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SCHOOL OF GRADUATE STUDIES

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By

Solomon Bekele Kebede

Center for Population Studies
Institute of Development Studies

Approved by the Examining Board

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Abstract

Ethiopia, as in many sub-Saharan African countries is undergoing extensive environmental degradation. This is manifesting itself through rapid deforestation, thinning of tree cover, soil erosion and declining soil productivity. Various explanations have been given for the causes of such degradation. Among the causes, the population growth-environment nexus has been extensively debated. As a result, contrasting views, i.e., the "Malthusian" and the "Boserupian" emerged. Similarly land degradation in sub-Saharan Africa is a subject of an on-going debate. Conflicting perspectives emerged on the effects of increasing population on land degradation. The bulk of literature emphasizes that land degradation is caused mainly by population pressure and several related issues, while a recently growing literature views population pressure as an important resource for conserving the environment through enhancing intensive farming of the agroforestry system.

The thesis aims at analyzing important components of the Gedeo agroforestry system namely IK, inclusion of varied large trees and crop diversity on household farms in the face of intense demographic pressure. The potential effects of demographic variables on the IK of agroforestry system, inclusion of diverse large trees, and the diversity of crops is analyzed by setting out three specific objectives. Data obtained from a survey of 420 sample households, Focus Group Discussions and Key informant interviews in 4 kebeles of Yirgachaffe woreda is employed for the analysis. Regression models are estimated to analyze the potential effect of demographic variables on IK of agroforestry practice, and the relationship between demographic variables and the inclusion of diverse large trees in croplands and to identify variables that explain the farm level crop diversity.

Results indicate that demographic pressure through a positive influence on the components of the agroforestry system, namely, IK system of the community, inclusion and conservation of more diverse large trees in croplands, and diversity of crop species on household farms is likely to enhance environmental conservation and agricultural production in the Gedeo setting. Hence, the intriguing question of how the study area is able to accommodate the high population density without facing serious environmental issues finds part of the explanation from the evidence that population pressure enhances the key environmental components of the agroforestry system.

This suggests that taking action to devising a way of transferring IK from the bigger sized and older households to the smaller sized and younger households, enhancing information and input sharing on the management of diverse large trees, and raising the capacity of small sized and female headed households is a useful strategy to enhance the important components of the Gedeo agroforestry system and thereby conserve the environment.

Chapter 1
General introduction

1.1 Background and problem definition

Ethiopia is situated in northeastern Africa, has a diverse climate and vegetation where traditional form of subsistence agriculture and pastoralism predominate. With an area of 1,133,380 km^2 (CSA, 2004) and a population size of 73,918,505 million (CSA, 2008), the country is the largest populous in sub-Saharan Africa next to the Nigeria (CSE, 1997). The successive national censuses of the 1984 and 1994 which were 39.9 and 53.5 million respectively (CSA, 2008) demonstrate a substantial increase in population size. The majority, i.e. 84% of the population live in rural areas with a natural resource based livelihood whereby agriculture is the mainstay (CSA, 2008).

Population growth causes increases in the demand for land both for dwelling and agricultural production which generally leads to fragmented land holdings (Bekele and Berhanu, 1998). With an average household land holding of 1.5 ha, smallholder farming is predominant in Ethiopia accounting for more than 95% of the total area under cultivation and 90% of agricultural production (EPA, 1998). The scarcity of arable land paved the way to the clearance of natural forests which results in forest and land degradation. In the early twentieth century about 35% of Ethiopia's land area and 66% including savannah woodland might have been covered with forest which has dwindled to 16% of the total land in the early 1950s (EFAP, 1994). Recently, the coverage is estimated to be 4.2% only (FAO, 2001). The clearing of forest cover gradually changed the scene and today the northern parts of the highlands are almost devoid of trees. Depletion of these resources have resulted in reduced agricultural productivity and subsequently in reduced quality of life. Views differ concerning the primary cause of such degradation.

The claim that the primary causes of natural forest destruction are increase in human and livestock population pressure and neglect of proper development and conservation policy of land based resources (Mersie, 1990; EPA, 1998) is rooted in the Malthusian theory (Malthus, 1798). As a result, large areas of the country are exposed to serious loss of soil fertility and degradation which has brought the country to its current plight of recurrent droughts and massive famines. Other scholars, basically extending from Boserupian notion of population as a positive force for environmental conservation (Boserup, 1965) provide a different explanation for the indicated scene. For instance, Becker (2005) indicates that the size and rate of population growth determines the rate at which production and investment must grow. He stresses that increase in population size directly influences economic activity by determining the potential number of producers and consumers in an economy.

The human response to land scarcity is reflected in the adoption of more productive tools which are used to intensify land and labor usage (Findlay and Findlay, 1987). In line with this, there is a recently growing attention towards long term sustainability and environmental consequences of the intensification of agricultural systems including integrated agriculture (Tesfaye, 2005).

In the midst of integrated agriculture, extended areas of traditional agroforestry exist in the south and southwestern parts of Ethiopia. This agroforestry system has been stable for centuries supporting very dense population of up to 700 persons/km^2 (Tesfaye, 2005), and in some cases going as high as 1,115 persons/km^2 (GZFEDD, 2008). In such settings, people, through accumulation of experiences and close understanding of the environment for a long time develop indigenous knowledge to respond to survival challenges. The development of indigenous knowledge, covering all aspects of life, including management of natural environment, has been a matter of strength to the people who generated them (SLUF, 2006). The traditional agroforestry practice in much of the southern Ethiopia has contributed for controlling the factors that degrade soil fertility in the northern part (Tadesse, 2002; Tesfaye, 2005). Traditional agroforestry is believed to enhance agricultural sustainability due to the intimate association between multitudes of crops, trees and livestock that provide various ecological and economic benefits (Tesfaye, 2005).

One of the most known traditional coffee-enset-tree agroforestry areas in southern Ethiopia is the Gedeo zone of the SNNPR. Tadesse (2002) found that the Gedeo agroforest contains an organized of mosaics of crops including annual herbs and medium-aged enset (10 years), coffee (30 years) and long living multi-purpose trees (>100 years) and shares more with natural forests whereby the people manage on a slightly modified and localized natural forests. This allows farmers to derive maximum benefits on a sustainable basis as different components at different phases of development provide continuous harvests.

The Yirgachaffee Arabica-coffee which is regarded as one of the best in the world is growing in a unique indigenous agroforestry system in Gedeo zone. The uninterrupted interplays between the diverse plants and animals sustaining healthy functioning of the system (SLUF, 2006) this system has contributed to improvements in food security, regional and national economies and environmental resilience (Pattanayak, *et al.* 1996). However, it has generally been less studied (Tesfaye, 2005).

The forest base of the Gedeo agroforestry consisting of indigenous trees, coffee, enset, annual and perennial crops is the mainstay of the people which enables them to develop indigenous knowledge of soil conservation and environmental management (Bekele, 2007). It is also indicated that the primary function of the Gedeo agroforestry is to produce foodstuffs as justified by the dominance of food plants through the high plant species diversity in their gardens some of which are of medicinal values (Fiseha, 2007).

Previous studies discussed above have provided explanation on the important characteristics and features of the Gedeo agroforestry system. However, insufficient attention has been paid to the important pillars of the integrated Gedeo agroforestry system, namely indigenous knowledge (IK) base, inclusion of diverse large trees and crop diversity as related to the existing demographic pressure. Little is known about the possible effects of the demographic, socio-economic and ecological variables on the different components of the agroforestry system.

Therefore, the purpose of the study is to analyze the links between demographic variables and the components of the Gedeo agroforestry system; namely IK, inclusion of diverse trees and crop diversity. This helps to obtain some empirical explanation for the claimed stability of the Gedeo agroforestry system in the face of increasing demographic pressure. Based on the findings, options for improving the Gedeo agroforestry system is highlighted.

1.2 Objectives of the study

1.2.1 General objective

The general objective of the study is to examine the response of the Gedeo agroforestry system to the existing demographic pressure. In the study, IK of agroforestry practice, incorporation of diverse large trees on croplands, and diversification of crops are analyzed in relation to demographic pressure, socio-economic and agroecologic variables. The IK of agroforestry practice, varied large trees and diversity of crops are considered to respond to the survival and economic needs of households and are important elements to conserve the environment in the context of demographic issues.

1.2.2 Specific objectives

1. To assess the potential effects of demographic variables on the IK of agroforestry practice.
2. To examine the potential effects of demographic variables on the inclusion of varied large trees on household farms.
3. To identify factors affecting crop diversity on household farms.

Data on the demographic variables (household size, age of the household head, sex of the household head, and migration status of the household) and IK of agroforestry practice is obtained from the household survey. The relationship between demographic variables and the IK of agroforestry practice is analyzed by estimating the logistic regression model. Data on the degree of inclusion of varied large trees on household farms is generated from the household survey. The potential effect of demographic variables on the inclusion of diverse trees is assessed by estimating the logistic regression model. Data on crop diversity is obtained from the household survey through counting useful crop species cultivated on the household farm. Data on the factors potentially influencing diversification of the agroforestry species is also obtained from the household survey. Identification of variables affecting crop diversification is conducted by estimating a multiple regression model.

To complement the quantitative analysis qualitative analysis is conducted based on data generated through focus group discussion and key informant interviews.

1.3 Rationale of the study

The study area is located in the southern highlands of Ethiopia. The land feature is mountainous gentle slope facing towards the Great Rift Valley (Tadesse, 2002), which is considered to be susceptible to degradation, under a different scenario. The Gedeos are settled, cultivating it and raising livestock on this land. The Gedeo zone has an average population density of 608 persons/km^2 and comprises one of the most densely populated woredas in the country, namely, the Wenago woreda with 1,115 persons/km^2 (GZFEDD, 2008).

Despite the high population density, the area is ever green, produces the world wide known organic Arabica Coffee and is unique for its intensified agroforestry system that preserves the natural ecosystem (Tadesse, 2002). It is therefore, appealing to explore the uniqueness of the interaction between the demographic pressures and the important elements of the Gedeo agroforestry system in order to understand the positive forces behind sustaining agricultural livelihood on the vulnerable landscape.

1.4 Significance of the study

The study provides insight into understanding the potential effects of demographic variables on the important components of the Gedeo agroforestry system. In doing so, it helps to see the role of demographic-agroforestry interaction in sustaining the livelihood of large population in the context of subsistence farming. The study also helps to identify factors that affect the functioning of the system both favorably and unfavorably as well as provides information to those who may be interested in conducting research in the area. The lesson learnt from the study provides useful input to inform policy through a better understanding of the Gedeo agroforestry practice in order to improve and strengthen the existing agroforestry system and indicate future directions.

1.5 Organization of the thesis

The paper consists of seven chapters. The second chapter provides review of literature and the conceptual framework of the study whereas the third chapter focuses on the study design and methodology. Chapter four deals with the estimation of the potential effects of demographic variables on the IK of agroforestry practice and Chapter five focuses on examining the potential effect of demographic variables on inclusion of diverse trees on croplands. Chapter six identifies factors affecting crop diversity on the farm. Finally, Chapter seven presents the general conclusions drawn from the study and indicates future actions.

Chapter 2
Literature review and conceptual framework

2.1 Population size and related theories

The relationship between population growth and environmental degradation are subjects of heated debate. The debate mainly takes place in two schools of thought: the Malthusian theory and the Boserupian theory.

2.1.1 The Malthusian Theory

The Malthusian theory argues that population growth is at odds with the earth's finite resources and nature's own ability to reproduce. Malthus (1798) maintains that population growth has a negative impact on the environment because it is the major source of depletion hence hunger, famine, increased poverty and conflict will result as people compete over declining resources. Malthus established his argument on the premise that "population when unchecked, increases in a geometrical ratio while subsistence increases in arithmetical ratio". This assertion was a turning point in the perception of the population-development linkage. Malthus further argued that population growth would be checked by a shortage of food (famine) and by the resulting increase in deaths (Malthus, 1798).

The neo-Malthusians recently suggest that "over population" happened to the underdeveloped nations of these days is a major hindrance of the efforts to get out of poverty. Saigal, (1973, in Daniel, 2008) stressed that the future pattern of socio-economic development in the third world countries will be determined mainly by demographic factors.

2.1.2 The Boserupian theory

Boserup (1965) argues that population growth leads to intensification and increasing productivity. Boserup establishes her argument on the premise that growing population triggers economic and technological innovation and improvement and hence the population-environment link is a positive one. She further explains that resources will not be over-used but will be used more efficiently with technology playing a key role and hence population growth rather than being an obstacle to economic growth is actually a precondition for agricultural development.

Findlay and Findlay (1987) concludes that unlike the Malthusian, the Boserupian focuses on the question of how population growth affects agricultural production in contrast to agriculture limiting population growth. They take population as independent variable and claim it to be positively correlated with the dependent variable, technological development in agricultural production. The human response to land scarcity is reflected in the adoption of more productive tools which are used to intensify land and labor usage. A related note states that Boserupian should not view soil fertility as fixed and given by nature, instead, can be improved by substituting the agricultural technology to a better one, which is likely to be a result of an increase in population (Braggion and Abramitzky, 1995).

Opposite to Malthus who decided that the productive opportunities are always fully exploited, Boserup maintains that the intensity with which farmland is cultivated is not limited but the state of knowledge of how to increase land productivity can also be raised by increasing the working time (Weisdorf, 2003). Large population includes sufficient labor force to engage in highly specialized agricultural production and in value-adding production which sufficiently supplies many consumers (Weber and Regmi, 2000). In line with this, Turner (1996) indicates that population growth is the central source of demand driving intensification of cultivation, particularly among subsistence and peasant producers. He further elaborates that in the Boserupian perspective the state of technology determines the level of cropping intensity by which much of this technology is endogenously driven. Concerning the population-resource nexus, Terefe (2001) argues that it is neither population nor its growth rate and density that matters in resource use and abuse. Rather, it is the capacity of the resource base, the technology, and socio-economic and institutional factors that lead people to make decisions on how to use resources.

2.2 Agroforestry

Agroforestry is a modern name for an age-long land use management combining trees with other crops and/or animals. Agroforestry systems are dynamic ecologically based sustainable land management, involving a deliberate retention of trees in farm or rangelands so as to optimize the benefits from diverse tree-crop-livestock interactions that increases and sustains the overall production of land the management practices of which are compatible with the cultural practices of the local population (Nair, 1989; MacDicken and Vergara 1990; AFTA, 1997; ICRAF, 1997).

Examples of agroforestry systems include alley cropping, multilayer tree gardens, intercropping of trees on pasture or cropland, live hedges, and shelterbelts (Schroeder, 1995). All these systems have certain elements in common i.e., a deliberately selected tree species are included in the farms or range lands to promote production activities.

Sub-Saharan Africa is undergoing extensive environmental degradation manifested as rapid deforestation, thinning of tree cover in wooded fallow, the creation of grasslands, soil erosion, and nutrient depletion and declining soil productivity (UNEP, 1985). The same source explains that these aspects have arisen mainly from short-sighted exploitative farming methods with limited development efforts and sustenance perspectives. However, in some areas of the region, traditional farmers have already been responding to the need of sustaining production through the traditional agroforestry system (Jeffrey and Schroth, 2005). Responses include production by selectively incorporating multipurpose woody species which they consider useful and effective in enriching the production system. The positive role of agroforestry system includes cycling substantial amounts of organic matter in the form of tree pruning which is returned to the soil, the potential to conserve soil carbon, retard degradation and promote sustainably of soil fertility (Schroeder, 1995). Soil organic matter provides additional exchange surfaces that are critical for nutrient retention (Cerri, *et al.* 1991). Traditional farmers in the tropics have developed a wide range of agroforestry and soil conservation strategies to adapt their crop and livestock production systems with the marginal conditions of their lands, to minimize climatic risk and increase household food supply with inherently accumulated indigenous knowledge (Edouard, 2001).

Thus traditional agroforestry systems consist of an integrated system of diverse crops, trees, livestock and soils, which are basically operated through the indigenous knowledge of the people. This study focuses on the practices of indigenous knowledge, inclusion of diverse trees and crop diversity as important components of the agroforestry system in the study area.

2.2.1 Indigenous knowledge (IK) of agroforestry practice

IK is a knowledge that is unique to a given culture or society unlike the knowledge gained at formal institutions (SLUF, 2006). It is a result of many generations, long years experience, careful observations and experiments that developed in the process of interaction of humans with their environment in a given culture (Alcorn, 1984; Martin, 1995). The development of indigenous knowledge systems, covering all aspects of life, including management of natural environment, has been a matter of survival to people who generated them, hence, people of different localities have developed their own specific knowledge on resource use, management and conservation (Cotton, 1996).

The IK practice in agroforestry systems incorporate locally based species and techniques that have been used traditionally for many generations and in some cases for thousands of years. Due to farmer experience and acceptance over many decades, such traditional knowledge based systems provide a strong, locally based framework for future agroforestry development (Thaman and Whistler, 1996; in Wilkinson, *et al.* 2000). By combining production with conservation and land improvement techniques, the agroforestry approaches can increase the acceptability and adoption of sustainable practices (Young, 1997, in Wilkinson, *et al.* 2000).

2.2.2 Inclusion of diverse large trees on farmlands

Trees in the agroforestry systems have important uses such as holding the soil against erosion, retard degradation and improving soil fertility by fixing nitrogen or bringing minerals from deep in the soil and depositing them by leaf-fall and conserve soil carbon (Martin and Sherman, 1992). Also perennial multipurpose crops provide a flow of benefits which includes construction materials, food for humans and animals, fuels, fibers, and shade over a long period of time. Moreover, trees protect crops from wind damage, soil from wind erosion and helps maintain microbial activity. The shade keeps top soil cool and protected from drying; the root systems reduce nutrient leaching, bind soil, and prevent erosion; the leaf litter enhances soil physical, chemical, and biological conditions which make soil more resistant to erosion and more able to absorb and hold water (Wilkinson, *et al.* 2000). Likewise, trees provide habitat for birds, insects and other animals that help maintain pest/predator balance in the system and thus reduce the need for pesticides.

Agroforestry that included fuel wood production are consistent with current land use and thus have the greatest potential to accumulate carbon (Unruh, *et al.* 1993). Trees store carbon from the air, helping to reduce CO_2 pollution and global climate change (Wilkinson, *et al.* 2000). Agricultural lands are believed to be a major potential sink for large quantities of carbon if trees are reintroduced to these systems and managed together with crops and/or animals. Thus, the importance of agroforestry as a land-use system is receiving wider recognition not only in terms of agricultural sustainability but also in issues related to climate change and CO_2 mitigation (Albrecht and Serigne, 2003). Overall, the socio-economic and cultural benefits of tree systems have long been recognized particularly among the highly populated traditional societies.

2.2.3 Diversity of crops on the farm

One of the typical features of tropical agroforestry system is the high diversity of component species. In such system there is a great diversity in the types of trees, shrubs, vegetables and crop species, animals, as well as in the spatial arrangement of these components (Mergen, 1987). Multistoried cropping systems intercept and use sunlight at all levels (Wilkinson, *et al.* 2000).

The high diversity of species in agroforestry, which combines crops, trees and animals having different uses and production cycles, is considered as an essential component of sustainable agriculture (Herzog, 1994) because of the wide socioeconomic and ecological roles it plays in these systems. A successful agroforestry system allows synergistic interactions between woody and non-woody components to increase sustain, and diversify total land output (Swaminathan, 1987). Diversified household food sources and balanced nutritional diet is derived from multitudes of herbaceous and woody plants and animal products throughout the year. Moreover, mixed cropping systems help to reduce dependence on purchased products and resources, and thus reduce vulnerability to changing market conditions (Wilkinson, *et al.* 2000).

2.3 Demographic pressure and agroforestry systems: the nexus

The environment-population nexus in sub-Saharan African countries is a subject of competing views. For example, land degradation is more severe in areas with high population density in sub-Saharan Africa (FAO, 2001) and particularly population increase in East Africa is linked with increase in land based resources degradation (Woomer and Muchena, 1993; in Muchena, *et al.* 2005). It is also said that the northern highlands of Ethiopia have been facing repeated environmental crisis associated mainly with population pressure driven deforestation and continuous tillage that cause soil degradation and drought (Amede, *et al.* 2001; Holden, *et al.* 2005). Others view population increase as an important resource for conserving the environment through intensive farming (e.g., Boserup, 1965; Chew, 2001; Regmi, 2003).

Population growth, increasing economic needs, environmental degradation and shortage of arable land altogether make the development of sustainable and efficient agricultural system crucial. Traditional agroforestry systems have evolved with time in response to population pressure and depletion of non-renewable resources from extensive (hunting, pastoralism and shifting cultivation) to more intensive forms of land use systems (Chew, 2001; Arnold, 1997 in Regmi, 2003; Egger, 2005). Agroforestry practices can improve productivity and reduce inputs, while mitigating some of the environmental damages caused by the past processes of deforestation and the removal of trees from the landscape (Wilkinson, *et al.* 2000). It is indicated that although average land holdings are as small as below 1 ha, agroforestry systems make maximum use of the land such that the level of productivity depends on the potential and the degree of management of the resource base (Sharma and Sharma, 1993; Regmi, 2003).

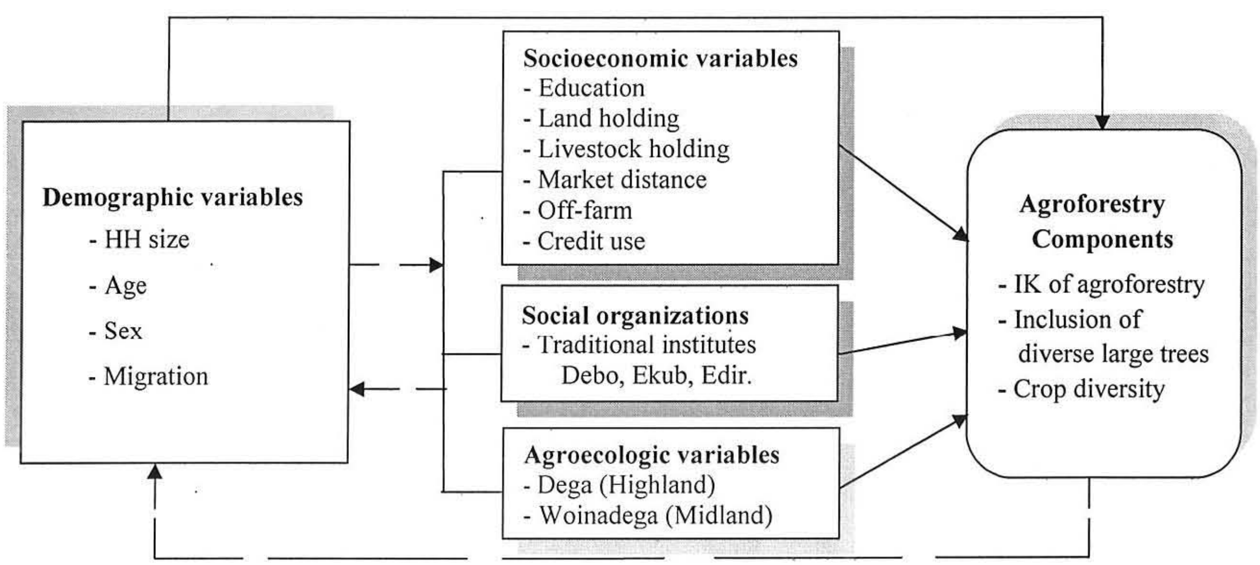
Agroforestry systems, beyond their importance of increasing land productivity, also increase the carrying capacity of land in order to accommodate large population. Agroforestry land use systems in tropical Africa came as a response to increasing population pressure and support a high population density of up to 400 people/km^2 (Egger 2005). A carrying capacity of about 500 persons/km^2 for well-managed homegardens (Fernandes, *et al.* 1989; Tadesse, 2002), and in some cases even up to 700 persons/km^2 (Nair 1993) has been reported. Parts of East Africa such as the Lake Victoria basin support some of the densest rural populations in the world i.e., 500 - 1200 persons/km^2 (Hoekstra and Corbett, 1995).

The population density of agroforestry based livelihoods of the Gedeo zone in Ethiopia goes as high as more than 1000 people/km^2 (GZFEDD, 2008). In such settings although the role of agroforestry systems in accommodating dense population is long established, exploring the actual effect of population size on the functioning of the agroforestry system components helps to understand the peculiarity of the system in sustaining livelihoods.

2.4 Conceptual framework

The agroforestry system is expected to be influenced by the demographic, socio-economic, traditional and ecological factors (see figure 2.1). The study focuses on the influence of demographic factors on the IK practice, inclusion of diverse trees and crop diversity on the farm which are the integral components of the agroforestry system in the study area.

***Demographic variables*:** The demographic variables considered in the study are household size, age and sex of the household head and migration status of the household. It is expected that demographic variables have a bearing on the components of the agroforestry system under study, i.e., household level IK, inclusion of varied trees, and crop diversity. For instance, differences in household size and age may cause differences in household endowment of IK. Differences in the sex of the household head may affect the components of the agroforestry system through differences in labor availability and gender-based division of labor. Tadesse (2002) found that men in the Gedeo zone are responsible for producing the cash crops-coffee, trees and tree products while women are responsible for producing, processing and marketing enset which has implications for differences in IK, inclusion of diverse trees and crop diversity on the farm.



Note: Directions indicated by the broken lines are potential links that are not directly examined in the study.

Figure 2.1 Conceptual framework of the interaction of the demographic, socio-economic, and agroecologic variables with the agroforestry system.

Socio-economic variables: in this category, variables such as access to education, household assets (i.e. land and livestock), market, credit, and off-farm participation are considered to affect the components of agroforestry system. These variables may affect access to and practice of IK through their effect on the degree of social contacts and knowledge sources. It may happen that diversity increases with the increase in per capita land holding such that farmers with little access to land may focus on the production of few staple food crops. On the other hand, under circumstances of little access to land, farmers experience diversification and integrated production systems by including trees on small farms in order to minimize risk, remain competitive, and sustain their livelihoods (Workman and Nair, 1995).

Social organizations: Participation in different community based social organizations affects the diversity of species in crop lands (Wiersum, 1982; in Tesfaye, 2005). Farmers experience and traditional systems of combining production with conservation and land improvement determines the species selection that influences on farm species diversity (Young, 1997) as well as the inclusion of trees. It is also expected the participation in community based informal social organizations facilitate the network and exchange of indigenous knowledge and experience among the members of the community.

Agroecolgical variables: Altitude and climate are important ecological factors that influence local IK, the composition of diverse trees and crop diversity on the farm. Rainfall and temperature are the two important elements of climate that influence the components of a particular agroforestry system.

Chapter 3
Research methodology

3.1 The study context

Ethiopia is a federal republic consisting nine regional states namely, Tigray, Afar, Amhara, Oromia, Southern Nations Nationalities and Peoples (SNNPR), Gambella, Benshangul-Gumuz, Harari and Somali. The study area, Yirgachaffe woreda, is located in Gedeo zone of the SNNPR (see Figure 3.1).

SNNPR is located in the south and southwestern Ethiopia covering about 10% (110,932.9 km^2) of the total area of the country and inhabited by population size of about 15,760,743 which is nearly 20% of the national population that makes the region the third populous in the country (CSA, 2008) with average density of 142 persons/km^2 (SNNPRSA, 2007). The survival of 90% of the population in the region is based on subsistence agriculture (SNNPRSA, 2007). The region is divided in to 13 zones and 8 special woredas. Gedeo zone is one of the 13 zones with a capital town Dilla located 360 km away from Addis Ababa.

Gedeo zone has a total area of 1,347 km^2 out of which 107,160 ha is cultivated, 6,455 ha forest, 6,884 ha grazing and 5,348 ha cultivable, 1,562 ha uncultivable and 7290 ha miscellaneous land (GZFEDD, 2008). The zone contains six woredas and two town administrations one of which is Yirgachaffe woreda. The total population of the Gedeo Zone is estimated at 843,928 of which Yirgachaffe woreda accounts for 181,977 (SNNPRSA, 2007). The physical, demographic and socio-economic characteristics of Yirgachaffee woreda is presented in what follows.

Location and climate: Yirgachaffee woreda is one of the six rural woredas of Gedeo zone, located 395 km from Addis Ababa. The woreda geographically located between 6^0.09'- 6^0.32' north latitude and 38^0.08'- 38^0.32' east longitudes (SNNPRSA, 2007). The mean annual rainfall is in the range of 1200-1800 mm and the mean annual temperature ranges between 15^0 - 20^0C (SNNPRSA, 2007). The woreda receives rainfall for most of the year with mainly bimodal distribution. The first one is the main and long rainy season, a combination of summer and autumn, which is known as 'Kiremt' that lasts from June to November. The second rainy season is the short one known as 'Belg' that lasts from March to May. The Woreda is characterized by having two main agro-climatic zones; namely, Woinadega and Dega.

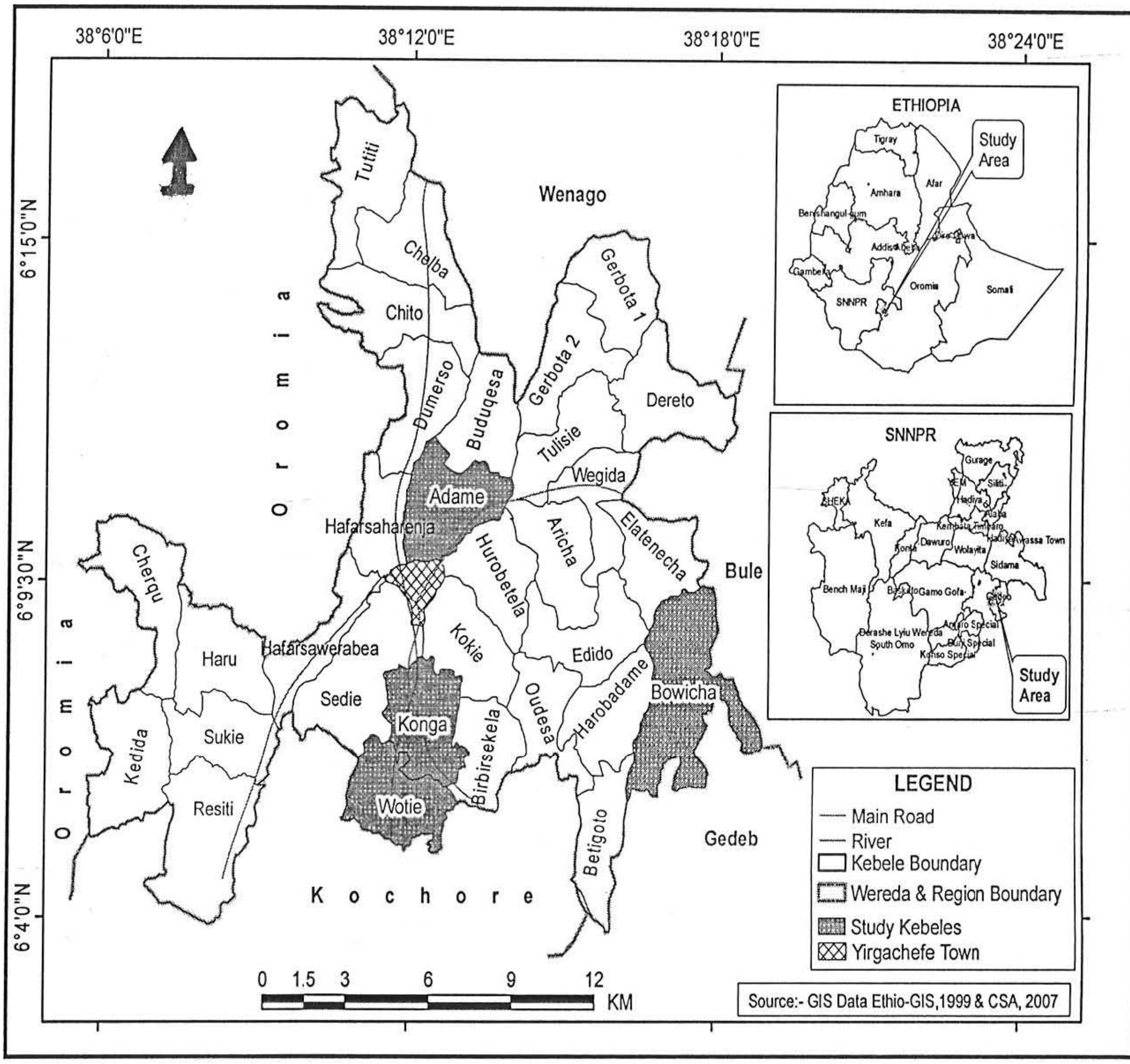


Figure 3.1 Map of the study area, Yirgachefe woreda, SNNPR,Ethiopia.

Landscape, soil, and land use: the topography of Yirgachaffee woreda is characterized by mountains, gentle slopes and permanent rivers. The altitude ranges from 1501-2500 masl and the total area covers about 317.55 km^2 (SNNPRSA, 2007). The common soil type in Yirgachaffe woreda is dystric nitosols, which is one of the widely distributed soils in the zone known to be well drained, important for forest and shrubs as well as perennial and annual crops (GZFEDD, 2003). In the woreda various trees and shrub vegetations mixed with perennial crops of coffee and enset as well as annual crops are grown all together on peasant farm holdings, i.e., the agro-forestry system which is the indigenous practice of the Gedeo people for conserving soil, balancing the ecosystem and sustaining productivity. A considerable proportion of the cultivated land is covered by coffee-enset intercropping with multipurpose trees.

Population and economic activity: the total population of Yirgachaffee woreda is 181,977 of which 91,122 and 90,854 are male and female respectively (SNNPRSA, 2007) and the population density is 700/km^2 (YWARDO, 2009). Smallholder peasant agriculture is the dominant economic activity in the area and the agricultural sector employs over 85.5% of the population (SNNPRSA, 2007). Coffee is the major cash crop and source of income followed by enset, which is both a cash crop and the main food crop in the area.

Table 3.1 Population of the Gedeo zone and Yirgachaffe woreda during 1997/8-2006/7.

Year	Gedeo zone (area = 1,347 km^2) Population	Yirgachaffee woreda (area = 317.55 km^2) Population
1997/98	640,941	155,724
1999/99	662,333	160,803
1999/00	684,029	165,945
2000/01	705,987	171,148
2001/02	728, 065	176,380
2002/03	-	-
2003/04	-	-
2004/05	796,266	177,317
2005/06	819,878	192,472
2006/07	843,928	181,977

Note: the - stands for non-availability of data. The population densities for 2005/2006 are estimated at 627 and 641 persons/km2 for Gedeo zone and Yirgachaffe woreda respectively.

Source: SNNPR-BOFED (2009/10); SNNPR-SA (2006/7).

3.2 Data and methods

Primary and secondary data sources are employed to generate data at woreda, kebele and household levels for the period 2009/2010. Primary data is collected from household survey by using questionnaires and from key informants and focus group discussions (FGD) by using structured and unstructured interviews, and field observations. Secondary data is collected from official reports.

3.2.1 Survey data and methods

Household survey conducted to collect data on demographic and socio-economic characteristics, types and size of crops, trees and livestock, farm management and cropping/planting practices, as well as knowledge sources of these practices.

3.2.1.1 Sample selection

Yirgacheffee woreda is divided in to 31 administrative kebeles with a total of 41,069 households (SNNPRSA, 2007). Purposive selection of four kebeles is conducted with the aim of capturing a reasonable representation of the main characteristics of the agroforestry system in the area (e.g. main agroecological differences, varying tree systems, diversified cropping, varying population density; varying degrees of coffee growing).

Sample size is determined based on Cochran (1977), $N = \frac{p(1-p)Z^2}{e^2} + 10\%$ (contingency rate)

Where, N is sample population
p is estimated proportion of population (0.5)
Z is value of confidence interval (1.96)
e is standard error (0.05).

Accordingly a total sample of 422 households is randomly selected with equal distribution among each kebele. However, due to inconvenience and reluctance by some respondents 420 complete responses are collected, such that 100 complete questionnaires are collected from each of Wotie and Adame kebeles while 114 and 106 complete questionnaires are collected from Konga and Bowicha kebeles respectively.

3.2.1.2 Analytical approach

The questionnaire which was prepared in English is translated in to Amharic because Amharic is expected to be understood by most of the respondents. To ensure the reliability of data and to make respondents more comfortable during the face to face interview, enumerators are selected on the basis of fluency in Amharic and Gedeuffa (the local language) as well as familiarity to the rural locality of Yirgacheffe Woreda. Enumerators have been trained prior to data collection to ensure common understanding of the contents of the questionnaire and the techniques of conducting the data collection. Moreover, enumerators were subject to close follow-up and supervision in the course of the data collection.

The survey data is organized and analyzed using Statistical Package for Social Sciences (SPSS). Before running the analysis some internal consistency checks are made to assess the quality of data. The analysis consists of descriptive statistics and estimation of regression equations. Binary logistic regression models are estimated to analyze potential effect of demographic variables on IK of agroforestry practice (objective 1) as well as to assess the potential effects of demographic variables on the inclusion of diverse large trees in croplands (objective 2). Lastly, multiple regression equation is estimated to identify the variables that explain the farm level crop diversity (objective 3).

In the estimation of the IK of agroforestry practice and the inclusion of diverse trees equations, the goodness of fit of the logistic regression models are checked. The classification table and the Hosmer and Lemeshow test are conducted to assess if the model fits the data. The classification table shows the percentage of observed cases that are correctly predicted (classified). The significance level of the Hosmer and Lemeshow tests the hypothesis that the observed data are significantly different from the predicted values from the model (Field, 2003). So in effect we want a non-significant value for this test, which indicates that the model does not differ significantly from the observed data. The ANOVA table is used to test the fitness of the multiple regression models.

3.2.2 Qualitative data and methods

General information about physical and socio-economic characteristics of the area is collected through focus group discussions with concerned professionals in the woreda ARDO and through other available local sources. The information was also useful for the selection of kebele level FGD participants and key informants. Moreover, structured and unstructured interviews and FGDs are conducted with key informants and community elders concerning knowledge and practice of the agroforestry system, perception of population pressure and response to the pressure, and the selection of crop and tree species in the agroforestry system. Field observations are made to collect and verify data on agroforestry practices, selection of crop species, and cropping patterns.

3.2.2.1 FGD participants and key informants selection

Participants of the FGDs and key informants are selected based on their knowledge and practice of the agroforestry system, crop and tree species in the agroforestry system, perception of population pressure and the community response to the growing pressure. Members of the FGDs consist of community elders and knowledgeable persons in the Kebele, while the key informants include kebele administrators and development agents (DAs). A total of four FGDs conducted one in each kebele with the number of participants per FGD ranging between five and ten.

3.2.2.2 Analytical approach

Qualitative analysis is conducted on the data collected through the FGDs and key informant interviews by synthesizing the key consensus views on the links between demographic pressure and the IK practice, inclusion of LITs and crop diversity during the discussions. Interviews are taped and transcribed. The analysis involves a series of replays of the audio data.

3.3 Ethical considerations

Respondents have been explained about the objective of the study and are asked to participate in the study by responding to each question in the survey instrument. Consent has also been sought from the key informants and FGD participants. Respondents are also given the liberty of only responding to some of the questions and even to terminate in the event of losing interest to continue to participate. In such cases, replacement of interested respondents is opted for.

3.4 Variable definition and descriptive statistics

This section describes the explained and the explanatory variables included in the estimation. A summary of the description of the variables is presented in Tables 3.2 and 3.3. In order to attain the three specific objectives, which the study set out to achieve the main objective, three dependent variables are analyzed. These are IK of agroforestry practices, inclusion of diverse trees and crop diversity on the household farm. These variables are expected to respond to the changes in demographic variables after controlling for the socio-economic and agroecological variables.

3.4.1 Dependent variables

Indigenous knowledge of agroforestry practice (IKagfo): is the traditional community knowledge accumulated over time and handed over through generation by which the people maintain livelihood in a way friendly with the environment (Donkoh and Awusabo, 1999). It is expected that as demographic pressure increases, households apply IK for innovating new techniques of sustaining agricultural productivity and environmental resilience so that the limited land can be efficiently used to accommodate the demographic pressure. *IKagfo* is estimated as a function of a range of demographic and other explanatory variables in order to address specific objective 1 of the study.

Table 3.2 Description of dependent variables included in the estimation

No	Variables	Variable name	Unit (measurement)	Freq	%	Descriptive statistics (N= 420) Max	Min	Mean	Std. dev
1	IK of agroforestry practice	*IKagfo*	1= IK more dominated	321	76.4	-	-	-	-
			0= IK less dominated	99	23.6				
2	Inclusion of large indigenous trees	*LITs*	1= More inclusion	368	87.6	210	5	41.5	23.9
			0= Less inclusion	52	12.4				
3	Crop diversity	*Diversity*	Count index	420	100	28	4	13.8	3.8

Note: The hyphen (-) indicates that the given descriptive statistics does not apply for the specific variable.

Inclusion of large indigenous trees (LITs): is what gives the study area a feature of natural forest rather than just farmlands. These diverse trees, usually tall enough to make the upper most canopies, are the major components of the agroforestry system in the study area and provide diverse economic benefits and ecological services. Inclusion of LITs is regressed over a range of demographic and other explanatory variables in order to address specific objective 2, i.e., to assess the potential effect of demographic variables on the degree of inclusion of LITs on the household farm.

Crop diversity (Diversity): in the study crop diversity on a household farm mainly focuses on the cultivated species of crops and trees through intercropping and/or crop rotation on the same land management unit having different uses and production cycles. Diversity of species is considered as an essential component of sustainable agriculture because of the wide socioeconomic and ecological roles it plays. Hence, crop diversity is expected to respond to the demographic pressure through the drive to meet subsistence needs, adjustment in labor availability and risk perception.

3.4.2 Explanatory variables

Household size (HHsz): refers to the total number of persons living in the household during the study period. Household size is one of the demographic variables which is a direct indicator of population size. Depending on the degree of access to formal education and extension, increase in household size is expected to increase the IK pool in the household that can be used in managing the agroforestry system. Moreover, through increasing labor availability household size may enhance cultivation and protection of LITs and crop diversification which enables households to meet subsistence needs and sustain the environment. The mean household size of the sample respondents is 7.4.

Table 3.3 Description of explanatory variables included in the estimation

No	Variables	Variable name	Unit (measurement)	Descriptive statistics (N= 420) Freq	%	Max	Min	Mean	Std. dev
		Demographic variables							
1	Household size	*HHsz*	No of HH members	420	100	2	15	7.4	2.6
2	Age of the HHH	*age*	No of live years	420	100	20	95	55.6	14.1
3	Sex of the HHH	*sex*	1= Male	386	91.9	-	-	-	-
			0= Female	34	8.1				
4	Migration of the HH	*HHmigrn*	1= Migrant	93	22.1	-	-	-	-
			0= Non-migrant	327	77.9				
		Socio-economic variables							
5	Education of the HHH	*educ*	Completed grade level	420	100	12	0	3.6	3.1
6	Land holding size	*landsz*	ha	420	100	4	13	1.13	0.7
7	Livestock owning	*livstok*	1= Yes	376	89.5	-	-	-	-
			0= No	44	10.5				
8	Market distance	*marketdst*	Minutes	420	100	255	15	96.4	57.8
9	Off-farm participation	*offfarm*	1=Crop prodn & others	136	32.4	-	-	-	-
			0=Crop production only	284	67.6				
10	Social organization	*socialorg*	1=Info & material excha.	180	42.9	-	-	-	-
			0=Labor exchange	240	57.1				
11	Agroecology	*ecology*	1=Woinadega (midland)	220	52.4	-	-	-	-
			0=Dega (highland)	200	47.6				
12	Credit use	*credit*	1= No	343	81.7	-	-	-	-
			0= Yes	77	18.3				

Note: The hyphen (-) indicates that the given descriptive statistics does not apply for the specific variable.
HH and HHH stand for household and household head respectively.

Age (age): refers to the age of the household head. Aged household members are expected to affect IK endowment of the household through greater accumulation of experience which can directly be used in farming as well as in preserving and transferring to the youth of the household. Age is also expected to affect the degree of inclusion of LITs through affecting the age, size and composition of LITs as well as crop diversity through affecting risk perception. The mean age of the sample households is 55.6 years.

Sex (sex): refers to the sex of the household head. Depending on the degree of division of labor and difference in environmental awareness and access to information, knowledge and sources of planting materials between males and females, sex is expected to influence IK, LITs, and crop diversity. Of the sample households, 8.1% are female headed and 91.9 are male headed.

Migration (HHmigrn): in the study, a household is considered migrant if it changed the original place of residence either for work or for education. Migration of the household through the transfer of knowledge, experience, and planting materials from its original place is expected to affect the IK practice, inclusion of LITs and crop diversity on the household farm. The study includes 22.1% migrant households and 77.9% non-migrant households.

Education (educ): refers to the educational status of the household head measured as the maximum level of completed formal education. It is expected that as the household head is more educated and informed, IK practice, inclusion of LITs and crop diversity can be affected depending on the degree of substitutability of IK and modern knowledge and the degree of change in environmental awareness. The mean completed level of education for the sample households is grade 3.6.

Land size (landsz): is the total area in ha of farmland owned by the household head. Land size as an important wealth indicator may affect IK practice, particularly if the wealth status of the household is important for the degree of IK endowment and practice through causing differential access. Moreover, the size of land can limit the degree of inclusion of LITs and crop diversity on a household farm. On the other hand, households with small land size may find it worth increasing the diversity of trees and crops in order to minimize risks. Data on household land size is obtained from the household land title certificate. The mean land holding size for the sample households is 1.1 ha.

Livestock holding (livstok): is the household ownership of livestock which is an element of the household asset and a component of the agroforestry system. Livestock holding, through supplying the household subsistence and providing manure for the soil, is expected to interact with the household IK practice, inclusion of LITs and crop diversity. 89.5% of the sample households own livestock while 10.5% of them do not own.

Market distance (marketdst): measures the distance in minutes walk from the home of the household to the woreda (main) market. Proximity to market is expected to matter for the IK of agroforestry, inclusion of LITS as well as diversifying crops through influencing access to market and non-market information. The mean walking distance to the woreda market is 96.4 minutes for the sample households.

Off-farm participation (offfarm): captures the participation of the household head in income earning occupations other than farming. Off-farm occupation contributes to the household income and information access which may have implications for the IK of the household and the degree of farm level LITs and crop diversity. Depending on the type of off-farm activity, increase in off-farm participation may increase the IK pool as well as environmental awareness of the household which may have a bearing on LITs and crop diversification. Household heads participating in off-farm activities account for 32.5% of the sample households and those not participating account for 67.6%.

Social organizations (socialorg): focuses upon household participation in informal community based social organizations categorized between labor exchange organizations and material and information exchange organizations. In the study area, Debo is found to be an important informal organization that the community established as a joint working arrangement which involves sharing labor, materials and information/experience. Through influencing labor, material and information exchange among members, social organizations are expected to affect IK practice, LITs, and crop diversity on the farm. Households participating in labor based community organizations constitute 57.1% of the sample whereas those participating in material and information based community organizations makeup for 42.9% of the sample households.

Agroecology (ecology): captures the agroecological characteristics of the study woreda categorized as Dega (highland) and Woinadega (midland). Possible variations in IK practice, LITs and crop diversification across agroecologies are expected due to differences in natural and socio-economic characteristics. Of the sample households 47.6% are from the Dega agroecology and 52.4% are from the woinadega.

Credit use (credit): captures the household's use of agricultural credit during the study period. There are formal and informal credit organizations in the study area. The common source of formal agricultural credit in the area is the Agricultural and Rural Development Office (ARDO) which mainly provides credit in kind in the form of agricultural inputs. It is expected that household access to credit influences components of the agroforestry system (i.e., IK of agroforestry practice, LITs and crop diversity) through influencing input availability and knowledge/information of input use. Sample households who are credit users account for 18.3% and the non-credit users account for 81.7%.

3.5 Indicators for the dependent variables

3.5.1 Indicator for IK of agroforestry practice

IK is a complex concept. In this study IK of agroforestry practice is measured through the assessment of household knowledge of cropping and farm management practices by identifying the knowledge source of these practices. The source of knowledge for each cropping and farming management practice is broadly categorized as modern and indigenous.

Knowledge of cropping and farming management practices

Under the knowledge of cropping, land preparation, planting and sowing practices, cropping management, planting and harvesting seasons (months) and measure of crop maturity for harvest are examined. Under the knowledge of farm management (technologies), maintenance of soil fertility, increasing productivity, weed and pest control mechanisms, and use of farm equipments and tools are examined.

Knowledge source of cropping and farming management

The survey questionnaire includes questions that inquire respondents to state the knowledge source of household cropping and farming management practices. Four alternative responses (*parents, schools, DAs, Community*) were provided for the query "where did the household head get this knowledge from?" Responses for each practice are classified as IK or modern knowledge on the ground of counting responses. Parent and the community are considered as sources of IK, because IK is orally handed over to the youth by their parents and the community through learning on the job and observation. Schools and DAs are considered as sources of modern knowledge either through formal education or through training and professional advises.

Consequently, out of the five cropping practices (*land preparation, planting and sowing practices, cropping management, planting and harvesting seasons (months), and measure of crop maturity for harvest*), a respondent who gets 3 or more counts of the particular knowledge source (i.e., IK or modern) is considered as dominantly applying that respective knowledge. For example, a household head with responses of 3 or more counts of *parents or the community* or sum of the two, as knowledge source for a given practice, is considered as experiencing IK more dominated practice, or IK less dominated practice if otherwise.

The same procedure is followed to identify the knowledge source of the farming management practices (*maintenance of soil fertility, increasing productivity, weed control, pest control, and farm tools/equipments*). Finally, the indicator for *IKagfo* is obtained by aggregating the IK of cropping and the IK of farm management practices on the basis of which the household agroforestry practice is categorized in to IK more dominated and IK less dominated. Accordingly the IK of agroforestry practice is measured as a binary variable reflecting the degree of dominance of IK in the household agroforestry practice. Among the sample households 76.4% are those with IK more dominated practice whereas 23.6% are those with IK less dominated agroforestry practice.

3.5.2 Indicators for inclusion of large indigenous trees (*LITs*) on croplands

There are plenty of large trees and shrubs intercropped with variety of crops in the agroforestry system of the study area, however, this section deals with indicators of the degree of inclusion of large indigenous trees (*LITs*) in household farms. Although trees such as Eucalyptus have important socio-economic benefits, they are not the focus of this analysis due to the reasons that they are not included in farmlands as they are believed to cause land aridness thus they are mostly found around the road side and swampy areas. They are not indigenous and have no cultural values as well.

The lowest size of *LITs* included in farms of the sample households is 5 and the highest is 210. The mean size and the standard deviation of *LITs* included on the household farm are 41.5 and 23.9 respectively. The indicator for *LITs* is defined as a binary variable to capture household farm categories with less and more included LITs on the basis of the number of LITs contained per household farm. The cut off point for inclusion categories, i.e., 18, is determined by subtracting the standard deviation from the mean size of LITs. Accordingly, households that include 18 and below units of LITs on their farm are considered as including less LITs, while those including 19 units of LITs and above are taken as including more LITs. Thus, 12.4% of the sample households' fall in the less inclusion category and 87.6% fall in the more inclusion category.

3.5.3 Indicators for crop diversity

The diverse crops and trees grown in the study area contribute to environmental conservation and produce diversified outputs that satisfy subsistence needs of the household. The diverse crops include perennial crops, annual crops, fruits, vegetables, root crops and trees. Perennial crops include enset (false banana), coffee, sugarcane and khat. Annual crops include cereal crops such as maize, barley, wheat and tinkish (resembles sorghum but with edible stem), bean, peas, haricot bean and cowpea. Vegetables and root crops consist of cabbage, green pepper, onion, tomato, pumpkin, carrot, beat root, yam, taro and sweet potatoes; and fruits including avocado, guava, banana, mango, papaya and apple. The most important trees in the area include cordia/wanza, miletia/birbira, vernonia/girawa, ficus/shola, croton/bisana, syzygium/dokima and podocarpus/zigba. In this study, crop diversity is measured by counting the number of crop and tree species on household farms. Overall 58 crop species and 52 tree species are identified on the sample household farms (see tables A 3 and A 4), the average per household being 7.2 crop species and 6.6 tree species. The mean species count for the sample households is 13.8.

Chapter 4
The effects of demographic pressures on the IK of agroforestry

4.1 Background and problem definition

The interplay between population growth and the environment has been widely debated. Consequently, opposing views of the "Malthusian" (e.g., Malthus, 1798; Meadows, 1972; Ehrlich, *et al.* 1993) and the "Boserupian" (e.g., Boserup, 1965; Khan, Brown and Martel, 1976; Simon, 1996) speculate alternately. The Malthusian claim that unchecked population growth will ultimately lead to a complete collapse of the natural environment where as the Boserupian argue that the combination of population growth and natural resource scarcity will drive innovation that conserves natural resources and increases the material services that the resources deliver.

An interesting aspect that comes along with growing population size is the accumulation of knowledge capital (traditional or modern), which can be harnessed for better productivity and environmental results. One component of such knowledge is the indigenous knowledge (IK). IK is the accumulation of traditional experience that has been developed over time in a community mainly through intimate understanding of the environment in agriculture (Tekai and Kama, 2005). IK has over the years been effective as a resource for environmental management and sustainability (Hart and Vorester, 2006). Recent concerns about and commitments to ensuring environmental management emphasized the important role IK can play. Such focus on IK has been reflected in the World Conference on Environment and Development [WCED, 1987], United Nations Conference on Environment and Development [UNCED, 1992], and the World Summit on Sustainable Development [WSSD, 2002] to incorporate all knowledge systems including IK to protect and sustain the environment (Donkoh and Awusabo 1999). International organizations such as the World Bank, ILO, UNESCO, and FAO are explicitly acknowledging the contribution of local knowledge in the developing world particularly in low-external-inputs to sustainable development (Reijntjes, *et al.* 1993; IIRR, 1996; SLUF, 2006). Governments of countries like Ghana, Uganda, South Africa and Philippines are integrating IK in their development policies and programs (Donkoh and Awusabo, 1999; SLUF, 2006).

There is no clearly stated policy direction in Ethiopia concerning the use of IK of agroforestry practice in the environmental conservation and sustainable development schemes. It is however, recognized that the environment in the south and south-western highlands of Ethiopia is relatively conserved in the presence of dense population through the IK based traditional agroforestry system (Tesfaye, 2005).

In particular, the Gedeo people are known to have rich tradition of IK based agroforestry system which they have been practicing since time immemorial. As a result, the Gedeo indigenous agroforestry system although established on a fragile land, represents one of the oldest traditionally intensified farming systems in Ethiopia, accommodating high demographic pressure (Tadesse, 2002; SLUF, 2006). The question then becomes how the IK practice in the Gedeo agroforestry system and environmental management in general evolves with the change in demographic pressure for which little empirical evidence exists.

This study is, therefore, intended to provide empirical evidences of the potential effects of demographic variables on the IK practice by controlling for the effect of other socio-economic and agroecological variables. The analysis is based on data collected from Yirgacheffe Woreda, Gedeo Zone, SNNPR, Ethiopia during the year 2009/10.

4.2 Data and methods

Agroforestry system in the Yirgachaffe Woreda is characterized by rich IK system of the Gedeo people practiced to sustain livelihoods and conserve the environment. Data on the main demographic, socio-economic and agroecologic factors and on the most important knowledge sources of cropping and farming management practices are obtained through the survey and qualitative methods.

Data on the demographic, socio-economic, and agroecologic variables as well as selection of agroforestry crop and tree species, cropping/planting and farm management practices and knowledge sources of these practices are generated from the household survey. For this analysis, IK is measured by aggregating the knowledge sources of cropping and farming management practices based on which the overall household agroforestry practice is classified into IK more dominated and IK less dominated. The demographic variables by exerting pressure through demand for subsistence, the socio-economic variables by indicating endowments and through influencing information and material exchange, as well as the agroecologic variables by causing differences in natural characteristics are expected to affect the IK of agroforestry practice.

The potential effect of demographic variables on the IK of the agroforestry practice is analyzed by estimating a binary logistic regression model (Gujarati, 1988) given by:

$$Y = \beta_0 + \beta_1\chi_1 + \beta_2\chi_2 +,\ldots,+ \beta_\kappa\chi_\kappa + e$$

Where: Y is the probability of IK more dominated agroforestry practice
$\chi_1,\ldots,\chi_\kappa$ are set of demographic and other explanatory variables
β_0 is a constant
$\beta_1,\ldots,\beta_\kappa$ are coefficients
e is the error term.

The goodness of fit of the model is checked by the percentage of correctly predicted data using the classification/prediction table and the Hosmer and Lemeshow tests of the overall significance of the model. The classification table shows 93.6% of the data is correctly predicted. The Hosmer and Lemeshow test ($\chi^2 = 3.579$, $p < 0.893$) came out not significant, which indicates the rejection of the hypothesis that the observed data are significantly different from the predicted values from the model. Accordingly, the model is predicting the data fairly well. The same conclusion has been drawn using the model χ^2 test (χ^2 (11) = 80.637, $p < 0.000$).

The coefficients, probability level (β) and odds ratio Eχp(β) indicate whether a particular variable is associated with IK of agroforestry practice statistically significantly. The odds ratio Eχp(β) explains the likelihood effect of explanatory variables over the explained (Field, 2003). Thus Eχp(β) >1 indicates a positive relationship, i.e., higher probability for IK more dominated agroforestry practice, whereas Eχp(β) <1 indicates a negative relationship, i.e., lower probability for IK less dominated agroforestry practice. The value of Eχp(β) = 1 indicates the explaining variable has no effect on the dominance of IK practice.

Data on the IK of the agroforestry practice, community perception about the population pressure and the response to the pressure and the links between demographic pressure and IK practice are obtained from the FGD and key informants through structured and unstructured interviews. Interviews are taped, transcribed and the analysis involves a series of replays of the audio data.

4.3 Results

The analysis focuses on assessment of the potential effect of demographic variables on IK of agroforestry practice, the effects of socio-economic and agroecological variables controlled for.

4.3.1 The effect of household size on the IK of agroforestry practice

Table 4.1 shows that *HHsz* positively affects IK more dominated agroforestry practices at the 5% of level of significance. This indicates that large sized households are more likely to carryout IK more dominated agroforestry practice. The result is thus associated with the expectation that through enhanced interaction and use of varied ingenuity, increase in household size increases the IK pool in the household that can be used in managing the agroforestry system. This result coincides with the findings of Bekele (2007) that increase in household size enhances IK of soil conservation practice in Wonago woreda of the Gedeo zone; and the findings of Chalachew (2004) that identifies a positive relationship between large household size and soil and water conservation measures in Alemaya.

Table 4.1 Parameter estimates of Logistic regression model for IK of agroforestry *(IKagfo)*

Variables	*Variable name*	B	SE	Eχp(β)
Household size	*HHsz*	.149**	.065	1.161
Age of the HHH	*age*	.060*	.012	1.062
Sex of the HHH	*sex*	-.709	.500	.492
Migration status of the HH	*HHmigrn*	-.269	.341	.764
Education of the HHH	*educ*	-.064	.045	.938
Land holding size	*landsz*	-.401*	.206	.669
Livestock owning	*livstok*	-.402	.391	.669
Market distance	*mrketdst*	.002	.003	1.002
Off-farm participation	*offfarm*	-.142	.333	.867
Social organization	*socialorg*	-.660**	.312	.517
Agroecology	*ecology*	-1.228*	.344	.293

χ^2 (11) = 80.637, p< .000; * p < 1%; ** p < 5%; ***p <10.

The FGDs and key informants explain that the Gedeos have a tradition concerning household size. The households in the community prefer to have as much family members as possible for reasons related to improving land productivity. In order to achieve this need; the Gedeo fathers encourage marriage of their sons and daughters in the ages below 20. The known community elders blessing to the youngsters on different occasions as well as during the wedding ceremonies is *"Hori! Birasai! Wasaa hochchiki qooddattoo qico Mageni atee horo.* That means *'Reproduce! Be multiplied! May God enlarge your family to the extent that your family size goes beyond the number of plates you have at home and hence use enset leaf as a plate!* The reason why they want to have as many children is explained by a saying that *"Ileeki qotteedhdhaan. A man who has children farms well."* Besides, when children get to help households in farm works, parents teach them to care for young growing trees during slashing which the youth in the household are responsible for. This informal teaching-learning system descended over many generations constituting a specific IK system of agroforestry practice. Hence, the area is characterized by both high population density and well farmed fields with diverse crops and trees which constitutes much of the subsistence. When the Gedeo fathers expanded towards the study area with the increase in population size and continued clearing the upland bushes for farming and settlement, natural trees were favored. Then the people through observation of the important values of these trees have developed knowledge of the importance of trees for shade, soil protection and other socio-economic and cultural values. Besides households identify trees that are useful to be included in croplands based on the local knowledge of their benefits in keeping ecological balance. Therefore, it is promising to say agroforestry in the study area is the traditional farming system of the Gedeos, based on their IK system developed through time.

4.3.2 The effect of age of the household head on the IK of agroforestry practice

age also positively affects IK more dominated agroforestry practice at the 1% of level of significance demonstrating that as age of the household head increases households are more likely to apply IK more dominated agroforestry practice. The finding is aligned with the expectation that aged population are likely to have greater accumulation of IK which can directly be used in current farming as well as in preserving and transferring it to the youth of the household. The result corresponds to the findings of Dula (2007) that identifies a positive correlation between increase in age of the household head and environmental conservation in achieving rural livelihood strategies in Arjo district of east Wellega.

Other variables affecting the IK of agroforestry practice

Land holding size

landsz is negatively affects the likelihood of IK more dominated agroforestry practice at the 10% level of significance. That is as land size increases households are less likely to practice IK more dominated agroforestry practice. The negative relationship could be because households with relatively larger land size are likely to be more market oriented and hence are to pursue more modern farming than IK based one. The result coincides with the findings of Bekele (2007) that identifies a significant decrease in the probability of practicing IK of soil conservation by households with relatively large size of land in Wonago woreda of the Gedeo zone.

Social organization

socialorg is also negatively affects IK more dominated agroforestry practice at the 5% level of significance implying that household participation in material based social organizations decreases the likelihood of IK more dominated agroforestry practice. This may be because participation in labor based social organizations like Debo better enhances exchanging and practice of IK than participation in the material based ones.

Agroecology:

Ecology similarly negatively affects the likelihood of IK dominated agroforestry practice at the 1% level of significance indicating that households located in the Woinadega agroecology are less likely to carry out IK more dominated agroforestry practice than those located in the Dega.

4.4 Discussion and conclusion

The study results provide an explanation of the potential effects of demographic variables namely household size and age of the household head on the IK of agroforestry practice of Yirgachaffe woreda.

Household size is an important demographic factor that is found to have a significant positive effect on the likelihood of household's application of IK more dominated practice in the agroforestry system. Correspondingly increase in the size of the household increases household engagement in farming to which they employ IK intensive dominated agroforestry practice in order to meet increasing subsistence needs. As an indication a saying "*a man who has children farms well*" corresponds with the drive to satisfy the growing demand of increasing household size by working more productively. Large size households, hence, likely motivated to experience IK more dominated agroforestry practice that allows them to conserve the environment and sustain productivity. The households also transfer their IK system to the youngsters by training sons on farm fields. Based on this, devising a system of IK transfer from the larger-sized to the smaller-sized household would assist in maximizing the benefits of IK practice. In line with this, as empirically indicated, enhancing labor-based informal social organizations assists in the exchange and spreading IK dominated agroforestry practice. Furthermore, age of the household head is found to have a positive relationship to the likelihood of IK dominated agroforestry practice. With the Gedeos preference towards larger family size, increase in the age of the household head is likely to go hand in hand with larger household size, making the effect of age on IK both directly and through increasing household size. Aged households are likely to have greater accumulation of IK of cropping and farm management both through greater degree of community contact and experience over the years and through greater knowledge pool caused by larger household size. As a result their agroforestry practice is likely to be dominated by IK and constitutes a practical conservation of IK along with transferring to their young successors.

In conclusion, demographic variables namely increase in household size and age of the household head are important resources for sustaining productivity and the environment through enhancing and conserving IK more dominated agroforestry practice. Therefore, increase in population size is not pressures that destruct the environment on which their life is based. Rather, people like the Gedeos through their IK system arrange methods and shape their behaviors so as to positively interact in the way they possibly conserve the environment and sustain productivity.

Correspondingly, Kendie and Ghartey (2000); SLUF (2006); Donkoh and Awusabo (2009) explain IK as an effective resource for environmental management and sustainability which are being matters of survival to the people who generated them. So, if IK contributes to the better environmental management, this study therefore, is an evidence of the cases where demographic pressure is not necessarily harmful to the environment. Rather, the study is an indication of the possibility that population enhances conservation of the environment through enhancing the community practice of IK of agroforestry. Population increase as a need-driving motive and aged people as traditional authorities are at the center of the existence of IK among the Gedeo households. The aged also found to be the internal strength of the IK system through their accumulated skill and experience which they transfer to the young successors. In this regard, enhancing the transfer of IK from the older to the younger households is a useful strategy to sustain IK of agroforestry practice in the area.

Chapter 5

Effects of demographic pressure on the inclusion of large indigenous trees on the farm

5.1 Background and problem definition

Highlands of Ethiopia are ecologically suitable for forest vegetation which were originally covered with dense forests of various types while the arid parts are covered with scanty vegetation (Mekete, 1999). As forests are important both as sources of basic raw materials and environmental stabilization, their decline is a major contributing factor to land degradation and desertification, especially for countries in or bordering the wider Sahel region to which the Sahara desert spreads (Grainger, 1986). Ethiopia, as one of the countries bordering the Sahel region is facing a two sided threat, namely, the encroaching of the Sahara desert, and deforestation exacerbating desertification.

The rate of deforestation in the country has been accelerating over the decades. Since the turn of the century, the original forest cover was reduced to 16% in the 1950s, to 3.6% in the 1980s and to 2.7% in 1989 (Markos and Dilnesaw, 1998). EFAP (1994) estimates the annual loss of natural forest cover in the range of 150 to 200 thousand ha/year. Forest decline is one of the major factors for environmental deterioration. Deforestation affects the lives of many people and other lives in the world (Grainger 1986), and its effect is highly pronounced in developing countries like Ethiopia. The spatial distribution of forest resources shows that Northern Ethiopia is almost totally devoid of natural forests to the extent of per-capita availability of forest resources being nearly zero (Markos and Dilnesaw, 1998).

A considerable literature blames population increase for the forest decline. For instance, it is stated that increasing population pressure in the highlands of Ethiopia in the past 40 to 50 years has led to rapid deforestation and exposing the land to severe water erosion (Paulos, 2001). Other literature indicate socio-economic, bio-physical and policy factors are equally or even more crucial than population pressure in determining the rates of deforestation (WRI, 1990; Cunningham, 1995).

On the other hand, there are studies that view large population as part of the solution rather than the problem. In line with this, Chew (2001) and Arnold (1997) claim that traditional agroforestry systems have evolved with time in response to population pressure and depletion of non-renewable resources (in Regmi, 2003). Agroforestry system involves trees combined with crops and animals on the same land management unit (Nair, 1993; Tamale, *et al.* 1995) which makes it useful and effective in enriching the production system and stabilizing the environment (Jeffery and Schorth, 2005). Thus, the forest resource depletion is better controlled in areas where agroforestry system is predominant.

An important element in the agroforestry system is the inclusion of multi-purpose large trees in croplands. There are diverse large trees and bushy shrubs integrated with crop cultivation in the Gedeo agroforestry system which establishes multipurpose benefits extending beyond the community. The purposely grown trees in the agroforestry system as woody perennials significantly contribute for sustaining the environment for e.g., organic matter for croplands, protection from erosion, source of food, forage, fuel, construction material, medicine, clear and permanent water (Kang and Wilson, 1987; Young, 1989; Ingram, 1990).

The Gedeo traditional agroforestry system which features the densely populated and fragmented household farms almost natural forest by the incorporation of such varied and plenty of large trees on subsistence farms is one of the living examples of protected environment in the presence of population pressure. The question then arises how these large trees in the Gedeo agroforestry system are sustained in the presence of intense demographic pressure.

The study is, therefore, intended to provide empirical evidence on the potential effects of demographic variables on the inclusion of large trees by controlling for the effects of other socioeconomic and agroecologic variables. The analysis is based on data collected from Yirgacheffe Woreda, Gedeo Zone, SNNPR, Ethiopia during the year 2009/10.

5.2 Data and methods

The agroforestry system of Yirgachaffe Woerda is characterized by the inclusion of varieties of LITs and bushy shrubs in croplands. Data on the key demographic, socio-economic, and agroecologic factors and the diverse species of LITs included on household farms are obtained through survey and qualitative methods.

Detailed data on the demographic, socio-economic, and agroecologic variables and the species and size of varied demographic variables on the LITs included on household farms is generated through household survey. Inclusion of LITs is measured by subtracting the standard deviation from the mean size of LITs as a cutoff point to divide the households into those with more inclusion and those with less inclusion categories. The potential effect of demographic variables on the inclusion of LITs in croplands is analyzed using binary logistic regression model. The logistic regression model Gujarati (1988) used in the analysis is given by:

$$Z = \alpha_0 + \alpha_1 \chi_1 + \alpha_2 \chi_2 +, \ldots, + \alpha_K \chi_K + e$$

Where: Z is the probability of inclusion LITs on the household farm

$\chi_1, \ldots, \chi_K$ are set of demographic and other explanatory variables

α_0 is a constant

$\alpha_1, \ldots, \alpha_K$ are coefficients of various explanatory variables

e is an error term.

The goodness of fit of the model is tested by the percentage of correctly predicted data using the classification/prediction table and the Hosmer and Lemeshow tests of overall significance of the model. The classification table shows 90.2% of the overall data is correctly predicted. The significance level of the Hosmer and Lemeshow test (χ^2 = 6.581, $p < 0.582$) came out not significant, which indicates the rejection of the hypothesis that the observed data are significantly different from the predicted values. Accordingly, the model is predicting the data fairly well. Same conclusion has been drawn by using the model χ^2 test ($\chi^2 (11) = 31.532$, $p < .001$).

The coefficients, probability level (β) and odds ratio Eχp(β) indicate whether a particular variable is associated with inclusion of LITs statistically significantly. The odds ratio Eχp(β) explains the probability effect of explanatory variables over the explained. Thus Eχp(β) >1 indicates a positive relationship, i.e., higher probability for inclusion of more LITs, where as Eχp(β) <1, indicates a negative relationship, i.e., lower probability for inclusion of less LITs. The value of Eχp(β) = 1 indicates the explaining variable has no effect on the inclusion of LITs.

Data on the importance of LITs on croplands, the community perception of conservation of LITs and the effect of demographic factors on the inclusion of LITs at household and community level are obtained from the FGD and key informants through structured and unstructured interviews. Interviews are taped, transcribed and the analysis involves a series of replays of the audio data.

5.3 Results

The analysis focuses on the assessment of the potential effect of demographic variables on the inclusion of LITs in the agroforestry system by controlling for socio-economic and agroecologic variables.

5.3.1 The effect of household size on the inclusion of large indigenous trees on the farm

Table 5.1 shows that *HHsz* positively affects inclusion of LITs in the agroforestry system at the 10% level of significance indicating that large size households are more likely to include additional LITs in croplands above the smoothened average level. The result is related to the expectation that large household size through increasing labor availability enhances cultivation and protection of LITs.

Table 5.1 Parameter estimates of Logistic regression model for inclusion of LITs (*LITs*)

Variables	*Variable name*	α	SE	Exp(α)
Household size	*HHsz*	.139**	.080	1.149
Age of the HHH	*age*	.027*	.013	1.027
Sex of the HHH	*sex*	.561	.559	1.735
Migration status of the HH	*HHmigrn*	.353	.424	1.423
Education of the HHH	*educ*	.065	.059	1.067
Land holding size	*landsz*	.052	.279	1.053
Livestock holding	*livstok*	.478	.425	1.613
Market distance	*mrketdst*	-.004	.003	.996
Off-farm participation	*offfarm*	1.061*	.402	2.888
Social organization	*socialorg*	.477	.378	1.611
Agroecology	*ecology*	.335	.418	1.398

$\chi^2(11) = (31.532, p< .001)$; * $p < 1\%$; ** $p < 5\%$; $p < 10\%$.

5.3.2 The effect of age of the household head on the inclusion of large indigenous trees on the farm

There existed a positive relationship between the *age* and inclusion of LITs at the 5% level of significance that indicates aged population are more likely to include and conserve LITs in croplands above the smoothened average level. This finding is associated with the prediction that as age of the household head increases the degree of inclusion of LITs increases by age, size and type.

The FGDs emphasize that the culture perpetuated by the elderly people has strong influence on sustaining LITs in the community. The culture offered the community and in particular the elderly sense of ownership of LITs found on individual household farms. In cases of declining forest attribute of farms due to deforestation of farm trees, the elders in their cultural prayer and in different public ceremonies beg ancestral gods to return the previous trees for the people. The prayer goes *"Annuwiki mageno! eeddi woddixxa haqichchuwwa no'owa hissi"* which denotes *god of our fathers! Please, restore the previous trees.* This is because households in the community traditionally learned the importance of trees for shading crops, cooling farmland and improving soil fertility (i.e., *gaaddissaa, fichchatixxa qiidaanna buttina shshaqqishsha*) and hence plant them with enset and other crops. Gradually the shading values of trees expanded with the introduction of coffee planting in the area. There are diverse trees intercropped in farm lands favoring a number of water streams around the homesteads, which has notable implications for saving the time of women and children for searching fuel wood and fetching water. This presents an opportunity for children to attend school and for women to engage in other household chores and income generating activities. The elderly people also seriously confront individuals who haphazardly eliminate LITs from their own farms. This indicates how deep the lives of the community is attached to the LITs and how much these trees are beloved, respected, and considered as public responsibility by the community.

Other variables affecting inclusion of large indigenous trees on the farm

Off-farm participation

The variable *offfarm* positively affects the inclusion of trees in the household farm at the 1% level of significance showing that households that participate in off-farm activities are more likely to increase inclusion of LITs in croplands beyond the smoothened average level. This may be because participation of the household head in off-farm activities facilitates access to information, planting materials and income which enhances the inclusion of more LITs on the farm.

5.4 Discussion and conclusion

The study results provide an explanation of the potential effects of demographic variables on the inclusion of LITs in the agroforestry system of Yirgachaffe Woreda.

The study demonstrates that increase in household size is positively associated with the inclusion of more LITs on the farm. Large households find it imperative to include more LITs on their farm because of availability of labor and the need to produce more subsistence and some cash crops that as well require shading from trees. The qualitative result also signifies that large households include more LITs in farmlands to sustain land productivity, expand options of subsistence like additional income source as well as to save labor and time for searching fuel wood, water and forage and thereby enhancing involvement in more productive activities for women and children. Therefore, owing to the various economic and ecological benefits inclusion of LITs appears to constitute part of the local response to the increasing population pressure in the study area.

Likewise aged people, due to greater degree of exposure to the cultural practices and accumulated understanding of the environment over the years, favorably influence the inclusion of LITs on household farms. Similarly the qualitative result emphasizes that the tradition in the study area allows elders to have control over LITs. In cases of declining forest aspect of household farms, the elders pray towards ancestral gods for return of LITs and they play the role of policing individuals who unfairly get rid of LITs from their own farms.

In conclusion, inclusion of multipurpose tree species as explained in (Ingram, 1990; Tejwani and Lai, 1992; Grimbel, *et al.* 1994; Jeffery and Schorth, 2005) constitutes multiple benefits including the environmental stability. Therefore, if inclusion of diverse large trees ensures environmental resilience, this study is an evidence of the cases whereby demographic pressure not necessarily causes deforestation and environmental degradation. Rather, the study is an implication of the possibility that large population enhances environmental conservation through enhancing cultivation and conservation of large indigenous trees (LITs) on croplands. Thus, large population and aged people are important demographic variables for sustaining the environment through intercropping and policing LITs and establish a relative harmony between demographic pressure and environmental resource base in the Gedeo setting, thereby established accommodative agroforestry system through which the forest attribute of the area sustained over time. Accordingly, enhancing transfer of information and inputs from older and larger size households to younger and small size households is a useful intervention to enhance inclusion of more LITs on household farms.

Chapter 6
Factors affecting crop diversity on the farm

6.1 Background and problem definition

Diversity[1] of crops on the household farm is considered as an essential component of agroforestry system because of the wide spread socio-economic and ecological benefits it offers. Some of the benefits include decreased risk of production failure, increased productivity of resources over time (Nettings and Stone, 1996), provision of output flexibility and alternative production in unfavorable circumstances (Wojtkowsky, 1993) and year round production of food and wide range of other products such as fire wood, fodder, spices, medicinal plants, and ornamentals (Christianity, 1985; Fernandes and Nair, 1986). Crop diversification has a potential to serve as repositories of genetic diversity, besides acting as insurance against pests and disease outbreaks, which may be very severe in monoculture (Michon, *et al.* 1983). Through enhancing effective nutrient cycling and reducing hazard of leaching and soil erosion (Wiersum, 1982; Jensen, 1993) and offering wider ecological services such as landscape and soil protection, water cycle and air quality (Cromwell, *et al.* 1999), prevents environmental deterioration commonly associated with monoculture production systems (Fernandes and Nair, 1992). Moreover, higher agrobiodiversity on the farm makes an important nutritional potential for subsistence households (Kidist, 2009). The most commonly cited benefit of farm diversification is the leveling out of farm income, both throughout the calendar year and over a number of years, thus farming families viewed diversification as a way of 'not having all your eggs in one basket' (Medhurst and Seagrave, 2007).

Against this backdrop lies the question of how crop diversification interacts with demographic pressure observed in many developing countries. Growing populations will have a serious impact on the demand for food especially in subsistence economies. Malthus (1798) and neo Malthusians (e.g., Meek, 1953; Cipolla, 1962; Ehrlich and Ehrlich, 1972) argue that population increase puts additional pressure on limited natural resources, particularly land, with the negative impact of reducing the average area of arable land and activating the law of diminishing returns. The more optimist viewpoint about population growth has generally been related to its role of

[1] Diversity is defined as the variety and variability of plants, animals and microorganisms at genetic, species and ecosystem level involving the whole agroecosystem that is actively managed by farmers (Cromwell, *et* al. 1999). For this study, diversity is defined at the species level of crops and trees at the farm level, i.e., annual crops, fruits, root crops and vegetables, perennial crops, and multi purpose indigenous trees.

fostering social, cultural and technical change (Boserup, 1965). It is indicated that agroforestry land use systems in tropical Africa came as a response to increasing population pressure and evolved from extensive to more intensive and sedentary forms of land use systems, which support a high population density of up to 400 people/km^2 (Egger, 2005). The population density in the agroforestry based Gedeo zone of Ethiopia goes as high as more than 1100 people/km^2 (GFEDD, 2008). In the agroforestry system, although average land holdings are as small as below 1 ha, households cultivate various types of crops for the purpose of ensuring food sufficiency and reducing production risks (Sharma and Sharma, 1993; Semwal, *et al.* 2003; Saxena, *et al.* 2005).

The high diversity of the agroforestry system of the southern and south western highlands of Ethiopia combines crops, trees and animals having different uses and production cycles which is an essential component of sustainable agriculture because of the wider socioeconomic and ecological roles it plays (Tesfaye, 2005). Particularly the Gedeo agroforestry is a traditional farming system by which the people conserve the environment and benefit from its diversified outputs (Tadesse, 2002; SLUF, 2006). The extent to which such diversification of crops is influenced by demographic factors is an empirical question. Moreover, the different views concerning the interaction between population growth and natural resource management and use do not clearly explain how crop diversity might be affected by such interaction.

This study is, therefore, an attempt to empirically identify factors potentially affecting crop diversity on the household farm with a specific focus on the effect of demographic variables based on the data collected from Yirgacheffe Woreda, Gedeo Zone, SNNPR, Ethiopia during the year 2009/10. The results provide some insight into the interplays between demographic factors and crop diversification with potential environmental implications.

6.2 Data and methods

The agroforestry system of Yirgachaffe woreda is characterized by diverse crops and tree species. Data on the demographic and other factors potentially affecting crop diversity are obtained through the survey and qualitative methods.

Household data on the demographic, socio-economic, agroecologic variables and the type and size of crop and tree species are generated through the survey questionnaire. An indicator for crop diversity is obtained by counting the number of crop and tree species on the household farm. The demographic variables (household size, age, sex and migration) by exerting the demand side pressure, the socio-economic variables (access to education, land, livestock, market, credit, off-farm and social organizations) through setting the resource endowment limits and the agroecologic variables through exerting natural differences are expected to affect crop diversity at the farm level.

The potential effect of demographic and other variables on crop diversity is analyzed using the multiple regression model given by:

$$D = \delta_0 + \delta_1 \chi_1 + \delta_2 \chi_2 +,\ldots,+ \delta_\kappa \chi_\kappa + e$$

Where: D is the extent of crop diversity

$\chi_1,\ldots,\chi_\kappa$ are set of demographic and other explanatory variables

δ_0 is a constant

$\delta_1,\ldots,\delta_\kappa$ are coefficients of the various explanatory variables

e is the error term.

The goodness of fit of the model is checked by the model F test and the ANOVA test of the overall significance of the model. Having the F- statistic and P- value given by ($F(12, 407) = 6.07$, $p < 0.000$) the model is statistically significant, i.e., a significant proportion of the variation in the farm level crop diversity in the area is explained by the variables included in the estimation. The same conclusion has drawn based on the ANOVA test of overall significance of the model.

Data on the agroforestry system, the community perception of population pressure, response to the pressure in terms crop diversification are collected from the FGD and key informants through structured and unstructured interviews. Interviews are taped, transcribed and the analysis involves a series of replays of the audio data.

6.3 Results

The analysis focuses on identifying demographic, socio-economic and agroecological variables affecting crop diversity on the farm with a specific focus on the effect of demographic variables.

6.3.1 The Effect of demographic variables on crop diversity

6.3.1.1 Household size

Table 6.1 shows that *HHsz* positively affects crop diversity at the 5% level of significance. This indicates that large sized households have more diversified farms in terms of crop and tree species. The result matches to the expectation that larger household size through increasing labor availability enhances cultivation and diversification of crops which enables households to meet subsistence needs and sustain the environment.

Table 6.1 Parameter estimates of multiple regression model for crop diversity *(Diversity)*

Variables	Variable name	Unstandardized Coefficients		Standardized Coefficients
		δ	E	δ
-	*(Constant)*	12.18	1.763	-
Household size	*HHsz*	.215**	.076	.145
Age of the HHH	*age*	.015	.014	.057
Sex of the HHH	*sex*	1.607**	.674	.116
Migration status of the HH	*HHmigrn*	.271	.433	.030
Education of the HHH	*educ*	-.032	.061	-.026
Land holding size	*landsz*	.576**	.277	.100
Livestock owning	*livstok*	2.090**	.655	.170
Market distance	*marketdst*	-.006***	.004	-.095
Off-farm participation	*offfarm*	.440	.441	.055
Social organization	*socialorg*	-.354	.393	-.046
Credit use	*credit*	-1.191**	.454	-.122
Agroecology	*ecology*	-1.721*	.422	-.228

$R^2 = 0.633$; $F (12, 407) = 6.07$, $p < 0.000$; *p< 1%, **p< 5%, ***p< 10%.

The FGDs results indicate that as the size of the household increases the number of crops increases in species, variety and size. The Gedeos have a traditional rule that encourages both household size and diversification of crops mainly food crops. The saying goes "Bira-saxxe hori! *Oosee gaadhdhiaa kaajeeldaabaashshaa kinni minee giddii'ninna baaxxee giddii'ni iindaachchi gophpheemoxxe,* i.e., to mean *increase in number and for your children not to seek food outside let your home and homestead be full of foodstuffs."* Such an important drive for the households to diversify crops on the farm is sustaining the increasing household subsistence needs. Each component of the diversity does have different arrangements in space and time and provide year round production.

6.3.1.2 Sex of the household head

Sex is similarly positively affects crop diversity at the 5% level of significance which indicates that male headed households have more diversified agroforestry species than their female counterparts. One possible explanation for this finding could be that diversification of agroforestry species is labor and material intensive. If in this case male headed households have more labor and material endowment and access, then the result that male headed households have more diversified crops is not surprising. This indicates that female headed households with no adult off-springs would find it difficult to maintain diversified crops on their farms. The FGDs further explain that female headed households are not considerably involved in diversifying crops because of their dependence on hired labor and sharecropping to combat labor shortage.

6.3.2 Other variables affecting crop diversity

6.3.2.1 Land holding size

Landsz positively affects crop diversity at the 5% level of significance indicating that households with relatively larger land holding have higher diversity of crops. As expected the size of land can affect the crop diversity on a household farm through providing more space for including more species on the farm as well as through increasing income to buy more inputs and planting materials.

The FGD also highlighted that land is basically accessed through inheritance from parents to sons. Parents expected to distribute land when sons get married as a result land holding size is falling and scarcity and land fragmentation is increasing overtime. The FGD further describe that married sons traditionally tend to live with their parents as traditional security of parents and supply of the household labor to maintain the intensive farming, i.e., the diversification of crops. Although land holding is declining overtime, households utilize the small land unit for cultivating diverse crops and trees and raise livestock. Consequently, they secure harvest of different crops throughout the year and hence ensure subsistence and sustain the environment.

6.3.2.2 Livestock owning

Livstok is too positively affects crop diversity at the 5% level of significance. That is, households who own livestock have higher crop diversity than those who do not own. The result matches with the expectation that livestock owning enhances crop diversity through supplying traction power and manure for the soil.

6.3.2.3 Market distance

Marketdst negatively affects crop diversification at the 10% level of significance indicating that as distance from the main market increases the degree of crop diversity on the farm decreases. This may be because households with the relative proximity to the main market may have more access to information, inputs and planting materials which enhances crop diversity than households located farther from the market.

6.3.2.4 Credit use

Also households who do not use *credit* have less diversified crops at the 5% level of significance. The finding matches with the expectation that households with better access to credit have higher probability of diversifying crops through enhancing access to farming information, inputs and planting materials.

6.3.2.5 Agroecology

Ecology is similarly negatively affects crop diversity at the 1% level of significance. That is, households in the Woinadega agroecology have less diversified crops than those in Dega. Differences in natural characteristics, access to market and environmental awareness as well as management practices may have caused the observed differences in crop diversity between the studied agroecologies.

6.4 Discussion and conclusion

The study results provide explanation of the factors potentially affecting the farm level crop diversity in the agroforestry system of Yirgachaffe woreda with a specific focus on the effect of demographic variables.

Household size is found to be an important demographic factor that positively affects crop diversity on the farm. The qualitative result also indicates that the community believes in increasing both household size and diversity of crops. Large size households are motivated by the drive of satisfying the rising need of household subsistence to favor increased crop diversity on the farm. Thus, large size households through diversification of crops increase the capacity of the environment in order to respond positively to the needs of the increasing population. Male headed households are found to diversify crops more than female headed ones which may result from several gender based division of labor and differences in access to labor, inputs and information. This gives males in the area more influence over the diversification of crops for sustenance and conservation of the environment. The qualitative result also indicates that female headed households are not considerably involved in diversifying crops because of dependence on hired labor and sharecropping to combat labor shortage. Enhancing information and input transfer from larger to smaller-sized and female headed household heads is an important intervention to maximize the benefits of crop diversification.

Land size is found to be one of the factors that positively affect crop diversity. Although households in the study area are basically smallholder subsistence farmers those who have relatively larger size of land have more diversified crops than others. Although households' land holding is falling over time due to land sharing among the married sons, the potential threats of increased land fragmentation on the remaining household farm seems to be offset by the fact that married sons stay with their parents in order to continue labor provision necessary to the intensive farming which involves high crop diversity. Similarly households who own livestock have greater degree of crop diversity on their farm. This may result from the contribution of livestock activity for supplying manure for cultivation and subsistence for the households and hence reducing the pressure on the crops.

Furthermore, market distance has a significant effect on diversification of crops such that households with more proximity to the main market increase crop diversity. This may be because households located closer to the main market include market demanded crops on their farms due to access to information. Likewise credit use significantly affects the diversification of crops, i.e., households that did not use credit during the study period have less diversified crops on the farm than those who used. From this increasing access to credit could be one intervention to enhance farm level crop diversity.

Agroecology also makes a significant difference on diversification of crops with more diversity measured among the Dega households than the Woinadega ones. The Dega households cultivate more annual/cereal crops hence diversification is achieved more through crop rotation and through mixed cropping. In the Woinadega where perennial crops are predominant crop diversification is achieved more through sedentary form of mixed cropping.

To sum up, increase in household size and sex of the household head are important demographic assets for sustaining productivity and the environment through enhancing crop diversity in the Gedeo scenario. Crop diversity provides year round food production and wider ecological benefits (Wiersum, 1982; Jensen, 1993; Cromwell, *et al.* 1993) and protects environmental hazards associated with monoculture production (Fernandes, *et al.*1989; Jensen, 1993). Therefore, if Crop diversity provides year round food production and wider ecological benefits and protects environmental hazards associated with monoculture production, this study is thus an evidence of the cases whereby demographic pressure is not necessarily degrade the environment and cause subsistence scarcity. Thus, the Malthusian assertion which often blames population growth and the poor cannot be applied to a situation where survival is ensured like in the Gedeo people. Therefore this study is an indication of the possibility that population pressure enhances agricultural production for sustaining livelihoods and environmental conservation through enhancing crop diversity on subsistence farms.

Therefore, large size households as a need-driving motive to meet increasing subsistence needs, and male headed households as of their better access to labor and material endowment are basic components to sustain the environment and ensure subsistence through adapting crop diversity in Gedeo accommodative agroforestry system. As a result raising the capacity of small-sized and female headed households helps to maximize the benefits of crop diversification.

Chapter 7

General conclusions

The purpose of this study is to analyze important components of the Gedeo agroforestry system namely IK, inclusion of LITs and crop diversity on household farms in the face of intense demographic pressure. To this end, three specific objectives are set out forming the basis for the analysis of the potential effects of demographic variables on the IK of agroforestry system, inclusion of LITs, and the diversity of crops. The analysis is conducted based on regression analysis of household survey data as well as conducting FGDs and key informant interview. This chapter is thus presents a summary of the main conclusions drawn from the analysis, consideration for intervention, limitations of the study and indicates directions for future research.

7.1 Empirical findings of the study

The main results of the analysis conducted in Chapters 4, 5, and 6 are presented by highlighting the specific objectives. The findings pertaining to the specific research objectives are presented in what follows.

Specific objective 1: To assess the potential effects of demographic variables on the IK of agroforestry practice.

The analysis in Chapter 4 shows that the demographic variables, household size and age of the household head, are positively correlated with the likelihood of IK more dominated agroforestry practice on the farm. Some of the socioeconomic variables; namely, land size, participation in social organizations and agroecology too are significantly correlated with the odds of IK more dominated agroforestry practice.

Regarding demographic variables large sized households increases IK more dominated agroforestry practice for two reasons. First, there is high chance that the IK pool in the household increases with the increase in the number of household members. Second, with increase in household size comes an increasing need for subsistence which necessitates more intensive agroforestry practice through the application of IK. Both cases enhance intensive application of IK for better land management. The qualitative findings also suggest that as the household size increases the Gedeo people practice more IK on their farm which they developed by adapting from nature through observing the values of trees for shading, soil fertility, ecological balance, better sustenance and environmental quality. They used this knowledge in order to conserve the environment, sustain productivity as well as build the capacity of the environment so as to carry increased population pressure to satisfy their traditional need of having as much household size as possible. This is aligned to the Boserup's (1965) argument of a favorable impact of population growth on the environment through enhanced innovation.

Similarly the age of the household head has a positive implication for increasing household IK practice. This arises from the greater accumulation and practice of IK of production and farm management enhanced through greater degree of community interaction and experience over the years among the elderly households.

In conclusion, demographic variables namely: increase in household size and age of the household head provides an important resource for sustaining productivity and conserving the environment through enhancing IK more dominated agroforestry practice on the farm.

Population increase is an important drive for the development and practice of the IK system in the study area. Moreover, aged people have accumulated skill and experience of IK which they currently apply for preserving the environment and transferring to the young successors. Aged people as traditional authorities and culturally conservatives appear to be the internal strength of the IK system. Therefore, growing number of people and aged people are at the center of the existence and perpetuation of IK and thereby conservation of the environment among the Gedeo households. In line with this, Donkoh and Awusabo (2009); Kendie and Ghartey (2000); SLUF (2006) describe IK as an effective resource for environmental management and sustainability which are being matters of survival to the people who generated them.

Specific objective 2: To examine the potential effect of demographic variables on the inclusion of LITs on household farms.

The analysis in Chapter 5 shows that household size and the age of the household head are positively associated with the likelihood of inclusion of more LITs on the farm.

Attributable to the increase in the availability of household labor and extended contacts, increase in household size favors the inclusion and management of more LITs on the farm. Moreover, the fact that some of the LITs have important direct contribution for household livelihood reinforces the inclusion of more of such trees on the farm among larger sized households.

Aged households too, through their understanding of the environment built up over the years, and the greater degree of their exposure to cultural practices as well as community interaction, they tend to increase the inclusion of large indigenous trees in croplands.

In addition to the function of keeping soil fertility, providing shade for crops, balancing the ecology and offering socio-economic and cultural values, the community recognizes the role of LITs in facilitating schooling opportunity for children and engaging in petty trading for women. Moreover, the community has cultured sense of ownership and conservation of LITs found on individual household farms and in particular the aged people of the community feel responsible for overseeing and policing LITs as community resources. In cases of declining forest feature of farms due to cutting off farm trees, the elders confront individuals who spontaneously eliminate LITs from their own farms. Also, as children grow up parents train them how to plant, protect and wisely use the young trees on the farm.

In conclusion, increased population size and aged people are found to be important demographic variables that motivate the inclusion of more LITs on household farms in the Gedeo setting. The cultural values and the community recognition of the benefits of conserving LITs is the integral component of the relative harmony between the existing demographic pressure and environmental resource base on the Gedeo agroforestry system.

Specific objectives 3: To identify factors affecting crop diversity on household farms.

The analysis in Chapter 6 deals with the factors that affect crop diversity on the farm. Demographic variables; namely, household size and the sex of the household head positively affect the farm level drop diversification. The result also shows that land size, livestock holding, market distance, agroecology, and credit use are found to have significant effect on the extent of diversification of crops.

The drive to meet increasing subsistence needs of the increasing household size and the addition of labor force to run a more labor intensive crop diversification stimulates households to increase crop diversity on the farm. Results from the qualitative analysis also highlight the Gedeos' principle of encouraging large household size along with higher crop diversification focusing on foodstuffs. Households, instructed by the principle, cultivate diverse species with adaptive arrangement in space and time for providing year round production in response to the increasing household size. The community recognizes that demographic pressure positively influences crops diversification from where households achieve their subsistence needs and advance environmental sustainability. The findings further show that male headed households have more diversified crops than female headed ones which may result from the gender based socio-economic differences existing in the community. This may as well be because females are more involved in petty trading (Wayo, *et al.* 2003) or that female headed households face labor scarcity to diversify crops in their farms particularly if increasing diversity is labor intensive.

Moreover, households with larger land size have higher crop diversity than those with smaller land size which resulted from the additional room for including more species on the farm. Similarly households who own livestock are found to diversify crops more than households who do not own livestock. The supply of inputs and subsistence from the livestock activity in enhancing crop diversification is worth noting here. Proximity to the main market and credit use through enhancing access to diverse crop knowledge and planting material promotes crop diversification on the farm. In addition, due to variation in agroecology, household farms in the Woinadega are less diversified than those in the Dega. As a result of differences in natural characteristics Woinadega is dominated by perennial crops and hence the diversification is characterized by sedentary form of farming while the Dega is dominated by annual crops thus the diversification is characterized by crop rotation.

In conclusion, the findings of the study explain that crop diversification appears to be one of the activities or adaptation strategies a growing population triggers in the context of traditional agroforestry systems. For the Gedeo households the effectiveness of this strategy is reinforced by land size, livestock ownership, market and credit access, and the specific agroecological characteristics.

Generally, the findings in Chapters 4, 5 and 6 demonstrate that large household size, an indicator for population increase, motivate the Gedeo households to maintain and develop important agroforestry assets namely IK more dominated agroforestry practice, inclusion and conservation of LITs as well as crop diversity on the farm. This gives part of the explanation for the uniqueness of the Gedeo agroforestry system in accommodating high population pressure with less environmental issues. Given that environmental conservation is enhanced through IK practice (e.g., Hart and Vorester, 2006; SLUF, 2006), planting more trees (e.g., Wilkinson, *et al.* 2000; Serigne, 2003; Jeffery and Schorth, 2005) and increasing crop diversity (e.g., Semwal, *et al.* 2003; Saxena, *et al.* 2005; Tesfaye, 2005) the evidence from the current study indicates that the link between demographic pressure and environmental conservation is not necessarily negative. The finding seems to be aligned to the findings that population growth across a wide range of population densities in Burkina Faso has not proved any evidence of widespread soil degradation and fertility decline in the cereal cultivated fields (Mazzucato and Niemeijer, 2001; in Muchena, *et al.* 2005). Similarly, in the semi-arid areas of India, villages have been managing natural resources for centuries without the land showing symptoms of irreversible degradation under rising population pressure (Walker and Ryan, 1990; in Muchena *et al.* 2005). A much stronger evidence in this regard is the finding of less erosion with more people in the semi-arid areas of Eastern Kenya (Tiffen, *et al.* 1994) and that households with larger size use more intensive soil conservation practice than others in Gedeo zone (Bekele, 2007). The result corresponds to the Boserupian notion of a positive population-environment link through population fuelling technological innovations (Boserup, 1965) and to the argument that traditional agroforestry systems evolved in response to population pressure and depletion of resources (Arnold, 1997; Wilkinson, *et al.* 2000; Chew, 2001).

However, this view does not deny the existence of degradation but calls into question the widespread belief that developing countries are degrading their soils simply because of raising population pressure and their farming practices. Furthermore, the findings of this thesis should only be taken to show the favorable relationship between the current demographic variables and the selected environmental indicators.

7.2 Opportunities and threats of the agroforestry system in the area

The findings of this study asserts that rising population pressure may not necessarily be the main cause of the widespread land degradation claimed for developing countries with large population argued by (EPA, 1998; Bekele and Berhanu, 2001; Paulos, 2001). Rather, demographic pressure potentially influences households and communities to direct the human-nature interface in the way of adapting the system to achieve mutual advantages. Practicing IK dominated agroforestry, inclusion of more diverse trees and diversification of crops in the study area are some of such adaptation responses. That is, population increase is found to be an important input for enhancing the IK system, management of more diverse trees and crop diversification on the farm. Aged people too, owing to their accumulation of knowledge and experience and as they are traditional authorities, are the centre of the existence and practical transfer of the IK system and inclusion and management of diverse large trees. Male headed households also because of their better access to labor and material endowment have a favorable influence over diversification of crops. Thus, as long as the harmonious interaction between the demographic variables and important pillars of the Gedeo agroforestry system (namely: the IK system, inclusion and management of LITs and diversification of crops) existed the system continues to be the central strength of environmental management in the area.

On the other hand, the dynamic nature of demographic and socio-economic characteristics implies that the current human-nature interface in the Gedeo setting may not continue as it is. First, the Gedeo IK system is based on communication of oral transmission while the young generation learns from the aged orally, through observation and on the job training. The question, therefore, is whether such oral modes of transmission continue to be effective in sustaining the natural resource base and local livelihoods. The expansion of modern education may become a possible challenge to the traditional mode of transmission of the IK and thereby constitutes a potential threat to the existence of IK based agroforestry system and environmental management. Moreover, the evidenced unfavorable effect of market orientation implies that an increased tendency towards more market oriented farm management favors more modern farming than the IK based one. Thus, increased market orientation is also a potential threat to the IK based agroforestry and environmental management system although it is difficult to conclude about the effectiveness of the alternative system without further empirical evidence.

Second, the forest characteristic of the Gedeo agroforestry system is based on the intercropping of diverse large trees on household farms. Some of these trees need several years, for e.g., more than half a century to reproduce (Tadesse, 2002). However with the expansion of urbanization this forest attribute attracts a number of timber traders and wood-furniture producers. Selling the trees appears highly paying in the short run due to lack of accounting for the longer term environmental costs arising from cutting such large indigenous trees. The apparently high price of the large trees motivates young farmers and those with less off-farm opportunities to engage in cutting the trees and thereby putting the large trees that establish the forest attribute of the area under severe stress.

Third, the findings of the study show that households with a relatively large land size have more diversified crops. However, with the increase in population size, household land holding tends to decline over time causing increased land fragmentation and shortage of farmland. As a result, land shortage appears to be a potential threat for crop diversification. The tendency to grow more commercial crops may as well be a potential threat for the crop diversity based environmental management.

7.3 Considerations for intervention

The demographic variables through favorably affecting the important components of the Gedeo agroforestry system (IK of agroforestry, incorporation of LITs, and crop diversity) are inferred to have a useful contribution for sustainable productivity and environmental management.

Since increase in household size and age of the household head are important in the practice of IK dominated agroforestry system, devising a way of transferring IK from the bigger-sized and older households to the smaller-sized and younger households e.g., through enhancing community based social organizations is a useful strategy. Acknowledging the role of IK as a valuable instrument in natural resource management (Donkoh and Awusabo, 1999; SLUF, 2006), intervention and policy mechanisms by national, regional and local GOs and NGOs is suggested to preserve and employ IK for sustainable development in Ethiopia. Moreover, mechanisms should be designed to protect the Gedeo indigenous knowledge system, which is basically transmitted through oral communications. For instance, integration of indigenous knowledge into the formal educational system assists in enhancing the use of indigenous knowledge by the younger generation who now spend more time in the school.

Similarly, as LITs are found more among larger and older households, enhancing sharing of information on the management of LITs for the smaller and younger households helps in expanding the inclusion of LITs on household farms. Moreover, strengthening and supporting the community policing of LITs by government officials is suggested for the protection of LITs. Further more, since large and male headed households are important in diversification of crops, raising the capacity of small-sized and female headed households helps to maximize the benefits of crop diversification. Access to credit is found to have important contribution for diversifying crops. Therefore, increasing household access to favorable credit services in the study area is recommended in order to harness the environmental benefits of increasing crop diversity on the farm.

In recognition of the fact that the relative environmental stability of the Gedeo agroforestry is attributed to the observed practice of IK, conserving LITs and crop diversity on household farms, promotion of IK and LITs based crop diversification in populous areas where agroforestry initiatives are limited or absent is recommended. It is also acknowledged that no other farming practice than IK based traditional agroforestry system is proved more productive and sustainable in the highly rugged and steep agricultural landscapes, under highest agricultural population densities in rural areas and in the increasing land fragmentations (SLUF, 2006).

Particularly if the current trend of population increase is to continue, intervention by GOs and NGOs on the extension of non-tillage farming sectors for e.g., cattle fattening, honey production, and development of labor intensive small scale industries, and service sectors is strongly suggested to accommodate population resource beyond the land tillage. Moreover, resettlement schemes to the sparsely inhabited nearby areas of the Oromia region is suggested. New settlements may favor the expansion of the agroforestry knowledge and its wider application for better environmental stability and development. Hence, consensual intervention by inter-regional governments is suggested.

7.4 Limitations of the study and indication for further research

The main difficulty encountered during the study is the event that some respondents misunderstood the data collection effort as a preparation for identifying 'development' heroes for reward and thus tend to abuse the data while others, due to the fear of increase in taxation were reluctant to cooperate. In both cases, when an attempt made to convince the respondents of the true cause of the research failed, replacing respondents is opted for. Moreover, there was a difficulty of getting officially recognized secondary data from different government offices due to the high attrition rate of experts from their respective positions.

Although the study implies that younger households tend to have IK less dominated agroforestry practice than older ones it does not explore the future prospects of IK in the area. Further research is needed to see whether the future generations would be interested in the use of IK, whether the oral mode of transmission of IK continues to be relied on and whether the landless have developed awareness and interest in the use of IK that they may need to apply while working as daily farm laborers. Again, this study finds that currently smaller farmers use more IK dominated but less diversified agroforestry practices, but it does not tell if there is a threshold land size below which any additional IK practice ceases to be effective in sustaining productivity and conserving the environment. Further research is needed on this so as to identify the compatible type of land related and other interventions.

Finally, the study attempts to find an explanation for the relative stability of the Gedeo agroforestry in the face of increasingly high population density, through analyzing the links between demographic variables and important components of the Gedeo agroforestry system (IK, LITs and crop diversity). The links between demographic variables and environmental sustainability is basically inferred from the qualitative analysis. Although there is some literature on the latter link in general, a specific quantitative analysis of such link on the Gedeo agroforestry would give a better understanding of the effect of demographic variables on the sustainability of the Gedeo environment. In line with this, an analysis of the dynamics of the components of the Gedeo agroforestry system and food security status would be useful to understand how the natural resource base of the system and livelihood situations evolve over time.

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Appendix I

Table A 1 population, land use and altitude by study kebeles, woreda and zone.

	Populat-ion	Land area (ha)					Altitude (masl)
		Cultivated	Grazing	Forest	Others	Total	
Wotie kebele	6754	871	3.5	1.5	37	913	1950-2120
Adame kebele	8788	919	-	-	20	939	1770-1970
Konga kebele	8073	824	-	-	35	859	1800-1950
Bowicha kebele	5561	1869.5	5	200.5	25	2100	2100-2500
Yirgachaffe woreda	181,977	27,590.75	1123.95	1831.98	1203.33	31,750	1501-2500
Gedeo zone	843,928	107,160	6884	6455	15145	134700	1500-3000

Note: - stands for non-availability of data.
Source: SNNPRSA (2007); GZFEDD (2008); BOFED (2009/10); YWARDO (2009/10).

Appendix 2

Table A 2. Crops grown and livestock reared in the agroforestry

Crop categories				Livestock
Perennial crops(p)	Annual crops	Vegetables & root crops	Fruits(p)	
Coffee	Maize	Kale	Avocado	Chicken
Enset	Barley	Cabbage	Mango	Sheep
Sugarcane	Wheat	Spinach	Papaya	Goats
Qat	Oats	Lettuce	Banana	Cows
Gesho *	Tinkish*	Tomato	Orange	Oxen
Tobacco	Bean	Carrot	Mandarin	Bulls
Koseret*	Peas	Potatoes	Apple	Heifers
	Chickpeas	Beet root	Pineapple	Calves
	Lentils	Onion	Guava	Horses
	Haricot beans	Garlic	Fig	Mules
	Cowpea	Leek	Casmir	Donkeys
	Flex	Green pepper	Tiringo*	Bees
	Korerima*	Pepper	Peach	
	Dinbilal*	Pumpkin	Bull-heart	
	Ginger *	Eggplant	Strawberry	
	Sun flower	Yam	Koppie*	
	Besobila	Taro	Lemon	
	Nana*	Sweet potatoes	Koshim*	
	Tenadam*	Cassava		

Note: (p) Perennial crop species. * Local names.

Table A 3. Dominance of crops by rank order

Crops	Dominance by sample HHs N	Percent	Rank
Enset	413	98.33	1
Coffee	316	75.24	2
Cabbage	293	69.76	3
Guava	241	57.24	4
Maize	225	53.07	5
Onion	170	40.48	6
Yam	136	31.63	7
Barley	121	28.14	8
Bean	114	27.14	9
Green pepper	113	26.91	10
Sugarcane	99	23.57	11
Apple and cassava (r)	92	21.91	12
Bullheart	90	21.43	13
Peas	74	17.62	14
Haricotbean	70	16.67	15
Taro	69	16.43	16
Cowpea	68	16.19	17
Tomato, carrot, beatroot	57	13.57	18
Tinkish	46	10.95	19
Sweet potatoes	37	8.81	20
Wheat	15	3.57	21

(r) Recently introduced by the local ARDO

Appendix 3

Table A 4. Trees included in croplands in the study area

No	Tree name			Socio-economic and ecological values									
	Scientific	Amharic	Gedeuffa	Food	Fodder	Shade	Soil pro-tection/ fertility	Spring flow	Me-dici-ne	Crop prote-ction	Fuel	Constr-uction	Live fence
1	Cordia africana	Wanza	Wodeesa	x		x		x	x		x	x	x
2	Milletia ferrugenia	Birbira	Dhadhato		x	x	x		x		x	x	
3	Vernonia amygdalina	Girawa	Ebicha		x	x	x	x	x		x	x	
4	Discopodium eremanthum	wublo	Reejje			x	x	x	x		x	x	
5	Erythrina abyssinica	Korch	Woleenna		x	x	x	x	x		x	x	
6	Ficus sur	Shola		x(1)	x	x	x	x			x	x	
7	Euphorbia abyssinica	Kulkual				x			x	x	x		
8	Hagenia abyssinica	Koso				x			x		x	x	
9	Polyscias ferruginea	Yetota wonber	Tala'a			x	x				x	x	
10	Justica shimperiana		Cho'e		x	x	x	x	x		x	x	
11	Arundinaria alpina	Kerkeha	Leemme		x		x	x	x		x	x	
12	Podocarpus falcuta	Zigba	Birbirsa				x		x		x	x	x
13	Juniperous procera	Tsid							x		x	x	x
14	Croton macrostachyus	Bisana	Mokoniisa			x			x	x	x	x	
15	Moringa olifera	Shifera	Shifarra	x	x	x			x		x		
16	Acacia lahai		Garbe	x(1)	x	x	x		x		x	x	
17	Schefflera abyssinica	Geteme	Gatame		x	x	x	x	x		x	x	
18	Syzigium guineense	Dokima	Badessa	x		x						x	
19	Aningria adolfi	Kerero	Guduba			x					x	x	
20	Albizia gumifera		Gorbe										
21	Aningeria altisima		Gudubo								x	x	
22	Phonix reclinate	Zenbaba	Meexxe		x		x	x					x
23	Maytenus undata		Kombolcha		x	x	x	x			x	x	

24	Acacia brevispica		Gorgora		x	x		x	x	
25	Acacia nilotica		Burquqe		x			x		
26	Boswellia papyrifera	Etan zaf			x			x	x	
27	Casuarinas equisetifolia	Shiwshiwe						x	x	x
28	Celtis africanus		Sisa		x			x	x	
29	Acacia abyssinica	Girar (thorny)			x			x	x	x
30	Acacia albida	Girar (non-thorny)		x	x			x	x	
31	Acacia bussei	Dewni girar	Xedecha	x	x			x	x	
32	Dodonaea anguistifolia	Kitkita			x		x	x	x	
33	Maesa lanceolata	Kelewa					x	x	x	x
34	Maytenus senegalensis	Yedega atat	Haxaxae		x			x	x	
35	Olea capensis		Seetaamo		x			x	x	
36	Olea africana	Weyira			x		x	x	x	x
37	Ficus sycomorus	Warka			x	x	x	x	x	x
38	Podocarpus falcatus		Deega		x			x	x	
39	Apodytes dimidiata		Donkoka	x	x			x	x	
40	Bersama abyssinica		Tibirro		x		x	x	x	
41	Prunus africanus	Tikur inchet			x			x	x	
42	Terminalia basilei	Abalo			x			x	x	x
43	Ricinus communis	Gulo	Qobbo		x			x		
44			Amaado		x			x	x	x
45			Chekata		x			x	x	
46			Motoqamo		x		x	x	x	
47			Mi'e		x	x	x	x	x	
48			Hangadhdh		x	x		x	x	
49			Ouraga	x	x	x		x	x	
50			Suke		x			x	x	
51		Gofer inchet			x			x	x	
52			Ononoo		x			x	x	x

Note: [1] indicate trees that favor the growth of mushrooms.

Appendix II

Survey questionnaire

This survey questionnaire is a component of the research being conducted on *Agroforestry a diversified agriculture accommodating dense population: The case of Yirgacheffe Woreda, Gedeo Zone, SNNPR*. You are kindly requested to provide reliable information pertaining to each question. The information to be obtained through this questionnaire will remain confidential and used only for the intended research. Your name will not be mentioned in the presentation of the findings.

Thank you in advance for your cooperation.

I. General Information of the study HH.

I.1. Location information of the HH:

1. Kebele ___________________ Village name or number ________________________
2. Walking distance in hr. from the HH to the local (village) market _____________, to the main road ______________, and to the main (woreda) market ________________.
3. The HH agroecologic characteristics (1) Dega ☐ (2) Woinadega ☐
4. HH demographic and Socio economic Characteristics.

I.2. Survey of Demographic and Socio economic Characteristics of the study HH.

NB: HH refers to household

	HH member	Relation to HHH	Age	Sex	Marital Status	Migration status	HH size	Educational status		Health status	Off farm participation
Line no	Name (Id no) of HH members	0=Head 1=Husband 2=Wife 3=Daughter 4=Son 5=relative 6=others (specify)	How old is ____? (completed years)	1=Male 2= Female	1=Never married 2=Currently married 3=Divorced 4=Widowed 5=Separated	1= Not migrant 2= Permanent migrant 3 = Temporary migrant	No of persons in the HH	Can ___ read and write? 1= Yes 2 = No	If yes, completed grade level	1=Healthy (who works throughout the year) 2=Sick (who was out of work due to illness for three months & above)	1= Livestock raising 2= Coffee trading 3=Kocho trading 4=Grain trading 5=Petty trading 6=Carpentry 7=Weaver 8=pottery 9=Daily laborer 10=Remittance 11= others (specify)
01											
02											
03											
04											
05											
06											
07											
08											
09											
10											

Note: HHH refers to household head

5. If your HH size is increasing over the last five years, why is it increasing? Because

1) Increase in HH size provides more labor force participation

2) Value of children 3) Support other relatives 4) Others (specify)

6. If your HH size is decreasing over the last five years, why is it decreasing?

1) Death 2) migration 3) divorce 4) others (specify)

II. Land and livestock holding.

7. Do you own land? 1) Yes 2) No

8. If yes, what changes occurred on your land operated over the last five years?

Land type		**Unit (ha/ local unit)**	Land operated change over the last five years										
			Increasing / expanding 1= yes 2= no						**Decreasing 1= yes 2= no**				
			buying	Renting	inheriting	gift	Share crop	Grabbing	selling	gift	Renting	Share crop	grabbing
Cultivated	Non irrigated												
	Irrigated												
Fallow													
Grazing													
Marginal													
Others (specify)													
Total land size													

9. Do you own livestock? 1) Yes 2) no

10. If yes, what changes occurred on your livestock holding over the last five years?

No	Type of livestock	Size	Change over the last five years **1=increase 2=decrease**	Reason for	
				increasing	decreasing
1	Chicken				
2	Sheep				
3	Goats				
4	Cows				
5	Oxen				
6	Bulls				
7	Calves				
8	Heifers				
9	Horses				
10	Mules				
11	Donkeys				
12	Beehives				
13	Others (specify)				

Potential reasons

Increasing	decreasing
1=buying	1=selling
2=breeding	2=slaughter
3=gift	3= gift
4=share-breeding	4=share-breeding
5=others (specify)	5=death
	6=theft
	7=others (specify)

12. How many times do you produce crop per year?

1) Once only during belg 2) once only during meher 3) twice during belg and meher

13. Has your production frequency/year increased (the change b/n now and before five years)?

1) Yes 2) no

14. What kind of species do females in the HH cultivate?

1) Coffee 2) Enset 3) Grain 4) Vegetable 5) Root crops

6) MTS 7) Lentil, bean & peas 8) others (specify)

15. Explain why females cultivate the selected crops more? ____________

16. What kind of species do males in the HH cultivate?

1) Coffee 2) Enset 3) Grain 4) Vegetable 5) Root crops

6) MTS 7) Lentil, bean & peas 8) others (specify)

17. Explain why males cultivate the selected crops more? ______________

18. How does market availability affect farm crop species?

1) Expands few cash crops like coffee 2) expands the production of enset 3) Increase the production of grain 4) Increase the production of root crops 5) Increase the production of vegetable 6) Increase the production lentil, bean & peas 7) others (specify)

IV. IK of agroforestry
IV.1. Cropping knowledge

No	List of crop	C1	C2	C3	C4	C5	C6					C7					C7				
		Land preparation 1= tillage 2= minimum tillage 3= non tillage	**Cropping system** 1=sowing seed 2=planting seedling	**Cropping management** 1=randomly 2= in rows	**Planting -harvesting months**	**Measures of crop maturity to harvest** 1= fully mature (ripe) 2=some parts are ripe 3=leaf yellowed/ dried 4= corm are fully dormant	**Where did the HH get this knowledge from?** 1= parents 2= school 3= DAs 4= Peer/ community 5=others (specify)					**Did the HH get modern training/advice?** 1= yes 2= no					**If yes, who provide the training?** 1= GOs 2= NGOs				
							C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5

IV. 2. Farm management

No	**Maintaining soil fertility/ Increasing productivity**	Application 1= Yes 2= No	Where did the HH get this tool/equipment and input? 1=ARDO 2=NGOs 3=Credit organizations 4=Local markets 5=Prepared by the HH 6=Exchange b/n HHs 7=Others	Where did the HH get this knowledge from? 1=Parents 2=School 3=Das 4= Community 5=Others	Did the HH get the training from? 1= Yes 2= No	If yes, who provide the training? 1= GOs 2= NGOs
1	Mixed cropping					
2	Intercropping					
3	Shade cropping					
4	Shifting cultivation					
5	Fallowing					
6	Mulching					
7	Applying compost					
8	Applying manure					
9	Applying ashes					
10	Applying chemical fertilizer					
11	Improved seed/ seedling					
12	Others (specify)					
	Weed control					
1	Thinning					
2	Slashing					
3	Bush / slash burn					
4	Hand weeding					
5	Mulching					
6	Resistant variety					
7	Intercropping					
8	Shifting cultivation					
9	Fallowing					
10	Shade cropping					
11	Herbicides					
12	Others (specify)					
	Pest control					
1	Slash burn & smoking					
2	Intercropping					
3	Resistant variety					
4	Dusting with ash					
5	Removing diseased plant / leaf					
6	Fallow/shifting cultivation					
7	Use plants as repellent /attractant					
8	Scaring device for vertebrates					
9	Pesticides					
10	Others (specify)					
	Farm tools/equipment					
1	Hoe					
2	Slasher					
3	Oxen plough					
4	Irrigation tools					
5	Pesticide sprayer					
6	Herbicide sprayer					
7	Others					

V. Traditional institutes.

21. Does the local culture (tradition) promote farm species diversification in your kebele?
    1) Yes 2) No
22. Which cultural elements promote of farm species diversification?
    1) Get the community respect 2) preference over daughters/sons for marriage
    3) Elders' blessing 4) others (specify)
23. Are you participating in community based organizations like Ekub, Edir or Debo? 1) Yes. 2) No.
24. If yes, how do you evaluate their role in your effort of crop diversification? They
    1) Facilitate exchanging of information and planting materials 2) Facilitate labor exchange for timely farm operation

Checklist for focus group discussion and key informants' interviews

1. Evaluation of the following trends over time in the kebele

    1) Population size 2) HH land holding size 3) forested land size

2. Mention the main components of agroforestry species and source of knowledge;

    2.1 Perennial crops, annual crops, vegetable, root crops, lentil, bean & peas

    2.2 MTS: 1) Intercropped with crops: food, fodder, fuel, construction, medicine, fertilizer, shade, soil conservation, water conservation, climate management and income.

    2) In grazing lands: fodder, shade, fuel 3) Living fences and boundaries

    4) In public fields: shade, fuel, fodder

    2.3 Discuss the values of crops explained above in relation to the following aspects
    1) Environmental 2) socio-economic 3) cultural value

    2.4 Identify MTS in general and indigenous MTS that are important ingredients of agroforestry system in the area; discuss the trend over time.

    2.5 Identify factors affecting the size/availability of MTS and indigenous MTS on
    1) farm 2) communal land 3) protected areas

    2.6 Identify dominant crops among the intercropping species in the area/kebele and discuss trends of dominancy order over time.

    2.7 How do you explain the practice of agroforestry in the area, the source of this knowledge and the ways it transferred through generation.

3. Identify livestock that can be included in the agroforestry, explain their importance and the knowledge source.

4. Mention farm tools/equipments and inputs employed in the locality, identify between the modern and the traditional, where the community get them from, as well as the knowledge source.

5. Mention farm management techniques most common in the community and sources of knowledge of employing them.

6. Discuss the link between increase in population size at community level and the size of crop species over time.

    - As population increase:- 1) Enset increase/decrease 2) Coffee increase/decrease 3) Grain increase/decrease 4) Root crops increase/decrease 5) Vegetable increase/decrease 6) Lentil increase/decrease 7) Fruit increase/decrease 8) Khat increase/decrease 9) sugarcane increase/decrease 10) MTS increase/decrease 11) Indigenous MTS increase/decrease

    - Changes observed over time in the kebele in relation to population increase and on farm inclusion of large MTS in general and indigenous MTS in particular.

- The contribution of increase in population size for the expansion of IK of agroforestry, and the role of IK in turn in the accommodation of the increasing population size.

7. Relationship between age of the HHH and diversification of crop species in the community:
    - as age of the HHH increase the number of crop species increase/decrease,
    - if there are crop species most preferred as age of the HHH increases,
    - the link between age of HHH and size of MTS and indigenous MTS.
    - The effect of age of the HHH on the expansion and preservation of IK of agroforestry in the area.

8. The effect of sex difference on diversification of crop species in the community:
    - Do females or males diversify crop species more?
    - Type of crops that females cultivate commonly in the in the community.
    - Type of crops that males cultivate commonly in the in the community.
    - How do males and females differ on inclusion of large MTS in farm as well as the inclusion of indigenous MTS? Where did the community get the knowledge involving the two sexes in diversification.

9. The link of marriage with crop species diversification in the community:
    - What is the role of marriage in the community for the diversification of farm species and expansion of IK of agroforestry?

10. The effect of Migration on diversification of crop species in the community:
    - How the community explained migration condition in the area?
    - The effect of migration on diversifying crop species and expansion of IK of agroforestry.

11. Education condition in the area and the link with crop species diversification.
12. Health condition in the area and its effect on diversifying crop species.
13. The effect of market availability on crop species diversification.
14. The role of cultural institute on diversifying crop species.
15. If there is local name for IK of agroforestry in the area and recent perception for this IK.

    1) on its sustainability 2) if there is fear of losing it

Declaration

The thesis is my original work, has not been presented for a degree in any other university and that all sources of material used for the thesis have been duly acknowledged.

Solomon Bekele		27-06-2011
Student	Signature	Date

I confirm that this thesis has been submitted with my approval as the supervisor of the same.

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