plantations caused a decline of the natural forest in which farmers still rely on for some ecosystem services. Farmers, mainly those who lived nearby the plantations, claimed that the Enterprise replaced the native trees with exotic ones during the establishment stage. Indeed, the manager of the Enterprise recognized the fact that in 1985 when plantations were established, the methods used in order to clear the site and facilitate the establishment of the plantations were tree clearing and burning. As he stated,

*"During the establishment of the plantations the methods used were cutting and burning the natural forest, replacing it with exotic tree species. I think that had a negative effect on the natural forest.*

## Economic effects

The establishment of plantations on farmlands led to a loss of agricultural land for some of the interviewed farmers (5 out of 20). Mainly those who lived near the plantations (4 out of 10), reported that they lost part of their land during the establishment stage. One farmer raised the issue that they lost their farmland without any compensation. It should be mentioned, though, that two farmers who lost their agricultural fields admitted that their perception towards plantations changed over the years. Specifically, they argued that at the establishment stage they had a negative perception of the plantations but with time realized the value of the forest plantations and the derived benefits such as firewood and grazing.

The data show that plantations affected farmers' livelihoods via employment opportunities. Based on the discussion with the manager of AFE, farmers participated and worked in activities such as planting, pruning, thinning and logging. It was observed that households situated closer to the plantations were more involved in such activities compared to those located at a distance from the plantations. However, farmers complained about the employment opportunities which were very few, for a short period of time, with low salary and hard working conditions. Farmers also raised the issue that the Enterprise preferred to hire workers from their employees' extended families and not from the farmers who lived around the forested area.

Another effect of plantations on farmers' livelihoods resulted from the operations of the Enterprise. Incentives were given to the farmers with the view to encourage and motivate them to start planting trees on their land. For instance, the Enterprise offered tree seedlings of *Eucalyptus, Cupressus* and avocado to the farmers free of charge or for sale at a reduced price. Indeed, the majority of the interviewed farmers (17 out of 20) stated that they established their private small-scale plantations from tree seedlings provided by the Enterprise. As a result, farmers achieved to meet part of their needs of wood by the trees grown on their own land. In many cases, they even sold timber products originating from their private plantations and therefore increased their income.

The households situated far from the plantations (6 out of 10) had the view that the plantations had no effects on their livelihoods. Those farmers argued that they did not lose their land, had no problems with wildlife and that they only occasionally went to the plantations to collect firewood.

**Table 7**. Farmers' answers with regard to the effects of plantations on their livelihoods according to household location and gender. Female (F) and male (M)

| **Effects of *C. lusitanica* and *E. saligna* on farmers' livelihoods** | **Households closer to the plantations** | | **Households distant to the plantations** | |
|---|---|---|---|---|
| | **F** | **M** | **F** | **M** |
| *Effects related to the management of the plantations and operations of AFE* | | | | |
| Collection of branches, leaves, sticks, seeds | 5 | 4 | 3 | 4 |
| Livestock grazing | 5 | 3 | - | 2 |
| Motivation for on-far tree plantings | 2 | 3 | 1 | 1 |
| Provision of wood | 1 | - | - | - |
| Farmers needs are not considered | 3 | 5 | 2 | 5 |
| Farmers' disagreements with Enterprise | 4 | 3 | 1 | 2 |
| *Environmental Effects* | | | | |
| Crop destruction by wildlife | 3 | 3 | 1 | 1 |
| Better climatic conditions | 2 | 2 | 2 | 2 |
| Shelter | 2 | 1 | 1 | - |
| Aesthetic value | - | 2 | - | - |
| Replacement of native trees with exotic tree species | 2 | 2 | 1 | 2 |
| *Economic effects* | | | | |
| Loss of agricultural land | - | 4 | - | 1 |
| Employment | 1 | 3 | 1 | 1 |
| Tree seedlings or seeds from the plantations | 4 | 5 | 4 | 4 |

## The role of Munessa-Shashemene natural forest on farmers' livelihoods

The information, gathered by the 20 households, reveals that farmers were still dependent on the natural forest which contributed to their livelihoods in various ways.

The results from the interviews show that natural forest was an important source of timber products. Almost all of the interviewed women (9 out of 10) stated that collected firewood from the natural forest was necessary(?). According to the respondents, natural forest also provided farmers with high value construction wood. Native trees, such as *Juniperus procera* and *Podocaprus falcatus* were suitable for hut construction, agricultural tools or furniture. Shrubs were also collected from the natural forest and used to tie things. The natural forest role was also valuable for grazing. Specifically, most of the farmers who lived close to the plantations and natural forest indicated that they grazed their livestock in the above forested sites.

The results from the interviews also show that natural forest had an economic value for the households. Farmers not only saved income by collecting timber products (construction wood) that otherwise must have been bought from the local wood market but they also generated income by selling timber products (firewood) provided by the natural forest. The data from the interviews also indicate that farmers relied more on the natural forest especially in periods when food was scarce. As a female-farmer said,

*"When the crop yield is not enough, we use the natural forest to generate income".*

The environmental value of the natural forest was also raised during the interviews. Some farmers (7 out of 20), stated that natural forest *"attracts rain"* and overall created better climatic conditions. One man mentioned the aesthetic value of the natural forest while a woman raised the importance of natural forest for providing the farmers and their livestock with shelter.

# Discussion

## Long-term effects of forest plantations on SOC

Nearly 30 years have passed since the establishment of the *C. lusitanica* and *E. saligna* plantations in Lepis and the current results showed that SOC has increased under the reforestated site resulting in a net C sink. In 2001, when *C. lusitanica* was 15 years old and *E. saligna* was 17 years old, the results showed that the amount of C stored in the top 10 cm soil layer had the order: *C. lusitanica* > NF > *E. saligna* > TF > MF. After 10 years, the amount of C accumulated under forest plantations and natural forest had increased whereas a decrease in SOC was observed for the farmlands. Despite the changes in the amount of C stored under the different land uses over the 10-year period, the above land-use order remained the same.

The study showed that reforestation of mechanized farmland with *C. lusitanica* and *E. saligna* plantations led to a net accumulation of SOC. At the 0-20 cm soil depth the *C. lusitanica* and *E. saligna* plantations had 70 % and 39 % respectively higher SOC storage compared to mechanized farmland. According to Laganiere, *et al.* (2010) there is a higher potential to increase SOC when trees are planted on an agricultural land (26 %) in comparison to pasture land (3 %) or grassland (less than 10 %). Also, Guo and Gifford (2002) estimated an increase of 18 % of SOC when a farmland is converted to plantation. However, there are also studies showing that afforestation carried out on agricultural land caused a significant reduction in SOC (Neufeldt *et al.,* 2002) or only had a minor effect even after several years since the establishment of plantations (Smal and Olszewska, 2008).

The difference in SOC observed between *C. lusitanica* and *E. saligna* plantations indicated that SOC was influenced by the type of tree species. This is also confirmed by Lemma *et al.* (2007) who studied the factors that affect the SOC sequestration under different exotic tree plantations which were established on abandoned arable land and grown under the same environmental conditions. Lemma *et al.* (2007) found that over a 20 year-period, *C. lusitanica* had the highest SOC (32.8 Mg $ha^{-1}$) followed by *P. patula* (26.3 Mg $ha^{-1}$) and *E. grandis* (18.1 Mg $ha^{-1}$). They attributed the highest SOC found under *C. lusitanica* to the higher total litter production and in particular the amount of woody litter which has a slower decay rate than leaves and fine roots. They concluded that the litter quality and the differences in the microclimatic conditions contributed to a smaller extent to the differences observed in SOC among the tree species.

In the present study, *C. lusitanica* at its maturity age (25 year-old) was found to sequester a significantly higher amount of C than *E. saligna* and slightly higher than natural forest in the top 10 cm soil layer. This is in agreement with Abate (2004) who reported greater amounts of SOC under *C. lusitanica* compared to natural forest and *E. globulus*. The higher amount of SOC stored under *C. lusitanica* can be explained by the larger amount of litter biomass of *Cupressus* than *Eucalyptus.* What possibly could have made the difference in SOC between *Cupressus* and *Eucalyptus* was the larger quantity of branches and coarse root litter produced under *Cupressus* plantations (Lemma *et al.,* 2007; Abate, 2004). The lower amount of litter produced under *Eucalyptus* plantations in combination with the slow decomposition rate resulted in a lower amount of SOC.

On the other hand, the insignificant difference in SOC between *C. lusitanica* and *E. saligna* observed in the 10-20 cm soil depth can be explained by the similar root biomass of *Cupressus* and *Eucalyptus.* Abate (2004) estimated 107 kg/tree of below-ground biomass under *C. lusitanica* and 104 kg/tree under *E. globulus.* With regard to the decomposition rate of the total litter amount, the C:N ratios of *Cupressus* and *Eucalyptus* differed insignificantly which indicated the similar decomposition environment. However, *Cupressus* had a slightly lower C:N ratio which might indicate a somewhat faster rate of litter decay. Indeed, Lemma *et al.* (2007) found that the needles of *C. lusitanica* decomposed faster than the leaves of *E. grandis* while they reported a similar decomposition rate for the roots.

Changes in SOC over time were observed for the same tree species. In the current study, total SOC increased by 25 % under *C. lusitanica* and 20 % under *E. saligna* within a decade. Similarly, Lemma, *et al.* 2007, found an increase of 14 % in SOC under *Cupressus* accompanied by an 8 % increase in total biomass within a 2-year period. Based on data from several studies Paul (2002) in a literature review reported a decline in SOC at the initial stage of plantations followed by an increase which may lead to soil C sequestration in the long term.

The fact that SOC under *Cupressus* and *Eucalyptus* has increased with time has probably been reinforced by the stand management. The rotation period of *Cupressus* (25 years) and *Eucalyptus* (5-7 and 15 years) in combination with the silvicultural treatments (pruning, thinning) appeared to have favoured the stand productivity and thus probably enhanced the C inputs to the soil. However, it is important to note that *Cupressus* and *Eucalyptus* litter was considered as an important source of firewood for the farmers of the case study, who collect branches especially during pruning and thinning periods. Despite the extraction of woody litter, a significant net C accumulation was observed over the years.

With respect to the total SOC stock under the different land uses in the 0-20 cm soil depth, natural forest had a lower SOC compared to the plantations. This is due to the low amount of C found under the natural forest in the 10-20 cm soil depth, compared to plantations and farmlands. The current results of SOC for the 10-20 cm soil depth were similar to those obtained ten (10) years ago by Lemenih *et al.* (2004). The SOC of the natural forest in the 10-20 cm remained low over the decade and a possible explanation for this might be the low input of fresh carbon as is indicated by the low C:N ratio found in the deeper soil layer under natural forest. The natural forest site in this study is located close to the village which probably results in an intensive collection of litter for biofuel purposes.

## The effect of long-term agricultural management practices on SOC

Mechanized and traditional farmland had 23.5 % and 18.3 % lower SOC content respectively compared to the natural forest. During the last decade mechanized farmland lost 14 % (0.96 kg $m^{-2}$) of SOC while traditional farmland lost 2.8 % (0.18 kg $m^{-2}$) which indicates that the differences between the land uses are increasing. This is the case even if the SOC in the Andosol study is characterized by a relatively high resistance to soil degradation (Lemenih, *et al.,* 2008). The difference in the rates of C losses between these two farming systems is possibly attributed to the way that the natural forest was converted to farmland and the intensity of tillage (Lemenih *et al.,* 2004). The mechanized farmland was created by removing all the vegetation while the traditional field was created by cutting and burning the native trees and the ash contributed to the return of some of the soil nutrients. The intensity of tillage also differed as the field under mechanized agriculture was plowed by a tractor while the crop field under traditional agriculture was ploughed by an ox-plow.

## Livelihood activities adopted by the farmers in Lepis

The vulnerability context of the case study includes food insecurity, small size of agricultural land, decline in soil fertility, environmental shocks (drought, flood), shortage of wood, lack of off-farm and non-farm activities, reduced income and a population pressure competing for the limited natural resources.

Farmers appeared to have adopted a combination of farming activities to secure subsistence for themselves and their families. Livelihood diversification was the dominant strategy in order to tackle the problem of wood scarcity and food insecurity.

The farmers' investment in *Eucalyptus* tree plantings was aimed to cover part of their needs of firewood and construction wood. Especially in periods when the food crops became scarce, *Eucalyptus* proved to be an important "capital" as it was easily converted to cash money. Farmers covered different aspects of *Eucalyptus* cultivation. They established tree nurseries in their household yard, had a small number of *Eucalyptus* trees in their homestead or a small-scale plantation on or around their cropland.

The analysis of the data gathered by the interviews shows that farmers followed various ways with the aim to secure food crop production and the successful establishment of *Eucalyptus* trees. For instance, farmers preferred to grow *Eucalyptus* on their household yards rather than on agricultural fields. The reasons behind this preference were (1) the small size of their farmlands, (2) the higher risk of *Eucalyptus* theft when planted on an agricultural field at a distance from their homestead and (3) because they were aware of the fact that *Eucalyptus* could affect soil fertility negatively. Additionally, farmers used *Eucalyptus* as a live fence and tended to plant it on the borders of their farmland. In this case, in order to prevent the effect of *Eucalyptus* on agricultural crops they created a trench on their fields so as to avoid the penetration of *Eucalyptus* roots into the farmlands where food crops were grown.

It was also observed that farmers planted *Eucalyptus* extremely dense due to the small size of the land available for tree plantings. Farmers also tended to harvest their *Eucalyptus* when the trees were older than 5 years in order to generate a higher income as mature *Eucalyptus* trees were sold at higher prices compared to young *Eucalyptus*. However, in critical times, when food was scarce, farmers tended to diversify their income and harvest *Eucalyptus* at a younger age (< 5 years ) in order to generate a quicker return on cash.

However, the private plantations of *Eucalyptus* grown by farmers were not enough to meet their high needs in tree products. Farmers had to collect wood from other wood sources such as the natural forest and the forest plantations of AFE. Another common activity in which women were highly involved was the collection of firewood from the natural forest and trading it on the local wood market. This allowed the women to supplement the household income and in fact was considered a profitable self-employment way given the fact that firewood originated from the natural forest was sold at a higher price (45-50 birr) compared to Eucalyptus firewood (40 birr). Especially, when farmers had serious subsistence's problems, they illegally cut trees from the natural forest and/or forest plantations and sold the tree products on the local market.

The role of the Enterprise and the PA was important and influenced farmers to increase livelihood diversification. Aiming to reduce the illegal cuttings observed in the plantations and natural forest, the Enterprise and the PA motivated the farmers to engage in *Eucalyptus* tree plantings. They provided the farmers with incentives such as tree seedlings, training and technical advice. Thus, farmers were informed about where to plant *Eucalyptus*, how to manage it and when to harvest in order to achieve a higher income. The role of the PA was also significant because the PA provided the farmers with trade licenses which proved that the sellers traded wood originating from their private small-scale plantations and in this way the access to the market became easier.

**Figure 16.** Small-scale *Eucalyptus* plantations planted too densely.

**Figure 17.** Trade of firewood collected from the natural forest.

## Who benefits more from the *C. lusitanica* and *E. saligna* plantations?

According to Ribot and Peluso (2003), access is *"the ability to benefit from things"* while property is defined as *"the right to benefit from things"*. The difference lies in the meanings between ability and right. Access is a broader definition which includes the term property as an individual can benefit from things without holding the property rights.

The Access to the *Cupressus* and *Eucalyptus* plantations provided the farmers with an ability to derive benefits from it. Following the above definition, access to the forest plantations was a question of power rather than property for the farmers. The distinction between access through property and access through power was evident when comparing the case of farmlands and forest plantations. Villagers got access to their farmlands by holding the user-rights of their land (property) while they could get access to forest plantations and natural forest through power. On the other hand, the Enterprise had access and derived benefits from the forest plantations through property. Differences in power could be observed between the farmers and more specifically between male and female farmers and those who lived near and far from the plantations.

Land was a key livelihood asset for the farmers and every stakeholder wanted to maintain their land-holdings, gain land and control the access to it. Land, both agricultural and forested was an integral part of the farmers' livelihoods and played a significant role in building a resilient and sustainable livelihood. Consequently, a land use change from agricultural to forested land and vice versa inevitably had effects on their livelihoods. For instance, the fact that some of the farmers (5 out of 20) lost part of their agricultural land when the plantations were established worsened their problem of food insecurity and caused a decline in their income. On the other hand, the trend of on-farm *Eucalyptus* plantings managed by farmers proved to supplement their income and improve their livelihoods.

On one hand, the Enterprise controlled the access to the forest plantations and natural forest and on the other hand farmers wanted to maintain access or gain access illegally. The Enterprise controlled the access to the plantations of *Cupressus* and *Eucalyptus* via laws and forest guards. The Enterprise derived benefits from the plantations as it secured the productive capacity and the profits of the company.

The example of prohibition to grazing in the young *Eucalyptus* plantations pictures in a better way who was more powerful and benefited more from the access to the land. Forest guards controlled the access and banned the grazing in the young plantations of *Eucalyptus* in order to secure the successful regeneration. On the other hand, farmers wanted to gain access to the young *Eucalyptus* plantations and graze their livestock. As a result, conflicts often emerged between guards and farmers. This example illustrates that the Enterprise and the forest guards had more power compared to farmers hence, had more access and derived more benefits from the land. This is a case of unequal distribution of benefits.

Furthermore, it can be stated that differences in power were observed between farmers. For instance, households situated far from the plantations did not benefit in the same way compared to those households located near the plantations. With regard to grazing, farmers who lived far from the plantations reported that they grazed their cattle at other grazing sites due to the fact that the cattle were not healthy and strong enough to walk such a long distance. Another difference in power was also observed between the farmers. Those who lived far from the forest plantations benefitted less as they did not know when the thinning and harvesting period started in order to collect the branches. Those farmers mainly covered their needs for firewood from the natural forest and the trees grown on their own land.

Based on the results it was observed that farmers maintained access and benefited from the forest plantations and natural forest either legally or illegally. The company controlled the access and made the laws which defined which activities were allowed and which were banned in the plantations. Farmers could maintain access to the plantations when following the rules or gain access to the plantations when acted against the rules. For instance, farmers maintained access to the forest plantations when grazing their livestock in the mature stands and collecting firewood. However, farmers gained access to the plantations when they illegally cut trees from forest plantations or grazed their livestock in the young stands of *Eucalyptus*.

A difference in access was also observed between male and female farmers. With respect to illegal access, male farmers were more powerful compared to women as they were physically stronger and gained access by cutting and carrying trees from the natural forest and plantations to their households. Particularly, the female-headed households were the most powerless as they did not have the skill and strength for making illegal cuttings. Additionally, male farmers maintained more access to the plantations and derived more economic benefits compared to women in terms of labor opportunities. However, the Enterprise was the one that controlled the access to the labour opportunities while the farmers were those who wanted to maintain access to employment with the view to increase their income.

Access to land available for tree plantings was an important livelihood asset for the farmers to carry out *Eucalyptus* planting. Farmers who had more access to land could plant more trees thus, derived more benefits and had more chances to improve their livelihoods. Shortage of land was the main obstacle preventing farmers from planting more trees. Based on the results it can be stated that small landholder farmers were the most disadvantaged as they did not have land available for more tree plantings. Moreover, the female headed households were less powerful due to the fact that they had lost their husbands and they did not have enough strength and skill to increase their planting of *Eucalyptus* even if they had land available for tree plantings.

## REDD+ perspective

If we assume that the plantations of *Cupressus* and *Eucalyptus* belonged to a REDD+ project we can clearly see that the plantations managed to enhance C stocks in the study area. However, there could be a problem of leakage. Leakage in the context of the REDD mechanism was defined in the Bali Action Plan and occurs *"when an enhancement of C can be achieved in an area that belongs to a REDD project but at the same time there is a source of C in a forest area which is outside the REDD project area"* (Angelsen, 2008). In Lepis it will be difficult to prevent leakage of C as illegal cuttings are still ongoing in the adjacent natural forest due to the high need for timber products and agricultural land. The establishment of the plantations in combination with the control through guards is likely to have increased the pressure on the natural forest and resulted in deforestation. The key driver of leakage in a REDD+ project is the deforestation for agricultural purposes (Angelsen, 2008). This is an important aspect in a country like Ethiopia where there is a high rural population density and low agricultural productivity. The leakage of C originating by the land use change from a natural forest to agricultural land is difficult to be prevented unless agricultural intensification can be achieved and more land set aside for tree plantation. However, the spontaneous plantation of *Eucalyptus* and other tree species on the small-holder farmland is an activity that might counteract leakage.

# Conclusion

Based on the results it can be concluded that:

- The land use change from mechanized agriculture to plantations created a C sink in the study area.
- The plantation of *Cupressus* was more suitable to sequester SOC than *Eucalyptus* plantation. However, *Eucalyptus* plantations also had positive effects on SOC which increased with time.
- Natural forest had a lower total C stock (0-20 cm) compared to forest plantations. At the same time, natural forest was more attractive to farmers compared to forest plantations. Especially in uncertain times of their livelihoods, farmers generated income through selling timber products collected from the natural forest in order to maintain subsistence for themselves and their families.
- The establishment of forest plantations created a C sink but appeared to have failed to fulfill the objective with regard to the protection of the natural forest. Illegal cuttings and trading of timber products originating from the natural forest were still ongoing in the study area.
- The establishment of forest plantations had different effects on farmers' livelihoods. The household's distance from the plantation area contributed to this. The group of farmers who lived closer to the plantations was affected more due to the establishment of plantations than those who lived further away from the plantations. However, those farmers who lived near the plantations had easier access to collect firewood and graze their livestock and had more job opportunities and access to shelter and got inspired to start on-farm tree plantings. On the other hand, they also had to face problems associated with the plantations such as loss of agricultural land due to the plantation establishment, crop destruction by wildlife and conflicts with the forest guards.

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# Appendices

**Appendix 1. Questionnaire used for households' interviews**

Effect of forest Plantation on Soil Carbon Sequestration and on farmers' livelihood: A case study in Ethiopia.

Questionnaire for semi-structured interview with the farmers

The target group of the specific questionnaire is the farmers who live in households located either relatively close to the plantations or at a distance from the plantation area. The aim of the questionnaire was to assess the farmers' perception towards plantation projects and get a deeper understanding of if and how their livelihoods have been affected by the plantations.

Questionnaire Number: _________

Date of Interview: ___________

Interviewer: ______________________________

Translator: ______________________________

**A. Introduction**

My name is Anatoli, a student at the Swedish University of Agricultural Science. In the context of the Master's thesis I am carrying out a survey on the plantations and the farmers' perceptions towards the plantations and the Natural forest. Information is necessary in order to understand if and how the plantations contribute to farmers' livelihood. I would like to inform you that a recorder will be used during the interview in order to keep track of the given answers. Please, feel free to answer any question(s) as well as do not answer any question(s) that you do not feel comfortable with. All the answers will be kept confidential.

Code of respondent Household: ________________________________________

GPS Coordinates of respondent Household: ______________________

**B. General Information**

1. Sex: Female Male

2. Age: ________

3. How many people live in this household? ____________

4. Number of Adult Females _____ Adult Males ____

5. Children (<18 years) Number of Boys ____ Number of Girls ____

6. What are your main farming activities to generate income?

______________________________________________

______________________________________________

7. Do you participate in any off-farm activities in order to secure income and cover your family needs?

______________________________________________

______________________________________________

8a.Do you have land to farm? Yes No

8b. If yes, what is the approximate size of your farmland that you have in total?

______________________________________________

8c.size of the farmland that you cultivate

☐ Crops ☐ trees

☐ Grazing ☐ others

9. What crops do you cultivate in your farmland and/or garden?

______________________________________________

______________________________________________

**C. Tree growing issues**

1a. Do you have trees in your land (garden and/or farmland)? Yes No

1b. If yes, what kind of trees do you have in your land (garden and/or farmland)?

2a. Do you plant trees in your land (farmland and/or garden)? Yes No

2b.If yes, what kind of trees do you prefer to plant? Please, justify your answer. Have you ever planned any eucalyptus or cupressus?

2c. If No, are you interested in planting trees? Why are you interested in?

3. Where do you prefer to plant trees?

4. Where did you get the tree seedlings from planting these trees?

5. Do you get any benefit from the trees that you have planned? How do you use these trees, what are the uses for these trees?

6. What did motivate you to plant these trees? (is it for commercialization or for subsistence use or both)

7. When do you feel that you can use trees for your needs? Do you feel freer to cut trees from your homegarden or your farmland?

8. Do you think that you plant more or less trees now than you did 10 years ago?

9. Where do you get your firewood to cover your needs?

10. Do you buy or do you sell wood or both?

11.Do you get any income from selling tree products? Yes No

If yes, how important is your income generation from selling tree products?

Very Important Important Less important Not important

**D. Land Tenure issues**

1. How did you get access to your farmland?

2. Do you have any documents that prove that you own the land that you farm?

Yes No

**E. Plantations**

1. Could you tell us if you get any benefit from the plantation? If yes, what are the benefits that you get from the plantation?

2. What type of activities are you allowed to do in the plantations?

2a. Are you allowed to collect any materials from the plantations? Yes, No

If yes, what type of materials?

3. Do you get any other benefit or any productive function from the plantation?

4. Do you cut trees from the plantation for immediate use?

Yes No

5a. Do you think that the establishment of plantations has affected your livelihood? Positively and/or negatively? Please, justify your answer

5b.Could you tell us if the plantations have had any impact on the way you use the land?

6. Are you satisfied with the benefits that you get from the plantations? Yes No

If No, please justify your answer.

**E. Shashamane Forest Industry Enterprise**

1. Has anybody of the household been employed by the industry permanently or in a short period**?** Yes, No

2a. Do you agree with the way that the plantations are managed? Yes No

2b. If no, can you propose any other way?

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3. Do you think that your needs of the community are taken into consideration by the existing forest management? Yes, No

4a. Have you ever had any disagreement with the Industry? Yes No

4b. If yes, what was the main reason?

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4c.If possible, would you be interested in working in activities related to plantations project? Yes, No

Please, explain your answer.

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5. What role would you like the Arsi Forest Enterprise to play in your community?

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**F. Munessa Shashamane Natural Forest**

1. Do you get any benefit from the natural forest? If yes, can you give some examples?

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2a. Do you think that the Munessa shashamane natural forest is decreasing or increasing?

2b. If yes, what do you think are the main reasons for increase or decrease?

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3a.Does the community has any influence on the management of the natural forest?

3b. What is the role of the community in the management of natural forest?

**G. Additional comments**

**Thank you very much!**

## Appendix 2. Questionnaire used for the interview with the Arsi Forest Enterprise

***Questionnaire for semi-structured interview with the main representative of Arsi Forest Industry Enterprise***

The focus of the questionnaire is to assess the Shashamane Forest Industry Enterprise attitude towards the plantation and evaluate if and how the Industry interacts with the Local population.

Date of Interview: ___________

Interviewer: ______________________________

Translator: _________________________________

**A. Introduction**

My name is Anatoli, a student of the Swedish University of Agricultural Sciences. In the context of my Master's thesis I am currying out a survey on the plantations and the farmers' perception towards the plantations and the Natural forest. Information is necessary in order to understand if and how the plantations contribute to farmers' livelihood. I would like to inform you that a recorder will be used in order to keep track of the given answers. Please, feel free to answer any question(s) as well as do not answer any question(s) that you are not comfortable with. The answers will be kept confidential.

Name of Industry's representative: ______________________________

GPS Coordinates of the Company: ______________________________

**B. General Information**

1. When did the Industry become establish? ______________________________

2. Total Number of staff: ________

Number of Males: ________ Number of Females: ________

3. How many ha of plantations are under the management of the SFIE?

______________________________

4. How many hectares are the plantations of *Cupressus lusitanica* and *Eucalyptus saligna*?

______________________________

5. How many hectares of *Cupressus lusitanica* and *Eucalyptus saligna* plantations belong to Munessa-Shashamane natural forest?

______________________________

6. How is the ownership of the company? State and/or private?

______________________________

7. Is the land where the plantations have been established owned by the company?

8. What kind of forest products do you produce?

______________________________

9. Where and to whom do you sell the products?

10. What is the productive capacity of the Industry?

**C. Plantations**

1a. Do you follow a specific forest management plan for the plantation? Yes, No

1b. If yes, would you like to describe what is the management plan that you follow?

2. What activities are allowed to do in the plantations?

3. Do you have any problems in terms of illegal logging or any other human disturbing activities?

4. What measures have you taken to protect the plantations? Are they effective?

5. What are your criteria to employee guards or workers for working in activities related to the plantations?

6. Do you offer a permanent or short period job opportunities to the guards?

7. What benefits do you think that the plantations and the industry offer to the local community?

8. Do you give any kind of incentives to the local community in order to embrace the plantation?

9a. Do you think that due to the establishment of plantations farmers have been motivated to plant more trees on their farm or garden? YES , NO

9b. If yes, do you support such kind of activities and in which way?

**D**. **Munessa Shashamane Forest**

1a. Do you follow a specific forest management plan for the natural forest?

Yes or No?

2. What activities are  allowed to do n the natural forest?

3. Do you think that the natural forest still continues to decline? Yes, No

.If yes, what do you think are the main reasons for the forest decline?

4. Do you think that the establishment and operation of plantations has had any kind of impact on the natural forest? Please, give reasons for your answer.

5. What do you do to protect the natural forest?

**E. Local community**

1. Have you ever had any disagreement with the local community? Yes, No

If yes, what is the most common reason?

2. Are you interested in establishing a REDD project in the area in order to protect the natural forest?

**F. Comments**