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SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF *PROSOPIS JULIFLORA* IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE, ETHIOPIA

BY

WONDIMAGEGNEHU SHIBRU LEMMA

November, 2015
ADDIS ABABA

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SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF *PROSOPIS JULIFLORA* IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE, ETHIOPIA

A THESIS SUBMITTED TO INDIRA GANDHI NATIONAL OPEN UNIVERISITY /IGNOU/ IN PARTIAL FULFILAMENT OF THE REQUIREMENT FOR MASTER OF ARTS IN RURAL DEVELOPMENT (MARD)

BY

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November, 2015

ETHIOPIA

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DECLARATION

I declare that this thesis entitled SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF PROSOPIS JULIFLORA IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE, ETHIOPIA, submitted by me for the partial fulfillment of MA in Rural Development to Indira Gandi Open University (IGNOU). It is my genuine work and that, all sources of materials used for this thesis have been duly acknowledged. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Place .....

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CERTIFICATE

This is to certify that Mr Wondimagegnehu Shibru Lemma student of MARD (Master Art in Rural Development) from **Indira Gandhi** Open University, New Delhi was working under my supervision and guidance for his project work for the course MRDP-001. His project work entitled "**SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF *PROSOPIS JULIFLORA* IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE**" which he is submitting his genuine and original work.

Place _____ Signature _____

Date _____ Name _____

Address of Supervisor_____

_____

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ACRONYMS

APADB	Afar Pastoral Agriculture Development Bureau
AFEDB	Afar Finance and Economic Development Bureau
ARWDS	Afar Rangelands and Water Development Study
CBD	Convention on Biological Diversity
CSA	Central Statistical Agency
EARO	Ethiopian Agricultural Research Organization
EPE	Environmental Policy of Ethiopia
FGD	Focus group Discussion
GEF	Global Environment Facility
GISP	Global Invasive Species Program
IAS	Invasive Alien Species
IBC	Institute of Biodiversity Conservation
IWSS	International weed science society, 2005
KII	key Informant Interview
HDRA	Henry Doubleday Research Association (HDRA),
m a.s.l	meter above sea level
NBSAP	National Biodiversity Strategy and Action Plan
PCDP	Pastoral Community Development Project
PNSP	Productive Safety Net Program
SPSS	Statistical Package for Social Science
USFS	United States Department of Agriculture (USDA) Forestry Service technical assistance

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ABSTRACT

This study was carried out to assess the ecological and socio economic impact of of Prosopis juliflora in pastoral society of Lower Awash, Afar National regional state Ethiopia. The methodology used to study were collecting primary data at field level and secondary data from secondary sources. 94 households were selected purposively as a sample descriptive statistics were used to analyze the data collected. The result of the study indicate that a large proportion of the individuals perceived that prosopis was introduced into their locality by Awash river flooding (42.6%), and through livestock dung (24.5%), In addition to this, it was disclosed that P. juliflora has both advantages and disadvantages. The local people benefited from the plant in charcoal making, firewood collection and construction material. The plant has also been used as shade tree around the village. If properly managed it shows positive implication on the soil amelioration, micro-climate. On the other hand the plant has some negative impact, it decreased the size of range lands, woodlands and Invasion of P. juliflora causes loss of biodiversity and ecological service, affect livelihood of the pastoralist and agro-pastoralist, it also effect on livestock production because it encroaches grazing land and crop production. Other impacts of Prosopis juliflora include its thorns are harmful for human beings and livestock population. Prosopis juliflora has endangered several plant and animal species in the high and medium infestation areas. These include 10 tree species, 15 endangered grass species and medium sized plant species (shrubs) with its local use and 9 wild animals endangered or reduce in the area . Even though the majority of the sampled households use P. juliflora as a source of income in the form of charcoal and fuel wood for sale or home consumption, they perceive it as undesirable species that has to be eradicated, but the pastoralist and agro-pastoralist call for its eradication because under the current management system the disadvantages outweigh the advantages. Management techniques explored was burning the tree was the most commonly used technique about 31% of the pastoralists in the highly infested area and 21% in the medium infestation area tried to control prosopis by burning it. The other technique practiced to control prosopis was hand pulling (uprooting) as reported by 22% of the farmers in the high infestation area. To ensure the successfulness and sustainability of management techniques, commitment, participation and continuous follow up of the community and different stakeholders should be given more focus to control the invasion and re-invasion of P. juliflora. In general, there is no as such a formal and strengthened coordination mechanism among the stakeholders on the prosopis control and eradication practice in the district.

Key words :-***P. juliflora; IAS, socio economic, ecology control measure, Dubti, Ethiopia***

1. INTRODUCTION

1.1 Background

The spread of invasive alien species (IAS) is now recognized as one of the greatest threats to the ecological and economic well-being of the planet. IAS are causing enormous damage to biodiversity and on agricultural system we depend on. These alien species out compete, infect or transmit diseases, compete, hybridize with the native ones or attack them (Wittenberg and Cock, 2001). With increasing trade and globalization, movement of people and goods also increased. This facilitated the spread of IAS.

Avery good example of such exotic species which have been introduced in most tropical and sub-tropical countries including Ethiopia is *P. juliflora*. The plant has been cultivated for shade, timber, forage, food, and firewood (Pasiecznik *et al*., 2001). However, contrary to its purpose of introduction, the plant escaped out of control and has invading farm lands, pasture lands, rangelands, irrigation schemes and causes for many land use/ land cover changes.

In the past, action to prevent and mitigate the effects of invasive alien species has been largely focused in the developed countries. However, in developing countries, invasive alien species cause similar or worse problems, for development as well as conservation of biodiversity (GISP, 2004). Ethiopia is one of the developing countries affected by IAS and for two decades, Invasive Alien Species (IAS) have been clearly identified as one of the emerging problems facing the country (EARO, 2005).

Prosopis juliflora, being a drought tolerant plant, primarily threatens the Desert and Semi-desert scrubland, and Acacia-Comiphora woodland ecosystems of Ethiopia (Institute of Biodiversity Conservation (IBC), 2005). These ecosystems account a large proportion of the total land mass of the country and host several national parks. They embrace nationally and internationally valuable natural heritages and are, particularly, home for pastoralists and agro-pastoralists whose life is dependent on the services of these ecosystems (Berhanu & Tesfaye, 2006; IBC, 2005).

prosopis juliflora is a highly drought tolerant, fast growing and has outstanding coppicing power which gave it competitive advantages over native species of the invaded regions. This fact coupled with the already lost natural immunity of the region due to severe environmental degradation in the past highly hastened the rate of invasion and aggravated the problem posed by the species (Berhanu

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& Tesfaye, 2006; IBC, 2005; Shiferaw *et al*., 2004). A vast area of land is now invaded and the impact of the species on biodiversity is expected to exacerbate in the future (Ryan, 2011).

P. juliflora has been identified by the Environmental Policy and the National Biodiversity Strategy and Action Plan as a major threat to biodiversity of the country and economic well being of its people. However, little attempt has been made in terms of research and management of IAS. Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia (Taye, 2009) .

There is little knowledge and experience on how to manage and utilize these plants, and there have been few policies or strategies in place for quick action this helped *P. juliflora* to become an invader. This paper presents the literature on the distribution merit and demerit of *Prosopis juliflora* with special focus on the Afar pastoral situation. Evaluating socio-economic impact assessment in selected sites of Ethiopia is of paramount importance for designing appropriate control and prevention strategies of invasive species. Hence, a study will be conducted in selected sites to evaluate control baseline condition and to assess socio-economic and biological impacts of *Prosopis juliflora.*

1.2 Statement of the Problem

The combined effects of human activities and natural factors such as climatic changes lead to the depletion of natural vegetation and drastic decline in dry land productivity (Haysom and Murphy, 2003). *Prosopis Juliflora*, is now proved to be a notoriously invasive alien species. The fast spread of this plant species has resulted in the monoculture, that has suppressed native plants by prohibiting water and sunlight. Currently, this prickly tree has covered more than 1.2 million hectares of land in Afar (APADB 2011,annual report). Invasion of rangelands caused shortage of grazing land for livestock, which resulted in drastic reduction of livestock number as well as product. Thorns damage eyes and hooves of camels, donkeys, and cattle then by poisoning eventually lead to death. *P. juliflora* is invading potential croplands forcing local farmers with less capital and machinery to abandon their farmland and settlement. In general, this is a matter of serious concern for the life of the local people as pastoralists depending on livestock for their livelihood (Senayit *et al.*, 2004).

The rapid spread of the plant also presents a number of social, ecological and economic concerns. Its vigor and competitiveness makes it a formidable invader of different land use

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systems, particularly along rivers, lakes, swamps, farmlands, grazing lands and ponds, causing devastation of these important habitats and ecosystems through intensive and aggressive colonization (IWSS, 2005). Exotic species, therefore, contribute to social instability and economic hardship, placing constraints on sustainable development, economic growth, poverty alleviation and food security.

This paper, therefore, intends to assess the ecological and socio-economic impacts of *P. juliflora* in Dubti District, Afar National Regional State. Such knowledge helps to have better understanding about the extent of the distribution of the plant and the rate of expansion and the positive and negative impacts of the plant in the study area. Moreover, the study suggests effective controlling mechanisms to curb some of the negative impacts caused by the species.

1.3 Objective of the Study

The overall objective of this study is to assess the socio-economy and ecological and impact of *prosopis juliflora* in Dubti District Lower Awash Basin.

Specific objectives of the research were :

- To assess the socio economic and ecological impact on the local community and their environment .
- To see the existing *Prosopis juliflora* management by different stakeholders
- To recommend appropriate management options to control the species

1.4 Research Questions

- Is there any socio economic ecological impact of *prosopis juliflora*?
- What are the major socio economic ecological impact in the society and the environment in which they live?
- What kind of control technique are available?
- Is there any integration among the different stakeholders towards prosopis management *prosopis juliflora*?

1.5 Significance of the Study

Areas invaded by invasive species and areas at risk from further invasion need to be identified and mapped. Alternative uses of the invaded lands and restoration plans need to be developed based on the potential of those lands in specific locations. Local people in the invaded areas should be well advised and supported to carry out sustainable management of the cleared lands to prevent re-

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invasion. Alternative control methods such as biological methods or combinations of biological and mechanical methods, as well as different utilization options should be researched, and demonstrated to government partners and local people to prevent further invasion of new areas and to restore invaded areas in ways that benefit local communities (Dubale, 2006).

The findings of this study would therefore, expected to spark valuable information to researchers, policy makers and development institutions working in the area besides serving as input in designing and developing effective development interventions that will complement with local *Prosopis juliflora* management. Moreover, the would be recommendation believe to serve as valuable ingredients to other similar areas having identical scenario.

1.6 Scope and Limitation of the Study

The study will examine to assess socio economic and ecological impact of *prosopis juliflora* on the in the Dubti district, Afar Region during the period of 2012//2013. It was difficult to collect reliable and quantifiable data on income and expenditure that would help to assess the economic impact of *p.juliflora* , because of time, budget and other resource limitations the study focused only on one selected district of the region.

1.7 Organization of the thesis

The thesis has organized into five main chapter.. The first chapter deals with the introduction and statement of the problem, objectives, significant of the study and scope and limitation of the study . The second chapter covers review of related literature which include overview of *prosposis juliflora* , its introduction to the region, tree's merit and demerits and control measure. The third chapter described about the material and method set used. In this chapter location, climate, topography, population , socio economic situation and methodologies used in the study were discussed. Chapter four emphasizing mainly on result and discussion, in this part the main finding of the study were discussed in detail. Finally, chapter five covers conclusion and recommendation the study.

2. REVIEW OF LITRATURE

2.1 Alien Invasive Plants

Invasive Alien Species (IAS) are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential (Raghubanshi *et al.*, 2005). Many alien species support our farming and forestry systems in a big way. However, some of the alien species (*P.juliflora* in the case of Afar) become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and out-compete native species. IUCN defines Alien Invasive Species as an alien species which becomes established in natural or semi natural ecosystems or habitat, an agent of change, and threatens native biological diversity.

According to CBD (2001), invasive alien species are species introduced deliberately or unintentionally outside their natural habitat, where they have the ability to establish themselves, invade, out-compete natives and take over the new environment. These invasive are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments (Raghubanshi *et al.*, 2005).

Invasive species have now affected every ecosystem types on the planet and considered as the second greatest global threat to biodiversity, after habitat destruction (Essa *et al.*, 2006; Raghubanshi et al., 2005). Moreover, climate change such as global warming triggers suppression of native biodiversity by invasive alien species (Kathiresan, undated). The invasive species impact on native species directly competing for resource such as food and breeding sites as well as indirectly by altering habitat and modify hydrology, nutrient cycling and other ecosystem processes. These impacts dramatically change the ecosystem both positively and negatively.

2.2 Ecology and socio-Economic Importance of *Prosopis juliflora*

2.2.1 Overview of *P. juliflora*

Prosopis juliflora is native to the Caribbean, Central America and northern South America (Pasiecznik *et al.*, 2004). Mesquite has a very wide soil and site adaptability: from sand dune to clay soils; from saline to alkaline soil; from < 200 to > 1500 m above sea level altitude; and from 50 to 1500 mm mean annual rain fall (m.a.r.) (Pasiecznik *et al.*, 2004; Zeila *et al.*, 2004). It is one of the

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most common trees in semi-arid and arid parts of the sub-tropical and tropical zones (Pasiecznik *et al.*, 2001; Pasiecznik *et al*., 2004).

Soil nutrient conditions and physical characteristics are hardly limiting the growth of mesquite(Pasiecznik *et al.*, 2001). But better performance was observed on free draining than water logging soils (Ameha, 2006). *Prosopis juliflora* performs well within 150 to 600 mm of mean average rainfall (Muthana, 1988). In this regard, the xerophytic adaptation of the leaves and the presence of lateral and tap roots play a vital role (Pasiecznik et al., 2001). The lateral roots are useful for utilizing erratic rains whereas the deep tap root can reach ground water (Pasiecznik *et al.*, 2001). The species can survive as high as 50 ^{0}C and 70 ^{0}C air temperature and soil temperature, respectively (Pasiecznik *et al.*, 2001). Pasiecznik *et al.*, (2004) summarized the ecological adaptations of *Prosopis juliflora* as it can survive on inhospitable sites where little else can grow; tolerating some of the hottest temperatures ever recorded, and on poor, even very saline or alkaline soils.' These remarkable features of mesquite allow it to proliferate in arid to semi arid areas.

Avery good example of such exotic species which have been introduced in most tropical and sub-tropical countries including Ethiopia is *P. juliflora.* The plant has been cultivated for shade, timber, forage, food, and firewood (Pasiecznik *et al.*, 2001 and Rezene Fessehaie, 2006). However, contrary to its purpose of introduction, the plant escaped out of control and has invading farm lands, pasture lands, rang lands, irrigation schemes (Rezene Fessehaie, 2006) and causes for many land use/ land cover changes.

As a result the plant rapidly invaded vast areas of agro- and silvo-pastoral lands, affecting both the biodiversity and socio-economic environment. Forest invasive species can negatively affect forest ecosystem or damage specific forest products. *P.juliflora,* like any invasive species, is invasive only under conditions that are favorable to their spread (Geezing *et al*., 2004).

The success of *P. juliflora* is largely attributed to the high number of seeds produced and their efficient dispersal mechanisms (Shiferaw, *et al.*, 2004). In addition, its fast growing ability, dormant seeds, attractive and rewarding pods, seeds maintaining viability in the droppings of livestock and wild animals, resistance to browsing, incredible ability of re-sprouting and fast coppice growth (Shiferaw, *et al.*, 2004), and high water use efficiency (Felker *et al.*,

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1983) contribute to its invasion. Now *P. juliflora* has become the national number one invasive species in Ethiopia (EARO and HDRA, 2005).

According to Abdillahi *et al*., 2005 unrestricted spread of *P. juliflora* will result in several risks and environmental impacts. These risks and impacts can be:

- Loss of native plants through competition as well as occupation of their natural environment and habitats Reduction of available nutrition of livestock and destruction of rangelands, thus resulting in adverse impact on a large segment of citizens depending on cattle breeding as a source of living.
- Ground water depletion as the plant have well developed roots and can absorb water from very deep up to 15 meters and sometimes reaching ground water layers which constitute the main source of water resources.
- Caused problems to breeders, because consumption of leaves by camels lead to their sickness, causes flatulence, diarrhea and sometimes constipation as well as eating their solid seed pods may result in falling out cattle teeth and reduction of their ability to graze (Shetie, 2008). Studies on *P. juliflora* tree in India revealed that their spread resulted in destruction of many endangered herbaceous mammals such as the grey hare and desert fox. Their thick thorns prevent mature birds from maneuvering and hunting prey. Moreover, in Ethiopia the thorn is damaging animal hooves and vehicle tire (Abiyot, *et al*.,2006). The thorn of *P. juliflora,* on penetrating the eye cause more inflammation than expected from physical injury.

2.2.2 *P. Juliflora* in Ethiopia and Afar Regional State

Prosopis juliflora is one of ecological important woody plant composition found inform both shrubs and bush structure. It is exotic plant species deliberately introduced to the country and becoming harmful rangeland invader. *Prosopis juliflora* has survived where other tree species have failed and in many cases become a major nuisance. *Prosopis juliflora* has invaded, and continues to invade, hundred thousand hectares of rangeland in the sub-basin. It was introduced to Middle Awash sub-basin, specifically to Werer, some 30 years before by a British man called William Ulcro (FGD and KII results of Awash Fentale, Amibera and Gewene pastoral districts Elders). Ulcro, who was in charge of the Middle Awash Irrigation Project, introduced the species unauthorized (Kassahun *et al.,* 2005). Mesquite was planted as hedge around offices, residential areas and along road sides within the compound of Middle Awash Basin Water Resources Agency based at Werer.

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The introduced species to Ethiopia was *P. juliflora*, which belongs to the family *Fabaceae*. The plant is predominantly xerophilous spiny and sometimes unarmed evergreen tree with height of 3-15 meters depending on genetic difference and other environmental factors, but under favourable environmental conditions some individuals may reach 3 up to 20m. *P. juliflora* landraces often have multi-stemmed, coppiced and prostate shrub forms with long branches and a crown that even touches the ground and have erect, flat topped and decumbent tree forms. *P. juliflora* produces coppices except those stumped at 10 cm below the ground (Hailu, *et al*,.2004). According to S. Demissew,2010 *P. juliflora* in Ethiopia it is Called '*Weyane/Dergi-Hara'* (Afar), *'Biscuit'* (Dire-dawa), elsewhere; mesquite, *algarrobo*, *Prosopis*.

Local elders at Werer were told about the benefits of mesquite in order to get their permissions to plant its seeds and seedlings in Middle Awash area (personal communication with elders at Werer). The scheme continued until 1988 aided by various programs including Food for Work Program (EARO and HADRA, 2005). This gave good opportunity for mesquite to base in the valley. Then, the plant started expansion through competing against grasses and indigenous trees. Consequently, starting from the early 1990s, local people began to realize the outweighing negative impacts compared to the expected benefits of the species (FGD and KII results of Awash Fentale, Amibera and Gewene pastoral districts Elders).

In addition, a research at Middle Awash area revealed that about half of the seeds which passed through animal digestive tracts have the ability to germinate (Hailu et al., 2004). According to their findings, the maximum germination percentage was observed on seeds recovered from warthogs (47%) followed by goats (37%). They also observed up to 2833 seeds recovered from a kilogram of cattle dropping. This shows the amount and possibility of mesquite seeds transportation to far distances within livestock digestive tracts. On top of this, the seeds can germinate under wide ranges of temperature (20 - 40^{0} C) and moisture stressed environments (Abiyot and Getachew, 2006). Besides, the strong poisonous thorns and bushy growth habit of mesquite in the Middle Awash area act as repellent for human to utilize its benefits (Kassahun *et al.*, 2005). It is due to these reasons that mesquite has unchecked expansion in the area. So far, there is a number of surveys were conducted to assess and know the infestation and/or invasion size and areas coverage mesquite invasion Middle Awash Sub-basin by a numbers of researchers, scholars, developmental studies, students and etc with initiation and collaboration of Farm Africa international NGO. However, despite the invasion rate per annum was roughly estimated to 50,000 hectares, the infestation areas, coverage, rate and etc are not clearly mapped. The species

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has also occupied a number of hectares in the Lower Awash area of the region and is still expanding to other parts. These lands were basically life supporting units for Afar pastorals through providing pastures for their livestock and ecological goods such as traditional medicines, wild fruits and materials for house construction. In addition to Afar region Dire-Dawa regions, currently the species is spreading in arid and semi-arid parts of Somali, Oromia and Amhara regions (Ameha, 2006) and the species is declared to be the country's number one invasive plant species (EARO and HADRA, 2005).

In Ethiopia, *P. juliflora* has covered an area of one million hectares (APADB, 2011). It has now been expanded to the south-eastern and south-western parts of the country reducing the farm land, choking out local plant species and drastically reducing the grazing land and now considered as the national number one invasive plant (EARO and HDRA, 2005). The tree was found to have both positive and negative effects on the livelihood of the invaded community and the environment.

Although there is no precise written document why, when, where, and who introduce *P. juliflora* to Ethiopia, the local people of Amibara district of the Afar National Regional State, stated that *P. juliflora* was introduced by an English person from Sudan in 1970s through the Middle Awash Irrigation Project (Rezene Fessehaie, 2006; Hailu Shiferaw *et al*., 2004) and was planted over a large area of the Middle Awash rift valley by local people in 1980 as wind break, shade and shelter around their village.

The Amibara Woreda of the Afar National Regional State is thought to be the putative starting point of the spread of *P. juliflora* in Ethiopia. It represents degraded semi-arid ecosystem. Since 1980s the plant has spread rapidly in eastern Ethiopia, from the Middle Awash Valley in to the Upper Awash Valley and Eastern Hararghe and some localities of Raya Azebo plains of South Tigray. The invasion has also reported in the town of Arba Minch and neighboring localities in South region of the country (Rezene Fessehaie, 2006).

In the Afar region of Ethiopia, where *P. juliflora* is having dramatic impacts across the landscape, its spread and impacts on resources has been ranked as one of the leading threats to traditional land use, exceeded only by drought and conflict (EPP, 2006). Nationally, *P. juliflora* has been ranked as the most problematic plant invader in Ethiopia (Tessema, 2007).

According to local communities, the prosopis invasion has resulted in multiple negative effects on their food security, livelihoods and the region's environment (Dubale, 2006). The invasion of prosopis has caused considerable declines in livestock production and productivity due to the loss of dry season grazing areas to prosopis plants. Palatable indigenous trees and pasture species such as *Chrysopogon plumulosus, Cenchrus ciliaris* and *Setaria acromelaena* have all reduced. Indigenous such as *Acacia tortilis, Acacia senegal* and *Acacia nilotica* have also declined in the rangelands due to the invasion. Pods and branches of these trees are the main dry season feed sources for livestock. Zelalem (2007) reported that camel ownership has reduced almost by one-third over the last five years alone while the mean number of calves and heifers was reduced by fivefold. He also noted a higher rate of decrease in numbers of sheep and goats compared to camels, perhaps due to the relative advantage of camel to browse tall woody plants.

The cost of land clearance became a common problem encountered in all farming areas affected by the invasion of the plant. Agro-pastoralists in Gewane and Amibara districts spent large amounts of money to clear the invasive plants from lands for cultivation (up to US$100/hectare/year) (Geesing, 2004). Moreover, malaria cases increased since invasion of *P. juliflora*. This may be as a result of the moist microclimate in invaded areas provided a favourable environment for mosquito's multiplication. This observation was similar to reports from Kenya also experiencing the invasion of *Prosopis* (Mwangi, 2005).

With the reduction of grazing and cultivable land, joined with recurrent droughts, people in the Afar region became highly food insecure and dependent on government food aid for their survival. In highly occupied areas people are now vulnerable to food aid on average for 5-6 months in good years and for up to 10 months in drought times (Getachew, G. 2008). Due to these impacts to local productivity, the majority of the pastoralists were forced to diversify their livelihoods to include crop farming, daily labor, charcoal production and trade or combinations of these.

2.2.3 ***Meri***t and demerit of *prosopis juliflora*

Merit of prosopis juliflora

As to the positive effects, *P. juliflora* is a multipurpose tree/shrub whose wood is used for firewood, charcoal, posts, poles, and a sawn timber; its pods can be used as a livestock feed and for making human foods; and environmental services provided by nitrogen fixation, shade, shelter, live and dead fencing, erosion control, soil improvement and reclamation are

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remarkable. Secondary products from this tree includes honey (as a bee forage), edible exudates gums, fibers, tannins, foliage for fodder, mulch, biopesticides and medicines, and other uses for wood and pods such as particle board, wood chips for energy generation, pods for ethanol production, galactomannan gums from the seeds and other specialist products (Pasiecznik *et al*., 2001; Hailu, 2002).

- **Overall socio-economic benefits**

P.juliflora provides valuable resources to local communities in the form of fuel wood, timber, fodder for livestock such as goats, sheep, and cattle. It can be used as shade in hot climates, as wind breaks or for the stabilization of sand dunes that threaten to encroach into inhabited land areas. Moreover, *P.juliflora* is extremely tolerant towards a wide range of climatic, soil physical and chemical factors. As a result of those attributes, *P.juliflora* is widely regarded as a useful resource for rural communities which are facing increased natural resources shortages due to population pressure, drought and other climate hazards, as well as armed conflict (Shiferaw 2004; Pasiecznik *et al.*, 2001).

On the other hand, *P.juliflora* has a potential for positive ecological impact. Prosopis trees could reduce soil loss due to water and wind erosion. It is also proved to be effective in improving soil fertility and is useful for reclaiming moderately saline soils and degraded lands. These properties of the tree have made the species suitable instrument to fight desertification in dry regions. These benefits of the species are behind the introduction of the species in Ethiopia and the species has positively contributed in this respect (Berhanu & Tesfaye, 2006; Zeila, 2005). It is also suggested that Prosopis could be considered a potential tree for sequestering carbon dioxide and may be instrumental in the mitigation of climate change (Zeila, 2005; Yemane, 2007).

- **Energy Source**

Particular consideration (measured by the many reports of research trials) is given to the ability of Prosopis as a source for fuel wood of high quality. Due to its high biomass production, high wood density and low ash and moisture content, the species is broadly regarded as an excellent energy source - including the production of charcoal - and usually out performs other native and alien tree legumes. Rural communities have to meet their energy needs. In some countries, up to 86% of this comes from cut wood. This has led to serious deforestation and desertification in many parts of the hot dry land regions (GARG 1999), and leads increasingly to resource-based conflict. The continuous spread of *Prosopis juliflora* provides rural communities with a rare opportunity unrestricted access to fuel wood.

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- **Source of Wood**

P. juliflora plays important role in human life in many arid and semi-arid regions of the tropic and subtropics of the world. The wood is probably the most important product of *P. juliflora* species used either as a fuel wood or structural material (Mwangi and Swallow, 2005). As a fuel it can be burned directly or made in to charcoal, and as a timber it can be used as poles or made into furniture. The wood does not spit, spark, or emit much smoke and burn slowly with hot and even heat with specific gravity 0.70 or higher. Thus, it is called wooden anthracite (Pasiecznik *et al.*, 2001). Moreover, the durability, strength, less shrinkage; less cracking and hardness make the wood of *P. juliflora* more useful for many purposes (Pasiecznik *et al.*, 2001; Victor *et al.*, 2007).

Mesquite is reported to produce good quality firewood and charcoal. Because of its high biomass production even on degraded land, it provides more firewood than other tree species (Ahmed *et al*, 1994). In India, it is grown on wastelands as a resource to fuel energy for cities and villages (Ahmed et al, 1994). However, there are conflicting reports on the quality of the fuel wood. According to Esther and Brent (2005) the fuel wood is of good quality with high calorific value, whereas local people from Ng'ambo area of Kenya claimed that the fuel wood produced poisonous smoke (Anonymous, 2004). They also complained that the wood is soft and easily attacked by insects which make the tree unfit for fuel wood and house construction (Anonymous, 2004).

- **Soil Fertility**

Prosopis juliflora has documented merits like improving soil fertility, controlling soil erosion, stabilizing sand dunes, providing fuel woods, bio energy production, feed/forage for livestock, life fencing and for construction of timber and furniture wood (Zeila *et al.*, 2004; Esther and Brent, 2005; Kassahun *et al.*, 2005; Stefen, 2005). However, there are also research findings which contrast some of the described benefits. In some studies, the physico-chemical property of soil under mesquite canopy was found to be better than the adjacent open field (e.g. El Fadl, 1997 cited in Esther and Brent, 2005) which may be due to nitrogen fixation, leaf litter addition and change in soil structure due to deep tap root system (Pasiecznik *et al.*, 2001). However, there are also observations where soil texture under mesquite canopy and open field were not significantly different (Ameha, 2006); besides Zainal *et al.* (1988) (cited in Pasiecznik *et al.*, 2001) noted that litter of *Prosopis juliflora* reduces soil fertility. There was also considerable improvement in soil texture and soil organic matter under the tree canopy, with soils under

the canopy having higher total nitrogen and available phosphorus, and lower soil pH than soils in the adjacent open field (El Fadl, 1997).

- **Animal Feed**

Focus has also been given to the research of *P.juliflora* as a browse for livestock and a processed fodder resource. Pastoralists, the poor and those living in hot arid desert zones are believed to benefit the most, particularly during the dry season when feed resources are becoming scarce. In particular, the high protein content of the pods has been referred to. The leaves, which are only relatively palatable, are still a potentially valuable browse when everything has dried out. These are also of importance to animal production. Many researchers feel that it is foremost the rural poor or landless that profit from Prosopis, as it provides "income safety nets for the survival" (Shiferaw 2004; Pasiecznik *et al*., 2001).

2.2.4.2 Demerit of *prosopis juliflora*

The negative effects include reduced crop fields and grazing areas, invasion into wetlands that reduces their value for watering and dry season grazing, invasion into the lakeshore areas making fishing more difficult, consumption of seed pods that damage teeth of goats; sharp, strong and poisonous thorns that cause wounds to livestock and human beings. Increased disease incidence associated with microclimate change due to invasion and reduced utilities from indigenous herbs, trees and wild animals were also cited as the negative effect of the tree. Besides, the invasion blocked paths to water points, grazing areas and between villages and served as shelter for predators (Shakeleton *et al*., 2006; Easther Zeila, ; 2008).

2.2.4 Treat for Pastoralism and Agro- Pastoralism

The ecological impact of Prosopis has been translated into social, economic and political dimensions in the country. The most important socio-economic impact of Prosopis is associated with its replacement of pasture lands and native trees of browsing value, which are the sole sources of feed for the livestock of pastoral communities. Pastoralists are the most affected by the invasion as their livelihood mainly relies on livestock production system. Agro-pastoralists of the invaded region are also one of the most affected by the invasion having their farm and pasture lands replaced by *Prosopis.* In extreme cases, these people have been compelled from their farm lands as a direct consequence of *Prosopis* invasion (Dubale, 2008; Rangi, 2009; Ryan, 2011).

Over 700,000 hectares of grazing land and cultivable land following the Awash River is currently either invaded or at risk of invasion in the Afar Region (USFS, 2006) . This accounts for 15% of the

region's productive land (4,670,316 hectares), excluding wetlands, water bodies, sandy and rocky areas (4,856,251 hectares). In the Afar people are predominantly pastoralists that depend on livestock rearing, or agro-pastoralist for their survival. However, the *P. juliflora* invasion, coupled with recurrent droughts that strike the area, has left the people unable to maintain these subsistence livelihoods.

- **Treat to Biodiversity**

Currently, *P. juliflora* poses a threat to indigenous biodiversity where ever it is established in Ethiopia in general, in the Middle Awash area in particular because of its weedy and invasive nature (Mehari, 2008). The invasion by *P. juliflora* reduces grass availability and stocking density by livestock. It impacts the plant biodiversity by creating a physical barrier on seedlings of other plant species, preventing sunlight to reach to the under canopy vegetation, lowering the water table and by releasing various chemicals that may have negative effect on the native plant species.

- **Allopathic Effect of *P. juliflora***

Prosopis inhibits the germination or growth of many plant species growing in its vicinity through allelopathic substance(s) exuded from its leaves, roots or fruits (Warrag *et al*., 2003) . This may be due to slow decomposition and heavy accumulation of leaf litter below P. juliflora may possibly result in accumulation of toxic substances in the soil layers, inhibiting growth of other species. The leaves of *P. juliflora* contain various chemicals including tannins, flavinoids, steroids, hydrocarbons, waxes and alkaloids (Pasiecznik *et al.* 2001). These are known to have effects on the germination and growth of other plant species. As a result of this, the plant diversity (both the number of individual plants of a species and the number of species around *P. juliflora*) will be affected by the allele-chemicals. Low light under *P. juliflora* canopy also make other plant species' survival difficult.

2.2.5 Policy Challenges in the Management of *Prosopis juliflora*

To combat the serious threats posed by invasive species, it is crucial to devise management strategies and policies. Even though *Prosopis* has already revealed its multifaceted and critical problems in Ethiopia, there has not been clear policy or strategy towards *Prosopis* or to invasive species management in general (Fessehaie, 2006). It is, however, recognized as a major threat to biodiversity and economic wellbeing of society by plans such as the Environmental Policy of Ethiopia (EPE) and the National Biodiversity Strategy and Action Plan (NBSAP) and Forest Resource Strategy of the country (Berhanu, n.d.; IBC, 2005). In contrary to this plans, however, the National Action Plan of

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the country recommended Prosopis tree as a potential tree to combat desertification (Anagae *et al.*, 2004) signifying the existing policy dilemma towards Prosopis. This contradiction of policy directions indicates lack of coordinated design of one policy direction based on a comprehensive analysis and understanding of the problem. Such coordinated effort seems difficult in Ethiopia where institutional mandates in the management of invasive species are unclear and fragmented interventions are common.

2.2.6 Prosopis juliflora control methods

Mechanical control

Mechanical control options include the physical felling or uprooting of plants, their removal from the site, often in combination with burning. The equipment used in mechanical control ranges from hand-held instruments (such as saws, stashers and axes) to power-driven tools such as chainsaws and brush cutters, and even to bulldozers in some cases (Matthews and Brand, 2004).

Chemical Control

Herbicides can be applied to prevent sprouting of cut stumps, or to kill seedlings after felling or burning. Herbicides can target, for example, grasses or broad-leaved species, leaving other plants unharmed. However, there are legitimate concerns over the use of herbicides in terms of potential environmental impacts. Although newer herbicides tend to be less toxic, have shorter residence times, and are more specific, concerns over detrimental environmental impacts still remain. The use of chemical control is often governed by legislation, and the effective and safe use of herbicides requires a relatively high level of training; both of these factors can restrict the use of chemical control on a large scale (van Wilgen *et al.*, 2001).

Biological Control

Biological control has been defined as the use of living organisms to control pest species . Biological control, instead of eliminating the target organism, aims at establishing an equilibrium which maintains its population at a level of negligible harm (Bani 2002).

“Eradication by Utilization”

This phrase was first coined by Tessema (2012) to explain the economic exploitation of invasive species as a means of harnessing their economic potentials for meeting basic human needs and at the same time control its spread and possibly eradicate them. As unpopular as this concept seems, it is already being practiced in many African countries and other

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developing countries, where the rural people, in short of basic amenities, were forced to start exploiting these invasive species, only to find out that these invasive species have somewhat better qualities that their indigenous species.

The case study of *Prosopis juliflora* as an invasive species in many of the developing countries has been widely reported. However, it was discovered that the wood is an excellent fuel, the timber is hard and compares favorably with finest hardwoods such as Teak and Mahogany (Pasiecznik *et al.* 2001). The sweet nutritious pods are relished by all livestock and are made into different foods and drinks. Honey from the flowers is of high quality, the gum is similar to gum Arabic, barks and roots are rich in tannin, leaves can be used as mulch and the tree is a nitrogen fixer to the soil. The pods are used to make flour for cakes, biscuits and bread, pop syrup, coffee substitutes and animal feed in Ethiopia (Admasu 2008).

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location of the study area

The Afar National Regional State is located in the Northeastern part of Ethiopia within the main Ethiopian rift system between 9°to 30° North latitude, and 39° to42 ° East Longitude. Amhara and Tigray Regions, to the South by Oromia, to the East by Somali region and the republic of Djibouti, and to the North by the state of Eritrea, bound the region to the West. The region has an estimated area of about 92,000Km^2 (ARWDS, 2001).

Dubti is one of the 32 Weredas in the Afar Region and is located at a distance of 580 km north-east of Addis Ababa. The Woreda is bordered on the south by the Somali Region, on the southwest by Mille, on the west by Chifra, on the northwest by Administrative Zone 4, on the north by Kori , on the northeast by Elidar, on the east by Asayita, and on the southeast by Afambo. The capital city of the region Semera is found in the Wereda (Afar Regional Atlas, 2009).

The study area covers 226,283.5 ha in Dubti Wereda in the Lower Awash rangelands. Dubti Wereda consists of 15 Kebeles of which four urban, eight agro-pastoral & 3 pastoral kebeles. The Awash River flowing North-Eastward via southern Afar provides a narrow green belt and enables life for the flora and fauna and for the inhabitants as well. Awash River is the only water source for both

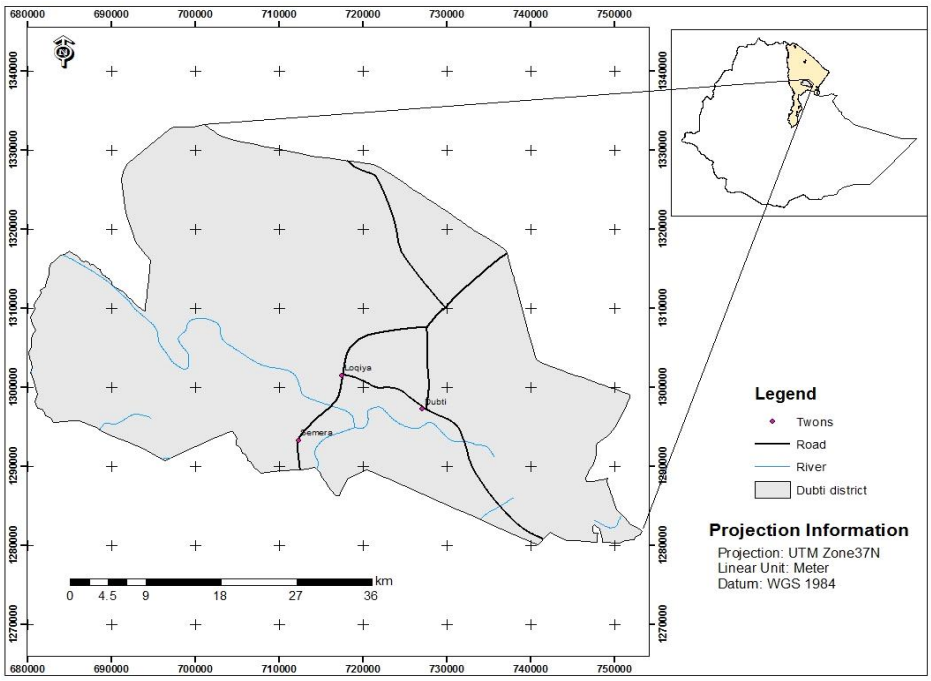

Figure 1 Location of the study area

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3.1.2 Climate and Rainfall

The area is commonly known with very wide diurnal, seasonal temperature fluctuations and high intensity of solar radiation due to the dry atmospheric condition and clear skies. The major rain seasons with in the study area are named as Karma (which represents the rainy season which starts at the month mid-June to mid-September, Dedae (which represents the rainy season which starts at the month of October and ends at November, and Segum (which represents the rainy season which starts at the month of March–April. The area has mean annual rainfall of 200 mm. Mean minimum and maximum temperatures are 25^0 C and 42^0 C respectively.

3.1.3 Physical Features of the Area

The Dubti Pattern, consisting of sandy ridges alternating with basins of clay and silty soils. In general, the region is characterized by large areas of sandy to loamy soils with vast areas of alluvial plains. traversed by many seasonal streams draining the Awash River

3.1.4 Topography and Drainage

The average elevation of the Dubti district is 300 m.a.s.l. The study area is almost flat land and resent alluvial deposit of alluvial and out wash fans are common in the plain areas that extend along both sides of the Awash River. The Southern part of the study area is characterized by flat to almost flat land form with many narrow residual hills and ridge.

3.1.5 Population and Socio-economic Situation

Based CSA (2007) this District has a total population of 65,314, of which 32,400 were living in rural areas whereas the remaining 32,914 are living in urban areas. The production system of the Afar region is dominated by pastoralism (90%) from which agro-pastoralism (10%) is now emerging following some permanent and temporary rivers on which small scale irrigation is developed (Afar Regional Atlas, 2009).

Pastoral and agro-pastoral production systems which mainly dealt with extensive livestock production systems are the major farming and/or production systems on which most of the livelihoods of communities depends on. Nonetheless, other supplementary activity are also one of the production systems helping local society livelihoods like employment at Tendaho sugar plantation, petty trades, mining (AFEDB, 2011).

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3.2 Sample Size And Sampling Technique

94 households were selected purposively. *prosopis juliflora* infestation vary from area to area in the district. The first strata consisted of individuals from high prosopis infested area while the second strata consisted of individuals from medium prosopis infested area and the third stratum was the individuals from non-*prosopis* infested area. Accordingly, the sample size in the high infestation and medium infestation areas were thirty-five and twenty-four individuals were interviewed from the area that was not yet infested with prosopis. The selected households encompass different occupation like pastoralist agro pastoralists, casual workers and charcoal maker. The main reason for selecting the households purposively was pastoralists and agro pastoralist who have extensive knowledge of the area and who know the socio economic and ecological impact of *prosopis juliflora* in the area.

A group containing 8-10 elderly people with deep knowledge of the study sites were selected for an in-depth interview and focus group discussions. However, key informant group discussions were also conducted to gather other relevant qualitative information. Apart from this those organizations who are working in prosopis management were interviewed about their means of control and coordination mechanism.

3.3 Method of Data Collection

3.3.1 Primary Data Collection

a) Structured Interview : Cross-sectional primary data were collected using a pre-constructed questionnaire designed to obtain information about the social characteristics of respondents, drought and its effects on the study area, the impact of land-use change on agricultural production, livestock production as well as pasture rand land condition and alternative livelihood strategy . The questionnaire was built on the author's background knowledge of the study area, group discussions with the key informants, and numerous questionnaires completed during previous research in the region. Moreover, a pretest with five rural persons was carried out for further improvement of the questionnaire. Key informants were asked whether the questions were clear and their interpretations were explored to see whether the intended meaning was clear. At the same time they provided multiple choices to open questions. The interviews were carried out by

personal contact. The interview will be conducted within the respondent's territory and in interviewing atmosphere where interruption or correction is none.

b) Focus Group Discussion (FGD): To complement the household survey, basic descriptive information were collected at the kebele and village level in each survey site. This technique helped to acquire useful and detailed information, which might be difficult to collect through the household survey. A total of six focus group discussions comprising six to eight members (clan leaders, two key informants, one women representative and one youth representative) were made. It is one of the most commonly used qualitative data collection approaches. Discussion were conducted with randomly selected respondent under the guidance of a moderator.

c) Key Informant Interview:

To obtain information about historical changes in the study area, an interview was held with five elderly rural people from each village. The information focused on the changes in land use and land degradation, crop productivity, cultural practices and grazing species composition (for example disappeared, decreased, increased and invader plant species). However, in the local community, narration is the only means for documenting such information from generation to generation, and this knowledge may disappear with the death of the knowledgeable elderly persons, if other means of documentations were not used. This information can play important roles in restoring the degraded agricultural and pasture lands. The key informants were Local elders, clan leaders, religious leaders, individual male, individual female, this was done to complement the questionnaire and to have a detailed in sight in land use land cover change.

d) Direct Observation: Field observations were made in the study area This informal technique will help to generate ideas and acquire useful and detailed information about land use land cover changes in the study area.

3.3.2 Secondary data

Secondary data and information was also collected from various published and unpublished sources.

3.3.3 Data analysis

Data collected from interviews were coded, computerized and analyzed using the Statistical Package for Social Science (SPSS) version 20.00. Descriptive statistics and correlations analysis were used to explain the socio-economic characteristics of the respondents as well as the relationships

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between different factors, for example factors driving land-use change patterns, and to determine rural people's attitude and perception towards land-use change and its impact on their livelihoods.

4. RESULT AND DISCUSSION

4.1 Socio-Economic Impacts

4.1.1 Socio-Economic characteristics

The total sample size were 94 out of which 35 from high infestation category, 35 medium infestation category and the remaining 24 are from low infestation category.

Table 1 Sample size in the prosopis focus areas

Respondent category	n	%
High infestation	35	37.2
Medium infestation	35	37.2
No infestation	24	25.5
Total	94	100.0

Source; sample survey 2013

Age is a socio-economic characteristic that has a bearing on adoption of new ideas and technologies. The average age of the overall sample individuals was 42 years ranging from 22 to 61. From the total sampled interviewed 23 of the respondents to the household questionnaire were females while the remaining 73 were males (Table 3).

Based on the sample households survey results show that the average family size is 6 persons, ranging from 4 to11 and the average age of sample household is 42. .

Table 2 Sex and Age of the sample respondents in the *prosopis* focus areas of Dubti district

Prosopis focus area	Sex of Respondents				Age of Respondents		
	Male		Female		Mean	Minimum	maximum
	No	%	No	%			
High infestation area	25	71.4	10	28.6	42.86	22	61
Medium infested Area	27	77.14	8	22.86	42.40	25	60
Low infested area	21	87.5	3	12.5	43.58	24	61
Total	73	77.66	21	22.34	42.78		

Source; sample survey 2013

Although a significant proportion of household heads were not able to read and write, further analysis of educational level of family members indicated that on the average there are 7 family members in the high and medium infestation area, and more than 3 family members in the no infestation area who could read and write (Table 3). This implies that awareness creation and extension programs designed to control/manage *prosopis juliflora* can take this opportunity to reach the local community.

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Table 3 Educational level of the sample HH in the *prosopis* focus areas of Dubti district

Educational level	High infestation N=35		Medium infestation N=35		No infestation N=24		Overall sample N=94	
	n	%	n	%	n	%	n	%
Illiterate	31	88.6	32	91.4	21	87.5	84	89.4
Primary school	4	11.4	3	8.4	3	12.5	10	10.6
Total	35	100	35	100	24	100	94	100

Source; sample survey 2013

Sample of individuals selected from the three strata in the rural areas included individuals of different occupation (Table 3). 25.7% of the respondents in the high infestation area, 22.8% in the medium infestation area and 100% in the area that is not yet infested make their primary living in livestock (cattle, camel, sheep, and goat) rearing. 51.4% of the respondents in the high infestation area, 60% in the medium infestation area make their primary living in livestock(cattle, camel, sheep, and goat) rearing and crop(maize onion tomato) production. 22.8% of the respondents in the high infestation area, 17.1% in the medium infestation area make their primary living selling firewood and charcoal made of *Prosopis juliflora* tree.

In addition to their primary occupation the sample individuals were also involved in other types of activities to earn money as supplementary income. Sample households high, medium and low infested area supplement their leaving as casual worker 31%, 28.5% and 11.4% respectively. In addition to this sample households high, medium and low infested area did not supplement their leaving from any source are 51.4%, 48.55% and 37.1% respectively.

Table 4 Primary and Supplementary income of the household in the three infestation areas

Prosopis focused areas	Primary Income						Supplementary Income					
	Livestock (Pastoral)		Livestock and crop production (Agro pastoral)		Charcoal production		Casual worker		Quarry selling		No supplementary	
	No	%	No	%	No	%	No	%	No	%	No	%
High infestation area	9	25.7	18	51.4	8	22.8	11	31.4	6	17.1	18	51.4
Medium infested Area	8	22.8	21	60	6	17.1	10	28.5	8	22.8	17	48.5
Low infested area	24	100	-	0	-	0	4	11.4	7	20	13	37.1
Total	41		39		16		25		21		38	

Source; sample survey 2013

Family size is one of indicators of household labor availability. Provided that labor remains an essential input in prevention and/or control of *prosopis*, designing prevention and control program requires determination of household labor availability. In this study, it is found that the average family size of the overall sample individuals was eight ranging from 1 to 35 (Table 5). This was because, in this study area, there was a practice of polygamy and as a result, some households have large family sizes.

Table 5 Family sizes of the sample individuals in the *prosopis* focus areas of Dubti district

Prosopis focus area	n	Mean	Minimum	Maximum
High infestation	35	8.94	2	35
Medium infestation	35	6.91	1	20
No infestation	24	6.08	1	15
Overall sample	94	7.31	1	35

Source; sample survey 2013

4.1.2 Individuals' perception on means and sources of introduction of *prosopis*

The result of the formal survey indicated that individuals perceived that *prosopis juliflora* was introduced into their locality by different ways. A large proportion of the individuals perceived that

prosopis was introduced into their locality by Awash river flooding (42.6%), and through livestock dung (24.5%) (Table 6). Even the individuals in no *prosopis* infestation areas have their own observations and perceptions on how *prosopis* was introduced into the localities where it is dominant at the time of the study. According to key informants the plant used to appear in the military camp which is found in the nearby Awash River. About 24.5% of the sample individuals in non-infestation category perceived that *prosopis* was intentionally introduced into neighboring localities by government and NGO extension program. 8.5 % of the sampled household believed it was introduced through wind to their area.

Table 6 Means and/or sources of introduction of *prosopis* into focus areas of Dubti district

Means of introduction	High infestation N=35		Medium infestation N=35		No infestation N=24		Overall sample N=94	
	N	%	n	%	n	%	n	%
Gov Agriculture extension program	3	8.6	5	14.3	9	37.5	17	18.1
NGO Extension program					6	25.0	6	6.4
wind	5	14.3	3	8.6	6	25.0	8	8.5
Awash river flooding	18	51.4	16	45.7	3	12.5	40	42.6
Through cattle dung	9	25.7	11	31.4	24	100.0	23	24.5

Source; sample survey 2013

4.1.3 Individuals' perception on the dissemination status of *prosopis juliflora*

According to a key informant survey, prosopis was disseminated in the area because of the cattle. The cattle feed on the pods and the seeds are distributed all over through their dung. The findings of the formal survey confirmed this assertion. Both in the high and medium infestation area 88% of the respondents perceived cattle dung to be the agent by which *prosopis* seeds are disseminated (Table 7). Likewise, the sample individuals in the area that is not infested believe that dung is an agent that facilitates dissemination of *prosopis.* The seeds are also transported to distant places by flood. The types of animals which have great contribution for the invasion, based on focus group discussion and key informant interview were cattle, goat, warthog, camel, donkey, monkey and sheep. Sheep is the least in contribution for *P. juliflora.*

Table 7 Agents facilitating dissemination of prosopis in focus areas of Dubti district

Means of introduction	High infestation N=35		Medium infestation N=35		No infestation N=24		Overall sample N=94	
	N	%	N	%	n	%	N	%
Livetock Dung	30	88	26	74	21	88	78	83
Flood	-	-	3	9	-	-	3	3
Wind	-	-	2	6	-	-	2	2

Source; sample survey 2013

Degree of awareness of individuals about the invasiveness of the weed is one of the factors influencing decision of individuals to be involved in management of *prosopis.* In this regard sample individuals were asked about their perception of invasiveness of the plant. All of the respondents in the high infestation category replied that *prosopis* is a highly invasive plant (Table 8). In the medium infestation area 80% said that prosopis is highly invasive whereas 6%% regarded invasiveness of *prosopis* as medium. The proportion of sample individuals in the no infestation area that considered *prosopis* to be a highly invasive plant was 67%. From the overall sample 84% perceived that *prosopis* is a highly invasive weed.

Table 8 Individuals' perception of invasiveness of prosopis in Dubti district

Invasiveness	High infestation N=35		Medium infestation N=35		No infestation N=24		Overall Sample N=94	
	n	%	n	n	%	%	n	%
High	35	100	28	80	16	67	79	84
Medium	-	-	6	17	7	29	13	14
Low	-	-	1	3	1	4	2	2

Source; sample survey 2013

Figure 2 Densely invaded *prosopis juliflora*

4.1.4 The effects of *prosopis juliflora* on crop production

Dubti district is known for its high potential of cotton production. The effect of existence of *prosopis* in farmlands, field borders, and roadsides is revealed in the increased cost production as a result of clearing *prosopis* infested land.

Although almost all of the sample individuals in the formal survey are not engaged in crop production, about 89% in the high infestation area and 86% in the medium infestation area noticed that prosopis has negative impact on crop production whereas only 50% of those in the no infestation area were aware of effects of *prosopis* on crop production.

4.1.5 The Effects of Prosopis juliflora on Livestock Production

The findings also indicate that *prosopis* has an effect on livestock production as perceived by all the sample individuals in high and medium infestation areas. Moreover, 92% of the individuals in no infestation areas have believed that *prosopis* has an effect on livestock production.

Prosopis juliflora affects livestock production in different ways. According to all of the sample individuals in high infestation category and medium infestation category, *prosopis* encroaches grazing land. Moreover, all of the individuals in high infestation category and 94% in medium infestation category believed that *prosopis* threatens animal health (Table 9). Its thorns are bad for the livestock (It blinds them, and if it pierces the leg of an animal the animal will not recover easily) and the human being. It was reported that neck of cattle, sheep and goat which have fed on pods of *prosopis* for a prolonged period will be twisted ultimately leading to death. According to the key

informants the number of cattle, which have died because of *prosopis,* is larger than those, which died because of drought. Focus group discussion indicated that, animals also develop dental problems when they feed on pods for extensive periods. Such animals became emaciated and finally die. In addition, continuous feeding on the pod of *P. juliflora* also causes teeth decay on the goat and it makes undigested ball matter in side their stomach. The local people also believe that if pods of *prosopis* are supplied to livestock as supplement feed with grass it wouldn't entail the health problems mentioned above. Even the individuals from no infestation areas have awareness of the different effects of *prosopis* on livestock production.

The effect of all these is that the present overall level of herd productivity is lower than it was in the past. As traditional production system fails to maintain the livelihood of the households due to shrinkage of pasture land by *P. juliflora* invasion. As a result of all these, some pastoralist take alternative actions regarding of their long stay traditions change their means of living in to small scale farming by clearing *P. Juliflora*

Figure 3 Leaves and thorns of *P.juliflora*

Table 9 Effect of prosopis on livestock production as perceived by sample individuals

Effect on livestock production	High infestation		Medium infestation		No infestation	
	n=35	%	n=35	%	n=35	%
Encroaches grazing land	35	100	35	100	20	83
Threatens animal health	35	100	33	94	22	92

Source; sample survey 2013

4.1.6 The Effect of *Prosopis* on Human Health

The findings also indicate that *prosopis* affects human health as well. According to 94% of the individuals in the high infestation category, 91% in the medium infestation category and 92% in the no infestation category, *prosopis* has an effect on human health. The most important effect of *prosopis* on human health is that its thorns cause itching and bring tetanus (Table 10). Its thorns can even cause blindness. Focus group discussion indicted that, the incidences of thorn injuries, malaria cases, snake bites and hyena attack were increased in the area following the invasion. For the cases of malaria it was stated that the moist microclimate created in invaded areas provided a favorable environment for mosquito's multiplication.

Table 10 Types of effects of *prosopis* on human health in Dubti district

Type of effect of *prosopis* on human health	High infestation		Medium infestation		No infestation	
	n=35	%	n=35	%	n=24	%
The thorn causes itching	12	83	25	71	16	67
Tetanus because of its thorn	10	29	6	17	3	13
Blindness	2	6	2	6	2	6
Aggravates malaria problem serving as harboring place for mosquitoes	9	-	1	3	2	8

Source; sample survey 2013

4.1.7 Other Impacts of *P. juliflora* on Local Community

The local people use *Prosopis juliflora* as multi- purpose tree. Charcoal making and pods for animal feed are the fare collected to feed animal in time of feed shortage. The plan is widely uses in the area as charcoal making and fire wood, construction material. *Prosopis* pods for livestock feed use

are known as feed of livestock but is not commonly used the most known use of prosopis *juliflora* in the area. Medicinal value of the plant is not known widely in the area. From the key discussion the local people had indicated that if properly managed it shows positive implication on the soil amelioration, micro-climate.

Table 11 Uses of *P. juliflora* in both highly and less Infestation area

Use	High infestation area Number 35		Medium infestation area Number 35	
	Number	percent	Number	percent
For construction and fencing pool	9	25.7	8	20
Charachoal	13	37.1	12	28.5
Fire wood	8	22.8	11	37.4
Medicinal value	1	2.8	-	
Pods for goat livestock feed	5	14.2	4	20

. Source; sample survey 2013

4.2 Ecological Impact of *prospis juliflora*

4.2.1 The effect of *prosopis juliflora* on biodiversity

According to the result of both informal and formal surveys introduction of *prosopis* to Dubti district has affected biodiversity of the area. Interviewed community leaders and individuals have the perception that several plant and animal species have disappeared from the area due to *prosopis.*

Results of the formal survey has showed that 94% of the sample individuals in the high infestation area and 97% in the medium infestation area believed that considerable number of plant species have disappeared from the area because of *prosopis.* The way the local community was using these plant species are described in tables 12,13, 14

Disappearance of grasses from the area is the most disappointing to the local people as they heavily depend on grazing land for livestock production. The most striking fact, according to key informants, is that plant species that have disappeared in the *prosopis* infested area are still existent in the area that is not yet infested.

Table 12 Endangered tree species as perceived by individuals and their utilization

Local Name (Afar)	**Scientific Name**	**Utilization**
Garssa/Gerssa	*Dobera glabra*	• Feed for Camel and Human being(Its fruit)
Hedayito	*Grewia ferruginea*	• Feed for camel and goat • Used for construction of Afar traditional house • Edible fruit for Human • Used to make bed
Mederto	*Cordia sinensis*	• Feed for goat camel and cattle • Edible fruit for Human • The bark used for rope • Used for construction of Afar traditional house • Medicine for malaria
Adebto	*Grewia biscolor*	• Used to make bed • The bark used as a rope for house construction to bind poles • Used as walking stick • Used as fuelwood
Adayito	*Salvadora persica*	• Feed for Camel • Used as tooth brush • Fruits used as spice • Has medicinal value
Keselto	*Acacia nilotica*	• The pod feed for Camel, goats and cattle • The leaves feed for goats • Used for good taste of water in Afar traditional water container which is made by hide • Used for house and fence construction • The bark used to remove hair during hide processing • Used as good quality charcoal and shade tree
Adgento	*Acacia seyal*	• The Gum used as sweet feed • The gum and bark used for hide and skin processing • The pod used as feed for cattle • Used as good quality charcoal and fuelwood
Adedo	*Acacia Senegal*	• Feed for goat, camel and cattle • The Gum used as sweet feed
Gerento	*Acacia oerfota*	• The gum used as feed for children • Used for construction of Afar traditional house • Flowers used as a feed for goat • The leaves used as a feed for camel and goat
Mekarto	*Acacia mellifera*	• Feed for goat and camel

Source; sample survey 2013

Table 13 Endangered grass species and medium sized plant species (shrubs) as perceived by individuals and their utilization

Local Name (Afar)	Scientific Name	Utilization
Melif	*Ischaemum afrum(J.F.gmel)Dandy*	• Feed for cattle, sheep, goat and equines • Used for construction of Afar traditional house esp. for roof and wall
Durfu	*Chrysopogon plumulosus Hochst*	• Feed for cattle, sheep, goat camel and equines • It increase milk and meat production. • Feed for camels during younger stage
Isisu	*Cymbopogon schoenanthus(L.) Spreng.*	• Feed for cattle, sheep, goat and equines • Used for construction of Afar traditional house esp. for wall
Ayiti Adayita	*Tragus berteronianus Schult.*	• Feed for cattle, sheep, goat camel and equines
Deleita	*Setaria acromelanea(Hochst.) Th.Dur & Schinz*	• Feed for cattle, sheep, goat and equines
Serdoita	*Cenchrus ciliaris*	• Feed for cattle, sheep, goat and equines
Beruli	*Ecinocloa colona(L.) Linc*	• Feed for cattle, sheep, goat and equines
Denikto	*Brachiaria ovalis Stapf*	• Feed for cattle, sheep, goat camel and equines
Hmilito	*Sporobolus pellucidus Hochust*	• Feed for cattle, sheep, goat and equines • Used for construction of Afar traditional house, house broom and bed
Bekele Iso	*Aristida adoensis Hochust*	• Feed for cattle, sheep, goat and equines
Afaramole	*Dactyloctenium scindicum boiss*	• Feed for cattle, sheep, goat, equines and camel.
Asa Iso	*Bothriochloa radicaans (Lehm) A.camus*	• Feed for cattle, sheep, goat and equines
Iyaito	*Panicum coloratum L.*	• Feed for cattle, sheep, goat and equines
Rareita/ Dorobaito	*Cynodon dactylon(L) pers*	• Feed for cattle, sheep, goat and equines
Gewita	*Urochloa selerochiaena chiove.*	• Feed for cattle, sheep, goat and equines

Source; sample survey 2013

Table 14 Wild animals endangered or reduce in the area

Local Name (Afar)	Scientific Name	Common name
Bieyda	*Oryx gazelle*	Oryx
Goroia	*Struthio camelus*	Ostrich
Da'ema	*E. grevyi*	Grevys Zebra
Bekiela/Tinchel	*Lepus habessinicus*	Abyssinian hare
Segerie	*Madoqua saltiana*	Dik-Dik
Waydido	*Gazella soemmerringi*	Soemmerring's gazelle
Galie fiela	*Litocranius walleri*	Gerenuk
Sera	*Tragelaphus imberbis*	Lesser kudu
Goroja	*Kobus ellipsiprymnus*	Water buck

Source; sample survey 2013

About 87% of the respondents in the high infestation area, and 67% in the medium infestation area believed that several animal species have fled the area because of *prosopis*. Animal species that have migrated from the area include Zebra, Sala, Yemeda Fiyel, Dikula, and ostrich. The main reason for this happening is lack of grasses and ostrich prefers to live in an open area than in dense trees. According to key informant and the formal survey result the number of some new animal species is increasing in the area. Twenty-three% in the high infestation area, 3% in the medium infestaion area an 13% in the no infestation area said that the number of Kerkero is increasing. Whereas 23% in both the high and medium infestation area reported that snake population is rising.

4.2.2 Allelopathy of Prosopis juliflora

Based on the local key informant discussion, areas invaded with *prosopis juliflora* did not grow other grass and tree species in underneath and nearby the plant. *Prosopis* inhibits the germination or growth of many plant species growing in its vicinity through allelopathic substance(s) exuded from its leaves, roots or fruit. This may be due to slow decomposition and heavy accumulation of leaf litter below *P. juliflora* may possibly result in accumulation of toxic substances in the soil layers, inhibiting growth of other species (Etana *et al*., 2012).

4.2.3 Impacts of *P. juliflora* on land rehabilitation

Local people had observed that sandy areas that were covered with good soil when invaded by *P. juliflora* because it controls floods and holds soil, serving as a barrier for erosion. They also said that areas cleared of *P. juliflora* provides better harvests as compared to previously farmed lands and suspected it could be due to fertility improvement by *P. juliflora.* The local people also has experience in rehabilitation the waste land due salinity problem by Tendhao Sugar cane plantation that was used for number of years. . Brady (2000), Michael and Donald (2002) and Malcolme (2000) also indicted that, the litter from the tree are a source of nutrient and the leguminous woody species

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fix nitrogen to the soil system which increase soil fertility. Previous similar results (Abebe *et al.*, 2006; Mendes, 1990; Singh, 2000) show that *P. juliflora* has ameliorating effects on soils, which show reductions in soil pH, electrical conductivity and exchangeable Na levels, and increasing organic matter, total N and available P. Therefore, if appropriately managed *P. juliflora* can reclaim salt-affected soils degraded areas of the district

4.3 Management technique used to control *prosopis juliflora* in the District

Now a days since the disadvantages outweigh the advantages all development actors especially the the pastoralist and agro-pastoralist livelihood facing challenge they call for *P. juliflora* eradication. On the other hand, all of charcoal makers did not want *P. juliflora* to be eradicated since they earn their livelihood totally from the species. Due to these two aspects of impacts of P. juliflora there is an evidence of conflict on management of the species. Therefore, for successfulness of the management techniques the conflict must be resolved.

Many people in the district call for its eradication. Yet the experience from other countries shows that *P. juliflora* is extremely difficult and expensive to eradicate once it gets established (Zeila, 2005). Because eradication efforts have been neither cost effective nor technically successful, it seems the best option might be to adapt land use to its management and use (Esther and Brent, 2005).

4.3.1 Dubti District Pastoral Community Development Project (PCDP)

The objective of Dubti District Pastoral development Project undertake development related activities in selected Kebeles of the district through a participatory Community development approach so as to make the surrounding population food self-sufficient. Controlling *prosopis juliflora* in the district is one of the prime objectives of the pilot project unit because of the adverse effect of the tree on grazing land. The strategy adopted to control *prosopis* is clearing infested areas in collaboration with the local people the project provide hand tools use for cutting the tree and minor daily allowance for those participated in the eradication program. Even though considerable achievement in *prosopis juliflora* eradication, due to non continuous effort the cleared areas infested again.

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4.3.2 Productive safety net program (PSNP)

According to Dubit District pastoral l agricultural office experts, one of the key objectives of the PSNP is to create community assets through the implementation of public works. Dubti District was one of the District were PSNP was functional since 2007 . In the public work program the food insecure pastoralist identified and will participate in any public work program and received food for what they accomplished. Based on this *prosopis* control and eradication one of the primary agenda of the wereda especially in highly and medium prosopis infested areas. Pastoralist use some hand tool material to wipe out the plant. In this regard many achievements were recorded. Many *prosopis* occupied range lands were cleared from the plant. Unfortunately the plant grow in a short time unless it is cultivated. This make high disappointment and the fight against the disease become less effective as time goes and this results *prosopis* to occupy the most fertile and productive rangeland of the area.

4.3.3 Tendaho suger factory project

Prosopis juliflora has been observed in the area since the late 1980s and it is spreading at an alarming rate. Infestation of farmland by *prosopis* has increased production cost because of the control measures that the farms have to take. The control technique used by the Tendaho Sugar fatory are clearing using bulldozer, uprooting using human labour and burning *prosopis* trees found on farmland, road sides, and irrigation and drainage canals. followed by reclamation measures such as cultivating with sugar cane plantation.

4.3.4 Eradication campaign at a Community level

There has been a campaign to control and eradicate *Prospois juliflora* in high and medium infestation area in the year 2010 with participation of different stakeholders such as Afar Pastoral and agro pastoral research institute Afar Pastoral and Agricultural Development Bureau and wereda level workers the local community members. The total number of people mobilized was about 200. This kind of campaign has been mobilized twice and was discontinued since then. Nevertheless, members of the community Debel and Harloaf kebeles who are mainly pastoralists and agro pastoralists , have been mobilizing themselves from time to time to clear the land infested by prosopis.

Very few individuals obtained a training on how to control *Prosopis juliflora*. In the highly infested PA about 21% of the interviewed pastoralists have been trained on techniques of *prosopis* whereas only 8% of those interviewed from the medium infestation area replied that they were trained. In the area that is not yet infested, no one has reported to be given training.

With regard to control techniques applied by pastoralists, burning the tree was the most commonly used technique (Table 14). About 31% of the pastoralists in the highly infested area and 21% in the medium infestation area tried to control *prosopis* by burning it. Clearing was practiced by 29% of the respondents in the high infestation area and by 3% in the medium infestation area. The other technique practiced to control *prosopis* was hand pulling (uprooting) as reported by 22% of the farmers in the high infestation area.

Cutting and pouring used car oil on the cuttings was practiced by 6% of the respondents in the high infestation area. In general, several alternative techniques were applied to control *prosopis* in the high and medium infestation areas Table(15). However, herbicide was not used as a good option to control *prosopis*. According to the information obtained from key informants, the areas not yet infested with prosopis were aware of the negative effects of *prosopis* and as a result, they have established local by-laws for the members of the community to uproot the seedling of *prosopis* whenever it appears anywhere in their locality.

Table 15 Techniques used by pastoralists to control *Prosopis juliflora*

Technique	High infestation area		Medium infestation area	
	n	%	n	%
Burning	11	31	7	21
Clearing	10	29	1	3
Hand pulling (uprooting)	7	22	-	-
Cutting and pouring used car oil on it	2	6	1	3
Cutting and putting dung on it	-	-	1	3
Total	34	99	16	48

Source; sample survey 2013

(Table 16) shows the perception of pastoralists on the effectiveness of the measures they have taken to control *prosopis*. The majority of the respondents, i.e. 46% in the high infestation area and 24% in the medium infestation area believed that although the measures taken were good for the time being, they were not effective techniques as *prosopis* trees grow again.

Table 16 Effectiveness of past efforts to control *prosopis* in Dubti district

Effectiveness	High infestation area		Medium infestation area	
	N	%	n	n
It was not successful (temporarily good but tillers again)	16	46	8	24
It was successful (didn't grow again)	2	6	2	6

4.3.5 Problems encountered in prevention, control and awareness creation programs

One of the problems encountered to clear plots encroached by *prosopis* is shortage of labor force as the youth has to look after the livestock. Quite often it is the older generation and the under ages who remain in the homesteads and these people are not physically strong enough to take the responsibility of clearing up land covered by *prosopis*.

4.3.6 Weaknesses of past efforts

- Lack of coordination among different stakeholders: Many organizations were involved in the campaign but there was poor communication among them.
- The number of vehicles that would serve to transport the campaigners was not enough.
- There was shortage of tools and "used car oil".

4.4 Suggested Control Strategies

- **Formation of association of charcoal makers*:*** Charcoal making could be one of the options to control *prosopis*. The Afar people do not have the culture of making charcoal and it is considered locally as "Newir", which means against the norm of the society. It is usually the highlanders who make charcoal in the Afar National Regional State. However, past experiences indicate that charcoal makers who normally come from the highlands of the country cut not only *prosopis* but also other trees that are meant to be conserved. Hence a control mechanism has to be designed so as to make sure that charcoal makers make charcoal only from prosopis. Formation of an association of charcoal makers that has the permission to make charcoal is one of the suggested options to control *prosopis*. Nevertheless, such an association is a viable option only if the association has members both from the Afar Nationality and the highlanders. Because, among the Afar people cutting trees (other than

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prosopis) is a taboo and anyone who has cut a tree would pay its debt to the society by slaughtering an ox or a cow of his own. The Afar members of the association would overview the activities of the association. The National Regional State should allocate prosopis infested lands to the associations so that the activities of the association would not be haphazard and unplanned.

- ***Contractual labor:*** Another approach is to hire labor for clearing *prosopis* infested lands on contractual basis.
- ***Appropriate time of campaign:*** A successful campaign is one which gives due consideration to the seasonal change in labor force availability. The campaign has to be planned in consultation with the local community. The period between July and September is the most appropriate time. Because, the youth which are responsible for looking after the livestock will be in the area during this period.
- ***Sustainability:*** Controlling *prosopis* is not a onetime agenda for various reasons. Millions of seeds of *prosopis* are believed to be found in the soil and these seeds would grow any time they get rain. Hence control strategies have to be designed on a long term basis.

- ***Participation:*** For a successful accomplishment of control programs, active participation of different stakeholders is essential. This includes District Administrator, other governmental and nongovernmental organizations, tribal leaders, and pastoral community.
- ***Awareness creation:*** The media can play an important role in a control program. The problem has to be given due emphasis by Regional and Federal Governments as it is a disaster to the region in particular and to the country as a whole. Radio broadcasts in different languages, TV programs and Newspapers have to create awareness among the people on the potential threats that arise from *prosopis* and the possible mitigation measures.

Tribal leaders strongly believe that the government should consider this problem as one of the most critical problems of the country such as famine and HIV/AIDS. Moreover tribal leaders are willing to mobilize local community to support any effort geared towards controlling *prosopis*.

1.1 Coordination Mechanisms Among Stakeholders

Even though there are several stakeholders involved in the management of IAS in the selected pilot sites, there was no as such a strengthened platform that brings all of them together. However, during the control of IAS, especially at the time of campaigns, several stakeholders come together. For

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instance, urban residents, rural farmers, research centres, District Office of Agriculture staff and the whole society came together and participated in campaigns to clear *prosopis juliflora*. The pastoralists, research centre and Office of Agriculture staff have participated in the campaign organized to clear *prosopis.* In all these cases, the coordination mechanism was informal and it was a onetime event for specific purpose.

There is also a formal forum known as Research Extension Farmer Advisory Council that mainly links farmers, researchers and extension personnel. The purpose of this forum is to plan research activities based on the priority needs of the farmers and other clients. There are also workshops that are organized to evaluate research findings and introduce agricultural technologies to wide audience. In these workshops, several stakeholders from different governmental and non-governmental organizations are invited to participate and share experiences. Such kinds of forum provide an opportunity to share experiences, introduce new research findings to large audience and disseminate information on research outputs. In general, there is no as such a formal and strengthened coordination mechanism among the stakeholders. The existing coordination system depends on the interests of the stakeholders and there are no mechanisms to maintain commitments. For instance, unstable financial sources are among the priority problems that places coordination mechanisms among stakeholders at stake.

To strengthen existing coordination mechanisms and maintain sustainability, the stakeholders need to share costs and other responsibilities. There is also a strong need to address the interests and priorities of the stakeholders. It is also important to establish formal linkage mechanisms to acknowledge the contributions offered by the stakeholders. New coordination mechanisms among the stakeholders could also be established based on their common interests, needs and priorities. This helps improve problem identification, prioritisation and solving mechanisms in a more integrated and sustainable ways. It also strengthens participatory research, extension and development efforts taking into consideration the interests and priorities of the stakeholders. Participatory research approach that involves the participation of key and relevant stakeholders helps strengthen participatory technology generation, dissemination, utilization and evaluation mechanisms. Therefore, strengthened, need based and sustainable coordination mechanisms among stakeholders is one of the basic requirements for addressing key problems related to invasive alien species, and recover and maintain biodiversity.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Invasive alien species can have a significant impact on development, affecting sustainability of livelihoods, food security and essential ecosystem services and processes. The result of the study indicate that a large proportion of the individuals perceived that prosopis was introduced into their locality by Awash river flooding (42.6%), and through livestock dung (24.5%), In addition to this, it was disclosed that P. juliflora has both advantages and disadvantages. The local people benefited from the plant in charcoal making, firewood collection and construction material. The plant has also been used as shade tree around the village. As sampled households described if properly managed it shows positive implication on the soil amelioration, micro-climate.

Invasive alien plant species, *P. juliflora* has become a great threat to biodiversity and challenge for the livelihood of the local communities in the study area. The species has invaded shrub land, open bush land, Acacia woodland, cultivated land, bare land, range land and water points respectively and has become a threat to the biodiversity in the area. Invasive Alien species are causing considerable threat to biodiversity and food security in Ethiopia. According to local people *Prosopis juliflora* has endangered several plant and animal species in the high and medium infestation areas. These include 10 tree species, 15 endangered grass species and medium sized plant species (shrubs) with its local use and 9 wild animals endangered or reduce in the area .

This study has tried to assess ecological socio-economic impacts of *Prosopis juliflora* in Dubti district. It also evaluates existing activities in prosopis management by different stakeholders and coordination mechanisms among these stakeholders. Possible conflicts of interest in management of *prosopis* and suggested possible solutions have also been suggested. The information generated in this study will provide basis for comparison with the situation after the full project intervention.

Prosopis juliflora is believed to be introduced to Dubti district in late 1980's. Agents facilitating dissemination of *prosopis* in the area are dung, flood and wind. *Prosopis juliflora* has endangered several plant species in the high and medium infestation areas. These include 10 tree species, 15Endangered grass species and medium sized plant species (shrubs) with its local use and 9 wild animals endangered or reduce in the area. These plant species are, however, still existent in the study site that is not yet infested. Other socio-economic impacts of *Prosopis juliflora* include its negative effect on livestock production because it encroaches grazing land. Over and above its thorns are harmful for human beings and livestock population. Even though the majority of the sampled

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households use *P. juliflora* as a source of fuel wood for sale or home consumption, they perceive it as undesirable species that has to be eradicated.

These are decisive factors to control *P.juliflora*, therefore, any future management intervention must ensure the above mentioned factors consideration. If no management intervention is taken in good time, *P. juliflora* has the potential to wipe out pastoralism in the near future. *Prosopis juliflora* is an invasive weed whose control/management is controversial as there is conflict of interest among different groups of the community. Control programs should be designed in such a way that conflict among stakeholders will be resolved. This ensures sustainability and success of the control program.

A high percentage of household head in the study area are illiterate indicating that distribution of written materials to popularize management techniques cannot be a reliable strategy. Other means such as radio programs, field days and training opportunities have to be made available.

5.2 RECOMMENDATIONS

In light of the finding of this study, the following recommendations are made;

- Applying the existing knowledge with high commitment, active participation of different stakeholders, and management techniques have to be designed on a long-term basis;
- Way of privatizing land and expansion of farms in most irrigable site of the district needs to be explored as way of controlling *P. juliflora;*
- Emphasis should be given for thinning with digging out the root system followed by pruning to encourage silvopastoral system of agro forestry through improving tree and under storey yield;
- As the invasion is increasing significantly it couldn't be managed by local community, cooperatives or other stakeholders alone. There is a need to motivate private companies to engage on *P. juliflora* management by providing relevant information from the regional and federal government;
- Information on distribution of *P. juliflora* is essential for planning. Therefore, using high resolution remote sensed data needs to be developed and applied for all areas of the region invaded by *P. juliflora;*
- Further research should be conducted on climber plant which could suppress the growth of *P. juliflora;*

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APPENDICES

Annex I

Pastoralists and Agro-Pastoralists Survey Questionnaire

The Questionnaire is designed to assess the impact of *P. juliflora* on the livelihood of pastoralists in Dubti Wereda.

I. General Information about the Respondents

Name_____ Age_____ sex_____ Region _____ Zone_____
Woreda_____ Village _____ Date of interview_____
Occupation(main income)_____ For how long did you live in this area (locality)? (Year)_____

II. Ecological and Socioeconomic Information of *P. juliflora*

Distribution and economic importance

1. When did you know this plant (year)?
   a. Less than 10 years b. 11-20 years c. More than 20 years
2. Where did first it appear?
   a).In rangeland b). On the bank of river c). Irrigated farms d).other (specify) _____
   _____
   _____
3. Who introduced in this area first?
   a). Mechanized farmers b). By Awash River
   c). Government office d). NGOs e).other (specify)_____
   _____
4. Which disadvantage/negative effects does it have for livestock? (Multiple answers possible)
   a) animals get injured (e.g. by thorns) f) it's poisoning/toxic for animals
   b) animals die from eating g) don't know
   c) animals get diarrhoea
   d) animals get paralysed
   e) Others (please specify):_____
5. How the plant disseminated from one area to the other?
   a). through cattle or animals b). through human activities c). through water run off
   d). through wild animals e). others (specify)
6. What type of impacts does *P. juliflora* cause in agriculture in general?
   a) decrease productivity b) decrease grazing lands c) hampers farming d) injure & kill animals e) decrease plant diversity f) other (specify)
7. Does *P. juliflora* have ecological importance? 1. Yes ----(go to question No. 16) 2.No
8. What is its ecological importance?
   a). control soil erosion b). combat desertification c). use as shade tree
   d). used as wind break e). other (specify)
9. What do you use it for? (Multiple answers possible)
   a) fence/shelterbelts e) windbreak i) Others_____
   b) livestock fodder f) bricks j) I do not use it
   c) fuel wood g) building construction
   d) charcoal production h) shade
10. Have you ever been made charcoal from *P. juliflora*? 1. Yes 2.No
11. How many backload do you collect per week?
12. Did you sell it or use for home? 1. Yes 2.No

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13. If you sold it, how much is one back load of P. juliflora wood costs?
14. How many sacks of charcoal do you produced per month? How much you sold it?
15. Have you ever been collected *P. juliflora* pod? Why?
16. How many Kg of *P. juliflora pod* did you collect per month?
17. How much you sold a Kg of *P. juliflora* pod?
18. Does *P. juliflora* have disadvantages? 1. Yes 2.No
19. What are its disadvantages? a). Invade new areas b). Prevent movement of animals
    c). Poisoning animals d). Formation of impenetrable thicket e). Other (specify)
20. What are these negative effects on animals?
    a) Killing the animal b) Poison animals c) Injuring animals d) Other (specify)
21. Which animals mostly affected by the plant?
    a). Cattle b). Goats/sheep c). Camels d). Wild animals e). Others (specify)
22. Which disadvantage/negative effects does it have for the grassland? (Multiple answers possible)
    a) it takes water away c) it take sun light away b) it takes nutrients away d) nothing else grows next to it e) grass does not grow f) don't know g) Other (please specify):_____
23. Have you ever been made your farm cleared from *P. juliflora* by others? a). Yes b).No
24. How much you paid for a hectare of land? _____
25. Have you ever tried to control invasion of *P. juliflora?* a). Yes --(go to question No.26) b). No
26. Which mechanisms you used?
    a). Removing by hand b).fire c). Using bulldozers d). Using chemicals
    e). Biological method f). Collecting pods and charcoal making g).Others (specify)
27. Do you want the plant to be completely removed? 1. Yes 2. No
28. What is your perception about the plant?
    a) It is disadvantageous b). It is economical and useful
    c) It is neither disadvantageous nor economical d) Other (specify)
29. Was the spread of *P. juliflora* increasing from time to time? 1. Yes 2. No

30. If the invasions of the plant continue at this rate, what will happen in the next 10 years?
    a) All the crop lands and range lands will be invaded by the plant
    c) We lost all our

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animals

d). We displaced totally from our village

e) We will get chance for firewood/charcoal

g) We will be better off than today

h) Other (specify)

31. Do you have anything to add that is important to you?

No_____ Yes, (specify)_____

Annex II

Regional / Woreda Administration/ Pastoral and Agricultural office Management Team/ survey Questionnaire

Region----------Zone_____Woreda/District_____

Date of interview_____ Occupation of the respondents_____

1. When did you notice *Prosopis* first? In the Region/ Wereda_____
2. How did *Prosopis* come to your Region/ Wereda? _____
3. How would you describe the abundance of *Prosopis* in your Region/ Wereda?
   1. High 2. Medium 3. Low
4. Would you describe the area coverage of *Prosopis* in your Region/ Wereda in hectare?

   _____
5. How do you describe the status of dispersal of *Prosopis* in your Region/ Wereda since the time of its introduction?
   1. It is increasing 2. It is decreasing 3. No difference 4 No noticed at all
6. If it is increasing, how do you describe its dispersal rate?
   1. Very fast 2. Very slow 3. Not noticed at all
7. If it is decreasing, describe the reasons.
   1. B/c of manual and mechanical control measures applied by the Region/ Wereda
   2. B/c of chemical control measures applied by the Region/ Wereda
   3. Others (explain)
8. . List the advantages and disadvantages of *P. juliflora.*

   a).Advantage----------

   b).Disadvantage----------

   _____
9. Dose *Prosopis* generate income to the Region/ Wereda? If yes, how much per month? (it could be in terms of tax)_____
10. Have you ever addressed the problem of *Prosopis* in any top level management meetings of your Organization? Yes/No.
11. Are you taking any steps to control or promote *Prosopis*? If 'yes' state the mechanisms and from whom you got it.

Mechanism	**Learned from**	**Effectiveness of the mechanisms**
1. _____	_____	_____
2. _____	_____	_____
3. _____	_____	_____

12. Have you ever attempted to prevent or control *Prosopis* privately or in collaboration with others?
    1. Yes 2. No
13. If there were any attempts made, what kind of attempts were they? _____

    _____

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14. What were the outcomes? _____

_____

15. If the attempts failed, what was the reason behind? _____

_____

16. Have any other individuals or organizations ever attempted to prevent/control *Prosopis* ?

1. Yes 2. No

17. If yes, mention the names of the individuals or organizations and their attempts?

	Name	**Types of control**	**Effectiveness**
1.	----------	----------	----------
2.	----------	----------	----------
3.	----------	----------	----------

18. Could you say that the individuals or organizations attempts were effective?

1. Yes 2. No

19. What would you say to eradicate *Prosopis*? _____

_____

20. Do you observe any pastoralist ethnic group/clan resource use conflict arises due to the invasion of the species?

A. Yes B. No

21. What measures should be taken so as to control the spread of *P. juliflora* by the society?
22. 1. Creating awareness 2. Formulating traditional laws 3. Utilize the plant properly and effectively 4. Other (list)
23. Is there awareness creation program in on the management of *p.juliflora* in for expert/ pastoralists'? If yes how often _____
24. Is the community is willing to participate in the management of *p. juliflora*

A. high B. Medium C. Low

25. What will happen in the Woreda in the next 5-10 years if no controlling measures on the plant take place?

a) The society will displaced from their village b) pastoralists will change their livelihood c) income of the society will increase d) the Woreda will totally invaded by this plant e) others (please specify)

26. Indicate your Region/ Wereda total financial expense in the management of *p.juliflora*

Expenses for controlling/ preventing *Prosopis*	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total expenses of the organization by prosopis										
Total income of the organization by prosopis										

27. Do you have anything to add that is important to you?

No_____yes, (specify)_____

_____

Annex III

INDIRA GANDHI NATIONAL OPEN UNIVERISITY
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THESIS RESEARCH PROPOSAL

on

SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF *PROSOPIS JULIFLORA* IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE, ETHIOPIA

BY

WONDIMAGEGNEHU SHIBRU LEMMA

September , 2013
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INDIRA GANDHI NATIONAL OPEN UNIVERISITY
SCHOOL OF CONTINUING EDUCATION

SOCIO-ECONOMIC AND ECOLOGICAL IMPACT OF *PROSOPIS JULIFLORA* IN LOWER AWASH, AFAR NATIONAL REGIONAL STATE, ETHIOPIA

A PROPOSAL SUBMITTED TO INDIRA GANDHI NATIONAL OPEN UNIVERISITY /IGNOU/ IN PARTIAL FULFILAMENT OF THE REQUIREMENT FOR MASTER OF ARTS IN RURAL DEVELOPMENT (MARD)

BY

WONDIMAGEGNEHU SHIBRU

ENROLMENT NO:- 099100873

September, 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

APARD	Afar Pastoral and Agriculture Bureau
EARO	Ethiopian Agricultural Research Organization
GEF	Global Environment Facility
IAS	Invasive Alien Species
IBC	Institute of Biodiversity Conservation
HDRA	Henry Doubleday Research Association (HDRA),
SPSS	Statistical Package for social Science

INDIRA GANDHI NATIONAL OPEN UNIVERISITY
MASTER OF ARTS IN RURAL DEVELOPMENT (MARD)

Signature _____

Name _____

Address of Guide _____

Name and address of student _____

Telephone number _____

Email _____

Address _____

Enrolment No :- _____

Date of submission _____

Name of study centre :- _____

Name of the Guide _____

Title of project : _____

_____

_____\

Signature of Student _____

Approved /Not Approved:- _____

Date of Approval;- _____

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1. INTRODUCTION

1.1 *Background*

The spread of invasive alien species (IAS) is now recognized as one of the greatest threats to the ecological and economic well - being of the planet. IAS are causing enormous damage to biodiversity and on agricultural system we depend on. These alien species outcompete, infect or transmit diseases, compete, hybridize with the native ones or attack them (Wittenberg and Cock , 2001). With increasing trade and globalization, movement of people and goods also increased, this facilitated the spread of IAS.

Avery good example of such exotic species which have been introduced in most tropical and sub-tropical countries including Ethiopia is *P. juliflora.* The plant has been cultivated for shade, timber, forage, food, and firewood (Pasiecznik *et al.*, 2001). However, contrary to its purpose of introduction, the plant escaped out of control and has invading farm lands, pasture lands, rangelands, irrigation schemes and causes for many land use/ land cover changes.

In the past, action to prevent and mitigate the effects of invasive alien species has been largely focused in the developed countries. However, in developing countries, invasive alien species cause similar or worse problems, for development as well as conservation of biodiversity (GISP, 2004). Ethiopia is one of the developing countries affected by IAS and for two decades, Invasive Alien Species (IAS) have been clearly identified as one of the emerging problems facing the country (EARO, 2005).

Prosopis juliflora, being a drought tolerant plant, primarily threatens the Desert and Semi-desert scrubland, and Acacia-Comiphora woodland ecosystems of Ethiopia (Institute of Biodiversity Conservation (IBC), 2005). These ecosystems account a large proportion of the total land mass of the country and host several national parks. They embrace nationally and internationally valuable natural heritages and are, particularly, home for pastoralists and agro-pastoralists whose life is dependent on the services of these ecosystems (Berhanu & Tesfaye, 2006; IBC, 2005).

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prosopis juliflora is a highly drought tolerant, fast growing and has outstanding coppicing power which gave it competitive advantages over native species of the invaded regions. This fact coupled with the already lost natural immunity of the region due to severe environmental degradation in the past highly hastened the rate of invasion and aggravated the problem posed by the species (Berhanu & Tesfaye, 2006; IBC, 2005; Shiferaw *et al*., 2004). A vast area of land is now invaded and the impact of the species on biodiversity is expected to exacerbate in the future (Ryan, 2011).

P. juliflora has been identified by the Environmental Policy and the National Biodiversity Strategy and Action Plan as a major threat to biodiversity of the country and economic well being of its people. However, little attempt has been made in terms of research and management of IAS. Their high seed production capacity and spread, adaptation to wide climatic and soil conditions, spread by animal movement and their association with pastoralists way of life and overgrazing are challenges to their management in Ethiopia (Taye, 2009) .

There is little knowledge and experience on how to manage and utilize these plants, and there have been few policies or strategies in place for quick action this helped *P. juliflora* to become an invader. This paper presents the literature on the distribution merit and demerit of *Prosopis juliflora* with special focus on the Afar pastoral situation. Evaluating control baseline conditions and pilot survey of biological and socio-economic impact assessment in selected sites of Ethiopia is of paramount importance for designing appropriate control and prevention strategies of invasive species. Hence, a study will be conducted in selected sites to evaluate control baseline condition and to assess socio-economic and biological impacts of *Prosopis juliflora*.

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1.2 *Statement of the Problem*

The combined effects of human activities and natural factors such as climatic changes lead to the depletion of natural vegetation and drastic decline in dry land productivity (Haysom and Murphy, 2003). Invasion of rangelands caused shortage of grazing land for livestock, which resulted in drastic reduction of livestock number as well as product. Thorns damage eyes and hooves of camels, donkeys, and cattle then by poisoning eventually lead to death. P. juliflora is invading potential croplands forcing local farmers with less capital and machinery to abandon their farmland and settlement. In general, this is a matter of serious concern for the life of the local people as pastoralists depending on livestock for their livelihood (Senayit *et al*., 2004).

The rapid spread of the plant also presents a number of social, ecological and economic concerns. Its vigor and competitiveness makes it a formidable invader of different land use systems, particularly along rivers, lakes, swamps, farmlands, grazing lands and ponds, causing devastation of these important habitats and ecosystems through intensive and aggressive colonization. Moreover, it also reduces the effectiveness of developmental investments by choking irrigation canals, fouling industrial pipelines, and threatening hydroelectric schemes (International weed science society, 2005). Exotic species, therefore, contribute to social instability and economic hardship, placing constraints on sustainable development, economic growth, poverty alleviation and food security.

This paper, therefore, intends to assess the socio-economic and ecological impacts of *P. juliflora* in Dubti District, Afar National Regional State. Such knowledge helps to have better understanding about the extent of the distribution of the plant and the rate of expansion and the positive and negative impacts of the plant in the study area. Moreover, the study suggests effective controlling mechanisms to curb some of the negative impacts caused by the species.

1.3 *Objective of the Study*

General Objective

The overall objective of this study is to assess the socio-ecologic and ecological impact of *prosopis juliflora* on the livelihood of Dubti District pastoralist in Lower Awash Basin.

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Specific objectives

The study has the following specific objectives:

- To assess the existing activities in *Prosopis juliflora* management by different stakeholders in the selected pilot sites and also examines the coordination mechanisms among these stakeholders.
- To examine the possible conflicts of interest in the management of *Prosopis juliflora* and suggest feasible solutions to address the problems.
- To recommend appropriate management options to control the species

1.4 *Significance of the Study*

Areas invaded by invasive species and areas at risk from further invasion need to be identified and mapped. Alternative uses of the invaded lands and restoration plans need to be developed based on the potential of those lands in specific locations. Local people in the invaded areas should be well advised and supported to carry out sustainable management of the cleared lands to prevent re-invasion. Alternative control methods such as biological methods or combinations of biological and mechanical methods, as well as different utilization options should be researched, and demonstrated to government partners and local people to prevent further invasion of new areas and to restore invaded areas in ways that benefit local communities (Dubale, 2006).

The findings of this study would therefore, expected to spark valuable information to researchers, policy makers and development institutions working in the area besides serving as input in designing and developing effective development interventions that will complement with local prosopis management. Moreover, the would be recommendation believe to serve as valuable ingredients to other similar areas having identical scenario.

2. REVIEW OF LITRATURE

2. Socio-Economic Importance of *Prosopis juliflora*

2.1 *Overview of* P. juliflora

P. juliflora is a multipurpose dry land tree or shrub native to South America, Central America and the Caribbean (Pasiecznik, et al., 2001). It has been introduced and naturalized in many parts of the world (Africa, Asia, and Australia) during the last 100-150 years (Pasiecznik, *et al*., 2001). However, despite its qualities and uses in its natural range, prosopis becomes a serious invading weed when introduced into non-native areas without proper management (Shiferaw, et al., 2004).

Avery good example of such exotic species which have been introduced in most tropical and sub-tropical countries including Ethiopia is *P. juliflora*. The plant has been cultivated for shade, timber, forage, food, and firewood (Pasiecznik *et al*., 2001 and Rezene Fessehaie, 2006). However, contrary to its purpose of introduction, the plant escaped out of control and has invading farm lands, pasture lands, rang lands, irrigation schemes (Rezene Fessehaie, 2006) and causes for many land use/ land cover changes.

As a result the plant rapidly invaded vast areas of agro- and silvo-pastoral lands, affecting both the biodiversity and socio-economic environment. Forest invasive species can negatively affect forest ecosystem or damage specific forest products. *P.juliflora*, like any invasive species, is invasive only under conditions that are favorable to their spread (Geezing *et al*., 2004).

The success of *P. juliflora* is largely attributed to the high number of seeds produced and their efficient dispersal mechanisms (Shiferaw, *et al*., 2004). In addition, its fast growing ability, dormant seeds, attractive and rewarding pods, seeds maintaining viability in the droppings of livestock and wild animals, resistance to browsing, incredible ability of re-sprouting and fast coppice growth (Shiferaw, *et al*., 2004), and high water use efficiency (Felker *et al.*, 1983) contribute to its invasion. Now *P. juliflora* has become the national number one invasive species in Ethiopia (EARO and HDRA, 2005).

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According to Abdillahi *et al*., 2005 unrestricted spread of *P. juliflora* will result in several risks and environmental impacts. These risks and impacts can be:

- Loss of native plants through competition as well as occupation of their natural environment and habitats Reduction of available nutrition of livestock and destruction of rangelands, thus resulting in adverse impact on a large segment of citizens depending on cattle breeding as a source of living.
- Ground water depletion as the plant have well developed roots and can absorb water from very deep up to 15 meters and sometimes reaching ground water layers which constitute the main source of water resources.
- Caused problems to breeders, because consumption of leaves by camels lead to their sickness, causes flatulence, diarrhea and sometimes constipation as well as eating their solid seed pods may result in falling out cattle teeth and reduction of their ability to graze (Shetie, 2008). Studies on *P. juliflora* tree in India revealed that their spread resulted in destruction of many endangered herbaceous mammals such as the grey hare and desert fox. Their thick thorns prevent mature birds from maneuvering and hunting prey. Moreover, in Ethiopia the thorn is damaging animal hooves and vehicle tyres (Abiyot, *et al*.,2006). The thorn of *P. juliflora*, on penetrating the eye cause more inflammation than expected from physical injury.

2.2 P. juliflora *in Ethiopia and Afar Regional State*

The introduced species to Ethiopia was *P. juliflora*, which belongs to the family *Fabaceae*. The plant is predominantly xerophilous spiny and sometimes unarmed evergreen tree with height of 3-15 meters depending on genetic difference and other environmental factors, but under favourable environmental conditions some individuals may reach 3 up to 20m. *P. juliflora* landraces often have multi-stemmed, coppiced and prostate shrub forms with long branches and a crown that even touches the ground and have erect, flat topped and decumbent tree forms. *P. juliflora* produces coppices except those stumped at 10 cm below the ground (Hailu, et al,.2004). According to S. Demissew,2010 *P. juliflora* in Ethiopia it is Called '*Weyane/Dergi-Hara*' (Afar), '*Biscuit*' (Dire-dawa), elsewhere; mesquite, *algarrobo*, Prosopis.

In Ethiopia, *P. juliflora* has covered an area of one million hectares (ABoARD, 2009). It has now been expanded to the south-eastern and south-western parts of the country reducing the farm land, choking out local plant species and drastically reducing the grazing land and now considered as the national number one invasive plant (EARO and HDRA, 2005).

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The tree was found to have both positive and negative effects on the livelihood of the invaded community and the environment.

Although there is no precise written document why, when, where, and who introduce *P. juliflora* to Ethiopia, the local people of Amibara district of the Afar National Regional State, stated that *P. juliflora* was introduced by an English person from Sudan in 1970s through the Middle Awash Irrigation Project (Rezene Fessehaie, 2006; Hailu Shiferaw et al., 2004) and was planted over a large area of the Middle Awash rift valley by local people in 1980 as wind break, shade and shelter around their village.

The Amibara Woreda of the Afar National Regional State is thought to be the putative starting point of the spread of *P. juliflora* in Ethiopia. It represents degraded semi-arid ecosystem. Since 1980s the plant has spread rapidly in eastern Ethiopia, from the Middle Awash Valley in to the Upper Awash Valley and Eastern Hararghe and some localities of Raya Azebo plains of South Tigray. The invasion has also reported in the town of Arba Minch and neighboring localities in South region of the country (Rezene Fessehaie, 2006).

In the Afar region of Ethiopia, where *P. juliflora* is having dramatic impacts across the landscape, its spread and impacts on resources has been ranked as one of the leading threats to traditional land use, exceeded only by drought and conflict (EPP, 2006). Nationally, *P. juliflora* has been ranked as the most problematic plant invader in Ethiopia (Tessema, 2007).

According to local communities, the prosopis invasion has resulted in multiple negative effects on their food security, livelihoods and the region's environment (Dubale, 2006). The invasion of prosopis has caused considerable declines in livestock production and productivity due to the loss of dry season grazing areas to prosopis plants. Palatable indigenous trees and pasture species such as *Chrysopogon plumulosus*, *Cenchrus ciliaris* and *Setaria acromelaena* have all reduced. Indigenous such as *Acacia tortilis*, *Acacia senegal* and *Acacia nilotica* have also declined in the rangelands due to the invasion. Pods and branches of these trees are the main dry season feed sources for livestock. Zelalem (2007) reported that camel ownership has reduced almost by one-third over the last five years alone while the mean number of calves and heifers was reduced by fivefold. He also noted a higher rate of decrease in numbers of sheep and goats compared to camels, perhaps due to the relative advantage of camel to browse tall woody plants.

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The cost of land clearance became a common problem encountered in all farming areas affected by the invasion of the plant. Agro-pastoralists in Gewane and Amibara districts spent large amounts of money to clear the invasive plants from lands for cultivation (up to US$100/hectare/year) (Geesing, 2004). Moreover, malaria cases increased since invasion of *P. juliflora*. This may be as a result of the moist microclimate in invaded areas provided a favourable environment for mosquito's multiplication. This observation was similar to reports from Kenya also experiencing the invasion of Prosopis (Mwangi, 2005).

With the reduction of grazing and cultivable land, joined with recurrent droughts, people in the Afar region became highly food insecure and dependent on government food aid for their survival. In highly occupied areas people are now vulnerable to food aid on average for 5-6 months in good years and for up to 10 months in drought times (Getachew, G. 2008). Due to these impacts to local productivity, the majority of the pastoralists were forced to diversify their livelihoods to include crop farming, daily labour, charcoal production and trade or combinations of these.

2.2 Merit and Demerit of prosopis juliflora

2.2.1 Merit of prosopis

As to the positive effects, *P. juliflora* is a multipurpose tree/shrub whose wood is used for firewood, charcoal, posts, poles, and a sawn timber; its pods can be used as a livestock feed and for making human foods; and environmental services provided by nitrogen fixation, shade, shelter, live and dead fencing, erosion control, soil improvement and reclamation are remarkable. Secondary products from this tree includes honey (as a bee forage), edible exudate gums, fibres, tannins, foliage for fodder, mulch, biopesticides and medicines, and other uses for wood and pods such as particle board, wood chips for energy generation, pods for ethanol production, galactomannan gums from the seeds and other specialist products (Pasiecznik, 1999; Pasiecznik et al., 2001; Hailu, 2002).

2.2.1.1 Overall Socio-Economic Benefits

P.juliflora provides valuable resources to local communities in the form of fuel wood, timber, fodder for livestock such as goats, sheep, and cattle. It can be used as shade in hot climates, as wind breaks or for the stabilization of sand dunes that threaten to encroach into inhabited land areas. Moreover, *P.juliflora* is extremely tolerant towards a wide range of climatic, soil

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physical and chemical factors. As a result of those attributes, *P.juliflora* is widely regarded as a useful resource for rural communities which are facing increased natural resources shortages due to population pressure, drought and other climate hazards, as well as armed conflict (Shiferaw 2004; Pasiecznik et al., 2001).

On the other hand, *P.juliflora* has a potential for positive ecological impact. Prosopis trees could reduce soil loss due to water and wind erosion. It is also proved to be effective in improving soil fertility and is useful for reclaiming moderately saline soils and degraded lands. These properties of the tree have made the species suitable instrument to fight desertification in dry regions. These benefits of the species are behind the introduction of the species in Ethiopia and the species has positively contributed in this respect (Berhanu & Tesfaye, 2006; Jama & Zeila, 2005). It is also suggested that Prosopis could be considered a potential tree for sequestering carbon dioxide and may be instrumental in the mitigation of climate change (Jama & Zeila, 2005; Yemane, 2007).

2.2.1.2 Energy Source

Particular consideration (measured by the many reports of research trials) is given to the ability of Prosopis as a source for fuel wood of high quality. Due to its high biomass production, high wood density and low ash and moisture content, the species is broadly regarded as an excellent energy source - including the production of charcoal - and usually outperforms other native and alien tree legumes. Rural communities have to meet their energy needs. In some countries, up to 86% of this comes from cut wood. This has led to serious defforestation and desertification in many parts of the hot dryland regions (GARG 1999), and leads increasingly to resource-based conflict. The continous spread of Prosopis provides rural communities with a rare opportunity: Unrestricted access to fuel wood.

2.2.1.3 Source of Wood

P. juliflora plays important role in human life in many arid and semi-arid regions of the tropic and subtropics of the world. The wood is probably the most important product of *P. juliflora* species used either as a fuel wood or structural material (Mwangi and Swallow, 2005). As a fuel it can be burned directly or made in to charcoal, and as a timber it can be used as poles or made into furniture. The wood does not spit, spark, or emit much smoke and burn slowly with hot and even heat with specific gravity 0.70 or higher. Thus, it is called wooden anthracite

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(Pasiecznik et al., 2001). Moreover, the durability, strength, less shrinkage; less cracking and hardness make the wood of *P. juliflora* more useful for many purposes (Pasiecznik *et al.*, 2001; Victor *et al.*, 2007).

2.2.1.4 Soil Fertility

Another area that has attracted great interest is the potential ability of Prosopis to regenerate sodic wastelands, due to its high survival rate and relatively good tolerance towards soil salinity, low pH and water logging. This would increase the productivity of these degraded lands (GARG, 1999). There was also considerable improvement in soil texture and soil organic matter under the tree canopy, with soils under the canopy having higher total nitrogen and available phosphorus, and lower soil pH than soils in the adjacent open field (El Fadl, 1997).

2.2.1.5 Animal Feed

Focus has also been given to the research of *P.juliflora* as a browse for livestock and a processed fodder resource. Pastoralists, the poor and those living in hot arid desert zones are believed to benefit the most, particularly during the dry season when feed resources are becoming scarce. In particular, the high protein content of the pods has been referred to. The leaves, which are only relatively palatable, are still a potentially valuable browse when everything has dried out. These are also of importance to animal production. Many researchers feel that it is foremost the rural poor or landless that profit from Prosopis, as it provides “income safety nets for the survival” (Shiferaw 2004; Pasiecznik et al., 2001)

1.1.2 Demerit of prosopis

The negative effects include reduced crop fields and grazing areas, invasion into wetlands that reduces their value for watering and dry season grazing, invasion into the lakeshore areas making fishing more difficult, consumption of seed pods that damage teeth of goats; sharp, strong and poisonous thorns that cause wounds to livestock and human beings. Increased disease incidence associated with microclimate change due to invasion and reduced utilities from indigenous herbs, trees and wild animals were also cited as the negative effect of the tree. Besides, the invasion blocked paths to water points, grazing areas and between villages and served as shelter for predators (Shakeleton et al., 2006; Easther and Brent, 2008; Zeila, 2008).

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- **Treat for pastoralism and agro pastoralism**

The ecological impact of Prosopis has been translated into social, economic and political dimensions in the country. The most important socio-economic impact of Prosopis is associated with its replacement of pasture lands and native trees of browsing value, which are the sole sources of feed for the livestock of pastoral communities. Pastoralists are the most affected by the invasion as their livelihood mainly relies on livestock production system. Agro-pastoralists of the invaded region are also one of the most affected by the invasion having their farm and pasture lands replaced by Prosopis. In extreme cases, these people have been compelled from their farm lands as a direct consequence of Prosopis invasion (Dubale, 2008; Giessen, 2011; PFE, IIRR, & DF, 2010; Rangi, 2009; Ryan, 2011).

Over 700,000 hectares of grazing land and cultivable land following the Awash River is currently either invaded or at risk of invasion in the Afar Region (USFS,2006) . This accounts for 15% of the region's productive land (4,670,316 hectares), excluding wetlands, water bodies, sandy and rocky areas (4,856,251 hectares). In the Afar people are predominantly pastoralists that depend on livestock rearing, or agro-pastoralism for their survival. However, the *P. juliflora* invasion, coupled with recurrent droughts that strike the area, has left the people unable to maintain these subsistence livelihoods.

- **Treat to Biodiversity**

Currently, *P. juliflora* poses a threat to indigenous biodiversity where ever it is established in Ethiopia in general, in the Middle Awash area in particular because of its weedy and invasive nature (Mehari 2008). The invasion by *P. juliflora* reduces grass availability and stocking density by livestock. It impacts the plant biodiversity by creating a physical barrier on seedlings of other plant species, preventing sunlight to reach to the under canopy vegetation, lowering the water table and by releasing various chemicals that may have negative effect on the native plant species.

- **Allopathic Effect of *P. juliflora***

Prosopis inhibits the germination or growth of many plant species growing in its vicinity through allelopathic substance(s) exuded from its leaves, roots or fruits (Warrag et al., 2003) . This may be due to slow decomposition and heavy accumulation of leaf litter below

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P. juliflora may possibly result in accumulation of toxic substances in the soil layers, inhibiting growth of other species. The leaves of *P. juliflora* contain various chemicals including tannins, flavinoids, steroids, hydrocarbons, waxes and alkaloids (Pasiecznik et al. 2001). These are known to have effects on the germination and growth of other plant species. As a result of this, the plant diversity (both the number of individual plants of a species and the number of species around *P. juliflora*) will be affected by the allele-chemicals. Low light under *P. juliflora* canopy also make other plant species' survival difficult.

1.2 Policy Challenges in the Management of Prosopis

To combat the serious threats posed by invasive species, it is crucial to devise management strategies and policies. Even though Prosopis has already revealed its multifaceted and critical problems in Ethiopia, there has not been clear policy or strategy towards Prosopis or to invasive species management in general (Fessehaie, 2006). It is, however, recognized as a major threat to biodiversity and economic wellbeing of society by plans such as the Environmental Policy of Ethiopia (EPE) and the Biodiversity Strategy and Action Plan (NBSAP) and Forest Resource Strategy of the country (Berhanu, n.d.; IBC, 2005). In contrary to this plans, however, the National Action Plan of the country recommended Prosopis tree as a potential tree to combat desertification (Anagae et al., 2004) signifying the existing policy dilemma towards Prosopis. This contradiction of policy directions indicates lack of coordinated design of one policy direction based on a comprehensive analysis and understanding of the problem. Such coordinated effort seems difficult in Ethiopia where institutional mandates in the management of invasive species are unclear and fragmented interventions are common.

1.3 Prosopis Control Methods

2.4.1 Mechanical Control

Mechanical control options include the physical felling or uprooting of plants, their removal from the site, often in combination with burning. The equipment used in mechanical control ranges from hand-held instruments (such as saws, slashers and axes) to power-driven tools such as chainsaws and brush cutters, and even to bulldozers in some cases (Matthews and Brand, 2004).

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2.4.2 Chemical Control

Herbicides can be applied to prevent sprouting of cut stumps, or to kill seedlings after felling or burning. Herbicides can target, for example, grasses or broad-leaved species, leaving other plants unharmed. However, there are legitimate concerns over the use of herbicides in terms of potential environmental impacts. Although newer herbicides tend to be less toxic, have shorter residence times, and are more specific, concerns over detrimental environmental impacts still remain. The use of chemical control is often governed by legislation, and the effective and safe use of herbicides requires a relatively high level of training; both of these factors can restrict the use of chemical control on a large scale (van Wilgen et al., 2001).

2.4.3 Biological Control

Biological control has been defined as the use of living organisms to control pest species. Biological control, instead of eliminating the target organism, aims at establishing an equilibrium which maintains its population at a level of negligible harm (Bani 2002).

2.4.4 "Eradication by Utilization"

This phrase was first coined by Tessema (2012) to explain the economic exploitation of invasive species as a means of harnessing their economic potentials for meeting basic human needs and at the same time control its spread and possibly eradicate them. As unpopular as this concept seems, it is already being practised in many African countries and other developing countries, where the rural people, in short of basic amenities, were forced to start exploiting these invasive species, only to find out that these invasive species have somewhat better qualities that their indigenous species.

Exploitation of Prosopis julifora: The case study of Prosopis as an invasive species in many of the developing countries has been widely reported. However, it was discovered that the wood is an excellent fuel, the timber is hard and compares favourably with finest hardwoods such as Teak and Mahogany (Pasiecznik et al. 2001). The sweet nutritious pods are relished by all livestocks and are made into different foods and drinks. Honey

from the flowers is of high quality, the gum is similar to gum Arabic, barks and roots are rich in tannin, leaves can be used as mulch and the tree is a nitrogen fixer to the soil. The pods are used to make flour for cakes, biscuits and bread, pop syrup, coffee substitutes and animal feed in Ethiopia (Admasu 2008).

3. RESEARCH METHODOLOGY

3.1 Description of the Study Area

The study will be carried out in Dubti district of the Lower Awash Basin. Dubti is one of the 32 districts in the Afar Region and located at a distance of 580 km northeast of Addis Ababa. The district is bordered on the south by the Somali Region, on the southwest by Mille, on the west by Chifra, on the northwest by Administrative Zone 4, on the north by the Administrative Zone 2, on the northeast by Elidar, on the east by Asayita, and on the southeast by Afambo. The average elevation in this district is 300m.a.s.l. Mean minimum and maximum temperatures are 25^0 C and 42^0 C respectively. The area has mean annual rainfall of 200 mm.

3.2 Location

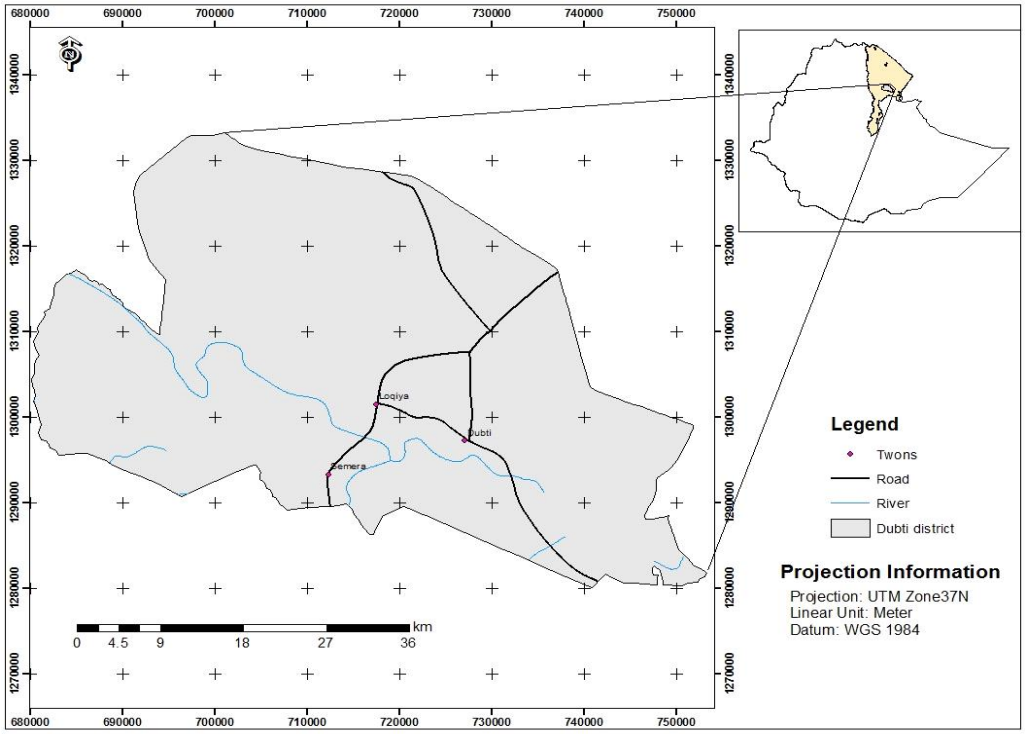

Figure 4 Location of the study area

3.3 Data collection techniques

3.3.1 Sample Size

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Socio economic data will be obtained from randomly select head of households. To collect the required household data will be take consideration the following procedures . After getting the total head house head it will be possible to determine total sample size of the survey . A total of number households are will be select for the questionnaire, based on the established sample frame of the selected Kebeles.

94 households will be selected purposively. *prosopis juliflora* infestation vary from area to area in the district. The first strata will consist of individuals from high prosopis infested area while the second strata will consist of individuals from medium prosopis infested area and the third stratum will be the individuals from non-*prosopis* infested area. Accordingly, the sample size in the high infestation and medium infestation areas were thirty-five and twenty-four individuals will be interviewed from the area that was not yet infested with prosopis. The selected households will encompass different occupation like pastoralist agro pastoralists, casual workers and charcoal maker. The main reason for selecting the households purposively was pastoralists and agro pastoralist who have extensive knowledge of the area and who know the socio economic and ecological impact of *prosopis juliflora* in the area. Apart from this those organizations who are working in prosopis management were interviewed about their means of control and coordination mechanism.

Household Survey: This is a formal survey method where a semi- structured interview scheduled will be employed with closed or open-ended questions for eliciting information from respondents. Prior to conducting the interview, pre-test of the interview will be made. On the base results obtained from the pre-test, necessary modification will be made. Eight trained technical assistants (MOFA Advisors) and the principal researcher will administer a structured interview. The interview will be conducted within the respondent's territory and in interviewing atmosphere where interruption or correction is none.

Focus Group Discussion (FGD): To complement the household survey, basic descriptive information will be collected at the kebele and village level in each survey site. This technique will help to acquire useful and detailed information, which might be difficult to collect through the household survey. It is one of the most commonly used qualitative data collection approaches. Discussion will be made with randomly selected respondent under the guidance of a moderator. Checklist will be prepared to guide topics for open-ended discussion.

Key Informant Interview: To complement the questionnaire and to have a detailed in sight in to soil conservation practices in the areas in-depth interviews and discussion.

Direct Observation: is one of the other methods used to collect primary data. It will carry out through systematic watching, listening and recording of different data. This informal technique will help to generate ideas and acquire useful and detailed information about land use land cover changes in the study area.

Data to be collected: Fore this research, the following data to be collected; farmer's socio-economic characteristics, demographic and personal attributes of farm households, biophysical or plots and cropping characteristics, perception of soil erosion problems, technology attributes and institutional factors.

3.3.2 Data Collection

The socio-economic impacts of *Prosopis juliflora* will be assessed based on knowledge of the local communities: Structured questionnaire will be designed and administered to different respondent categories. The target groups will be stratified into three categories to investigate the economic impacts of *Prosopis juliflora* under varying scenarios. These include:

a) Invasive of concern not (yet) present,

b) Invasive of concern established, and

c) Invasive of concern in high abundance.

Data will be also collected from other stakeholders such as governmental organizations, non-governmental organizations, and town dwellers. Secondary information will be collected from different published and unpublished sources available from governmental, non-governmental and international organizations.

A random sample of 138 individuals of different occupation (indigenous/local people), 11 charcoal makers, and 7 town dwellers will be interviewed. The respondents (other than charcoal makers and town dwellers) will be categorized into three strata. The first strata consist of individuals from high prosopis infested area while the second strata consist of individuals from medium prosopis infested area and the third stratum will be individuals from non-prosopis infested area. The sample sizes in the high infestation and medium infestation areas was thirty-five each (Table 1). Twenty-four individuals were interviewed from the area

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that was not yet infested with prosopis. A structured questionnaire will be used to collect data from respondents.

3.3.3 Analytical techniques

The questionnaires will be coded and the data entered to computer for analysis. A statistical software (SPSS) will be used to summarize the information and analyze the data. A holistic approach will be followed so as to come up with intervention measures that take the entire social, economic, institutional and agro-ecological environment of the communities into account.

3.3.4 Analytical Techniques

Description of existing activities in *Prosopis juliflora* management by different stakeholders and coordination mechanisms among them are will be presented. Weaknesses and gaps in the existing activities and coordination mechanisms will be identified. Descriptive statistics such as percentage and frequencies will be used to summarize the information when appropriate.

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4. WORK PLAN

Table 17 work plan

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Phase	Key Activities	Participant	Duration
Preparatory stage	▪ Field visit to get overview of the study area ▪ Briefing and discussing with Kebele Administration chairmen and cabinet members ▪ Site selection (sampling) ▪ Secondary data gathering ▪ Preparing data collection instruments	-Researcher -Enumerators	Sep 2013
Data collection stage	▪ Identifying key informants ▪ Key informant interview ▪ Focus grouping discussions ▪ Undertaking case studies ▪ Conducting formal survey	-Researcher -Enumerators -Advisors (ten days each) -Sample households	Oct-Dec 2013
Writing stage	▪ Processing data ▪ Write up ▪ Thesis submission	-Researcher	Jan-April 2013

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5. BUDGET

Table2 Stationary and supplies

No	Items	Unit	Qty	Unit price (Birr)	Total (Birr)
1.	Typing paper (Interview schedule)	Pak.	5	80	400
2.	Computer paper	Pak.	5	80	400
3.	Printer toner	No.	1	3000	3000
4.	RW-CD	No.	3	20	60
5.	Writing pad	No.	10	10	100
6.	Pen	No.	20	3	60
8.	Film developing and printing	roll	3	72	216
10.	Video memory	No.	3	75	225
11.	Sound recorder with accessories	No.	1	500	500
12.	Sound recorder cassettes	No.	10	10	10
	Sub total				**4971**

Table 3 Personal costs

No	Items Detail	Estimated Cost				Total Cost	Remark
		Unit	Amt.	Amt. Per unit	Total cost		
1.	Researcher ▪ Field work ▪ Consultation ▪ Library	 days days days	 20 12 8	 208 208 208	 4160 2496 560	 4160 2496 560	
3.	Enumerator/ Advisors	6	15	100	1500	6240	
4.	Driver ▪ Per diem	 days	 30	 208	 6240	 6240	
	Sub total					**12480**	

1 0 Fuel and Lubricant

No.	Item	Unit	Amount	Unit price (Birr)	Distance travel (km)	Total cost (Birr)
1.	Fuel ▪ Petroleum	 lt	 420	 18.00	 2400	 8400
2.	Lubricants	kg	6	60	2400	600
	Sub total					**9000**

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Table4 Budget summary

No.	Items /details	Sub totals (Birr)	Remarks
1.	Stationary and supplies	**4971**	
2.	Personal costs	12480.00	
3.	Fuel and lubricants	900	
4.	Total	18851	
5.	**Grand total**	**37,202**	

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Annex IV Curriculum vitae of supervisor

CARRICULUM VITAE

I. PERSON SPECIFICATION

Name	Wondimagegne Chekol
Date of Birth	January 20, 1957
Place of Birth	Gonder, Ethiopia
Nationality	Ethiopian
Sex	Male
Marital Status	Married
Language	Amharic, English, German

II. EDUCATION

PhD in Agriculture, Goettingen University, Germany, 1989-1994

MSc in Agriculture, Goettingen University, Germany, 1983-1987

BSc in Plant Science, Addis Ababa University, Alemaya College of Agriculture, Alemaya, Harar, 1977-1980

Bahir Dar Secondary School, 1969-1972

Bahir Dar Elementary School, 1963-1969

II. TRAINING and Study Visit

Leadership and Management at St. Mary's University College (2011)

Soft ware package for social science at St, Mary's University College (2011)

Project Cycle Management at St. Mary's University College (2010)

Three-month researches leave at Bonn University, DAAD, Germany (2013)

Three-month researches leave at Bayreuth University, DAAD, Germany (2009)

SAQA (South African Qualification Authority (2008)

Quality Assurance Mechanism in Higher Education Institutions, Addis Ababa (2007)

Management of Vocational Education, Tianjin University of Technology and Education, Tianjin, Peoples Republic of China (2007)

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Leadership and Management, Ethiopian Management Institute, Addis Ababa (2003)

Three-month researches leave at Bayreuth University, DAAD, Germany (2005)

Project planning and Monitoring, ASARCA, Nairobi, 2004

Monitoring and Evaluation, EARO, 2002

Identifying and calcifying local indicators of soil fertility, CIAT, Arusha, Tanzania

SAS Software and Basic Biometry, EARO, 2002

Three-month researches leave at Bayreuth University, DAAD, Germany (2005)

Three-month researches leave at Osnabrueck University, DAAD, Germany (2001)

Three-month research leaves at Osnabrueck University, DAAD, Germany (1999)

Addis Ababa Teacher Training Institute, 1973, Ethiopia

III. WORK EXPERIENCE

Assistant Professor and Dean of Institute of Agriculture and Development Studies, School of Graduate Studies , St. Mary's University, March 2014 to date

Assistant Professor and Director of Center for Educational Improvement, Research and Quality Assurance, St Mary's University College since September, 2009 to 2014

Member of the task force to produce "The Ethiopian National Qualification Frame work", Representative of Higher Education Sector. Produced Ethiopian National Qualification Framework and Implementation Documents for the Ministry of Education

Senior Expert and team Leader Quality Audit in Higher Education Relevance and Quality Agency, since December, 2006

Worer Research Center Director, 2003 -2006

Associate Researcher I EARO, Worer Agricultural Research Center 1999-2006

- Soil research Section Head, Worer Agricultural Research Center 1999-2003
- Dry land natural resource management research program coordinator, EARO, Worer Agricultural Research Center, 2001-2006
- Drainage Research Project Coordinator, 2001-2004

Team leader of Prosopis juliflora management task force at Worer Research Center 1999-2006

Assistant Lecturer, Alemaya College of Agriculture, 1982

Assistant Administration Head of the Department of Plant sciences, Alemaya College of Agriculture, 1982

Graduate Assistant, Alemaya Agricultural University, 1981, Ethiopia

Guest Lecturer Awassa College of Agriculture, 1981/1982, Ethiopia

Graduate student, International Live stock Center for Africa (ILRI), 1988, Addis Ababa, Ethiopia

High school teacher, Arbaminch Secondary School, 1974-1976, Ethiopia

V. RESEARCH

Publications

Wondimagegne Chekol, 2014: *Prosopis julifora* Management in Afar Regional State, Stakeholder Analysis: Paper Presented on IGAD International Workshop May 1-3, 2014 Submitted for publication, July 30, 2014

Wondimagegne Chekol and Imfred Neumann, 2014: Prosopiss , Parthenium Elements for an Integrated Strategy of Alien Species (IAS) Control in Afar Region State: Paper Presented on IGAD International Workshop May 1-3. 2014, Submitted for publication on July 30, 2014

Wondimagegne Chekol and Abere Menalu, 2012: Selected Physical and chemical characteristics soils of irrigated farm lands, Ethiopia, Ethiopian Journal of Agriculture 127-141
Wondimagegne Chekol 2013: Soil Dynamics and Ecological change in middle Awash and lower Awash basin (unpublished)

Wondimagegne Chekol and Daneil Alemayehu 2013: Physical Characteristics of natural resources and land use patterns of Awash Basin (unpublished)

Wondimagegne Chekol and Tigist Belay 2010: State of Educational Quality in Ethiopian Higher Education Institutions, Proceedings of the national conference on Quality of Education in Ethiopia, 2010: 48-61.

Wondimagegne Chekol, Solomon Alemu, Sisay Tekele, Bob Campbell et al 2008: Gonder University Institutional Quality Audit Report. HERQA Publication Series 029

Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , H. Kevin et al 2008: Jimma University Institutional Quality Audit Report. HERQA Publication Series 031

Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , H. Kevin Asefa Abegaz et al 2009: St Mary's University College Institutional Quality Audit Report. HERQA Publication Series 035

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Wondimagegne Chekol, Solomon Alemu, Kassahun Kebede , Asefa Abegaz et al 2009: Addis Ababa University Institutional Quality Audit Report. (Unpublished)

Wondimagegne Chekol, 2009: Constructing the Third – Generation Ethiopian National Qualifications Framework, Proceedings of the national conference on Linking Higher Education with Industry, 2009: 48-61.

Wondimagegne Chekol, Asmare Demelelew, Keevy James et al: 2008 Concept and implementation framework of Ethiopian Qualifications, Ministry of Education of Ethiopia

Wondimagene Chekol and Heluf G/Kidane et al, 2006: Chemistry, Properties, Evaluation Management and Reclamation of salt affected soils and irrigation Waters in Ethiopia, ERO Publications

Wondimagegne Chekol, 2005: The effects of NP fertilizer on the yield of cotton, annual research repot, EARO.

Wondimagegne Chekol and Alemayehu Eshete, 2005: Impact of Irrigation on socio economic and environment in the middle and lower Awash River basin, annual research report, EARO.

Wondimagegne Chekol, 2004: Characterization of the soils of Lower and Upper Awash Basin, Ethiopia, annual research report, EARO.

Wondimagegne Chekol, 2003: Characterization of the soils of Southern Hledeghe Range Land in Middle Awash Basin, Ethiopia, annual research report, EARO.

Wondimagegne Chekol, 2002: Soil types: their potential and constraint for crop production in the Middle Awash Basin, Ethiopia, annual report, EARO.

Wondimagegne Chekol and Engida Mersha (eds) 2000: Proceedings of the fifth conference of the Ethiopian Society of Soil Science, Addis Ababa, Ethiopia.

Wondimagegne Chekol, 1994: Boden-catenen der basaltruecken-intramontanebenen-landschaft in der fusszone des Choke-bergmassives in hochland Aethiopian province Gojjam (PhD Desertation), Goerg-August University, Goettigen, Germany.

Wondimagegne Chekol, 1987: Das Boden-Brennen (Guie) in Aethiopian untersuchung zur veraederung der boden-eigenschaften insbesondere der naehrstoff reakitivitaet. MSc Thesis) Georg-August University, Goettingen.

Tamire Hawando, Wondimagegne Chekol et al, 1982: Soil fertility studies on major soils occurring in Hararghae Highlands (published in summary results of a soil science research program).

Tamire Hawando and Wondimagegne Chekol and et al, 1982: Effects of soil and water conservation on the yield and growth of sorghum in Hararghae Highlands, annual report soil science research program, Alemaya College of Agriculture.

Tamire Hawando, Wondimagengne Chekol et al 1981: Land use planning, soil fertility and soil conservation studies in Harerghe Highlands; summary research report, Alemaya College of Agriculture, Ethiopia

Extension work, Legambo Project (FAO funded), main activities were: soil classification and mapping, Land use planning, soil conservation and Agro-forestry, Alemaya College of Agriculture 1979-1982, Ethiopia

VI SKILL and ATTITUDE

Computer literate, Word and Excel

Aware of HIV/AIDS and Gender Equality

Familiarity with Afar community and culture and their way of working

VII OTHER ACTIVITIES

Vice President of the Ethiopian Soil Science Society since 2010

Editor in chief of the Ethiopian Society of Soil Science, since 2000

Chairman of the African and Asian Academician, George-August University, Germany (1990-1994)

Coordinator in the scaling up of modern Agricultural Technology in Afar Regional State (2003-2006)

Serves as Advisor and Co-advisor of MSc students at Hawassa and Haremaya Universities, since 2003 to date)

Member of the screening committee for German Academic Exchange Service (DAAD) PhD Scholarship candidates

Member of the advisory committee of the DG of Ethiopian Agricultural Research (2003) Institute

Partner for the implementation of Afar Livestock Recovery Project of FAO Funded by Norwegian Development Fund (2003- 2006)

Resource Person of Farm Africa Projects in Afar Regional State (1999-2006)

Partner for the implementation of PCDP Project in Afar Regional State (2003-2006)

Partner for SASAKA Global Rice Research and seed production since 2005 to date

Vice Chairman of the Ethiopian Soil Science Society since 2010
Secretery of the Ethiopian Soil Science Society since 2010 -213

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Member of Ethiopian Agricultural Society

Member Ethiopian Soil Science Society

Member of German Soil Science Society

Reference:
Dr. Tareke Berehe, ATA
Dr. Berga Lemga, ATA
Dr. Kidane Georgis