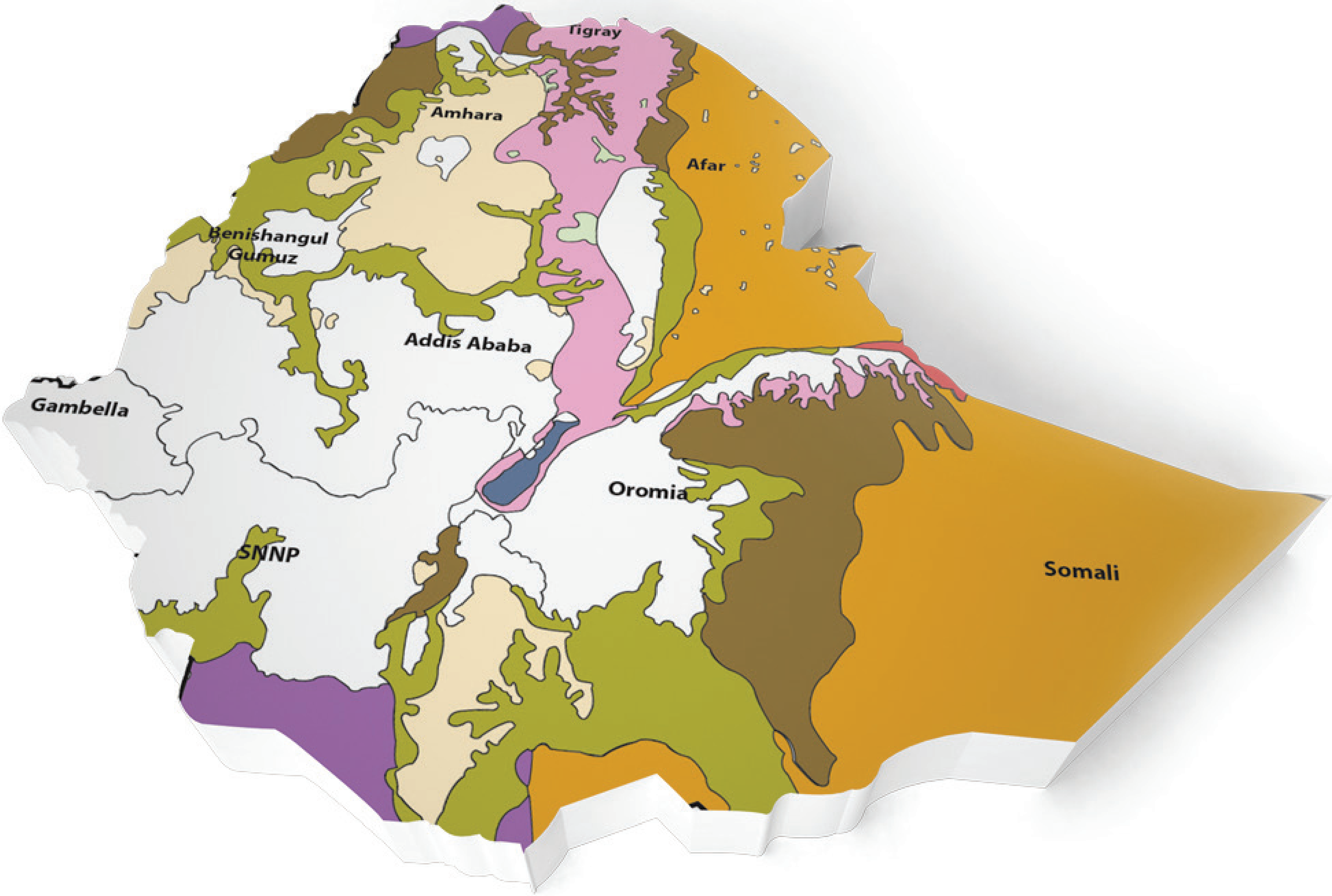

Integrated Drylands Management in Ethiopia

Proceedings of the High Level Policy Forum 6 - 7 March 2014, Semera, Afar National Regional State

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United Nations Development Programme

Ethiopia Country Office

Addis Ababa

FORWARD

Drylands in Ethiopia cover about seventy five percent of the total land mass of the country. These drylands harbor one third of the population of Ethiopia and this number is continuously increasing as more and more people migrate from highly-degraded highland areas into the drylands. However, if well managed, drylands have tremendous potential to contribute to livelihood improvements and economic development. They have unexploited diverse agro- ecological resources, which include rich and diverse plant and animal species and huge underground water resources in the Afar region.

Despite these potentials, drylands management in Ethiopia is beset with challenges that require the application of science and innovation and human efforts to bring about change and sustainable management of drylands in ways that both promotes livelihood and resilience to shocks. Some of the key challenges that make this task additionally complex is the lack of inadequate delivery of public services and amenities exacerbated by inadequate social and physical infrastructure, high incidence of human and livestock diseases, water scarcity and extreme weather condition as well as land degradation due to population pressure and increasing spells of droughts among others.

The UNDP appreciates the difficulties in promoting human development and poverty reduction in the face of increasing climate variability for household and communities living in arid agro-ecological zones. The government has important roles to play, and needs to be capacitated to search for home-grown solutions and draw upon proven approaches and technologies to ensure that programmatic interventions are effective and sustainable.

The UNDP in Ethiopia is privileged to partner with the government of Ethiopia to support sustainable management of drylands and thereby ensuring that these drylands habitats provide avenues for livelihood improvements and resilience to climate related shocks. In particular, UNDP is proud to partner with and support the Afar Environment Protection, Land Use and Administration Agency (EPLUAA) in building local capacities for promoting diversified livelihoods and coping strategies of pastoral communities living in dryland areas. The capacities of the people of Afar and local institutions have been enhanced and the utilization of natural resources made more efficient and sustainable. Sustaining these interventions remain critical in advancing human progress in the Afar region and other communities living in arid climatic conditions.

Sustainability can be attained with strong political will and robust and visionary policies and strategies supported by all stakeholders, and promoting policy dialogue is key in this regard. UNDP working with the Afar regional government organized a multi-stakeholder high level policy forum on dry lands management in Ethiopia to discuss and share research based findings and best practices. This publication compiles the proceedings of the high level policy forum held in March 2014 and codifies some of the latest research findings and best-practices on climate change adaptation, resilience building and dryland ecosystem management systems. It also provides insights on livestock production and value chain development that is so critical in enhancing livelihoods of pastoral communities, and how strong institutions and policies can help to bring about conservation and sustainable utilization of dryland resources in the Afar region and other dryland areas in Ethiopia.

I am confident that you will find this compilation useful, insightful and stimulating to read.

Samuel Bwalya

Country Director
UNDP Ethiopia

Message from the Agency Manager

Elema Abubaker

Afar Environment Protection Land Use and Administration Agency, General Manager

Climate change (global warming) is caused by the emission and accumulation of green house gasses in to the atmosphere due to increased in human population and technological development.

Though, Developed countries who followed carbon intensive development path for the past centuries are more responsible for the occurrence of climate change, developing countries whose contribution for carbon emission is negligible are severely affected by adverse impact of climate change. The vulnerability of developing countries such as Ethiopia to climate change is attributed to limited economic resources ,low levels of technology, poor information and skills, poor infrastructure, unstable or weak institutions, and Inequitable empowerment and access to resources which are most evident in emerging regions like Afar. Likewise, the impact of climate change is more evident and exacerbated.

The Afar National Regional State is geographically located in low land area which has got very hot temperature, obtain small and erratic annual rain fall and is vulnerable to climate change. due to this reason the region is suffer from recurrent drought, excessive hot temperature, occurrence and transmission of human and livestock diseases, invasion of range land with exotic weeds and bushes, loss of bio diversity, drinking water shortage which thereby hinders the effort of pastoral and Agro pastoral community of the region to assure its food security.

Although it is very difficult to protect climate change induced hazards, activities to improve the adaptation capacity of the pastoral and Agro pastoral communities in response to climate change is being undertaken in the region with more emphasis and special attention. With regard to this, Afar Integrated Dry Land Management Project has been working on strengthening the adaptive capacity of Afar people in building climate resilient sustainable development in the region.

Since all economic and social sectors are affected by climate change induced hazards, it is crucial to integrate and organize all stakeholders to take integrated measure on all sectors so as to increase the adaptation capacity of regional community. In this regard, AIDLMP achieve successful results on natural resource development and protection, range land management, renewable alternative energy source provision, alternative income generation, animal health, provision of drinking water, small scale irrigation development, capacity building at all level and hence degraded areas are being reclaimed and problems related to climate change have been minimized so that the community is benefited.

Starting from the launching of the project, number of expected and unexpected problems were faced which hinder the project activities to be implemented as per the annual work plan. but those problems were solved gradually by dedicated and unreserved effort of project personals at all level specially the effort of higher officials and program advisors of UNDP country office, and DDC officials and advisors was very appreciated.

Finally, I would like to give my deepest gratitude to all who directly or indirectly contribute their best for the success of the project on behalf of me and Afar Environment Protection Land Use and Administration Agency.

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1. AIDMP Policy Forum Workshop Opening Speeches Summary

Ato Berhanu Solomon

Ato Berhanu Solomon from the Ministry of Environment and Forest (MEF) started the meeting by delivering speech on behalf of HE State Minister Kare Chawecha. In his speech, Ato Berhanu stated that dry lands are increasingly becoming hotspots of a number of economic development activities in the country. He also noted that dry lands are frontiers of desertification, where mismanagement of natural resource leads to degradation of their potential to provide goods and services vital for economic use. This problem is further compounded by the vulnerability of areas to the effects of climate change. Hence, he indicated that the government is strongly supporting projects like the AIDLMP and other similar interventions. To address development and environment related strategic challenges, the government of Ethiopia has developed Climate Resilient Green Economy (CRGE) strategy – both the green economy and resilience strategy components, and created the CRGE facility to mobilize resources needed to implement the strategies on ground. The dry land areas like Afar are the priority areas to combat desertification and adapt to the impacts of climate change, while making the desired progresses in economic development. ■

W/ro Sinkinesh Beyene

W/ro Sinkinesh Beyene delivered opening speech on behalf of Mr. Samuel Bwalya, UNDP Country Director. She stated that climate change is a global problem that requires a global solution grounded in national actions. Tackling the root causes of drought and climate change requires a long-term approach both from national authorities and development partners. She highlighted that there is an urgent need for stepped up efforts to adapt to and mitigate the effects of climate change, and hoped that this forum will help advance this important agenda by highlighting the important contributions that drylands management can make to this end. She gave extensive presentation on the state of drylands, their economic significance, key challenges and what UNDP is doing globally and in the country to address their sustainable development. ■

Ato Elema Abubeker

Ato Elema Abubeker, Director General of EPLUA, on his behalf welcomed participants to Semera/ Afar and gave a brief overview of the regional state and the project intervention area. The workshop with officially opened by the speech and guidance notes given by the Guest of Honor, HE Ato Awel Arba, vice president of the Afar National Regional State.

HE Ato Awel Arba welcomed participants to the area where human evolution started, and home of many natural attractions. He mentioned that Afar is the driest harsh environment, and yet with the oldest history of human exploitation of natural resources. He explained how the community managed resources sustainably over centuries, and the current challenges for sustainability due to climate change, population growth and land use changes in line with the national economic development plans. He explained that the Government of Ethiopia has given special attention and adopted policies, strategies and programs for integrated development of pastoralist and agro-pastoralist areas. He also noted that support from the development partners is vital for successful implementation of the strategies on ground.

The Guest of owner thanked the Royal Norwegian Government and the people of Norway for generous financial support, UNDP and the Ministry of Environment and Forest for technical support and follow-up of the AIDLM implementation. He also thanked the different sectors in the region for concerted efforts to implement the project. He wished successful deliberations during the workshop, expressed high expectations of policy relevant recommendations, and promised to implement recommendations of the forum in collaboration with development partners. ■

Session on climate change adaptation and resilience building in the drylands

2. Agricultural and pastoral technologies and practices for climate change adaptation in lowland dryland areas of Ethiopia

Kidane Georgis

ABSTRACT

Key words: Dryland areas, climate change, technology, adaptation

Drylands in Ethiopia cover about 75 percent of the total land mass of the country. Drylands consist of a wide range of agroecologies, including arid, semi-arid and dry sub-humid. Drylands are most prevalent in the north, east, central Rift Valley areas, south and southeastern parts of the country where diversified agricultural environments prevail. The lowland dryland areas in Ethiopia - the focus of this paper - cover about 61 percent of the land mass of the country. The altitude of lowlands ranges from -124 to 1,500 metres above sea level (m.a.s.l.) and average annual rainfall varies between 200 and 700 mm. The length of the growing period is 90 to 180 days. Drylands are habitat to various types of domestic and wild animals. Rangelands, for example, are important for providing forage for livestock and wildlife. They are also central for livestock genetic resources. For example, Borana cattle, Jijiga cattle, black head Ogaden sheep, the Afar goat, the Somali goat and the camel are distinct breeds of livestock. Their conservation and utilization deserve full understanding of the ecosystem.

It is estimated that about one-third of the populations in Ethiopia live in drylands. The human population in drylands is continually increasing as more people are moving from the highly-degraded highland areas to the fertile lowlands. As the population increases beyond the carrying capacity, the land resources are poorly managed and land degradation follows. The agricultural production system is largely rain fed, with rainfall distribution being highly variable due to climate change and variability. This is the major challenge of production systems, even though the lowland drylands are naturally rich in various resource bases. Most of the oil crops and livestock for the export market come from the drylands.

The drylands, with their untapped potential, have been marginalized by policymakers, researchers, planners and development workers in the past. But now the government has realized this and has developed viable policy for climate resilient green economy (CRGE) development that focuses on mitigation and adaptation. Adaptation and mitigation strategies are being reviewed and possible options are suggested. Currently, almost all technologies in crop, livestock and natural resources developed by national and international agricultural research systems (e.g., CGIAR) are documented and this will form the basis of discussion in this paper.

It now well established that the major challenges threatening dryland communities are related to degradation of the environment and natural resource bases. Ongoing natural resource degradation leads to soil and vegetation loss, fertility decline, water stress, climate change and drying up of water resources, such as lakes and rivers. The other overriding factor limiting agriculture production and productivity in the dryland areas is climate change and variability. Major issues in developing drylands using a climate change perspective in terms of adaptation and developing resilience will be discussed in this paper.

Despite their importance, little is known about the major challenges and problems, with special focus on climate change and variability, deterring the development of the dryland areas in Ethiopia. In addressing these problems, this report emphasizes adaptation to climate change and variability in agriculture-based livelihood systems and underlines the importance of creating awareness about the impact of climate change among communities, policymakers, researchers, extension workers and development planners when addressing challenges. The paper will highlight climate change effects observed in the drylands, strategies used by national research systems to address the major challenges that dryland production systems face due to climate variability and change, document inventoried technologies and practices used in agricultural-based livelihood systems in crop and livestock production, assess the current climate change challenges and their likely future impacts and assess the relevance of the technologies developed in order to identify best-bet practices to improve livelihoods of dryland farming communities.

The emphasis in this paper is on opportunities, rather than constraints, when developing dryland areas and addressing ecosystem challenges, taking into consideration ongoing climate change. The paper will conclude by suggesting and identifying what needs to be done within crop and livestock farming (e.g., agriculture and related land uses) and in forest and water management to increase productivity to achieve better livelihoods and food security, reduce emissions, increase sequestration and enhance environmental sustainability.

Introduction

Background

Dryland areas are important nationally, regionally and internationally. These dry areas account for about three billion hectares (19 percent of global land area) and are home to more than 1.7 billion people, or 25 percent of the global population. About 41 percent of the population in dry areas depends on agriculture as the major source of its livelihood. Regionally, drylands in Eastern Africa provide livelihoods to people through a host of ecosystem goods and services (Georgis, 2010). Realization of those benefits is hampered by poor understanding of the right mix of interventions needed to balance sustainable management and use of the fragile environment that is highly vulnerable to degradation. The ecosystems, particularly the rangelands, occupy a very large area, 88 percent in Kenya, 83 percent in Tanzania, 40 percent in Uganda, 75 percent in Ethiopia and almost all of Somalia, Eritrea and Djibouti (Georgis, 2005). The dryland areas harbour about one-third of the Ethiopian population, and it is continually increasing due to migration of environmental refugees from the highly-degraded highland areas.

The dryland areas have high potential for economic development. They consist of wide and diversified agroecologies and are endowed with a wide diversity of crop plants, as well as wild plant and animal species. They have comparative advantages over high rainfall areas due to reduced disease pressure and more sunlight. Hence, the highest yield and most prosperous agricultural areas in the world are in lowland dryland areas. In Ethiopia, the importance of developing these areas to improve production systems for economic development and overall livelihoods of the people residing in these areas is crucial.

Currently, there is are misconceptions about the importance of dryland areas for economic development. People often believe that dryland areas do not have great potential for development. This paper aims to demonstrate the potential of dryland ecosystems and their resource bases for sustainable development.

In order to have a clear understanding about dryland ecosystems, it is important to define and describe what the drylands are, their geographic coverage, their resource bases and potential and their major challenges in the context of climate change. The paper specifically focuses on agricultural and pastoral production systems, their development challenges and technologies that have been generated through research in response to these intrinsic and climate-change related challenges.

The Ministry of Agriculture defined and delineated the agroecologies of Ethiopia, including the resource bases, farming systems, area coverage, location, potentials and constraints. Accordingly, the country is divided into 32 agroecological zones based on the length of the growing period and thermal zones. Georgis et al. (2010) classified the drylands of Ethiopia using the agroecological zones of the Ministry of Agriculture. The authors used additional input from the aridity index (P/PET), where P is precipitation and PET is potential evapotranspiration as calculated by the Penman method (Doorebos and Pruitt, 1977), taking into account atmospheric humidity, wind and solar radiation. This approach is comprehensive and up-to-date, and hence adopted in this paper.

According to the Ministry of Agriculture (formerly, the Ministry of Agriculture and Rural Development), drylands in Ethiopia cover 51.4 percent of the total landmass (MoA, 2005). According to Georgis et al.'s (2010) reclassification using the aridity index methodology of UNESCO (1977), dryland areas cover more than 75 percent of the landmass of Ethiopia. All areas within arid, semi-arid and sub-humid agroecological zones are classified as drylands.

Dryland areas are defined as those production systems where water stress is a major constraint, with a high variability for agricultural production. In general, drylands are low rainfall areas, but not low potential areas. The rainfall is limited in amount, erratic, with uneven distribution, and hence, frequent drought is a common experience. Rainfall is also generally concentrated in a few heavy storms with high intensity. Vegetation is scattered, degraded and very sparse, leaving the soil uncovered. In many drylands, except maybe valley bottoms, the soils have low organic matter content, are highly eroded and are poor in fertility. The existence of high temperature with strong wind also causes high evapotranspiration rates and limits moisture availability. In general, the ecology is fragile and the environment is unstable.

The core problem in the dry areas is the scarcity of water for crop, feed and fodder production and human and livestock consumption. This is further aggravated by climate change and variability (erratic rainfall), which leads to drought disasters, threatening the survival of humans, livestock and wildlife. Most efforts of development agencies that provide food aid in drought-affected areas have not contributed to sustainability of ecosystems and improvement of livelihoods of the people. Adoption of best approaches to improving human wellbeing, while sustaining ecosystems, through provision of economic benefits and poverty reduction has remained largely elusive.

Farmers in drylands face a number of challenges: low crop and livestock productivity, frequent drought, poor soils and degradation of the natural resource base. Poverty and food insecurity are widespread. Despite considerable efforts to improve the situation through research and development, technology penetration is still low. The future is likely to bring even more formidable challenges due to the impacts of climate change on agriculture.

Objectives

This paper aims to identify key interventions needed in agriculture, pastoralism, forest and water management and related land use to deliver increased productivity, reduced emissions, increased carbon sequestration, environmental sustainability, better livelihoods and food security.

Materials & methods

Descriptions of the dryland areas in Ethiopia

According to the classification of Georgis et al. (2010) the dryland areas of Ethiopia include arid, semi-arid and sub-moist zones with growing periods ranging from less than 45 days to 120 days. The dryland areas of Ethiopia are mostly situated around the borders of the country and centrally following the Great Rift Valley. These drylands fall under the category of dry savannahs with lower rainfall and longer dry seasons. They are situated in many parts of the country, in the north, north eastern, south eastern and central Rift Valley areas (Figure 1).

Data sources and compilation methods

A variety of data sources were evaluated and reviewed for this paper, as well as consultations held. The main topics, sources and methods of compilation are described below.

Review of literature on:

- Climate change and agricultural production systems that address the issue in Ethiopia and other countries in sub-Saharan Africa
- Dryland agricultural research and development work by the National Agricultural Research System (NARS) of Ethiopia
- Strategy development for drylands in Ethiopia
- agricultural-based livelihood systems in drylands in the context of climate change
- technology, policy changes, agricultural development to increase crop production in semi-arid areas
- Ethiopia's Climate Resilient Green Economy (the country's climate-resilient strategy for the agriculture and forestry sectors)
- Other documents on adaptation of technologies and practices for increased agricultural production in dryland areas, including Georgis (2010).

Review of books and research findings on:

- the role of dryland agriculture for future food security, crop

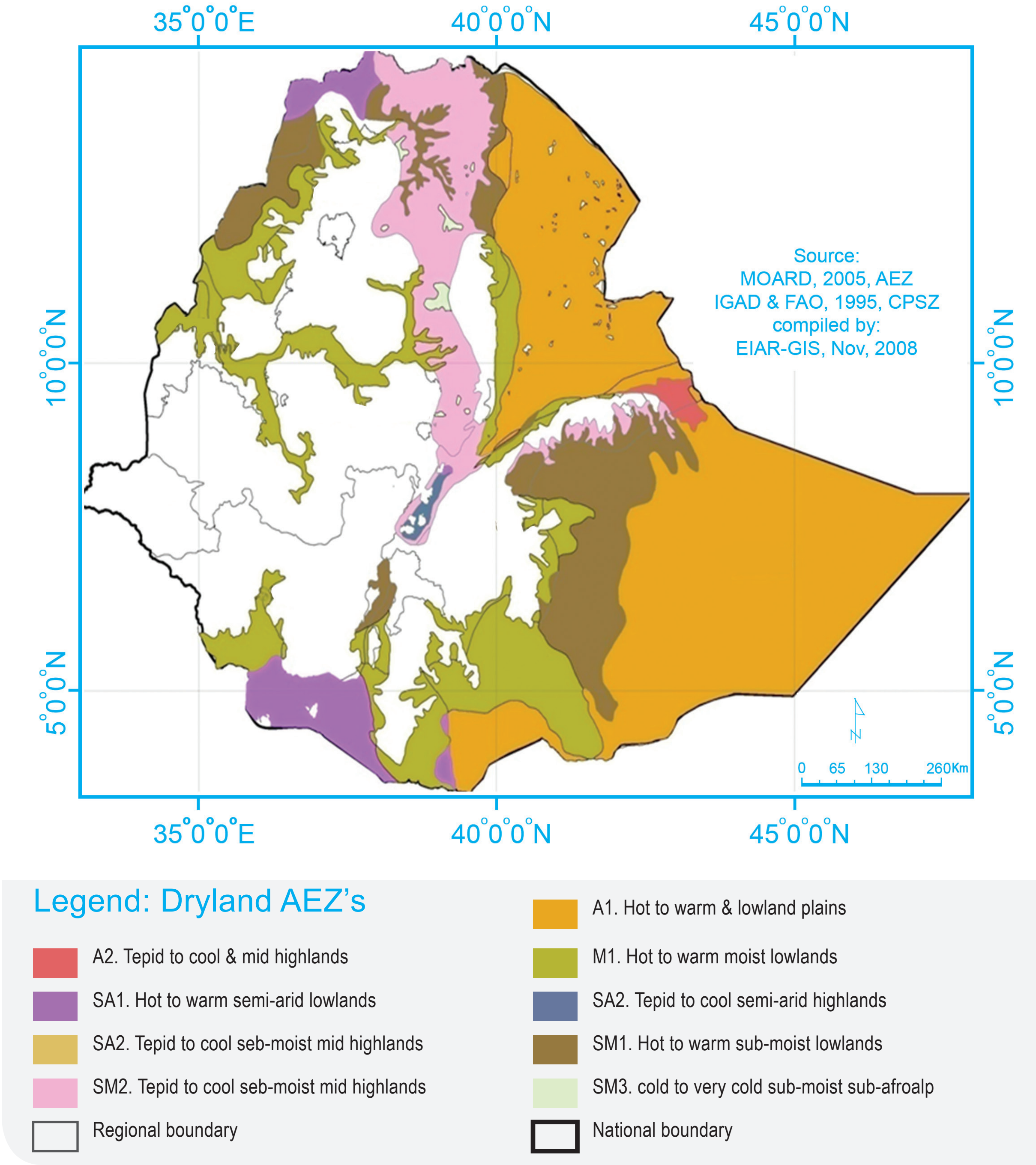

Figure 1. Dryland agroecologies - includes all coloured parts

production, natural resource conservation and management

- pastoral and agropastoral production systems and food security
- agricultural technology options in pastoral areas
- agricultural water management
- pastoral development-range land and crop production
- watershed management for natural resource conservation and management in the semi-arid areas of Ethiopia
- the International Center for Agricultural Research in the Dry Areas (ICARDA) strategic plan 2006 - 2016

Review & discussion of research work done on dryland agriculture in Ethiopia and other relevant dryland production systems in sub-Saharan Africa and around the world, including:

- Technologies developed by NARS (federal, regional, higher learning institutes), the CGIAR centres (ICARDA, ICRISAT, CIMMYT, ILRI, IITA), United Nations agencies (FAO, UNDP) and regional programmes, such as the Intergovernmental Authority on Development (IGAD), the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)

Consultations with NARS staff and reference of special documents

- Consulted groups include the Ethiopian Institute of Agricultural Research (EIAR) Crop Research Directorate, Pastoral and Agropastoral Research Directorate and Soils and Agronomy and Forestry Directorate
- Reviewed dryland strategy, national strategies with emphasis on dryland agricultural research strategies (federal, regional) (EIAR, 2000).

Key findings & discussions

Geographic distribution and production systems of drylands

Geographic distribution

According to Georgis et al. (2010), dryland areas are widely distributed in all regional states of Ethiopia, except Gambella in the southwest. Drylands occur mainly in the north, east, central, south and southeastern parts of the country, with very wide and diversified agricultural environments and farming systems. They include highlands, mid-altitude and lowland areas. The climate, temperature, rainfall and soil types vary considerably with altitude.

The main blocks of dryland areas are the following (see Figure 1 above):

- Northern dryland areas: these areas include almost the entire Tigray National Regional State, except some parts of the western zones, substantial areas of Amhara National Regional State (most parts of north and south Wello, most areas of the Oromia zone within the Amhara region, Wag Hamra, parts of south and north Gonder and north Shewa).
- The northeastern and southeastern dryland areas: this includes most parts of the Afar and Somalia National Regional States.
- The central dryland areas: central Rift Valley areas around Alem Tena, Bulbula, Ziway and the Arsi Zone from Dera to Sire in Oromiya National Regional State.
- The south and southeastern dryland areas: Elkere, Dollo, Neghelle Borena, Hamer and Bako, Bodi, Yabello to Moyale and parts of South Omo.

Production systems

Pastoral production systems

In Ethiopia, pastoralism is one of the most important production systems. In fact, among the sub-Saharan African countries, Ethiopia encompasses the largest pastoral and agropastoral production system both in terms of area of coverage, human and livestock populations and resource diversification. These production systems are important economically, socially and politically. The areas under pastoral and agropastoral production systems have resources which could be used for development and improve the livelihood of millions of people who reside in the areas. Pastoral and agropastoral lands of Ethiopia embrace an area of around 620,000 km2 which includes 122 woredas that fall under seven national regional states: Afar, Dire Dawa, Somali, Oromia, SNNP, Gambella and Benishgul. It is estimated that the total grazing areas of the pastoral and agropastoral woredas is about 545,100 km2 or 89 percent of their total land surface area (PADS, 2003).

The ecosystem in pastoral areas is heterogeneous and has varied and diversified agroecologies with different production systems, socio-economic conditions and resource bases. These factors should be clearly known and documented so that policymakers and planners can use them to intervene in development programmes to increase agricultural production with the aim of attaining food and feed security and enhanced natural resource bases on a sustainable basis (Georgis, 2003).

Crop production systems

The drylands cover eight agroecological zones, which are sub-divided into 17 crop production systems and a water body (see Figure 2).

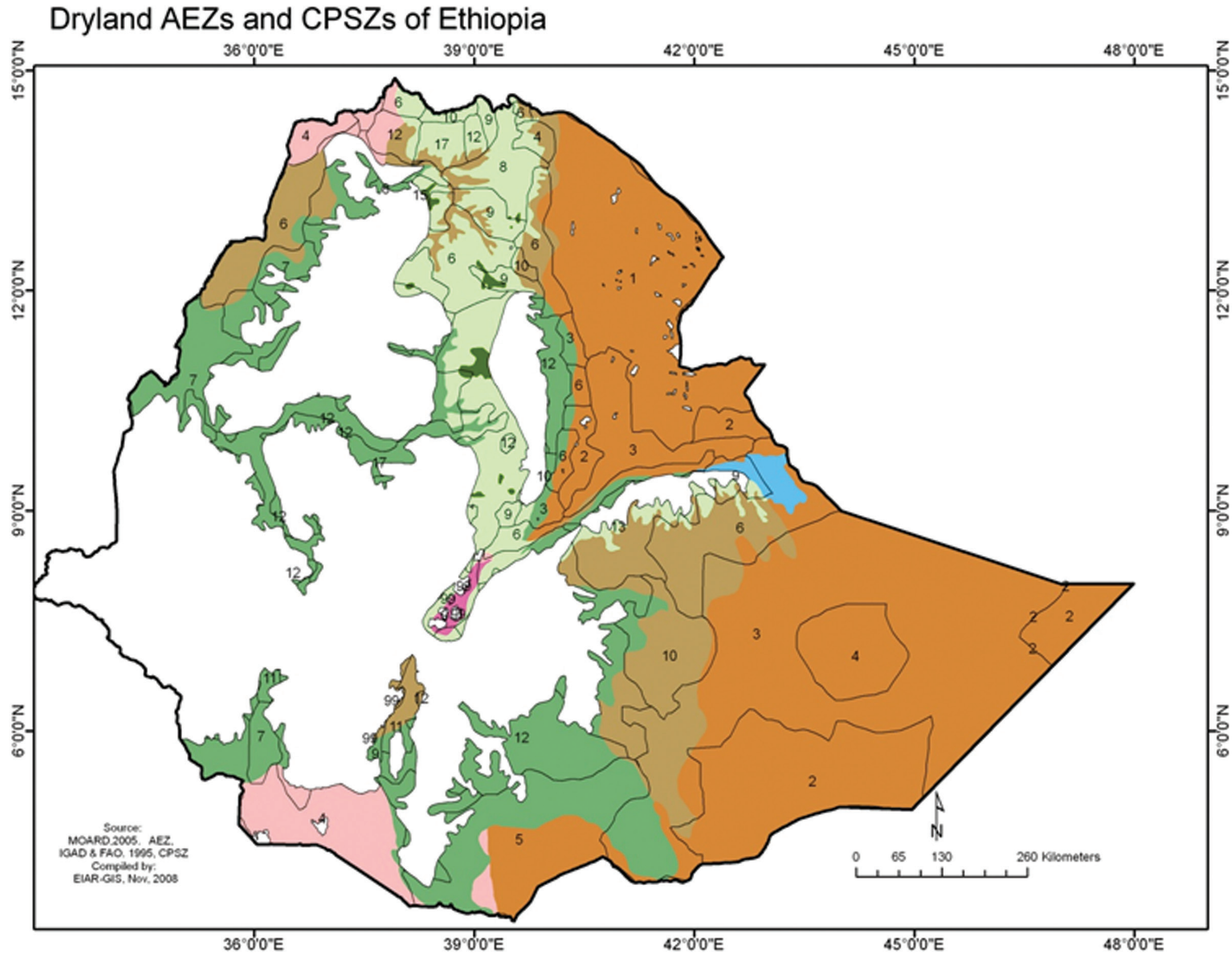

Figure 2. Dryland agroecology zones and crop pasture production system zones

The semi-arid regions (constituting parts of the drylands) are the major crop production systems, having the following characteristics:

1. No growing season will have nearly the same amount, kind or range of precipitation as the previous season and the temperature average, range and extremes will also be vastly different;

2. Management practices cannot be planned or managed the same way from season to season; and

3. The soil resource base and water holding capacity does not remain the same for any long period once an agroecosystem is introduced into a dryland region.

Abundant sunshine and cloud-free days induce rapid growth when moisture conditions are favourable, but these conditions cannot be sustained through the season, thereby demanding careful soil and water management (Srinivas et al., 2004). Development programmes can be planned based on these characteristics to address problems of the areas.

Resource bases of dryland areas

The drylands are naturally rich in natural resources. Drylands are home to various types of domestic and wild animals. Rangelands, for example, are important in providing forage for livestock and wildlife. Drylands are also the main centres of sorghum, finger millet, field peas, chickpeas, cowpeas, perennial cotton, safflower, castor beans and sesame production (Georgis, 2003).

The biodiversity in the drylands in general and in Ethiopia in particular is highly diversified. For example, Kenya has nearly 7,500 plant species of which at least 265 are endemic. Ethiopia also has over 6,000 species of higher plants, of which at least 600 are endemic. Drylands are a centre for livestock genetic resources, as exemplified by Ethiopia, Kenya, Sudan and Somalia. For example, in Ethiopia, the Borana and Jijiga cattle, the Black-headed Ogaden sheep, the Afar goat and the Somali goat and camel are distinct breeds of livestock in the drylands. Their conservation and utilization deserves full understanding of the ecosystem.

The details of resource bases in the dryland areas are summarized as follows:

- ***Water resources:*** Drylands are endowed with water resources much of which have been untapped and have valuable potential. For example, they have substantive river systems and groundwater, which are cradles of important watersheds and riverside ecologies, diversity of fish and have high values for hydropower and irrigated commercial crop agriculture. There are three categories of water basins in the area (EPA 1998):

  - ***Surface water - lakes:*** There are seven major lakes of the Rift Valley, namely: Ziway, Langano, Abiyata, Shalla, Awassa, Abaya and Chamo. These lakes are used for commercial fisheries, irrigation, recreation & industrial purposes.

  - ***Surface water - rivers:*** There are twelve river basins with a total surface run-off of about 110 billion m3. Major river basins are Awash, Genale-Dawa, Wabi Shebele, Baro-Akobo, Tekeze, Merb, Fafem and Abay. Some of these rivers are used for commercial fisheries, irrigation, recreation and industrial purposes.

  - ***Groundwater:*** There is also a high potential of groundwater in many pastoral areas, including the Rift Valley areas of Oromia, Eastern Afar and Eastern Tigray and Somali. These areas have large quantities of groundwater along the valleys that can irrigate millions of hectares for food and cash crop production.

- ***Soil resources:*** If the land is well managed, particularly in pastoral areas and valley bottoms, there is a high agricultural potential, with nutrient-rich soils, and providing possibilities for surpluses.

- ***Biodiversity:*** Agricultural bio-diversity is very high in certain parts of pastoral areas. There is a rich diversity of genetic resources of livestock and crops, such as cereals, sorghum, millet, wild grasses, pulses, cow peas and pigeon peas. The drylands are likewise rich in plant and animal species. Most dryland areas in the south, southeast and northeast fall within the Horn of Africa Biodiversity Hotspot.

- ***Energy:*** There are substantial energy resources, including gas, petroleum and geo-thermal sources in the Rift Valley, as well as mineral resources in several parts. Energy reserves have a high potential for economic development, but these reserves have barley been explored and tapped.

- ***Wildlife and tourism:*** There is a tremendous diversity of wildlife that is known to be an attraction for tourism. Most of the country's 277 species of wild mammals and 861 species of birds are found in the rangelands. Most parks, endemic bird areas, game reserves and controlled hunting areas are found in the drylands. There is a great potential in the dryland areas for developing the tourism industry of Ethiopia which can increase hard currency earnings and improve the livelihoods of pastoralists.

- ***Anthropology & archeology***: Drylands have anthropological and archeological importance. The remains of human ancestors were mainly discovered in the dryland areas in northeast Ethiopia. The oldest remains of our species, Homo sapiens, were also found in these regions and have attracted the attention and interest of world anthropologists and archeologists. This has placed Ethiopia as one of the primary sites of human origin, evolution and civilization. This has more than monetary value and benefits, and could further benefit the tourism industry.

Climate change and challenges of the drylands

Climate change is one of the major environmental, social and economic threats facing Ethiopian agriculture in the drylands. This situation can be explained mainly by human intervention via various economic activities, including forest clearance and plowing of steep slopes resulting in land degradation and desertification. Several reports noted that the temperature in Ethiopia is on a rising trend. Rainfall is another monitoring variable, but no conclusion has been reached whether the total rainfall is in a declining trend or not. However, because of the shift in rainfall onset dates, the length of growing periods is declining. Overall, the changes are reflected in reduced agricultural productivity and reduced adaptive capacity of society to climate change.

Therefore, in drylands, climate change is emerging as one of the most important challenges in terms of agricultural production and productivity, and is threatening the overall livelihood of the people residing in these areas. There are clear trends of climate change and variability in Ethiopia as indicated by increased drought frequency, long dry spells, highly variable rainfall between and with seasons and limited and sometimes heavy rains. These adverse impacts are also affecting agricultural production and water balances, distribution of vectors of diseases and more frequent and severe hydrological extremes with serious negative impacts on water resource systems. The drying of lakes (e.g., Haramaya Lake and many others), reduced river flow and other water resources are all indications of climate change.

The threat from climate change on dryland development is severe because Ethiopia has a natural resource-based economy and a large rural population that remains directly dependent on rain-fed agriculture. Approximately 85 percent of the population earns a living from agriculture and over 40 percent of all exports are agricultural products. Agriculture contributes 45 percent of GDP. About one-third of the income is generated by agriculture, with crop production and livestock husbandry accounting for half or more of household incomes. The poorest members of society are those most dependent on agriculture and environmental resources for their livelihoods, making the situation even worse.

The impacts of climate change in dryland areas that are leading to agricultural yield decline, decline in the quality of pasture and livestock production and reduced vegetation cover place millions of people in the drylands at risk of exacerbated food insecurity and malnutrition. According to the Intergovernmental Panel on Climate Change (IPCC) (2007), the overall cost of adaptation to climate change in Africa could be as high as five to 10 percent of the continent's GDP, and similar figures are expected in the dryland areas of Ethiopia.

Water stress and drought

In the drylands one of the key problems related to climate change is water stress and associated drought. Water stress is a universal problem and common denominator to all semi-arid areas. Water is the central production factor affecting sustainability and food security. This is aggravated by climate change, which is a consistent threat in the semi-arid areas. Consistent shifts in the rain pattern and recurrent drought are becoming more prevalent, while rainfall patterns are expected to become more erratic. Agroecosystems of semi-arid areas consequently are vulnerable to food and feed shortage. This problem in some situations is likely to become even more difficult in the future. Global Circulation Models (GCM) scenarios for some East Africa countries point to an overall reduction in soil moisture availability. Long-term change in temperature and rainfall patterns is having a serious impact on biodiversity.

Many countries around the world are facing water scarcity. In many sub-Saharan African countries, availability of fresh water has already dropped to 170 m-3/year, well below the internationally recognized water scarcity standard of 500 m-3/year. The water poverty index (WPI) is a reflection of the fact that in a number of countries water resources is misused and not managed sustainably, contributing to scarcity. Irrigation accounts for about 80-90 percent of all water used in the drylands. However, increasing competition for water among several sectors will likely reduce the share for agriculture to about 50 percent by the year 2050 (ICARDA, 2006).

Natural resource degradation

In most drylands food demand is outstripping production due to rapid population growth (about two percent annually). The proportion of the total area that is arable land is lower (4-11 percent) than in other climatic zones in other developing countries (ICARDA, 2006). In addition, soil fertility is a declining asset in most agricultural lands in semi-arid areas.

This is caused by the ever-increasing human and livestock population and the associated demand for basic natural resources, such as land, water, forest products and other agrobiodiversity resources and their products (Georgis, 2005).

Grazing pressure

Increasing human and livestock populations have become a major threat to land use systems, such as pastoral areas where livestock production is practiced and a considerable number of wildlife exist. This is leading to land degradation, overgrazing and loss of biodiversity.

The conversion of grazing areas into large-scale sedentary agriculture through irrigation is also marginalizing the grazing areas. For example, recently two dams for large-scale sugarcane production for two sugar factories were established in the middle of the grazing areas of the Afar pastoralists in Rift Valley areas of Ethiopia. These dams resulted in land clearing, shortage of grazing areas leading to overgrazing, and have triggered ecological degradation and conflict. As a result, the demand for animal feed also exceeds the region's current production level. Such feed shortages, coupled with water shortages and the threat of diseases, are leading to low production and aggravation of poverty.

Soil salinity is also constraining agricultural production in the pastoral Rift Valley areas, particularly in Afar. For example, salt-affected soils in Ethiopia cover a total land area of 11,033,000 ha, the highest in Africa (Georgis et al., 2004).

Pests and diseases

Apart from drought, up to 40 percent annual losses are estimated to be caused by a large number of pests and diseases which damage crops and livestock in semi-arid regions. The semi-arid ecology, particularly in the rangelands, is encroached by invasive weeds, such as prosopis juliflora, that replaces the more nutritive browsing varieties. This has resulted in sharpened conflicts in recent years between land users over pastures and water resources (PADS, 2003).

Research findings & technologies for climate resilient agriculture in the drylands

After assessing the problem of agricultural production in relation to climate change in the drylands of Ethiopia, the next logical step is to take inventory of available technologies and practices developed by national and international research systems (NARS, CGIAR, non-governmental organizations and others) for adapting to climate change. This includes mainly technologies for crop, livestock, agroforestry and natural resources conservation and management. Agricultural and natural resource technologies available to adapt to climate change, including crop, livestock, natural resource conservation and management, are briefly described in this section.

Crop technologies available for climate adaptation in the drylands

Maize

NARS and the International Maize and Wheat Improvement Center (CIMMYT) have developed maize varieties that are drought tolerant and early maturing, which can be used in areas faced with the risk of yield reduction due to reduced rainfall. Several varieties have been released by the national programmes and are planted on hundreds of thousands of hectares. Many new, even better drought-tolerant varieties and hybrids have been identified (ASARECA, 2010).

In Ethiopia, there are about 20 maize varieties released for the dryland areas. The discussion in this paper

Figure 3. Melkassa-6Q improved maize variety with a high protein content Source: Wegary, 2010.

focuses on the high-yielding hybrids (Georgis et al., 2010), including drought-tolerant varieties, like Melkassa and Melkassa 2. The yields of these hybrids range from 4.5 to 6 t/ha; they are drought resistant and early maturing (less than 120 days). One of the success stories in the dryland areas of Ethiopia is the release and adoption of a variety called Melkassa-6Q. Melkassa-6Q is high yielding (4.5-5.5 t/ha), early maturing (flowering in 60 days, maturating in 120 days), drought tolerant, nutritionally enhanced (QPM) and disease tolerant. It is a good example of adaptation to the Rift Valley of Ethiopia and other similar areas. For adoption of these drought-resistant varieties by user communities, it is recommended that there are more on farm demonstrations, with farmer participation, in order to mainstream and scale up the technologies in drought-prone areas of the country.

Sorghum

There are several improved cultivars of sorghum. About 120 have been released across sorghum-growing areas. These are early maturing, capable of escaping terminal drought, disease and pest resistant, and have the desired market traits for East Africa. Recently, an additional 81 varieties were released for most countries in eastern, southern and central Africa. Yields of improved varieties are 20-40 percent higher than local varieties and have been tested and released in a number of countries, including multiple releases, and are ready for scaling up (Georgis, 2010).

There are also three hybrid sorghum varieties released for drylands of East Africa and Ethiopia. These hybrids have a yield advantage of 25-60 percent over traditional varieties and yield even more in dry years.

Small cereal (millet and tef)

Several millet varieties, both pearl millet and finger millet, have been developed by NARS and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) that are drought resistant, early maturing and adapted to the semi-arid areas of Africa. Pearl millet is suitable to drylands in regions that are too hot, dry and with poor soil fertility. Finger millet can be grown under diverse agroecologies and offers good nutritional value, with 5-40 times more Ca, Iron and phosphorus. There are also genetic resources, collected, conserved and characterized, which could be utilized by NARS for breeding for improved crop production. There are 14 pearl millet and 13 finger millet varieties released for semi-arid and arid agroecologies, which should be used to increase crop production in water stress areas of Ethiopia and other East Africa countries (Wegary, 2010).

Among small cereals, tef is important for climate change in Ethiopia and potential for other countries too. It is a stable and stand by crop in the drylands where rain is short and highly variable. There are many varieties recommended by NARS that are short cycle and pest and disease tolerant and that are a fit for areas with short and variable rainfall. Improved varieties, such as Kuncho, give substantial yield increases, up to four t/ha, as verified by the Ethiopian Agricultural Transformation Agency (Tareke Berhe, personal communication).

Barley and wheat

Barley crops for both food and malting are important for stallholder farmers in the highland zones of Ethiopia, Eritrea and Kenya. Barley is an important food and malting crop. Both NARS and CGIAR centres (including ICARDA) have released improved varieties: 17 for food and three for malting. High yielding varieties produce up to seven t/ha.

Wheat is important for food and cash in the crop production system. The major problem of wheat production is a new race of wheat stem rust disease that is spreading rapidly and threatening wheat and barley

Figure 4. drought-resistant sorghum hybrid (P9501A x ICSR) Source: Wegary, 2010.

production worldwide. With the efforts of ICARDA and NARS, a new high yielding variety (Ug99) and disease-resistant variety was released in Ethiopia and two new varieties are expected to be released shortly. Elite germplasm are also identified in more than 20 countries in Africa and worldwide. This noble work can be scaled up for wider use.

Grain legumes

There are many important legume species and varieties that can adapt to climate change. For example, the common bean (Pharsalus vulgaris) is one of the most important grain legumes grown in many areas of Africa. It is an important food and the cheapest source of plant protein for poor farmers. It is produced mainly in areas with rainfall of 500 - 800 mm annually (Masumba, 1984).

Improved common beans developed in drought-prone areas that can be used for climate change adaptation include pigeon peas, cowpeas and mung beans. These are multipurpose crops used as human food grain, fodder, fuelwood, to improve soil fertility and as cash crops for export. They are drought resistant and suitable for climate adaptation, and their yield is reasonably high.

Oil crops

Many varieties of sesame, groundnuts and safflower are drought-resistant, short-cycle, high-yield crops. There are many varieties recommended by NARS in Ethiopia as having the potential to be adapted for climate change. Almost all of these crops fetch good prices.

Root crops

Cassava is a very important crop in Africa as a food security crop, particularly in dryland areas vulnerable to climate change. Improved varieties have been released for Ethiopia and other African countries, like Rwanda, Uganda, Tanzania and Zimbabwe, and there is a likelihood that a new wave of cassava production will take place and go a long way toward alleviating the food situation in the continent in drought-prone areas.

From an agronomic point of view, cassava is important for soil fertility improvement and weed control, both of which are main constraints in the drylands. Because of its massive leaf production which drops to form organic matter thus recycling soil nutrients, cassava requires little or no fertilization and yet will maintain a steady production trend over a fairly long period of time in a continuous farming system (Shiferaw, 2012).

An FAO project has been successful in distributing more than 200,000 planting materials of six improved cassava varieties to the Hawassa Agricultural Research Center and Mekelle University. A number of farmers in Meisso woreda have secured their food and even obtained additional income through growing of drought-tolerant root and tuber crop varieties, particularly cassava. These farmers who received only 20-30 cassava cuttings have multiplied the planting materials and expanded the crop in their farms. They have also provided cuttings to their neighbors and relatives. The results obtained by farmers who are first round recipients have encouraged other farmers living in area. As a result, the ripple effect through farmer-to-farmer exchanges of planting materials of these improved varieties is increasing. This points to root crops, such as cassava, as excellent for food security under the ongoing threat of climate change. An example of an improved cassava variety in the arid and semi-arid varieties is shown in Figure 7 below.

Figure 6. Improved sesame variety for adaptation to climate change Source: Georgis, 2013.

Figure 7. Improved cassava variety demonstration plots at Gamila woreda Source: Shiferaw, 2012.

Soil and water conservation and management for improving adaption of crops to climate change

Above described some of the many improved crop species and varieties that can lead to increased food production in drought-prone areas experiencing climate change in Ethiopia. However, the potential of the improved crop species and varieties cannot be exploited unless integrated with improved management practices in holistic packages. In the drylands, water stress, low soil fertility, pests and disease are the major constraints and so must be included as a package. Therefore, the strategy should be to enhance the livelihoods of the poor in semi-arid farming systems through integrated genetic and natural resource management strategies.

There is much evidence that appropriate agronomic management practices, such as improved soil and water, fertility conditions, pest and disease control, are more critical factors for determining crop yield than improved variety alone. There are improved crop species and varieties which are drought and pest resistant, heat tolerant, early maturing, with high yield potential that were developed by research systems, but the genetic potential of these improved varieties can best be exploited when used in combination with improved agronomic management practices.

In the United States, for example, where sorghum yields tripled in 30 years from, 1.2 metric tons per hectare in 1950 to more than 3.8 in 1980, the genetic contribution was estimated to be from 28 to 39 percent (Miller and Kebede, 1984). Over 60 percent of these very large yield increases were due to improved agronomy practices, especially fertilization, herbicides and water control. The new cultivars are generally more responsive to higher input use and gave high yield under conducive environments.

Improved agronomic practices play a major role in increasing crop production on a sustainable basis. Thus, a technological development strategy needs to include both breeding and improved agronomy. The message is clear that under dryland farming conditions the agronomic management practices mentioned above are very critical in determining the productivity of crops and should be used with improved varieties to exploit their genetic potential.

Soil and water management

The tied ridges in situ soil and water harvesting technique

Tied ridges as an in situ soil and water harvesting technique has proven to be very effective for soil and water conservation in Ethiopia and many other African countries. The technique has been extensively tested and evaluated with smallholder farmers in Kenya, Ethiopia, Eritrea, Zimbabwe, Uganda, Tanzania, Burkina Faso, Nigeria and other areas in Africa (Georgis, 2003). The experimental evidence of the effectiveness of tied ridges for soil and water conservation and its impact in yield increase and water use efficiency is well demonstrated. Its use increased grain and straw yield of crops by 150 percent and 90 percent, respectively, compared to traditional methods of planting in the flat seedbed in many semi-arid areas of East African countries, including Ethiopia, Eritrea, Kenya, Uganda, Zimbabwe and Sudan. However, the technology has not been widely adopted by farmers.

Figure 8 below is a picture of tied ridges, with a description of how to construct them, including a description of the size, height, width between rows and ridge height. The description also indicates the time needed to make the cross ties and the frequency and time of weeding.

Improving water productivity

Improving rainwater management alone cannot deliver increased productivity. Water management must form part of a farming system that includes a whole range of inputs, such as fertilizer, pesticides, improved seeds and adequate farm power. In the drylands, where the key problem

Technology: Tied Ridge, In-situ Water Harvesting

Description semi permanent ridges (ideally about 20-25 cm in - 1% across the slope, cross ties are put in to a height of ½ to 2/3 the height of the ridges at intervals of 1 to 2 meters depending on slope, however in flat topography the interval could be wider up to 5 m interval. The ridges are constructed using an animal -drawn plough or ridger in a deeply ploughed up field (approximately 23 cm).

Figure 8. Tied ridges in-situ soil and water harvesting Source: Georgis, 2003.

Technology: Tied Ridge, In-situ Water Harvesting

Cross ties are put in after ridging using a cultivator with a worn-out moldboard attached on the rear tine position. For maize attached on the rear tine position. For maize and sorghum the standard spacing of 75 cm is used and planting is done into a fully moist ridge, Two hand weeding operation are recommended, the first being 2-3 weeks after germination and the second soon after re-ridging and re-tying when the crop is knee high (maize). about

Table 2. Integrated agronomic management practices for improving water productivity

Management practices	Yield t/ha increase
Broadcasting, no fertilizer, late weeding six weeks after emergence, flat planting (farmers practice)	1.3
Row planting, no fertilizer, late weeding six weeks after emergence, flat planting	1.7 (37)
No fertilizer, late weeding six weeks after emergence, tied ridges	1.9 (46)
No fertilizer, early weeding three weeks after planting, tied ridges	2.3 (73)
40 N 46 P2O5, early weeding three weeks after planting, tied ridges	2.9 (117)

in crop production is water stress, water needs to be conserved and to make farming more productive, water conservation must be integrated with other improved agronomic practices so that the soil water retained can be used effectively. Weeds should be controlled as early as possible to avoid completion. Fertilizer needs to be applied at the recommended rate. Such integrated management practices have resulted in increased maize yield in the range of 37-117 percent as can be seen in Table 2.

Mulching for building soil fertility and enhancing water conservation and utilization

Most soils in semi-arid areas are highly degraded with poor physical, chemical and biological properties. The soils have the problem of compaction or surface sealing or crusting which leads to low water infiltration and high runoff. Mulching is traditionally used to alleviate these problems and research results in the central Rift Valley indicated that use of mulches at the rate of three tons increased yield by 30 percent compared to without mulching. The mulching materials are obtained from pigeon peas and sesbania sesban, which are drought resistant, and can easily be produced locally in many drought-prone areas. The use of sesbania sesban mulches was also found to increase grain and stover yield substantially in wheat compared to the control without mulching (Gebrekidan, 2005).

Livestock production and climate change

Practices and technologies for adapting to climate change in livestock production

There are several traditional practices in livestock production used to adapt to and mitigate climate change. Many of these practices and innovations are documented by Georgis et al. (2010).

Conservation of grazing resources

To mitigate feed shortages in the dry season, pastoralists sell their sheep, goats and cattle, especially males and unproductive females, in order to purchase grain for home consumption.

Depending on the degree of severity of drought, in order to adapt pastoralists may: reduce the herd (at these times when pressure for selling breeding stock rises); select drought and heat tolerant livestock species; change the type of livestock; or diversify their stock.

Feed shortage is one of the major constraints in livestock production in Ethiopia and most East African countries. Research activities have been carried out by NARS and CGIAR, universities, non-governmental organizations, etc. to improve feed availability and strengthen food security in relation to climate change. Activities have included natural pasture improvement, backyard forage introduction and development, integration of forage legumes into cereal production systems and various forms of utilization of feed resources for livestock production.

Area closure for rehabilitation of rangelands and improve feed sources

Livestock herders also use traditional practices to conserve and rehabilitate rangelands. Natural forage is improved by closure of certain areas to allow the natural pasture to regenerate. Enrichment planting with suitable fodder crops and trees is also carried out to fill the gap when there is no natural vegetation.

As an example of this, highly degraded areas were selected and enclosed by local communities and development agencies in dryland areas to allow the natural pasture to rehabilitate and vegetate. Then drought-resistant herbaceous legumes and grass species were promoted to improve the fodder quality (Catholic Relief Services, 2008).

Forage species and varieties for climate change adaptation

Several leguminous shrubs which are drought-resistant forage crops, such as pigeon peas, saltbush, Senna and Opuntia, are grown in watershed areas in many districts in semi-arid areas. These forage crops can grow in areas with rainfall as low as 200 mm per year. They are nutritious perennial forage shrub for small ruminants and cattle. They provide protein and minerals (especially salt, e.g. from salt bush) needed by ruminants. In addition, there are several feed resources, including forages identified by NARS and CGIAR (mainly by ILIRI) which are playing an important role in drylands by having a multipurpose value for the farmer, beyond just being a feed resource for livestock (Georgis et. al., 2010).

The most important leguminous fodder trees indigenous to eastern Africa are acacias and aidherbia albida. There are about 130 species of acacia widely distributed in Africa. Many are very drought-tolerant and can survive over a wide range of altitudes. One of the most widespread and useful acacia species is the umbrella thorn (A. tortilis), whose pods and seeds are an important feed resource for livestock and wildlife in Africa (Menwyelet et al., 1994). From a nutritional analysis of seeds of various acacia species, Tolera et al. (2000) concluded that these seeds could partly help solve the shortage of energy and protein feedstuffs during the dry season and supplement low quality forage grazed by ruminant livestock. This analysis suggests that there are many feed sources in the dryland areas which could be used to adapt to climate change and increase livestock production on a sustainable basis.

Agroforesty practices for improving agricultural production and climate change adaptation

Agroforesty is widely practiced by traditional farmers in East African countries, including Ethiopia, Kenya, Sudan and Eritrea. Despite its potentials this old practice is still a much-neglected area in terms of research and development and needs research to quantify contributions to improve productivity. There is substantial evidence to show that alley cropping can result in higher productivity, better control of the environment and can safeguard against unfavourable conditions,

Figure 9. Promoting the growth of climate smart trees and shrubs

including climate change and variability.

In traditional agroforestry in many dryland areas, trees are kept by small-farmers on farmland for various uses. Some of the important uses farmers attribute to trees are soil fertility maintenance, soil and water conservation, a feed source, shade for crops, animals and humans, source of cash and firewood. In Sudan, Ethiopia, Eritrea and other countries, farmers maintain Faidherbia albida trees in their farm for fertility maintenance and increased yields (Georgis et al., 2010).

Agroforestry is important for natural resource conservation and increasing organic matter, thereby improving soil fertility, soil water holding capacity and availability and the resilience of the soil. This contributes to increased production on a sustainable basis in dryland areas. Agroforestry should be scaled up in all dryland areas of East Africa.

In recent years, interest has grown in the utilization of multipurpose trees, particularly tree crops. The variety of products that can be obtained from them and their number of uses should push multipurpose trees to the forefront in rural development in many East African countries. Documentation of multipurpose tree crops in landscape conservation, with particular emphasis in adapting to climate change, is important and should be promoted.

In semi-arid areas of Africa, there are some important trees species which are currently used to conserve soil and water and improve agricultural production for adaptation to climate change, such as Azadira chtaindica (neem), Moringa stenopetala, Moringa oleifera and Leuceana leucocephala. There are also many useful shrubs, such as Cajanus cajan (pigeon peas) and Opuntia ficus-indica (cactus).

Fodder trees, forage grasses and legumes found in natural pastures in East Africa are essential for soil stabilization, provision of ground cover and as wind breaks to prevent soil erosion. They contribute to soil fertility through decomposition of organic matter and microbial nitrogen fixation. Forage grasses and natural pastures are also important in carbon sequestration (Georgis et al., 2010).

Natural pastures, fallow land and crop residues are the major source of livestock feeds in many areas where available agricultural land is used for food crop production, relegating livestock production to be supported by marginal lands not suited to crop production. The fluctuating feed supply and poor quality of the available feeds, especially during the long dry season, are major constraints to increasing livestock productivity in dryland areas.

In general, the food values of African trees and forests have not been systematically explored and documented. Despite frequent recurring famines, these have so far been given little attention. The reluctance to systematically catalogue the food values of Ethiopian trees and forests is further persuaded by the rapid destruction of natural forest vegetation and the low level of dependence on forest food, as compared to eastern and southern African countries.

Nonetheless, these wild plants can be very important for food security, particularly in light of the current threats of climate change. There is substantial opportunity to domesticate wild plants and to expand their market value. In a situation of a rapidly changing global environment, wild plants are important reserves of biodiversity for human use. However, the challenge is that now many of the plant species used as wild food are rapidly disappearing, even before being known to science. There is an urgent need for their conservation, as prioritized in the country's climate change adaptation programme, the National Adaptation Programme of Action (NAPA).

Available technologies to adapt to climate change and increase livestock production

There are some technologies developed to improve livestock production in the face of climate change. The challenge now is how to get these technologies and practices to be adapted and adopted by user communities. Some communities may require new technologies and others may need the revival of traditional technologies and practices. The important thing is to sieve out what works, identify the best-bet technologies and then seek ways to make them available to livestock herders. Below are some of the available technologies.

Genetic improvement for livestock production under climate change focusing on climate smart livestock species and breeds: breeding and selection

Genetic improvement of livestock in Ethiopia remains a challenge. Local problems encountered in traditional livestock production systems were not considered in the development of improved breeds, therefore, prescribed 'improved' breeds and crossbreds have not solved the problem of smallholder farmers under dry or low-input systems.

Rearing small ruminants and camels to adapt to climate change

The introduction of small ruminant breeds is contributing to adaptation to climate change and food security and improving livelihoods of pastoral and agropastoral communities in the drylands.

There are several indigenous sheep breeds, such as the Afar sheep and blackhead Somali sheep, which are hardy and drought resistant. They are useful for climate adaptation in the drylands. Below are additional small ruminant breeds that maybe useful for climate change adaptation efforts.

Dorper sheep

The Dorper is a South African mutton breed from the initial crosses between Dorset Horn and Blackhead Ogaden, also called Blackhead Somali and Blackhead Persian. These breeds have Ethiopian blood. Dorper sheep are widely distributed in some African countries, such as Botswana, Zimbabwe, Zambia, Kenya and South Africa. Dorper sheep can also be found in North America and other countries around the world.

Dorper sheep are highly adaptable and do well in harsh, hot and dry conditions, as well as under more intensive operations. As a strong and non-selective grazer, the Dorper can advantageously be incorporated into a well-planned range management system. The characteristics of the breed include the ability to walk long distances in permanently dry areas and in times of drought. Dorper sheep have a natural tolerance to high temperatures and heavy insect populations, most probably due to their Blackhead Persian origin. The breed is well adapted to dry environments and a wide range of production systems. They are productive in areas where other breeds barely survive. Other good characteristics include high fertility rates with an unrestricted breeding season and the body of Dorper sheep, except the belly and the face, is covered with a mixture of hair and some coarse wool. Dorpers have a black head and neck with a white body, but there are also solid white Dorper sheep. Both rams and ewes are polled. Dorper sheep are relatively big and ewes under a favourable environment weigh about 60 kg. Dorper sheep are fast growing with good conformation for meat production.

Dorpers also have fast growth with mature rams weighing between 100 and 125 kg. Mature ewes average 73-100 kg and have excellent meat qualities. A live weight of about 36 kg can be reached by the Dorper lamb at the age of three-four months. The Dorper has a thick skin which is highly prized and also protects the sheep under harsh climatic conditions. The Dorper skin is the most sought after sheep skin in the world and is marketed under the name of Cape Glovers. The skin comprises a high percentage of the income (20 percent) of the total carcass value.

Goat breeds for climate change adaptation

NARS have identified and collected many indigenous goat breeds which adapt to climate change in pastoral and agropastoral areas of Ethiopia. These include the breeds described below.

Somali goats: Short-eared Somali goats are widely distributed in northern and eastern Ogaden and Dire Dawa. Long-eared Somali goats are found in all parts of the Ogaden, the lowlands of Bale and the Borana zones of Oromia and in some parts of the Sidama zone of the Southern Region. Short and long-eared Somali goats are related.

Abergele goats: The Abergele goat is believed to be a relative of the Afar and Worre goat. Abergele goats are found along the Tekeze River and other parts of Ethiopia. Abergele goats are stocky, compact and well built. The goats have a straight to concave facial profile. Both males and females have horns, and in most cases the horns in males are much bigger and spiral shaped. Abergele goats are widely prevalent in the Afar region. Abergele goats are milked for domestic consumption. Their skin is also used to make aprons, containers, etc.

Afar goats: Afar goats are stocky, compact and well built. The goats have a straight to concave facial profile. Both males and females have horns, and in most cases the horns in males are much bigger and spiral shaped. The coat of most Afar goats is plain and patchy. Spotted coat colours are common. The hair is short and smooth in both sexes and males have beards and ruffs. Mean height at the shoulders is 71.4 cm and 65 cm for adult bucks and does, respectively.

Boer goats: The Boer goat is one of the hardiest of all small stock breeds in the world. The Boer goat has the ability to adapt to almost any climate, from the hottest dry desert climate, as in Namibia and Australia, to the snow covered mountains of Germany. The present day Boer goat appeared in the early 1900s when ranchers in the Eastern Cape Province of South Africa started selecting for a meat type goat. The general characteristics are that the Boer goat is a large, double-muscled animal developed specifically for meat and hardiness. Boer goats have a high resistance to disease and adapt well to hot, dry, semi-deserts. Acclimatization is often a slow process, taking a year or longer.

The fertility rate is high, with a kidding rate of 200 percent being common for this breed. Puberty is reached early, usually about six months for males and 10-12 months for females. The Boer goat also has an extended breeding season, making possible three kiddings every two years. Producing weaning rates in excess of 160 percent, the Boer goat doe is a low maintenance animal that has sufficient milk to rear an early maturing kid. Does are reported to have superior mothering skills compared to other goats.

Performance records for this breed indicate exceptional individuals are capable of average daily gains of over 200 g/day in a feedlot. More standard performance would be 150-170 g/day. The mature Boer buck weighs between 110 and 135 kg and does between 90 and 100 kg. The Boer goat also has excellent carcass qualities, making it one of the most popular breeds of meat goat in the world.

Camels

Camels are important livestock species for drought-prone areas. Camels have special adaptation features to survive under the harsh conditions of dryland areas. Camels are raised under traditional management systems. Despite the major importance of camels, there has been limited research and development efforts related to camels and camel husbandry in the dryland areas of eastern Africa. There are several camel breeds which are fit to be adapted for climate change adaptation efforts that could be scaled up by NARS (Georgis et al., 2010).

Conclusions and recommendations

Below are some research and development approaches that can be taken to promote climate change adaptation in dryland production systems and some potential tools to improve dryland production systems under the threat of climate change.

Make a broad and strategic plan: Agricultural production must undergo a paradigm shift at all levels of administration if rapidly growing human and animal populations in semi-arid areas of Ethiopia are to be fed and the natural resource base sustained. Business as usual is no longer an option. With a transition to climate-resilient, low-emitting production systems, agriculture can become part of the solution to sustainable development.

In the drylands there are multiple challenges in terms of climate change, including degradation of ecosystems and food insecurity, requiring an integrated approach to solve the problems. An integrated and cross-sectoral approach at all levels, including on a landscape and watershed level, must be developed to face climate change and support agriculture and food security. There are many successful experiences and best practices in Ethiopia (Georgis et al., 2010) and other semi-arid areas of Africa to achieve the “triple win” of climate-smart agriculture. Action must be taken to scale-up, replicate and adapt what works. This should be backed by conducive institutional and policy frameworks and climate-smart strategies, including science, technology, education and extension services. Agriculture and rural development must be integrated into other national political processes, supported by assessments at the local level.

Urgently address serious issues: The challenges and solutions for increased production should be clearly understood to improve the economic development of agricultural communities. In line with this, it is important to identify urgent actions to be taken to prevent food insecurity and degradation of ecosystems, including preventing the loss of biodiversity. To this end, a roadmap for action on agriculture needs to be developed.

A theme that appears repeatedly in this paper is food security and to achieve it requires agricultural production systems to change in the direction of higher productivity and production lower output variability and greater eco-efficiency. This includes promoting ecoagriculture. Such green growth in the agricultural sector is fundamental for food security, socio-economic growth and environmental sustainability. Small- and family-based farming systems, particularly in developing countries, are vital for green growth and climate-smart agriculture, including organic systems.

Support and revive traditional knowledge and practices: Farmers in semi-arid parts of Africa have tremendous time-tested knowledge and practice in management of fragile dryland ecosystems and how to adapt to threats of climate change. Pastoralists and agropastoralists have been custodians of the land, water, forests, biodiversity and other services for time immemorial and their experience and practice is important and does not have a substitute.

Laying a supportive foundation: Appropriate institutions, sound policy frameworks and good governance are required at all levels to achieve climate-smart agriculture and must create an enabling environment for sustainable farming and for climate-smart agricultural investments from all sources, be it government, donors or the private sector. This should be done within a broader landscape approach, at the watershed scale.

Step up research and development: It is important to establish a centre of excellence in the country that can coordinate all research and development programmes taking place in the dryland areas, and be involved in networking and collaborative work. Research programmes are needed to investigate all production systems in dryland areas. Research and development activities should particularly focus on and be oriented toward the following activities:

- Risk management, drought mitigation, climate change mitigation and adaptation;
- Integrated water and land management, improving biophysical, economic social and environmental returns per unit of water;
- Community and institutional frameworks;
- Policy options to stimulate technology adoption; and
- Diversification and market

research to encourage farmers to shift from subsistence to a market orientation.

Network and coordinate to address common problems: Given the complex challenges faced by dryland communities, which span many disciplines, and the trans-boundary nature of many of the constraints to dryland development, no single country can manage the research systems and efforts required to improve dryland natural resource management and utilization. Networking alliances and partnerships, including bilateral and on regional and international bases, should be established to ensure more efficient use of resources, better public relations and resource mobilization.

The interconnected nature of today's agricultural challenges, including ecosystem degradation, food security and climate change, requires coordination at national, regional and international levels. The private sector should also be brought into this endeavor, since the private sector has a key role to play in climate-smart agriculture and food security, food production, processing, marketing and development and application of new technologies, including eco-efficient and responsible investments.

Promote tools and technologies for climate smart agriculture: Increased productivity is necessary to meet the needs of people for nutritional food, feed for their animals, fiber, energy and other products, while conserving the functions of natural ecosystems. To this end, sustainable agricultural intensification and increased productivity is recommended, rather than expanding areas under cultivation. The focus should be on intensification and diversification and increasing yield and water use per unit of land, rather than on expansion of areas under cultivation, as the latter is becoming impractical. Population increases are leading to shortages of land for cultivation. The support of public and private institutions to ensure access of farmers to new technologies at competitive, affordable prices is vital. It is also important to remember that agriculture is related to other issues, such as livelihoods, market development, cultural aspects and biodiversity. Research agenda solutions should be tuned to "triple win" solutions, such as the CGIAR Climate Change Challenge Programme.

Expand the role of tree crops: There is an urgent need for restoration of degraded agricultural landscapes, in particular in drylands. A productive and diverse landscape will be more resilient to climate change and provide critical ecosystem, social and cultural services.

Including trees in the production landscape can help reduce erosion, increase nutrients in the soil and sequester carbon. Tree crop use should be coupled with conservation-oriented management practices, such as soil fertility enhancement, minimum tillage and organic agriculture. Such measures increase resilience while storing carbon in the soil.

There are many trees in drylands of Africa which could be used to increase resilience while storing carbon in the soil. An example of a successful agroforestry tree is Faidherbia albida, which sheds its leaves in the rainy season. Planting trees and restoring forests can also provide major benefits to both the quality and long-term reliability of water flows and increase water availability for agriculture and broader ecosystems functions.

Conserve and harvest water: Improved water harvesting and retention and water use efficiency are fundamental for increasing agricultural production. A suite of measures exists in both rain-fed and irrigated agricultural systems for water conservation and harvesting. Good examples of rain-fed systems found in Africa are raised seedbeds that trap water and keyhole gardens that use wastewater. Improved irrigation systems include mini-sprinkler and drip systems and precision timing in plant watering and crop systems. Another example is the intensive rice system which uses less water than traditional systems and lowers greenhouse gas emissions compared with traditional paddy systems.

Manage soil and nutrients: The availability of nitrogen and other nutrients is essential to increase yields. Methods and practices that increase organic nutrient inputs should be promoted. Examples of agroecological practices that contribute to soil and nutrient fertility enhancement include residue and manure and crop fertilization, agroforestry, more precise matching of nutrients with plant needs, controlled release and deep placement technologies and using legumes for natural nitrogen fixation and carbon sequestration. These practices can be used in combination with efficient use of artificial fertilizers and carbon sequestration. Efficient use of fertilizers – such as proper manure storage and management of artificial fertilizers and aspersion techniques – must also be encouraged to contribute to reducing greenhouse gas emissions.

Preserve genetic resources: Most countries in East Africa have rich biodiversity with highly-valuable genetic resources with tolerance to shocks of temperature extremes, drought, flooding, pests and diseases. Preservation of these genetic resources is fundamental for developing resilience of plants and animals to shocks, improving the efficient use of resources, shortening production cycles and generating higher yields and improving market access and germplasm exchange.

The role of farmers in preserving local crops and seeds is important. There is a need to support farmer's adaptation to climate change by conservation and maintenance of their crop diversity through incentives for their contributions to conserve crop genetic diversity. Policymakers and researchers should facilitate genetic resource preservation to benefit small farmers. For example, there are funds under the International Treaty on Plant Genetic Resources for Food and Agriculture, but not many African small farmers are benefiting from this fund.

Conduct livestock and other relevant research: Research and development in livestock has been neglected by researchers, development workers and policymakers in Ethiopia. There are very few technologies developed for improvement of rangelands and water management and little effort made to breed for improved breeds. There has also been little research work done on some types of livestock, such as camels.

There is a need to conduct research activities that can help improve grazing areas, including pastoralist-grazing, breeding and fodder management, and improve management and re-use of animal waste to reduce the carbon footprint of livestock and control water pollution. An example of the latter is the use of manure for biogas and as an organic fertilizer. There is also a need to research how aquaculture and fisheries can be sustained in the context of rising temperatures and water scarcity.

While much is known about mechanisms that could contribute to the development of climate-smart agriculture and pastoralism, much more remains unknown and needs to be researched and further studied. Research and development of plant and animal varieties, including livestock breeds, which are more robust to drought and flood, are critical. It is also important to address knowledge gaps in many areas, including, for example, cost-effective approaches for assessing soil carbon and more broadly assessment of the greenhouse gas profile of agricultural systems. Scaled up financing for research has an important role to play. It is also noted, to the extent possible, research should be open to ensure its widest possible benefit.

Improve knowledge sharing and access to information and technology transfer: Net¬working and knowledge sharing should take place between research and knowledge institutions and synergies looked for in research activities. In tandem with this, knowledge should further be shared among producers' organizations, non-governmental organizations, the government agricultural extension service sector, the private sector and research institutes, and joint approaches supported. As farmers' advisory systems are important to address climate change, they should be recognized and further developed.

Identify and scale up replicable models: Successfully scaling up replicable models requires a long term commitment, learning by doing and participatory approaches. Support mechanisms are needed to provide incentives to bridge the gap between short-term costs and longer-term productivity gains and to 'internalize externalities' for decision makers. It is also important to share experiences between countries.

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3. Analysis of pastoralist's adaptation to climate change and variability in the dryland areas of Afar, Ethiopia

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ABSTRACT

Key words: adaptation strategies, Afar, binary and multinomial logit models, climate change

Pastoralists throughout the Horn of Africa are the most vulnerable group to the impacts of climate change and variability. This study assessed pastoralist adaptation to climate change and variability in Afar National Regional State, Ethiopia. A total of 250 randomly-selected participants from Dubti, Asaita and Mille Districts of Afar National Regional State were included in the study. Descriptive statistics, binary and multinomial logit models were integrated with qualitative data analysis techniques to analyse data collected through household surveys, focus group discussions, interviews and document analysis.

According to the descriptive data analysis, the majority of the respondents perceived an increase in temperature (85.2 percent), a decrease in rainfall (79.6 percent) and increasing occurrence of drought (78.6 percent) over the last 30 years. Actual climate data analysis also indicated similar trends. The majority of the respondents have taken adaptation measures to these perceived changes in climate (86.4 percent). Results from the Binary Logit (BNL) Model revealed that pastoralists perception of increasing temperature and drought, ownership of radios, levels of education, farming experience and extension services have a positive influence on the decision of pastoralists to adapt to climate change and variability, while gender and nearness to river banks have a negative influence.

Afar pastoralists have generally used four major adaptation strategies to changes in climate change: mobility (49.6 percent), livelihood diversification (19.2 percent), herd management (12 percent) and fodder management (5.6 percent). Results from the Multinomial Logit (MNL) Model indicated that the choice of pastoralists between major adaptation strategies is significantly influenced by multiple factors. These factors are: the pastoralist's perception of climate change components (increasing temperature, decreasing rainfall and recurrent drought), ownership of radios, distance from river banks, level of education, the household head's gender and access to extension services. Hence, interventions to enhance adaptation of pastoralists to climate change and variability should be in line with these factors. More integrated extension services, establishment of climate data centres and more focus on livelihood diversification and herd management are recommended.

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Introduction

Background

There has been a growing consensus that climate change is one of the biggest environmental threats facing the world today. Climate change refers to a permanent shift in the state of climate components manifested by changes in the mean and/or the variability of its properties persisting for an extended period of time, typically decades or longer. It occurs either due to natural variability or as a result of human activity (IPCC, 2007). The most common manifestation of climate change and variability are changes and variability in temperature and precipitation as well as occurrences of extreme climatic events, especially drought, flooding, sea level rise and storms (hurricanes, tornado, typhoons, etc.). Empirical studies have confirmed that climate change poses direct negative impacts on agriculture, livelihood assets, water resources and the nutrition and health status of people (Henson, 2006; IPCC, 2007; Boko et al., 2007).

The most adverse impacts of climate change are predicted to hit hardest poor people in the countries of the developing world because of their geographic exposure, already fragile environments, dominance of climate-sensitive sectors in their economy and low adaptive capacity (IPCC, 2007; Deressa and Hassan, 2010). Pastoralism, which is a way of life based primarily on mobile raising of livestock, particularly small ruminants, cattle and camels, is one of the climate-sensitive livelihood systems that is and has been negatively affected by climate change and variability (Koocheki and Gliessman, 2005; Anderson et al., 2008). Many studies indicate that climate change is posing significant adverse impacts on the life of pastoralists (Koocheki and Gliessman, 2005; Anderson et al., 2008), such as the death of livestock (due to water shortages and heat stress), conflict over resource utilization and ownership, loss of land to agricultural encroachment, increase in frequency of flooding, spread of human and livestock diseases thriving in the wet season and the weakening of social institutions.

Pastoralists have a high degree of exposure to climate change due to their location in vast arid and semi-arid areas all over the world, including Africa and Ethiopia. Compared to highland areas, these areas are characterized by marked rainfall variability, fast return rate of drought cycles and associated uncertainties in the spatial and temporal distribution of water resources and grazing for animal feeding (Conway and Schipper, 2010). Pastoralists are also highly sensitive to such exposure to climate change due to their location in isolated, remote and underdeveloped areas. These areas are often highly conflict prone, food insecure and have poor basic service provision, with health and education indicators that are lower than national figures (IPCC, 2007; Deressa and Hassan, 2010). Moreover, increasing population growth, unresolved land tenure issues, poor market access, encroachment of large-scale state and private investment and all forms of prevailing political and socioeconomic marginalization make pastoralists more sensitive to the impacts of climate change. That also implies low adaptive capacity to climate change impacts (GebreMichael and Kifle, 2008).

For many years, pastoralists have developed management systems based on strategic mobility, which are well adapted to difficult conditions (Hesse and MacGregor, 2006). Mobility is a common feature of pastoralist's adaptation to changes in climate and scarcity of resources. In addition to mobility, pastoralists have been adapting to climate change thought strategies such as keeping animals that can endure seasonal feed shortages and long intervals between drinking; keeping large herds in the hope that some animals will survive a period of feed shortage; diversification into cropping, engaging in non-pastoralist activities, like trade, etc. (Hesse and MacGregor, 2006; Coppock et al., 2009; Niamir-Fuller, 1999). While studies about sedentary agricultural farmer's adaptation to climate change are abundant, studies on pastoralist's adaptation to climate change and variability are very limited. This is particularly true with local level analysis (Deressa et al., 2008). This study was carried out to contribute to filling the gap in this regard.

Objectives

The objectives of the study are to: (i) identify whether pastoralists in Afar region recognize climate change and variability, (ii) examine factors that influence the decision of pastoralists whether or not to adapt to climate change and variability; and (iii) assess factors that determine pastoralists' choice of different adaptation strategies to climate change and variability.

Materials and methods

Description of the study area

The study was conducted in Mille, Dubti and Asaita Districts in Zone One of Afar National Regional State in northeastern Ethiopia (Figure 1).

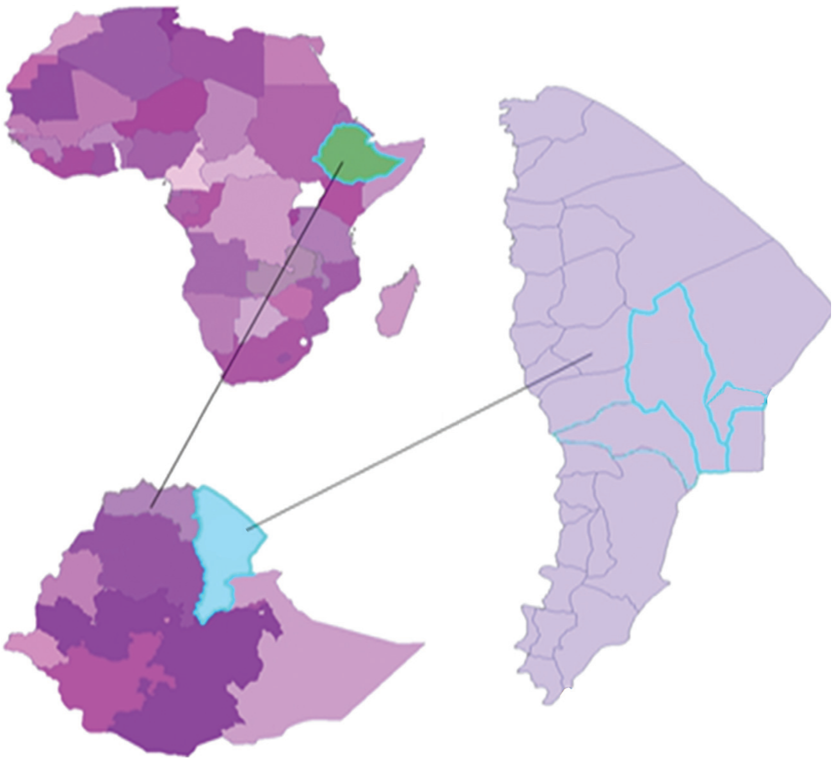

Figure 1: Map of the study areas

The altitude of the study sites ranged from 400m to 424m above sea level. The study area is characterized by lowland plains in a very hot and arid zone. It is distinguished by an arid and semi-arid climate with low and erratic rainfall. The mean maximum temperature ranges from 32.10C to 42.10C and the mean minimum temperature ranges from 15.5 to 24.90C. The hottest months are March to October and the coldest months are November to February. Mean monthly rainfall ranges from 3.9 to 57.7 mm. March, April, July and August receive the most rainfall. Distractive high winds accompanied by dust are very common every day in the afternoon. As a result, the region is a drought-prone area, with major shocks and hazards associated with a recurrence of drought that disrupts the livelihoods of the population.

Sampling design

A total of 250 households from the three districts were randomly selected for this study. To ascertain if pastoralists' perceptions of climate change and variability corresponded to actual long term climatic records, thirty years of climatic record data (precipitation and temperature) collected by the Ethiopian National Meteorological Service Agency was analysed and compared to findings from the household surveys. The climate data covers the period from1981 to 2011. Trends and variability of precipitation and temperature were analysed.

Methods of data collection

The principal method of data collection used was the household survey. For this purpose, structured questionnaires (open-ended and close-ended) were developed to gather pertinent information about the awareness of pastoralists to climate change and adaptation decisions and factors that determine a pastoralist's choice of adaptation strategies. The questionnaire was pre-tested for consistency, logical flow, coding and length, and amended accordingly. Training was provided for educated enumerators who understand and speak the local language (Afaraf) to facilitate successful data collection. In order to confirm pastoralist perceptions of climate change, secondary data (thirty-year rainfall and temperature data) was also collected from the National Meteorological Services Agency (ENMSA). In addition to the household surveys, focus group discussions and key informant interviews were carried out with pastoralists and other government authorities to supplement the survey data.

Methods of data analysis

Data collected from both household surveys and meteorological stations were quantitatively analysed by using SPSS version 17 and STATA version 12 software. Descriptive statistical techniques, such as frequency, mean, percentage and standard deviation, were employed to compare perception of agropastoralists to climate changes and variability. The Binary Logit (BNL) Model was employed to examine a pastoralist's decision to undertake any adaptation measure. Finally, the Multinomial Logit (MNL) Model was used to analyse a pastoralist's choice of the different adaptation strategies.

Model specification

The binary logit model

In order to determine whether adaptation is undertaken in response to observation of climate change, a probability model is used, in which the binary dependent variable is a dummy for undertaking any adaptation at all (i.e., Yi) and has only two possible values, 1 or 0, for either adapting or not adapting to climate change. Thus,

$Y_i = X_i\,\alpha + \varepsilon$ 1

It is assumed that the probability of observing pastoralist *i* undertaking any adaptation at all *(Yi = 1)* depends on a vector of independent variables *(Xi)*, unknown parameters *(α)* and the stochastic error term *(εi)* (Gujarati, 2003). Assuming that the cumulative distribution of εi is logistic, the probability that the pastoralist adapts to climate change is estimated using the logistic probability model specified as (Woodridge 2001):

$$P(Y=1|X)=\Lambda(x_1\,\alpha)= \frac{e^{x'}\alpha}{1+e^{x'}\alpha} \quad \ldots\ldots 2$$

Then the corresponding log likelihood function for the probability is:

$$lnL = \sum_{i=1}^{N} I_i\, ln[\Lambda(x'\alpha)] + (1-I_i)ln[1-\Lambda(x'\alpha)] \quad \ldots\ldots 3$$

Where I_i is the dummy indicator equal to 1, if the pastoralist i undertakes any adaptation at all to climate change and 0 otherwise. The marginal impact for each variable on the probability level is given by:

$$\frac{\partial P(Y=1|X)}{\partial Xk} = \frac{\partial \Phi(Y=1|X)}{\partial Xk} = \Lambda(X'\alpha)\,[1-\Lambda(X'\alpha)]\,\alpha k \quad \ldots\ldots 4$$

while the marginal effect for a dummy variable, say X_k, is the difference between two derivatives evaluated at the possible values of the dummy i.e. 1 and 0. Thus:

$$\frac{\partial P(Y=1|X)}{\partial X_k} = [\Lambda(X'\alpha)[1-\Lambda(X'\alpha)]\,\alpha_k\,]\,X_k=1-[\Lambda(X'\alpha)[1-\Lambda(X'\alpha)]\,\alpha_k\,)\,]\,X_k=0 \quad \ldots\ldots 5$$

The Multinomial Logit Model

In order to determine the factors influencing a pastoralist's choice of a particular adaptation method to climate change, the Multinomial Logit (MNL) Model was used, in which the dependent variable is multinomial, with as many categories as the number of adaptation methods to climate change. The use of the MNL Model is needed because pastoralists have to choose from many adaptation methods which are unordered and nominal in character (Bartels et al., 1999; Greene, 2000; Wooldridge, 2001; Gujarati 2003). The MNL Model assumes Independence from Irrelevant Alternatives (IIA) (Wooldridge, 2001).

$$P(Y=j|X) = \frac{exp(X\beta_j)}{(1+\sum_{j=0}^{J} exp(X\beta_j)} \quad \ldots\ldots 6$$

Where *βj* is a Kx1 vector and j = 0, 1, 2. . . J. Equation 6 can only provide the direction of the effect of contextual background on choosing a particular adaptation method. The marginal effects are obtained by differentiating equation 6 with respect to independent variables of interest. The marginal probability for a typical independent variable is given as:

$$\frac{P(Y=j|X)}{\partial X_k} = P(Y=j|X)(\beta_{jk}-\sum^{(j=1)} P_j\,\beta_{jk}) \quad \ldots\ldots 7$$

Description of variables

The dependent variable (DV) of the binary logit model is whether a pastoralist takes adaptation at all and it is coded 1 for taking adaptation or 0 for not taking adaptation. Literature states that there are limited studies on the adaptation of pastoralism to climate change and variability, while there are considerable studies on adaptation of sedentary crop farmers to climate change and variability (Hassan and Nhemachena, 2008). Hence, many of the explanatory variables employed in this study are selected with reference to such studies. The explanatory variables are as given below.

Household head's gender: As much empirical evidence indicates, this study hypothesized that pastoralist households headed by males will adapt to changes in climate better than their female counterparts.

Household's annual income: The total annual income of a given household which is expected to have a positive relationship to taking adaptation measures. Since many of the adaptation strategies require financial investment, pastoralists with higher annual income will adapt better to changes in climate and variability.

Farm experience: In this study, it is assumed that the more experienced a pastoralist is, the more successful he or she will be in adaptation to climate change and variability. This is because pastoralists know how and when climate changes and what strategies should be followed to respond to such changes.

Level of education: In this study, the level of formal education the household head has attained is hypothesized to have a positive significant effect on decisions regarding a pastoralist's adaptation to climate change.

Pastoralist's observation of changes in local climate variables: In this study, local climate variables are increasing temperature, decreasing rainfall and recurrent occurrence of drought. This study hypothesizes that the observation of increased incidence of drought, increasing temperature and decreasing rainfall will positively influence pastoralists' decisions to adapt to climate change.

Location of a pastoral around a river bank: The presence of the Awash River valley in the study area forced the researchers to include this variable in the model. This is due to the assumption that pastoralists near the Awash River valley in different parts of the region will find it easy to get water and animal feed, while the reverse is true for those in remote areas away from the river bank. Hence, it was hypothesized that the proximity of a pastoralist to the river bank will have a negative effect on decisions to adapt to climate change.

Table 1: Definition of explanatory variables used in the models

Variable	Type	Modalities (description)
Household head gender	Dummy	0=Female; 1=Male
Household's annual income	Continuous	Amount in Ethiopian Birr
Farming experience	Continuous	Number of years stayed in pastoralism
Level of education	Continuous	Number of years attended school
Frequency of drought occurrence	Dummy	0=No; 1=Yes
Increase in temperature	Dummy	0=No; 1=Yes
Decrease in rainfall	Dummy	0=No; 1=Yes
Located along river banks	Dummy	0=No; 1=Yes
Access to media (ownership of a radio)	Dummy	0=No; 1=Yes
Receive extension services	Dummy	0=No; 1=Yes
Rear cattle as major herd animal	Dummy	0=No; 1=Yes

Ownership of a radio: Access to timely information is fundamental to adaptation efforts to climate change and variability. Radio is one of the most commonly owned sources of media information by pastoralists. This study hypothesizes a positive relationship between a pastoralist's ownership of a radio and decisions to adapt to climate change, as well as to choose a given adaptation strategy.

Availability of extension services: In this study, it is hypothesized that pastoralists who receive extension services and visits tend to adapt to climate change. Here, extension services are expected to have a positive effect on a particular pastoralist's decision to adapt to climate change and to choose specific adaptation strategy.

Pastoralist's major herd: It is a well-established fact that all herd species do not have the same resistance to climate change and variability. The ability of a herd animal to withstand climate change stress varies from type to type. Pastoralists with cattle as their major herd are hypothesized to decide to quickly adapt to shortages of water and pasture caused by climate change and variability.

Key findings and discussion

Background of the respondents

The findings (Table 2) indicated that pastoralists in the study area have very low education levels. Out of the total respondents, 88.8 percent were found to be illiterate, while the remaining can only read and write. Moreover, 82 percent of the respondents fall into the poor wealth status category. As far as the gender of the respondents is concerned, 64.6 percent are males, while the remaining are females.

Table 2: Demographic characteristics of respondents (n = 250)

Variable	Total	
	Frequency	Percentage (%)
Education		
Illiterate	222	88.8
Read and write	28	11.2
Wealth status		
Poor	207	82.8
Medium	30	12
Rich	13	5.2
Gender		
Male	161	64.6
Female	89	35.4

Source: Author's field survey, 2013.

Pastoralist's perception to changes in temperature, rainfall and drought occurrence

The majority of pastoralists in the study area have perceived an increase in temperature (85.2 percent), decrease in rainfall (79.6 percent) and increased frequency of drought occurrence (78.6 percent) within the last three decades (see Table 3). The perception of pastoralists is found to be in line with actual climate data as recorded by the Ethiopian National Meteorological Service Agency (ENEMSA).

The data was collected from records of the last 30 years (1981-2011). The mean is calculated and presented as follows. All the stations in the study area experienced total annual rainfall amounts of less than 700 mm. The maximum total annual rainfall of Dubti, Mille and Asaita Districts was 255.1 mm, 324.4 mm and 662.4 mm, respectively. The lowest minimum total annual rainfall in the last thirty years was recorded in Asaita (45 mm). As expected, there is great average variability in rainfall totals (59.8 mm to 662.4 mm) with a mean of 286.2 and standard deviation of 126.76 mm. Strong variations and changes of rainfall totals have been recorded across the years (Figure 2).

Table 3: Pastoralist's perception to changes in selected climate elements (n = 250)

Variable	Total	
	Frequency	Percentage (%)
Increasing Temperature		
Yes (1)	213	85.2
No (0)	37	14.8
Decreasing Rainfall		
Yes (1)	199	79.6
No (0)	51	20.4
Frequent Drought		
Yes (1)	196	78.4
No (0)	54	21.6

Source: Author's field survey, 2013.

According to the recorded climate data, rainfall distribution is bi-modal throughout the region and interruptions in the performance of any rainy season will have an impact on the availability of pasture and water, as well as the overall food security situation of agropastoral communities. Rainfall amounts and distribution are of paramount importance to rain-fed agriculture in less developing countries, including Ethiopia (Deressa et al., 2009). Research on the climate of Africa by the Intergovernmental Panel on Climate Change (2007) revealed that the amount of total annual precipitation and distribution are highly variable both spatially and temporally.

Trends of temperature changes and variability

Like the rainfall data, temperature data for a thirty year period (1981-2011) were gathered from ENEMSA and analysed. The maximum mean annual temperature recorded over the 30 years was 37.5 ±1.22, 38.08±0.91 and 38.12±1.09 oC, while the minimum mean annual temperature was 34.5 ±1.27, 37±0.91 and 37oC ±1.09 in Dubti, Mille and Asaita Districts, respectively. The mean annual temperature of Dubti, Mille and Asaita Districts was 37.5±1.22, 38.08±0.91 and 38.12oC ±1.09, respectively.

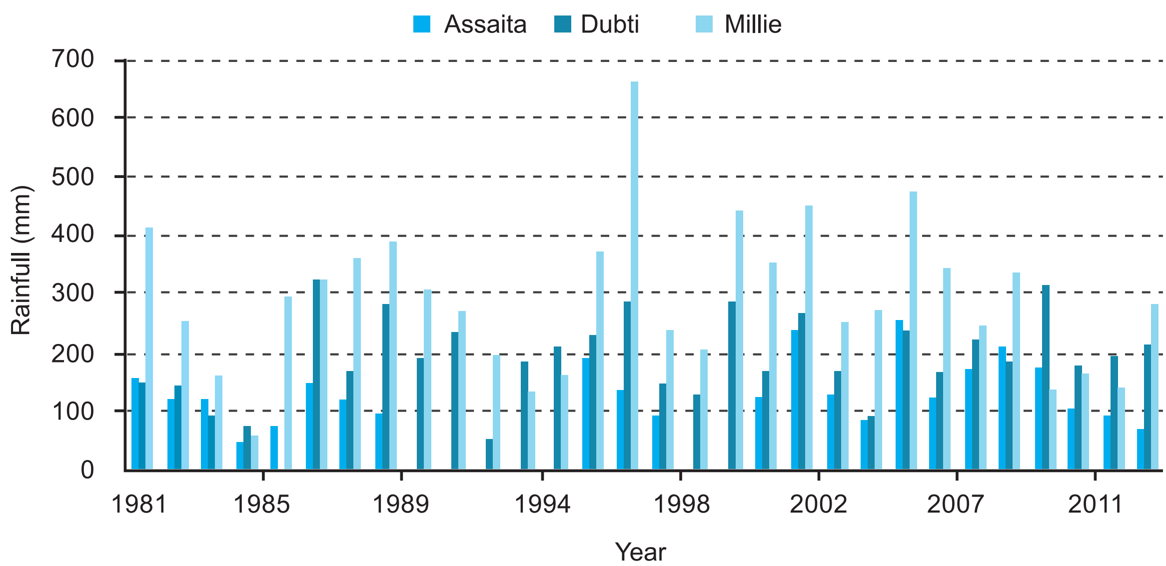

Figure 2. Rainfall trends in Dubti, Mille and Asaita Districts Source: ENMSA, 2013.

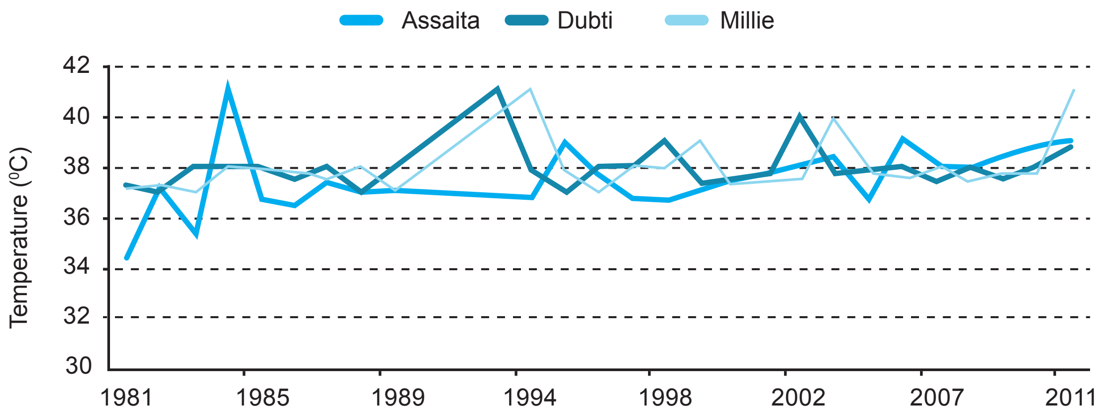

Figure 3. Temperature trends in Dubti, Mille and Asaita Districts (1981-2011) Source: ENMSA, 2013.

As the climate record data shows (Figure 3), the variance of temperature changes has increased regularly over the years analysed.

A study conducted in the highlands of Ethiopia found that temperatures have been increasing annually at a rate of 0.2°C over the past five decades (Legesse et al., 2013). The study concluded that this has already led to a decline in agricultural production. Regional research on predictions for climate change in Africa by the end of the twenty-first century was conducted in Kenya by Herrero et al. (2010). Their climate model simulations under a range of possible emission scenarios suggested that for Africa in all seasons the median temperature increase lies between 3°C and 4°C, roughly 1.5 times the global mean.

Pastoralist adaptation to climate change and variability

Adaptation strategies used by pastoralists

As indicated in the table below (Table 4), half of the respondents (49.6 percent) have used mobility from area of scarce water and fodder to areas of abundance within the Afar National Regional State. Such movement was made to areas that border the neighbouring regional states of Tigray, Amhara and Oromia. Pastoralists also stated that this adaptation strategy enabled them to temporarily settle around water points and grazing lands with abundant pasture for their livestock. Mobility has served pastoralists as a successful adaptation method to climatic and environmental hazards, as well as to adapt to the difficult nature of the arid environment. However, the effectiveness of this adaptation strategy is facing increasing pressure due to natural resource-based conflicts. Participants in this study's focus group discussions explained that before the establishment of a federal system in the country they could move to central parts of adjacent regions of Tigray, Amhara and Oromia, but this has become more difficult in the current era.

Table 4: Adaptation strategies used by pastoralists (n = 250)

Adaptation strategy	Frequency	Percentage (%)
Herd management	30	12
Fodder management	14	5.6
Mobility	124	49.6
Livelihood diversification	48	19.2
No adaptation	34	13.6
Total	250	100.0

Source: Author's field survey, 2013.

The second most important adaptation strategy to climate change and variability by pastoralists in the study areas was livelihood diversification (19.2 percent of respondents). Pastoralists have been engaging in different sources of livelihood, such as selling high quality charcoal (from Prosopis juliflora, an invasive tree - see Figures 4a and 4b - which the national government is aiming to eradicate through utilization), selling camel milk (see Figure 4c), selling tooth brushes, small-scale trade (in the nearby towns of Logya, Semera, Mille, Dubti, Asaita, etc.), selling fish products from irrigated areas around the Awash River and selling maize from Tendaho and other irrigation projects.

Figure 4: Photos of livelihood diversification activities in the study areas

Pastoralists stated that such livelihood diversification activities enabled them to be much more successful in trade activities, and there are even pastoralists that own cars, mini buses, bajaj (three-wheeled taxis) and conduct other types of trade.

The third most prevalent adaptation strategy to climate change in their locality (12 percent of the respondents) is herd management. Most pastoralists have reduced the number of their herds, while at the same time increasing

the quality of their livestock. Due to climate change-induced shortages of water and pasture, pastoralists in the study areas are also altering the composition of their herds. They are increasingly replacing cattle with goats, sheep, donkeys and camels. The change in composition of livestock has been facilitated by many social measures, like giving drought-resistant herd species as marriage dowry.

Lastly, the adaptation strategy used by 5.6 percent of the respondents was fodder management. This adaptation strategy has recently been introduced. Pastoralists in the study areas have begun to make hay and to purchase crop residues from adjacent sedentary farmers and agropastoralists. Some of the hay is sold to animal keepers in towns. As indicated by focus group discussion participants, this has been integrated with the cut and carry system of fodder collection, in which pastoralists cut pasture from protected areas, like the Awash National Park (prohibited for grazing), and carry it to an area where they can store and feed their livestock.

Factors influencing pastoralists' decision to adapt to climate change and variability

Having learned that the majority of pastoralists in the study area have accurately perceived changes in temperature and rainfall, as well as the frequent occurrence of drought, a Binary Logit Model was run to examine the factors that influence the decision of pastoralists whether and how much to adapt to the climate changes. In the model, the dependent variable (DV) was whether a particular pastoralist adapted to the changes in climate (Yes = 1) or (otherwise = 0). Along with this, the model has eleven independent variables (IV) that are hypothesized to influence the decision of a pastoralist to adapt to climate change and variability. The log-likelihood ratio test of the full model with all its predictors is -80.69671, which is smaller than the initial log-likelihood ratio of -111.56092; which makes the overall Chi-square test to be x2(11,N = 250)61.73, P<0.0005. Hence, it is concluded that the variables included in the model explain the variation in the regressand adequately and very well.

The results of the Binary Logit Model (Table 5) indicated that location or proximity of a pastoralist to the river bank of the Awash River has a significant negative influence on his or her decision to adapt to climate change. A one unit change in the proximity of a pastoralist to the river bank will decrease his/her probability of deciding to adapt to climate change by 10.2 percent (p<0.005). The focus group discussions participants stated that this is due to the relative abundance of water and fodder along the river bank. Studies have confirmed that farmers in different environments make different decisions in adapting to climate change (Seo et al., 2009; Nhemachena and Hassan, 2007). Different environments possess different types and amounts of resources for adaptation to climate change.

The marginal effect of a pastoralist having received extension services was found to be 8.5 percent. This implies that pastoralists who receive extension services have an 8.5 percent higher probability of adapting to climate change and variability (p<0.005). Many studies, like Etwire et al., 2013, Nhemachena and Hassan, 2007, Gbetibouo, 2009 and Deressa and Hassan, 2010, have ascertained that there is a positive relationship between receiving extension services and the decision to adapt to climate change. This is due to the fact that pastoralists who have contact with extension workers will have better knowledge and support in their efforts to adapt to climate change.

The probability of a pastoralist who owns a radio adapting to climate change and variability is 21.59 percent (p<0.001) higher than those who don't own a radio. As the researchers hypothesized, the focus group discussions participants stated that the information transmitted via radio about climate change impacts, adaptation strategies and market information provoke them to decide to adapt to climate change. This is similar to the findings of Deressa

Table 5: The binary logit model of a pastoralist's decision to undertake adaptation to climate change

Explanatory variable	Coefficients	Marginal effect (dy/dx)
Pastoralist's perception of increase in temperature #	1.8580***	0.2254*
	[0.6848]	[0.1165]
Pastoralist household owning cattle as a major herd #	0.9533**	0.0688**
	[0.4412]	[0.0336]
Pastoralist's perception of decreasing rainfall #	0.9676	0.0518*
	[0.6563]	[0.0281]
Ownership of radio #	2.1866***	0.2159***
	[0.4913]	[0.0571]
Household head's level of education	1.1701**	0.0634**
	[0.5392]	[0.0257]
Pastoralist who receives extension services #	1.4076***	0.0850***
	[0.5411]	[0.0284]
Pastoralist's perception of increasing drought occurrences#	1.4797***	0.0841***
	[0.5655]	[0.0288]
Household head's gender #	-0.4108	-.0274
	[0.4590]	[0.0293]
River bank #	-1.5307***	-0.1021***
	[0.5029]	[0.0339]
Farming experience	2.7612***	0.1749***
	[0.6365]	[0.0398]
Livelihood system #	0.1012	0.0071
	[0.4226]	[0.0296]
Constant	8.4363**	
	[1.4622]	
Observation	250	
LR χ2(11)	61.73	
(p-value)	0.0000	

and Hassan (2010) and Mandleni and Anim (2011) who have reported that access to information on climate change and variability through, for example, a radio positively affects adaptation to climate change.

The marginal effect of 6.34 percent ($p<0.05$) for pastoralist household head's level of education implies that pastoralists who are not illiterate have a 6.34 percent higher probability of adapting to climate change and variability. The more they are educated the more probable they will be to decide to adapt to climate change. A number of studies found that education and knowledge are crucial elements of climate change adaptation measures and natural resource management practices (Glendinning et al., 2001; Hassan and Nhemachena, 2008; Deressa and Hassan, 2010). The level of education of farmers was found to be positively associated with decisions to adapt (Hassan and Nhemachena, 2008) and negatively associated as with the studies of Okeye (1998) and Gould et al. (1989).

Pastoralists who have perceived increasing trends in temperature were found to have 22.54 percent higher probability of adapting to climate change and variability ($p<0.1$). In discussions with pastoralists, they stated that when temperatures increase their livestock suffers from heat stress, hence they are forced to take adaptive measures. The marginal effect for pastoralists perception of increasing drought frequency for the last three decades is 8.4 percent ($p<0.01$). This implies that pastoralists who have recognized the increasing frequency of drought have an 8.4 percent higher probability of adapting to climate change than the base case (those who have not perceived the higher frequency of drought). However, whether a pastoralist had noticed the decreasing amount of rainfall over the last three decades was found to have no effect on his or her decision to adapt to climate change. Many studies discovered that farmers who experience increased incidence of drought, increasing temperatures and reduction in rainfall are more likely to adapt to climate change (Komba and Muchapondwa, 2012; Nhemachena and Hassan, 2007; Gbetibouo, 2009; Deressa and Hassan, 2010). The findings of this study are in confirmation to those findings, except for rainfall.

The other most important predictor that determines the decision of pastoralists whether or not to adapt to climate change is found to be farming experience, with the marginal effect being 17.49 percent ($p<0.001$). The marginal effect implies that a unit change toward more farming experience from little farming experience will increase the probability of a given pastoralist to adapt to climate change and variability by 17.49 percent. Literature on the effects of farming experience on adapting to climate change have mixed conclusions. Some studies concluded that farm experience has no effect (Bekele and Drake, 2003; Hassan and Nhemachena, 2008), while some found a significant negative impact (Lapar and Pandy, 1999; 2006; Nyangena, 2007; Anley et al., 2007) and others found positive effects (Okeye, 1998; Bayard et al., 2007) on adaptation to climate change.

The results of this study's analysis also indicated that the probability of pastoralists who rear cattle as their major livestock herd to adapt to climate change is 6.88 percent higher than those who rear other types of livestock as their major heard (mainly camel and goats) $p<0.05$. In the focus group discussions, participants stated that cattle are highly dependent on climate-sensitive resources, as opposed to other types of herds, such as camel and goats. Hence, pastoralists decide to adopt climate change adaptation strategies because of the need to search for the feed and water requirements of their cattle.

Finally, the model results showed that the gender of the household head, the type of livelihood system (whether the pastoralist is undertaking some form of agriculture or irrigation) and household income was found to have an insignificant effect in predicting the decision of respondents to adapt to climate change and variability.

Factors determining pastoralist's choice of different adaptation strategies to climate change and variability

Different climate adaptation strategies have different levels of effectiveness. Obviously, pastoralists might prefer some adaptation strategies over others. In addition to such preferences, some adaptation strategies might be more appropriate than others in certain environmental and social contexts. An analysis of the factors that determine which adaptation strategies are selected can provide valuable information about the social context of the community under consideration and the social-economic, environmental and institutional factors that influence their decision to adopt a particular strategy (Yegbemey et al., 2013; Deressa et al., 2009: Nhemachena and Hassan, 2007). From this approach, a Multinomial Logit Regression model was run to analyse the factors that determine the choice of climate adaptation strategies by a given pastoralist.

The dependent variable (DV) of the models was adaptation strategies, which have four responses each, representing four different climate adaptation strategies (Where 0 = herd management, 1 = fodder management, 2 = mobility, and 3 = livelihood diversification). The base category for reference of comparison was the 'no adaptation' group. The model has 10 predictors (independent variables) that are hypothesized to influence the decision of northeastern pastoralists of Ethiopia to adopt certain adaptation strategies. Model output indicates a Log likelihood ratio of -261.0722 and a likelihood ratio chi-square (LR chi2 (40)) of 153.76 with a p-value < 0.0001 implying that the model as a whole fits significantly better than a model without predictor variables.

Herd management

Results for strategy one indicated that having cattle as a major herd increases the probability of herd management by 13.16 percent (p<0.01) as opposed to the rearing of other types of herds, such as camel and goats. According to the focus group discussion results, cattle have low adaptive capacity to the impacts of climate change compared to other types of herd. Hence, pastoralists having cattle as a major herd are forced to manage their herd. Pastoralists who own radios have a 6.72 percent (p<0.05) higher probability of adapting to climate change through herd management than those who do not (Deressa et al., 2008). One year increase in farming experience increases the probability of using herd management as an adaptation strategy by 6.11 percent (p<0.01). The probability of using herd management as an adaptation strategy increases by 5.49 percent (p<0.05) when the level of education of the household head increases by one year. Pastoralists who have perceived increasing frequency of drought in their locality were found to have a 13.82 percent (p<0.05) higher probability of using herd management as an adaptation strategy. Receiving extension services from nearby farmer training centres (FTC) increases the probability of using herd management by 11.37 percent ((p<0.01). Households headed by males were found to have a 7.37 percent (p<0.05) higher probability of adapting to climate change and variability through herd management compared to female headed households. Being located near the banks of the Awash River has resulted in a 0.43 percent (p<0.1) lower probability of using herd management as adaptation strategy.

Fodder management

Pastoralists who have perceived increasing temperature in their locality have a 0.04 percent (p<0.05) lower likelihood of using fodder management as an adaptation to climate change and variability compared to those who have not. Table 6 also indicates that pastoralists who rear cattle as their major herd have a 2.73 percent (p<0.05) higher probability of using fodder management due to the fact that fodder is mostly used by cattle compared to other herd types. It was also found that a one year increase in the level of education of the household head increases the probability of using fodder management as an adaptation strategy to climate change and variability by 0.01 percent (p<0.05). The argument behind this is that fodder management requires considerable skill and some behavioural change. Pastoralists who have received extension services were found to have a 5.33 percent (p<0.01) higher likelihood of using fodder management as an adaptation strategy than those who have not received extension services. The likelihood of using fodder management as an adaptation strategy is 1.72 percent (p<0.05) higher for more experienced pastoralists than those who are less experienced. This indicates that when pastoralists have a higher level of education and more farming experience they tend to use fodder management, because with education and experience they acquire the necessary knowledge on how to manage fodder for their livestock.

Notes:

Base category for adaptation methods is "No adaptation"

P values are in brackets; *, **, *** imply significance level at 10%, 5%, and 1% respectively

(#) dy/dx is for discrete change of dummy variable from 0 to 1

Table 6: The multinomial logit model marginal effects for a pastoralist's choice of specific adaptation strategies to climate change

Explanatory variable	**Adaptation strategies**			
	Herd management	Fodder management	Mobility	Livelihood diversification
Pastoralist's perception of increases in temperature #	0.0847	-0.0004**	-0.1548	0.0356*
	[0.062]	[0.022]	[0.144]	[0.081]
Pastoralist household owning cattle as a major herd #	0.1316***	0.0273**	-0.0185	-0.0567
	[0.002]	[0.033]	[0.791]	[0.213]
Pastoralist's perception of decreasing rainfall #	0.0384	1.02e-07	-0.0177**	0.0755*
	[0.297]	[0.783]	[0.037]	[0.067]
Ownership of a radio #	0.0672**	-3.79e-07	-0.3024***	0.0291**
	[0.041]	[0.217]	[0.000]	[0.046]
Household head's level of education	0.0549**	0.0001**	-0.0886	0.1291
	[0.042]	[0.024]	[0.446]	[0.227]
Pastoralist who receive extension services #	0.1137***	0.0533***	-0.0376**	0.1718***
	[0.001]	[0.003]	[0.038]	[0.006]
Pastoralist's perception of increasing drought occurrences#	0.1382**	6.67e-08	-0.0198**	0.0283**
	[0.022]	[0.851]	[0.037]	[0.027]
Household head's gender #	0.0737**	-1.69e-07	0.2596***	-0.4285***

Mobility

Results from strategy three indicates that pastoralists who have perceived a decreasing amount of rainfall have a 1.77 percent ($p<0.05$) lower likelihood of using mobility as an adaptation strategy. Respondents stated that when they perceive rainfall is decreasing, they mostly opt for other strategies rather than moving in search of water elsewhere. In addition, owning a radio decreases the probability of using mobility as an adaptation strategy by 30.23 percent ($p<0.05$). These days, the government is encouraging pastoralists to permanently settle and to benefit from public service infrastructures, rather than to move across the region. This policy direction of the government is frequently discussed in the mass media and pastoralists are increasingly becoming aware of it.

In addition, the federal system of government does not allow cross-border mobility of pastoralists among adjacent regional states, as was common in the past. Receiving extension services was found to decrease the probability of using mobility as an adaptation strategy by 3.76 percent ($p<0.05$). Pastoralists explain that extension service experts and development agents usually encourage and train them on how to manage their herd and fodder and how to diversify their livelihood. A perception of the increasing frequency of drought, the location of a pastoralist near to the Awash River banks and farming experience have also decreased the probability of using mobility as an adaptation strategy by 1.98 percent ($p<0.05$), 12.05 percent ($p<0.1$) and 0.81 percent ($p<0.1$), respectively.

The results of the focus group discussions with respondents indicated that when pastoralists perceive that drought occurrence is increasing, they tend to reduce their reliance on pastoralism and to diversify into other means of livelihood. Participants of the focus group discussions also stated that there is a relative abundance of fodder and water near the banks of the Awash River, which makes them not choose to move to other locations. Moreover, they have stated that when their experience in farming increases, they realize that mobility is a traditional way of adapting to climate change and they decide to adapt through other strategies, such as herd and fodder management. The other predictor variable having a positive effect on mobility was gender. Households headed by males were found to have a 25.96 percent ($p<0.001$) higher probability than those headed by females to use mobility as an adaptation strategy to climate change and variability.

Livelihood diversification

As for the results from strategy four, the perception of pastoralists of increasing temperatures has increased the probability of using livelihood diversification as an adaptation strategy by 3.56 percent ($p<0.1$) compared to those who have not noticed temperature changes. Perception of respondents to a decreasing trend in rainfall has also increased the likelihood of using livelihood diversification as an adaptation strategy by 7.55 percent ($p<0.1$). Pastoralists who have perceived an increasing frequency of drought occurrence were found to have a 2.83 percent ($p<0.05$) chance of livelihood diversification than those who have not. Respondents stated that the heat stress caused by increasing temperatures and the lack of water and pasture caused by low rainfall and drought have been forcing them to abandon livestock rearing and diversify to other means of livelihood. Ownership of a radio, having received extension services and farming experience has increased the probability of using livelihood diversification by 2.91 percent ($p<0.05$), 17.18 percent ($p<0.01$) and 8.05 percent ($p<0.1$), respectively. The focus group discussion participants stated that the government regularly transmits radio programmes that explain the importance of livelihood diversification and how to get involved in it. Such radio programmes have a considerable effect on creating awareness and motivating pastoralists to use livelihood diversification as an adaptation strategy.

Respondents also stated that development agents and other workers that provide extension services are always encouraging pastoralists to diversify their livelihood to other sources of income. In the focus group discussions, pastoralists reported that as their farming experience increased, they had come to understand the lack of productivity of livestock keeping and therefore are gradually shifting to some other livelihood sources, such as irrigation-based farming and petty trade. The results from strategy four have also indicated that households headed by males have a 42.85 percent ($p<0.001$) lower likelihood of using livelihood diversification than those headed by females. This implies that females are more successful in livelihood diversification, especially in petty trade and commercial activities. The nearer a pastoralist is located to the Awash River bank also increased the probability of using livelihood diversification as an adaptation strategy by 8.05 percent ($p<0.1$) over those who are located in areas farther away from the river bank.

Conclusions and policy implications

Conclusions

From the findings of this study, it is concluded that pastorals in the study area have an adequate perception of changes in climate, as well variability of weather elements. Due to this, they are mostly aware of the impacts that are prevailing and that could take place in the future. This in turn has initiated them to take adaptation measures to offset the impacts of climate change and variability. A pastoralist who owns a radio, receives extension services and has a higher level of education is more likely to decide to take adaptation measures. Similarly, pastoralists that have perceived increasing temperatures and drought occurrences, have longer experience and those whose major herd is cattle have a higher probability of taking decisions to adapt. The pastoralists who have decided to take adaptation measures have adopted either or some combination of the four major adaptation strategies. These are mobility, livelihood diversification, herd management and fodder management. The choice of pastoralists between the four major adaptation strategies was significantly influenced by multiple factors. These factors are: pastoralists' perception of climate change components (increasing temperature, decreasing rain fall and recurrent drought), ownership of radios, distance from river banks, level of education, gender of the household head and access to extension services.

Policy implications

To enable successful adaptation of pastoralists to climate change and variability, extension services should be provided to all pastoralists in a very integrated and local-people friendly way. First, it should be made available to all pastoralists who are in remote areas as well as those that can be easily accessed. Extension services need to be adjusted to the mobile nature of the pastoral communities (for instance, by distributing sources of media, like radios, or by arranging mobile posts for extension services). Secondly, extension services should not only focus on improving productivity, but should also integrate dissemination of daily, monthly, annual and multi-decade climate data so that pastoralists have adequate information on trends of climate change. Thirdly, the indigenous way of information dissemination of the Afar people, called dagu, should be harnessed for climate-related information dissemination and be accompanied with adequate training.

The other most important policy implication of this study is the establishment of a climatic data centre for the Afar National Regional State as a whole, as well as for all its administrative units. This centre would gather, analyse, record and disseminate climate change data relevant to pastoral production systems in dryland ecosystems. This centre would also finance and conduct research and adaptation projects in cooperation with concerned stakeholders.

Education is indispensable to climate change adaptation efforts. Hence, a special focus should be given to promoting education among pastoralists. However, this should not be limited to formal education. Informal ways of educating pastoralists (especially those who are illiterate) should be arranged. Through this, pastoralists can learn to read and write, which will facilitate adaptation efforts by easing the utilization of different adaptation technologies and relevant information.

Currently, mobility is the major adaptation strategy to climate change and variability. This strategy is, however, no longer effective because of border and ownership issues with neighbouring regions as well as the villagization programme of the government. Hence, pastoralists should be encouraged to use other strategies, like livelihood diversification and herd management, as well as fodder management to a lesser extent. When pastoralists diversify their source of livelihoods, they will decrease their dependence on livestock which is a highly climate-sensitive sector. This is also in line with the settlement programme of the government. Herd management is also a very important strategy. This strategy will enable pastoralists to have a highly productive but lower number of livestock. This, in turn, decreases pasture and fodder requirements and increases productivity of livestock. This strategy will also decrease the methane gas production that is released from high numbers of livestock.

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Session on dryland ecosystem management

4. Characterization of irrigated soils and irrigation water in relation to salinity and sodicity in the Middle Awash Valley, Ethiopia: implications for management of dryland degradation

Kebenu Feyisa Gonfa

ABSTRACT

Key words: dryland (arid and semi-arid regions), irrigated soil, irrigation water, salinity, sodicity

In Ethiopia, about 70 percent of the land mass is classified as drylands which are mostly characterized by low and erratic rainfall (moisture deficit areas) throughout the year. Knowledge about the status of soil quality indicators and irrigation water quality are required for sustainable land use of drylands.

This study was conducted in Fantale District, East Shewa Zone of Oromia Regional State in the Great Rift Valley of Ethiopia. The study focused on characterization and classification of irrigated soils and irrigation water by characterizing the physicochemical properties of soils and irrigation water of the Irrigation Site in relation to salinity and sodicity. Soil samples from four profiles (depth-wise) in representative locations and five irrigation water samples from different locations of the main canal and the Awash River were collected and analysed. The results revealed that due to the presence of lithological discontinuity, most of the soil's physical properties showed variability with soil depth. The soil pH values ranged from 7.4 to 8.7, ranging from slightly alkaline to strongly alkaline, while electrical conductivity of the saturated soil paste extract (ECe) ranged from 0.63 dS m-1 (non-saline soil) to 45.50 dS m-1 (highly saline soil). Both in the soil solution and the exchange site, Ca2+ and Na+ were the pre-dominant cations, whereas Cl- and HCO3- were the pre-dominant anions in almost all the profiles.

Accordingly, Ca and Na salts of Cl- and HCO3- were mainly contributing for the salinity developments in the study site. Therefore, having pH < 8.5, ECe > 4 dS m-1 and ESP > 15 percent in the surface, the soils of Profiles 1 and 3 were classified as saline sodic, while the soils represented by Profile 2 (ECe < 4 dS m-1 and ESP > 15) and Profile 4 (ECe < 4 dS m-1 and ESP < 15) classified as sodic soil and non-saline non-sodic (normal) soil, respectively. Although irrigation appeared to have contributed to some extent to the development of salt-affected soils, there is also a natural potential salinity as well as sodicity in the area. The irrigation water samples were moderately alkaline in reaction and moderately saline in salt content. The HCO3- salts of Ca2+ and Na+ ions are mainly contributing to the development of salinity and sodicity (alkalinity) hazards in the irrigation water. In general, the irrigation water was medium in soluble salt concentration, low in sodicity and safe in residual sodium carbonate hazards. Accordingly, the results showed that the irrigation water is potentially suitable for irrigation purposes, while the soils of the area are prone for secondary salinization and alkalization processes calling for proper management practices and frequent monitoring of the soil-water-plant relationships in relation to soil salinity, soil sodicity and specific ion toxicity effects.

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Introduction

Background

Salinization of land and water resources is a major landscape degradation issue worldwide (Rhoades, 1990). High concentration of salts in the root zone limits the productivity of nearly 953 million hectares (ha) of productive land in the world. According to recent reports, the area of salt-affected land coverage is estimated to be more than 60 percent in Australia, which has continued to expand (Robertson et al., 2010). In Africa it covers about 81 million ha of dryland areas (Szabolcs, 1979). Most of the salt-affected soils and brackish groundwater resources are confined to arid and semi-arid regions and are the causative factors for triggering the process of desertification. Generally, in irrigated areas, human-induced salinity- and sodicity-related land degradation is becoming a serious challenge for food and nutritional security in the developing world (Golchin and Asgari, 2008; Singh, 2009; Wahab et al., 2010).

Ethiopia is the first in Africa and the ninth country in the world having more than 11 million ha of salt-affected soils (FAO, 1988; Szabolcs, 1989) which are mainly found in the Rift Valley, Wabi Shebele River Basin and various lowlands of the country. Following the establishment of large scale irrigated farms, the problem become worse due to poor drainage systems and inappropriate water management practices coupled with unsound reclamation procedures. For instance, over 2,280 ha (Melka Sadi), 500 ha (Matahara), 300 ha (Asyta), 220 ha (Kebena or Yalo), 145 ha (Kesem), 100 ha (Gewane), 56 ha (Werer State Farm), 80 ha (Shoa, Kefa Dura), 20 ha (Mille) have been proved to be salt-affected soils. Moreover, it is expected that the salt-affected soils in these areas will dramatically increase in the next few years if current irrigation practices are allowed to continue without proper management (Tadesse and Bekele, 1996; Georgis et al., 2006).

As reported by Murphy (1968), the Rift Valley zone of Ethiopia as a whole is potentially a very valuable agricultural area. Moreover, Gebremariam (2003) indicated that the greatest concentration of water bodies in Ethiopia is located in the Rift Valley. Thus, there is a tendency to consider the use of these waters for irrigation as a solution to alleviate the problem of very unreliable rain-fed agriculture and a determinant for agricultural development and self-sufficiency with respect to food production. Realizing these options and opportunities, Ethiopia - which suffers from repeated drought, famine, low soil fertility, low productivity using rain-fed agriculture and high population pressure in the highlands (Lakew et al., 2000) - is currently seeing the need to extend agricultural production by using irrigation in vast areas of potentially-irrigable lands in arid and semi-arid lowlands of the country, where rain-fed production is difficult.

To understand how improved irrigation technology may assist in reaching these needs, it requires knowledge of salinity- and sodicity-related chemical properties of irrigation waters and the soils of the lands to be converted into irrigated agriculture. Such knowledge is believed to help producers and production managers to understand and make necessary modifications in the soil-salt-water balance and in ecosystem equilibrium that may arise as a result of introduction of irrigation farming (Rajabzadeh et al., 2009; Shahid et al., 2009a).

The Oromia Regional State has started an irrigation-based development project for ensuring food security and increasing agropastoralists' income in Fantale District of the East Shewa Zone. However, efforts to increase agricultural productivity with the help of irrigation, improved varieties, chemical fertilizers, better management practices and other agricultural inputs will only be possible if the project is supported by research on the soil and irrigation water qualities in order to practice effective control of soil salinity. Information on the physical and chemical composition of soils and quality of waters used for irrigation are essential for planning and implementing reclamation programmes in a timely and cost-effective manner that allows sustained crop production and promotes sustainable land use.

Even though white salt crust and shiny black soil surfaces are easily observable in the field, except for a few preliminary surveys on soil fertility, the irrigated lands in Fantale District have not been studied and as such there is a lack of baseline data and scientific information on the salt status of the soils and irrigation water. Therefore, knowledge about the status of the soil quality indicators and soil physicochemical properties and irrigation water quality, types and distribution of the salinity- and sodicity-related problems of the soils are required for sustainable land use of the area.

Objectives

Therefore, the objectives of the study were to:

- Characterize and classify the irrigated soils of Fantale District based on the existing salinity and/or sodicity status;
- Evaluate and classify the irrigation water quality based on its suitability for irrigation; and

- propose a way to manage salinity- and/or sodicity-induced land degradation (soil and water) in the study area.

Materials and methods

Description of the study area

Geographically, the study area is located in Fantale District, East Shewa Zone of Oromia Regional State (Figure 1), in the Great Rift Valley of Ethiopia, which is about 190 km east of Addis Ababa. Specifically, the study site is found at the Fantale Irrigation Project Farm at the western part of Lake Basaka and Matahara town (the capital of Fantale District) lying between 585320 - 589923 UTM easting and 963581 - 981706 UTM northing coordinating points (Figure 2). The area lies on altitude ranging from 950 metres above sea level (m.a.s.l.) at Lake Basaka to 1,900 m.a.s.l. at Fantale Mountain. .

According to data obtained from the Fantale District Land Administration and Environmental Protection Office (2009) and Dinka (2010), the climate of the area is characterized as semi-arid, with an annual mean temperature of about 25 OC (Figure 3 and Appendix Table 1). The area is also characterized by a long dry period and short rain season, where the evapotranspiration (ET) always exceeds the rainfall amount, except in July and August. The mean annual rainfall of the area is 553 mm (Figure 3 and Appendix Table 1). Rain-fed agriculture is unreliable for crop production in the area because of the insufficient amount of rainfall and its erratic distribution. Hence, irrigation has become an important agricultural activity.

As the site is situated in the central Rift Valley region, it is vulnerable to the occurrences of different tectonic and volcanic activities. As a result, the area is characterized with features of past and recent volcanic events, which is evident from the observation of vast lava extrusions at the foot slope of mountain Fantale and dots of extensive scoriceous hills in the locality (Mohr, 1971), as cited by Abejehu (1993).

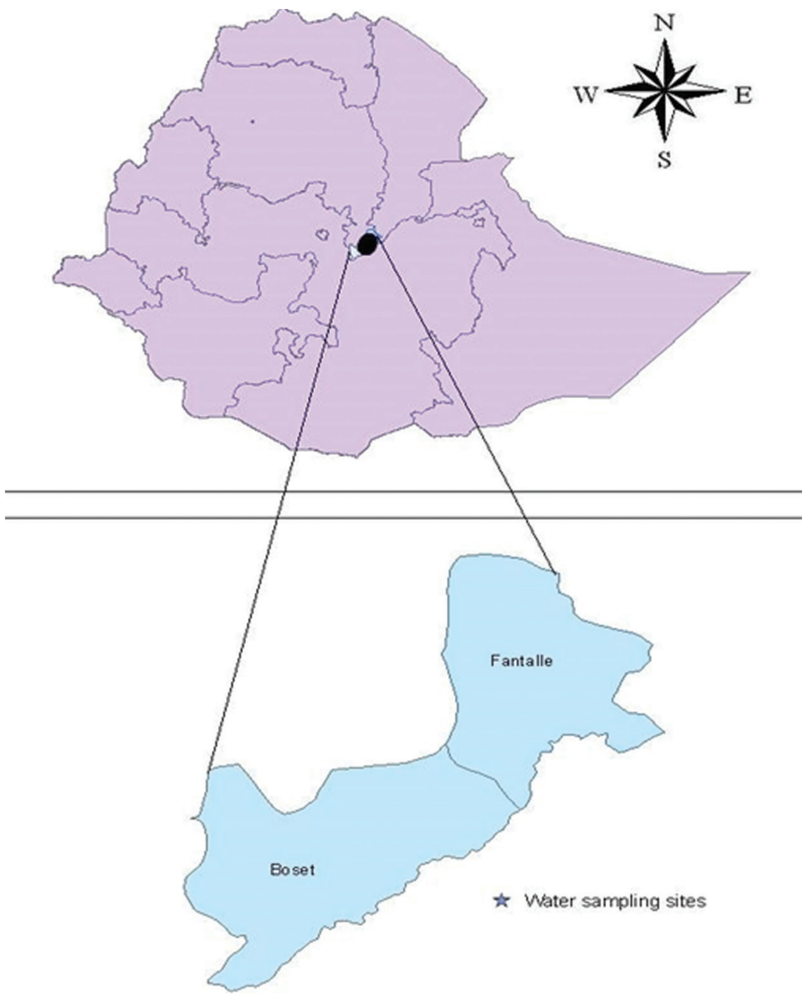

Figure 1. Map of the study area

The dominant soil type of the study area is Andosols and its parent material may be grouped as volcanic materials and skeletal soils of recent alluvial and colluvial deposits. In the site, there are accumulations of medium to very coarse textured volcanic rocks and also accumulated in the underlying soil under the conditions where the soils moved down from hills and are deposited on the rocky land surfaces.

Until recent years, the land was used only for communal grazing and the communities' lifestyle was pastoralist. However, at present, communities are becoming agropastoralists, with different crop production activities being practiced using irrigation along with rearing animals. This is mainly through different development initiatives being undertaken in the district, like the Fantale Irrigation Based Development Project. The Fantale District Irrigation Based Development Project was planned to cover a total of 18,000 ha of land, which was expected to feed 36,000 households, and currently about 1,000 ha of land is irrigated. According to the information obtained from the local community and field observations, the natural vegetation of the area includes different types of acacia trees, bushes and different grasses. However, recently, invasive plant species, such as Prosopis juliflora and Partineum, are invading the study site.

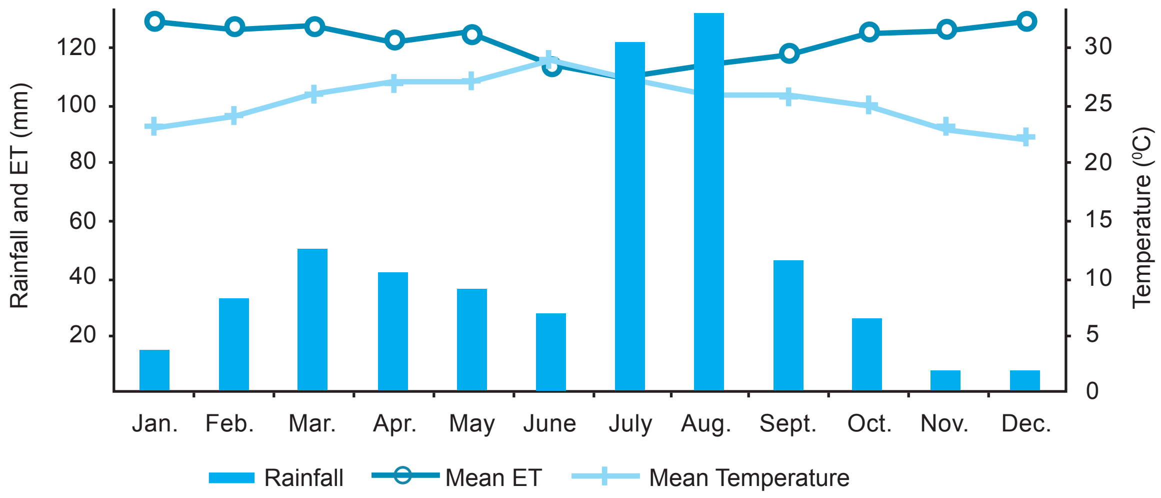

Figure 3. Mean monthly rainfall, ET and temperature of Matahara areas Source: Dinka, 2010.

Site selection, soil and irrigation water sampling

Site selection

General reconnaissance surveys and field observations were carried out to determine the representative sampling sites of the study, of which four representative soil profile sampling sites were selected and one profile was opened for each. The sampling site selection was done on the basis of site history of irrigated and non-irrigated lands, white salt crust formation on land surface (an indicator of saline soil), shining black crust soils on land surface (an indicator of sodic soil), vegetation type (salinity and sodicity loving plant species or halophytic plants), surface drainage condition (which naturally hold water) and crop stand status. Accordingly, Profiles 1 and 3 represent irrigated land with white salt crust appearances on the land surface at Mel-dhiba and Nukusa sites, respectively (Appendix Table 2). Profile 2 was selected for irrigated land with very poor crop stand, poor drainage conditions and shiny black soil surfaces, while Profile 4 was opened on a grazing land with no history of irrigation and cultivation as a control at Nukusa site.

Soil sampling

After site selection, soil profiles were opened on sites where indicators of the problems were seen during field observation (Appendix Table 2). For this study, soil samples were collected from four freshly opened soil profiles which were excavated to a depth of 2 metres, with 1.5 metres width and 1.5 metres length. Soil samples were collected from each horizon or layer depth-wise to determine selected soil physical and chemical properties in the laboratory. That is, the profiles were divided into their soil layers according to the evidence of pedogenic horizon development when applicable and to sampling layers where genetic horizons were not evident. Sampling and field description of the layers were made based on the guidelines for soil description (FAO, 2006), while soil colour was interpreted using the Munsell Color Chart (Munsell Color Company, 1975).

Irrigation water sampling

As the source of irrigation water was Awash River, water samples were taken from the Awash River and the main canal. Five water samples were collected during the dry season in early December 2010. A sample was collected from the Awash River at the diversion weir and the other four from the main canal diverted from the Awash River at 10, 20, 30 and 40 kilometre distances from the diversion weir (Appendix Table 3). The collecting, handling and analysis of the irrigation water samples were done according to the procedures outlined by the US Salinity Laboratory Staff (1954).

Soil and water analysis

Analysis of soil physical properties

The soil samples were air dried, ground and sieved through a 2 mm sieve and made ready for laboratory analysis. Soil physical properties, particle size distribution, particle density and bulk density were analysed, and from their results total porosity was calculated. Particle size distribution was analysed by the Bouyoucos hydrometer method using sodium hexametaphosphate as a dispersing agent as described by Sertsu and Bekele (2000). Soil particle density was estimated by the pycnometer method (Blake, 1965), while bulk density was determined on undisturbed soil samples following the core method. Finally, total porosity was calculated from the values of bulk density (ρb) and particle density (ρs) as:

Total Porosity (%)=

$$[1-(\frac{\rho_b}{\rho_s})]x100$$

Analysis of soil chemical properties

The soil chemical properties analysed include pH, ECe, basic exchangeable cations (Ca, Mg, Na and K), CEC, exchangeable acidity, soluble cations (Ca2+, Mg2+, Na+ and K+), soluble anions (Cl-, SO42-, HCO3-, CO32- and B). These parameters were analysed following their respective procedures as stated by Wolg (1971), Sertsu and Bekele (2000), Reeuwijk (2002) and from these values, sodium adsorption ration (SAR), residual sodium carbonate (RSC), percent base saturation (PBS) and exchangeable sodium percentage (ESP) were calculated.

Finally, the soils of the study site were classified into different salt-affected soil types and boron toxicity levels according to the criteria set by the US Salinity Laboratory Staff (1954) provided in Appendix Tables 4 and 5.

Analysis of irrigation water

Parameters like pH, EC, dissolved cations (Na+, Ca2+, Mg2+ and K+) and anions (Cl-, SO42-, HCO3- and CO32-) were analysed according to the specific methods described by Reeuwijk (2002).

At last, classification of the studied irrigation water was done based on salinity (EC), SAR, RSC and boron content in accordance with the criteria (Appendix Tables 6 and 7) established by the US Salinity Laboratory Staff (1954).

Key findings and discussion

Soil physical properties

Particle size distribution

The particle size distribution analysis revealed that sand was the dominant fraction in all of the soil profiles studied. This was followed by silt and clay fractions, in that order, although the distribution did not follow any consistent pattern with soil depth (Table 1). Accordingly, both the surface and the subsurface soils of Profiles 3 and 4 were dominated by sandy loam, while Profiles 1 and 2 were loam at the surface but sandy loam was dominant in the subsurface soils of Profile 2.

The possible reason for the pre-dominance of sand could be due to the young parent material deposited by erosion (alluvial/colluvial parent materials) and the removal of finer soil particles from the land surfaces by wind. In line with this, Abebe (1998) and Zewdie (2004) have also reported that the soils in the Rift Valley areas were highly eroded by wind during dry seasons because of their low structural stability, weak coherence, low bulk density and low moisture retaining capacity. The variation in particle size distributions within the soil depth were due to the recently deposited alluvial soil parent materials from which the soils have been developed. This indicated the presence of lithological discontinuity within the soil profile and was confirmed by the findings of other studies on soils of the Melka Sedi-Amibara plain of the Ethiopian Rift Valley (Gebrekidan, 1985). In addition, Fasika (2006) and Hailu (2009) observed a similar phenomenon in soils of the Southern Rift Valley of Ethiopia and the Dirma Irrigation Project at Dessie Zuria and Kalu Districts, respectively.

Soil densities and total porosity

The particle density ranged from 2.09 at the surface layer of Profile 1 to 2.85 g cm-3 at 74 -121 cm depth of Profile 3, while bulk density ranged from 1.02 at the surface layer of Profile 1 to 1.57 g cm-3 at the surface layer of Profile 2 (Table 1). However, the lowest (37.9 percent) and highest (58.8 percent) total porosity values were recorded at the surface layer of Profile 2 and at the bottom (121-160 cm) layer of Profile 3, respectively. In Profiles 1, 2 and 3, bulk density, particle density and the total porosity showed increasing trends regularly with the soil depth, respectively. While in the other profiles, they did not show a consistent relationship with depth up to the bottom layer due to the presence of lithological discontinuity similar to the particle size distribution.

According to Foth (1990), soils without structure, such as single grained and massive soils, have a bulk density of about 1.6 to 1.7 g cm-3. In relation to this, with its massive soil structure and bulk density of 1.57 g cm-3, the surface soil of Profile 2 could be considered as within the normal range. In addition, the possible reason for the highest bulk density at the surface soil of Profile 2 could be ascribed to high compaction and surface crusting due to cementing effects of calcium carbonate which resulted in less pore spaces. As a result, the lowest total porosity was recorded in the same layer as these are inversely related to each other. As a whole, the total porosities of the profiles were almost within the normal range, though lower from Profile 2 (Foth, 1990). According to Singleton et al. (1999), the particle density of soils containing allophane was small as it consists of hollow spheres. Based on the report of the same author, the volcanic soils of New Zealand containing allophone were characterized by particle density values ranging from 2.05 to 2.27 g cm-3 in the surface layer. In line with this, the minimum particle density value (2.09 g cm-3) recorded in the surface soil of Profile 1 in this study was within this range, most probably due to the same reason as to why volcanic ash soil parent materials dominated the study area.

Table 1. Some physical properties of the soils at the Fantale Irrigation Project site

Depth (cm)	Particle size distribution (%)			Textural class	Particle density (g cm-3)	Bulk density (g cm-3)	Total porosity (%)
	Sand	Silt	Clay				
Profile 1: Irrigated maize field with white salt crust on the surface at Mel-dhiba							
0-29	43.52	38.40	18.08	Loam	2.09	1.02	52.2
29-65	34.88	39.00	26.12	Loam	2.56	1.13	55.9
65-129	54.12	35.60	10.28	Sandy loam	2.69	1.25	57.6
129-183	45.48	38.20	16.32	Loam	2.65	1.31	50.6
Profile 2: Irrigated maize field with poor stand showing shiny black surface at Nukusa							
0-25	47.84	42.04	10.12	Loam	2.53	1.57	37.9
25-60	71.60	18.28	10.12	Sandy loam	2.73	1.49	45.4
60-94	67.28	24.60	8.12	Sandy loam	2.70	1.43	51.9
Profile 3: Irrigated maize field with white salt crust on the surface at Nukusa							
0-30	73.76	14.10	12.14	Sandy loam	2.54	1.18	53.5
30-74	60.80	29.10	10.10	Sandy loam	2.66	1.23	53.8
74-121	50.00	35.70	14.30	Loam	2.85	1.28	55.1
121-160	71.55	16.30	12.15	Sandy loam	2.67	1.10	58.8
Profile 4: Un-irrigated/uncultivated field/grazing land at Nukusa							
0-32	54.32	29.60	16.08	Sandy loam	2.63	1.31	50.2
32-69	71.60	18.70	9.70	Sandy loam	2.52	1.33	47.2
69-108	67.28	22.40	10.32	Sandy loam	2.56	1.25	51.2
108-151	68.20	21.58	10.22	Sandy loam	2.73	1.34	50.9
151-200	60.80	25.10	14.10	Sandy loam	2.69	1.22	54.6

Soil chemical properties

Soluble chemical properties

Maize field with white salt crust surface at Mel-dhiba (Profile 1)

The pH values of this field (Profile 1) ranged from 7.5 at the surface to 7.7 in the subsurface layers showing a slightly increasing trend down the profile (Table 2). According to the rating by Murphy (1968), the soil could be classified as slightly alkaline in reaction.

The ECe decreased from 45.5 at the surface to 28.00 dS m-1 in the subsurface. This indicates that the upward movement (capillary) of salt is much more than the downward (leaching) and the surface soil contained more salts than the underlying layers. It is also reported that surface salinity is a common problem in arid and semi-arid areas, due to evaporation of water from the soil surface and subsequent accumulation of salt over time (FAO, 1988; Rengasamy, 2006). Therefore, having the ECe >15 dS m-1 at surface soil, the site represented by Profile 1 was characterized as very strongly saline.

In the surface soil, Ca2+ was the pre-dominant cation followed by Na+. However, the concentration of Ca2+ decreased dramatically from 64.89 at the surface to 3.33 mmolc l-1 at the bottom layer (129-183 cm) where Na+ was pre-dominant (Table 2). On the other hand, Cl- was the highest among the anions throughout the profile followed by HCO3- and SO42-, with consistent decreases with soil depth above 129 cm depth. The SAR also followed the pattern of soluble Na+ and increased in the subsurface from 3.79 at 25-65 cm to 15.26 at the bottom layer consistently with the soil depth.

The highest concentrations of soluble cations and anions were found at the surface layer of the profile (0-29 cm) which resulted in high salt concentration. Hence, as the ions of Ca2+, Na+, Cl-, HCO3- and SO42- were present in high concentrations, chloride, bicarbonate and sulphate salts of sodium and calcium were the major contributors to the salinity development in the soils represented by this Profile. However, in the bottom subsoil layer, in line with the high pH value, the highest values of soluble Na+, HCO3-, RSC and SAR were recorded. Fasika (2006) also reported similar ions distribution patterns in his study on the soils of Alage ATVET College Campus in the southern Rift Valley of Ethiopia.

The concentration of B in the Profile increased from 0.419 at the surface to 1.214 mg l-1 at the bottom layer (129-183 cm) which was the maximum B concentration for the soils in the study site (Table 2). According to the B hazard classification criteria set by the US Salinity Laboratory Staff (1954), the surface soil was categorized as safe from B toxicity for most sensitive plants. However, the concentration in the subsoil revealed that appropriate management practices and care must be exercised to minimize its build up to the surface soil, as B imposes its toxicity effect on plant physiological processes.

Poor maize stand field with shiny black surface at Nukusa (Profile 2)

In the field supporting a poor maize stand and showing a shiny black surface (Profile 2), soil pH decreased gradually from 8.6 at the surface layer (0-25 cm) to 7.9 at the bottom layer (60-94 cm) (Table 2). According to the classification of soil reaction by Murphy (1968), the soils of this farmland were strongly alkaline at the surface and moderately alkaline at the underlying subsoil layers (25-94 cm depth).

The ECe ranged from 0.63 dS m-1 at the surface horizon to 3.00 dS m-1 at the bottom (60-94 cm) and increased linearly with depth contrary to the pH value (Table 2). Unlike in Profile 1, less accumulation of soluble salts were observed at the surface soil of this profile. This implies, leaching of salts dominated over the upward (capillary) movement. In the other words, the soluble salts have been moving from the surface down to the lower depths on account of irrigation water applied in excess of soil pore spaces. The result was in agreement with the findings of Sunitha et al. (2010) on soils of Dodda Seebi command area in India.

The predominant soluble cation was Na+ throughout the profile, followed by K+ at the surface and Ca2+ at the subsurface layers (25-94 cm). Similar to the ECe, but contrary to the pH values of the profile, the concentration of soluble Ca2+ increased linearly from 0.15 at the surface soil to 4.35 mmolc l-1 at the bottom subsurface layer with soil depth (Table 2).This is in agreement with the research findings of Birchall et al. (1995), Chorom and Rengasamy (1997) and Busaidi and Cookson (2003) who observed a negative association between soluble Ca2+ ion concentration and soil pH and a positive association with soil salinity. Among the anions, HCO3- was the predominant, followed by CO32- at the surface and SO42- at the subsurface layers. In line with the pH values, the concentration of HCO3- decreased consistently down the soil depth from 13.02 mmolc l-1 at the surface layer to 7.40 mmolc l-1 at the bottom layer of the subsurface (Table 2). Similarly, the maximum values of SAR (27.44) and RSC (13.37) were recorded in the topsoil, while RSC decreased consistently with depth to 1.82 mmolc l-1 at the bottom layer.

In general, the soluble bicarbonate and carbonate salts of sodium were the predominant salts contributing to the salinity problem in the soils represented by Profile 2, which was also similar to the findings of Hailay et al. (2000) on soils of the Abaya State Farm in the southern Rift Valley of Ethiopia. Furthermore, the surface soil was compacted due to the dispersion effects of Na+. As a result, less permeability of water, poor root depth and stunted maize growth were observed in the field. In addition, as the pH increased the concentration of Ca2+ and Mg2+ in the soil solution was reduced due to the formation of relatively insoluble calcium and magnesium carbonates by reaction with soluble carbonate of sodium (Warrence et al., 2002; Qadir et al., 2007b). This in turn results in their deficiency for plant growth. The solubility and availability of other essential elements like Fe, Mn and Zn could be also negatively affected.

Table 2. Soluble chemical composition of the soil profiles at Fantale Irrigation Project site in the Middle Awash Valley, Ethiopia

Depth (cm)	pH	ECe (dS m-1) at 25 °C	Soluble cations (mmol$_c$ l^{-1})				SAR	Soluble anions (mmol$_c$ l^{-1})					B (mg l-1)
			Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}		CO3-	HCO3-	Cl-	SO4-	RSC	
Profile 1: Irrigated maize field with white salt crust on the surface at Mel-dhiba													
0-29	7.5	45.50	64.89	2.60	27.65	1.36	4.77	trace	8.70	105.62	2.86	trace	0.419
29-65	7.5	28.00	16.59	0.95	11.22	1.04	3.79	trace	9.57	62.11	2.20	trace	0.422
65-129	7.7	28.00	8.22	0.86	14.46	0.83	6.79	trace	6.46	49.10	3.18	trace	0.802
129-183	7.7	28.00	3.33	0.55	21.21	0.73	15.26	trace	9.55	66.86	2.66	5.61	1.214
Profile 2: Irrigate field with poor maize stand showing shiny black surfaces at Nukusa													
0-25	8.6	0.63	0.15	0.19	11.25	0.47	27.44	0.74	13.02	0.66	0.25	13.37	0.325
25-60	8.2	1.81	1.83	0.34	6.46	0.32	6.21	0.92	10.19	0.67	1.43	8.94	0.274
60-94	7.9	3.00	4.35	0.98	11.66	0.23	7.15	trace	7.40	0.84	1.58	1.82	0.262
Profile 3: Irrigated maize field with white salt crust on the surface at Nukusa													
0-30	7.4	30.50	18.69	1.06	6.38	0.60	2.03	trace	6.93	64.07	1.65	trace	0.286
30-74	7.6	8.76	3.66	0.34	2.79	0.33	1.98	trace	2.57	14.89	1.41	trace	0.521
74-121	7.7	6.40	0.63	0.08	2.55	0.28	4.32	trace	3.80	9.93	1.53	3.09	0.360
121-160	8.7	8.03	0.01	0.01	1.98	0.22	19.80	0.85	4.10	6.15	0.85	4.93	0.824
Profile 4: Un-irrigated cultivated field/grazing land at Nukusa													
0-32	7.5	2.00	0.86	0.12	0.71	0.38	1.01	trace	6.91	0.52	1.03	5.93	0.439
32-69	7.8	5.82	4.69	0.47	0.55	0.38	0.34	trace	9.67	2.17	1.73	4.51	0.278
69-108	7.8	5.80	3.43	0.41	0.41	0.24	0.30	trace	6.33	2.59	1.14	2.49	0.276
108-151	7.8	4.30	1.43	0.23	0.54	0.23	0.59	trace	2.60	2.28	0.81	0.94	0.310
151-200	7.6	4.93	0.22	0.35	1.44	0.31	2.72	trace	4.43	4.40	0.97	3.86	0.353

ECe = electrical conductivity of saturated paste extract; SAR = sodium adsorption ratio; RSC = residual sodium carbonate

Unlike in Profile 1, the concentration of B in Profile 2 decreased regularly from 0.32 at the surface to 0.26 mg l-1 at the bottom depth (60-94 cm) (Table 2). These values were within the safe range (< 0.7 mg l-1) for most sensitive plants with regards to boron toxicity levels (US Salinity Laboratory Staff, 1954) as provided in Appendix Table 5.

Maize field with white salt crust surface at Nukusa (Profile 3)

The pH of the maize field with white salt crust surface (Profile 3) increased consistently with depth from 7.4 at the surface layer (0-30 cm) to 8.7 at the bottom layer (121-160 cm) (Table 2). According to the soil reaction levels for Ethiopian soils as indicated by Murphy (1968), the top soil of the profile was categorized as slightly alkaline, while the subsurface soils qualified for a moderate to strong alkalinity level.

However, the ECe of the soil showed a decreasing trend irregularly with depth, with the highest value (30.50dS m-1) at the surface layer of the profile. Like in Profile 1, the surface soil of this profile was also characterized by a higher concentration of soluble salts than the underlying subsurface layers as a result of capillary and evapotranspiration. Hence, the root zone was more likely to be influenced by salinity impacts as it lowers the osmotic potential of crops as described by Rengasamy (2010).

In soluble cation composition, the surface layer was dominated by soluble Ca2+ (18.69 mmolc l-1) followed by soluble Na+ (6.38 mmolc l-1), while their concentrations decreased consistently down the profile depth (Table 2). At the extreme bottom depth (121-160 cm), the soluble Na+ was dominating, in which the highest pH (8.7) and SAR (19.80) values were recorded in line with the availability of CO32-and RSC. Among the anions, Cl- was the dominant ion in the profile followed by HCO3- and SO42-.

Generally, the topsoil of this profile was characterized by a high concentration of soluble Ca2+, Cl- and HCO3-, while the extreme bottom of the subsurface layer was characterized by high Na+, Cl- and HCO3- concentrations. Therefore, the chloride and bicarbonate salts of sodium and calcium were the major salts contributing to the salinity problem in the soil represented by Profile 3, which was almost a similar phenomenon with that of Profile 1.

As in Profile 1, the concentration of B increased (variably) from 0.286 at the surface soil to 0.824 mg l-1 at the bottom of the subsurface layer. Therefore, the surface soil was safe for the most sensitive plants from B toxicity, however, the subsurface soil was marginal (US Salinity Laboratory Staff, 1954) as described in Appendix Table 5. Hence, remedial actions should be practiced to prevent the underlying subsurface soils coming to the surface.

Uncultivated field/grazing land at Nukusa (Profile 4)

The surface layer of Profile 4 had a pH value of 7.5 and an ECe value of 2.00 dS m-1 (Table 2). Even though the results showed increasing trends for both parameters, they did not show a consistent relationship with the soil depth. Therefore, the surface layer of this profile was categorized as slightly alkaline based on the classification of soil reaction set by Murphy (1968) and slightly saline in its soluble salt concentration, while moderately saline at the subsurface soil horizon (FAO, 1988).

Although the site of Profile 4 was not irrigated, its subsurface soil layers were categorized as saline soil. This indicated that although irrigation accelerates the development of salt-affected soil, the study area was naturally saline, which may be due to the salt rich soil parent materials and their deposition coming down from its surrounding upper areas by runoff combined with climatic effects. Similar factors were described by Yohannes (2010) as the major causes for the development of salinity and sodicity problem in some soils of the Dupti area in the lower Awash Valley of Ethiopia. Knowing the basic natural condition of irrigation sites is important to adopt appropriate management practices to cope up with salt impacts as a result of irrigation interventions on the soil environment (Shahid et al., 2009a). Therefore, reducing evaporation from the soil surface, selecting appropriate crops and irrigation methods and efficient use of the irrigation water need great attention at the site.

At the surface soil layer, the soluble Ca2+ was the dominant cation followed by Na+. But the extreme bottom layer of the subsurface soil layer (151-200 cm) was dominated by soluble Na+ (1.44mmolc l-1) like in the other three profiles (Table 2). Their concentrations did not follow a consistent relationship with the soil depth. Among the anions, HCO3- was the most dominant throughout the profile, followed by Cl- and SO42-. Therefore, having high (5.93mmolc l-1) values of RSC, the surface layer was dominated by Ca2+, HCO3- and SO42-ions, while ions of Na+, HCO3-and Cl- were more concentrated at the extreme bottom of the subsurface layer. As a whole, having high concentrations of Ca2+, Na+, HCO3- and Cl- ions throughout the profile depth, chloride and bicarbonate salts of sodium and calcium were the major constituents contributing to the salinity development in the soil of the grazing land which was almost similar to the soils of Profiles 1 and 3.

The B concentration ranged from 0.276 at the subsurface soil to 0.439 mg l-1 at the surface without any trend with soil depth (Table 2). The B concentration was <0.7 mg l-1 (class 1) that represented a safe level for the most sensitive plants from boron toxicity (US Salinity Laboratory Staff 1954), as provided in Appendix Table 5.

Exchangeable cations and cation exchange capacity

Maize field with white salt crust surface at Mel-dhiba (Profile 1)

Calcium was the dominant exchangeable cation followed by Na, Mg and K in the exchange site of the surface layer of the irrigated maize field with white salt crust surface appearances (Profile 1) (Table 3). The concentration of exchangeable Ca decreased linearly from 32.61 at the surface soil layer to 21.02 cmolc kg-1 at the bottom of the subsurface soil layer (129-183 cm), while Na increased from 8.74 to 11.03 cmolc kg-1 in same layers with the soil depth. This was in agreement with previous findings on the soils of the Alage ATVET College Campus in the southern Rift Valley of Ethiopia (Fasika, 2006). Due to the absence of soluble CO32- in the soil solution throughout the profile, more Ca was adsorbed in the soil exchange site. This resulted in the dominancy of Ca over the other cations both in the surface and subsurface layers of the soil exchange site. Similar findings were also explained by Gebrekidan (1985) and Fasika (2006) on soils of the Melka Sedi-Amibara plain and the Alage ATVET College Campus of the Ethiopian Rift Valley, respectively.

The CEC ranged from 41.10 at the surface soil layer to 42.23 cmolc kg-1 at the bottom of the subsurface soil layer which was dominated by exchangeable Ca (Table 3). As described by Brady and Weil (2002), CEC of a mineral soil ranges from a minimum of 2 cmolc kg-1 in sandy soil up to a maximum of 60 cmolc kg-1 in clay soil. Therefore, having a loam textural class, the CEC value obtained (41.10-42.23 cmolc kg-1) was within the normal range for mineral soils. Furthermore, the CEC recorded for the soil was high, which means that the soil has resistance to changes in the soil chemical composition that are caused by land use systems (Hazelton and Murphy, 2007).

The value of ESP was> 20 percent throughout the profile and variably in increasing order down the soil depth. These values followed the trends of Na values both at the surface soil layer as well as at the subsurface soil layer which was also observed on soils of Dodda Seebi command area in India (Sunitha et al., 2010). According to Horneck et al. (2007), soils with >15 percent ESP have a high sodicity risk due to the effects of Na on soil structure and toxicity to crops. Accordingly, the soils represented by this profile were characterized by sodicity hazards. Furthermore, there was a high (> 100 percent) value of PBS in the profile. The PBS high value could be associated with a high exchangeable calcium content as it was extracted by ammonium acetate which dissolves CaCO3 and probably exaggerates the Ca concentration of the exchange site. Based on the ratings given by Hazelton and Murphy (2007), the recorded PBS values were very high. This indicated that the exchange site was saturated by exchangeable bases with a very weak leaching effect.

Poor maize stand field with shiny black surface at Nukusa (Profile 2)

Unlike in Profile 1, Na was the dominant cation at the surface soil layer of Profile 2 followed by Ca (Table 3). The high exchangeable Na was accompanied by the high value of soluble Na+ in the soil solution, specifically at the surface soil. Such Na saturated soils had also been reported to occur at the Melka Sedi-Amibara plain (Gebrekidan, 1985) and Matahara Sugar Estate (Abejehu, 1993) in the Middle Awash Valley of Ethiopia. But, in this study high exchangeable Ca and Mg were recorded for the subsurface soil layers with a consistent increasing trend with the soil depth accompanied by a decrease in exchangeable Na.

The value of CEC was high (35.41cmolc kg-1) at the surface soils with no regular pattern with the soil depth. Therefore, the surface soil of this profile had moderate to high adsorbed cations with the dominance of monovalent over the divalent cations (Hazelton and Murphy, 2007).

The surface soil was also characterized by a high (35.61 percent) value of ESP which decreased consistently with the soil depth. As the ESP mainly depends on exchangeable Na content, it followed more or less the same trend with exchangeable Na, as was also pointed out by Sunitha et al. (2010) for the soils of the Dodda Seebi command area in India.

Moreover, soils with >15 percent ESP have a high sodicity risk due to the effects of Na on soil structure and toxicity to crops (Horneck et al., 2007). Hence, the soil of this profile was characterized by high sodicity hazards, especially in the surface layer. This may explain the compaction and cementing effects on soil structure that were observed due to the excessive Na and its associated impacts as described under morphological and physical properties. In relation to this, Mamedov et al. (2001) also explained that because of their moderate stability of the soil aggregates, loam soils are most susceptible to surface sealing as a result of high ESP impacts. Like in Profile 1, there was also high (> 100 percent) PBS in this soil profile indicating that the exchangeable site was saturated with the basic exchangeable cations indicating very low leaching.

Table 3. Exchangeable chemical composition of soils of the Fantale Irrigation Project site in the Middle Awash Valley, Ethiopia

Soil depth (cm)	Exchangeable basic cations, CEC and exchangeable acidity ($cmol_c\ kg^{-1}$)*							
	Ca	Mg	Na	K	Exchangeable acidity (Al + H)	CEC	ESP	PBS
Profile 1: Irrigated maize field with white salt crust on the surface at Mel-dhiba								
0-29	32.61	3.21	8.74	2.53	0.12	41.10	21.26	114.54
29-65	29.31	3.01	9.22	3.61	0.01	42.12	20.49	100.33
65-129	28.00	2.02	10.61	3.05	Trace	40.61	26.13	107.56
129-183	21.02	3.34	11.03	7.04	Trace	42.23	26.12	100.47
Profile 2: Irrigated field with poor maize stand showing shiny black surface at Nukusa								
0-25	11.24	1.48	12.61	2.18	Trace	35.41	35.61	105.93
25-60	23.55	5.81	1.59	2.71	Trace	33.37	4.76	100.87
60-94	25.38	8.69	1.56	2.24	0.08	34.60	4.51	109.45
Profile 3: Irrigated maize field with white salt crust on the surface at Nukusa								
0-30	23.39	2.51	4.64	3.76	0.10	30.10	15.42	113.45
30-74	34.19	3.67	4.69	4.58	0.10	42.27	11.20	111.49
74-121	30.14	2.31	5.49	5.70	0.03	40.80	13.45	106.96
121-160	27.59	1.61	11.18	6.59	Trace	41.04	27.26	114.56
Profile 4: Un-irrigated/uncultivated field/grazing land at Nukusa								
0-32	30.60	3.30	0.65	7.81	0.08	37.51	1.73	112.96
32-69	37.38	4.78	0.94	1.45	0.10	39.25	2.40	113.64
69-108	35.18	4.41	0.88	2.80	0.12	37.00	2.38	116.95
108-151	32.75	5.15	0.98	3.16	0.07	36.42	2.69	115.49
151-200	30.98	5.03	1.99	3.51	0.09	37.45	5.32	110.84

*CEC = cation exchange capacity; ESP = exchangeable sodium percentage; PBS = percent base saturation

Maize field with white salt crust surface at Nukusa (Profile 3)

In the irrigated maize field with white salt crust appearance on the surface soil at Nukusa (Profile 3), the exchange site was dominated by exchangeable Ca followed by Na, K and Mg, in that order (Table 3). Though Ca and Mg showed variability, Na and K increased consistently with the depth.

The CEC value was relatively lower (30.10 cmolc kg-1) for surface soils and higher (42.27 cmolc kg-1) for the subsurface (30-74 cm) soils. This indicated that the topsoil had less resistance capacity to chemical changes than the underlying subsurface soil layers. Throughout the soil profile, the values of CEC showed an inconsistent relationship with the soil depth as a result of the lithological discontinuity among the layers. Also, a similar finding was reported by Hailu (2009) on soils irrigated by waters from the Dirma River and groundwater sources in the south Wello Zone of the Amhara Regional State.

The surface soil contained 15.42 percent ESP which was high enough to negatively affect the soil profiles and plant growth (US Salinity Laboratory Staff, 1954; Horneck et al., 2007) and invariably showed increasing trends with depth from the second layer to the bottom layer. The ESP value followed the trend of Na values in the subsurface layers. Like in Profiles 1 and 2, high (> 100 percent) saturation with basic cations was also recorded in this profile, indicating that the exchange complex of the soils was saturated by exchangeable bases (Hazelton and Murphy, 2007).

Un-irrigated/uncultivated field/ grazing land at Nukusa (Profile 4)

Calcium was the dominant exchangeable cation at the surface soil layer of the un-irrigated and/or uncultivated land followed by Mg, K and Na. Their values were variable with the soil depth. The value of exchangeable acidity ranged from 0.08 at the surface to 0.12 cmolc kg-1 in the subsurface (69-108 cm) and showed no evidence of relationship with soil depth.

The CEC of the soil at the surface layer was 37.51 cmolc kg-1 and showed no consistent trend with the soil depth. Like in Profiles 1 and 3, the CEC of soils represented by this profile was controlled by high exchangeable Ca on the exchange complex. According to Hazelton and Murphy (2007), the CEC of this soil was rated as high.

The ESP ranged from 1.73 at the surface soil layer to 5.32 percent at the bottom of the subsurface (151-200 cm) layer and varied in an increasing trend with soil profile depth. According to the US Salinity Laboratory Staff (1954) and Horneck et al. (2007), the soil of this profile was characterized by less sodicity hazards. Like in the other three profiles (Profiles 1, 2 and 3), high (> 100 percent) PBS was recorded in this profile indicating the presence of a very low leaching effect.

Generally, in all of the soils of the study area and across soil depth, except at the surface soil of Profile 2, Ca was the dominant cation in the exchange complex followed by Na. The high PBS of the soils could be attributed to high exchangeable Ca content as well as preferential and stronger adsorption of the divalent cation over monovalent cations (Na and K). On the other hand, exchangeable acidity ranged from 0.01 to 0.12 cmolc kg-1 and PBS > 100 percent were recorded throughout all the profiles and such conditions were described as they were within the normal ranges for soils of semi-arid and arid regions (Garg and Jain, 1996). Sunitha et al. (2010) had also reported similar findings for soils of the Dodda Seebi command area in India.

Soil classification based on its salinity and sodicity level

The soils of the study area were classified according to the criteria set by the US Salinity Laboratory Staff (1954) as indicated in Appendix Table 4. Accordingly, by considering the values of pH, ECe (dS m-1) at 25 oC and ESP, the irrigated maize field surface soils of Profiles 1 and 3 were classified as saline sodic, while the irrigated field (Profile 2) supporting poor (stunted) maize stand was sodic soil (Table 4). On the other hand, the surface soil of the un-irrigated/ uncultivated field/grazing land (Profile 4) was non-saline non-sodic soil, while the underlying (subsurface) soil layers were saline making the soil potentially saline.

Table 4. Classification of soils into salt-affected soil types based on relevant soil chemical properties of the surface soils

Profile No.	Chemical properties of the surface soils			
	*pHe	ECe (dS m-1)	ESP (%)	Classification
Profile 1	7.5	45.50	21.26	Saline sodic
Profile 2	8.6	0.63	35.61	Sodic
Profile 3	7.4	30.50	15.42	Saline sodic
Profile 4	7.5	2.00	1.73	None saline-none sodic

*pHe = soil reaction of saturated extract; ECe = electrical conductivity of saturated extract; ESP = exchangeable sodium percentage

The results obtained in the underlying layers (subsurface) of the uncultivated field indicate that although irrigation contributed to the development of salt-affected soil types in the area, it seems that there is also a natural potential salinity as a result of weathering of parent materials (volcanic ash materials naturally rich in salts and basic cations) and the accumulation of soluble salts coming down from the upper catchments through runoff water during the rainy seasons combined with climate effects (low rainfall and high evapotranspiration). Almost similar factors were described as the major causes for the development of salinity and sodicity problems in some soils of the Dubti area in the Lower Awash Valley of Ethiopia (Yohannes, 2010).

Chemical composition and classification of irrigation water

Chemical composition of irrigation water

The pH value of the irrigation water increased in the order of 7.79, 7.99, 8.14 and 8.20 for Awash River at the diversion weir to the main canal at 10, 20 and 30 km from diversion weir, respectively (Table 5). In line with this, the EC of the irrigation water also increased from 0.256 dS m-1 for the Awash River at the diversion weir to 0.274 dS m-1 for the main canal at 40 km distance from diversion weir. These pH and EC values clearly indicated that the irrigation water was moderately alkaline with increasing salt content along the main canal on the way to the irrigation site. The dominant ions in the irrigation water samples were dissolved HCO3- and Ca2+, followed by Na+. This indicated that bicarbonates of calcium and sodium ions were the dominant salts in the irrigation water which was in agreement with the findings of Alamirew (2002) on the Awash River water.

Similarly, the value of SAR ranged from 0.91 for the main canal at 20 km to 1.16 (highest value) for the main canal at 30 km from the diversion weir (Table 5). Thus, based on the criteria of the US Salinity Laboratory Staff (1954) depicted in Appendix Table 6, the irrigation water in use had a low sodicity hazard (Table 6). Moreover, the lowest RSC value (0.37 mmolc l-1) was recorded for the main canal at 20 km and the highest (0.77 mmolc l-1) was obtained for the main canal at 40 km from diversion weir (Table 5). The result revealed that the irrigation water was low (safe) in residual sodium carbonate hazard for all water samples that were below 1.25 mmolc l-1 (US Salinity Laboratory Staff (1954) (Appendix Table 6).

The concentration of B in the irrigation water ranged from 0.158 mg l-1 (minimum value at the diversion weir) to 0.200 mg l-1 (maximum value for the main canal at 40 km from the diversion weir) (Table 5). According to B toxicity levels indicated by the US Salinity Laboratory Staff (1954), the concentration of B in the irrigation water was below the threshold value of toxicity level for sensitive crops which was less than 0.33 mg l-1. This implies that the quality of the irrigation water was safe for irrigation purposes with regard to B toxicity (Table 5 and Appendix Table 7).

Classification of the irrigation water

Even though EC, SAR and RSC values were in increasing order, especially along the main canal to the irrigation site, all the water samples revealed that the irrigation water was medium in soluble salt concentration (salinity hazard), low in sodicity hazard and safe in residual sodium carbonate hazard (US Salinity Laboratory Staff, 1954) (Appendix Table 6). Therefore, the current suitability classes show that the water was of promising quality for irrigation purposes (Table 6). Similar findings were also reported for the Awash River water at the Melka Sedi-Amibara areas (Gebrekidan, 1985) and at the Matahara Sugar State Farm (Abejehu, 1993; Alamirew, 2002) in the Middle Awash Valley Ethiopia.

Table 5.Chemical composition of irrigation water samples of the Fantale Irrigation Project site in the Middle Awash Valley, Ethiopia

Sampling sites			Soluble cations ($mmol_c\ l^{-1}$)					Soluble anions ($mmolc\ l^{-1}$)					
	pH	EC ($dS\ m^{-1}$)	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	SAR	CO_3^{2-}	$HCO3^{-}$	Cl^{-}	SO_4^{2-}	RSC	B ($mg\ l^{-1}$)
Awash river at diversion weir	7.79	0.256	1.52	0.47	1.06	0.17	1.06	trace	2.52	0.67	trace	0.53	0.158
Mc, 10 km from the weir	7.99	0.259	1.40	0.43	0.87	0.16	0.92	trace	2.32	0.27	trace	0.49	0.164
Mc, 20 km from the weir	8.14	0.261	1.44	0.51	0.87	0.16	0.91	trace	2.32	0.27	0.01	0.37	0.211
Mc, 30 km from the weir	8.20	0.271	1.52	0.28	1.04	0.17	1.16	trace	2.56	0.29	0.05	0.76	0.162
Mc, 40 km from the weir	7.88	0.274	1.40	0.39	1.06	0.18	1.13	trace	2.56	0.30	0.20	0.77	0.200

Mc = main canal; EC = electrical conductivity; SAR = sodium adsorption ratio; RSC = residual sodium carbonate

Table 6. Suitability classes of the irrigation water samples

Sampling sites	EC ($dS\ m^{-1}$)	SAR	(RSC $mmolc\ l^{-1}$)	Salinity hazard	Sodicity hazard	RSC class
Awash river at diversion weir	0.256	1.06	0.53	Medium C2	Low S1	Safe
Main canal, 10 km from diversion weir	0.259	0.92	0.49	Medium C2	Low S1	Safe
Main canal, 20 km from diversion weir	0.261	0.91	0.37	Medium C2	Low S1	Safe
Main canal, 30 km from diversion weir	0.271	1.16	0.76	Medium C2	Low S1	Safe
Main canal, 40 km from diversion weir	0.274	1.13	0.77	Medium C2	Low S1	Safe

C2 = salinity class two; S1 = sodicity class one; RSC = residual sodium carbonate

Conclusions and recommendations

Conclusions

To sustain irrigated agriculture in arid and semi-arid areas where potential evapotranspiration exceeds rainfall, controlling salinity and sodicity levels of the irrigation site is an essential activity. Effective control of soil salinity requires better understanding on the extent, distribution and types of salts. This work focused on the recognition of the problem, by characterizing the physicochemical properties of the soils and irrigation water quality in relation to salinity and sodicity levels and suggested possible soil and water management options for the sustainable utilization and productivity of the irrigated land in the locality.

The results revealed that the surface soils of Profiles 1, 2, 3 and 4 were light gray, dark gray, pale brown and gray in colour (dry) and grayish brown, dark grayish brown, brown and dark gray (moist), respectively. Concerning particle size distribution, sand was dominant, followed by silt fraction with low clay content throughout the four profiles. Accordingly, the surface soils of Profiles 3 and 4 were sandy loam, while that of Profiles 1 and 2 were loam in texture. The bulk density values of the soils ranged from 1.02 to 1.57 g cm^{-3}, with total porosity values ranging from 37.9 percent to 58.8 percent. Due to the presence of lithological discontinuity, most of the soil physical properties showed variability in their total contents and/or distribution within the depths of the soil profiles.

Concerning the soil's chemical properties, the soil pH ranged from 7.4 to 8.7 qualifying for slightly to strongly alkaline in reaction, while the ECe at 25 oC ranged from 0.63 to 45.50 dS m^{-1}. Both in the soil solution and the exchange site (solid surfaces), Ca^{2+} and Na^{+} were the dominant cations whereas Cl^{-} and HCO_3^{-} were the dominant anions in almost all profiles. Accordingly, Ca^{2+} and Na^{+} salts of Cl^{-} and HCO_3^{-} were the major salts constituting the high to excessive salinity and sodicity levels observed in the soils of the study area. The ESP values for surface soils of Profiles 1, 2, 3 and 4 were 21.26, 35.61, 15.42 and 1.73 percent, respectively. In line with this, the dominance of Na^{+} and HCO_3^{-} and increments in pH values followed almost similar trends among the soil layers within a profile. The presence of CO_3^{2-} in measurable quantities also coincided with pH values in the alkaline range (pH values from 8.2–8.7). The rise in pH was attributed to the highest concentration of HCO_3^{-} and the subsequent increasing contents of residual Na_2CO_3. Therefore, having pH < 8.5, ECe > 4 dS m^{-1} and ESP > 15 percent in the surface, the soils of Profiles 1 and 3 were classified as saline sodic salt-affected soil type, while the soils of Profiles 2 and 4 were categorized as sodic and non-saline non-sodic soils, respectively. Although irrigation is likely to contribute to the development of the salt-affected soil types in the area, there is a very natural potential for development of salinity and sodicity as a result of weathering of parent materials and alluvial deposition of salt rich materials from the upper catchments combined with high aridity of climate and high evapotranspiration rates.

Concerning the irrigation water samples, the pH value ranged from 7.79 to 8.20 which qualified for moderately alkaline, and the EC ranged from 0.256 to 0.274 dS m^{-1}, indicating that the irrigation water is moderately saline. Both the pH and EC were increased with increasing sampling distance from the diversion weir along the main canal on the way to the irrigated farmland. The dominant anion and cation in the irrigation water were HCO_3^{-} and Ca^{2+} followed by Na^{+}. Therefore, HCO_3^{-} salts of Ca and Na were the major dissolved salts present in the irrigation water. In general, having values of EC 0.256-0.274 dS m^{-1}, SAR 0.91-1.16 and RSC 0.53-0.77 mmolc l^{-1}, respectively, the irrigation water was medium in salinity hazard, low in sodicity (SAR) hazard and safe in residual sodium carbonate hazards. Even though the current results showed that the irrigation water is potentially suitable for irrigation, there is a threat in the future as the EC, SAR and RSC values were observed to increase with the increase in distance from the diversion weir or along the main canal towards the irrigation site as a result of addition of salts by dissolving from the sides of the earthen main canal as well as through washing and inflowing from the surrounding areas to the main canal by runoff during rainy season.

Generally, to manage salt-affected soils and maintain the salinity and sodicity levels of irrigation water at or below the current level, it is essential to delineate the salt-affected areas and reclaim them using chemical amendment integrated with biological management practices. As the site is naturally potentially saline, use of salt-tolerant crop species and even varieties, and use of appropriate irrigation and drainage methods along with efficient use of irrigation water which takes into account the leaching requirement of the soils should be adopted in order to control the rise of the groundwater table and to reduce soluble salt distribution in the site. In addition, undertaking further applied research investigating improved technologies of salinity and sodicity control, as well selection and development of salt tolerant crop plant species and/or varieties for the environment, is vital.

Recommendations

To assure sustainable productivity of irrigated drylands, attention should be given to preventing the ecosystem from salinity- and sodicity-induced degradation. To ensure this, the two items below are suggested.

1) There needs to be an independent institution for dryland management in the country that can:

- Monitor impacts of development activities in dry ecosystems;
- Direct water use efficiency in dry ecosystems;
- Guide irrigation methods in dry ecosystems; and
- Support reclamation methods of salt-affected soil and water.

2) A fully-equipped laboratory centre is needed that is dedicated to the analysis of soil-water-plant relationships of dry ecosystems and that can provide updated information to stakeholders.

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APPENDICES

Appendix 1: Long-term mean monthly weather data in Matahara areas

Month	Rainfall (mm)	Evapotranspiration (mm)	Temperature (0C)		
			Minimum	Maximum	Average
January	15	130	15	31	23
February	33	127	16	32	24
March	50	128	18	34	26
April	42	123	19	34	27
May	36	124	19	35	27
June	28	113	21	36	29
July	122	109	20	33	27
August	132	115	20	32	26
September	46	119	19	33	26
October	26	126	16	33	25
November	8	128	14	31	23
December	7	130	13	30	22
Annual	553	1472	18	30	25

Source: Dinka (2010).

Appendix 2: Locations of soil profiles and site description at Fantale Irrigation Site

Profile No.	UTM-easting	UTM-northing	Altitude (m.a.s.l.)	Land use and special features
P1	586877	975043	1020	Irrigated maize field with white salt crust on the surface at Mel-dhiba site
P2	589530	981706	1023	Irrigated poor maize stand field with shiny black colour at the surface at Nukusa site
P3	589709	981353	1029	Irrigated maize field with white salt crust on the surface at Nukusa site
P4	589923	981398	1018	Un-irrigated/uncultivated field or grazing land at Nukusa

Appendix 3: Locations of irrigation water sampling points at Fantale Irrigation Project Site

Sampling site	UTM-easting	UTM-northing	Elevation (m.a.s.l.)
Awash river at diversion weir	585320	963581	1183
Main canal, 10 km from diversion weir	585337	964133	1166
Main canal, 20 km from diversion weir	586906	970198	1092
Main canal, 30 km from diversion weir	586183	973818	1059
Main canal, 40 km from diversion weir	589339	980912	1023

Appendix 4: Classification of salt-affected soils based on their chemical properties

Salt-affected soil type	ECe at 25 °C (dS m-1)	Saturation (%) of the CEC with Na (ESP)	pH (H_2O)	Soil physical condition
Saline	> 4	< 15	< 8.5	Normal
Sodic (Alkali)	< 4	> 15	> 8.5	Very poor
Saline sodic	> 4	> 15	< 8.5	Normal
Non-saline non-sodic	< 4	< 15	≈ 7.0	Normal

Appendix 5: Permissible limits (mg l-1) for boron in saturation extract of soils

Class	Boron range (mg l-1)	Safety level for plants
1	< 0.7	Safe for most sensitive plants
2	0.7-1.5	Marginal for many crop plants
3	> 1.5	Unsafe for most tolerant plants

Source: US Salinity Laboratory Staff (1954).

Appendix 6: Classification of irrigation water based on its salinity (EC), sodicity (SAR) and residual sodium carbonate (RSC) hazards

Salinity (EC) hazard			Sodicity (SAR) hazard			Residual NaCO3 hazard		
Salinity class	Salinity hazard	EC (dS m^{-1})	Sodicity class	Sodicity hazard	SAR value	RSC class	RSC hazard	RSC (mmol$_c$ l^{-1})
C1	Low	0.10-0.25	S1	Low	< 10	1	Safe	< 1.25
C2	Medium	0.25-0.75	S2	Medium	10-18	2	Marginal	1.25-2.50
C3	High	0.75-2.25	S3	High	18-26	3	Unsafe	> 2.50
C4	Very high	> 2.25	S4	Very high	> 26	-	-	-

Source: US Salinity Laboratory Staff (1954).

Appendix 7: Classification of irrigation waters based on boron concentration

Boron class	Boron Hazard	Boron content (mg l-1) for different levels of crop tolerance		
		Sensitive plants	Semi-tolerant plants	Tolerant plants
1	Excellent	< 0.33	< 0.67	< 1.00
2	Good	0.33-0.67	0.67-1.33	1.00-2.00
3	Moderate	0.67-1.00	1.33-2.00	2.00-3.00
4	Poor	1.00-1.25	2.00-2.50	3.00-3.75
5	Unsuitable	> 1.25	> 2.50	> 3.75

Source: US Salinity Laboratory Staff (1954).

5. Composition and diversity of invasive plant species and their socio-economic impacts on livelihoods of pastoralists in the rangelands of Telalak District, Afar National Regional State, Ethiopia

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ABSTRACT

Key words: composition, diversity, invasive, livelihood

The study was conducted in Telalak District of Afar National Regional State of Ethiopia with the objectives of: (a) investigating the composition and diversity of the invasive plant species; and (b) assessing their socio-economic impacts on the livelihoods of the local people. Forty quadrats were laid in two parallel transects, each 20 kilometres long and one kilometer apart from each other. In each quadrat the composition, diversity, abundance and cover of woody invasive plant species were recorded. Five sub quadrats in each quadrat were laid out and a total of 200 sub quadrats (1m2) were used to assess the abundance, cover, composition and diversity of the herbaceous invasive plants. Socio-economic data were collected through semi-structured questionnaires, group discussions and visual observations to assess the socio-economic impacts, as well as the local people's perception towards the invasive plant species.

Thirty-two invasive plant species classified under 18 families were identified and recorded. Of these, 11 were invasive trees and shrubs and 21 were non-grass herbaceous invasive species. The result of estimated cover-abundance values indicates that 80 percent of the sampled areas were invaded by rangeland invasive species. There was a significant difference between invasion levels in coverage within the same site. The overall diversity index (H) and evenness (E) of the rangeland invasive plants in the study area were 3.64 and 1.04, respectively. Acacia mellifera, A. senegal, A. nubica and Grewia villosa were the most dominant woody invasive species in the study area.

Invasive plant species had an adverse effect on animal production and productivity, crop production, human health and the livelihoods of the local people. Most of the sampled sites had shown the highest level of invasion in the rangelands. Therefore, necessary interventions, like mechanical and biological controlling mechanisms, are recommended. In addition, general improvement of the rangelands in the sample sites of the study area is recommended. Governmental and non-governmental organizations should exert the maximum possible effort to control these destructive and noxious invasive plants so that animals, human beings and the environment can have a better future.

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Introduction

Rangelands cover about 65 percent of the total area of Africa (Friedel et al., 2000) and 62 percent of the total land mass in Ethiopia (Yemane, 2000). Rangelands are characterized by semi-arid to arid climatic conditions with high temperatures and low, unreliable and erratic rainfall. The vegetation is composed of graminoids, forbs and woody plant species (Mengistu, 1998).

One of the pressing problems of rangeland management is the invasion and spread of invasive rangeland plants and the associated reduction in forage supply. Annual loss of forage production and direct loss from poisonous plants severely impacts the range livestock industry (Harold and Child, 1975).

An invasive species (alien or native) may be defined as a species that causes or is likely to cause economic or environmental harm or harm to human health and does not provide an equivalent benefit to society. Invasive alien species are species introduced deliberately or unintentionally from outside their natural habitats where they have the ability to establish themselves, invade, compete with native species and take over the new environments.

Rangeland invasive plants are the most underestimated weeds in tropical rangelands, but they have influenced the pastoralist’s livestock production system through decline in biomass production and quality of forage, interfering with grazing, poisoning animals, increasing time spent for grazing, reducing land value, depleting soil and water resources and reducing plant and animal diversity. Invasive plant species alternative community composition depletes species diversity, affect ecosystem processes and thus cause huge economic and ecological imbalances (Thomas et al., 2001).

Bush encroachment is the invasion of aggressive and undesired herbaceous, thorny and woody species, resulting in an imbalance of the grass-bush ratio and a decrease in biodiversity and carrying capacity. It causes severe economic and ecological losses for pastoral communities. Trees and herbaceous invasive plants usually compete directly for water, light and nutrients and this also directly affects the whole rangeland vegetation (Gupta, 2002).

Ethiopia is one of the developing countries affected by invasive plant species over the last three or four decades and this has been clearly identified as one of the emerging problems facing the country. The government has identified a number of major invasive plant species in the country and declared the need for their control and eradication (EARO, 2002). Poor rangeland management in Ethiopia has resulted in serious land degradation, reduced biodiversity and a decline in nutritive values of the native plants and the gradual replacement of indigenous grasses by poorly palatable and unpalatable species (Mengistu, 2004).

The rangelands have been subjected to intense anthropogenic effects resulting from intensive livestock pressure and human interferences. Much of the landscapes in the rangelands are heavily degraded and are currently experiencing frequent and prolonged drought, loss of land productivity associated with decline in soil fertility and decrease in biological diversity. It appears that such phenomenon has given room for both alien and native invasive plants to spread, dominate and colonize the rangelands in terms of coverage, composition and diversity (EARO, 2002).

The rangelands found in Afar National Regional State are among the areas in Ethiopia which are severely affected by invasive plant species, mainly Prosopis juliflora, Lantana camara, Acacia mellifera, A. nubica, A. nilotica and Parthenium hysterophorus (ANRS, 2004). The problem of invasive plants has been very critical to the pastoral and agropastoral communities of Afar National Regional State. However, little or no attention has been given to understand, sort out and document the invading species composition and diversity, as well as the socio-economic impacts that these species have on the community.

Therefore, this study was undertaken with the following objectives:

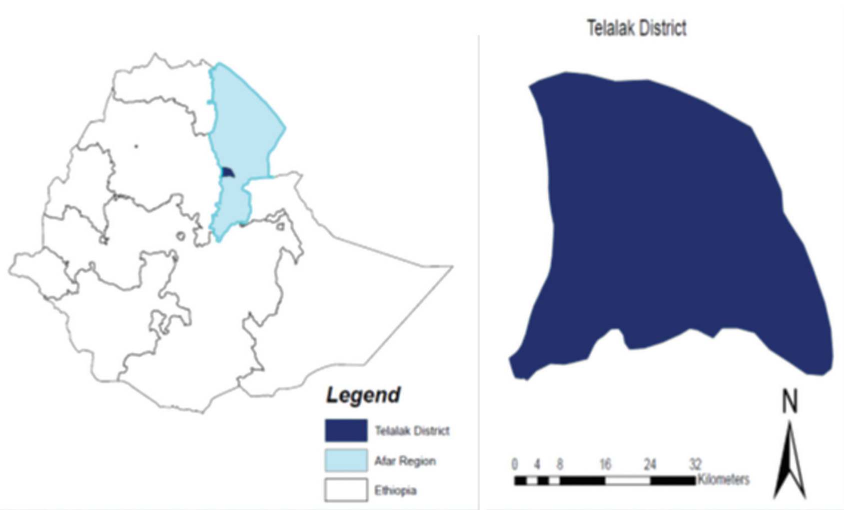
- to investigate the composition and diversity of the invasive plant species; and
- to assess their socio-economic impacts on the livelihoods of the communities in the study area.

Materials and methods

Description of the study area

Location and area coverage

The study was conducted in Telalak District, Zone Five, of Afar National Regional State, located 480 kilometres northeast of Addis Ababa and 170 kilometres southeast of the regional capital, Semera. It is found at 100 55’ 35”N and 400 12’ 28”E and bordered in the south with Dewe and Gewane Districts, in the west with the Amhara region, in the north with Mille and Adaar Districts and in the east with the Awash River and the Somali region. The study district covers 141,800 ha of land and has 11 Pastoral Associations (APADB, 2006) (See Figure 1).



The climate of Telalak District is characterized as arid (15 percent) and semi-arid (85 percent) agroecology. The altitude of the study district ranges between 500-1000 m.a.s.l. The area has mean minimum and maximum annual temperatures of 250C and 390C. The average temperature of the area is 300C. The total annual rainfall ranges between 300 and 750 mm and is characterized by a bimodal type with erratic distribution. The long rainy season (kerma) occurs between mid-June to mid-September and the short rainy season (sugum) occurs between March and April (APADB, 2006).

Vegetation, soil and land use system

The vegetation of the study area is mainly characterized by herbaceous and woody invasive plants and some native plants. The woody vegetation mainly includes species of the genera Acacia. Forbs and shrubs are also present. None and slightly palatable woody, herbaceous invasive plants and noxious weeds are present (APADB, 2006). The dominant soil type in the area is characterized as 60 percent fertile, 5 percent clay soil, 25 percent sandy and 10 percent other soil types (EARO, 2002). The study district is comprised of about 89.8 percent rangeland on which the livestock entirely depend for feed, 7.95 percent woodland, 0.5 percent water bodies and one percent stony bare land. The remaining 0.75 percent is cultivated and cultivable lands (ANRS, 2004). In the district, there are 660 ha of farming land, of which 260 ha is appropriate for rain-fed agriculture and the remaining 400 ha for irrigated crop production (APADB, 2006).

Sampling of invasive plant species in the study area

Prior to the actual study, a reconnaissance survey was undertaken to assess the rangeland situation of the study area. Elders, experienced people and development agents were involved in this reconnaissance survey to collect preliminary information on the rangelands.

Purposive sampling procedures (ILCA, 1990) were followed to identify and select respondents. Respondents were selected that had reliable information on the types of invasive plants, extent of invasion, their impact on native rangeland vegetation, toxicity, and the general socio-economic impacts of these invasive plants on the livelihoods of local people. Questionnaires were prepared to gather adequate information about the past and present condition of the area.

A field study was undertaken to determine and assess the identity, abundance, cover, composition and diversity of the invasive plant species in the study area. It was conducted during August to November 2010 when most of the sampled species were at full flowering or fruiting/ seeding stages.

A transect survey method (Moore and Chapman, 1986) was followed and two parallel transects, each 20 kilometres long running NE-SW, and one kilometre apart from each other, were established. A total of 40 quadrats (400 m2) were randomly laid out along the two transects. In consultation with pastoral respondents and available literature, all invasive plant species that are unpalatable and toxic or poisonous to any species of animals were identified and collected from each sampled quadrat. Some of the species collected from each quadrat were identified in the field. For those species that were difficult to identify in the field, their vernacular names were recorded, herbarium specimens were collected, securely pressed and transported to Haramaya University Herbarium for identification. Nomenclature of the plant species followed the Flora of Ethiopia (Hedberg and Edwards, 1989; 1995 and Hedberg et al., 2003) and the Flora of Tropical East Africa (Cufodontis, 1953-1972).

Sampling of the herbaceous invasive plant species cover

On each of the 40 main quadrats (400m2), five sub-quadrats (1m2) were laid in each corner and one on the centre of the main quadrat to measure the data on herbaceous invasive plant species cover. In total, 200 sub-quadrats were laid for herbaceous data collection. Cover abandunce of the herbaceous invasive plant species encountered in each quadrat was recorded using Daubenmire 1959 Cover Class Method (Wittenberg et al., 2004).The method involved visually designating one of the six cover classes (Table 19) to each quadrat. Each species within the quadrat was assessed separately based on its basal cover. The method involved a total estimate based on abundance and cover of the species. Following the methods suggested by Chellamuthu et al. (2005), the sample sites were categorized into two invasion levels: moderate (< 50 percent) and high (> 50 percent) of the total percent area coverage of invasive plants.

Sampling of woody invasive plant species

Land covered by tree and shrub invasive plant species identified in the rangelands of the study area was assessed as canopy cover percentage. Maximum and minimum diameters of each woody species were measured and calculated.

In each of the 400 m2 quadrats laid out along the parallel transects, the identity, abundance, height and diameter (maximum and minimum) at breast height (DBH) of individual woody invasive plant species (i.e., trees and/or shrubs) were recorded. For height, all woody invasive plant species were measured using locally-available long wooden poles of two and five metres and categorized into height classes. The number of individual trees and shrubs were directly counted. During counting, chalk was used to mark shrubs as they had been counted, to ensure that none were missed or double counted. The density of woody plants (trees and shrubs) were measured by counting the number in a sample quadrat and presented as density per hectare.

The percentage of canopy cover was obtained by measuring the maximum and minimum diameters of each tree and calculated using the formula below (Oikawa, 1985).

$$Cc = \pi\frac{(Dmax+Dmin)2}{4}$$

Cc = canopy cover, D_{max} = maximum diameter, D_{min} = minimum diameter

Density, frequency, dominance and importance value of invasive plant species

As Wittenberg et al. (2004) recognized, species density was determined by counting the number of individuals in the sample quadrat and converting the count into a hectare basis.

$$\text{Density of a species} = \frac{\text{Total number of individuals of a species}}{\text{Sample size in hectare}}$$

$$\text{Relative density (Rd)} = \frac{\text{Number of individuals of a species}}{\text{Total number of individuals of all species}}$$

$$\text{Species frequency} = \frac{\text{Number of samples in which a species occurred}}{\text{Total samples surveyed)}} \times 100$$

$$\text{Relative frequency (Rf)} = \frac{\text{Frequency of occurrence of a species}}{\text{Total frequency occurrences of all plant species)}} \times 100$$

$$\text{Relative dominance (RD)} = \frac{\text{Dominance of a species}}{\text{Dominance of all species)}} \times 100$$

The importance value index (IVI) was calculated using Curtis and McIntosh (1951)

$$IVI=Rd+Rf+RD$$

Species composition and diversity

The composition of the rangeland invasive plant species were determined by counting the number of individual invasive plants (herbaceous and woody invasive) per unit of sampled area. All invasive plants were counted and classified as herbaceous/broadleaved and woody invasive plants.

The species composition of the herbaceous and woody invasive plants were enumerated and recorded in each of the 1 m2 sub-quadrats and 400m2 sample quadrats, respectively, stretched along a 20 kilometre-long parallel transect. The diversity of the invasive plant species within and between the sample sites was computed according to Shannon (1949). The diversity index was estimated, as shown in the equation below (Wittenberg et al., 2004).

The Shannon diversity index takes into consideration both the richness and evenness of the species present within the given land or community.

$$H= -\sum_{i=1}^{s} pi \ \ ln\ (pi)$$

Where: H = species diversity index;

Ln = natural logarithm

Pi = ni/N is the proportion of individuals found in the ith species (ranges 0 to 1); and n = number of individuals of a given species; N = total number of individuals found (Shannon and Wiener, 1949).

The Shannon diversity index (H) takes into account the number of individuals as well as the number of species. High values of H would be representative of more diverse communities. If the species are evenly distributed then the H value would be high. So the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community.

$$E= -\sum_{i=1}^{s} pi \ \ ln\ (pi)/\ ln\ s$$

Abundance or equitability =

Where S = the number of species in the sample

This indicates how equally abundant each species would be and a high evenness of the weed species is a sign of a high invasion rate of that plant.

Assessing the socioeconomic impacts of invasive rangeland plants

Primary data were collected using structured questionnaires administered through face-to-face interviews by the researcher with the help of enumerators and development agents. To gather information on socioeconomic impacts, as well as the local people's perception of invasive rangeland plant species in the study area, data were collected through semi-structured questionnaires. Two Pastoral Associations from the first site (Telalak-Abaaro and Waydolele-Aluu) and two Pastoralist Associations from the second site (Halbin-Wale and Adalel-Dewe) (one from a highly invaded area and one from a moderately invaded area) were selected randomly. A total of 80 households, 20 from each Pastoralist Association, were selected using systematic random sampling techniques. Pastoralists and agropastoralists who had information about the past and present situation of the rangeland and the socio-economic impacts of invasive plants were selected with the help of development agents and the director of the district. Households who were absent during data collection were replaced with other households. Both male headed (60 households) and female headed (20 households) were included in the sampling.

Statistical analysis

The invasive plant species and native plants data measured from the sampling sites were subjected to SAS (2000) Version 9. Analysis of the data measured from the field was done by using the invasion level as treatment and the main quadrats as replications. Basal cover means of subquadrats (1 m2) were analysed by one way analysis of variance (ANOVA).

The various invasive plant species information and socio-economic impacts that were gathered from the sites in the structured questionnaires were subjected to appropriate statistical packages for social sciences software (SPSS version 16.0). Descriptive statistics were used for analysis of social data that were collected by simple survey.

The model used for analysis of the data:

Model:(yij)=μ+Ii+eij

Where:

yij = total data of invasive plant cover, μ = over all mean, Ii = invasion level effect

eij = error effect

Results and discussion

Rangeland invasive plants composition and diversity

A total of 29 invasive plant species belonging to 18 families were identified and recorded. These species were categorized under woody and non-woody/herbaceous/broadleaved invasive plants. There were no invasive grasses or sedge species observed in the area. This could be partly explained by the extensive bush encroachment, mismanagement practices and overgrazing of the area. Most invasive plants in the study area had no role in the livelihoods of pastoralists except some Acacia species. Nearly all invasive plants adversely affect animals, human beings and native rangeland vegetation. In the sampled area, 11 species of trees and shrubs and 18 species of herbaceous, non-woody invasive species were identified (Table 1).

Acacia mellifera, A. senegal, A. nubi000ca species were used for animal fodder, construction, firewood and charcoal production and as protection from the scorching sun for both humans and animals. Although invasive plants had the above listed benefits, the local people preferred the former plants, mostly grasses and legumes that were present 20 to 30 years ago.

The result of this study revealed that in the first site (Telalak-Abaaro and Waydolele-Aluu Pastoralist Associations), with moderate and high invasion levels, Acacia mellifera, A. senegal, A. nubica from woody and P. hysterophorus and Barleria parviflora from the herbaceous invasive species had a higher mean abundance value. In the second site (Halbin-Wale and Adalel-Dewe Pastoralist Associations), with a high invasion level, A. mellifera, A. senegal, A. nubica, Balantes aegyptica, Solanumincanum, Adhatoda schimperiana, P. hysterophorus were the dominant invasive plant species.

Table 1. Invasive rangeland plants and their vernacular names, life cycle and growth habit in the study district

Botanical names	Vernacular name (Afar)	Family	Life cycle	Growth habit
Abutilon fruticosum	Hayoukito	Malvaceae	Annual	Herbaceous
Acacia mellifera	Merkhato	Mimosoideae	Perennial	Tree
A. nubica	---	Mimosoideae	Perennial	Tree
A.senegal	Adodoyta	Mimosoideae	Perennial	Tree
A. oertota	Germto	Mimosoideae	Perennial	Shrub
Adhatodaschimperiana	Werabikala	Acanthaceae	Annual	Herbaceous
Aervapersica	Oilayto	Amaranthaceae	Perennial	Herbaceous
Asparagus asiaticus	Bekiltefre	Liliaceae	Perennial	Shrub
Balantesaegyptica	Sinkilila	Balanitaceae	Annual	Shrub
Barleriaparviflora	Bobo Eta	Acanthaceae	Perennial	Herbaceous
Calotropisprocera	Gelato	Asclepiadaceae	Perennial	Shrub
Commicarpusverticillatus	Garbeeto	Nyctaginaceae	Perennial	Herbaceous
Crotolariaalbicaulis	Airogit	Papilionoideae	Perennial	Shrub
C. comosa	Doetea	Papilionoideae	Annual	Shrub
Gallium simense	Olumeli	Rubiaceae	Annual	Herbaceous
Glycine wightii	Halana	Papilionoideae	Perennial	Tree
Grewiavillosa	Habelita	Tiliaceae	Perennial	Shrub/Tree
Hibiscus aponneeurus.	Hidayto	Malvaceae	Annual	Herbaceous
Hibiscus micranthus	---	Malvaceae	Annual	Shrub
Hypoestesforskalei	Doeto	Acanthaceae	Annual	Shrub
Indigoferaspicata	Burhata	Papilionoideae	Perennial	Herbaceous
Ipomoea ochracea	Agraboya	Convolvulaceae	Annual	Herbaceous
Leucasurticifolia	Kuntubli	Lamiaceae	Annual	Herbaceous
Ocimumcanum	Hibaki	Lamiaceae	Annual	Herbaceous
Ocimumlamifolium	Deartaba	Lamiaceae	Annual	Herbaceous
Partheniumhysterophorus	Democracy	Asteraceae	Annual	Herbaceous
Pileateteraphyla	Subahi	Urticeae	Annual	Herbaceous
Ruelliapatula	Dooto	Acanthaceae	Annual	Herbaceous/Shrub
Botanical Names	Vernacular name (Afar)	Family	Life cycle	Growth habit
Solanumincanum	Askena	Solanaceae	Perennial	Herbaceous/ Shrub
Tribulusterrestris	Bunket	Zygophyllaceae	Perennial	Herbaceous

The results showed that the second site was mainly invaded by woody species, whereas in the first site herbaceous invasive plants dominated. Among the herbaceous invasive plants, P. *hysterophorus, Aerva persica, Ipomoea ochracea* and *Crotolaria albicaulis* were dominant in the study area. In both sites, with different invasion levels, the mean abundance value of Acacia mellifera and P. hysterophorus were high (Table 2).

Table 2. Average number of invasive species per quadrat as per invasion levels

	Mean abundance values					
Botanical names	Site1 HIL	Site1MIL	mean	Site2 HIL	Site2(MIL)	mean
Abutilon fruticosum	3.9	1.3	2.6	1.8	1.2	1.5
Acacia mellifera	8.9	4.3	6.6	10.9	5.3	8.1
A. nubica	3.6	0.9	2.25	3.6	2.2	2.9
A. oertota	0.8	0.9	0.85	1.9	1.3	1.6
A. senegal	6.1	3.6	4.85	8.4	5.0	6.7
Adhatoda schimperiana	1.3	0.5	0.9	2.3	2.0	2.15
Aervapersica	5.6	2.2	3.9	8.0	5.4	6.7
Balantes aegyptica	3.3	0.9	2.1	5.6	2.2	3.9
Barleria parviflora	6.2	1.3	3.75	2.6	1.2	1.9
Calotropis procera	0.9	1.3	1.1	4.2	0.5	2.35
Commicarpus verticillatus	1	1	1	2.1	0.4	1.15
Crotolaria albicaulis	1.1	0.5	0.8	2.0	1.4	1.7
C. comosa	1.7	0.9	1.3	2.3	1.4	1.85
Gallium simense	2.6	1.2	1.9	1.8	1.2	1.5
Glycine wightii	2.8	1.2	2	1.8	1.5	1.65
Grewia villosa	1.1	1.2	1.15	4.0	1.3	2.65
Hibiscus aponneeurus	1.2	1.2	1.2	0.6	1.8	1.2
H. micranthus	2.8	1.4	2.1	4.9	1.8	3.35
Hypoestes forskalei	0.6	0.9	0.75	3.2	2.1	2.65
Indigofera spicata	2.6	1.1	1.85	4.2	1.5	3.35
Ipomoea ochracea	2.1	1.3	1.7	1.8	3.7	2.75
Leucas urticifolia	5.0	1.1	3.05	1.5	0.8	1.15
Ocimum canum	2.3	0.9	1.6	4.8	1.6	3.2
O. lamifolium	2.9	1.3	2.1	2.5	1.2	1.85
P. hysterophorus	10.9	8.3	9.6	6.4	5.0	5.7
Pileate teraphyla	3.1	1.7	2.4	3.3	0.9	2.1
Ruellia patula	4.1	1.0	2.55	1.8	1.1	1.45
Solanum incanum	1.9	0.8	1.35	6.1	2.9	4.5
Tribulus terrestris	2.1	1.4	1.75	3.5	1.4	2.45
Total	92.5	45.5	69.05	107.9	59.3	84

HIL- high invasion level; MIL- moderate invasion level

Invasive plant cover

Herbaceous invasive plant cover

The land covered by the herbaceous invasive plant species identified in the rangelands of the study area was assessed by basal cover percentage. The results showed that the total land covered or invaded by rangeland invasive plant species was 80 percent. P. hysterophorus and Aerva persica, Acacia mellifera, A. senegal, A. nubica and A. oertota were the dominant species (Table 3).

In the first site with a high invasion level, P. hysterophorus (3.21) and Aervapersica (0.7) had higher cover abundance values. In the second site with a high invasion level, these herbaceous invasive plants were higher in cover abundance values that accounted for 1.77 and 1.01, respectively. This implied that the above listed herbaceous invasive plants were dominantly covering rangelands in both sites (Table 3).

Table 3. Proportion of each species based on the cover abundance values as per invasion levels

Total cover abundance value of different invasion level						
Botanical names	Site1 (HIL)	Site1 (MIL)	mean	Site2 (HIL)	Site2(MIL)	mean
Abutilon fruticosum	0.42	0.20	0.31	0.16	0.09	0.13
Adhatoda schimperiana	0.34	0.20	0.27	0.29	0.16	0.23
Aerva persica	0.70	0.46	0.58	0.76	0.37	0.57
Barleria parviflora	0.12	0.12	0.12	0.29	0.11	0.2
Commicarpus verticillatus	0.34	0.18	0.26	0.18	0.04	0.11
Gallium simense	0.23	0.15	0.19	0.24	0.15	0.2
Glycine wightii	0.29	0.14	0.22	0.34	0.18	0.26
Hibiscus micranthus	0.23	0.23	0.23	0.22	0.11	0.17
H. aponneeurus	0.44	0.33	0.39	0.29	0.29	0.29
Hypoestes forskalei	0.33	0.15	0.24	0.17	0.14	0.16
Ipomoea ochracea	0.31	0.19	0.25	0.32	0.16	0.15
Indigofera spicata	0.12	0.24	0.18	0.42	0.20	0.31
Leucas urticifolia	0.34	0.31	0.33	0.38	0.27	0.33
Ocimumc anum	0.31	0.22	0.27	0.20	0.18	0.19
O.lamifolium	0.44	0.34	0.39	0.25	0.25	0.25
P. hysterophorus	3.21	1.60	2.4	1.77	1.45	1.6
Pilea teteraphyla	0.33	0.18	0.26	0.46	0.27	0.37
Ruellia patula	0.42	0.31	0.37	0.30	0.24	0.24
Tribulusterrestris	0.43	0.19	0.31	0.30	0.19	0.25
Total	9.35	5.74	7.57	7.34	4.84	6.01

HIL- High invasion level; MIL- Moderate invasion level

As indicated in Table 4, there was a significant difference between invasion levels in cover within the site. There was a significant difference between moderate and high invasion levels. There was higher herbaceous coverage in the high invasion levels of the two sites than in the moderate invasion levels; this is due to the presence of a large number of invasive plants. In the two sites of moderate invasion level, site two was higher than that of site one; this might be due to the presence of young, very small shrubs and bushes that are not growing well.

Table 4. The herbaceous plant cover for the two sites with different invasion levels

	Herbaceous cover in different invasion level (%)	
	HIL	MIL
Site1 (LSM ±SE)	0.625 + 0.034^{b}	0.356 ± 0.017^{a}
Site2 (LSM ±SE)	0.544±0.015^{b}	0.481 ± 0.016^{a}

$^{a\,b\,c\,d}$ in the same raw, indicates there is significance difference between the two sites

HIL = high invasion level; MIL= moderate invasion level

Tree and shrub invasive plant cover

The results show that Acacia mellifera, A.senegal and A.oertota were higher in canopy coverage. Generally, those invasive species cover more than 28 percent of the total canopy coverage. The remaining canopy coverage was attributed to other tree and shrub invasive species (Table 5 and Figure 2).

Table 5.The canopy cover of woody invasive species in the sampled area

Type of species	No. /Q	Area coverage (m2)
Acacia mellifera	9.5	97.06
A. oertota	6.0	35.24
A. nubica	3.8	26.60
A. senegal	8.0	87.22
Balantes aegyptica	6 .0	55.23
Calotropis procera	2.7	6.55
Crotolaria albicaulis	2.3	6.54
C. comosa	3.2	7.71
Grewia villosa	2.5	12.87
Hypoestes forskalei	5.0	16.10
Solanum incanum	5.0	0.87
Total		351.99

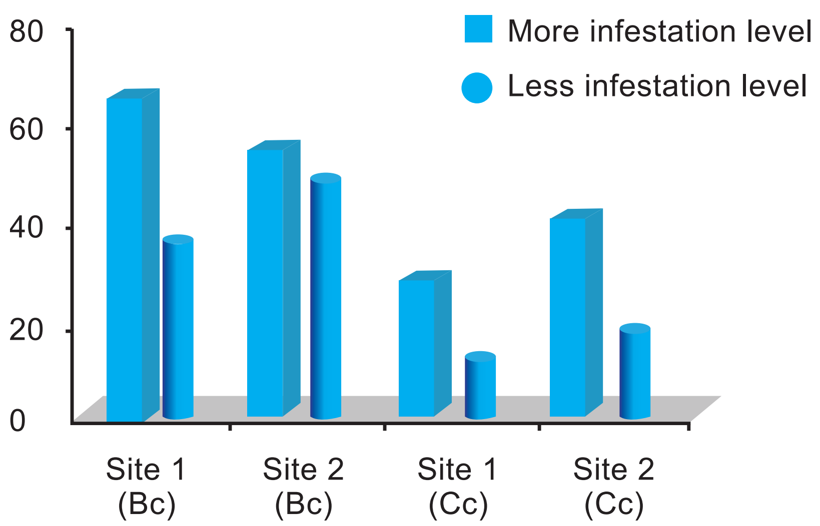


Figure 2. Basal and canopy cover for the two sites with different invasion levels (percent)

Height classes of woody invasive plant species

The largest proportion (68 percent) of woody invasive plant species in the study area was found in the height class of less than 4 m which, at least theoretically, can be considered within browsing height. The largest proportion (58 percent) of woody invasive plant species was found in the diameter class of < 4 m (Table 6); this might be due to cutting of trees from the top, stem and their branches for the purpose of charcoal production, house construction, farm equipment preparation, temporal bridge construction, fencing and as fodder for browser animals (camels and goats).

Table 6. Height and diametric coverage class distribution of trees and shrubs in the study area

Height (m)	%	Diameter (m)	%
<4	68	1-4	58
4-6	20	4-8	35
6-10	11	8-12	6
>10	1	>12	1

The very high abundance of small trees and shrubs suggests that the rangelands have been exposed to an increment of different disturbances and high usage of these plants. Some tree and shrub species, once defoliated or pruned by livestock or humans, could have poor regeneration capacity under the present conditions of the environment (i.e., greater aridity, low and erratic precipitation and increased livestock populations) in the study site.

Selective cutting of taller trees or shrubs, especially for charcoal making, house and local bridge construction, could be the main reason for the small proportion (1 percent) of larger height woody invasive species. The height of 1.5 m represents the mean browsing height for goats (Tainton, 1999). Some areas of the study district had trees with a height of 4-6 m (20 percent); this might be because of the less and/or unpalatable and thorny nature of the plants and measures taken by the Natural Resources Office of the district.

Invasive plant species richness and diversity

The effects of invasive plant species were not only revealed on the area coverage. Their greatest impact observed was on the distribution of native rangeland plant species that resulted in general biodiversity degradation. The overall diversity index (H) and evenness of the invasive species in the study area were 3.69 and 1.043, respectively (Table 7). The diversity and evenness result indicates the abundance of different species and the relatively even distribution of the species.

Table 7. Invasive plant species abundance/equitability (E) and Shannon diversity index (H) in the rangelands of Telalak District

Species	No/Q	Pi=n/N	lnPi	H	lnS	E
Abutilon fruticosum	12.3	0.04	-3.22	0.13	3.434	0.038
Acacia mellifera	9.5	0.03	-3.51	0.11	3.434	0.03
A. nubica	3.8	0.01	-4.61	0.05	3.434	0.015
A. oertota	6.0	0.02	-3.9	0.08	3.434	0.023
A.senegal	8.0	0.03	-3.51	0.11	3.434	0.015
Adhatoda schimperiana	11.4	0.04	-3.22	0.13	3.434	0.038
Aerva persica	15.8	0.05	-2.99	0.15	3.434	0.044
Asparagus asiaticus	12.4	0.04	-3.22	0.13	3.434	0.038
Balantes aegyptica	12.1	0.04	-3.22	0.13	3.434	0.038
Barleriaparviflora	3.8	0.01	-4.61	0.05	3.434	0.015
Calotropis procera	2.7	0.009	-4.71	0.42	3.434	0.122
Commicar pusverticillatus	3.6	0.012	-4.42	0.05	3.434	0.015
Crotolaria albicaulis	2.3	0.008	-4.83	0.04	3.434	0.012
C. comosa	3.2	0.01	-4.61	0.05	3.434	0.015
Gallium simense	11.3	0.04	-3.22	0.13	3.434	0.038
Grewia villosa	2.5	0.008	-4.83	0.04	3.434	0.012
Glycine wightii	12.5	0.04	-3.22	0.13	3.434	0.038
Hibiscus micranthus	11.0	0.036	-3.332	0.12	3.434	0.035
H. aponneeurus.	11.2	0.04	-3.22	0.13	3.434	0.038
Hypoestes forskalei	11.5	0.037	-3.30	0.12	3.434	0.035
Indigoferaspicata	11.7	0.038	-3.27	0.12	3.434	0.035
Ipomoea ochracea	12.4	0.04	-3.22	0.13	3.434	0.038
Leucas urticifolia	12.8	0.04	-3.22	0.13	3.434	0.038
Ocimum canum	4 .0	0.001	-6.91	0.01	3.434	0.002
O. lamifolium	3.6	0.012	-4.42	0.05	3.434	0.015
P. hysterophorus	28.8	0.095	-2.35	0.22	3.434	0.060
Pileateteraphyla	12.0	0.04	-3.22	0.13	3.434	0.038
Ruelliapatula	10.3	0.03	-3.51	0.11	3.434	0.032
Solanum incanum	4.6	0.015	-4.99	0.07	3.434	0.020
Tribulusterrestris	12.0	0.04	-3.22	0.13	3.434	0.038
Total	275.1	---	---	3.4	---	0.97

H = 3.4; E = 0.97

No/Q = number of individual species per 400m2; S = total number of species

The results showed that in the first site, a highly invaded area, quadrats number 9, 10 and 5 are rich in P. hysterophorus, where this species accounts for 25, 20 and 16, respectively. In these same quadrats the species richness was 8, 6 and 12, respectively. This implied that as the number of P. hysterophorus weed increased, the number of other broadleaved and woody invasive plant species decreased in number and abundance (see Figures 3-5). The second site was highly invaded by woody invasive plants mainly in quadrat number 5 (48), 1 (44), 6 (37) in a moderately invaded area and in quadrat number 7 (91), 10 (81), 6 (70) and 9 (69) in a highly invaded area.

Figure 3: P. hysterophorus in crop land

Figure 4: P. hysterophorus in rangelands

Figure 5: P. hysterophorus around a homestead

If the species are evenly distributed then the H value would be high. The H value allows us to know not only the number of species, but how the abundance of the species is distributed among all the species in the community. Diversity indices and equitability/abundance values of P. hysterophorus, Aerva persica and A.mellifera invasive plants were higher. This implied that these invasive plants were found more dominantly than others in the sampled sites and were higher in abundance. Acacia oertota, Crotolaria albicaulis, Calotropis procera, Grewia villosa, Ocimum lamifolium and O. canum were invasive species that had relatively lower diversity indices and abundance values (Table 7).

Woody invasive plants density, frequency and importance value

The density and frequency of the woody invasive plant species recorded in the study sites and quadrats varied considerably among species. The overall mean total density of woody invasive plants in sampled sites was 1,340 (837.5 woody plants ha-1) (Table 8). Mainly Acacia mellifera, A. Senegal and A. oertota were higher in relative density, which accounted for 18, 15 and 11 relative density, respectively. These invasive plants were higher in relative dominance also. Among woody invasive plants, Grewia villosa and Crotolaria albicaulis were lower in relative density (5 and 4, respectively).

Table 8. Rangeland woody invasive plant species and their importance value, density and frequency (percent)

Species	No./Q	D	Rd	Fr	RFr	Dom	Rdom	IV
Acacia mellifera	9.5	237.5	18	80	15	26	22	55
A. oertota	6	150 .0	11	38	7	10	9	27
A. nubica	3.8	95.0	7	38	7	11	9	23
A. senegal	8	200.0	15	75	14	32	27	54
Balantesaegyptica	6	150.0	11	63	12	14	12	35
Calotropisprocera	2.7	67.5	5	45	8	1	1	14
Crotolariaalbicaulis	2.3	57.5	4	43	8	2	2	14
C. comosa	3.2	80 .0	6	23	4	3	3	13
Grewiavillosa	2.5	62.5	5	28	5	5	4	14
Hypoestesforskalei	5	125.0	9	50	9	6	5	23
Solanumincanum	4.6	115.0	9	55	10	8	7	26
Total	---	1340	100	538	100	118	100	3.00

No/Q = average number of plants per main quadrat; D = density; Rd = relative density; Fr = frequency; RFr = relative frequency; IV = importance value; Dom = dominance; Rdom = relative dominance

Acacia species constituted more than 60 percent of the total woody invasive plants in the sample sites. *A.mellifera* and *A.senegal* was found in almost 90 percent of the quadrats. This may be due to the thorny nature of the plants that are not suitable for movement and entry of animals and are not easily palatable by animals and their drought-tolerant nature. The importance values of some top woody invasive plants in descending order were *Acacia mellifera* (55), A. *senegal* (54), *A.oertota* (27) and *Balantes aegyptica* (35). The greater the importance value the more competitive is the invasiveness. These invasive plants were also higher in relative dominance and frequency. Generally, the results revealed that the field was dominated with invasive plant species of families: Mimosodeae, Asteraceae and Amaranthaceae. *Acacia oertota, A. nubica, Balantes aegyptica, Hypoestes forskalei, Solanum incanum, Crotolaria comosa, C. albicaulis and Calotropi sprocera* found in the study area had an adverse impact on the rangeland ecology (Table 8).

Herbaceous invasive plants density, frequency and importance value

In the study area, the dominant herbaceous invasive plants were *P. hysterophorus* and *Aervapersica* that accounted for more than 60 percent of the total density of herbaceous invasive plants; of which 20 percent was *P. hysterophorus* (Table 9).

Table 9. Density, frequency and importance value of herbaceous invasive species in the study area

Species	No./Q	D	Rd	Fr	RFr	Dom	Rdom	IV
Abutilon fruticosum	12.3	307.5	4.4	45	5	2	1	10
Adhatodaschimperiana	11.4	285.0	4	45	5	3	2	11
Aervapersica	15.8	395.0	5.6	80	9.3	18	11	26
Asparagus asiaticus	12.4	310.0	4.4	50	5.8	8	5	15
Barleriaparviflora	10.8	270.0	3.8	30	3.5	6	4	11
Commicarpusverticillatus	10.8	270.0	3.8	30	3.5	5	3	10
Gallium simense	11.3	282.5	4.0	25	3	2	1	8
Glycine wightii	12.5	312.5	4.4	28	3.2	5	3	11
Hibiscus micranthus	11.0	275.0	3.9	5	0.6	2	1	6
H.aponneeurus	11.2	280.0	4.0	38	4.4	3	2	10
Hypoestes forskalei	11.5	287.5	4.1	25	3	4	2	9
Ipomoea ochracea	12.4	310.0	4.4	25	3	6	4	11
Indigofera spicata	11.7	292.5	4.2	38	4.4	3	2	11
Leucas urticifolia	12.8	320.0	4.5	34	4	5	3	12

Table 9. Density, frequency and importance value of herbaceous invasive species in the study area

Species	No./Q	D	Rd	Fr	RFr	Dom	Rdom	IV
Ocimum canum	11.2	280.0	4	30	3.5	6	4	12
O. lamifolium	10.6	265.0	3.8	38	4.4	2	1	9
P. hysterophorus	28.8	720.0	10.2	95	11	28	17	38
Pileatetera phyla	12.0	300.0	4.3	44	5	6	4	13
Ruellia patula	10.3	257.5	3.7	10	1	12	7	12
Tribulus terrestris	12.0	300.0	4.3	25	3	10	6	13
Total	252.8	6320	89.8	740	85.6	136	83	258

No/Q = average number of plants per main quadrat; D = density; Rd = relative density; Fr = frequency; RFr = relative frequency; IV = importance value; Dom = dominance; Rdom = relative dominance

As the result showed, the relative density values of *P. hysterophorus* (10.2), *Solanium species* (6) and *Aerva persica* (5.6) were higher. This implied that their abundance in the study district was higher and the relative frequency, relative density and relative dominance were also higher for these invasive plants. Lower relative densities were recorded in *Ruellia patula* (3.7), *Barleria parviflora* (3.8) and *Commicar pusverticillatus* (3.8).

The importance values of some top herbaceous invasive plants in descending order were P.hysterophorus (38) and Aerva persica (26). Even though the above lists were dominant, Leucasurticifolia, Ipomoea ochracea, Pileateteraphyla, Glycine wightii and others were also found (Table 9).

Management mechanisms employed

Most of the respondents (88.8 percent) revealed that they had tried to control invasive plants, but it was difficult even to reduce their distribution. This might be attributed to the high seed production capability with no dormancy period and fast growth and regeneration natures of the plants. Some respondents (11.2 percent) said that they did not try to control the invasive plants, and this might be due to their poisonous and allergen natures (Table 12).

Continuous hand clearing and uprooting of new seedlings of invasive species from farm lands, grazing lands and around settlements were the first option that most respondents carried out in the study area. The other most effective, but labour and cost intensive mechanical control method, which was frequently mentioned by the respondents was removing of the plant from 10-15 cm below the ground and use the land for crop production; this was also described by Shiferaw et al. (2004).

Livestock production and land tenure systems

Livestock production systems

The people in the study area kept multiple species and multipurpose stock, including camels, cattle, goats and sheep. The proportion of the different species of animals varied with the vegetation cover of the area. In the drier parts of the study area, camels and goats dominated herd composition, with mainly camels dominating the herds in the most arid areas.

In the study area, extensive livestock was the predominant production system which provided subsistence livelihoods for the local communities. Livestock production could be characterized as opportunistic management of rangelands with mobile herds. A central strategy was herd size maximization for day to day consumption and social prestige. This system provided goods for household consumption (milk, meat, butter, etc.) and live animals were used in transactions, such as exchanges and sources of cash from the market.

The livelihoods of the local people mainly depend on pastoralism, 75 percent, followed by agropastoralism, 25 percent (see Table 10). Most of the people interviewed replied that pastoralism was the main practice for household consumption and income generation in the study area.

The majority of the respondents revealed that pastoralists and agropastoralists generate their income from livestock and livestock products. Pastoralists living near towns, to some extent, earn their income from the sale of charcoal and firewood.

Livestock production constraints

The respondents in the study area explained that livestock production systems have been constrained and at present might not cover the family's basic needs. The respondents ranked feed shortage as the main livestock production constraint and drought as the second constraints (Table 10). In line with the present study, shortage of feed as a major constraint for livestock production was reported in Tanzanian pastoral communities

Table 10. Livestock production systems and major constraints in the study district, as prioritized by the respondents

Livestock production system					Fre (n=80) %			
Pastoralism					60		75	
Agropastoralism					20		25	
Total					80		100	
Constraints			Rank					
	1st	2nd	3rd	4th	5th	6th	7th	8th
Feed shortage	50	32.5	17.5	-	-	-	-	-
Drought	7.5	56.2	27.5	8.8	-	-	-	-
Bush encroachment	36.3	40	15	2.5	5	-	1.3	-
Diseases	5	-	12.5	82.5	-	-	-	-
Water shortage	-	-	-	6.3	48.8	15	28.8	1.3
Market problem	-	-	-	-	22.5	66.3	11.3	-
Land shrinkage	-	-	-	-	22.5	13.8	57.5	6.3
Conflict	-	-	-	-	1.3	5	1.3	92.4

Fre = frequency; n = number of respondents

(Angello, 1996). These constraints were similar to those reported in other pastoral areas of Ethiopia (Terefe, 2006; Hassen, 2006).

Land tenure systems

Respondents explained that in the past they were able to move freely and exploit the variability in resource availability over wide rangelands. However, now, expansion of large scale agricultural projects, increases in human and livestock populations, overgrazing, bush encroachment and water scarcity have contributed to the reduction of productive rangelands in both quantity and quality. Currently, a few numbers of pastoralists in the study area were practicing crop production on privately-owned land. Some pastoralists also owned small plots of enclosed grazing area nearby and around their crop land and homestead similar to that of the Somalia region (Hogg, 1995).

Nevertheless, up to now, the largest portion of the rangeland was communal. The reasons for communal use are to strengthen their culture of sharing information (daagu) and utilization of resources based on traditional norms and to strengthen their social bonds and ensure social security. This communal ownership of land was indicated in the reports of other researchers, such as Coppock (1994) for the Borana rangeland, Debalkie (2006) for Jijiga rangeland and Feye (2007) for the Gewane rangeland.

Respondents said that the communal rangelands were controlled by ethnic leaders (50 percent), community leaders (25 percent), family heads and all users of the area (Table 11). However, these communal rangelands were adversely affected by people who violate customary laws.

Table 11. Respondents land tenure system, responsible bodies and primary income sources in the study area

Description	Fre (n=80)	%
Privately owned	10	12.5
Communally owned	68	85.0
Both	2	2.5
Total	80	100
Responsible body		
Community leaders	20	25
Ethnic leaders	40	50
Family head	8	10
All users	12	15
Total	80	100
Primary income		
Livestock rearing	40	50.0
Cultivation	10	12.5
Trade	5	6.25
Rearing and cultivation	25	31.25

Fre = frequency; n = number of respondents

Socio-economic impacts of invasive plants

Impacts on rangeland vegetation

A major impact of invasive plant species on rangeland vegetation is that palatable and nutritious plants have been replaced by less palatable and unpalatable, useless and poisonous plants.

The respondents (80 percent) pointed out that problems related to invasive plant species in the study district had become severe, along with the harsh and prolonged drought. Almost all respondents agreed that the following were the major adverse impacts of invasive plants on rangeland vegetation in the study area:

- decrease in the availability of grasses and palatable plants, increase in poorly palatable and unpalatable and thorny plants;
- encroachment of native vegetation; and
- competition with locally-important plants for space, light, nutrients, and water.

According to the respondents, most of the valuable species in the areas which were suitable for animal grazing and browsing have disappeared due to the continued expansion of the invasive species. Furthermore, compared to the last twenty or thirty years, there has been a decrease in useful grasses and legumes. Instead, unpalatable and thorny plants (trees, shrubs, bushes and herbaceous weeds) that are hazardous for animal production and productivity have increased.

The pastoralists described some of the preferred grass species which have shown signs of serious decline in terms of biomass production and area coverage. These included *Chrysopogon aucheri, Cynodon dactylon, Dactyloctenium aegyptium, Aristida adscensionis* and *Panicum coloratum*. In some parts of the district, these valuable plant species have completely disappeared.

Table 12. Some invasive plant species and the type of disorders caused in animal species in the study area

Species	Animal affected	Disorders
P. hysterophorus	Cattle, goat, sheep and camel	Variety
Aerva persica	Cattle, sheep and goat	Bloating
Crotolaria species	All except camel	Diarrhea
Solanum incanum	Goat, sheep (sometimes)	Pneumonia
Solanum species	Goat, sheep	Pneumonia
Tribulus terrestris	Cattle	Bloating
Calotropis procera	All except camel	Bloating

Impacts on animal production, productivity and human health

Livestock are the primary victims of the adverse impacts of invasive rangeland species. Animal production is the main source of income generation and day to day consumption for pastoralists. The respondents revealed that the expansion of P. hysterophorus and encroachment of rangelands by woody and thorny species were the main reasons for reduction in animal productivity. Consequently, the area has also become more suitable for predators (hyenas, fox, snakes and other wild animals) and more difficult for house animals.

Respondents said that meat from livestock that fed on P. hysterophorus was lower quality. They further elaborated that when animals were allowed to graze only P. hysterophorus nobody likes to drink the milk because it has a bitter taste or taint. All respondents revealed that they faced problems marketing their milk from such animals, if alternatives were available. This idea was supported by Ayele (2007).

Most of the respondents revealed that tree invasive species were a major cause of injury and restricted animal movement for feeding. P.hysterophorus, Calotropis procera and Aerva persica were major causes for bloating, constipation, diarrhea and cough in animals. Large numbers of animals were lost due to constraints related to feed shortages and poisons from different invasive plants (APADB, 2006).

Invasive plants were hazardous to human health too, especially P. hysterophorus which was the main cause of skin scratches. Many respondents revealed that P. hysterophorus was the main cause for continuous coughing, asthma, bronchitis, lung disease, high fever, allergies and swelling. Supported by Ayele (2007), 50 percent of the respondents said that it causes stomach upset in animals and 31.3 percent revealed that it causes itching in humans. The respondents (50 percent) revealed that goat, sheep and cattle were the most susceptible animals for P. hysterophorus weed toxicity (Table 13).

Table 13. Respondents with animal and human health problems associated with P. hysterophorus in the study district

Description	Fre (n=80)	%
Livestock health		
Diarrhea	20	25
Cough	20	25
Stomach upset	40	50
No problem	0	00
Total	80	100
Animal type susceptible to P. hysterophorus toxicity		
Goat, sheep, cattle	40	50.0
Sheep and camel	10	12.5
Cattle	10	12.5
Goat and cattle	20	25.0
No problem	0	00
On human health		
Asthma	15	18.8
Itching	25	31.3
Allergic	20	25.0
Coughing	20	25.0
No problem	0	00
Total	80	100

Fre = frequency; n = number of respondents

Impacts on crop production

Most respondents revealed that crop cultivation in some parts of the district had started five to six years earlier due to the reduction in animal productivity, presence of arable land and water sources for irrigated agriculture. Sorghum, maize, sesame and cow peas were the principal crops used for cultivation. However, few households were engaged in crop production. The major constraints to people being involved in irrigation activities were expansion of *P. hysterophorus* and lack of finances, motor pumps and labour.

Currently crop production and productivity has reduced in most pastoral associations of the district due to the expansion of *P. hysterophorus* weeds and flooding. This point was supported by (Khosla and Sobti, 1981; Ebssa 2008).

During 2010-2011, there were 200 hectares of cultivated land in the district. However, in the first week of September 2010, all field crops and vegetables were damaged by flash floods coming from the highlands of the country. Flood hazards in the study district were a combined result of its topography, runoff from the highlands and intensive torrential rainfall conditions.

The respondents pointed out that there were four constraints to crop production: soil erosion due to flash floods was the major constraint (75 percent), followed by expansion of weeds (62.5 percent), inadequate rainfall and lack of motors for pumping water (56.3 percent) and lack of arable land (52.5 percent) (Table 14).

4. Conclusions, recommendations and the way forward

Conclusions

The study site was mainly covered by woody and non-grass herbaceous invasive plants. Acanthaceae, Mimosoideae, Lamiaceae, Malvaceae, Amaranthaceae and Asterceae were the dominant invasive plant families in the study area. In the Asterceae family, P. hysterophorus was the dominant and a very noxious invasive herb.

The sampled sites (80 percent) were covered by invasive plant species. Telalak-Abaaro and Waydolele-Aluu Pastoralist Associations sites were mainly invaded by herbaceous (P. hysterophorus, Aerva persica, Ipomoea ochracea, Indigofera spicata and Crotalaria albicaulis) and Halbin-Wale and Adalel-Dewe Pastoralist Associations were covered by woody (Acacia mellifera, A. senegal, A. nubica and A. oertota) invasive plants.

The dominant herbaceous invasive plants were P. hysterophorus, Aerva persica. The results showed that the relative density values of P. hysterophorus (0.102) and Aerva persica (0.056) were higher than others; this implied that their abundance in the study district was higher and the relative frequency, relative density and relative dominance were also higher for these invasive plants. The results indicated that species richness in the two sites was different.

Continuous hand clearing and uprooting of new seedlings of P. hysterophorus weed from farm lands, grazing lands and around settlements, removing of the plant from 10-15 cm below the ground and using that land for crop production were the main management methods.

The findings of this study indicated that livestock production systems in the area, including pastoralism and agropastoralism, are constrained by feed shortages, drought, bush encroachment, diseases and water shortages.

The rangelands of the study areas were owned communally; whereas most crop lands were privately owned. Invasive plants had adverse impacts on livestock and grain crop production and productivity, as well as on human health. Even though the demerits were more pronounced, invasive plants had some merits for the local people. Some forbs and shrubs have traditional medicinal value and some trees were used for construction purposes, fuel production, as feed for animals and fencing.

The present findings, based on the respondents' perceptions, clearly showed that the current status of the rangeland was highly affected by the recurrent drought, climate change, overgrazing, bush encroachment, natural disasters and encroachment of human populations.

To overcome these constraints, priority needs appear to be community-based environmental rehabilitation and conservation of natural resources, development of infrastructure and water systems, improvement of livestock development schemes and grazing management systems, enhancement of drought mitigation strategies, volunteer settlements and income-generation schemes and undertaking integrated rangeland and livestock research.

Recommendations

Invasive plants are found in many parts of the country. Further studies are highly recommended to gain a clearer understanding of the overall social and environmental impacts and their rate of expansion and invasion.

The way forward for future research

- The composition and diversity of invasive plants and their impacts on native vegetation were studied within one season, but these parameters are spatial and temporal. Therefore, wider studies should be made at different locations and seasons.
- The impacts of invasive plants on native rangeland vegetation were studied, but their impact on organic and inorganic components of soil could be more deeply studied.
- The impacts of invasive plants on animal and crop production were studied simply based on the perception of the local people, but there needs to be experimental research on their production and productivity.
- Some invasive plants produce toxic chemicals. To understand at what time/stage of maturity these plants produce more chemicals and which plants are the most toxic could be studied.
- Socio-economic impacts of invasive plants were studied, but it needs further social and economic analysis.

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Session on livestock production value chain in the context of enhancing pastoralists livelihoods

6.Analysis of small ruminants value chain in Yabello and Shinille Districts, Ethiopia

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ABSTRACT

Key words: value chain, shoats, pastoralists

With the objective of increasing access of poor pastoralists and smallholder farmers to meat and milk, the International Center for Agricultural Research in the Dry Areas (ICARDA) and the International Livestock Research Institute (ILRI) have initiated a programme known as 'More Milk, Meat and Fish by and for the Poor,' a CGIAR Consortium Research Programme (CRP 3.7) targeting the development of the small ruminants value chain. CRP 3.7 is being implemented in various countries, including Ethiopia. This study is part of the bigger CRP 3.7 and its major objective was to undertake a rapid assessment of the small ruminant's value chain and identify best-bet intervention options that would be used as entry points for the programme. The study was conducted in two pastoral districts (Yabello and Shinille). A rapid value chain assessment was done by teams of researchers from respective regional research centres ICARDA and ILRI during November 2012 to February 2013.

Several crosscutting issues needing research, development and policy interventions were identified in this process. Shortages of breeding rams/bucks, dilution of the genetic resource of pastoral areas as a result of restocking efforts after drought, lack of awareness about the hazards of inbreeding, shortages of clinical equipment, drugs and human resources, lack of awareness on improved shoat feeding practices and feed shortages are some of the constraints identified at the input supply and production stages of the value chain. The poor bargaining power of shoat producers, lack of vertical linkage of producers with buyers, lack of market information, lengthy marketing channels, lower proportion of the final price of shoats reaching producers and poor marketing infrastructures are some of the major market-related issues needing focused intervention. These and several other important constraints limiting the development of shoat value chain development at input supply, production, marketing, processing and consumption stages have been identified and prioritized through a series of stakeholder consultation forums for focused intervention. CRP 3.7 is preparing to implement interventions, including the strengthening of breeding practices of pastoralists, training of pastoralists, training extension agents and experts on improved shoat husbandry practices (breeding, feeding, housing, health care and marketing), making market linkages, improving market information systems and others.

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Introduction

Background

Diverse biophysical and agro-climatic conditions in Ethiopia make the country suitable for the production of various kinds of livestock. The shoats (sheep and goats) population of Ethiopia, including expert estimates of the pastoral areas, is about 66 million heads (Negassa et al., 2011). Shoats provide about 46 percent of the national meat consumption and 58 percent of the value of hide and skin production (Awgichew et al., 1991). Shoats have many advantages over large ruminants for most smallholder farmers, including among others: lower feed costs, quicker turnover, easier management and appropriate size at slaughter (Abegaz, 2002; Donkin, 2005). Shoats also have greater tolerance to less favourable conditions, as they suffer far less in mortality during periods of drought than large ruminants (Galal, 1983). In addition, subsistence farmers prefer shoats as the risk of losing large ruminants is too great (Sölkner et al., 1998).

Apart from subsistence, livestock play economic and cultural roles. In the system of the study areas, shoats have a very important role in contributing to food security as well as in mitigating environmental risks due to their unique adaptation to arid and semi- arid areas. Shoats are primarily used for milk and meat production for home consumption. Shoats are the major source of income for farmers and pastoralists to meet the immediate cash needs of the household. With the increased drought cycle and environmental degradation because of the effects of climate change, the pastoral community is expanding shoat production as an adaptation strategy. The increase in international demand for meat in general and the high demand for shoat meat in Middle Eastern countries is another incentive for increased shoat production in Ethiopia.

Nevertheless, under traditional production systems, the productivity of Ethiopian shoats is low due to slow growth rates and high kid mortality owing to inadequate and inefficient animal health services which will have implications for future shortages of marketable animals. Furthermore, current economic trends are significantly impacting the genetic resource base through early disposal of better animals for market. Therefore, there is an urgent need to increase productivity of shoats through improving the genotype along appropriate management interventions to bridge such gaps and improve household income, household nutrition and to meet the demand of the growing human population for livestock products and foreign markets. Clearly, therefore, interventions are needed that target the improvement of the shoat value chain starting from developing efficient input delivery systems, knowledge-based animal husbandry systems (including feeding, breeding, housing and health care systems) and identification and promotion of cost-effective marketing channels and coordinated supply chains that reduce the transaction costs among actors along the supply chain.

This calls for an understanding of input delivery, production, processing and consumption systems. It also requires an understanding of market performance, conduct, function, business linkages and constraints and opportunities along the value chain, as well as forward and backward linkages with the target areas. The purpose of this study was to assess the constraints and opportunities along the small ruminants value chain in Yabello and Shinille Districts, respectively of Oromia and Somali Regional States, Ethiopia, in order to come up with best-bet research, development and policy intervention options that would facilitate development of the small ruminant's value chain in the area. Implementation of these interventions in the districts would enhance production of best quality shoats that would meet market demand and fetch better prices. This is expected to improve household income and increase their access to milk, meat and other nutritious foods through better purchasing power as a result of increased shoat production.

Objectives

The main objective of the study was to characterize the goat value chain in order to identify best-bet intervention areas for the development of the shoat value chain in the area. Specific objectives of the study were:

- to identify the natural, technical, financial, legal and institutional opportunities and barriers that influence development of the shoat value chain;
- to identify best-bet research, development and policy intervention options for the development of the shoat value chain in the study areas; and
- to document important elements and modalities of market strategies to develop the shoat value chain.

Organization of the report

The report is organized in five sections. Section one introduces the report. Section two presents the research methodology used. An overview of results obtained through the rapid value chain assessment of sheep and goats in Yabello and Shinille Districts, including the core functions and their characteristics, is presented in Section three. Section four discusses the constraints and opportunities identified along the value chains. Section five concludes the report and recommends interventions.

Methodology

Description of the study areas

Yabello District

Yabello District is located in Oromiya National Regional State about 565 kilometres south of Addis Ababa on the main road from Addis Ababa to Moyale in the Borana rangeland. Borana rangeland is semi-arid with highly variable rainfall that ranges between 300 and 900 mm per annum, with highly spatial and temporal variability. The main rainy season extends from March to May, whereas the short rainy season lasts from October to November, followed by a long dry season. However, the actual length of the rainy season is getting shorter and shorter with time, and the area is prone to frequent drought. The short rains are unreliable. The predominant soil types of the area include red soil, black soil, white or gray soil and sandy soil. In most cases, the soil is well-drained, red, sandy loam. Livestock production is the mainstay of the Borana people, who live in pastoral and agropastoral areas. The major livestock reared by the Borana are cattle, camels, goats and sheep. The average stocking rate in Borana rangelands is approximately 15.6 TLU/ km2 (Cossins and Upton, 1988). Although livestock production is the dominant mode of production, crop production is also practiced in the area. Crop production practice is gradually expanding from the agropastoral to the pastoral areas.

Shinille District

Shinille District is one of the nine administrative zones of Somali National Regional State. Lying in the northernmost tip of the region, it borders Djibouti in the north, Somalia (Somaliland) in the northeast, Jijiga Zone on the southeast, Dire Dawa and Oromia regions to the south and the Afar region on the West. The population's livelihood mainly depends on livestock production. There is also a significant amount of trade and a small amount of crop production in the southern part. The altitude of Shinille District ranges between 950 and 1,350 metres above sea level. There are two rainy seasons, gu and karan, both of which are almost equally important. The gu falls between late March and late May, while the karan season is between late July and late September. In recent years, the karan has shown better reliability. Annual rainfall is between 500-700 mm. Rainfall is higher in the southern foothills and much lower in the northern central plains. In the extreme north and northwest, rainfall is much below this range.

Methods of data collection and sources of data

Both primary and secondary data were used in this study. Combinations of techniques were applied when collecting the data required to analyse the shoat value chain in Yabello and Shinille Districts. Participatory Rural Appraisal (PRA) tools, focus group discussion, key informant interviews and visual observation were used to collect primary data. Secondary data were collected from district offices. Relevant literature and documents were also reviewed to provide theoretical background. Each of the tools used for data collection are described below.

Focus group discussions

Focus group discussions were conducted with groups of men and women in each of the kebeles (the smallest administrative unit, equivalent to a neighbourhood). A total of four kebeles (two per district) were selected for this study. Four focus group discussions (two per district or one per kebele) were conducted in January 2013 with a total of 45 participants. The groups in each of the kebeles were composed of 10-12 men and women shoat producers.

Key informant interviews

The key informants identified for this study were experts in livestock extension, livestock marketing and cooperatives promotion, as well as abattoir managers, traders, meat supermarket managers, butchers, livestock researchers, transporters, veterinarians and non-governmental organizations. A total of 40 key informants were interviewed during the field data collection period.

Method of data analysis

The data collected from the field through focus group discussions, key informant interviews and personal observations were analysed using a thematic analysis approach. Quantitative data were analysed using descriptive statistical analysis techniques to calculate the distribution of costs and margins along the shoat value chain.

Conceptual framework

The 'value chain' describes the full range of value-adding activities required to bring a product or service through the different phases of production, including procurement of raw materials and other inputs, assembly, physical transformation, acquisition of required services, such as transport or cooling, and ultimately response to consumer demand (Kaplinsky and Morris, 2001). As such, value chains include all of the vertically linked, interdependent processes that generate value for the consumer, as well as horizontal linkages to other value chains that provide intermediate goods and services. Value chains focus on value creation – typically via innovation in products or processes, as well as marketing – and also on the allocation of the incremental value (Webber and Labaste, 2010).

A value system contains value chain actors, value chain service providers and the institutional environment. Value chain actors are those actors who exercise ownership of the product or its value addition, thus bearing the risk in handling the commodity. On the other hand, value chain service providers are those that provide service to value chain actors, either at cost or for free (e.g., a public extension service). In some cases, a value chain actor may be providing service to his/her own operation (e.g., a value chain actor may use his own transport service or processing facility). In such cases, the service becomes part of the value chain actor activities. Both value chain actors and value chain service providers operate under a given institutional environment. The institutional environment consists of both formal institutions (written laws and regulations) and informal institutions (Gereffi, 1995).

The key to the concept of the value chain is the idea of value addition. This is what distinguishes the value chain from 'market chains' or 'supply chains,' which focus on the logistical aspect of the transfer of the commodity (Webber and Labaste, 2010). Value chain analysis will undoubtedly identify many potential upgrading strategies. The goal, however, is to identify a few points (nodes) of intervention which, in the literature, are called 'leverage nodes' or 'leverage points.' These are nodes which, if addressed, will have the highest impact in upgrading the value chain. Value chain development is about implementation of upgrading interventions (Anandajayasekeram and Gebremedhin, 2009).

Key findings and discussions: Results of the value chain analysis

Mapping the core functions

The core functions in shoat value chains of Yabello and Shinille Districts consists of input supply, production, marketing, processing and consumption (Figure 1). The major activities under each core function and actors are illustrated below.

Input Supply	Production	Marketing	Processing	Consumption
Supply of: ▪ Breeding stock ▪ Veterinary services ▪ Credit services ▪ Feed (sometimes)	▪ Feeding ▪ Herding ▪ Housing ▪ Breeding	▪ Transporting ▪ Selling ▪ Buying ▪ Collection	▪ Slaughtering ▪ Chilling ▪ Packing ▪ Cooking in local dishes	▪ Slaughtering ▪ Chilling ▪ Packing ▪ Cooking in local dishes
▪ Pastoralists, ▪ YPDARC ▪ Private clinics ▪ Government and non-government organizations	▪ Pastoralists	▪ Collectors ▪ Small traders ▪ Big traders ▪ Brokers	▪ Hotels/ restaurants ▪ Butchers ▪ Supermarkets ▪ Export abattoirs	▪ Individual ▪ Consumers Pastoralists ▪ Foreign consumers

Figure 1: Core functions, activities and actors along the shoat value chains in Yabello and Shinille Districts

Input supply

Supply of breeding stock

The breeding stock in the study areas are obtained from pastoralists within the same community, markets outside the study areas and research centres. The pastoralist buys breeding stock from the surrounding pastoral markets or maintains female shoats as replacement stock. The important thing here is that pastoralists always go for their own local breeds. Restocking programmes after drought seasons are also important sources of breeding stock for the pastoral community. These breeding stocks can be bought either from markets within the affected pastoral area or neighbouring agropastoral areas with different agroecologies and breeds of animals (e.g., Konso and Guji). Hence, different breeds of animals could be introduced into the rangeland in this process. The Borana community has a self-rehabilitation culture known as busa gonofa. In this system, highly affected households will be selected after each drought season and given a certain number of replacement stock of goats, cattle and other species of animals that are contributed by relatively less affected households. The other sources of breeding stock are research centres (Yabello and Jijiga). These centres provide 50 percent Boer and 50 percent Dorper cross bucks to the pastoral community.

Feed supply

Shoat production in the study areas relies on grazing of natural pasture and browses. Though there are efforts made to supply supplementary feeds, such as hay, straw, wheat bran/ middling and oil seed cakes, to the rangeland during severe droughts, these feeds are targeting saving the lives of cattle, not usually shoats. Since water shortages do not allow pastoralists to grow forages, supply of forage seeds is not a common practice in these areas.

Veterinary inputs and services

Animal health services in the study areas are provided by public veterinary clinics in the district capital and small towns, health posts, community animal health workers, private vet clinics, private veterinary pharmacies and informal veterinary drug sellers. The quality of services provided and challenges in service provision vary with region. For instance, drug shortages were not reported from Yabello District, which has a revolving drug fund, while drug shortages are the major problem in Shinille District. All the health posts in Yabello District are functional, while only four out of 16 health posts in Shinille District are functional. The common problems among the two districts are shortages of vaccines, veterinary equipment and personnel. The private clinics and pharmacies in the areas provide complementary services to the public ones. The price of the private service providers is higher than that of the public clinics. However, the pastoral community uses private services when they cannot get some of the items from public service providers.

Production

Pastoralists rear shoats to sell as sources of income to meet the household's immediate cash needs, for milk production and to slaughter at home. Shoats also protect the selling of other household assets by generating income. When a household has problems that require cash, they first sell shoats. The major production activities are briefly described in this section.

Breeding

It is expected that pastoralists select breeding bucks/rams for their herd and manage these bucks properly. However, information obtained from focus group discussions with pastoralists reveals that Borana pastoralists do not select bucks for their goat herds and there is a shortage of rams. This is because of a high demand for yearling, uncastrated male goats in the market at better prices. Pastoralists take yearlings with good physical appearance to the market rather than maintaining them as bucks/rams in the herd. Moreover, one buck serves for over four years in a herd. This in turn brings problems of inbreeding. However, pastoralists indicated that they do not have any knowledge about inbreeding. Since bucks are herded mixed with does, there is no attempt to control mating.

There is a different scenario in Shinille District. Pastoralists in this area indicated that they select sheep and goat breeding stock by considering physical appearance, drought tolerance and milk yield. However, pastoralists in the area do not practice controlled mating for goats since bucks always stay with the flock. For sheep, controlled mating is practiced by the pastoralists. But this controlled mating is not for breeding-related reasons, rather it is because the pastoralists do not want sheep to reproduce during dry seasons as feed scarcity may cause abortion and death of lambs. However, as goats are browsers they can survive even when feed is not available. Similar to the pastoralists in Yabello District, knowledge about inbreeding and its drawbacks is limited among Somali pastoralists in Shinille District.

Feeding

Production of shoats in pastoral areas relies on grazing of natural pasture and browse species and the availability of these feed resources depends on availability of rainfall. There are two rainy seasons in Yabello District: the long rainy season (March-May) and the short rainy season (September-November). There is only one long rainy season (March-August) in Shinille District. As indicated in Figure 1, browses and pastures are more abundant during the long rainy season as compared to the short rainy season.

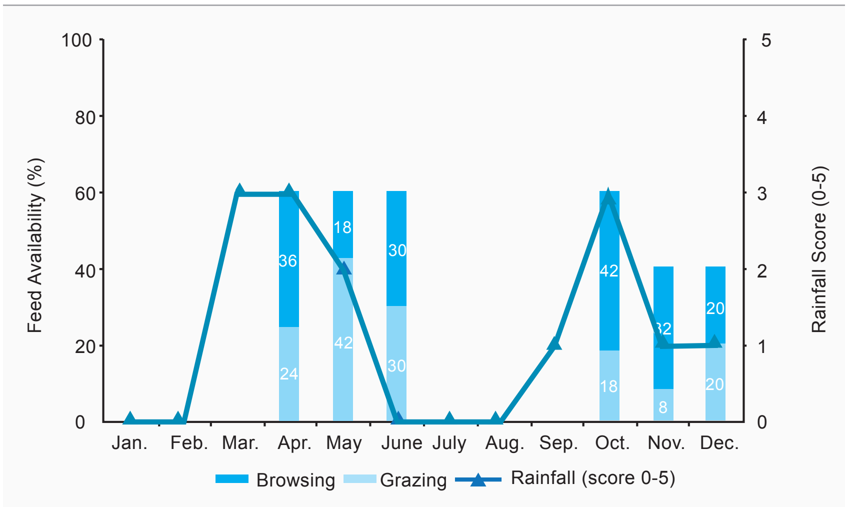

Figure 2a: Seasonal distribution of feed resources relative to the rainfall pattern in Yabello District

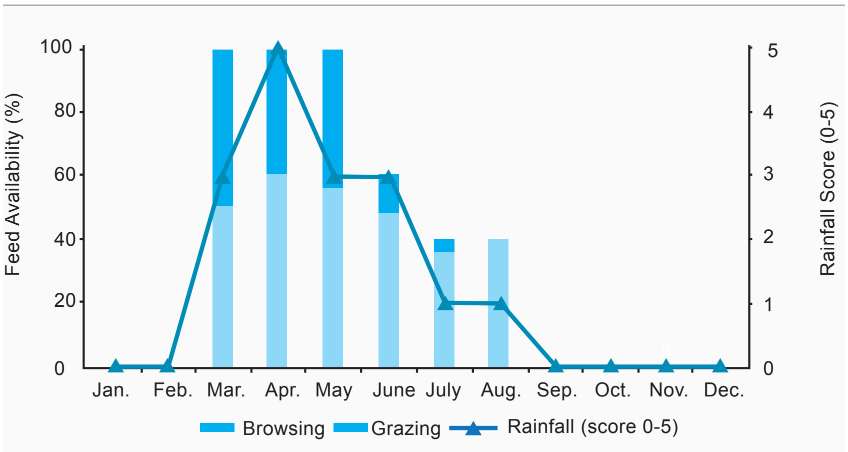

Figure 2b: Seasonal distribution of feed resources relative to the rainfall pattern in Shinille District

Grasses rejuvenate immediately after the first rain shower and the availability of feed improves within a short period of time, as long as there is a rainfall. The grasses and browses grown during the rainy season will support livestock for some months after the rain stops. However, this feed resource cannot support livestock year round; consequently, pastoralists use mobility as the major coping mechanism for feed and water shortages. This happens during the months when feed and rainfall availability is almost nil (See Figures 2a and 2b).

Housing

Shoats in the study areas are usually kept in fences that do not have roofing. In Yabello District, all types of animals, except kids, are kept in one house which is usually a fence with no roofing. Pastoralists build separate houses for kids and lambs known as dhokoba in Borana areas. Kids and lambs are kept in the dhokoba in order to protect them from being trampled and damaged by other animals, including bucks and does. Since pastoralists are producing shoat milk, it is also a mechanism to isolate the kids and lambs to prevent suckling so that pastoralists can harvest milk in the mornings. Households with small goat herds (an average of five) keep their goats within the main house of the household in order to protect them from predators and theft.

Pastoralists in Shinille District house mature does and ewes together, but they separate kids, lambs, bucks and rams. They separate the rams so that unwanted mating and reproduction of sheep will not occur when there is no grazing pasture.

Health care

The most common sheep and goat diseases in the study areas are cholera, Pest Petites Ruminant, copper deficiency and parasites, such as fasciola, ecto-parasites and shoat poxes and bovine brucellosis. Efficiency of animal health service delivery varies in the two areas. It is reported to be very weak in Shinille District as compared to Yabello District. Whenever animals get sick, pastoralists in Shinille District have two alternatives. The first alternative is to go to private pharmacies and purchase the common drugs with which they are familiar, such as Oxytetracyclin, Albendazole, Diazinone, etc., and treat their animals by themselves. Or they practice traditional treatment methods which are usually done using fire. These pastoralists believe that traditional treatment is less efficient as compared to modern treatment of animals, but they are compelled to use it as they do not have access to adequate veterinary services.

Milk production

Milk is produced from both sheep and goats, but only goat milk is consumed and marketed. Sheep milk is churned and converted to butter for sale. Milk production and productivity of shoats in the study area is affected by the availability of rain. During rainy season pastoralists obtain an average of 0.25-0.33 litres of milk per animal per day. Milking and milk marketing is undertaken mainly by women. The majority of shoat milk is consumed at home, mainly by children, because pastoralists believe that goat milk has very good nutritional value for children.

Processing

Processing of shoat meat in the study areas is mainly carried out by hotels and restaurants. Hotels and restaurants use shoat meat in a variety of dishes, including key wat (stews), tibs (roasted meat), dulet (fine chopped offal and red meat mixed with spices and butter) and wesla (a traditional Borana arrosto). Yabello District is one of the major sources of slaughter goats for export abattoirs in the Bishftu and Modjo area. The export abattoirs slaughter the shoats, remove the skins, chill the carcasses, wrap the carcasses in cotton fabric and transport the meat to the airport since exporters usually sell freight on board (f.o.b) at Bole airport. In addition, the export abattoirs export organs, such as testicles, penis, brain, intestine, kidney and liver, to other countries. There are firms specializing in the processing and export of intestines to other countries. The butchers in Addis Ababa, Hawasa and other big towns slaughter Borana goats and sell either the fried or raw meat in their premises or the carcasses are sold as take away to individual consumers. The supermarkets in Addis Ababa slaughter Borana goats and sell either the whole carcasses to hotels and restaurants or cuts of shoat meat, packed in various sizes. In Shinille District, shoats are mainly bought by Dire Dawa hotels, restaurants and individual consumers. Since Shinille District is closer to the border than to the centre of the country, shoats from there are channeled to the informal cross-border livestock trade rather than export abattoirs.

Consumption

Shoat meat is consumed by domestic and foreign consumers. Ethiopian shoat meat is exported mainly to the Middle East and North African countries. Because of the limited processing capacity of Ethiopian meat exporters, only chilled carcasses and organs are exported to these countries, targeting the lower-income immigrant groups. This is mainly because well-off people in Arab countries prefer better quality meat that is either freshly slaughtered on the spot or imported from Australia and other countries. Domestic consumers buy either raw meat from butcheries and supermarkets or buy live shoats and slaughter at home. Domestic hotels and restaurants serve domestic consumers with dishes made from shoat meat.

Support services

Extension services

The Oromia Pastoral Area Development Commission has zonal offices in all the pastoral areas of the region. Being one of the pastoral districts of the Borana zone, Yabello has a district office for pastoral development. This office has strong human resources relative to other pastoral districts. Each kebele also has three extension workers. There are animal health assistants and community animal health workers supporting the pastoralists in awareness creation, provision of vaccines and treatment of diseases. The livestock extension workers provide technical support to the pastoralists, but focus more on cattle and less on small ruminants.

Shinille District also has a crop and livestock development office at the woreda office. The number of staff at the kebele level is similar to that of Yabello District, and pastoralists are receiving technical support from these workers.

A common feature of the extension system in both districts is its gap in livestock marketing. Extension agents are lacking market information and knowledge to support the pastoralists. Thus, pastoralists rely on their own knowledge and experience, rather than expert advice in marketing their animals.

Credit services

Pastoralists in Yabello District obtain credit from three sources: the Oromia Credit and Saving Institution (OCSI), the Household Asset Building Programme (HABP) and their own credit and saving cooperatives. However, there was no micro-finance institution reported to serve pastoralists in Shinille District. The OCSI offers group-based loans that pastoralists take by forming groups of three to seven households. However, the terms and conditions of this credit do not consider the nature of animal production activities that need a longer grace period compared to crops. The maximum amount a pastoralist can get from this source is 2,000 Ethiopian birr in the first round. This amount increases by 20 percent if the pastoralist repays the first loan without any problem. The interest on this loan is 15 percent.

HABP credit is a type of credit extended to beneficiary households upon graduation from a Safety Net Programme to enable them to create assets. This credit is administered by financial institutions, such as OCSI, with close follow-up by the pastoral development offices. In order to be eligible for HABP credit, the pastoralist should produce a business plan with the support of the extension agent. The credit will be approved after the approval of the business plan by the district steering committee. The maximum amount of money that a pastoralist can get from the HABP credit programme is 4,000 Ethiopian birr and the interest on this loan is 10 percent per annum.

Pastoral community credit and saving cooperatives are established by community members. The source of their finance is members' contributions as share capital. Some non-governmental organizations supporting the community also provide seed money to such cooperatives. These community credit schemes are more flexible in serving the community as compared to OCSI and other institutions. However, the schemes usually have a shortage of capital to address the credit needs of their members.

The most important issue with regard to rural credit services is the level of understanding of the community about the terms and conditions. Since the credit institutions do not have sufficient staff, they could not reach the community and make them aware of the terms and conditions. Hence, most of the pastoralists are not clear what types of credit are available and what is required to get access to credit services.

Transportation services

According to the World Organization for Animal Health (OIE), animals should be transported in designated trucks that do not impede good handling. Animals should be provided with rest, food and water while in transport. Timely veterinary inspections and euthanasia (killing) should be done in a manner that minimizes the suffering of sick and injured animals. However, this is not respected in Ethiopia. A large proportion of the livestock reach markets by trekking all or most of the way (Kano, 1987). Thus, supply of live animals from the producers to the different categories of markets (primary, secondary and terminal markets) and slaughterhouses in the country is mainly carried out either by trekking or trucking or a combination of both.

Trekking is the predominant means of transporting animals from farm gates to the next nearby or primary markets. Though the primary livestock markets are the closest markets to the producers, the distance varies from place to place. In some places, the producers trek one to three hours to arrive at the primary markets to sell their animals. Most of the animals sold at the secondary markets are transported to the terminal markets and slaughter houses by truck. Ordinary trucks are the most widely used means of transporting live animals from the secondary markets to the terminal markets and slaughterhouses. However, such trucks are not suited for loading, unloading and transporting of animals.

Market information services

Though the Ethiopian Livestock Market Information System was tested and launched two years earlier, this system could not be sustained because of the weak institutional arrangements for data collection and transmission to the central system. The system was initiated and developed with support from externally-funded projects, and data collectors and transmitters were recruited from government offices. The projects were making additional payments to data collectors and transmitters on top of their regular government salaries as added incentive. However, this could not be sustained after the project phased out and data collection and transmission activities ceased and the system is no longer functional. If the system is to be re-started, there are issues that should be considered in terms of the dissemination of market information. That is, it has to be disseminated in the local dialects using FM radios to make it accessible to the pastoralists of the area. It is also important to consider the time of dissemination to be sure that pastoralists can give it due attention.

Marketing analysis of end markets

End markets determine the characteristics, including price, quality, quantity and timing of a product or service. End market buyers have a powerful voice and incentive for change. End market buyers are important sources of demand information, can transmit learning, and in some cases are willing to invest in firms further down the value chain (Campbell, 2008). End markets for shoats could be broadly classified as domestic and export markets. The characteristics of each of the major actors in the shoat value chain are discussed below.

Domestic markets

Domestic market demand can be categorized into demands by individual consumers, hotels, shoat butchers and supermarkets. An important development in the Ethiopian shoat value chain is the opening up of shoat butcheries and the retail of shoat meat in supermarkets of major towns. Goat meat was usually consumed in the lowland areas of the country, while highlanders used to focus on lamb. However, the shoat butcheries in Addis Ababa, Adama, Hawasa and other big urban areas have started serving goat meat. This is expanding to smaller towns too. This offers a very good opportunity for goat producers since it creates continuous demand for fattened goat. The price of goat meat is up to 160 Ethiopian birr/kg in butcheries, while it is 90-95 Ethiopian birr/kg in supermarkets. The higher price in butcheries is because of cost for the service and the freedom to select the parts to be cut depending on the consumer's preference. Supermarkets are also retailing shoat meat in pre-packed bundles. Both butcheries and supermarkets are slaughtering fattened male shoats. According to discussions held with a meat supermarket owner and manager, Addis Ababa consumers still prefer mutton to goat meat and the supermarkets slaughter more sheep.

The major consumers of sheep and goat in Ethiopia are domestic individual consumers. With the increase in population and improved household income, demand for shoat meat by individual consumers increases from time to time. This demand is highest during religious holidays, such as Easter, Christmas, New Year's and Ramadan, and it decreases during specific seasons of the year, such as the major fasting seasons for followers of Orthodox Christianity at which time livestock markets totally close in the highlands.

Export markets

Analysis of data from the Ethiopian Revenue and Customs Authority shows that Middle Eastern countries (12 countries) are the major market outlets for meat and live animals exported from Ethiopia. Among these countries, the lion's share of meat volume was exported to Saudi Arabia and the United Arab Emirates. Other destination markets for Ethiopian meat are Egypt, Yemen, Kuwait, Oman, Bahrain, Congo, the Democratic Republic of Congo, Turkey, Vietnam, Angola, Comoros Islands and India. Egypt, Angola, the Democratic Republic of Congo, Congo and Comoros Islands are beef markets, whereas Vietnam and Turkey are destinations for offal.

In general, although quality requirements vary, the shoat export market generally requires animals having the following characteristics: male, young (1-2 years) and with a live weight of 12-30 kg. The export market prefers non-castrated shoats with good body fat coverage, whereas the domestic prefers castrated males or female animals (Getachew et al., 2008). As indicated above, the most important markets for Ethiopian chilled shoat carcasses are the United Arab Emirates and Saudi Arabia. These markets have specific requirements, especially in terms of carcass weight. The United Arab Emirates market needs goat carcasses of 5-10 kg; this means the slaughtering animals should be 13-25 kg live weight. On the other hand, the Saudi Arabia market needs larger shoat carcasses (7-12 kg), which in turn requires slaughtering shoats of 16-30 kg live weight.

Despite the challenge of repeat trade bans, the Gulf States are currently the primary target destinations for Ethiopian meat exports. Within these countries, competing exporters include Australia, Brazil, India, New Zealand and Pakistan. Ethiopian meat sells at the lower end of the market in the importing countries. The market is segmented according to incomes, with higher-income populations preferring freshly slaughtered meat, while lower-income populations (particularly low-income expatriates) opt for low-cost meats that are usually frozen. This is the segment of the population that consumes chilled Ethiopian shoat carcasses.

Marketing channels

A marketing channel is an organized network of agencies and institutions which in combination perform all the activities required to link producers with consumers to accomplish marketing tasks (Bennet, 1988; as cited by Jaleta, 2011). Only a small portion of goods and services is consumed at the point of production and only a small fraction of any output is purchased by the ultimate consumers directly from the final producers (Jaleta, 2011). Thus, a marketing channel is a marketing process that performs several functions by bridging the gap between production and consumption. The analysis of marketing channels provides a systematic knowledge of the flow of goods and services from their production areas to the final market or end users.

Marketing of shoats in the study areas starts with the collection of goats of different classes and ages from production areas moving on to the end markets (Figure 3). In the process, animals pass successively through a variety of market actors before reaching the end users. The number and type of market participants differ along the different market channels. The various channels represent the available outlets in the areas through which sheep and goats move. Fourteen major shoat marketing channels are identified for animals originating from the study areas. The major marketing channels for animals from the study areas could be categorized into three groups:

Major marketing channels for domestic consumers:

- *Channel 1: Producers → Local hotels*
- *Channel 2: Producers → Collectors → Local Hotels*
- *Channel 3: Producers → Producers (for breeding purposes)*
- *Channel 4: Producers → Collectors → Individual consumers*
- *Channel 5: Producers → Collectors → Small traders → Supermarkets and butchers*
- *Channel 6: Producers → Collectors → Cooperatives → Individual consumers*

Major marketing channels for shoat meat exports:

- *Channel 1: Producers → Collectors → Small traders → Big traders → Export abattoirs*
- *Channel 2: Producers → Collectors → Small traders → Export abattoirs*
- *Channel 3: Producers → Collectors → Big traders → Export abattoirs*
- *Channel 4: Producers →Small traders → Export abattoirs*

Major marketing channels for live goat exports:

- *Channel 1: Producers → Collectors → Small traders → Big traders → Live shoat exporters*
- *Channel 2: Producers → Collectors → Small traders → Live shoat exporters*
- *Channel 3: Producers → Collectors → Live shoat exporters*

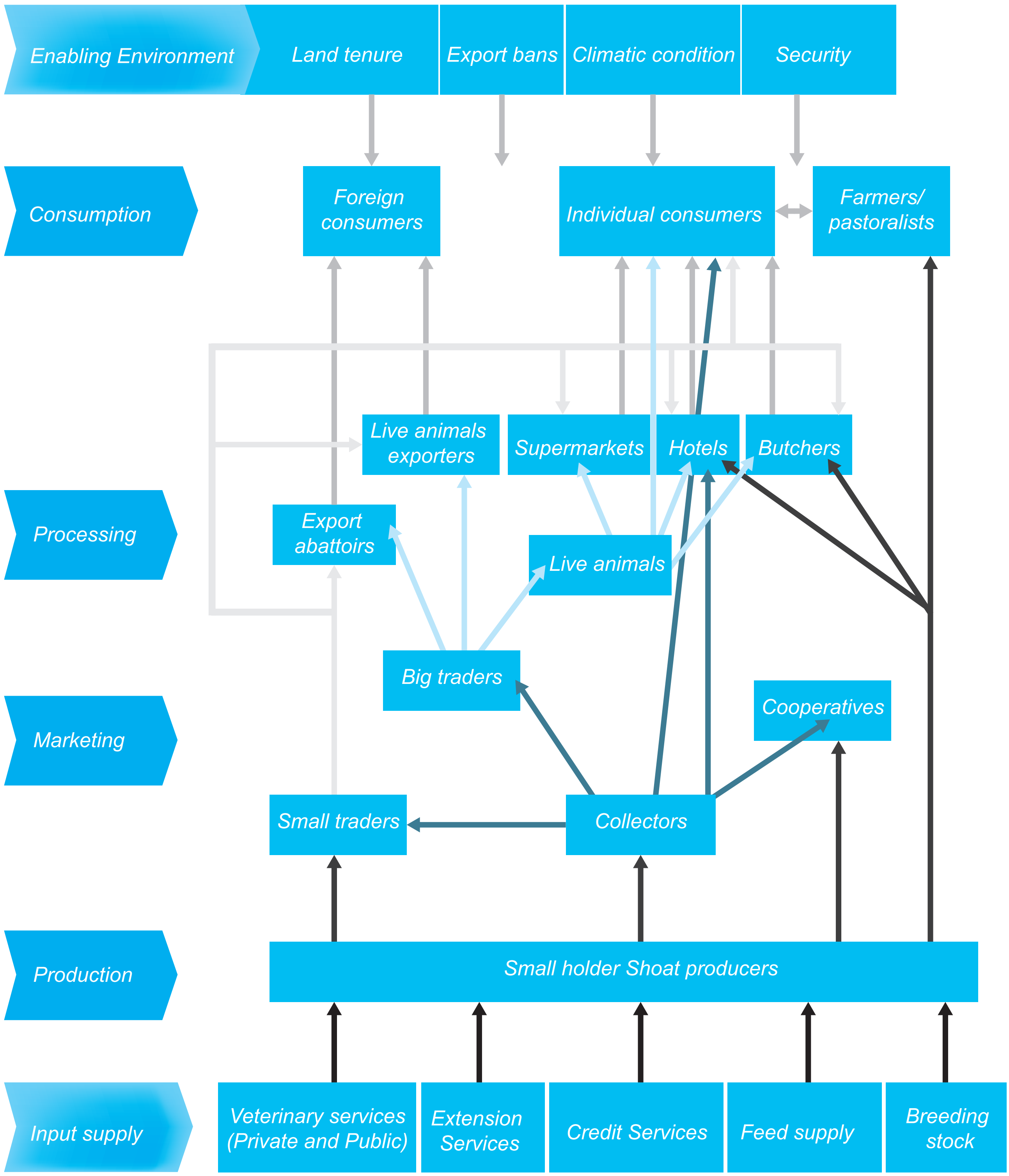

Figure 3: Value chain map for shoats produced in the selected intervention areas

The marketing channels are further described below.

1) Major marketing channels for domestic consumers

- *Channel 1: Producers → Local hotels*

Local hotels and restaurants are one of the few actors that have a chance to buy live goats from the pastoral producers. They can either buy at Yabello/Shinille market or go to rural markets in search of animals. Both producers and the hotels would benefit from this transaction. Since there is no involvement of intermediaries, this is the shortest possible channel and the margin that could have been taken by the intermediaries would be shared by the two parties.

- *Channel 2: Producers → Collectors → Local hotels*

In this channel, collectors are involved in selling goats to hotels, either in the market or at the hotel gates. Collectors can make 20 – 50 Ethiopian birr in this transaction. Their marketing cost is mainly the tax paid at the market gate if they buy animals in the market.

- *Channel 3: Producers → Producers (for breeding purposes)*

As indicated in the input supply section, the pastoralists get replacement stock from the market. Pastoralists usually buy from producers whom they know so that they can get the history of the animal. After the drought seasons, collectors and small traders also collect animals that could be used for restocking purposes and sale them to non-governmental organizations that will distribute them to pastoralists.

- *Channel 4: Producers → Collectors → Individual consumers*

Individual consumers in the study areas also have a chance to buy directly from producers. However, since the consumption pattern of individual consumers is seasonal according to religious holy days, individual consumers usually buy from collectors. This is because collectors are able to bring a substantial number of the required types of animals at these times.

- *Channel 5: Producers → Collectors → Small traders → Supermarkets and butchers*

Some supermarkets in Addis Ababa have permanent suppliers from Borana markets. These suppliers are small traders that usually supply animals to export abattoirs. These suppliers buy bigger shoats with good body conditions for supermarkets. They also supply similar animals to butchers in bigger towns, including Addis Ababa, Dire Dawa and Hawasa.

- *Channel 6: Producers → Collectors → Cooperatives → Individual consumers*

Shoat slaughter cooperatives in Shinille town are buying sheep and goat from producers and collectors, slaughtering them and retailing the shoat meat in their retail outlets. This is an important source of meat for the community living in and around Shinille town.

2) Major marketing channels for goat meat exports

These marketing channels are only for Yabello District. According to information obtained from focus group discussions with pastoralists and key informant interviews with traders in Shinille District, the area does not supply animals to export abattoirs. This is related mainly to competition from the informal cross-border livestock trade, since the area is closer to the border than the export abattoirs and the informal market pays better than the formal channels. The major marketing channels serving goat meat exports are:

- *Channel 1: Producers → Collectors → Small traders → Big traders → Export abattoirs*

This is a channel whereby some export abattoirs provide premium prices to big traders that can supply thousands of animals a week. Big traders in such cases establish huge networks of small traders and collectors in all corners of the country, including Borana markets, and collect as many shoats as they can. Small traders hand over animals to big traders since they cannot receive a premium price if they supply directly to the abattoirs because of their smaller quantities.

- *Channel 2: Producers → Collectors → Small traders → Export abattoirs*

This is the channel in which export abattoirs buy from any supplier that can supply at least a truck load of animals at the factory gate. In most cases, two or more small traders buy goats and share an ISUZU truck to take their animals to the abattoirs. There is no premium price in this channel since abattoirs have to deal with a number of small traders.

- *Channel 3: Producers → Collectors → Big traders → Export abattoirs*

Some big traders in Yabello District have a network of collectors that buy goats on a commission basis and supply thousands of animals a week to export abattoirs. These traders are also buying for live animal exporters. Big traders provide advance payment to collectors so that they can collect large numbers of animals at a time. The collectors working for these traders are usually relatives and long-standing customers that have built trust through honest performance with traders.

- *Channel 4: Producers → Small traders → Export abattoirs*

Pastoralists sell about 37 percent

of their marketed animals directly to small traders. These traders sell 16 percent of their goat trade volume to export abattoirs. As indicated in channel two above, two or more of such traders fill a truck and send the animals to export abattoirs.

Major marketing channels for live goat exports

- *Channel 1: Producers → Collectors → Small traders → Big traders → Live shoat exporters*

This is the longest channel to live shoat exporters with the involvement of many intermediaries. Some live animal exporters establish a network of collection in different parts of the country assigning all traders and collectors. This is used to collect the required number of animals within a very short period of time. Since the operation is usually to collect animals that will be used for sacrifice at the hajj ceremony, exporters have to collect a huge number of animals for the event.

- *Channel 2: Producers → Collectors → Small traders → Live shoat exporters*

Some small traders that have sufficient capital and a strong network of collectors buy the animals on their own and supply them to live animal exporters. This involves more risk since the traders keep the animals with themselves and there is high incidence of mortality. However, the small traders can benefit if they keep animals for a longer number of days and there is weight gain.

- *Channel 3: Producers → Collectors → Live shoat exporters*

Live animal exporters also establish their own network of collectors in addition to the animals they buy from small and big traders.

Actors in the shoat value chain

According to the value chain analysis framework, the actors in the value chain refer to those individuals or entities who engage in a transaction which moves a product from inception to end use. Actors must exchange money (or an equivalent service) as well as a product, which generally increases in value with each transaction (Campbell, 2008). The primary actors common to the livestock value chains in the study areas are producers (farmers), brokers, collectors, small- and large-scale traders, hotels, supermarkets, butchers, export abattoirs and individual consumers. Analysis of the characteristics of these actors and their marketing strategies helps in designing intervention measures suitable to overcome the major causes of high transaction costs and other factors that depress the proportion of the final shoat price that reaches producers. The characteristics of each of the actors are described below.

Export abattoirs

Yabello District is one of the major sources of goats for export abattoirs. These abattoirs are located at Bishoftu and Mdjo towns. Five out of the seven export abattoirs found in the country are located in these towns and these five abattoirs are buying animals at the factory gate. Their suppliers are mainly small and big traders. However, abattoirs buy from any person that can supply a minimum of 100 goats at a time. In order to deal with fewer suppliers and to encourage supply of large number of animals per trader, some export abattoirs provide premium prices to their customers that can supply thousands of animals a week. Each of the export abattoirs slaughters 2,000 goats a day on average and exports chilled shoat carcasses to Middle Eastern and North African countries. Some of them have opened domestic outlets for their meat in Addis Ababa. However, their major outlet is the export market. In order to encourage their suppliers, export abattoirs provide transportation services at cost for animals that are supplied to their plants. This is using ordinary ISUZU trucks. The time of payment varies by abattoir; some pay immediately, while others pay within two weeks.

Live animal exporters

Live animal exporters sell sheep and goat mainly to Saudi Arabia during the Arefa season for sacrifice at the hajj ceremony. For this purpose, live animal exporters need male, un-castrated shoats. Unlike the export abattoirs, live animal exporters need animals of larger live weight. The live animal exporters collect such animals from all corners of the country and export them mainly through the port of Djibouti. Since the temperature in Djibouti and all along the way to Saudi Arabia is very high, live animal exporters need animals from lowlands that can tolerate high temperatures. Thus, pastoral and agropastoral areas are the major sources of animals for live animal exporters. The collection of animals from these areas is through a network of traders and collectors reaching to remote areas that are far from markets. Such traders and collectors can go into the borders of neighbouring countries, such as Kenya, in search of export quality animals. However, their work is seasonal since Arefa is celebrated only once a year.

Cooperatives

There is a slaughter cooperative operating in Shinille town. This cooperative has a modern slaughter house and meat retail shops that have been built with assistance from USAID with the purpose of encouraging marketing of safe meat to the surrounding community. This project has also supported creation of employment opportunities for members of the cooperative and better market opportunities for shoat producers. The slaughter cooperative slaughters shoats in its own slaughter house and retails the raw meat. It is the major supplier of meat to Shinille town. This cooperative purchases 80 percent of its slaughter animals (shoats) from pastoralists and the remaining 20 percent from collectors. When there is a shortage in the supply of shoats, the cooperative collects animals from different areas, like Shinelle, Bisle, Harey and Ali Gur.

According to information obtained from the Yabello District office of cooperatives promotion, there are 90 primary cooperatives in Yabello District, out of which six are livestock marketing cooperatives. These cooperatives are organized based on the willingness of members using members' contributions as share capital. Some of them receive small amounts of money (up to 30,000 Ethiopian birr) as a revolving fund from some non-governmental organizations. These cooperatives are marketing shoats, cattle and camels, depending on the size of their working capital and the availability of demand for the species of animals. They buy both from members and non-members. Some of these marketing cooperatives tend to be actively involved in restocking programmes by supplying replacement stock from markets. There were efforts to engage the cooperatives in commercial destocking of animals during drought seasons. However, it was not a successful operation because of financial arrangements and other administrative issues.

The activities of cooperatives are run by the committee elected from members rather than employed professionals. Thus, lack of entrepreneurship skills, poor market linkages and non-transparency in management are their major problems. Heterogeneity of membership and the resulting conflict of interest is another problem hindering development of cooperatives in pastoral areas. Members of cooperatives are usually pastoralists organized willingly by contributing share capital. However, there are collectors that have better entrepreneurship qualities than other cooperative members. Such people are the ones that usually become leaders of the cooperative. At the initial stage they tend to run the cooperatives smoothly and members become convinced in their work. However, as time goes on and they get better linkages, some management members start doing their own business in the name of the cooperative. This channels the benefits of the cooperative to individual pockets while the cooperative takes all the marketing risks. Moreover, since cooperatives lack flexibility and their operation costs are very high compared to individual traders, cooperatives are less competitive in the market. Several government and non-governmental organizations operating in pastoral areas have created market linkages between export abattoirs and pastoral livestock marketing cooperatives. However, none of the cooperatives were found to be competitive and they could not continue in the business of supplying shoats to export abattoirs mainly because of the above mentioned problems.

Butchers

Butchers both in the study areas and bigger cities, such as Addis Ababa, Dire Dawa, Hawasa, Shashemene and Adama, slaughter goats and sell raw meat or roasted take-away meat. Butchers prefer fattened, castrated goats of 40-45 kg body weight. They do not slaughter female goats because of their higher fat coverage that makes their meat lighter relative to meat from male goats since they sell based on weight (kg). Butchers buy animals from small traders and retailers and the number bought at a time varies according to their market size.

Two types of butchers are operating in Dire Dawa town (the major consumer of Shinille goats). The first is the one serving the high-income groups of society. This type of butcher slaughters fattened male goats and serves both fried and raw goat meat on their premises. Since butchers have to rent houses in business centres to be accessible to most of their customers and they have to hire labour to provide the service, they charge higher prices. The other group of butchers are found in a market place called Melka Chebtu. There are hundreds of butchers in Melka Chebtu serving raw goat meat to lower income groups. These butchers slaughter any type of sheep and goat and the price is lower, as compared to the first group.

Supermarkets

Supermarkets are mainly found in big cities like Addis Ababa. Apart from shoat meat, supermarkets sell beef, chicken, pork and dairy products. They slaughter animals of different live weight depending on their customers' needs. Supermarkets mainly slaughter male sheep of 40-45 kg. In addition to packed meat, supermarkets sell carcasses to restaurants and hotels on a contract basis. Their prices are usually less than the butcher's price, but they increase according to the carcass weight needed by their customers. Supermarkets charge higher prices for carcasses of larger weight. They usually sell carcasses of over 12 kg to restaurants.

Supermarkets slaughter animals in municipal slaughter houses and do the cutting and packing on their premises. Since meat cutting and packing demands special skills, they hire one or two skilled persons (in cutting and packing for retail outlets) and let them train other workers. Supermarkets have cold rooms, deboning and packing facilities.

Hotels and restaurants

Hotels and restaurants in the study areas and in bigger towns and cities buy mainly female goats and process them into a variety of dishes. Hotels and restaurants usually buy old ewes and does because they perceive that such animals have larger proportions of meat (Legese et. al, 2008) and are cheaper. Hotels and restaurants in Yabello town buy from pastoralists and collectors and slaughter male yearlings to process them into wesla (the Borana traditional arrosto). Hotels and restaurants outside of production areas buy mainly from small traders and retailers. Some hotels and restaurants in Addis Ababa buy carcasses from supermarkets on a contractual basis.

Individual consumers

Individual consumers are livestock market actors that buy either live animals or meat for their own household consumption. Individual consumers buy live shoats from traders, collectors and pastoralist producers. They buy raw meat from butchers and supermarkets on a kilogram basis.

Individual consumers buy live shoats to slaughter for Ethiopian New Year, Christmas, Easter, Ramadan and some other special occasions. Though it varies with household income, they usually prefer fattened male shoats (mukit). Colour is an important criteria for individual consumers when selecting shoats in the market. Most consumers prefer a white-brown colour, whereas black is less preferable. There is a price difference of up to 100 Ethiopian birr per animal based on colour. Individual consumers usually want to buy from producers because they know that the price of animals is lower when buying from producers. In the bigger cities, individual consumers buy from any seller.

Pastoralists are both the buyers and sellers of shoats. Pastoralists usually buy young female shoats for breeding and sell male yearlings, old does and ewes and fattened shoats to other value chain actors.

During normal seasons, pastoralists sell shoats to meet their immediate need for cash and to maintain larger animals. However, the reverse is true during drought seasons or when they expect drought. In such cases, pastoralists first sell young cattle (young bulls, steers and heifers) since these animals are the most affected by drought. Goats are maintained to be sold during a severe drought season to buy food for the household and feed for larger animals.

Market information is scarce among pastoralists. In order to get market information, at least one person, either from the family or the neighbour, has to go to the market. Though it is not reliable, pastoralists try to get information from collectors (that are usually pastoralists). Though collectors go to villages to buy shoats, the preferred buyers for pastoralists are small and big traders. If possible, pastoralists try to go to the market and sell directly to traders since they believe that traders offer better prices than collectors.

Collectors

Collectors are important livestock market actors who collect animals from their own areas and from remote pastoral areas, reaching as far as the borders of neighbouring countries. Collectors are usually pastoralists themselves and collect animals as a sideline business activity. The have better social ties with pastoralists relative to other traders and also serve as sources of market information for pastoralists. However, they may distort the information for their own personal benefit.

Collectors operate using their own capital. However, they usually face financial constraints and try to get advance payments from small and big traders (their customers). They collect up to 20 animals at a time and sell them to small and big traders. Collectors usually earn a margin of 50 to 100 Ethiopian birr per animal, depending on the place of purchase and season. Collectors get higher margins if they buy animals from remote areas that do not have access to markets. During Ramadan and Arafa, collectors get better margins and have a higher market turnover because of the high demand for meat in Middle Eastern and North African countries.

Small traders

Small traders are those market actors that supply hundreds of animals every week either to big traders or to export abattoirs. Small traders also supply to hotels, butchers and retailers in Addis Ababa. They have their own network of collectors. The number of small traders is smaller than that of collectors and larger than that of big traders. Small traders usually operate using their own capital and sometimes receive advance payments from their buyers (big traders). Most of the small traders in Yabello District are doing shoat trading as a sideline business. They are involved in cattle trading and other business activities in addition to shoat trading. Small traders go to primary and secondary livestock markets and buy from pastoralists and collectors. The supply agreement between small traders and collectors is on a trust basis, with no formal contract signed between the two parties.

Big traders

Big traders are those livestock market actors that supply thousands of shoats to export abattoirs a week. Big traders operate using their own capital and are permanent suppliers to abattoirs. In order to ensure a continuous supply of a very large number of quality animals, some export abattoirs offer a premium price to big traders. This encourages the abattoirs to deal with a few large suppliers rather than many small traders and simplifies their administrative activities. Big traders in turn arrange a supply network with many small traders and share the premium price with them so that small traders supply to big traders getting their normal price plus part of the premium that big traders are getting. This creates a win-win situation for all three parties (abattoirs, big traders and small traders).

Big traders simply stay at Modjo (a town 70 kilometres from Addis Ababa, where there are a number of export abattoirs) and communicate with small traders, transfer money to their suppliers (small traders and collectors) through banks, receive animals from different corners of the country, let the animals rest for two or three days and then hand them over to the abattoirs. They go to secondary markets to coordinate the activity of their suppliers. They provide market information to their respective suppliers about the prevailing market price, type of animals and number required.

There are also big traders in Yabello town that have a network of small traders and collectors that operate throughout Boranaland. The big traders in Yabello town supply goats both to live animal exporters and export abattoirs. They also trade cattle and camels, depending on the availability of market demand for these species of animals. Big traders in Yabello stick to shoats trading because of a continuous unsatisfied demand for goats by export abattoirs. Some traders that we talked to during the field survey indicated that some of the export abattoirs delay their payments and this holds up their operating capital. However, they continue supplying to such abattoirs mainly because these abattoirs accept animals of lower quality as compared to others.

Most of the traders in Shinille town are small traders that supply shoats to the Dire Dawa market. They also collect animals for live animal exporters during the hajj season.

Brokers

Brokers mediate transactions between buyers and sellers. The activity of brokers varies from place to place. In weight-based transactions of male yearling shoats, mostly in the Borana area, their task is to channel greater numbers of sellers to a given buyer. In such cases, brokers do not have a role in influencing the price of a kg of live weight of animal for individual sellers. On the other hand, in Somali markets, where brokerage is based on the clan structure of society, brokering plays a pivotal role in livestock marketing. In such areas, no transaction takes place without the involvement of brokers. In these markets, apart from their influence on the price of animals, brokers provide a guarantee to buyers of the trustworthiness of the seller and will take responsibility if the animal is found to be stolen.

Relationships

Vertical linkages

The general pattern in shoat markets of the study areas is for producers to sell to different traders each time they go to the market, and for animals to change hands up to six times by the time they reach the final consumer. Thus, there is no vertical linkage between producers and any buyer in the shoat value chain. Even the most frequent buyers in the shoat markets do not have any contractual supply agreement with producers. Thus, there is no strong relationship and trust between buyers and producers. This is mainly because the production system is not market oriented and pastoralists are not following market demand and the quality requirements of important market actors. This challenges the competitiveness of the entire meat industry. As a result, there is low level of transfer of skills and knowledge from the buyers to producers. This keeps the production system continuing as it is.

The relationship between collectors and small traders, collectors and hotels, collectors and butchers has some sort of complementarity since there is a kind of long-standing mutual relationship between them. These relationships are based on trust without any formal contract. Collectors can sell shoats on credit to small traders and hotels and also take advance payments without any formal signature. This strengthens their relationship and also provides an opportunity for all actors to expand their business activity.

Horizontal linkages

Horizontal linkages, both formal as well as informal, between firms at all levels in a value chain can reduce transaction costs, create economies of scale and contribute to the increased efficiency and competitiveness of an industry. In addition to lowering the cost of inputs and services, horizontal linkages can contribute to shared skills and resources and enhance product quality through common production standards.

The livestock marketing cooperatives in the study areas are the basis for the horizontal linkages among pastoralists. These cooperatives are meant to boost the bargaining power of pastoralists and safeguard their members. However, because of their weak financial position, shortage of business skills and the lack of transparency among most of the cooperatives, they could not achieve their intended targets. Cooperatives are not strong enough to satisfy the interests of their members. Since they do not have good business skills, cooperatives are not competitive with individual traders. For instance, several of the cooperatives in the area signed agreements with export abattoirs but could not supply slaughter animals as per the terms of the contract while individual traders were able to do so.

While there is a vertical linkage among traders in the shoat value chain, a limited level of horizontal linkages are found among the export abattoirs and small traders. The export abattoirs have an association, the Ethiopian Meat Producer-Exporters Association. This association is the common platform for export abattoirs that protects their interest. The association fixes floor export prices, lobbies for better services at the airport and for policy changes and communicates with the government. The export abattoirs also share air cargo space, which would be prohibitively expensive if they had to individually charter cargo planes in their current scale of operation. On the other hand, export abattoirs are competing with each other in terms of supply of slaughter animals and buyers.

The horizontal linkages among small traders are primarily the use of common trucks for transportation of shoats to the next market level. Since small traders collect low numbers of shoats from different markets, it is not economical to hire a truck on an individual basis. Thus, small traders share trucks to transport shoats to either Modjo or Bishoftu. This reduces their transaction costs and improves their efficiency.

Governance in shoat value chain

The major buyers of shoats in pastoral areas are traders supplying animals for export abattoirs. These abattoirs buy specific types of animals for a variety of markets. Thus, product quality, volume and price are all determined by these export abattoirs and they in turn are governed by their customers in Middle Eastern markets. Export abattoirs increase prices when they need to supply huge volumes of meat within a short period of time, like during the Ramadan fasting season. Thus, market power concentrates at the higher end of the value chain (export market) and influences the types of animals to be supplied and prices of products. Since the nature of animal production in pastoral communities is not based on market demand and marketing is driven by immediate demand for cash rather than market signals, pastoralists remain price-takers, as compared to traders.

Constraints along the shoat value chain

This study has identified natural, technical, economic, legal and institutional constraints hindering the development of the sheep and goat value chains in the study area. These constraints will be described under each stage of the value chain.

Constraints at input supply stage

Shortage of breeding bucks

Yabello District is the major source of slaughter animals for export abattoirs. Young, un-castrated male shoats having good body condition are the most important animals for this purpose. Such animals fetch better prices for the pastoralist. As a result, pastoralists sell vigorous male yearlings that could be used for breeding purposes and the herd is usually left without breeding rams and bucks. Since male yearlings fetch better prices and sell immediately, weaker rams and bucks are left in the herd. Pastoralists borrow rams and bucks from their neighbours. One ram or buck is expected to serve several does.

No selection of breeding bucks

Though pastoralists in general have a wealth of experience in livestock breeding, they give less attention to goat breeding. Pastoralists do not select breeding bucks for their herds, do not understand the problem of inbreeding and will let one buck serve a herd for over four years. Bucks of unwanted colour, body size and those from mothers of low milk yield and low prolificacy are maintained in the herd since nobody is monitoring the issue.

Shortage of veterinary equipment and drug supply

Oromia Regional state has allocated a revolving fund for drug supply to each of its districts. This fund is serving its intended purpose in Yabello District. Since the revolving fund does not include a budget for procurement of clinical equipment, there is a serious shortage of budget to procure equipment in Yabello District. In Shinille District, there is no revolving fund for veterinary drugs and clinical equipment and a shortage of these items.

Thus, health posts and clinics in the study areas are suffering from shortages of drugs and clinical equipment. More specifically, shortages of clinical equipment in Yabello District and that of both vet drugs and clinical equipment in Shinille District.

Shortage of vaccines

Vaccination is one of the most important activities of district veterinary service units. District veterinary services provide vaccines for diseases, including Contagious Caprine Pleuropneumonia, Pest Petites Ruminant and goat pox. However, the amount of vaccines allocated for the district is not covering the number of animals in the district. This implies that the vaccination programme cannot meet its intended objective. This could be because of the volume of vaccines produced at national level or a problem in the distribution system.

Problem in maintaining cold chain for vaccines and provision of dead vaccines

The vaccines used in the study areas are transported for about 575 kilometres and are supposed to be maintained in the cold chain until given to animals. However, due to various reasons, including the quality of equipment used for this purpose, veterinary professionals in the area expressed worry about the problem of maintaining the cold chain of vaccines. This needs further investigation to identify the exact causes of the problem and in order to take appropriate action.

Vaccines provided for unidentified strains

To ensure the efficacy of vaccines it is important to first properly identify the strain of a disease before providing the vaccines. The veterinary professionals consulted during the field survey indicated that the strains of the diseases were not being properly identified. Vaccines provided without pre-identification of the strains have a high chance of failure.

Poor enforcement of veterinary service regulations

Though informal selling of veterinary drugs is forbidden by government regulations, it is common to see informal drug sellers availing drugs in the study areas. The problem with this system is that such sellers do not feel responsible and sell the drugs to anybody. The efficacy of drugs sold via this channel is another challenge. Since the sellers are not professionals, they can sell drugs from an unknown source and with an unknown level of efficacy to pastoralists. Such drugs are sold in ordinary commodity shops, human pharmacies and in an open market around the livestock markets. In a nutshell, there is a problem with the enforcement of government regulations on the informal sale of drugs.

Shortage of transportation facilities for vet service providers

One veterinary health post is built to serve three kebeles and one health assistant is assigned to each of these health posts. Since the kebeles are geographically large, some pastoralists have to travel up to three hours to reach a health post. In cases when animals are very sick and cannot walk to the health post, the pastoralist requests a health assistant to come to his domicile to help the animals. However, since health assistants do not have transportation, they fail to provide mobile services. If the health assistants try to reach some places on foot (since most areas do not have access to public transportation), it takes them a very long time and this influences the regular services at the health posts.

Problems with flexibility of terms, group collateral and loan size

As indicated in the input supply section, credit is available to the pastoralists in Yabello District through the Oromia Micro Finance Institution and Household Asset Building Programme (for safety net beneficiary households). However, to get credit from a micro finance institution one needs to have group collateral and most pastoralists do not want to enter such an arrangement. This is in order not to repay for defaulters in the group. Moreover, the amount of money obtained from this source is not enough for livestock activities. The repayment modality of this system also does not provide enough of a grace period for livestock rearing activities.

Constraints at the production stage

Feed shortages in times of drought

The pastoral livestock production system relies on grazing pasture for cattle and sheep and browsing of bushes for goats and camels. Pastoralists practice traditional feed conservation practices, such as preservation of standing pasture for calves and lambs during the drought season. However, they do not harvest these feed resources for use during critical drought seasons. Thus, feed and water shortages during drought seasons are very critical and pastoralists need external supplies of feed during such times.

Lack of awareness on improved shoat production and management practices

Despite the wealth of experience they have in livestock production and management, pastoralists are still using traditional methods. The extension system does not provide any training on improved shoat production and management practices. This is one of the major challenges in developing shoat value chain in the study areas.

Lack of a practice to provide supplementary feed to shoats, even in times of drought

Shoat production in the study areas relies on grazing of natural pasture and browse species. Though supplementary feeding is becoming a common practice for cattle, especially during drought, this does not apply for shoats. Shoats are not provided with any supplementary feed, even during drought seasons.

High incidence of diseases and parasites

According to the information obtained though discussion with district offices of pastoral development and private veterinary service providers, there is a high incidence of diseases, such as Contagious Caprine Pleuropneumonia, goat pox, Senorosis and parasites, such as ticks, lice, mengmites and hemoncus. The incidence of these diseases and parasites in the area contributes to the low productivity of shoats. The government is putting many resources into supporting the pastoral community to protect their livestock from these diseases. However, given the magnitude of the problem, more still needs to be done.

Poor animal housing

Pastoralists in the study areas use open top houses and fences for their animals. Shoats are housed mixed with other animals. This predisposes them to be trampled on by larger animals and to be physically damaged. It also has an impact on the productivity of shoats.

Short shelf life of milk due to poor handling and management, lack of improved or standard milk containers and equipment

Sheep and goats are both milked, but only goat milk is marketed. However, the handling and management during production and marketing of milk are poor in terms of hygiene and standards are lacking. Plastic jerricans are used as milk containers, which are very difficult to thoroughly clean inside. These things combined cause shoat milk to have a short shelf life and be of poor quality.

Constraints at the marketing stage

Lack of formal livestock market information

Pastoralists in the study areas do not have access to formal sources of livestock market information. Livestock market information used to be collected from Harobeke and Elweye markets and the database was accessible through sms messaging. However, this has been discontinued due to problems with institutional arrangements for data collection and dissemination. The district offices of pastoral development did not take this as their main task. The data used to be collected by experts in the same office who were paid a fee for their extra effort for data collection and transmission. However, this could not be sustained because the projects supporting this activity phased out. In addition to data collection and dissemination, the mode of data dissemination needs to be reconsidered. Pastoralists may not be able to use sms messages to get market information.

High transaction costs due to distance to markets

Livestock markets are found scattered over pastoral areas. As a result, pastoralists have to trek their animals for over three hours to reach the livestock markets. This causes weight loss and fatigue in their animals. This in turn reduces the price of the animals.

Non-uniform methods of selling (weighing scale vs. visual estimation)

Both visual estimation and weight-based transactions are used in shoat markets. Weight-based transactions are used for male yearlings that are sold to export abattoirs while other categories of animals are sold using visual estimation. The problem with using a weight-based transaction is that it is not uniformly used throughout the value chain. Collectors buy using visual estimation and sell the animal to small and big traders on a live weight basis. The issue here is that when buying, collectors try to suppress the price as much as possible to keep it below the price received when selling on a live weight basis. This impedes the transmission of price incentive from the end market to producers.

Clan conflict

Pastoral areas are home to different clans and ethnic groups. Conflicts usually arise because of competition over resources, such as the limited grazing land and water. Whenever there are conflicts, markets get disrupted and the supply of animals to the markets decreases dramatically. On the other hand, buyers feel insecure going to such markets. Figure 4 below compares shoat transactions recorded in Borana markets during a period with clan conflict (July to December 2006) and a period without conflict (July to December 2005).

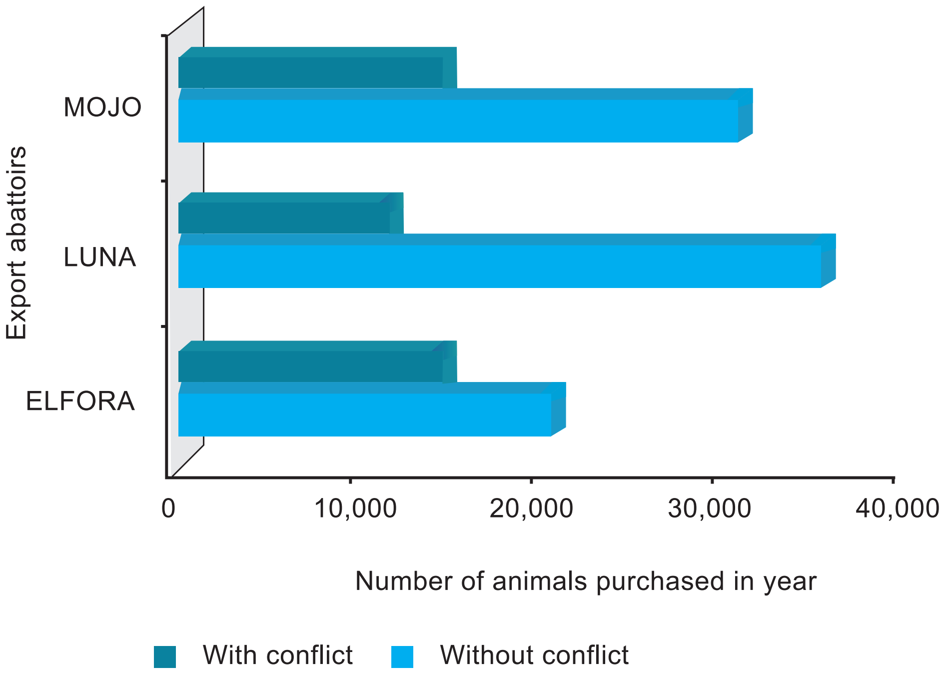

Figure 4: Comparison of shoats transactions during a period with clan conflict (July to December 2006) and without conflict (July to December 2005)

Source: Legese et al., 2008

During the period with clan conflict, there was a drastic decrease in the number of animals procured from the Borana livestock markets as compared to the same period a year earlier in the same markets without conflict. The difference can be over a 50 percent reduction in the number of animals procured by some of the export abattoirs. This shows the damage of clan conflicts on livestock markets and the livelihoods of the pastoral communities.

Shortage of supply of export quality shoats to the market

Most of the export abattoirs are operating at less than 50 percent of their installed capacity. One of the major excuses for operating under capacity is a shortage of export quality animals. On the other hand, pastoralists complain about the lack of market for their animals. This shows the existence of an information gap between suppliers of live animals (pastoralists) and the export abattoirs about what types of animals are needed, the number of animals needed and when they are needed.

Seasonality of supply and demand for shoats

There is seasonality in the supply and demand for shoats. Pastoralists sell their animals when there is a drought either to save them from the damages of the drought or to buy food for the household and feed for larger animals. They normally do not sell their animals during the rainy season unless they have a compelling financial need or there is a very attractive price. On the other hand, demand increases during the Ramadan fasting season and the Arafa holiday. These peak times of demand and supply of animals do not usually overlap.

Lack of vertical linkages of shoat producers to the other market actors

When pastoralists go to the market, they sell their animals to any willing buyer. They do not have a specific customer to whom they sell their animals. They also do not have a relationship of trust with any of the market actors. Traders do not consider pastoralists as important partners in the markets. They hide market information from pastoralists and try to suppress animal prices, even if there are increases in the terminal markets.

Weak horizontal linkages among shoat producers

Pastoralists share market information and support each other in several ways, especially in the restocking of herds after drought seasons. However, they are not well organized in marketing their animals. Though there are marketing cooperatives in some places, these cooperatives are not strong enough to serve their intended purposes of strengthening the negotiation power of pastoralists. Pastoral livestock marketing cooperatives still do not have the capacity to influence the market. Most of them have gaps in entrepreneurship skills, financial shortages that preclude being actively involved in the market and do not have a transparent management system.

Flow of animals to informal cross border trade

One of the justifications that export abattoirs mention for the shortage of supply to their plants is the flow of animals to neighbouring countries through informal cross-border trade. Several assessments confirm the flow of Ethiopian livestock to countries such as Kenya, Somalia and Puntland. The latter two countries are re-exporting Ethiopian animals and it is estimated that about 65 percent of their 3.5 million heads of annual live animal export every year through Berbera and Bosaso ports is sourced from Ethiopia through informal cross-border trade (FEWSNET, 2010; COMESA, 2009). In 2011, Ethiopia exported less than 784,000 heads of livestock through the formal export system. This means the formal system is exporting only 22 percent of the animals flowing to the informal cross-border trade.

Constraints at the processing stage

Low level of food preparation skill in the hotels and restaurants of the area

The major problem of hotels in the study areas is lack of expertise in preparation of dishes. Since the area is far from urban centres, skilled cooks are reluctant to go to such places.

Backyard slaughtering and poor slaughtering skills that spoil the quality of the meat and skin

Though there are rules and regulations prohibiting backyard slaughter of animals, this practice is the most dominant in the country. This regulation is enforced only on butchers. Hotels, restaurants and individual consumers still practice backyard slaughter of animals. Moreover, since animals are slaughtered by people that do not have any training in slaughtering and meat handling, this has a big negative impact on the quality of the meat and skins.

Constraints at the consumption stage

Non-standard base meat price

Meat prices in Ethiopia in general, and in the study areas in particular, are determined without consideration for the quality of the meat. Since the grades and quality standards for meat and live animals are not clearly disseminated to the public and are not enforced properly, nobody worries about following these regulations. Prices are usually fixed in bigger cities, such as Addis Ababa. Other towns, including those in pastoral areas where there is a better supply of animals, follow these urban prices without consideration of the added costs of transportation of live animals to the bigger towns and the lower price of animals in their own area.

Opportunities along shoat value chain

Government's commitment and support to increase the export of meat

In its five year growth and transformation plan, the Government of Ethiopia aims to increase meat exports to 110,000 tons in 2015. The government envisages earning one billion US Dollars from the export of meat and live animals by this time. Thus, the government is committed to supporting the private sector involved in export of these commodities. The government is assessing the constraints along the meat export value chain and is ready to take all necessary measures to increase the supply of live shoats to export abattoirs and the export of meat according to the target set in the growth and transformation plan. This should create better market opportunities for shoat producers.

Increasingly high demand for shoat meat in export markets

The demand for Ethiopian shoat meat has dramatically increased following focused market promotion activities by development projects that have been working in close collaboration with the government. This has created an opportunity for shoat producers to sell greater numbers of shoats at better prices. Meat export performance of the country has increased from 870 metric tons in 1991 to 18,000 metric tons in 2011-2012. Over 80 percent of this is goat meat (Legese et al., 2008).

Accessibility of the intervention areas to export abattoirs and central urban markets

One of the intervention areas, Yabello District, is located on the main Addis - Moyale road and is accessible to export abattoirs (Modjo and Bishoftu areas) relative to other pastoral areas. This implies that there is lower transportation costs for animals procured from these areas. All the export abattoirs are targeting this study area as their first priority for sources of animals. Thus, pastoralists in the intervention areas have a better market demand for their animals relative to pastoralists in other areas.

Construction of new export abattoirs

In addition to the existing five abattoirs, the construction of two new export abattoirs is being finalized in Modjo and Bishoftu areas. This will create more demand for shoat produced in the intervention areas.

Conclusions & recommendations

Conclusions

Pastoral areas are endowed with huge livestock resources, including sheep and goats. These areas are the major source of shoats for the export abattoirs and highland markets. The market (especially the export market) needs a continuous supply of male, uncastrated yearlings with good body condition. However, the pastoralists could not continuously supply animals of the required quality because of the short drought cycle and traditional production practices that could not cope with the system. Shoat production is based entirely on grazing of natural pasture and browses. No supplementary feeds are provided to shoats, even in drought conditions. Thus, animals taken to the market during dry seasons are skinny. Thus, they do not fetch attractive prices for the producers either in the domestic or export markets.

Recurrent droughts threaten the genetic base of pastoral animals in general and small ruminants in particular. Pastoralists are losing most of their animals (shoats) either by selling to procure food for their households and feed for larger animals or because of mortality during drought seasons. Restocking programmes collect breeding stock from neighbouring areas and provide them to the affected pastoralists. Introduction of non-local (for example, non-Borana breed goats to Yabello) to the rangeland is diluting the genetic potential of the original local breeds in terms of drought tolerance and other important traits. These problems have resulted in low productivity of animals in the pastoral areas. There is a need to look into focused interventions to improve the production and marketing practices of pastoralists. The research system also needs to look into development of appropriate breeding strategies to maintain the genetic potential of indigenous breeds of sheep and goats in the study areas.

Recommendations

The study has identified the core functions, actors, channels, opportunities and constraints along the shoat value chain in Yabello and Shinille Districts. The following recommendations are forwarded based on the findings the study. For simplicity of understanding, the recommendations are categorized into breeding, health care, marketing, transportation, etc.

Support improvement in goat breeding practices through the interventions below.

- Strengthen traditional *breeding* practices by establishing close relationships with communities to understand their systems and identify gaps.
- Train pastoralists on the need for appropriate breed selection and maintenance of breeding rams and bucks, the dangers of inbreeding and basic selection techniques.

Improve the animal *health* delivery system through the interventions below.

- Encourage and support regional governments to hire more veterinary technicians for health posts in order to resolve the current shortage of human resources at health posts.
- Establish revolving funds at woreda level for procurement of veterinary drugs.

- Allocate more funds for procurement of veterinary equipment for clinics and health posts.
- Establish and operationalize more health posts on a kebele basis in order to increase accessibility of veterinary services.
- Identify the precise strains of diseases for effective vaccination and treatment.
- Allocate sufficient doses of vaccines to the districts to ensure full scale vaccination in the districts though proper planning and consultation with the National Veterinary Institute.
- Provide cold chain facilities that can enable longer shelf life of vaccines, including alternative energy sources.
- Provide transportation facilities (motorcycles, mules and bicycles) for animal health technicians at health posts and clinics.
- Train extension agents, pastoralists, community leaders and managers of respective offices in shoat disease prevention and control.
- Support enforcement of the government rules and regulations on informal trade of veterinary drugs.

Improve pastoralist's access to credit services through the interventions below.

Support the establishment of rural micro-finance credit and saving institutions in pastoral areas that do not have such services (e.g., Shinille).

Facilitate discussion forums between credit service providers (Oromia Credit and Saving Institute), political leaders, community members and other stakeholders to resolve problems of access of the pastoral community to credit services.

- Support strengthening and establishment of rural credit and saving cooperatives in the intervention areas through training of leaders in cooperative management and provision of seed capital.

Improve availability of *feed and the feeding practices* of pastoralists through the interventions below.

- Promote conservation of locally-available feed resources through training of extension agents and pastoralists and demonstration of best practices and facilitate introduction of marketing of such feeds in the rangeland.
- Promote the use of drought-tolerant browse, such as cactus and acacia. This should also be supported with demonstrations, supply of planting materials and promoting the marketability of such feed in the area.
- Train extension agents, subject matter specialists and the community in shoat production and management with a special focus on animal husbandry and feeding using locally-available feed resources and efficient water utilization.
- Support awareness creation of improved shoat housing through training and demonstration.

In collaboration with other development partners, resolve problems hindering the smooth operation of national *livestock market information systems* through the interventions below.

- Institutionalize data collection and transmission from livestock markets in districts, making it the responsibility of the district office of marketing and trade.
- Link the district with national livestock market information systems.

Improve the livestock *marketing environment* through the interventions below.

- Support the establishment of primary livestock markets with all necessary facilities in needy remote pastoral areas in order to increase the off-take of shoats from remote pastoral areas that do not have easy access to markets.
- Promote a uniform method of shoat transactions (live weight or visual estimation based) throughout the value chain.
- Train pastoralists on the quality requirements of the different buyers of shoats in the market (export market, hotels and restaurants, butchers, etc.) and how to attain them.
- Organize regular, multi-stakeholder platforms to discuss the major shoat marketing problems, find common solutions and create market linkages between pastoral producers and other actors.
- Strengthen and establish shoat producer/marketing cooperatives in terms of management capacity and market linkages and finance.
- Support implementation of policy and development interventions that can reduce informal cross-border trade.
- Improve goat slaughter and meat processing skills in the area through the following interventions:

A) support town administrations so that they will create awareness of hotels and restaurants to use qualified chefs; and

B) organize unemployed youth in groups and train them in slaughtering techniques and link them to municipal abattoirs.

Support the popularization and enforcement of meat and live animal quality and standards through the interventions below.

- In collaboration with the Ethiopian Quality and Standards Authority, popularize the use of Ethiopian live animals and meat quality standards through electronic and printed media.
- Train live animal and meat graders.
- Lobby for the establishment and assignment of an appropriate institution to enforce the available grades and standards.
- Support the new institution in the enforcement of grades and standards.
- Encourage quality-based meat pricing in order to avoid unnecessary hikes in meat prices regardless of the quality of meat.

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Session on institutional and policy issues in the conservation and sustainable utilization of drylands

7. The impacts of development interventions on the customary institutions of forest resource management: the case of the Borana Oromo of Southern Ethiopia

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ABSTRACT

Key words: common-pool resources model, customary institutions, forest resource management, pastoral development programmes, state structures

This paper deals with the impacts of development interventions on customary institutions of forest resource management among the Borana Oromo of Southern Ethiopia. In Borana, two major categories of land are badaa (forestland) and gammojjii (lowland dryland). Customary institutions give due attention to both dry and forestlands. This study primarily focuses on the forestland. The study was initiated as a result of observations on deforestation of the Borana forestlands. The aim of the study was to assess the impacts of development interventions on customary institutions of forest resource management and socio-cultural aspects of the community attached to forestlands.

Qualitative methods based on primary and secondary sources were used in data gathering for the study. The primary data were generated from observation, in-depth interviews, focus group discussions, case studies and informal discussions. Secondary data were collected through review of related literatures. To analyse those data, the theory of common-pool resources was used.

The results of the study depict that most of the ceremonial grounds and holy trees of the Borana are found inside the forest areas. The mobile ritual villages of the Borana usually reside inside the forests to perform various cultural practices and thus, the belief systems attached to the forest grounds are the basic means of forest management. Moreover, different customary institutions at various levels and their members are responsible for forest management. However, development interventions such as urbanization, state structure and pastoral development programmes and policies ignored these customary institutions of resource management and used top-down development approaches. The impacts of inappropriate development interventions weakened customary institutions, changed range ecology and decreased the Borana land, leading to competition over forest resources and deforestation.

Therefore, it is recommended that customary institutions of forest resources management for conservation and sustainable use of forest resources are recognized. For this, there is a need to integrate customary forest management structures and /systems with state structures and /approaches at the local level. This involves participatory planning and management, building on the good practices of community institutions, with the technical support on up-to-date similar forest management practices provided by local state agencies. In such a way, best practices for resource management should be promoted. Participatory development approaches should be employed at all stages, including problem identification, planning, implementation, monitoring and evaluation.

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Introduction

Background

Like many other pastoral societies in Africa, the Borana have been commonly sharing and managing natural resources such as pasture, water and forest for ages. In line with this, they have established well-organized customary institutions, such as the gadaa - one of the renowned indigenous African institutions that deal with almost all aspects of human society: economic, political, ritual and military (Legesse, 2000). Under gadaa, various actions are taken at different levels for the sustainable utilization of resources. The upholding of resource management is achieved through vigorous structured assemblies. Bassi (2005) maintains that Borana are a society of assemblies that purposely engage in numerous meetings (e.g., clan meetings, pastoral coordination meetings, ritual meetings, general assemblies, etc.) at various levels to peacefully resolve issues related to social, economic, religious and political affairs. Furthermore, since Borana indigenous institutions have a wealth of skills and capacity to regulate access to resources, much literature depicted that the Borana rangelands represent a case of an exceptionally efficient and well-managed dryland area (Watson, 2001 and 2003).

Such efficient resource management can be attributed to the existence of a strong customary institution (gadaa). Conceptually, institutions include organizations, rules and regulations that determine the access to natural resources. They define the individuals' rights to a resource and the kind and extent of use of that resource. There are also established practices of environmental management (Watson, 2001). North conceptualizes institutions as 'the rules of the game' and 'players of the game' (North, 1990, cited in Watson, 2003). This is to mean that "groups of individuals bound together by some common purpose to achieve objectives." Jha (1999) defines institution as "standard ways of doing things which consists of three major components: norms serving as goal, roles constituted by norms and pattern of behaviour attached to norms and roles."

Many scholars have distinguished between formal and indigenous institutions. For instance, in Ethiopia, formal institutions are those backed by official legislature, such as 'Peasant' Association and Service Cooperative, and state legislature determining access to land and water (Watson, 2001). However, Watson argues that although theoretically the Borana customary institution, gadaa, can be included under informal institutions, practically they are not informal, as the Borana officially come together to elect leaders of their institutions.

Since informal institutions are part of indigenous ones that constitute all structures and practices that determine access to, type, degree and time of utilizing resources and arbitrate resource-based conflicts, policymakers, researchers and developers reached a consensus that indigenous institutions are key tools to be employed in development programmes to maintain sustainable resource management (Richards, 1985; Ostrom, 1990; Fairhead, 1992 and Chambers, 1997 cited in Watson 2001).

However, since incorporation of the Borana into the Ethiopian State, the successive Ethiopian governments have been putting pressure on the customary structure and weakening it by intervention of the state structure in operations at different levels (Arsano, 1997; Bassi and Adi, 2007). Subsequently, the classical top-down development approaches practiced by government and non-governmental organizations in the pastoral areas of Borana land overlooked the customary natural resource management systems, which finally resulted in severe environmental degradation and the declining of livelihoods (Hogg, 1993; Coppock, 1994; Oba, 1998, cited in Watson, 2001).

In Borana, two major categories of land are recognized: badaa (forestland) and gammojjii (lowland dryland). Most studies in the past focused primarily on inappropriate development policies that led to rangeland (lowland dryland) degradation and its effects on livelihoods of the Borana society. Less attention was paid to the impacts of development interventions on customary institutions of forest resource management, interaction between forests and people and interaction between state structure and the customary one. This research, therefore, attempts to fill these gaps.

Objective

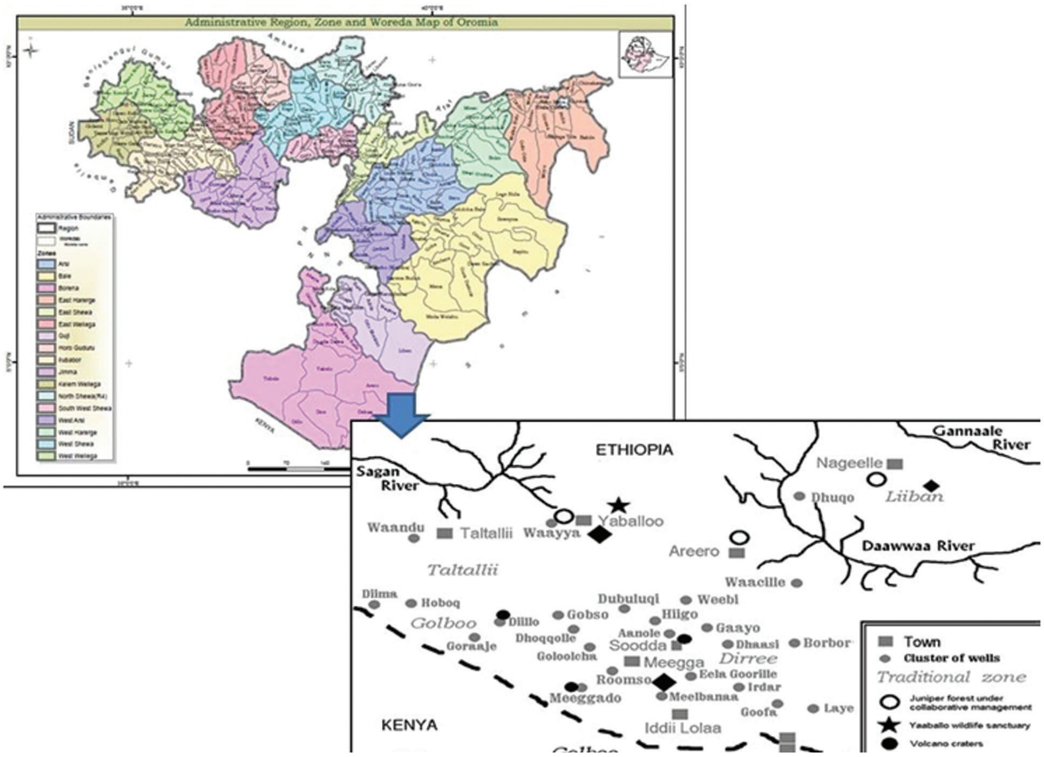
The principal objective of this study was to investigate the impacts of development interventions on customary institutions of forest resource management among the Borana Oromo of Southern Ethiopia.

Materials and methods

Description of the study area

The study was conducted in and around Arero Forest in Borana zone of the Oromia National Regional State, Ethiopia. It is located in the southern part of the state (between 3°36 – 6°38' North latitude and 3°43'- 39°30' East longitude) and borders Kenya. Yabello is the capital town of the Borana zone and lies 570 km south of Addis Ababa. The zone covers 48,360 km2 of which 75 percent consists of lowland and is frequently exposed to droughts. It is inhabited by almost one million people.

Arero forest is found in the middle of Boranaland, about halfway between Negelle and Yabello. The capital, Matagafarsa (Arero) town, is located at 660 km from Addis Ababa. The altitudinal range of the forest part is between 1,500 and 1,740 m.a.s.l.,



with annual rainfall of about 800 mm. The forest is one of the most southern high forests of Ethiopia, with well grown *Juniperus procera* trees. Other common trees include *Podocarpus falcatus, Prunus Africana, Olea europea ssp cuspidata, O. welwelchi, Croton macrostachyus, Fagaropsis hildebrandtii and Ochna insulata,* among others. The forest is heavily populated and is connected to expanding urban centres by road.

Arero is an important forest area for both the conservation and livelihood of the population in the area. Arero forest is important for its population of Prince Ruspoli's Turaco, one of the key range-restricted bird species found in the area. Other globally threatened species include Salvadori's seedeater. The area is home to 43 Somali-Masai biome bird species, which represented 44 percent of species restricted to this biome. Many mammal species occur in the area, including bushbuck, dikdik, warthog, wild pig, vervet monkey, black and white colobus monkey, black-backed jackal, squirrel, leopard, lion, hyaena, porcupine, Abyssinian hare and civet (EWNHS, 1996).

Figure 1. Map of the study area, with details of community conserve areas and forest priority areas

The forest is functionally connected to other forests and lowland rangelands in Borana that are traditionally managed as integrated parts of Borana land. The forest provides several economic, cultural and ecosystem services. It protects the watershed on the highlands, which contributes to the recharge of groundwater communally used in lowland areas. The forests are also used seasonally for grazing through regulated management arrangements. Traditional ritual and cultural sites of the Borana are located in the forest.

Study methods

The method used to collect the necessary data for this research was a qualitative method that includes primary and secondary sources. The primary sources were individuals and events that have been consulted through observation, focus group discussions, informal discussions, case studies and in-depth interviews. The secondary sources were a variety of related literature that was reviewed in the course of the research.

Data analysis and interpretation

There are various theoretical models that deal with natural resource management. Among others, theory of common-pool resources is employed in this research for data analysis. It deals with common property resources, such as forests, pasturelands, irrigation systems and fisheries.

Scholars have posited that the management of these resources can be controversial as it leads to problems of collective action. Ostrom et al. (1994) in Cox (2008), for instance, find problems of resource appropriation and provision. An appropriation problem can result in overconsumption of a subtractable resource in which an individual benefits from personal consumption at the expense of the community and the condition of the resource. A provision problem can result in under provision of the infrastructure needed to appropriate a resource. Since it is difficult to exclude free-riders from benefiting from the efforts of contributors, a provision problem can occur.

According to Hardin`s (1968) 'tragedy of the commons' theory, a set of pastoralists inevitably will overuse their pasture. This concept was for many years considered typical for common-pool resources not owned privately or by a government. Since Hardin theorized that users would be trapped in their tragic overuse of a resource, he advocated two solutions to prevent future tragedies: state control and individual ownership (Basurto and Ostrom, 2009). This type of thinking, in many cases, led to common property resources being ignored until the mid-1980s, and traditional resource property regimes were given over to state control and private ownership in different parts of the world.

Under this theory, overharvesting of resources frequently occurs when resource users are totally anonymous, do not have a foundation of trust and reciprocity, cannot communicate and have no established rules. Such a situation generates a highly predictable, finite supply of one type of resource unit (for example, forest produces only hardwood timber) in each relevant time period, whereas users are assumed to be homogenous in terms of their assets, skills, discount rates and cultural views. This theory universally assumes that anyone can enter the resource and harvest resource units. Users are viewed as able to gain property rights only to what they harvest. The resource is assumed to be an open-access property (Ostrom 1999).

This theory was commonly applied in situations of common-pool resources, regardless of the capacity of resource users to communicate and coordinate their activities, until the work of the National Academy of Sciences` Panel on Common Property (National Research Council, 1986) strongly challenged this approach.

Since that time, the conventional theory of common-pool resources has been challenged from various parts of the world. That is, many empirical studies have recognized that local users themselves have constructed viable institutions to use their natural resources sustainably (Berkes, 1989; Ostrom, 1990; Baland and Plateau, 1996; Hanna et al., 1996 cited in Gibson et al. 2005). As Basurto and Ostrom (2009) quoted (NCR, 1986; McCay and Acheson, 1987; NCR 2002; Dolsak and Ostrom, 2003; Basurto, 2005), traditionally, many smaller groups that use common-pool resources have developed a diversity of norms and rules that have enabled them to solve problems of overharvesting. Empirical studies also revealed that mere blueprint solutions imposed by external authorities cannot solve problems of resource management and many other central problems of development; rather participatory resource management is needed (Pritchett and Woolcock, 2003). Furthermore, once formal institutions expropriated ownership of forests from local people, the people perceived the forest as property of the government, rather than as local common property. Thereafter, local communities developed a loss of ownership, which is considered one of the reasons for escalating deforestation processes worldwide (Messerschmidt, 1983; Jodha, 1986; Poffenberger, 1990; Arnold and Stewart, 1991, cited in Ostrom, 1999).

According to data collected by a network of scholars associated with the International Forestry Resources and Institutions Research Programme, a successful outcome when using common resources can come through identification of multiple factors, such as characteristics of the resource, characteristics of the group, institutional arrangements and the external environment (Gibson et al., 2000; Foteete and Ostrom, 2004).

In Ethiopia, the Constitution of the Federal Democratic Republic of Ethiopia, 1995, Art 40(3), states the right to ownership of land as follows:

The right to ownership of rural land and urban land, as well as of all natural resources, is exclusively vested in the State and the peoples of Ethiopia. Land is a common property of the Nations, Nationalities and Peoples of Ethiopia.

Furthermore, according to Proclamation No. 456/2005, Art 5(3), the Ethiopian Government's ownership of rural land and communal rural land holdings can be changed to private as may be necessary (Bassi and Adi, 2007).

However, according to Borana custom, land in the Borana territory is the common property of all Borana people. Nonetheless, the government`s Department of Agriculture claims state ownership and responsibility for the management of forest resources (Tache and Irwin, 2003). In this paper, thus, the model of common-pool resources and its complexities were used to investigate the impacts of interventions on the role of customary forest resource management among the Borana Oromo of Ethiopia.

Key findings and discussions

Borana customary institutions

Broadly speaking, the Borana customary institutions have been categorized into two forms: micro and macro institutions. Both could be further divided into many branches. Each of them has a responsibility for natural resource management and other societal issues at various levels. For the purpose of this study, the macro institutions to be discussed are gadaa and qaalluu. The micro institutions include warra, maggaa, ollaa, ardaa, reera, madda and dheeda. All these institutions have their own leaders and members who have divisions of labour to manage natural resources, including forests.

Members of these institutions, such as herders, firewood collectors and even a passerby, have to report to their close supervisor when they observe anyone committing illegal exploitation of their common resources. Then the supervisor gives balanced judgment on the case in accordance with customary laws. If it is not settled at supervisor level, s/he will take the case to the next administrative body. For this reason, there is no independent body that oversees forest management; rather management of natural resources needs a collective action.

The Borana residence can be separated into yuuba and yaa`a. Yuuba comprises the majority of the Borana people who reside in different places in the Borana territory. Yaa`a are relatively few people who are frequently mobile and reside in ritual places until they finish their term of office. The Borana yaa`a can be categorized into yaa`a gadaa, yaa`a qaalluu, yaa`a raabaa and yaa`a gadaamojjii. Those who reside in the yuuba will often join a yaa`a in one way or another; those in a yaa`a must be graduated to the yuuba after a specified time period. For instance, one who is outside of a mobile ritual village may join one of these villages through election to be a gadaa councilor, to assist a gadaa councilor of his respective clan in their gadaa office, or to perform certain ceremonies with members of the ritual villages. Members of a mobile ritual village usually have a fixed period to complete their term of office and then re-join those outside of their residences.

Any disputable issue of the Borana is first dealt with by the jaarrota (council of elders) and lichoo jaartii (the past gadaa councilors) at different geographical units of the yuuba. If not resolved at that level, it will be judged procedurally at the ritual villages, and then finally will be resolved at the Gumii Gaayoo (general assembly of the Borana), the supreme legislative body of the Borana Oromo.

Micro institutions

Borana settlements are randomly distributed throughout their territories. Settlements are not based on the family unit or clan corporate; rather they are based on social organizations for resource sharing (Helland, 1991; Hogg, 1993; Arsano, 1997; Watson, 2000). This section describes the different micro institutions of the Borana and how they interact with one another in dealing with societal affairs and resource management. These institutions are, of course, hierarchal structures of the gadaa institution which are situated in different localities of Boranaland. Selection of leaders of these institutions is conducted informally by the members of their respective units with reference to the ability of persons to play leading roles.

Warra (nuclear family)

A warra is often the minimal unit in a village that includes a nuclear family (a father, a mother and unmarried children). It is sometimes extended families, such as a father and his married children. When it refers to extended families in the village, it usually serves as a section, which will be discussed under the next unit (moggaa). The head of this unit is called abbaa warraa (head of family); and the family named as warra ebeluu (family of so and so).

The head of the family manages the household properties and other issues pertaining to his household. A family member has to report to the family head when s/he comes across illegal exploitation of a forest resource. Then a family head takes the case to his close supervisor. The family head also has responsibility to conserve trees in or around his cattle enclosure and house compound.

Moggaa (families sharing a cattle enclosure)

The terms *moggaa/soloola/shanacha/labata* are used interchangeably, with a slight difference to indicate a section in a village that comprises a family or usually more than that. For instance, the moggaa is often one to two families, whereas soloola and shanacha (which are synonymous) are used to indicate a combination of a number of extended families or other unrelated families.

The most determinant point for the people in this section is that they commonly share a single cattle enclosure. They are collectively herding and watering livestock, sharing household furniture and food, if necessary. That is why the Borana say, *"Ollaan mana walti aanu"* (The best villagers are those who share neighbouring houses). *Abbaa moggaa/soloola/shanacha* (head of a section in a village) is an immediate neighbour who is in charge of the section in any social affairs. He may be selected on the basis of his old age, wealth, knowledge of customary systems or leadership position in the customary system.

A head of a section in a village represents members of his section at village level. He also resolves conflicts in the section. If not settled there, he will take the conflict issue to a fellow village head. From the day when a village encamps in a given area, the head of the section is responsible to manage land in his territory with its adjacent area outside the village. No one is allowed to use trees from those areas without his knowledge. Even the village head has no right to allow a newcomer to encamp in a section of his village without consulting the head of that section.

*Ollaa (*village*)*

An *ollaa* (village) is the collection of sections when the village is big, or it can be a section when it is small. Abbaa ollaa (head of the village) is often the most popular man among his villagers in terms of his charisma to organize, analyse and manage things according to aadaa Borana (Borana custom). But sometimes wealth and ascribed status, especially from father to son, are considered.

The ollaa is a territorial organization whose members help each other during crises (disease, famine, war, etc.) and during happy occasions, such as weddings, child birth, naming and other events. Members of a village can also help each other with problems related to herding and watering. For instance, if someone faces a shortage of labour for herding, the person will be allowed to affiliate with fellow villagers. Furthermore, if someone encounters problems getting access to water for a clan that does not have water wells over a given area, the Borana custom of water sharing systems will allow the person to join villagers and use water from their clans' water sources. In cases when livestock is missing in the bush or at a water point, fellow villagers can again help each other to search for it.

The head of village is the immediate supervisor of natural resources found in the territory of his village, herding grounds and watering sources. The village head also represents his fellow villagers at important occasions. For instance, if a person or a village wants to join his village or to settle nearby his village, he should be the first person to be consulted.

After all, any Borana can freely move out from his or her old village and join a new one. But reasonable pre-discussions and agreements have to be made with the heads and villagers of both villages. This is mainly because the resources in both communities are common properties that need pre-discussions to reach on consensus.

Ardaa (village or cluster of villages with a small grazing area)

An *ardaa* is a particular site that is inhabited by a village or cluster of villages. When it is occupied by a cluster of villages, it may be termed a reera (described in more detail below). An *ardaa* is a small grazing territory in which its residents can commonly share water, pasture and other resources within the context of *aadaa seera marraa-bishaan Booranaa* (Borana customary laws of pasture and water). Elders from a village or villages usually hold residential meetings on how to manage and share resources in their territory. Members of an ardaa also help each other with burial, name-giving, wedding and other ceremonies. The head of the ardaa is the village head when it is composed of only one village; and he is head of the cluster when it is inhabited by several villages.

Reera (cluster of villages using the same water source and grazing grounds)

A *reera* is the cluster of villages that are found in a specified site, or two or more close sites, inhabited by people who can use water from the same sources and their herds can use the same grazing grounds. It is where the inhabitants usually limit carrying notification of deceased persons and other messages. The *abbaa reeraa* (head of the cluster) is a famous man or, if possible, an ex-*gadaa* councilor selected from the members of each village in the reera area. He represents the members of his fellow cluster at the next larger territorial unit, the *madda*. People in the same cluster also have regular meetings to consolidate the natural resource management systems in their unit.

The head of the cluster arranges a smooth grazing relationship between his cluster and neighbouring clusters. For instance, between adjacent clusters there are usually common grazing lands which are not allowed for settlements and need continuous discussions among the users. Even though each water source has its own caretaker and an individual member of the community is responsible to manage the forests, the head of the cluster oversees whether management goes according to customary systems.

As part of the fieldwork for this paper, the principal researcher took part in a pastoral coordinating meeting at Dureettii wells on 14 January 2010 inside Areero Forest. At the meeting, misuse of water wells and settlements inside the forest were reported by water caretakers and other community members. The meeting was facilitated by the head of the Dureettii cluster. Finally, the participants decided on removal of the illegal settlements from the site within a week and re-arranging the watering quota system. Thus, a head of a cluster is responsible to settle conflicts that are not addressed at village level and others within his territory. If the case is not resolved, he reports it to the elders of the next territorial unit.

Madda (wider territorial unit with a permanent water source)

The *madda* is a wider territorial unit than the reera and its concept is derived from a permanent water source. It is made up of a combination of clusters, which often surround a water well at its centre. A *madda* is administered by a council of elders drawn from different clusters of that *madda*. In other words, the council of elders is composed of the heads of all clusters surrounding a permanent water source. They usually meet at water points to discuss how to share water and pasture among residents in their unit, or with other newcomers who come from other *madda* in search of better resources. At such meetings, relevant topics, such as the number of cattle kraals and where the newcomers should encamp and water their cattle, are identified and affirmed. If the new arrivals are over the capacity of a particular *madda*, they should agree and let others use resources from another *madda*.

Conflicts not settled at the *madda* level will usually be taken to neighbouring *madda* or to mobile ritual villages of *qaalluu*, *raaba* or *gadaa* found nearest to the contested *madda*. In principle, issues not resolved at *madda* can be appealed to mobile ritual villages of *qaalluu → raaba → gadaa →abbaa seeraa/ gumii gaayoo*.

Dheeda (combined units based on grazing lands)

The dheeda is a wider unit than a madda. In most cases it blends several maddas that are managed independently by a council of elders drawn from different maddas. The word dheeda literally means "grazing." Boku (2000) categorizes Boranaland into seven major micro-climate zones, or dheedas. They are Goomolee, Malbee, Golboo, Dirree and Wayaama in Dirree region of Boranaland and Golba and Diida in Liiban region of Boranaland.

Macro institutions

The leading macro institutions of the Borana are the *gadaa* and the *qaalluu*. Each plays independent roles among society. The *gadaa* leads the political role of the Borana and the *qaalluu* leads religious affairs. The major role of the institution of *gadaa* is to lead the Borana as a whole. To do this, the Borana *gadaa* has established various institutions that have their own leaders at different lower levels. Power in the *gadaa* system is highly decentralized and is exercised from periphery to centre, rather than from centre to periphery (Bassi, 2005). Therefore, leaders of various territorial units have full power to manage forest resources and other societal affairs. If they cannot resolve contested issues on resource management at their levels, they procedurally manage the cases until they reach the mobile ritual village of *gadaa*. It is there where final decisions are given, unless the *gadaa* councilors intentionally postpone cases to the gumii (assembly of the multitudes).

The *qaalluu* and the *gadaa* institutions have their own mobile ritual village. Each one of these villages is mobilized periodically to ceremonial grounds located in different forest areas of Boranaland to celebrate various ceremonies. These ceremonies are performed to deal with the integrated affairs of Borana, such as politics, religion, economy, etc. Kassam and Megerssa (1994) confirm that the political, juridical and economic aspects of the Borana are not separated from their religious beliefs, which fundamentally structure and unify their way of life. Nor is nature excluded from this worldview. Thus, Borana manage their forests through religious practices attached to nature, politics, economics and law.

Gadaa

Gadaa is a system of generation classes that attributes almost all human aspects such as military, political, economic and ritual (Legesse, 1973). Borana *gadaa* has five generations of classes that succeed each other after eight years of a *gadaa* period (Bassi, 1994). That is, individuals are enrolled in the class five positions below their father`s class. Thus, one *gadaa* period is eight years, whereas a *gadaa* cycle takes forty years. Borbor Bulee, a famous Borana oral historian, recalls the names chronologically of the seventy one *gadaa* leaders with their terms of office. He further states that Gadayoo Galgaloo (1457-1465) was the first *gadaa* leader of Borana Oromo after the *gadaa* had been interrupted for seventy two years. Although he did not recall their terms of office, he can recite the names of six *gadaa* leaders before the *gadaa* had been interrupted.

In one *gadaa* period, there are three branches of gadaas: *Gadaa Arbooraa, Gadaa Hawaxxuu* and *Gadaa Koonnituu*. Each branch has its own independent leader. Thus, there are three mobile ritual villages and three *gadaa* leaders in one *gadaa* period. Of these, *Gadaa Arbooraa* is the senior one and its leader is a leader of his class, as well as the leader of all Borana during his office term. The name of the Borana *gadaa,* particularly *Gadaa Arbooraa*, is always recalled using the name of its leader. For instance, if a *gadaa* leader is *Guyyoo Gobbaa*, that *gadaa* will be recalled as *Gadaa Guyyoo Gobbaa;* whereas, *Gadaa Koonnituu* and *Gadaa Hawaxxuu* are named after the name of their clans. Both *Koonnituu* and *Hawaxxuu gadaas* were autonomous *gadaa* branches given to *Hawaxxuu* and *Koonnituu* clans of the *goona moiety* by the Borana in the *gadaa* period of Bulee Dhaddachaa (1769-1777). Both clans were given this opportunity for the sake of intra-Borana conflict resolution and to defend peripheral land they were occupying against neighbouring groups.

Each class in power has three types of *hayyuu* (*gadaa* councilors) who are formally elected by the members of Borana society every eight years. They are *Hayyuu Adulaa*, *Hayyuu Meedhichaa* and *Hayyuu Garbaa*. These *hayyuus* are elected for each mobile ritual village of *gadaa*. For instance, out of six adulaa councilors for one gadaa period, four members are elected for Gadaa Arboora and one each for Gadaa Hawaxxuu and Koonnituu. From a total of 14 members of Hayyuu Garbaa, six are elected for *Arboora* and four each for Hawaxxuu and Koonnituu. Out of six members of Hayyuu Meedhichaa, three each are elected for *Hawaxxuu* and *Koonnituu*. Therefore, the number of *hayyuus* in one *gadaa* period is 26.

There is hierarchal power among the *gadaa* branches in effecting Borana concerns. For instance, if the councilors of a mobile ritual village of *Gadaa Koonnituu* cannot settle conflicts, they will take the cases to the mobile ritual village of *Gadaa Hawaxxuu*. If not resolved there, the councilors of both *Hawaxxuu* and *Koonnituu gadaas* take the cases to the mobile ritual village of *Gadaa Arbooraa. Gadaa Arbooraa* is often where final decisions of Borana concerns are made. Yet, there are very few cases which cannot be resolved at *Gadaa Arbooraa* and appealed either to *Gumii Gaayoo* or to consultations of a father of law (senior ex-*gadaa* leader). For instance, if the three incumbent *gadaa* leaders do not agree on the implication of a law, a father of law will be consulted, and there is no more reconsideration after decisions given by him. Or, if the appealed cases are very serious and the *Gumii Gaayoo* is going to be held in the near future, a *gadaa* leader of *Arboora* will deliberately defer the cases to the *Gumii Gaayoo* so as to publicize them and let others learn from measures taken at the *gumii*.

Qaalluu

The position of *qaalluu* is through a hereditary system. *Qaalluu* is considered a ritual leader. There are five *qaalluus* of Borana Oromo: *Qaalluu Odituu, Qaalluu Karrayyuu, Qaalluu Garjeedaa, Qaalluu Kuukkuu and Qaalluu Karaaraa*. Each of these *qaalluu* is named after the name of their clans or subclans. For instance, Odituu and Karrayyuu are names of Borana clans, whereas Garjeeda, Kuukkuu and Karaara are subclans of the Maxxaarrii clans of the sabbo moiety. Of these, the *Qaalluu Odituu* and *Qaalluu Karrayyuu* are the seniors who extend their blessings to all the Borana and beyond at the muuda ceremony (anointing ceremony). Borana believe that the origin of these two senior qaalluus has a divine source. The remaining three belong to the Maxxaarrii clan are given this position due to respect of the Borana towards the members of the Maxxaarrii clan in various ceremonial occasions.

At the *muuda* ceremony, a group consisting of a large number of men comes with a gift of young cattle for the *qaalluu* and in response the *qaalluu* provides his blessings. The *qaalluu* also serves as an intermediary between God and man (Bassi, 2005).

In addition, the *qaalluu* village is one of the mobile ritual villages of Borana, which periodically moves to different sacred grounds found in many places in the Borana forests to perform rituals. According to the Borana belief system, these rituals in the forests are conducted for the psychological wellbeing of the Borana people, their livestock and environment. For this reason, every Borana respect the rules pertaining to forest management.

The *qaalluu* ritual village has four councilors whose members are drawn only from *qaalluu* lineages. These groups have no political position in *gadaa* ritual villages. These councilors have decision-making power on resource management, conflict resolution and other societal issues, like other *hayyuus*. For instance, if a conflict related to resource management or other societal affairs is not resolved at a micro institution level found in a nearby *qaalluu* ritual village, councilors of the *qaalluu* ritual village will be responsible to deal with the case before councilors of the *gadaa* ritual villages.

Natural resource management

The Borana rangeland has mainly been categorized into lowland drylands (*gammoojjii*) and forestlands (*baddaa*). Its categorization is based on weather condition, soil type, plant species, water availability and so on. Forestlands have evergreen plants, usually thornless tree species, cool weather even during dry seasons, soft and tall grasses, shallow wells, moist weather in June and July (after the main rainy season), tall and big trees with undergrowth, black brown soil, mounted-land, etc. Due to the cool weather conditions and prevalence of small flies in the forestlands, especially during the rainy seasons, grazing inside these areas are favourable in the dry months.

The lowland drylands possess hot weather, deep wells, dense grass, scattered big trees, thorny bushes, green coverage during wet seasons and dusty soil. Grazing inside the drylands is more preferable during the wet seasons when seasonal groundwater is available and moderate weather is attractive enough for livestock to flourish. Therefore, both lands are complementary to one another.

According to Bassi and Boku (2008), the natural resources of the drylands and forestlands are conceived by the Borana community as strongly complementary. They are the shared heritage of the whole community. This is communicated through the following extract from a prayer:

Liibanii Dirreen nagaa;	Peace for Liiban and Dirree;
Liiban Golbaa Diidii nagaa;	Peace for Golba and Diida of Liiban;
Dirree tulaan sallan nagaa;	Peace for the nine tulaa wells of Dirree;
Baddaan sadeen nagaa;	Peace for the three forest grounds;
Malbee golboon nagaa;	Peace for Malbee and Golboo;
Booqqee sadeen nagaa;	Peace for the three Booqqee;
Baddaa gammoojjiin nagaa;	Peace for the forest and the drylands;
Areero Gooroon nagaa.	Peace for the hill lands of Areero.

Boranaland has two broad regions: Liiban and Dirree (see Figure 1). Liiban region is further categorized into golba (dryland area more attractive during the wet season) and diida (forest area often used in the dry months). Dirree region has three forest systems, Areeroo, Oobda and Gaamadu, which possess various ceremonial grounds and other resources. Dirree also has nine clusters of deep wells and three creator lakes of rock-salt, which are found in the dryland. Malbee-golboo is a wet season grazing area located along the Ethio-Kenyan border. All these have been categorized into forest and drylands. So the above prayer extract depicts that the drylands and forestlands of the Borana have their own substantial resources that benefit the Borana people and their livestock in different ways during different seasons. For this reason, the Borana give due attention to both types of land and their resources.

Forest management

Forestland has numerous resources that can benefit its users in various ways. Some of these resources are wildlife, water, pasture, trees, place of worship and so on. Among other things, pasture, water and trees are the most important forest resources for the life of the Borana people. Thus, for the purpose of this research, management of resources such as forest, water and pasture will be highlighted in the following discussions.

In Ethiopian Boranaland, there are four major forest grounds:

1) *Manquubsaa* Forest: situated in the Liiban region of Boranaland in the Guji zone;
2) *Areeroo* Forest: in Areero District of Borana zone;
3) *Oobda* Forest (sometimes called *Baddaa Goomolee*): covering the all northern parts of Yaaballo District; and
4) *Gaamaduu* Forest (sometimes referred to as *Baddaa Gooroo Fugug*): embraces some parts of Dirree, Dilloo, Miyoo and Mooyyale Districts of the Borana zone.

These forest systems are all natural forests and are where the Borana often perform cultural practices. According to an Oromia Forest and Wildlife Enterprise officer in Areero District, except the Gaamaduu Forest which covers a vast territory, the other three forests are included under Ethiopian National Forests. Particularly since proclamation No. 225 and 227 of 1965, both natural and plantation forests of Ethiopia came under state ownership (Eshetu, 2006).

Forest resources belong to all Borana and are communal among the Borana, though water resources ownership have been given to certain clans, which will be discussed later. Customarily, forest resources benefit the Borana people in various ways: trees benefit them for construction of houses, fencing of livestock enclosures, ceremonial purposes, sources of food and firewood. Forestlands serve as sacred grounds, refuge in times of war, diseases and droughts, home for wild game and a source of water and pasture. The roots, leaves and bark of some trees serve for the preparation of medicines. The forests also serve to maintain climatic conditions as they release cool weather and receive adequate rain. For these reasons, life of the Borana community highly depends on forest resources.

For the Borana, the above mentioned uses of forest resources for commercialization purposes are not allowed as in market-oriented societies; they are rather implemented in the form of communal need (Kassam and Megerssa, 1994). Thus, this latter kind of exploitation does not affect the sustainable management of these resources. For instance, firewood is usually collected from dried parts of certain trees, such as dried branches, dried small sticks or from dead and fallen trees. Livestock enclosures are built out of thorny bushes or branches of thorny trees; houses are constructed out of poles of thin trees and covered with grass. In relation to this, Borana custom prohibits the cutting of all branches of a big tree, cutting a tree at its lower stem, or uprooting a tree. Borana have a belief system that enables people to stick to this custom. They believe that bad fortune will befall the descendants of anyone who violates this rule. There is a saying among the Borana, “Extinction of one`s descendants will be the result when s/he cuts all the branches of a big tree.” Golo (1996) states that Borana rules about forest conservation, which were promulgated to the 37th Gumii Gaayoo, are as follows:

“The Borana aada rules against cutting big trees without leaving some branches, because they die when all their branches are cut down. Moreover, the land loses its adommen (beauty) without trees. Without trees we cannot have shelters and shade to protect ourselves and our livestock from danger and sultry. Parts of what we use at our homes are made of wood. Trees may be cut down whenever there is genuine need for them. The bushes that suppress the growth of grass should be cleared away. The GGA has, therefore, prohibited cutting big trees at roots or without leaving branches on them.”

Symbolic value of forests

Forestlands are blessed with ceremonial grounds. For the Borana, forest grounds can fully serve as wayyuu (holy places). This is because God naturally blessed them with evergreen cover, cool weather, a long rainy season, shallow water wells or ever-flooded spring water and multiple natural resources that can allow permanent settlement of the people. That is why almost all the ceremonial grounds of the Borana people are situated in the forest areas, particularly those for mobile ritual villages. According to the Borana psychological makeup, the materialization of these ceremonies attributes fertility, good health, peace and prosperity for their people, livestock, land and environment.

The Borana mobile ritual villages of gadaa, raaba, gadaammojjii and qaalluu have their own ceremonies, which are performed seasonally at different sacred grounds in the forestland. Each of these ceremonies cannot be described in this work. Some of the major ones are dhibaayyuu and sacrifices of he-goats, bullocks and old cows. Sacrifices of these livestock are done in the shade of a tree, near a water well, near a stone and so on.

The term dhibaayyuu, is formed from two Oromo words dhiba and bay`uu, which means “trouble/problem/ difficulty” and “to save or to protect from danger.” Thus, the dibaayyuu ceremony is conducted to protect against problems. There are two types of dhibaayyuu: one done at a water well and the other one done at a tree (Leus, 2006). The dhibaayyuu in the shade of a tree is usually performed by members of gadaa ritual villages and that near a water well is done by members of gadaammojjii and other community members outside of ritual villages. A particular water well used for the dhibaayyuu ceremony is known as an eela dhibaayyuu (well of dhibaayyuu). Concerning this, Kuraa Adii, a Borana elder and son of an ex-gadaa leader, recited the following extract from a dhibaayyuu prayer that is celebrated in the shade of a tree by members of mobile ritual gadaa villages:

Dhibba sa`ayyoo horii;	Be prosperous with hundreds of cows;
Oo oyyoyyoo jilaa;	Because of the glorious ceremony
Dhibba namayyoo horii;	Be prosperous with hundreds of people;
Oo oyyoyyoo jilaa;	Because of the glorious ceremony;
Horaa nagayaan galii;	Safely come home from the watering point;
Oo oyyoyyoo jilaa;	Because of the glorious ceremony;
Horiin daara ba`ii;	Be clothed with the sale of livestock;
Oo oyyoyyoo jilaa.	Because of the glorious ceremony.

The prayer demonstrates how Borana life relies on livestock. During this ceremony, all gadaa councilors, including gadaa leaders and their assistants, wear traditional dress and carry miyyuu (milk-pot full of milk) and go to the holy tree.

There are some forest trees that are used for specific ceremonies and as holy trees. Others are taken to be a member of certain clans. First and foremost, the Borana belief systems that are attached to forest trees help protect the forest and its resources more than any other places. Guyyoo Gobbaa, an incumbent Borana gadaa leader (2009-2017), and other Borana elders, narrated the ceremonial and symbolic values of certain trees as follows:

Hindheensa/Jiruu-kuraa (Juniper procera): - A common and dominant forest tree in each of the forest systems of Boranaland, this tree is euphemized particularly during ceremonial occasions and named jiruu-kuraa ("life-salt"). This is because it has a longer life span than other trees in the Borana forest. It is also never attacked by termites even when it is dead and buried underground for ages. Since it grows gray hair like old people, it symbolizes old people and is respected as old people are respected. Its branches and gray hair are collected for various hulluuqqoo ceremonies (rituals performed to pass through disasters such as war, disease, drought, fire, flood, etc.). It is also used as a pole on which the Borana wave their flag on the election day of senior gadaa councilors.

Gaddaa (Fagara chalybea): This tree is found in both bushy and forested lands. It is used for the doorpost of ceremonial halls of gadaa. The sacrifices of bullock and he-goat take place in its shade.

Garbii (Faidherbia albida): This forest tree is used for a shrine, and sacrifices of bullock and he-goat are undertaken in its shade. It is also used as a qaallicha (sacred shrine) where sacrifices of an old cow are carried out.

Birbirsa (Podocarpus falcatus): This tree is only found in the forest and used as a shrine with sacrifices of bullock and he-goat.

Canaa (Haplocoelum foliolosum): Mostly grown in forestland and used as a shrine for sacrifices of bullocks and he-goats. It is a shrine used by the delegates of a gadaa to take baallii ("power") from the outgoing gadaa leader by sacrificing a bullock and to rest for a while on the way coming home. The incumbent gadaa leader who takes over the gadaa power spends three days of his confinement in the shade of this tree. Canaa is also used as a tree shrine at which the official election of Borana gadaa councilors is declared.

Dambii (Ficus thommingii): This tree usually grows in sources of water. It can be found in the bush and forestlands and is used during the odaa ceremony. The odaa ceremony is organized by the outgoing gadaa leader in his eighth year of gadaa office. The ceremony is organized to present gifts of cattle to the qaalluu and in turn to take his blessing. It is considered a graduation ceremony for the outgoing gadaa class. During this ceremony, an interested individual Borana who is outside of gadaa ritual villages can join to take the blessing of the qaalluu (Leus, 2006). A ceremonial hall which was built during the election of senior gadaa councilors is only built out of this tree, except for the doorpost, which is made out of the Canaa tree.

Waddeessa (Cordia africana): In Boranaland, the natural waddeessa forest tree is only found in the Miyoo Forest of the Gaamaduu Forest system. Its branches are used as a holder of the maxxaarrii (a ritual stick used for the odaa ceremony). Its branch is also used as a ritual stick cut for a father for the name-giving ceremony of his first born son. Thus, a Waddeessa stick symbolizes father of a son.

Daannisa (Apodytes dimidiata): This tree is found in all four forest systems of Boranaland. A Borana married male carries a Daannisa ritual stick on the day of birth of his sons, during the dhibaayyuu and odaa ceremonies. When a Borana male carries a Daannisa staff and ties a turban on his head, other fellow Borana automatically can tell that so and so's wife gave birth to a son. So, the Daannisa symbolizes one`s son(s).

Ejersa (Olea europea ssp cuspidata): This is the second largest dominant plant species found in the forest systems of Boranaland. It is a forest tree used for a shrine where sacrifices of bullock and he-goat are carried out. Its branches are also used as a bokkuu (ritual stick with a knobbed head) of gadaa councilors that signifies authority. Qoraan olkaa, a very short ritual stick used during songs sung by the raaba grade and gadaa ritual villages during the olka ceremony, is cut from the branch of this tree.

Dhaddacha (Acacia tortilis). This tree is grown both in bush and forestlands. It is a shrine tree where sacrifices of bullock and he-goat are carried out. Borana meetings are usually held in the shade of a big Dhaddacha tree. Even the Gumii Gaayoo Assembly is held in the shade of this tree.

Interestingly, Borana associate some trees with members of certain Borana clans. For instance, they associate the Dhaddacha tree with members of the *digaluu* clan of the *sabbo moiety*. They also associate the Harooressa tree (*Grevia bicolour*) with members of the harooressa submoiety of the goona moiety. The Fulleessa tree (*Acacia drepanolobium*) is associated with members of fulleelle submoiety of the goona. Since the members of these clans consider these trees as their own members, the Borana belief system prohibits them from using these trees for the purpose of firewood and misusing them for any other purpose. These trees symbolize human beings and the Borana as a whole treat them as their own members.

As a result of the above belief systems, Borana take forestlands as holy grounds where most places of worship are found, and therefore cutting a forest tree without good reasons and killing wild animals that dwell in the forest contradict the seera aadaa Borana (Borana customary law). Even when the need for cutting a branch of some forest trees are essential for ritual reasons, a cutter wears ritual clothes, carries tobacco and goes to the forest. When s/he finds that sacred tree, s/he pours out the tobacco on the ground under the tree so as to save it and cuts branches from other trees of the same species. Pouring out of tobacco symbolizes the begging for forgiveness as that tree and its territory are sacred beings.

Furthermore, if people want to kill wildlife for certain ritual and social reasons, they will wait until it comes out from the forested ground. Then, killing is culturally permitted. In cases when a wild animal is wounded outside of a forest and runs into the forest, it will never be pursued as it reaches its sacred home.

Because of its holiness, if a crime is committed in a forest area, a guilty person can be fined with a curse or qakee (a fine of thirty heads of cattle) and other penalties according to customary laws of forest management. For instance, in the group discussion, elders narrated the following cases pertaining to misuse of a tree in general and forest tree in particular.

Case-1

Aseebo was a famous Borana man. He belongs to the Karrayyuu clan of the sabbo moiety, and he was head of a cluster that used to live in Galchat, Yabello District. He made a law known as butaa Aseeboo (“pull of Aseebo”).

Under this law, when a wrongdoer was investigated, s/he was laid on their back and dragged on gravel stones. This law was initiated when members of Aseebo`s pastoral coordination unit cut down branches of trees with their seeds instead of merely collecting them. So, from that day onward, Aseebo started punishing people by pulling them over gravel.

Since Aseebo fined guilty people under his coordination with this special law until the days of his retirement, his community members used natural resources wisely.

Case-2
Halakee Bonayyaa belongs to the Karrayyuu-Aabbolee of the Borana clan. He cut down branches of the Qaallicha Miyoo (the holy tree of Miyoo), which is found in Gaamaduu Forest system.

The tree stands around the gadaammojjii ritual ground at Miyoo. The case was reported to customary leaders and Halakee Bonayyaa was fined with thirty heads of cattle. The Borana elders confirmed that the qakee fine of thirty cattle is equivalent to the blood price for a murdered body.

Qaallicha is where the gadaammojjii ceremony takes place every eight years. The naming ceremony of dabballee (the first gadaa grade), the grandsons of gadaammojjii grade, is carried out under this holy tree. During the ceremony, those who do not have a child pray to God to give them children.

According to Borana elders, qaallicha trees symbolize prominent Borana prophets that lived in the old days, such as Jiloo Nuuraa Dooyyoo. Qaallicha Nuuraa and Qaallicha Dooyyoo, the prominent holy trees that are located in the Liiban region of Boranaland, are named after these prophets.

A curse is usually placed when a wrongdoer is not investigated or s/he fails to accept his/her fault. This kind of cursing is often led by an abbaa gadaa. In Borana cultural beliefs, the curse of a holy tree itself when one misuses it is more effective than the people`s curse (Bartels, 1994). According to Borana customary laws, cursing is the worst fine. It includes social outcaste, such as alienation from resource sharing, cultural practices, political and any kind of social affairs.

Because the Borana believe that areas where holy trees exist are sacred grounds. Not only the power of holiness is invested in the sacred trees, but also the enactment of customary laws protects the trees as well as the forest areas where these trees are found.

Water management

Borana lands customarily possess four main sources of water: adaadii (shallow wells), tulaa (deep wells), haroo (ponds) and galaana (rivers). But there are other small water sources, particularly available during the rainy seasons (Boku, 2000). Adaadii water wells are mostly found in forest areas; whereas haroo and tulaa are found in drylands. Water in the forest systems is considered among the Borana to be bishaan haadha hiyyeessaa (“water of an orphan child`s mother”), because harvesting this water needs less investment than tulaa water. Adaadii water naturally springs up from swampy areas under stones and is available throughout the year where a single herder manages to water cattle, or its spring may be found above 2 metres in depth in dry, sandy rivers. However, tulaa water is found on average at 14 metres under the ground and requires much more labour to harvest. Thus, Borana households that possess limited labour mostly reside in forest system areas.

Borana water tenure systems vary on the basis of categorization of water sources. Compared to other natural resource tenure systems, water resources are relatively semi-private, with the exception of river water (Oba, 1998). River water is an open access resource. The remaining water sources have rules and regulations to be followed for anyone to get access to them. For each of these water sources there is an abbaa konfii (konfii owner) and abbaa herregaa (water caretaker). Ownership of ponds and adaadii wells in certain areas of Borana territory is restricted to the coqorsa system, which will be discussed at length later.

Tulaa (deep wells)

In areas where there are tulaa wells, a capable and interested Borana clan is allowed to possess more than one water well over a specified area. Although initial excavating of the ground is started by the abbaa konfii, material and human resources used in the course of excavation and management of tulaa wells is mobilized by members of a well alliance clan. As a result of this, most of the tulaa names possess the name of their respective clan, and the water sharing system is among the fellow clan members. This does not restrict other Borana who have social bonds with members of this clan from getting access to it. For instance, a sunsum person, who usually belongs to another clan, culturally waters his cattle at laagaa (next to the abbaa konfii`s cattle) on the watering day of the abbaa konfii. Moreover, other social bonds like friendship, in-laws and village affiliation can permit one to use water outside of his/her clan. This often happens when there is a scarcity of water resources, or a scarcity of manpower to lift up water from the wells among a fellow clan.

According to Boku (2000), tulaa wells have three watering days headed by three different people: the first day is termed guyyaa konfii ("watering day of the konfii owner"), the second day is called guyyaa olaa ("watering day of the well alliance clan") and the last day is known as guyyaa qara goree ("watering day of other members of the clan owning a tulaa well"). On each watering day, the head person of the watering day is responsible to manage all the watering rules on his respective day, under supervision of the water caretaker.

The caretaker of the tulaa well is a free servant and an honest, formally appointed individual from clan members outside of the konfii. He must be a willing person who comes on each watering day to supervise and has to have indigenous knowledge of water sharing systems among the Borana in general and his own clan in particular. Apart from this, there are elderly people of the same clan who usually oversee whether the management of the caretaker is progressing in a logical manner or not.

Adaadii (shallow wells)

Adaadii wells are often found along the watershed of the forested mountainous and plateau areas. Dida (2012) states that *adaadii* wells in forest systems have high yields of water year round that can accommodate a huge number of users, whereas those in plateau areas have less water and can benefit only a few harvesters. During the dry months *adaadii* wells in plateau areas often serve for domestic consumption.

According to most informants, *adaadii* water is used before *tulaa* water. This is because the Borana first lived in forestlands, where *adaadii* water is naturally generated. Over time, the Borana people expanded their lives into the *gammojjii* lands which have underground water that needs more resources to establish and manage.

Ownership of *adaadii* wells is traced through the *konfii* or *coqorsa* systems. The *konfii* system of *adaadii* wells was established a long time ago. When a person belonging to a certain Borana clan first discovers a source of water which has never been investigated by anyone else, ownership is approved only when the discoverer lights fire at the source with the presence of witnesses. Then, *konfii* ownership is given to the founder and passed down to his descendants, and the well's owners are his clan members, of course. *Coqorsa* ownership is when a particular geographical unit of land is officially given to a specified Borana clan. Once the *coqorsa* title is recognized, ponds and *adaadii* water sources found in that catchment area, even those investigated or created by members of another clan, belong to the coqorsa-owning clan. Recognition of *coqorsa* ownership is conducted by the Borana assembly, headed by the gadaa leader.

Coqorsa is literally a type of evergreen grass grown over swampy areas and has deep roots that cannot easily be removed. According to the Borana, *coqorsa* is senior to all grasses. It is mostly found at the source of *adaadii* and *tulaa* wells. Therefore, in this context, *coqorsa* symbolizes seniority and perpetual ownership of water. It is also carried along with a ritual stick during various ceremonies.

Coqorsa ownership can be approved in many ways. First, *coqorsa* is approved to a given clan to defend a part of Boranaland from their neighbours when a large number of this clan accidentally occupies areas at the boundary of Boranaland. Gomolee land, which is *coqorsa* of the *hawaxxuu* clan of the *goona* moiety, is an example. Second, when a person discovers a source of water at a forest site before anybody else, the remaining sources in that system belong to the *coqorsa* of his respective clan. *Adaadii* wells in the *Areero* Forest, which are the *coqorsa* of Digaluu-Tiittii clan, belong to this category. According to informants Moluu Soraa and Moluu Guyyoo, elders of Digaluu-Tiittii, Adaadii Tiittisaa, the first wells in the Areero Forest that were investigated by their own clan are called tiittile. Following that, *coqorsa* ownership of many clusters of wells in different areas of this forest was given to their clan. The third method of receiving *coqorsa* ownership is when two Borana clans have a dispute over ownership of a water source. In this case, when the ownership of a contested source is given to one clan, then the other clan may be given another area as *coqorsa* as a mechanism of conflict resolution. The *coqorsa* of Hara Hawaxxuu was given to the *Hawaxxuu* clan as a result of conflict resolution between the *Hawaxxuu* and Digaluu-Nuurtuu clans over the ownership of Hara Digaluu.

There are three Borana clans that have been given *coqorsa* ownership: the *Hawaxxuu*, *Karrayyuu-Walaabuu* and Digaluu-Tiittii. The coqorsa owner of the Digaluu-Tiittii clan covers all areas of the Areero Forest; the *Hawaxxuu* clan have ownership of Goomolee land, which runs from northeast of Areero District down to the Sagan River; and the area between east of Areeroo Forest and Diida Haraa location belongs to the Karrayyuu-Wallabbuu clan.

Like tulaa wells, utilization systems of adaadii are facilitated by a chosen water caretaker. The water caretaker usually comes from a clan of a source owner. But sometimes, if the elders from the owner clan are not found in that locality, an elder from any Borana clan can be assigned as caretaker. A caretaker should be one who knows about customary water management systems and is good at coordination. If he is different from the well owner clan, he should be delegated by elders of the well owner`s clan. Although adaadii wells over a certain area are owned by a single or few Borana clans, other fellow Borana have rights to use water from that sources.

Adaadii and tulaa water wells have not only supplied water for livestock and domestic consumption, but they also serve as sacred grounds where various ceremonies are performed for the well-being of people, livestock and the environment. Among others, Kuraa Adii recites the following songs during the dhibaayyuu ceremony near wells:

Fororee

Oo fororee;	Oh, there is abundance;
Fororsaan roobe;	It has rained in abundance;
Robee laga yaase;	The rain has flooded along the dry river;
Ilmee laguu baase;	Creatures are saved from the time of risk;
Madda gabbise;	There is plenty of water in the water source;
Diqqaa guddise;	The immature beings have grown up;
Guddaa gaamarse.	The matured beings have lived well.

Roobaan Sii Gale

Oo rooban sii galee;	Oh, I come back home with rain;
Waareen gannaa misaa;	Pre-milking dawn grazing of the main rainy season is with plenty of fresh grass;
Ta bonaa furmaataa;	That of dry season is with reviving showers;
Furmaatii roobinnaa;	Be the reviving showers rain;
Roobee lolaassinna.	Be the showering makes flood.

Furmataa is one-three days of rain showers in the dry season before the main rain comes and that reduces the shortages in the dry time *Waaree* is pre-milking grazing at dawn during the rainy season when there is an abundance of fresh grass.

This is a type of *dhibaayyuu* performed near water wells by members of the community and *gadaammojjii* ritual villages. *Fororee* is a *dhibaayyuu* prayer recited by members while walking to the *dhibaayyuu* well; whereas, *roobaan sii gale* is recited while coming back home. *Dhibaayyyuu* is often conducted near water wells during dry seasons when the rains are coming late, or after the rainy season, to officially open the water wells for public use. When performed before the rain comes, it is a prayer for rain, and when it is after rainy season, it is to give thanks for the abundant water in the well and so that it will be blessed. Thus, the song depicts the seeking of abundant rain and how significant rain is for living beings. It also shows the importance the Borana belief system attaches to wells.

Haroo (ponds)

Like the *tulaa* wells, ponds are dug in different parts of the *gammoojjii* lands of the Borana. In the vicinity of many Borana rural villages, there is at least one pond. It is originally initiated by a man either to obstruct ongoing flood-water while raining or to build a dam along a dry river during non-rainy time, in order to catch water during the rainy season. Once a pond is initiated, Borana have well-established customary systems for the expansion of the pond. That is, forcing any user of that pond to dig the pond for expanding its capacity while s/he is using it for domestic or livestock purpose. Likewise, the users are not only pushed to expand the pond, but they are also obliged to remove sediment that enters the pond as a result of runoff. Disobeying this rule is failure to maintain access to water from any source throughout Boranaland.

The pond maker and his extended family are the *konfii* owners, and the ownership of the pond belongs to the pioneer`s clan. Most ponds are named after the person who initiates them, whereas some are named after certain clans. This latter naming usually happens when several ponds are established at a specified site by individuals of the same clan.

A caretaker of a pond can be from any Borana clan who respects his own assignments and commits fairly to his duties and responsibilities in accordance to customary laws. The caretaker is selected and dismissed by the members of that community. Ineffective management of a pond may result in changing the caretaker at a community meeting No one has the right to access a water source without the knowledge of the caretaker.

Although any Borana has the right to get access to water from a pond of his fellow Borana, there are some special modalities to be taken into account. Since ponds do not have natural springs that feed them all the time, the Borana have special rules for the management of the water of the ponds. For instance, when rainwater comes into the ponds, there is plenty of groundwater available from other means. Thus, ponds are fenced and officially closed until to the next dry season. Closing and opening of a pond is conducted through consensus reached at community meetings.

Before the opening of the ponds, a pastoral coordination meeting is summoned to identify the number of beneficiaries of the ponds. If there are many ponds, those that will be reserved for dry herds (herd units that consist of bulls, oxen, young cows and dried cows usually kept at satellite camps), lactating herds (herd units consisting of milking cows and one or two bulls kept at the main camps) or and domestic consumption are located, or the number of beneficiaries allocated to each pond is identified. If there is one pond in the area of the main camps, the dry herd is usually allowed one or two watering days. Then they have to move to another place with another water source. In other words, that pond will be reserved for lactating cows and domestic consumption.

When the amount of water in the pond goes down substantially, and the rainy time is not close, another pastoral coordination meeting is organized to discuss the issue. Then the remaining water is reserved for small livestock and domestic consumption. According to *seera-aadaa haraa* (customary laws of ponds), when the pond is close to dry, the water that is left is reserved for domestic use.

In general, an individual Borana has the right to get access to any water source of the Borana in the name of being Borana. But there are rules that enable some people to claim priority use rights. For instance, if the amount of water in a source is getting low, the livestock of the *gadaa councilors* (incumbent and previous ones), ritual leaders, customary healers, blacksmiths and other respected persons in society are given priority use rights. Others must move to another source. This is mainly because these people often provide free services to the community.

Pasture management

Borana clans are not territorial based. They are rather distributed throughout Boranaland. Thus, pasture in any part of Boranaland is communal property. That is why even though the Borana of Kenya and of Ethiopia are mobile, they can easily manage to share this scarce resource in a harmonious manner. During the field research, a large number of Kenyan Borana and others on the Ethiopian side took their livestock inside the Areero Forest and its adjacent areas for grazing. The Kenyan Borana told the researchers that other Kenyan Borana have been allowed to graze in Mooyyale-Ethiopia, Dilloo, Dhaas, Yaaballo, Dirree, Miyoo and Taltallee Districts of the Borana Zone, as pre-arranged with the Ethiopian Borana.

However, harvesting of this resource has its own common rules to be followed. Any Borana who wants to join other fellow Borana residing in another territory of Boranaland due to various factors has to communicate with the existing residents beforehand. For instance, he sends an abuuruu (an “investigator”) to assess the availability of pasture and water, the physical and health condition of livestock and the number of users over a new area. If the condition of the new area is better than his residence, the man informs the pastoral coordinating elders of the area and explains the condition of his area and the need to move to the new area. Borana customary use of pasture allows a new-comer to share pasture resources in any territory of Boranaland. But what matters is that the prior settlers are responsible to decide where the new-comers should be settled. This is because in any residential unit, there are areas reserved for small stock, wet and dry seasons grazing, and satellite and main camps (Boku, 2000).

Like water management, when the amount of pasture is declining due to a long dry season or overharvesting by a high concentration of livestock on a grazing unit, the Borana usually organize a community meeting in order to let the dry herds, together with other herds, move to another location.

Impact of development interventions on customary resource management

This topic deals with various development interventions and their impacts on customary resource management systems of the Borana Oromo during successive Ethiopian regimes. The Borana Oromo were conquered and incorporated into the Ethiopian State by the army of Menelik II in the 1890s (Borbor Bulee, interview, 4 February 2010; Bassi, 2010 and Oba, 2013). Before this incorporation, the Borana gadaa system was an independent system that governed the people and their territory.

Following the conquest, each successive Ethiopian government has established its own structures and superimposed them on the Borana customary institutions of resource management. Among other things, urbanization, state structures, and pastoral development programmes and policies interfered with Borana systems and institutions. Since these actions did not consider the local context for managing people and their resources, they caused tremendous changes in socio-cultural aspects and the environment of the Borana (Boku and Irwin, 2003; Bassi, 2010; Oba, 2013).

Urbanization

Many of the old Borana towns, such as Nageelle-Booranaa, Yaaballo, Meegga, Mataa-Gafarsaa and Hiddii Lolaa, are located inside the Borana forest systems. Boku and Irwin (2003) note that these towns were established as garrisons for the conquering army of Menelik. This conquest was followed by settlement of immigrants from the Ethiopian highlands in and around the garrison towns (Oba, 2013). These settlements resulted in deforestation. In line with this, Taddesse Berisso (1995) states that the objectives of the existence of towns in the conquered areas of southern Ethiopia were as follows:

Menilek`s policy upon conquering an area in the south was to establish garrison towns at intervals throughout the region. These towns housed soldiers needed to maintain control of the region, along with officials such as tax collectors, judges and local governors. His effort to promote urbanization was motivated by military and political factors and, therefore, the development of towns was not a genuine drive to build an urban system. Consequently, his effort did not aim to create cities that were economically viable; rather it left a legacy whereby a new type of economically oriented urban system was superimposed on the traditional structure. These towns were thus highly dependent on the exploitation of the peasant produces for their survival and on the surrounding forests for firewood and wood for construction. Since there were no policies to regulate forest use, towns had been, and still are, a threat to the surrounding forests.

As so far discussed, Borana value their forestlands as sacred grounds and as such they have norms and systems to control these lands. But the highland immigrants, as well as the conquering army of Menelik, did not have the same value to control use of forested areas. Therefore, they created new exploitation systems inside the forests. These systems caused deforestation and obstructed access to ceremonial grounds and other forest resources for local communities. For instance, in and around Mataa-Gafarsaa, Meegga, Yaaballo and Nageelle towns there are clusters of water sources that the Borana were obstructed from using.

In addition to firewood collection, the urban residents introduced logging of forest trees, particularly juniper trees, for house construction in towns in the Borana zone. As urban centres are expanded in many Borana places, logging of forest trees and commercializing of them are increasing. In addition, urban dwellers and poor peri-urban immigrants with agricultural backgrounds have commenced making farmlands inside the forests. This unwise exploitation of forests has brought about degradation and deforestation of forestlands in the vicinity of these settlements. In line with this, Bishaw (2008) reports the main causes of deforestation in Ethiopia are expansion of agricultural land, overgrazing, firewood collection, logging of poles for house construction and increased populations.

State structures

Gadaa had been the only governance institution of the Borana Oromo before Boranaland was conquered and incorporated into the Ethiopian state under Menelik II. Under the gadaa system, there were, and still are, several structured institutions at different units of Borana territories. It was through the manifestation of these governance structures that all affairs of the Borana, including social, political, economic and ritual issues, used to be regulated.

However, Amae (2005) states that after the Menelik conquest, the gadaa lost its government status at the national level and subsequently was relegated to the Borana Oromo “traditional” institution in the eyes of historians, politicians, anthropologists and sociologists. Despite this, the Borana Oromo still elect their customary leaders through the gadaa system every eight years. However, Legesse (2000) suggests that the roles of the gadaa institution are eroding over time due to colonization pressures, though its functions are still active among the Borana Oromo.

The imperial period (1890s-1974)

The Borana were subjugated by Menelik II's army and incorporated into the Ethiopian state during the gadaa period of Liiban Jaldeessaa whose term of office runs from 1889 to 1897 (Borbor Bule, interview, 2010). Immediately following the incorporation, the state established its own structure which was quite different from the Borana structure. Oba (2013) states that Borana governance power was shared equally among the two major moieties of Borana, *Sabba* and *Goona*. The *Qaalluu* of *Odituu* (*goona*) and the *Qaalluu* of *Karrayyuu* (*sabbo*) were given the Ethiopian title of *balabat* (an imposed system of the empire). Accordingly, under this newly imposed system, *Annaa Boruu* of *Odituu* and *Geedoo Jiloo* of *Karrayyuu* and their descendants represented the Borana.

Borana informants assert that the state gave representation of the Borana to the *warra qaalluu* ("people of the *qaalluu* lineage") because the power of *qaalluu* is hereditary and resembled the imperial system of the Ethiopian state (the power of *balabat* was likewise hereditary). Whereas the traditional *gadaa* system elected their leaders and a person`s term of office changed every eight years; this was considered inconvenient by the imperial rulers.

The state structures working in the community were the *balabat*, the *inderasee*, which is corrupted by the Borana as *andarasee*, the *qoroo* and the *harka*. The *balabat* is a high post given to very few people who represent the central government at the community level. *Andarasee* is a post given to those who represent the balabat in a certain geographical unit. *Qoroo* is a lower post than *balabat* which is appointed by the government to govern one or two *maddas*. Harka is a lower post that represents the *qoroo* in his absence.

During those days, the main roles of the state representatives at community level were to assign and collect taxes, deal with conflicts and handle the election of customary leaders, including the *gadaa councilors*. However, the election of *gadaa councilors* and the governing of various institutions at lower levels were mainly the authority of the *gadaa* institution rather than the *qaalluu* institution.

Even though they were assigned by the state structure, many of the community leaders of those times were elderly people who had good knowledge of the values and norms of customary systems. Thus, customary resource management systems in various geographical units, such as the *ollaa, reera, madda* and *dheeda*, of Boranaland were to some extent running along customary systems. But this does not mean that there was no state intervention in customary systems of resource management. For instance, *Moluu Soraa* and *Moluu Guyyoo* narrate the following case:

Case-3

The Areero District governor of the imperial time was a Borana, belonging to the Digaluu-Eemmajii subclan of the Digaluu clan of sabbo moiety. He had a car and many herding units of cattle.

He controlled the management of all water wells found in the Areero Forest, which belonged to the coqorsa owner of Digaluu-Tiittii, another subclan of the Digaluu clan.

He assigned water caretakers only from his own subclan and monopolized some wells to be used only by his cattle and others to wash his car. One day, he denied the previous gadaa leader, Taadhotee Adii, who belongs to a clan that owns Areero wells, and Qaamphee Diidoo, of the Warr-jiddaa clan which has an inter-clan belief relationship (sunsuma) with the owner clan, to access the Areero wells. Then both moved to other Borana water sources, outside of the district.

Thereafter, since this rule breaks the Borana belief that allows a man free use of water from his fellow sunsuma`s source and that allows a gadaa leader to access water from any water source of the Borana, all the wells of the Areero Forest uniformly dried up for some time. Finally, the governor himself confessed his fault and went to Qaamphee`s residence carrying cultural objects according to Borana custom to request forgiveness. Qaamphee accepted the request and the wells became full of water again.

The result reveals that the Borana resource management systems believe that violation of the systems may harm not only the wrongdoer, but also nature itself.

The military period (1975-1991)

The military period in Ethiopia commenced with a proclamation of land reform and the 'Development through Cooperation Campaign" of 1975-1976 that intended to transform the old order and the oppressive administrative arrangements of the imperial era (Helland, 2000). It marked the end of the *balabat* system and the beginning of a new territorial-based government political structure known as the kebele, which is equivalent to the present day Pastoralist Associations. The Ethiopian state has established Pastoralist Associations since 1978, with the specific aim of facilitating active resource management to avoid environmental damage and providing services to pastoralists as cheaply and as efficiently as possible (Helland, 1997). In Boranaland, the Pastoralist Associations replaced the customary units of land called *madda* (Hogg, 1993).

Still, this system did not incorporate the customary leaders of resource management at different units. The system had executive, controlling and social court committees and other various subordinates at different administrative levels in the community. Particularly, the secretary of the executive committee was drawn from those who could read and write and the remaining were elderly people from among community members. In most cases, the leaders were selected by members of their respective Pastoralist Associations with reference to their ability to take on a leadership position and their knowledge of customary systems. Since the formation of the Pastoralist Associations, non-governmental and government development programmes would reach the community only through consultation with Pastoralist Association leaders, without considering the potential of indigenous knowledge.

During the military regime, some changes were made in the election of customary leaders and customary resource management systems. Among others, the leading role of electing customary leaders, particularly *gadaa* councilors, which was snatched from the *gadaa* leaders under the *balabat* system, was restored to the hands of *gadaa* leaders at *Gumii Gaayoo* in 1980 (Borbor Bule interview, 29 January 2010). Thereafter, issues pertaining to election of *gadaa* councilors were fully administered by the customary leaders of the *gadaa* institution. Although the Pastoralist Association leaders were different people from customary leaders, in the early period of this regime, resource management at different units was conducted relatively in accordance with the customary system. But, toward the end of this period, the divisions into Pastoralist Associations brought about resource-based inter-Pastoralist Association conflicts along the imaginary borderlines of various Pastoralist Associations in Boranaland. Even inter-Pastoralist Association mobility for harvesting water and pasture was not allowed without showing supportive letters from one`s respective Pastoralist Association. Thus, these conflicts hindered the mobility of the Borana pastoralists to certain territories of their land.

The period post-1991

The framework of external divisions of Borana territories into Pastoralist Associations remains unchanged under the current administrative structure. But the internal structures and ways of assigning leaders have changed. For instance, Pastoralist Association leaders in different geographical units are selected on the basis of their participation in the ruling party. This is quite different from selecting customary leaders at various territorial units based on one`s ability to manage things. Pastoralist Association leaders may also be young people who are too immature to take leadership positions at the community level, according to Borana custom.

The role of many customary institutions *(ollaa, reera, madda, etc.)* and their leaders and the role of elderly people and ex-gadaa councilors have been ignored through misrepresentation in the new government structure. For instance, the following customary structures were overlapped with parallel government structures:

Customary structure	*Government structure*
Shanacha	*Gooxii*
Ollaa	*Garee*
Reera	*Zoonii*
Madda	*Ganda*

Ganda is an Oromo term used instead of Pastoralist Association, and zoonii in this case refers to a cluster of villages. Garee comprises about 25-29 households and gooxii is another administrative unit within garee. These government structures institutionally and functionally replaced the customary ones. This is confirmed by an extract from a statement made at an action-research workshop of the Borana Conserved Landscape on 22 July 2007, in which Yaaballo says, "… in Ethiopia there is no clear distinction between the roles and mandate of government and the roles of customary institutions, and that in our territory the government structure is replacing the customary structure at all levels down to the village, and in many sectors, including the management of natural resources," (Bassi and Adi, 2007).

The customary structure of ollaa and its leader still exists, but the government has established garee instead of ollaa. The garee has its own leader, different from the head of the village. A garee leader is young, a member of the ruling political party and selected by his fellow party members at a Pastoralist Association meeting. He represents his village at different affairs. One of the key informants was an ex-gadaa councilor and head of his village in the customary way. According to his view, he is fully consulted on the issues of his respective clan, but rarely on common resource management and resolving conflicts. He emphasizes that the leaders of government structures at the Pastoralist Association level do no respect customary leaders as other fellow Borana do.

In comparison with previous Ethiopian governments, the current government seems to have a positive attitude towards the gadaa institution, but the way the government is treating gadaa is eroding the customary system. For instance, from the different types of councilors of the three mobile ritual villages in a gadaa office, the state structure is now giving due attention only to a gadaa leader who is leading a class in power. The government has also ignored the roles of various lower level customary institutions at different units. So, this is quite different from the gadaa structure. Customarily, it is not a single person or a single institution, but rather the harmonization of different institutions that constituted the gadaa system as a whole.

In addition, many of the Pastoralist Association leaders consider natural resources in their respective administrative areas as their own private property rather than communal property. For instance, some of them illegally provide farmland to private owners, intervene in the role of water caretakers, inhabit the buffer areas between two adjacent Pastoralist Associations which are not allowed to be settled, and construct private kaloos (range enclosures). Once such case is narrated by informants to support these views, as follows:

Case-4
Midanuu is a buffer zone found at the border of the Halloona Pastoralist Association in the Arero District and in the middle of the Diida Haraa and Weeb Pastoralist Associations of the Yaaballo and Areero Districts, respectively.

A rich man and Pastoralist Association leader from the Halloona Pastoralist Association settled in that area 10 years earlier and established a large, private kaloo. At several community meetings, the participants decided to dissolve his settlement. But, after accepting the decision, he did not put it into practice and provided groundless reasons. Finally, the issue was, according to procedure, reported to the gadaa, and district and zonal offices. His settlement has not yet been removed.

On 14 January 2010, during the field work, the lead author attended a pastoral coordination meeting held at the gadaa ritual village of Arboora. Unfortunately, that meeting was not successful due to the dropping out of expected participants and then the meeting was postponed to another time. Some of the elders who were present told researchers that the objectives of the meeting were to discourage inappropriate settlements and private kaloos in Areero District. Of many cases, the above case was included.

However, this does not mean that the gadaa structure is totally passive in managing natural resources in its environment and in settling conflicts over those resources. For instance, on 14 March 2010, the lead author also attended a meeting on an inter-Pastoralist Association resource-based conflict which was held at gadaa Arbooraa, and a summary of the case that was narrated follows:

Case- 5
Maddoo Abbameegaa is located between the Qaawaa Pastoralist Association of Areero District and the Danbalaa Baddanaa and Hiigo Pastoralist Associations of Dirree District.

Maddoo Abbameegaa is an open grazing area reserved for the settlements of these Pastoralist Associations. But four years earlier, a village from Qaawaa Pastoralist Association camped in this area. The elders, past gadaa councilors and Pastoralist Association leaders from the three Pastoralist Associations organized meetings and discussed the illegal settlement of the village. But they disagreed on the situation, as members of the Pastoralist Association with the settled village supported its settlement and others took the opposing side. Then, the case was reported to the gadaa Arbooraa and the gadaa organized a meeting on 14 March 2010.

At that meeting, the gadaa councilors listened to both sides. After holding a long discussion, they persuaded those who supported settlement of the village in the open grazing reserve that the village was not in the right place and that it had to be removed from that area. They all agreed that the village must leave the area within two months. Finally, the incumbent gadaa councilors gave a mandate for the next process to the past gadaa councilors from both disputants.

This shows the prevalence of inter-Pastoralist Association conflict and how people tend to take the side of their own Pastoralist Association without referring to customary resource management systems. It also indicates that the gadaa structure is still playing its role, regardless of the superimposition of state structures.

Pastoral development programmes

The pastoralist population of the world is estimated to be 30-40 million, of which Africa shares about 15-20 million (Sandford, 1983, cited in Yigezu, 1996). Yigezu also suggests that about 60 percent of the African continent is estimated to be arid and semi-arid areas where people depend on pastoralism for their livelihood. Regardless of their contributions to the continent's affairs, many developers have undermined pastoral production systems. That is, many past pastoral development policies set for many African pastoralist societies were inappropriate, as they did not fully consider customary resource management systems. For instance, researchers, policymakers and developers viewed pastoralism as traditional strategies for livestock production and land use so that it is an inappropriate to promote commercialization and change (Sandford, 1983, cited in Coppock, 1994). Sandford further states a prevailing view of some outsiders that the livestock of pastoralists are thought to cause a great threat by degrading rangeland environments because of the apparent reluctance of pastoralists to market animals and destock.

Pastoralists constitute 12 percent of the total Ethiopian population and occupy the arid and semi-arid regions located at the peripheral zones of the country. They comprise 29 different ethnic groups. Pastoralism provides direct employment and livelihood to over 7.7 million people and pastoral territories are home to 42 percent of the national livestock population (Coppock, 1994, cited in Adi, 2007).

Despite these contributions to the socioeconomic value of the country, very little consideration was given to Ethiopian pastoral areas until the mid-1960s (Desta, 1996). From the 1960s onward, many development activities have been undertaking to improve the infrastructures of pastoral communities. However, as noted above, many development interventions in pastoral areas of Ethiopia have not taken into account customary systems of resource management.

Past rangeland development interventions of Ethiopia were based on the theory of "tragedy of the commons" which advocates that grazing lands are used communally, while livestock are owned individually (Angassa and Adugna, 2006, and Berisso, 2006). As was already mentioned in the theoretical framework of this paper, this theory implies that every user of the common-pool resources has access to a resource, but nobody takes care of it. It was also believed that pastoralists wanted to maximize their herds at the expense of communally-owned grazing lands, which resulted in land degradation. Angassa and Adugna further state that since policy-makers had preconceived concepts of settlement and ranching, they did not adequately consider features of customary pastoralist livestock management, which was based on splitting and moving herds between wet and dry season grazing lands.

In addition to this, Berisso (2006) states that 'Unilineal Evolutionary' and 'Cattle Complex' theories influenced pastoralist-area development interventions in Ethiopia, in particular, and Africa in general. The Unilineal Evolutionary theory assumes that economic development advances from hunting and gathering to horticulture and pastoralism and then to agriculture and finally to industrialization (ibid). In other words, human society develops from simple to complex technologies in a unilineal manner. So in the case of Ethiopia, pastoral economies had to develop toward agricultural production. According to the Cattle Complex theory, pastoralists possess vast herds for cultural and social values instead of economic and ecological rationales (ibid). The Borana rangeland has been one of the areas in which pastoral development programming has been focused in the country.

Pastoral development programmes in Borana areas

As noted above, several pastoral development projects were implemented in Boranaland to improve pastoral production systems since the 1960s. First, in 1965, a pilot project was initiated by the Ethiopian government in collaboration with USAID in the Diida Haraa Pastoralist Association of Yaaballo District. A second livestock development project was funded by the World Bank and initiated in 1973. A third major project in this series – called the Southern Rangelands Development Unit (SORDU) – operated between 1975 and1984 with donations from the World Bank and the African Development Bank (Angassa and Adugna, 2006; Berisso, 2006; Boku, 2000; Hogg, 1996; Coppock, 1994 and Desta, 1996), and continued until recently with funding from the Ethiopian government.

The objectives of these development programmes were to improve the status of animal health and bolster market outlets to effect dramatic increases in cattle off-take for domestic consumption and export. This was supposed to lead to higher incomes and an improved standard of living for the Borana and to enhance their contribution to the national economy. The main activities of these programmes were construction of ponds, improvement of infrastructure (roads and livestock markets), improvement of veterinary services and oppressing customary rangeland burning systems to control bush invasion. Although the proposed ideas for live animal off-take for domestic consumption and export were not practically carried out, the remaining activities were indeed implemented.

Ironically, although spending millions of dollars on these programmes, the net impacts of these interventions were larger populations of cattle that degraded the land and high concentrations of human populations around water points (Coppock, 1994; Oba, 1998). All these, finally, resulted in invasion and domination of the rangeland by woody species and increasing human dependency on relief and rehabilitation (Coppock, 1994; Hogg, 1996; Berisso, 2006 and Angassa and Adugna, 2006; Oba, 1998). These projects failed to achieve their objectives because the planning and implementation approaches used had little participation of the local people and did not adequately consider customary natural resource management systems (ibid). The following research findings show the impacts of the above development interventions.

In Boranaland, 82.2 percent of the rangelands are threatened by a combination of bush encroachment, unpalatable forbs and shrubs. Only 17.2 percent of the rangelands were free from either bush encroachment or invasion by unpalatable forbs. Bush encroachment is in climax stages in 24.1 percent of the rangelands. In 25.9 percent of the rangelands, changes in the herbaceous layer were caused by unpalatable forbs (Oba, 1998, cited in Angassa and Adugna, 2006).

In addition to natural population growth trajectories, other factors have contributed to the rapid growth of human and animal populations among the Borana. The most influential among these are an improvement in human health services since the Ethiopian revolution of 1974 and that of livestock since the introduction of the above projects (Helland, 1991).

Gurroo Diidaa, a Borana elder, confirms that the above development interventions have brought radical changes to the Borana rangeland ecology and their pastoralist way of life. He narrates the following case from his experiences on the impacts of development interventions in the Diida Haraa Pastoralist Association of Yaaballo District of Borana zone:

Case-6
Diida Haraa Pastoralist Association is situated 30 km east of Yaaballo District. It covers large areas along the Areero-Yaaballo road.

It was one of the prominent wet season grazing areas of the Borana rangeland before the above interventions. Gurroo remembers that Diida Haraa used to be a home for many wild animals, such as ostrich, oryx, hartebeest, gazelle, zebra, lion and so on. In the course of the SORDU development programme, eight big ponds were built in Diida Haraa. Then, many Borana pastoralists who resided around the tulaa wells came and settled around the ponds. He also remembers that the SORDU programme held annual vaccination campaigns for livestock and constructed many roads.

The veterinary campaigns eliminated the outbreak of cattle diseases, such as rinderpest, lung disease and others. The construction of the ponds increased the number of livestock and human populations became sedentary around the ponds. He further recalls that many of the settlements currently found in Diida Haraa have been there for about 30 years. Consequently, wild animals, like lion, oryx and hartebeest, are extinct in the area. Overpopulation caused rangeland degradation that resulted in bush invasion. He bitterly remembers that in the past, inhabitants of Diida Haraa had a hard time finding enough thorny bush for fencing livestock enclosures and collecting firewood. But now, the disadvantageous bush has invaded all areas and displaced grass.

He concludes by noting that the livestock of inhabitants of Diida Haraa now must depend on other grazing areas of Boranaland, particularly the Goomolee area (part of the Oobada Forest) and the Areero Forest. This is creating pressure on the forests and competition over forest resources between Borana and their neighbours, as well as intra-Borana competition.

Water development programmes in Borana areas

Many water development programmes have been implemented in Boranaland by the Borana themselves and by government agencies and non-governmental organizations. The focus here is on those which have had a serious effect on customary resource management systems. Accordingly, machine-built ponds and motorized bore-holes established by the government and non-governmental organizations are the major ones. Development of big ponds was aimed to reduce concentration of populations around dry season grazing areas by establishing water ponds in wet season grazing areas. This policy overlooked the seasonal mobility of pastoralists due to the arid nature of their environment that helps with effective management of rangeland degradation. As Berisso (2006) suggests, the implication of this policy was not to build on traditional pastoralist modes of production, but rather to transfer it to agricultural modes of production in order to sedentarize the pastoralists. Furthermore, the rangelands used by the newly-established permanent ponds were overstocked, leading to severe ecological degradation (Oba, 1998).

According to a Borana Zone Water Resource Development officer, the establishment of motorized water points is to attain the national consensus for water development that calls for potable water to be available within 1.5 kilometres in rural areas of the country. This is, however, not in line with Borana customary water development systems that consider the various territorial settlement units. Customarily, Borana can have at least 30-40 kilometres between two permanent water sources, particularly tulaa wells, to incorporate the effective management of pastureland into the water management system.

Management of these new water points is quite different from the Borana customary systems of water use. In the Borana custom, ownership rights to water points are given to identifiable clans, under which their management is supervised. No user pays for access to the customary water ponds. But access to the motorized water points is a pay-for-use system. This payment is collected for the purchase of gas-oil and replacement of spare parts. Besides, because the newly-established water points have never belonged to any Borana clan, developers usually handed them over to the respective Pastoralist Association leader. Then the Pastoralist Association leader formed a committee or caretakers who closely supervised the systems under his management. Since this system did not link to customary water management systems, the water points established by developers usually failed to achieve their objective. In line with this, Watson (2003) narrates hereunder the case she quoted from a development worker in Borana Oromo of Ethiopia:

Interviewer: *What does it mean when you say you work with 'the community'?*

Development worker: *We support traditional institutions and organizations like the 'gadaa.' Peasant Associations were imposed during the Derg regime (1974-1991) and bypass traditional institutions and the elders…They cause problems and make people destitute... There is evidence to show that 'tradition' still works. For example, the traditional deep wells are still working, whereas the modern ones are mostly broken.*

Moreover, there is a huge ongoing water development project being run by the Oromia Water Enterprise Agency in pastoral areas of Boranaland. The plan is to establish motorized bore-holes at different points. Then these systems will be joined together through pipelines and cover about 2,000 kilometres. Some Borana informants have little knowledge about this project, whereas others are reluctant to share their views on it. Is it really the project aimed to improve pastoralism or to encourage sedentarism? Not clear. If the objectives and implementation of this project do not consider the reasons for failure of past water development programmes in pastoral areas of Boranaland, it will be feared that the impacts of this project will be the end of pastoralism in Boranaland.

Farmland expansion activities in Borana areas

The Borana predominantly depend on a livestock economy and their livelihood and sources of wealth are traditionally measured by the number of cattle available (Boku and Oba, 2010). However, crop cultivation has been expanding in pocket areas of the semi-humid zones of Boranaland since the Menelik conquest. The introduction of agriculture commenced when Menelik`s soldier-settlers and highland immigrants settled around the garrison towns (Helland, 2000). Helland states that much of the agricultural land around these towns belongs to the descendants of these settlers. He further states that farming is also practiced by neighbouring groups, such as the Konso and the Burji, who settled in Boranaland. The Borana informants confirm that much of the farmland at the foot of the Areeroo Mountains belongs to town dwellers that originally came from other areas of the country.

The informants also said that the Ethiopian government has been implementing crop production policies in Borana pastoral areas for rural development programmes since the downfall of the imperial regime. Today, those Borana who reside around the forests and along the bottomlands have picked up agricultural practices to diversify their livelihoods.

Establishment and consolidation of villagization and resettlement schemes were among the Ethiopian government's strategies implemented to strengthen the socioeconomic structures of rural people since the socialist revolution of 1974 (Berisso, 1995). As one of these programmes, the government resettled about 300 households at Bokdha, inside the Areero Forest, following the severe drought of 1984-1985. These resettlers were drawn from different areas of Boranaland that were highly affected by the drought. According to informants from this resettlement, they were resettled there because the forest is wet enough for crop production, and to this day they continue to cultivate inside the forest. But this has had negative effects on the forestlands. According to a forestry worker at Areero District, the density of the forest areas adjacent to this settlement is getting thinner and thinner due to illegal logging of commercialized timber.

According to Borana customs, however, the bottomlands are usually reserved for grazing of small livestock and the forestlands are reserved for dry season grazing. Moreover, cutting down of big trees and cultivating crops along the forests edges are in contradiction to Borana customary law for forest resource management and doing so, in the past, used to be stopped through the enforcement of customary law. For instance, Oba (1996) states that many Borana violated these customs and started cultivating in the forest; then Daawwee Gobboo, a gadaa leader (1697-1705), organized a group of people to punish those who had cultivated in the forest by burning their crops and customary leaders, like the hayyuus (gadaa councilors), were strangled.

After all, agriculture in Boranaland is unsustainable due to the aridity of the land. According to the Borana elders, those Borana who practice agriculture might benefit from its production once in six years due to the unreliable rainfall. For this reason, farmland is considered an issue of rangeland encroachment, competition over resources and deforestation. Regarding farmland expansion, Coppock (1994) suggests that about 2-3.4 percent of Boranaland is under cultivation. Grain per capita in farm households met only 26 percent of the annual requirement per person, equivalent to three to four months of self-sufficiency per household (Boku and Oba, 2010). Not only has crop cultivation not enabled self-sufficiency, according to Boku and Oba, but it has also resulted in fragmented grazing lands.

Case-7
Badhaasa is a part of the Areeroo Forest found in the Haroo Diimtuu Pastoralist Association of Areeroo District.

Badhaasa was where the mobile ritual village of Gadaa Arbooraa (Yaa`a Guyyoo Gobbaa) was situated during the field work for this study. On 14 January 2010, the lead author attended a meeting at the Areeroo District Administrator's Office at which the members of the ritual village of Arboora were accused by people from Haroo Diimtuu because their cattle entered the accusers` farmlands. The district administrator settled the case according to Borana custom.

This portrays how the expansion of farmland inside forests hinders the settlement of the mobile ritual villages which, according to Borana customs, reside in the forests. It also reveals how the change from a communal land tenure system to private ownership creates conflict among communities.

The Participatory Forest Management Project

Before the incorporation of Boranaland into the modern Ethiopian state, the Borana managed their forests using customary leaders based in various territorial units. After the incorporation, Boranaland, together with its resources such as the forests, was nationalized. At that point, management of forests was taken away from communities and given to forest guards assigned by a government agency. Under this arrangement, overexploitation of forest resources was accelerated due to urbanization, selling of timber and firewood, and expansion of farmlands and settlements inside the forest.

It was under this pressure that SOS Sahel, a national non-governmental organization, developed a Participatory Forest Management Project. This project took place in three national forests of Boranaland, namely Negeelle, Areero and Yaaballo Forests. The project was implemented from 2003-2007.

According to an SOS Sahel field worker in Areero, under the project, many forest management groups were formed at different administrative levels: community, madda level elders, block level elders, district level elders , justice, police and district administration officers; Pastoralist Association level development agent, elders and gadaa representatives) and the General Assembly. These management groups were formed after a stakeholder's analysis had been undertaken and were created by building upon customary resource management systems.

The Participatory Forest Management Project groups received a legal certificate in the form of an agreement made between the communities and their respective District Pastoral Development Office, on behalf of the Oromia Agriculture and Rural Development Bureau. During an early phase-out of the project, SOS Sahel handed over the Participatory Forest Management Project groups to the relevant government offices. After the government had done a structural adjustment for forest management, the agreements were also made between local communities and the District Forest and Wildlife Enterprise Office.

The Areero District Forest and Wildlife Enterprise expert informed the researchers that the approaches used to organize technical training for the Participatory Forest Management group members had some problems. For instance, during the life span of the project, when training and quarterly forest management meetings were organized, the participants were paid incentives by SOS Sahel. That incentive enabled the groups to establish fair management systems and, hence, the forest condition was improved during the life of the project.

After the phase-out of the project, the government faced a budget shortage when organizing monitoring meetings. The groups were reluctant to attend meetings without payment.

If a member of a Participatory Forest Management group observes illegal exploitation inside the forest, the member reports to the group in the respective area. If the case cannot be resolved at that level, it will be taken to court. But the court system does not work effectively for forest management. Pastoralist Association leaders also interfere in the role of Participatory Forest Management groups. Thus, ineffective judgments of the courts and interference from Pastoralist Association administrations reduces the desire of some members of the Participatory Forest Management groups to expose illegal extractors of timber and other misuses of the forest. Thus, sustainability of the Participatory Forest Management system is under question unless other options are formulated. Finally, the current condition of the forest is far below the status of when the Participatory Forest Management Project was operational.

When asked about the paradox behind the name of the new forest agency, Oromia Forest and Wildlife Enterprise, which was established on devastated forests in the country, the Areero District Forest and Wildlife Enterprise expert replied that what matters is how to utilize forests; not the existence of the organization. He added that the objectives of this agency are to manage and conserve existing forests, enhance development of government and community forests, maximize income, utilize forests in a sustainable way, and expand activities for social and economic development.

Nuuraa Diidaa, a Borana elder, narrates how state interventions affected the forest resources in Boranaland as follows:

Case-8

Immediately following the incorporation of the Borana into the modern Ethiopian state, some Somali pastoralist groups and others from the highlands of Ethiopia who are culturally different from the Borana came to reside in Boranaland.

As urbanization increased, these immigrant people started to overexploit the forests for the selling of timber and firewood to town dwellers. On top of this, the government administration ignored the customary resource management systems and nationalized land ownership and its resources, particularly the forests. Since customary institutions were denied their power of protecting the forests, overharvesting of forest resources gradually increased. For instance, some people were licensed to use the forest ground for crop cultivation.

Nuuraa bitterly remembers the deforestation processes as follows: “Forest resources I used to know in the Borana forests during my early childhood had gone away: Lattuu Liiban (’chat’ of Liiban) which was a natural forest only found in Manquubsaa Forest system, and used on gadaa ceremonial occasions; rhino, buffalo, elephants, giraffe and so on are now extinct from our land.”

Only very recently, after a significant portion of the forest is gone, has the government started a discourse about participatory forest management systems. The local people explain this with a proverb: “Waraabessa dabree sareen dutti” (A dog barked after a hyena had left.) In summary, the main causes of deforestation are commercialization of timber and firewood, weakening of customary institutions and cultivation inside the forestlands.

Conclusions and recommendations

Conclusions

Forest resources are the collective property for the entire Borana and thus, each member of the society is responsible to manage them. Forestlands were and continuing to be the sacred grounds for the Borana people. The Borana holy shrines and ritual places for the mobile ritual villages are found inside the forests. For the sake of belief, any kind of mistreating the forest resources is culturally prohibited. Thus, the Borana belief systems attached to forest lands are more effective than anything else for sustainable forest management.

However, development interventions such as urbanization, state structure and pastoral development programmes and policies ignored the customary institutions of resource management and used the top-down development approach. The impacts of these interventions have resulted in erosion of customary institutions, change of range ecology and shrinkage of Boranaland that led to competition over forest resources and deforestation.

Recommendations

To create a healthy environment in Boranaland, the points below are recommended.

- For sustainable use and conservation of forest resources, customary institutions of forest resource management should be recognized by policymakers, development practitioners and researchers.
- Government structures and customary institution structures should work hand-in-hand in planning and execution of forest resource management. Customary institutions should play a pivotal role in participatory management, while the state structure provides technical support, in order to come up with a viable state of sustainable forest management that benefits all.
- To control population pressures, measures like family planning for humans and livestock, early off-take and limits for livestock populations in line with land holding capacities ought to be set, along with improved health services.
- Settlement and crop production inside the forests which leads to overutilization of forest resources should be discouraged.
- Participatory development approaches should be employed for development projects, starting from the identification of the problem, to planning, implementation, and through to the monitoring and evaluation phase.

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Annexes

Annex 1: The Borana Kinship Systems

The Borana Moiety Systems

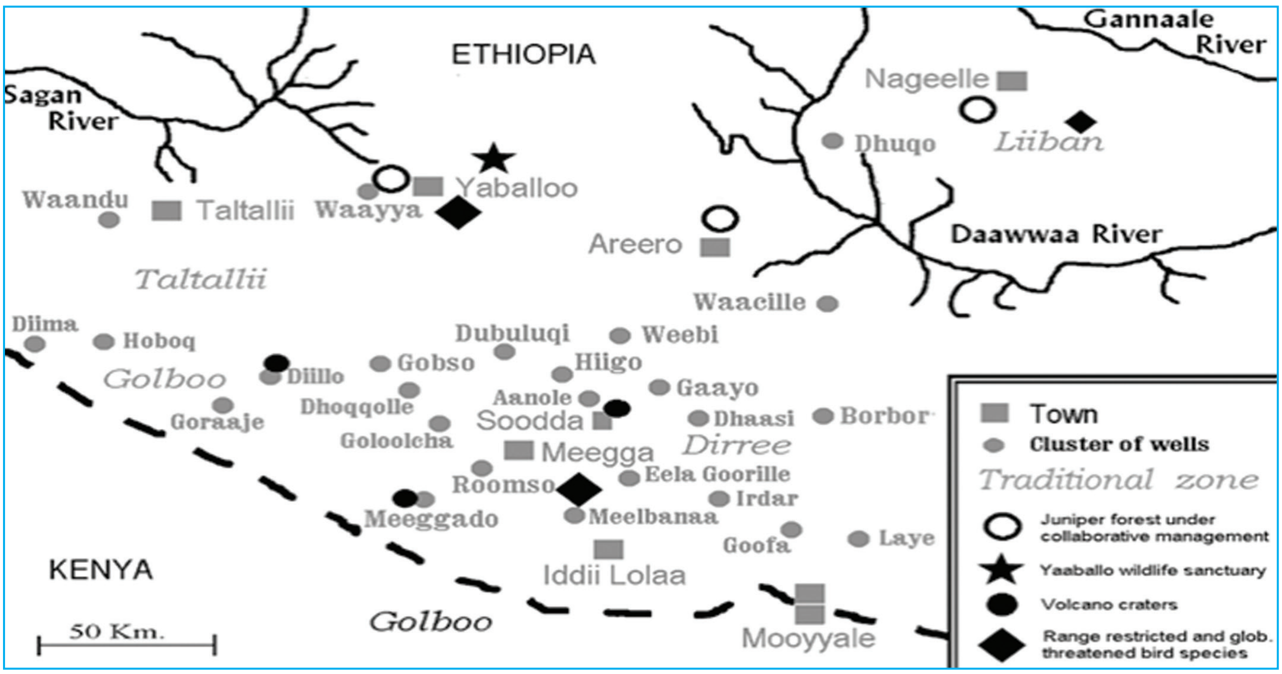
Borana

1.Goona Moiety	***II. Sabbo Moiety***	
a.Fulleelle	*b.Harooressa*	
1. Daaccituu	*1. Arusii*	*1. Digaluu*
2. Maccituu	*2. Hawaxxuu*	*2. Maxxaarrii*
3. Odituu	*3. Qarcabduu*	*3. Karrayyuu*
4. Galaantuu	*4. Halchaayyaa*	
5. Siraayyuu	*5. Warr-Jiddaa*	
6. Bachituu	*6. Malliyyuu*	
7. Koonnituu	*7. Danbituu*	
8. Noonituu		

Annex 2: Glossary of local terms

This list does not include words used once in the paper and their meanings given in brackets. The meanings of the following words are according to contextual usage.

Aadaa	*custom, tradition*
Abbaa	*father, head, owner*
Adaadii	*Shallow water wells*
Adulaa	*senior gadaa councilors*
Baddaa	*Forestland*
Balabat	*local state representative during the Imperial period*
Coqorsa	*ownership title given to certain Borana clans over a portion of land with its water sources*
Gadaa	*generational classes assuming political, ritual and economic responsibilities*
Gadaammojjii	*senior elders (ninth gadaa grade) perform special rite of passage that enables them retired from political leadership*
Gammoojjil	*dryland*
Gumii	*assembly of multitudes*
Hayyuu	*gadaa councilor*
Kaloo	*pastureland enclosed for calves*
Konfii	*digging stick of a deep well used by an initiator of that well at the first step of digging; it symbolizes ownership title of water source.*
Qaalluu	*hereditary ritual leader come down from heaven*
Raaba	*can be raaba doorii (senior raaba, sixth gadaa grade) and raaba didiqqaa (junior raaba, fifth gadaa grade). It is one of the mobile ritual villages at preparatory grade to succeed the incumbent gadaa leader*
Seera	*customary law*
Sunsuma	*reciprocal respect and fear among certain Borana clans*
Tulaa	*deep water wells*
Yaa`a	*residences of mobile ritual villages*
Yuuba	*residences outside of mobile ritual villages*



Annex 3: Community conserved areas and indigenous conservation

(Source: Boku and Bassi, 2008.)

8. An assessment of the land tenure system and conflict resolution: Tendaho Irrigation Project case study, Lower Awash Basin, Ethiopia

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ABSTRACT
Keywords: agropastoralist, Asaita District, conflict resolution mechanisms, Dubti District, land ownership

This study was conducted to assess the land tenure system and conflict resolution mechanisms related to the Tendaho Irrigation Project, in Asaita and Dubti Districts, northeastern Ethiopia. Questionnaires, semi-structured interviews, focus group discussions and field observations were used to collect data. A total of 70 respondents were sampled for the questionnaire survey. According to key informants, 14,532 hectares are currently irrigated by the state. The land tenure system in Dubti District is based on state ownership, while in Asaita District land is owned both privately and communally. Recurrent conflicts among the state, clan leaders and pastoralists have occurred over the last decade in Dubti District. The root causes of the conflicts are inappropriate land compensation payment systems, alienation of pastoralists and enclosing of their grazing land, inequitable share of compensation payments among community members and damage on the state irrigation farms caused by agropastoralists. Consequently, many disagreements between the local community and the state and damages to expensive irrigation equipment have occurred. Pastoralists have frequently expressed their grievances by diverting irrigation canal water to the desert, letting their cattle inside the sugarcane farms and setting fire to the sugarcane crops. Limited participation of pastoralists in decision-making processes and the project itself has led to the damage of the farms and properties. As a solution, social committees drawing from among clan leaders, pastoralists, district officials and the court system have been formed to resolve the conflicts. The government is working with the committees and local authorities to ensure the participation of pastoralists at every stage of the project and to strengthen existing community-based peace-building processes.

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Introduction

Millions of rural poor people in developing countries depend on natural resources for their livelihoods. The effective use of these resources to raise up from poverty often depends on the institutions that govern the resources and the land tenure systems (Dick-Meinzen and Gregorio, 2004). Land tenure systems are diverse and complex, and can be formal or informal, statutory or customary, permanent or temporary, private or of common property. Thus, many national and local systems are made up of a multiplicity of over lapping tenure systems that govern the rights of people to use, control and transfer land (IFAD, 2008). Such multiple and overlapping tenure systems have implications on the livelihoods of local people associated with natural resource-based conflicts. This is due to the fact that land tenure rights are embedded within the broad spectrum of human rights and the livelihoods of people. Issues of food security, sustainable livelihoods, coping strategies and environmental security are closely linked to land tenure systems (ECA, 2004). According to Dick and Nkonya (2005), land tenure rights are directly related to efficiency and equity. Hence, tenure insecurity results in resource-based conflicts. If these conflicts are not properly addressed, they can escalate into violence, disrupt projects and undermine livelihoods.

In Africa, as in many parts of the developing world, centralized control over natural resources persists. In some cases, trends point more towards centralized consolidation of the right to use and allocate valuable resources, such as land, water, wildlife and timber (Dick and Nkonya, 2005). Due to this, natural resource-based conflicts between local groups and other more powerful actors, including state agencies and private investors, remain widespread across the continent and is, often, intensifying. Furthermore, conflicts arise from differences in perceived priority of management objectives between local people and central governments.

Since the middle of the twentieth century, the Afar National Regional State has been an arena of natural resource-based conflict between local communities and the state, mainly over the control of irrigable land and water resources (Bondestam, 1974, Said, 1997, Aredo, 1999, Rettberg, 2010). In particular, the fertile lands along the Awash River have been a bone of contention between Afar clans, agropastoralists and the state. With the establishment of large-scale cotton and sugarcane farms by successive Ethiopian governments since the 1960s, traditional communal grazing areas have been transformed for commercialized irrigation agriculture and pastoralists have been increasingly displaced (Kassa, 2001).

Reducing poverty and food deficiency by improving agricultural productivity occupies a central place in the strategies of the Ethiopian government. The government has committed itself to the reduction of poverty by half through the endorsement of the Millennium Development Goals (MoWR, 2001, MoWR, 2002). Expecting a great degree of agricultural production intensification under formerly rain-fed dryland farming systems, the government now pursues irrigation development as one of the strategic interventions in achieving the Millennium Development Goals, as well as the recently declared Growth and Transformation Plan. Hence, over recent years, tremendous efforts, involving huge financial and labour investments, are underway to promote large-, medium- and small-scale irrigation schemes. The current Tendaho, Kessem, Fentale and Koga irrigation projects and major construction projects making rainwater harvesting ponds are evidence of the commitment of communities and the government to aggressively pursue irrigation development (Bekele, 2010).

The Tendaho Irrigation Project, which is found within the lower Awash River Basin, northeastern Ethiopia, is one of the major large-scale development projects designed to achieve the government's strategic policies of Agricultural Development Led Industrialization (ADLI) and the Growth and Transformation Plan. The Tendaho Irrigation Project is expected to supply the raw material required for sugar factories, which are going to be established under the Growth and Transformation Plan. Apart from this macro-scale development objective of the Tendaho Irrigation Project, it will also play a large role in reducing unemployment, poverty and food insecurity, facilitating the permanent settlement of nearby pastoralists and promoting the supply of agricultural products and other cash crops that further enhance the successful linkage between agriculture and industry. Hence, the project is hoped to be a promising development for nearby agropastoralists and pastoralists (local communities) and the country at large.

Even though its importance is uncontested, this project has been under continuous pressure from natural resource-based conflicts between the state and local clan leaders and agropastoralists due to contested land tenure right issues and unfair distribution of benefits and compensation costs associated with the project farmland (Bondestam, 1974, Said, 1997, Aredo, 1999, Rettberg, 2010). According to GebreMichael (2011), the success of a large-scale irrigation development project like Tendaho depends highly on the absence of conflicts related to land tenure and the benefit sharing derived from the project as well as land compensations costs associated with it. Appropriate land tenure systems and tenure security enhances the successful management of natural resources and reduces conflict (ECA, 2004, Dick and Nkonya, 2005).

The overall objective of this study, therefore, was to assess implications of the land tenure systems and conflicts between the state and agropastoralists on irrigable land resources in the Tendaho Irrigation Project. The specific objectives were to: (i) evaluate the impact of the land tenure system on conflicts among pastoralists, clan leaders and the state over the use of irrigable land resources; (ii) asses the causes of conflict among and between the state, clan leaders and pastoralists over the use of irrigable land resources; and (iii) assess the consequences of these conflicts and conflict resolution mechanisms.

Materials and methods

Study area

The study was conducted in the Tendaho Irrigation Project catchment area, which is situated in the Lower Awash Valley of Afar National Regional State, northeastern Ethiopia. The project is located about 600 kilometres from Addis Ababa. It is situated 11° 40’ 77’’ N and 40° 57’ 49 ‘’E, between Dubti and Asaita Districts, at an altitude of 402 m.a.s.l. (Figure 1). It is a man-made dam constructed mainly for the purpose of irrigation of sugarcane plantations. The project is designed to irrigate about 60,000 hectares of land in the Dubti, Dat-Bahri, Asaita and Afambo areas for sugarcane plantations. The project is expected to benefit nearly 35,000 families living in the catchment basin through irrigated pasture development and availability of animal feed from sugarcane by-products. During the implementation process, a number of job opportunities have been created. It is fed by the Awash River, one of the longest perennial rivers originating from the highlands of Ethiopia. The vast irrigable land resources, grazing land, bushlands and the Awash River flood plain are the most important dryland resources in Ethiopia.

The Tendaho Irrigation Project catchment area is characterized by lowland plains and is a very hot area located in the arid zone of Ethiopia. The mean maximum temperature ranges from about 32 to 42 °C and the mean minimum temperature from about 16 to 25 °C. The hottest months are March to October and the coldest months November to February. Mean monthly rainfall ranges from 4 to 58 mm. March, April, July and August receive the most rainfall. Destructive high-level winds, accompanied with dust, are very common every day in the afternoon. As a result, Afar National Regional State is one of the drought-prone areas with major shocks and hazards associated with the recurrence of drought that disrupts the livelihoods of communities.

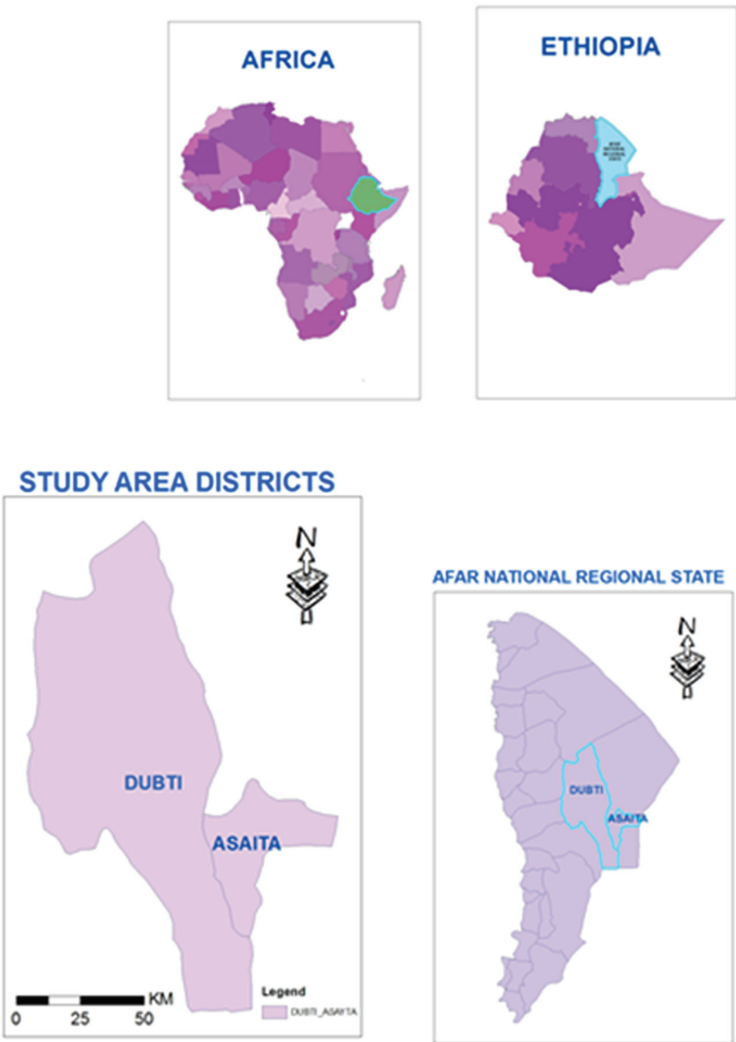

Figure 1. Map showing the study areas

The Tendaho Irrigation Project site is located within an area known as ‘Tendaho’, which forms the centre of the Afar triangle. Tendaho is a low lying area of land, where the East African, the Red Sea and the Gulf of Eden rift systems converge. This area is filled by various types of sedimentary deposits ranging from clay to gravel, volcanic tuffs and hot spring deposits. The Pleistocene age sediments in the area consist of marine and lacustrine clays, silts, sandstones, siltstones, mudstones and conglomerates. The bedrock underlying the sedimentary rocks are Pleistocene age flood basalts belonging to the Afar group of the Ethiopian volcanic series.

Afar, Amhara and Tigray are the ethnic groups in the study area. The majority of the sampled population belongs to the Afar ethnic group. Traditional livestock production, rain-fed and irrigation agriculture and selling of charcoal are the principal sources of livelihoods for most of the people. They cultivate mainly maize, tomato, cotton, cabbage, onion and sugarcane. Cattle, camels, donkeys, sheep and goats are the main livestock types raised in the area. The Tendaho Irrigation Project is initiated and run by the Sugar Corporation of the Federal Democratic Republic of Ethiopia.

Data collection

Sampling procedure and sample size determination

Multi-stage sampling was used to select agropastoralists to be interviewed. The first stage involved a purposeful selection of *Kebelle*[19] Peasant Association administrations under the Tendaho Irrigation Project sites from Dubti and Asaita Districts. The second stage involved the selection of agropastoralists from lists of households in the selected Kebelle Peasant Associations. A total of 70 respondents were sampled, of whom 35 were from Asaita District and 35 from Dubti District. Furthermore, thirty households were purposefully selected based on their knowledge as recommended by the local people (mainly elders) and development agents for the focus group discussions and interviews.

Questionnaire survey

A structured questionnaire (open-ended and close-ended) was developed to address the contributions of the Tendaho Irrigation Project to the improvement of the livelihoods of agropastoralists. The questionnaire was tested before implementation for its consistency, logical flow, coding and length, and amended. Enumerators who had completed preparatory school and college and who understand and speak the local language (Afarif) were recruited. Training on the content of the questionnaires, including where, when and how to conduct the interviews with agropastoralists, was conducted in advance for these enumerators.

Secondary data were obtained from the Agricultural Offices and Natural Resource Units of the selected districts, Afar Region Land Administration Bureau and Tendaho Sugar Factory Project Office.

Interviews

Semi-structured interviews were conducted with Tendaho Irrigation Project officials, clan leaders, agropastoralists, development agents, officials of Afar National Regional State and officials of district land administration offices. The interviews with clan leaders and agropastoralists were carried out using the local language (Afarif). At the beginning of each interview, the aim of the interview was clearly explained to informants to invoke clear and objective responses. This technique enabled the tapping of indigenous land administration systems and state-community interactions over irrigable land resources.

Focus group discussions

Focus group discussions with individuals from the Kebelle Peasant Associations, clan leaders, agropastoralists, development agents and community representatives were carried out. The discussions were held at the irrigable fields. Proportionally three focus group discussions, one in Asaita and two in Dubti, were made. Each group had 10 participants, composed of women, elders and youngsters. To facilitate the discussion under each group, a check list was prepared in advance. The collected data helped to triangulate the information obtained under different approaches.

Data processing and analyses

To analyse the data, both qualitative and quantitative data analyses tools were used. The triangulation method was employed to analyse and evaluate the validity of the information collected using the different methods. The collected data was coded, entered into a computer, analysed, interpreted and synthesized using software called Statistical Package for Social Sciences (SPSS) Version 17. Accordingly, the assessment of land tenure systems and conflicts between the state and local community was analysed using simple descriptive statistics.

Results and discussion

Demographic characteristics of respondents

The age of respondents ranged between 21 and 64, with an average age of 40 years. The overwhelming majority of the population are young, implying that the pressure on the land is on the increase. The average household size was five, which is similar to other areas in Ethiopia and Afar National Regional State. Nearly all the households were nucleated families.

The level of education was low as almost all of the respondents (94.3 percent) were illiterate (Table 1). According to the respondents, since the people in the study areas are agropastoralists, it is difficult to expand education services for people with no fully permanent settlement, which explains the high level of illiteracy. The levels of education and training have implications on the capability of households to manage their resources and receive extension services. The livelihoods of the respondents are dependent on crop cultivation, livestock production and selling of fuelwood and charcoal. Hence, the socioeconomic status of the respondents was measured in terms of the size of agricultural land and the number of heads of livestock they own.

[19] The lowest administrative unit in Ethiopia.

Table 1.Education, wealth status & social position of the respondents

Variable	Total	
	Frequency	Percentage (%)
Education		
illiterate	66	94.3
primary education	3	4.3
read and write	1	1.4
Wealth status		
low	51	73
medium	17	24.3
high	2	2.9
Social position		
clan leaders	12	17.1
pastoralists	58	82.9

Most of the respondents (73 percent) were classified as low income. The majority of the respondents were agropastoralists (82.9 percent) and the remaining are clan leaders. The low income level of the respondents was attributed to not only the displacement of agropastoralists from their grazing lands, but also to the inappropriate administration of compensation payments by clan leaders (see the detailed explanation on the cause of conflicts). Crop cultivation using irrigation agriculture, animal rearing and selling of fuelwood and charcoal offer good opportunities for improvement of the livelihoods of agropastoralists (Table 2). In particular, the agropastoralists of Asaita District are highly dependent on irrigation agriculture to sustain their daily lives.

Table 2. Means of income generation to improve the livelihoods of agropastoralists

Sources of income	Response	Frequency	Percentage(%)
Crop cultivation	Yes	66	94.3
	No	4	5.7
Animal rearing	Yes	62	88.6
	No	8	11.4
Selling fuelwood and charcoal	Yes	40	57.1
	No	30	42.9

Land use types

More than70 percent of the informants confirmed that there are three major land use types in the study area, which play a large role in the livelihoods of agropastoralists (Table 3). According to the key informants, 14,532 hectares of land is irrigated by the state in Dubti District and a vast amount of land is irrigated by the agropastoralists in Asaita District. Smallholder agropastoralists in Asaita District also use rain-fed agriculture, which is characterized by rainfall that is short in duration and erratic. Informants noted that the majority of land in the study area is used for grazing by pastoralists and agropastoralists. Water resources and livestock, such as camels, goats, sheep, donkeys and cattle, are the most abundant resources in the study area (Bekele, 2010). Pastoralists use customary systems of tenure in which land is common property and managed by the recognized leaders of the community. Hence, individual ownership is either rare or unknown.

Table 3.Land use types in the study areas

Land use types	Response	Frequency	Percentage(%)
Irrigation agriculture	Yes	54	77.1
	No	16	22.9
Rain-fed agriculture	Yes	52	74.3
	No	18	25.3
Grazing land	Yes	50	71.4
	No	20	28.6

The livelihood of the people depends mainly on crop and livestock production. Agriculture is mainly irrigation and rain-fed, with annual crops being dominant. The major crops grown in these districts are maize, tomato, onion, cabbage, sugarcane and green pepper. Fruits, such as lemon, papaya and banana, are also cultivated (Kassa, 2001, MoWR, 2001, MoWR, 2002, Rahmato, 2007, Bekele, 2010, GebreMichael, 2011).

Land tenure system

Land tenure refers to rules and norms and institutions that govern how, when and where people access land or are excluded from such access. Four types of land control - namely state, communal, joint and private - were recorded in the study areas (Table 4). The majority of irrigable land in Dubti District is controlled by the state and communities, whereas private and communal control is very common in Asaita District. There are often disagreements in Dubti District. Some of the respondents noted that sugarcane farms in Dubti District are controlled jointly by the state and the communities. The average land size for individual plots in the study area was three hectares, which is quite large by Ethiopian standards.

Land is public property in Ethiopia. The Constitution of the Federal Democratic Republic of Ethiopia (December 1994) proclaimed that 'Land is a common property of the nations, nationalities and peoples of Ethiopia and shall not be subject to sale or to other means of transfer (Bishaw, 2001, Gebreselassie, 2006, Dercon and Ayalew, 2007, Crewett et al., 2008, Elhadary, 2010). Despite the fact that land is the basic source of livelihoods in rural Ethiopia, it has been under state ownership since the 1975 national land reform.

Since then, there have been many land redistributions and readjustments in an attempt to accommodate newly forming households (Bewket, 2003). Traditionally, land is a communal resource in the Afar National Regional State. Accordingly, the clan is the lowest social unit to which communal property rights over land and other natural resources are defined. Land is, therefore, divided among all clans in the Afar National Regional State as a function of resource potential and the dominance of a clan (either in number or political power). Clan land often comprises strategic resources, such as grazing areas, including dry season retreats, browsing resources and water points (Bishaw, 2001 and Gebreselassie, 2006).

Table 4. Land tenure types in the study areas

Land tenure types	Response	Frequency	Percentage(%)
private	Yes	48	68.6
	No	22	31.4
state	Yes	46	65.7
	No	24	34.3
communal	Yes	28	60
	No	42	40
joint	Yes	35	50
	No	35	50

Access to land is an important issue for the majority of Ethiopians who, in one way or the other, depend on agricultural production for their income and subsistence. Hence, the government has embarked on new measures to promote greater tenure security and, partly, address the serious food crises that the country continues to face in spite of increased food aid and new agricultural development programmes. These measures include land certification and registration and resettlement (Assegid, 2001, Holden and Bekele, 2002 and Rahmato, 2007).

However, as noted above, until this time, the pastoralists have customary land rights, which are based on a combination of groups and individuals. The customary land rights system led to inequitable appropriation of land compensation payments by the clan leaders. The questions now are: how can land tenure be secured; how can pastoralists benefit from their land; and how can government development projects proceed safely without conflicts with pastoralists? Here one can understand that whatever strategies are selected, the central concern of the government and the relevant bodies is to strengthen socially acceptable, economically viable and ecologically sustainable land use, which minimizes chaos and reduces poverty.

Land compensation payments

Appropriate land tenure systems and tenure security enhances the successful management of natural resources and livelihood improvement (Assegid, 2001, ECA, 2004, Dick-Meinzen and Nkonya, 2005, Maxwell and Wiebe, 1999).The Tendaho Irrigation Project contributes its part to the achievement of the vision of the Ethiopian government to develop a green economy by providing raw materials to the bio-fuel industry. Informants from Dubti District indicated that the Tendaho sugarcane farming is owned by the state. The state is using the irrigable land resources and, in return, individual agropastoralists receive compensation payments from the government. The compensation payment is made to the clan leaders through the Sugar Corporation Authority (SCA) without the involvement of agropastoralists. However, clan leaders share very small amounts of the money with agropastoralists, and some clan leaders do not even share any money with their community members. Hence, frequent conflicts arise among the state and agropastoralists and, even, between clan leaders and agropastoralists.

In agreement with this study, various reports from elsewhere in Ethiopia (Wood, 1993, Nari, 2000, Edossa et al., 2005, Unruh, 2006, Rahmato, 2007, Kimani, 2008, Wakhungu et al., 2008) explained that land in the Awash Valley was expropriated without compensation or with only token compensation, which usually went into the personal pockets of clan leaders. Pastoralists were excluded from the sugar plantations in the Awash Valley and had no access to either flood or irrigation waters available in their locality (Koraro, 2000, Holden and Bekele, 2002, Rahmato, 2007). Various authors have further described that important seasonal grazing areas and transit corridors were closed off to herds and herders, forcing many to change their herding strategies and travel longer distances in search of pasture and water (e.g., Bogale, 2006, Gomes, 2006).This in turn indicates the need to develop strategies which support and develop pastoralist herding.

Actors in the conflicts

Eighty percent of the respondents stated that agropastoralists are in conflict with the government for different reasons. Around 71.4 percent of the respondents agreed there was frequent conflict between pastoralists and clan leaders due to inequitable utilization of the irrigable land compensation payments received from the Sugar Corporation. The remaining respondents revealed that repeated conflicts happened among agropastoralists due to lack of proper communication between themselves and the state.

The majority of the pastoralists perceived no benefits from the Tendaho Irrigation Project. However, a small number of pastoralists, especially those who have been employed or participated in the project and obtained benefits through infrastructure facilities and payment of land compensation, believed that the project has multiple advantages for the region and for the country at large. For this reason there were conflicts between pastoralists. Exposure to social unrest poses substantial risks in the attainment of development projects. Hence, for the success of large-scale sugarcane farming projects, such as the Tendaho Irrigation Project, smooth communication and mutual understanding between the local community and the state is very important. Otherwise, land owners may become mistrustful and develop suspicions about the merits of the project (UN, 2004, Asperen and Mulolwa, 2006, Hagmann and Mulugeta, 2008, Wakhungu et al., 2008).

Various findings (e.g., Nari, 2000, FAO, 2003, Herrera et al., 2006, Meur et al., 2006, Kimani, 2008, Adisa et al., 2010, Elhadary, 2010) show that effective sharing of information on polices, laws, procedures and project objectives can enhance the success of programmes and projects and reduce conflict. For instance, villagers destroyed a water piping system because they believed that the system would reduce water flow to their community. This destruction occurred despite the fact that hydrological studies indicated the system had no threat to the water supply. The planners and project staff need to effectively communicate this information to the local communities, to create awareness about the merit of the project and maintain a healthy relationship with pastoralists and agropastoralists.

Rahmato (2007) also confirmed that the alienation and enclosure of extensive land and water resources in the Awash River Basin is the underlying factor responsible for the conflict in the basin today. Development here consists of large irrigation and agro-industrial schemes that rely almost exclusively on the waters of the Awash River. According to a recent estimate, over 150,000 hectares of land have been brought under such development (Flintan and Tamrat, 2002, Tafesse, 2008). This has meant alienating and enclosing valuable flood land by commercial interests and the government and excluding pastoralists from access to their traditional dry and wet season grazing areas.

As a result of these changes in land use in the Awash Basin, pastoralists in Afar National Regional State have lost rights of access to their customary grazing lands, which, in turn, have severely disrupted their traditional livestock management strategies. As a result, most communities blame the government for the intrusions of investors and government development projects into their territory and the loss of their land and water resources. The outcome has placed pastoralists in deep crisis. According to the key informants, many Afar clans have been forced to move their livestock further into the highlands where they have also come into conflict with crop cultivators.

The unfair delivery system of payment for land compensation, coupled with the alienation of pastoralists and enclosing of their valuable flood plain grazing land and water points, has displaced pastoralists from accessing such resources. This has brought conflicts between the state and pastoralists.

Primary causes of conflicts

Natural resource conflicts have been a constant in human history due, in part, to the multiple and competing demands on resources (Anantha et al., 2000, Warner, 2000, Humphreys, 2005, CHF, 2006, FAO, 2009). Conflicts can arise if user groups exclude others from participating in natural resource utilization and management. Most respondents are familiar with irrigated land-related conflicts in their surroundings. The main causes of these conflicts are an inappropriate delivery system for compensation payments (82.3 percent), damage on state irrigation farms caused by agropastoralists (75.7 percent), alienation of pastoralists and enclosing of their grazing land (71.4 percent) and an inequitable share in benefits (71 percent). The key informants also confirmed that the government allocated appropriate compensation payments for land taken from agropastoralists, which was delivered through the Sugar Corporation Authority. As confirmed by the majority of informants, the lack of a transparent compensation delivery system, which is the major cause of conflicts between pastoralists and state and clan leaders, needs to be resolved and corrected.

The findings of this paper are in agreement with a scenario reported by the Food and Agriculture Organization of the United Nations (FAO) (2003) that follows. An FAO report explained that an international development agency had provided support to rehabilitate and improve a traditional hand-dug well controlled by a single local clan. The agency insisted that landowners sign legally-binding documents to ensure that the improved well was for use by all community members. However, the land holding clan dissuaded others from using it by invoking customary law. The same is true in the case of the Tendaho Irrigation Project; therefore, to sustain the Tendaho Irrigation Project and expand its land coverage and activities as planned, awareness must be raised about the project's merits to the locality and to the national economy and the state must give due attention to improving the livelihoods of pastoralists by providing alternative grazing lands, appropriate compensation payments and secured land rights.

Rate of conflicts

The form and intensity of conflicts vary widely in space and over time within any community. Conflicts manifest themselves in many ways, ranging from breaking rules to acts of sabotage and violence (Kimani, 2008, FAO, 2009, Takeuchi and Marara, 2009, Elhadary, 2010). Almost all of the respondents replied that conflicts over the use of irrigable land resources have been common since sugarcane farming began in the Tendaho area. Moreover, the majority of key informants stated that there were frequent conflicts among the state, clan leaders and district administrators as well as between agropastoralists (64.3 percent). Some of the respondents indicated that there were rare (22.9 percent) and medium disagreement (12.9 percent) in the last eight years, respectively. Though the Tendaho Irrigation Project contributed considerably to the livelihoods of the communities of Dubti District, conflicts occurred year after year between disadvantaged pastoralists and the state. As a result of these, the majority of pastoralists of Asaita District strongly disagree with the expansion of the project to their district because they do not want similar problems as experienced by communities in Dubti District.

The state and development agencies should address the problem with the existing delivery system of compensation payments. That requires the participation of pastoralists and promoting awareness creation for clan leaders with regard to developing and putting in place a fair and transparent compensation delivery system. By so doing, the rate of conflicts may be reduced.

Various studies have shown that conflicts over natural resources occur at various levels and involve a variety of actors (Koraro, 2000, Holden and Bekele, 2002, Herrera et al., 2006, Baribeau, 2012). These include conflicts among local men and women over the use of trees, neighbouring communities disputing control of woodlands and villages, and community-based organizations, governmental and non-governmental agencies in conflict over the use and management of large forest tracts (Castro and Nielsen, 2001, Wood, 1993, Kimani, 2008, Wakhungu et al., 2008). As noted above, conflicts can emerge if user groups are excluding others from participating in natural resources utilization and management. Thus, involvement of pastoralists at every stage of any project is paramount.

Consequences of conflicts

Conflicts arise when different interests and needs are incompatible or when the priorities of some user groups are not considered in policies, programmes and projects (Adams, 2001, Castro and Nielsen, 2001, IFAD, 2008, Kimani, 2008, FAO, 2009). Such conflicts of interest are inevitable features of all societies. Currently, the scope and magnitude of natural resource conflicts have increased and intensified. These conflicts, if not addressed, can escalate into violence, cause environmental degradation, disrupt projects and undermine livelihoods. The majority of the key informants indicated that because of conflicts, agropastoralists and pastoralists frequently diverted the water canal to the desert, distracting expensive irrigation equipment (e.g., hydro-flumes and motors) of the Tendaho Irrigation Project, let their cattle in the sugarcane farm and set fire to the sugarcane crops. Key informants and focus group discussions reported similar consequences.

Tenure security, coupled with community participation in natural resource management and utilization, could reduce conflicts and result in meeting a range of local needs. A report by a World Conservation Union Working Group also confirmed that “in many countries, community involvement is proving to be a cost-effective, socially-just and environmentally-sound approach to stabilizing natural forests” (Gebre-Mariam,1994). Thus, participatory approaches have demonstrated their value and viability.

Conflict management and resolution mechanisms

According to the key informants, the state believed that indigenous institutions and local knowledge was of paramount importance in conflict management and should be given due emphasis in peacebuilding interventions. Hence, the state selected 60 facilitators or social committee members from clan leaders, pastoralists and district officials who are working as mediators between the state and pastoralists and resolving conflicts. The court system is also used when the intensity and severity of conflicts were beyond the capacity of the facilitators.

Participation of pastoralists at every stages of the project and promoting existing community-based peacebuilding processes by merging customary law with formal state institutions was found convenient for conflict resolution. A case study conducted by Castro and Nielsen (2001) revealed that co-management agreements among indigenous people, state agencies and other stakeholders offer substantial promise as a way of dealing with natural resource conflicts in a participatory and equitable manner. Ingles et al. (1999) and Khalkheili and Zamani (2008) also noted “the promotion of collaborative management is based on the assumption that effective management is more likely to occur when local resource users have shared or exclusive rights to make decisions about and benefit from resource use.”

In the case of inter-ethnic and pastoralist-state conflicts, the design of projects should involve all land owners (Holden and Bekele, 2002, Koraro, 2000, Herrera and Passano, 2006, Blench, 1996, Maxwell and Wiebe, 1998, Sørli et al., 2005, Aredo and Ame, 2006) and efforts must be geared towards developing an integrated approach to conflict management (Humphreys, 2005, Opiyo et al., 2012, Grimble and Wellard, 1996, Tesfay and Tafere, 2004, FAO, 2006, Roe et al., 2009, Ikejiaku, 2009). Huggins et al. (2005) and Theron (2009) also highlighted the importance of reforming institutional (including policy) and judicial systems related to resolving land conflicts. Also, the management of irrigable land resources needs to be decentralized, flexible and consistent.

Conclusions and recommendations

Conclusions

Results indicated that the irrigable land of the Tendaho Irrigation Project is controlled by the state, which pays alternative compensation to pastoralists that have customary ownership rights of the land. However, clan leaders have received payments on behalf of their communities, but failed to distribute it fairly. Thus, pastoralists lost their precious grazing land and water points without any compensation. Consequently, frequent conflicts have occurred between the state and pastoralists and, hence, irrigation tools and equipment, water and time have been lost or wasted and project expansion programmes have been severely affected.

To resolve the ongoing conflicts, the state has set up social committees with members from clan leaders, pastoralists and district officials. In addition, the court system is used when the intensity and severity of conflicts goes beyond the capacity of the social committees.

Meanwhile, the Tendaho Irrigation Project has been playing a significant role in improving the livelihoods of many of the surrounding people. Therefore, it is concluded that any intervention in conflict resolution and peacebuilding should give due emphasis to building the capacities of various peace and conflict-resolution committees and local institutions that can facilitate dialogue and create awareness about the merits of the project and land ownership rights among clan leaders and pastoralists.

Recommendations

Based on the findings, the below recommendations are forwarded.

- The state should revisit its land tenure policy for pastoral areas of the country and secure pastoralists' use rights, as well as provide land for local communities to address questions of ownership.
- To achieve sustainable development in the study areas, the ongoing irrigation project must be of benefit to and accepted by the pastoralists; this could be achieved through genuine local community participation.
- Land compensation payments made by the state should be distributed to all community members and must be supported by repeat training and awareness creation about the merit of the project and other livelihood options.
- To secure the project's expansion and development (which is now irrigating about 25 hectares, but has been designed to irrigate about 90 hectares of land), the national land tenure policy has to be implemented by the state in the pastoral and agropastoral areas like the tenure implemented in Amhara, Tigray and Oromia regions.

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Annex 4: Opening Speech

9. Opening Speech of the Vice President, Afar Regional State

HE Ato Awel Arba

Officials of the Federal Government and Other Regional States of Ethiopia; UNDP and other partner organization Representatives; Officials, Experts and Community Representatives from Afar National Regional State,

Ladies and Gentlemen,

First of all, I would like to express my heartfelt gratitude to have you all at this high level policy forum discussing the management of drylands in Ethiopia. It is well known that our regional state is the hottest and driest of all regional states in Ethiopia and we appreciate the organizers for choosing Semera as a venue for this high level policy forum.

Ethiopia is the tenth in the world and the first in Africa in terms of livestock population. Most livestock are found in pastoralist-dominated regional states, of which Afar is one of the most important regions. Our regional state is also endowed with a number of perennial rivers suitable for irrigation development, large areas of arable land, a myriad of wild animals, mineral resources and different natural attractions, like active volcanoes and salt pans.

Ladies and Gentlemen,

As you all know, Afar is where our ancestors and modern human beings first lived on the Earth. Hence, it has been exploited by human beings for much longer periods than any place on the Earth. This long period of exploitation has led to land degradation, natural resource depletion, human and livestock disease outbreak and desertification, which is further exacerbated by current trends of climate change. These problems are the major challenges to making economic progress in the region and also hold back the regional state from contributing its share to the development of the country.

Our people have lived in this challenging environment for centuries, relying on indigenous natural resource management practices. Given the current trends in climate change, the national plan for accelerated economic growth, and high population growth, however, the indigenous natural resource management practices alone cannot be sustainable. Hence, the Government of Ethiopia has given special attention and adopted policies, strategies and programmes for integrated development of pastoralist and agropastoralist areas and have already launched implementation on the ground.

Along with broad government interventions, a number of projects are being implemented with the support of different partners and non-governmental organizations. One such project is the Afar Integrated Dryland Management Project (AIDMP), financially supported by the Government of Norway, and technically supported by UNDP and the federal Ministry of Environment and Forest. The AIDMP has benefited pastoralist and agropastoralist communities and built their adaptive capacities to climate change, improved local livelihoods and made valuable contributions to development initiatives in the regional state.

However, given the extent and complexity of problems and development challenges that prevail in the region, the current interventions are not adequate. Hence, we strongly request continued and increased support from donors, government and non-governmental development partners. We expect that this forum discusses lessons learned from the AIDMP, research papers are presented on various topics and good practices are exhibited here and that this generates a number of policy ideas that are relevant to address the problems of dryland management in the region and the rest of the country. I would like to confirm that our regional government welcomes the outcomes of the forum for policy uptake and practical implementation. We also welcome all support of development partners to this end.

Ladies and Gentlemen,

Finally, I would like to thank the Royal Norwegian Government and the people of Norway for generous financial support, UNDP and the Ministry of Environment and Forest for technical support and follow-up of project implementation and the Ministry of Finance and Economic Development for enabling smooth financial flows and monitoring that enabled successful implementation of the project. The project would not have been implemented without the dedicated and relentless efforts of regional and woreda level implementing sector institutions of the Afar Regional State, particularly staff members of the coordinating Environmental Protection and Land Use and Administration Authority. On behalf of the Afar Regional Government, the people of Afar and myself, I would like to thank all those who contributed to the successful implementation of this project. I wish you successful deliberations during these two days of the high level policy forum discussion and declare that the workshop is officially open.

Thank you. ■

10. Welcome Speech of the State Minister, Ministry of Environment and Forest

Ato Kare Chawicha

Presented by Ato Berhanu Solomon

Your Excellency Ato Ismael Ali Sero, President of Afar National Regional State, Invited Guests, Ladies and Gentlemen,

It gives me great pleasure to be here with you at this High Level Policy Forum on Integrated Dryland Management workshop.

As you all know, drylands cover a large part of our country. Such areas are increasingly becoming hotspots of a number of economic development activities in our country, like the Tendaho Sugar Project in Afar. Drylands are also frontiers of desertification, where mismanagement of natural resources leads to degradation of their potential to provide goods and services vital for economic use. In addition, drylands are the most vulnerable areas to the effects of climate change. Given the size, economic importance and vulnerability of the drylands, the Government of Ethiopia has given due attention to mainstreaming integrated dryland management in all development interventions.

The Government of Ethiopia works closely with different development partners on integrated development of drylands that arrests desertification while adapting to climate change. A good example is the Afar Integrated Dryland Management Project (AIDMP) being implemented by the Afar National Regional State and UNDP, with financial support from the Government of Norway. The project is expected to contribute to: (1) building institutional capacity for integrated dryland management; (2) promoting sustainable dryland management practices; (3) supporting livelihood diversification activities; and (d) disseminating information on integrated dryland management so that good practices are scaled up in other parts of the region and the country. The project can contribute to our efforts to combat desertification and achieve a Climate Resilient Green Economy (CRGE) strategy.

Your Excellency, Ladies and Gentlemen,

As you all know, Ethiopia has developed the CRGE strategy, with the goal of reaching middle income economy status by 2025. The Government of Norway and UNDP have been key strategic partners in developing and operationalizing the CRGE strategy. UNDP has played key roles in development of the CRGE and its operational modalities, while Norway is one of the pioneer development partners to make commitments of financial support for the facility. We expected this partnership to last long, and to support us in reaching our economic development goals faster, following a sustainable and green growth path.

In this workshop, the outcomes of the Afar Integrated Dryland Management Project are expected to be showcased. In addition, the findings of researchers on thematic areas relevant to integrated dryland management are expected to be presented, alongside exhibitions of good practices.

I am confident that you will come up with a number of ideas for policy uptake and good practices to scale up integrated dryland management in all parts of Afar and the rest of the country. I wish you fruitful deliberations during the workshop. The Government of Ethiopia welcomes recommendations of sound scientific research and best practices in the field to implement its long-term development strategies like the CRGE on the ground. I expect that the outcomes are documented and communicated to our ministry for policy uptake.

Excellency, Ladies and Gentlemen,

Once again, I wish you fruitful discussions in this workshop, and look forward to your policy and development-relevant recommendations.

Thank you and good luck! ■

11. Welcome Speech of the Head, Afar Environmental Protection, Land Use and Administration Agency

Ato Elema Abubeker

Your Excellency Ato Awel Arba, Vice President of the Afar National Regional State, Senior Officials of our regional state and the federal government, UNDP and donor agency Representatives, Invited Guests, Ladies and Gentlemen,

First of all, I would like to welcome you all to the capital of Afar National Regional State, Semera. Our regional state is characterized by dry and hot weather conditions. The topography also includes areas below sea level, like the Dallol Depression, vast flat and gentle areas, steep slope and mountains.

The livelihood of our people is mainly pastoralism, with some agropastoralism, agriculture and trade. Irrigated agriculture is expanding along the main rivers, like Awash and Kesem.

Your Excellency Vice President, Ladies and Gentlemen,

As you all know, our regional state is endowed with several natural and historical tourist attractions. Archeological sites where remains of human ancestors like Lucy are found in Afar. The presence of natural attractions like Erta Ale, natural parks and wildlife reserves like Awash, Yangudi Rasa, Ali Dege, Gewane and Mille Serdo in our regional state also shows how rich it is in terms of biodiversity. This demonstrates that our region not only is the origin of human ancestors, but of many plant and animal species. However, current climate trends, population growth, agriculture, urbanization and other socio-economic changes are serious challenges for sustainable natural resource management.

Your Excellency Vice President, Ladies and Gentlemen,

Implementation of integrated natural resource management is the only viable option to overcome these pressing challenges. This requires building on lessons learned from good practices and research findings. Over the past eight years, UNDP and the Federal Government were supporting us to implement integrated natural resource management in our regional state. The project started as a pilot at Mille and scaled up to five woredas and was implemented as the Afar Integrated Dryland Management Project (AIDMP). The project focused on four key outputs: (i) institutional support for integrated dryland management; (ii) strengthened capacity for sustainable dryland management; (iii) livelihood diversification activities support; and (iv) sustainable land management communication and information dissemination.

The project has produced encouraging results. We have gained experiences through visits of neighbouring regional states and Uganda.

At this high level policy forum, good practices of the community, lessons from project implementation and research findings on different thematic areas are presented. I am glad to welcome you all again and hope that you will generate important ideas for policy and development practices during this workshop. ■

12. Speech of the Country Director, United Nations Development Programme

Dr. Samuel Bwalya

Presented by Sinkinesh Beyene

His Excellency Ato Awel Arba, Vice President of the Afar National Regional State, Senior Government Officials, Development Partners, Ladies and Gentlemen,

I would like to warmly welcome you all to this policy forum on the management of drylands in Ethiopia.

Climate change is a global problem that requires a global solution grounded in national actions. Tackling the root causes of drought and climate change requires a long-term approach both from national authorities and development partners. There is an urgent need for stepped up efforts to adapt to and mitigate the effects of climate change. It is my hope that this forum will help advance this important agenda by highlighting the important contributions that dryland management can make to this end.

Distinguished Guests,

Drylands occupy 41 percent of the earth's land surface and are home to 35 percent of its population. Such is the magnitude of dryland populations that failure in the drylands will mean failure for the global community. The benefits of conservation in dryland ecosystems can make a major contribution to achieving the Millennium Development Goals.

The responses to uncertainty of people living in drylands □ and their successes and failures in managing pressures on their ecosystems □ are relevant in a world in which the future of these ecosystems is uncertain. People living in drylands are likely to suffer disproportionately from the impacts of climate change engendered mainly by the developed world.

As the driest areas of the region, the drylands of East Africa face unique challenges, which affect lives and livelihoods of their residents. However, these areas also have significant potential, which can be converted into beneficial economic opportunities with the right mix of policies, investments in infrastructure and access to credit and markets.

Ladies and Gentlemen,

For transformational change, institutional structures and capacities for dryland management need to be strengthened. So far, efforts in Ethiopia to respond to the problem of growing climate change-induced hazards in pastoral areas have been promising and are expanding over time. Despite this, the scale and intensity of climate change-induced hazards (particularly drought, unseasonable floods, disease outbreaks, expansion of invasive bush species) is growing fast and the magnitude of damages from such climatic and other natural hazards continues to rise.

Building trust and achieving positive development outcomes takes time. Pilot projects must be evaluated, replicated if successful, and scaled up to have significant impact. Changing policies and laws and building institutions takes longer than a short project cycle. Strong partnerships between the government, civil society and development partners, national ownership and leadership, capacity development – these are not only theoretical principles of effective development cooperation; they are also key elements of achieving results and success on the ground.

Your Excellency, Invited Guests,

We at UNDP aim to provide technical expertise, practical policy advice and programme support for poverty reduction and development in the drylands of Ethiopia and particularly the Afar region. From January 2010 to December 2013, UNDP supported the Afar Regional Government in implementing the Afar Integrated Dryland Management Project in five districts of the regional state.

The project sought to improve the livelihoods and coping mechanisms of the pastoral communities in these districts. This was done by enhancing the capacity of the organized communities to sustainably manage and use natural resources. The communities were supported financially and technically to build mud-brick houses, to establish fodder banks, to engage in soil and water conservation activities and to use solar panels. These are just a few examples of successful capacity development.

The existing adaptive capacity of the dryland communities, assisted by appropriate policies and research, can offer viable pathways to development. The notion that standard development policy can adequately address risk and vulnerability in drylands must yield to emerging approaches that build on local and customary practices.

Ladies and Gentlemen,

This all demonstrates the urgency of addressing climate change through initiating effective and realistic adaptation plans that primarily focus on utilizing and scaling up locally-available adaptation practices and building institutional capacity in the hazard-prone pastoral areas of the country.

Life in drylands requires inhabitants to be continually dynamic in response to their changing environment. Resilience-focused approaches offer opportunities to build development from the bottom up, from a concern and a deep respect for the people who are the most resilient in the face of crisis – those who are facing and confronting it. New approaches to dryland development aim to harness the expertise of dryland communities and apply it more broadly. The success of these approaches, particularly at the local level, is vital to the delivery of more effective, inclusive and sustainable outcomes.

Crucially, policy planning should merge dryland issues into broader development frameworks. This will require a systemic process to integrate drylands into policies, laws, institutions and governance structures. The potential of the drylands will be unleashed through the participatory and country-led development and implementation of strategies that improve the well-being and resilience of dryland people and ecosystems through both targeted and mainstream development initiatives.

Looking forward, I likewise believe that the international community will see the importance of enhancing assistance and support — financial, technical and human — to sustainable dryland management.

Distinguished Guests,

The objectives of today’s policy dialogue are threefold: first, to identify the policy gaps for scaling up best practices and creating awareness among the general public about the economic importance of drylands; second, to share experiences with the various stakeholders on the benefits of sustainably managing and utilizing drylands; and third, to explore avenues for mobilizing additional resources to scale up best practices of the Afar Dryland Management Project and other similar programmes and projects on drylands.

I hope this policy dialogue will serve us as a forum for learning, a successful exchange of ideas and a clear way forward for conducive policies on conservation and sustainable dryland management.

Thank you. ■

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