

**HOUSEHOLDS' PERCEPTIONS ABOUT *PROSOPIS JULIFLORA* AND
LANTANA CAMARA: THE CASE OF AMIBARA AND TULO
DISTRICTS OF AFAR AND OROMIYA NATIONAL REGIONAL
STATES, ETHIOPIA**

MSc THESIS

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**Households' Perceptions about *Prosopis juliflora* and *Lantana camara*: The
Case of Amibara and Tulo Districts of Afar and Oromiya National
Regional States, Ethiopia**

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I hereby certify that I have read and evaluated this thesis entitled ‘Households’ Perception about *Prosopis Juliflora* and *Lantana Camara*: The Case of Amibara and Tulo Districts of Afar and Oromiya National Regional States, Ethiopia’ prepared under my guidance by Ousmane Seid. I recommend that it be submitted as fulfilling the thesis requirement.

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DEDICATION

This thesis manuscript is dedicated to my mother, Mrs Hawa Mohammed, who played a key role in guiding my life in general, and for successful completion of this work in particular.

STATEMENT OF THE AUTHOR

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BIOGRAPHICAL SKETCH

The author was born from his mother Hawa Mohammed and his Father Seid Hussen in Awsi resu Zone of Afar, Aysaita town, in August 1993. He attended his elementary and high school education at Simbile primary school and Mohammed Hanfere secondary and preparatory school respectively. He completed his high school education in July 2011.

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ACRONYMS AND ABBREVIATIONS

ANRS	Afar National Regional State
CBD	Convention on Biological Diversity
DA	Development Agent
EFY	Ethiopian Fiscal Year
FAs	Farmers Association
FDRE	Federal Democratic Republic of Ethiopia
GISP	Global Invasive Species Programme
HDRA	Henry Doubleday Research Association
IAS	Invasive Alien Species
ISAC	Invasive Species Advisory Council
ISSG	Invasive Species Specialist Group
IUCN	International Union for Conservation of Nature
MoA	Ministry of Agriculture
NSPM	National Strategy on Prosopis Juliflora Management
OLS	Ordinary Least Squares
PARDBA	Pastoral and Agro-pastoral Development Bureau of Afar
PRA	Participatory Rural Appraisal
TLU	Tropical Livestock Unit
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
UNEP	United Nations European Program
US FS	United States Forest Service
USDA	United States Development Association
WAS	Worer Agro-meteorological Section
WTA	Willingness to Accept
WTP	Willingness to Pay

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**Households' Perceptions about *Prosopis Juliflora* and *Lantana Camara*: The Case of
Amibara and Tulo Districts of Afar and Oromiya National Regional
States, Ethiopia**

ABSTRACT

*This study explores households' perceptions about the effects of *Prosopis juliflora* and *Lantana camara* invasions in Amibara and Tulo districts of Afar and Oromia National Regional States of Ethiopia, respectively. The study used cross-sectional data collected from 260 randomly selected households, 130 households from each district, from 15 selected kebeles through semi-structured questionnaire. To measure households' perceptions about the invasive species, perception index was constructed based on a five point Likert scale with different perception indicators ranging from strongly disagree to strongly agree. Two limit Tobit regression was also used to determine factors affecting households' perceptions. The findings show that abundance of *P. juliflora* and *L. camara* in the study areas were increasing through time mainly due to mobility of dispersal agents and ease of spreading. With regards to *P. juliflora*, results revealed that households' mean perceptions rating is 0.37 and out of 130 sample households 117, 1 and 12 disfavored, favored and indifferent concerning the invasion by the species respectively. Similarly, concerning *L. camara*, households' mean rating of their perceptions is 0.40 and among 130 sampled households 108 disfavored the species; while 17 of them favored it and the rest 5 were indifferent. Empirical evidences indicate that gender, market distance, extension service, and livelihood strategy had a significant negative influence while proximity to the bush land had a significant positive effect on households' perceptions about *P. juliflora* invasion. Likewise, the finding shows that gender, education level, family size and market distance had a significant negative influence while land holding had a significant positive effect on households' perceptions about *L. camara*. Almost all sampled households have employed some form of control measures on their private land. The measures are uprooting seedlings, cutting, and burning though not effective, especially in Amibara district. The study recommends that government bodies in collaboration with stakeholders should design programs which take into account households' interests, demographic and socio-economic characteristics, and institutional factors for a successful management of *P. juliflora* and *L. camara* invasions.*

Keywords: *Prosopis juliflora*, *Lantana camara*, Households' Perceptions, Two limit Tobit regression

1. INTRODUCTION

1.1. Background of the Study

Humans are distributing species to parts of the world where they have not naturally dispersed and some of these non-native species become invasive in their new environment, thereby altering ecosystem processes or causing problems for human activities (Mack *et al.*, 2000). So, invasive alien species can be defined as species which establish outside their natural past range and dispersal potential and, once established, rapidly extend their range in the new region, causing significant harm to biological diversity, ecosystem functioning, socio-economic values, and human health in the invaded region (Hulme *et al.*, 2013). Globally, it became a common phenomenon and often also has detrimental effects on rural households in developing countries that they invade (Richardson and Rejmanek, 2011). They occur in all taxonomic groups and can affect all types of ecosystem. Invasive species, therefore, are considered one of the important drivers of ecosystem change and the second biggest cause of biodiversity loss worldwide after habitat destruction (CBD, 2010). The effects of invasive plants on natural habitats are more complex than the direct negative impacts. Their additional potential positive impacts such as providing economic and ornamental values have sparked a controversy as to whether they are friends or foe, pest or providence, and weed or wonder (Pasiecznik *et al.*, 2001).

In Ethiopia, IAS are of a great concern, posing particular problems on biodiversity of the country, agricultural lands, range lands, national parks, water ways, lakes, rivers, power dams, roadsides and urban green spaces with great economic and ecological consequences. The Federal Government of Ethiopia has identified a number of major invasive plant species in the country and declared the need for their control and eradication (Taye *et al.*, 2007). These include, parthenium weed (*Parthenium hysterophorus*), water hyacinth (*Eichhorniacrassipes*), mesquite (*Prosopis juliflora*), and *L. camara* and Acacia species such as *A. drepanolobium* and *A. melifera*.

Prosopis juliflora (*P. juliflora*) become one of the world's worst invasive alien species causing severe environmental degradation to the arid and semi-arid lowlands of the Horn of Africa and threatening the livelihood and thus food security of pastoral and agro-pastoral communities (Pasiecznik *et al.*, 2001). Many countries such as Ethiopia, Sudan, Kenya, Eritrea, and Somalia are heavily affected. In Ethiopia, the plant was first introduced to Afar region in the late 1970's with the aim of stopping desertification, greening up the region, and preventing drought (Wakie *et al.*, 2016). Even if *P. juliflora* is first introduced to Afar National Regional States, then spread to Oromia, Amhara, Somali, and Dire-Dawa regions, but particularly it became a serious topic in Afar and Dire-Dawa regions. On the other hand, *Lantana camara* (*L. camara*) is one of the known allelopathic weed plants in many parts of the world (Day *et al.*, 2003). In Ethiopia, it is an exotic species and it has wide ecological tolerance and growing successfully in various soil types (Day *et al.*, 2003). Some of the hotspot areas of *L. camara* in Ethiopia include South Wollo, Debre Zeit, Dire Dawa, Harerge (i.e. including Tulo district) and Somali region (Binggel and Desalegn, 2002).

Even though the negative impacts outweigh, both *P. juliflora* and *L. camara* have positive contributions to the ecology and economy of the people that they invade. Therefore, invasive exotic plant species bring both costs and benefits to local people but to deal with the threat of biological invasion, several international policies, guidelines, agreements and conventions have been ratified and are being implemented (Heywood and Brunei, 2008). According to Panneta and Timmins (2004), the first criterion for eradication success or management plans is that the sociopolitical environment should be suitable. Public perceptions of IAS, therefore, are crucial for evaluation of the management strategies and a key factor in the shaping policies and interventions that are both effective and accepted by interested parties. Thus, this study examined rural households' perceptions and their determinants in the Amibara and Tulo districts of Afar and Oromia regions of Ethiopia respectively.

1.2. Statement of the Problem

In Ethiopia's Afar region, with 90% of the Afar population being (agro-) pastoralists and their livelihood mainly depending on livestock production using rangeland, the *P. juliflora* invasion

has been growing out of control for more than a decade and has been devastating range land areas as they are degraded, and forage grass and livestock productivity has declined drastically as a result (Wakie *et al.*, 2012; Gerber, 2012). Its invasion is estimated well above 1 million hectares (1,117,510 hectares) taking over prime grazing and irrigable lands and the spread of the plant is advancing at the rate of about 50,000 hectares annually in the region alone (PARDBA, 2012). In sum, in monetary it costs the communities around 2.2 billion birr as a result of its invasion (Ilukor *et al.*, 2014). Moreover, the *P. juliflora* invasion, coupled with recurrent droughts that strike the area, has left the people unable to maintain subsistence livelihoods.

Harerge (i.e. including Tulo district) is also one of the hotspot areas for *L. camara* which infests pastures, grazing lands, orchards, and crops. Additionally, the allelopathic qualities of *L. camara* also reduce the vigour of native plant species and limit their productivity (Solomon and Adane, 2015). *L. camara* has also the potential to interrupt the health and regeneration process of other species by decreasing germination, growth of seedlings and biomass production which in turn increases mortality and decline of plant species (Sharma and Raghubanshi, 2006).

Despite *P. juliflora*'s negative impacts and varying perceptions among the large part of the community (farmers), it is used for fire wood, fencing, wind breaking, and charcoal making and sell to generate income (Oduor and Githiomi, 2013). Both crushed and uncrushed *P. juliflora* pods can be fed to animals (Berhanu and Tesfaye, 2006). Furthermore, in Afar region, *P. juliflora* is also attributed to have increased crop yields by 29% (Jema and Abdu, 2013).

Similarly, *L. Camara* is mainly used as hedge plant to contain or keep out livestock, ornamental uses by local communities, to control soil erosion, provision of animal fodder; and in some areas it is used as medicinal plants, firewood and mulch; for example, its oils have been shown to serve as repellents against malaria transmitting mosquitoes (Dua *et al.*, 2010; Solomon and Adane, 2015). Leaf extracts of *L. camara* exhibit antimicrobial, fungicidal, insecticidal and nematocidal properties. Verbascoside, which possesses antimicrobial,

immunosuppressive and antitumor activities, has been isolated from this invasive species (Neena and Josha, 2013).

Generally, rural households' preferences over the invasive plants may change, as the nature of the goods and services offered by those plants continues to change with time and technology; and it is influenced by how their economy depends on these species (e.g. Binggeli, 2001; Shackleton *et al.*, 2007). Some species which are considered detrimental to a specific group of rural people may be considered useful to others (e.g., Kannan *et al.*, 2008; Mwangi and Swallow, 2008). Community's perception and attitude also change over time as values and priorities change, and as unforeseen impacts begin to manifest themselves. Perceptions and attitudes can become different, especially between those with vested interests in growing trees or trading in their products and those depicted IAS as undesirable because of their impacts on biodiversity and ecosystem services (van Wilgen, 2012). A variety of opinion between those holding opposing views is also constantly changing, adding to the complexity of the issue. This is because IAS has differing characteristics offering a variety of ecosystem services, and that farm households in developing countries are heterogeneous.

This conflict of interest led to explicitly call from both science and policy for research on communities' perceptions in order to garner public support for IAS control programmes (Fischer *et al.*, 2011). But, most researches focused more on biological invasions and impacts, more often on ecological aspects (eg. Binggel and Desalegn, 2002; Berhanu and Tesfaye, 2006; Solomon and Adane, 2015; Wakie *et al.*, 2012; Haregeweyn *et al.*, 2013; Wakie *et al.*, 2016) than on social perceptions and attitudes of the people (van der Wal *et al.*, 2015). Reaser (2001) and Mack (2001) demonstrated that IAS is the result of human values, decisions and behaviors and they suggested that focusing on them might be a more effective long-term strategy for IAS management than concentrating only on ecological factors. It is therefore reasonable to expect the optimal policy to vary with geographical location and perceptions of the community towards the plants and the need to carry out such studies for informing appropriate policy development.

Furthermore to the best of my knowledge, detailed review of literature have revealed that there are no studies carried out in the study areas which quantified perceptions based on multiple indicators and identify factors influencing households' perceptions concerning *P. juliflora* and *L. camara*. Therefore, this study has been designed to measure households' perceptions and factors affecting their perceptions about *P. juliflora* and *L. camara* invasions in Amibara and Tulo districts of Afar and Oromia regions of Ethiopia respectively.

1.3. Objectives of the Study

The general objective of the study was to assess households' perceptions about the effects of *P. juliflora* and *L. camara* invasions in Amibara and Tulo districts of Afar and Oromia regional states of Ethiopia, respectively.

The specific objectives of the study were:

- To measure rural households' perceptions and identify factors affecting their perceptions about the effects of *P. juliflora* invasions; and
- To measure rural households' perceptions and identify factors affecting their perceptions about the effects of *L. camara* invasions.

1.4. Research Questions

The following research questions were addressed by this study:

1. How do rural households' perceive invasions by *P. juliflora* and *L. camara* in the study areas?
2. What are the factors determining rural households' perceptions about the effects of invasions by *P. juliflora* and *L. camara* in the study areas?

1.5. Significance of the Study

Despite the complexity in defining and understanding perceptions and their connection to behavior, wide consensus exists that focusing on human belief systems, perceptions or attitudes and the behavior that follows, might help to foster public buy-in on policies regarding IAS. These perceptions can also help to evaluate the effectiveness of past interventions, including the criteria that those who initiated the intervention did not think of in the first place. For instance, IAS present complex situation especially when they present both positive and negative outcomes to the environment and people's livelihood. In such circumstances, the policy makers or initiators of these interventions should be flexible and allow the adjustments of policies or programmes in cases of un-intended outcomes. Generally, the result of this research may provide clue for pastoral and agro pastoral communities, and farmers, regional and federal policy designers and other concerned entities about invasive species; given the research gap and literature on households' perceptions about *P. juliflora* and *L. camara* in the study areas, conducting such research would have its own role on development activities that are initiated to mitigate the adverse effects of IAS; it may also serve as a spring board for further studies in the area.

1.6. Scope and Limitations of the Study

The study was delimited to Amibara and Tulo districts of Afar and Oromiya National Regional States of Ethiopia respectively due to high intensity of the invasive species in the study areas and resource limitations. The study is primarily focused on households' perceptions about *P. juliflora* and *L. camara* invasion and its determinants. The study depends on cross-sectional data which will not capture the dynamic nature of people's perceptions and attitude towards an invasion. With likert scale also there is a difficulty to judge what a single score mean.

1.7. Organization of the Thesis

This thesis starts from part one which introduced the problem statement and described the specific problem addressed in this study as well as objectives, significance, scope and limitation of the study. The second part is chapter two which presents a review of literature associated with the problem addressed in this study. The third part presents the methodology and procedures used for data collection, presentation and analysis. Part four contains an analysis of the data, presentation of the results and discussion of the research findings. Chapter five offers a summary and conclusion, implications for practice and recommendations for future research. Part six contains all the literature that was referred to in the main body of the thesis. The last part seven contains material that would be too tedious to put into the main text.

2. LITERATURE REVIEW

In this chapter, definitions of basic concepts, review of relevant theoretical and empirical literature on the research topic are presented.

2.1. Definitions of Basic Concepts

2.1.1. Invasive alien species (IAS)

Invasive alien species are species, native to one area or region, that have been introduced into an area outside their normal distribution, either by accident or on purpose, and which have colonized or invaded their new home, threatening biological diversity, ecosystems and habitats, and human well-being (UNEP, 2006). Invasive alien species are also commonly referred to as invasive, aliens, exotics or non-indigenous species. Invasive alien species are also defined by CBD (2008) as non-native (aka alien) species whose introduction and/or spread threaten biological diversity which include plants, animals and microbes which are non-indigenous species introduced to new vicinities where they do not occur naturally.

Table 1: Definitions of invasive species by different organizations

Definitions	Organization
A species that is not native to the ecosystem under consideration whose introduction causes or is likely to cause economic or environmental harm or harm to human health.	National Invasive Species Council, 2001
Species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.	Convention on Biological Diversity (CBD)
Non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health.	Global Invasive Species Programme (GISP)
Animals, plants or other organisms introduced by man into places out of their natural range of distribution, where they become established and disperse, generating a negative impact on the local ecosystem and	International Union for Conservation of Nature (IUCN)

species.	
Species, subspecies, or lower taxon occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce.	Invasive Species Specialist Group (ISSG)
An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human Health	Invasive Species Advisory Council (ISAC)

Source: Neena and Joshi (2013)

As the above definitions indicate, invasive alien species cause (or have the potential to cause) harm to ecosystem, economies and/or human health (Clay, 2011). This study uses the definition by GISP that defined IAS as “a non-native organisms that cause (or have the potential to cause) harm to the environment, economies, or human health”. In this study, IAS generally refers to woody plants in rural parts of Ethiopia.

2.1.2. *P. juliflora*

Prosopis juliflora (*P. juliflora*) is native to Central and South America, spreading from southern Mexico to Panama and from the Caribbean Islands to northern South America (Venezuela and northern Peru) which has been introduced globally over the last 200 years. As mentioned by Pasiecznik *et al.* (2001), there are three origins for the name *Prosopis* which all rooted to ancient Greek. These are: ‘a kind of prickly fruit’, ‘bardane’ (a type of thorny plant) and the third as ‘pros’ meaning ‘towards’ and ‘opis’, wife of Saturn (the Greek goddess of abundance and agriculture). According to them, the name *juliflora* derived from two words, *julus* (meaning ‘whip like’) and *flora* (refers to the long inflorescences). Commonly, *Prosopis juliflora* is called mesquite, honey mesquite, Mexican thorn or cashaw (Pasiecznik *et al.*, 2001). It has at least four vernacular names in Ethiopia, *Yeferenj biskut/Dergi-Hara /Woyane* in Afar region and *Biskut* around Dire-Dawa (Zeraye, 2008).

The genus *P.* Linnaeus emend. Burkhart (1976) was systematically described and organized into five sections that together contain 44 species and a large number of varieties. The genus belongs to the family Leguminosae (Fabaceae), sub-family Mimosoideae. *P. Juliflora* belongs to section Algarobia that has six series; specifically it belongs to the series Chilensis that contain eleven species and many varieties. *P. juliflora* is particularly closely connected to *P. pallida*, and it is customary to refer to the two species as the *P. juliflora* – *P. pallida* complex, as the genetic variation is large and hybridization between these two species and some other species in the series is common. The *P. juliflora* – *P. pallida* complex contains the only two species that are truly tropical in their requirements and have a low tolerance for temperatures below zero degrees Celsius (ElFadl, 1997; Pasiecznik *et al.*, 2001; Räsänen, 2002).

P. juliflora is an evergreen tree or shrub with a large crown and an open canopy, growing to a height of 5-10 m armed with stipular spines 0.5-2.5(-5) cm long (Thulin, 1989). The stem of the plant is green brown in colour, sinuous and twisted with axial strong thorns. The thorns vary in appearance, number and size which can be found in pairs, solitary or both on the same branch (Pasiecznik *et al.*, 2003). The leaves are bipinnately compound with 1-2(-4) pairs of pinnae, leaflets 6-29 pairs, commonly many more than 9 pairs, the leaflets mostly 5–10 mm long, linear-oblong, glabrous, often hairy, commonly rounded at the apex (Thulin, 1989). *P. juliflora* flowers are yellowish in spiciform racemes, 5-10(-15) cm long without any particular fragrance or attractiveness, though relished by bees. Flowering begins at the age of 3-4 years. The bisexual, pea like flowers are cross pollinated by wind and insects (Orwa *et al.*, 2009). Flowers lateral to the axis with a tubular, light greenish-yellow, 1.5 mm wide calyx with hooded teeth; corolla light greenishyellow, composed of 5 petals with 3 mm wide pubescent along its edges (Orwa *et al.*, 2009). Fruit is a non-dehiscent pod, straight, linear, falcate to annular, with a coraceous mesocarp in 1 segment or divided into several segments; seeds compressed, ovoid, hard, dark brown, with mucilaginous endosperm surrounding the embryo; cotyledons flat, rounded, epigenous when germinating (Orwa *et al.*, 2009). Pod is pale brown, linear straight or slightly curved, 8-29x.8- 1.7cm, compressed, with a sugary pulpy mesocarp (Thulin, 1989). Under normal environmental condition the plant has two kinds of root systems: the first type of root is a deep vertical root system made up of normally one or two main tap roots which may further divide at lower depths, and the second is a lateral root

system, which extends horizontally in all directions just below the soil surface. The deep root system anchors the tree and brings up groundwater to the tree, while the lateral roots collect rain and other surface water as well as nutrients just below the soil surface. The tap roots can reach a depth of 20 – 25 m, but trees have been found that can reach substantially deeper (Pasiiecznik *et al.*, 2001). Hence, the increase in root biomass of *P. juliflora* largely contributes to tolerate climatic extremes. So, this adaptation favors the weed to predominate over other native floras that are susceptible to these extremes.

2.1.3. *L. Camara*

The word *L. camara* derives from Latin word ‘lento’ which means to bend (Ghisalberti, 2000). The species was first described and given its binomial name by Linnaeus in 1753 (Kumarasamyraja *et al.*, 2012). It is the genus of verbenaceae family with approximately 270 species existing worldwide and sub specific taxa of woody shrubs (Bhakta and Ganjewala, 2009). *L. camara*, a native species of South, Central America and the Caribbean islands, has its presence recorded even in Brazil, Florida, Jamaica, Mexico, and Trinidad. The species is spread over wide geographical range in neotropics but none is reported from Old World (Day *et al.*, 2003). Some species of *L. camara* are also believed to originate from Africa and one from India (Heshula, 2009). The genus *L. camara* ranked among the worst 100 invasive alien species in the world. The diverse and broad geographic distributions of the species beyond its native range are the reflection of its wide ecological tolerance, ability to conquer diverse habitats and its success on a variety of soil types (Day *et al.*, 2003). It is a cosmopolitan weed and has been declared as a noxious weed in many parts of the world (Goulson and Derwent, 2004). It is particularly a weed of the tropics and sub-tropics of the worldwide becoming naturalized in approximately 60 countries (Day *et al.*, 2003).

Shortly, the physical description of *L. Camara* presented as it is a heavily branching shrub that grows 2–4 m high as compact clumps or dense thickets. It is able to climb to 15 m with the support of other vegetation. It has arching stems that are square in cross-section, with pithy centers and short, backwardly hooked prickles or spines. Aged stems can be up to 15 cm in diameter. The leaves are 2–10 cm long with toothed edges, bright green on the upper

surface and paler green, hairy and strongly veined on the underside. They grow opposite one another along the stems, and their size and shape depends on the type of *L. camara* and the availability of light and moisture. The plant has a shallow root system made up of a short taproot with lateral roots branching out to form a mat. The inflorescences (clusters of 20–40 individual flowers) are about 2.5 cm in diameter. Tightly packed, angular flower buds open from the outside towards the centre of the inflorescence as they mature. Single-seeded hard green fruit, of about 5–7 mm, grow in clusters and ripen to shiny black or purple fleshy berries. Crushing the stems and leaves produces a strong characteristic smell (Binggeli, 2003).

2.1.4. Perceptions

Perception is our sensory experience of the world around us. This involves recognizing environmental stimuli and the actions that are responses to those stimuli. It is a key to gaining information and understanding the world around us. Without it, we would not be able to survive in this world filled with stimuli surrounding us. This is because perception not only molds our experience of the world but allows us to act within our environment. According to Lindsay and Norman (1977), perception is the process by which organisms interpret and organize sensation to produce a meaningful experience of the world. In other words, a person is confronted with a situation or stimuli. The person interprets the stimuli into something meaningful to him or her, based on prior experiences. However, what an individual interprets or perceives may be substantially different from reality.

As a result, environmental perceptions have commonly been defined as awareness of, or feeling about, the environment and as the act of apprehending the environment by the senses. A more encompassing definition was provided by psychologist Ittelson (1973) who described environmental perception as a multi dimensional phenomenon, as a transactional process between the person and the environment. Hobbs and Salter (2006) defines environmental perceptions as the way in which an individual perceives the environment; the process of evaluating and storing information received about the environment. Decision makers cannot but base their judgments on the environment as they perceive it.

Perception is closely related to attitudes. Allport (1935) defined an attitude as a mental or neural state of readiness, organized through experience, exerting a directive or dynamic influence on the individual's response to all objects and situations to which it is related. Attitude is a mindset or a tendency to act in a particular way due to both an individual's experience and temperament. A simpler definition of an attitude is a state of readiness, a tendency to respond in a certain manner when confronted with a certain stimuli (Oppenheim, 1992).

Definitions of perceptions are as varied as the components that constitute perception itself. Whilst exact definitions are numerous, most contain an aspect of evaluative direction that can be held at varying levels of intensity: either positive or negative (Oppenheim, 1992), favour or disfavor (Manfredo and Dayer, 2004), and approval or disapproval (Asunta, 2003). Secondly they have content: an entity (Asunta, 2003), an object or action (Manfredo and Dayer, 2004), a stimuli (Oppenheim 1992). Now, after reviewing various definitions, it is generally accepted that perceptions represents a psychological tendency that is expressed by evaluating a particular stimuli, entity, place, thing, event or invasion with some degree of favor or disfavor.

2.2. Impacts of IAS

IAS has a significant impact on ecological and socio-economic aspects of the area they invade. Accordingly impacts of *P. juliflora* and *L. camara* invasions are reviewed and presented hereunder.

2.2.1. Impacts of *P. juliflora*

2.2.1.1. Negative impacts

***P. juliflora* as a trigger for land use change:** When more and more of the previous dry season pastures were taken over by *P. juliflora* in the 1990s and the first decade of the 20th century, while at the same time most wet season pastures were inaccessible due to the risk of violent clashes with the Issa who had settled on the occupied land, the available grazing

resources in Baadu could not sustain all the 21 clans that had their clan territories in the area. Land became increasingly a scarce resource and in order to make use of the *P. juliflora* invaded areas clan elders and leaders decided to lease out these areas of communal clan-based grazing land to private agricultural investors. Therefore, the increase of large-scale agriculture by mostly non-Afar investors has to be seen as an adaptation strategy of the Afar pastoral elite to benefit from the *P. juliflora* invaded areas which they could not use otherwise due to lack of capacity (Rettberg, 2014).

Rural livelihood: Invasive alien species (IAS) like *P. juliflora* reduces agricultural production and productivity by affecting crop or livestock production, farm or grazing land and human health. Related to this, Mohammed (2012) pointed out that *P. juliflora* has spread outside the designated plantation areas, adversely affecting natural habitats, rangelands and cultivated areas in many parts of the country. *P. Juliflora* is the most common naturalize species, and it has been declared a noxious weed in Kenya, with legal disputes over compensation for its spread and subsequent loss of livelihoods, especially in pastoral regions (Mwangi and Swallow, 2008)

Human health: The expansion of *P. juliflora* has brought associated health problems to the local community. Accordingly, leg and hand infections and soft tissue infections were the most frequently (>5 cases/month) recorded diseases. Other diseases, such as cellulitis, upper and lower respiratory tract infections, and blindness, have been reported to occur occasionally (<5 cases/ month). Upon penetration of the eye or skin of humans and animals, the thorn of *P. juliflora* causes more inflammation than would be expected based on the physical injury. An injury from the thorn of this species does not heal easily despite the use of intensive medical treatments (personal communication with the pastoralists). This irritation may be due to waxes in the thorns (Sharma *et al.*, 1981). Burning the wood in a fireplace can also cause dermatitis (Duke 1983).

Livestock production: According to Wakie *et al.* (2016), over the past four decades, the number of livestock owned per household in the seven studied villages of Afar has declined by more than 50%. The main reasons reported for the decline include drought, disease,

annexation of Afar lands by rival Issa ethnic groups, land-grabs by foreign companies and the central government for large-scale agribusiness, and invasion by *P. juliflora*. The most negatively affected domesticated animals (ordered by level of impact) were cattle, camels, sheep, and goats, respectively. According to the study, donkeys are the least affected. The only *P. juliflora* related impact reported on donkeys in the current study is injury from the species' thorns. However, Mosweu *et al.* (2013) has reported deaths of donkeys and horses in Botswana after feeding on *P. juliflora*.

Culture: *P. juliflora* invasion has changed the culture of Afar people. Afar culture discourages the felling of native trees. Charcoal making was considered a bad practice, and those who made charcoal, or gave permission to others to make charcoal, were punished by traditional laws. However, due to its negative impacts, felling *P. juliflora* trees is tolerated by a large majority of the Afar people. Afar regional policies also encourage clearing *P. juliflora* trees, and producing *P. juliflora* charcoal. Many people in Afar made money by producing and selling *P. juliflora* charcoal (Dubale, 2008). Motivated by this new source of income, some Afar people started harvesting native plants such as *A. nilotica* and *C. aculeatum* for charcoal making purposes, often using *P. juliflora* as a pretext. The study pointed out that the culture of protecting native trees in Afar has been eroded and the harvesting of native trees for charcoal making now is tolerated. *P. juliflora* is commonly found in most of the Afar landscape. Open areas which were used as venues for playing Afar traditional sports are now invaded by *P. juliflora*. Weyane has also blocked roads, reduced peoples' visibility, and thus made night walks dangerous (Wakie *et al.*, 2016).

Native species and biodiversity: *P. juliflora* negatively affects the native flora by invading grasslands, shrub-lands, and woodlands. The most affected useful native grass and herb species include *Chrysopogon* spp. (durfu), *Eragrostis* spp. (denikto), *Setaria* spp. (delaita), *Cenchrus* spp. (serdoita), *Hyparrhenia* spp. (isisu), *Cynodon* spp. (rareita), and *Andropogon* spp. (melif), while the most affected useful native tree species include *Combretum aculeatum* (kilito), *Acacia tortilis* (ehebto), *Acacia nilotica* (keselto), and *A. senegal* (Wakie *et al.*, 2016).

2.2.1.2. Positive impacts

Erosion control: The most beneficial part of soil layer is the top soil, which takes many years to develop. Top soil is rich in nutrients and valuable soil microorganisms. This top soil is prone to water and wind erosion. Loss of soil can be controlled by putting up wind breaks, planting cover crop and cultivation practices. *P. juliflora* has been used to capture wind erosion and stabilize sand dunes in arid and semi-arid region. The plant can serve as wind break when planted across the direction in which the wind blows (Mwangi and Swallow, 2005). The capacity to block the flow of wind depends up on height, density and thickness of the stands. Apart from preventing the loss of fertile soil, the plant decrease wind damage to crops, loss of soil moisture, develop the microclimate. It is reported that in Sudan the wind speed inside a five-year-old *P. juliflora* plantation was reduced by an average 14%, while potential evaporation was reduced by 22 percent (El Fadl, 1997).

Rehabilitation of degraded lands: *P. juliflora* enriches the soil with nitrogen from the atmosphere obtained through symbiosis with cowpeatype Rhizobium (Orwa *et al.*, 2009). In addition, the roots form mycorrhizal associations with Glomus fungi. Plants with both Rhizobium and mycorrhizal associations show significantly higher nitrogen fixation rates than those lacking the mycorrhiza. However, nitrogen fixing ability of *P. juliflora* has been found to be mainly limited to young seedlings (Geesing *et al.*, 2004). *P. juliflora* has an extraordinary ecological amplitude and tolerance for a variety of elements. Despite being an introduced invasive, it has been recognized as one of the promising species for the rehabilitation of soils with salinity regimes equivalent to that of seawater and reclamation of industrial sites (mined areas) by taking up toxic chemicals from polluted soils (Victor *et al.*, 2007). The plant is very effective in reclaiming highly sodic soils by restoring productivity and fertility (Victor *et al.*, 2007). It increases the amount of soil organic matter in the soil directly and thereby positively influences the potential of soil to absorb soil moisture which leads to sustainable soil fertility (El-keblawy and Al-Rawai, 2006). For instance, in Afar, it is reported that *P. juliflora* attributed to have increased crop yields by 29% (Jema and Mohammed, 2013). This is because organic carbon and total nitrogen concentrations in soils under *P. juliflora* is higher than in the open areas (El Fadl, 1997).

Combating drought and desertification: Drought and desertification is a problem of international dimensions. For example, it is reported that in Afar, the area was faced severe drought and desertification. The practice of nomadic pastoralism with free grazing has stimulated the distribution of this species because the undigested, but treated seeds pass through the digestive system of the livestock and are disseminated by migratory animals (Mohammed, 2012). This seed dispersal on vast areas has helped natural regeneration and naturalization of this species. Consequently, the desert is blooming and eroded, denuded hills are also becoming green due to its fast growth and drought-hardy inherent capacity of the plant. Initially, it was also introduced for the sake of stopping desertification, greening up the region, and preventing drought (Wakie *et al.*, 2016).

Economic benefits of *P. juliflora*: *P. juliflora* plays important roles 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 used either as a fuel wood or structural material (Mwangi and Swallow, 2005). As a fuel it can be burned directly or made into charcoal, and as a timber it can be used as poles or made into furniture.

A general ban on charcoal production including invasive trees such as *P. juliflora* appeared to be common in Ethiopia (Mwangi and Swallow, 2005). This remains a barrier for utilization of *P. juliflora* products. However, in Afar region, there was pilot initiative where cooperatives were provided with license to produce and market *P. juliflora* charcoal. Households involved in charcoal production and sales obtained good income and diversified their livelihood base to better cope with food insecurity. With the income local people were able to cover their household expenses (clothes, medical services and food) and build their asset base by purchasing livestock (Dubale, 2006).

Additionally, this activity has given significant employment opportunities to the local people. But, due to the lack of extension and regulatory service by government offices and due to failure to respect requirements by users, the activity became unmanageable and was banned by the region government until the problems were rectified (NSPM, 2017).

2.2.2. Impacts of *L. camara*

2.2.2.1. Negative impacts

L. Camara has many negative impacts including potential to disrupt succession cycle, displacing native biota resulting in decreased biodiversity (Murali and Setty, 2001). It has a serious impact on native biodiversity and recent research in Australia shows that it threatens more than 1400 native species and 100 threatened ecosystems. This includes 279 plants and 93 animals listed under state and/or national threatened species legislation. Its infestations alter the structural and floral composition of native communities (Sharma and Raghubanshi, 2010). As the density of *L. Camara* in forest increases, allelopathic interactions increase and hence there is decline in species richness (Day *et al.*, 2003). It is a major problem in agriculture lands in various regions of India because once established the species forms dense and impenetrable thickets thereby outcompeting native pastures, blocking the movement of grazers in addition to causing poisoning. *L. camara* has numerous secondary impacts as it harbors serious pests such as malaria mosquitoes and tsetse flies, resulting in grave health issues. These alter fire regimes significantly by providing fuel load provided. The species has been implicated in destructive wildfire in various regions of India (Hiremath and Sundaram, 2005).

L. camara is a major problem in agricultural areas in most regions of India as it forms dense thickets, spread gregariously, outcompete pasture species, and affects both flora and fauna. The field cases occur mainly in young animals that have either been newly introduced into an area where *L. camara* grows, or are without access to other fodder. Children and adults in many countries often consume ripe fruits of *L. camara*, without any ill effects. However, consumption of green fruit has proved to be fatal in some parts of India. Apart from causing death of livestock, sub lethal doses of *L. camara* toxin causes reduction in potential production, manifested abortion, loss of milk production in dairy cows, and chronic wasting in beef cattle (Sharma and Raghubanshi, 2012).

In agricultural situations, *L. camara* invades pastures and grazing lands, fence lines, riparian areas, cultivated land and orchards. Productivity costs in Australian grazing sector has been estimated that *L. camara* infestations cost the Australian grazing sector more than \$104 million per year (2005–06 values) in lost productivity, with landholders incurring an average cost of \$42.78/ha per year where *L. camara* is present. However, there is considerable variation in these figures depending on the density of infestation and level of management activity. Another study estimated that increased mustering costs alone can be as much as \$65 per hectare in densely infested areas for the beef industry and \$55 per hectare for the dairy industry.⁵⁵ following this the controlling cost estimated that land managers in the grazing industry spend more than \$17 million annually on *L. camara* control (Tumaneng-Diete, 2007).

Thus, in summation, *L. camara* invasion in natural ecosystem results in widespread loss of native species diversity and disrupts ecosystem structure and functioning (Iyengar, 1933; Murali and Setty, 2001; Sharma *et al.*, 2005; Taylor *et al.*, 2012). However, very little qualitative and quantitative evidence is available to validate these claims in Ethiopian settings. Information on potential harm caused by anthropogenic induced activities facilitating invasion is also lacking.

2.2.2.2. Positive impacts

As habitat: *L. camara* thickets can provide a substitute habitat for a range of animals, including bandicoots, whipbirds, quail, wrens, birdwing butterflies and brush turkeys, where it has replaced the natural understorey vegetation. However, due to the structural and nutritional simplification caused by *L. camara* invasion, these habitats cannot support the range of animals found in most environmental systems. In addition, *L. camara* provides a refuge for feral animals such as cats, pigs, rabbits, foxes and wild dogs, which compound the negative impacts on native plant and animal populations (Bhagwat *et al.*, 2012).

As a buffer: In some disturbed rainforest areas, *L. camara* prevents invasion by grass and other weeds, and can form a useful temporary buffer along forest edges for bush regeneration

projects. However, this management technique should be treated with caution as there is the potential for seed spread into breaks and disturbed sections of the rainforest, further affecting the integrity of the system. In areas of more open vegetation, such as sclerophyll forests, this technique should not be employed as *L. camara* will readily invade open-canopy systems (Tumaneng-Diete, 2007)

Farm management: In some agricultural contexts, infestations of *L. camara* are thought to prevent soil compaction, and are valued as a source of organic matter for pasture renovation or improvement. The weed is also considered to be useful in steep areas and stream banks for stabilizing soil and preventing erosion. In some cases, it suppresses weeds perceived to be worse. Once again, these management techniques should be considered carefully. There must be the capacity, on behalf of the land manager, to eventually control *L. camara* infestations for there to be any advantage in reduced soil compaction and increases in organic matter. In addition, *L. camara* may reduce deep erosion; however, as the surface soil below *L. camara* infestations is relatively devoid of ground cover, it is prone to desiccation and loss of humus layers due to surface run-off (Queensland Government, 2004).

Garden ornamental: The sale and distribution of all varieties of *L. camara*, including horticultural varieties, has been banned in all states and territories of Australia. *L. montevidensis* (creeping *L. camara*) is also restricted in selected areas. However, *L. camara* is still valued for its colour and low maintenance requirements and remains a common fixture in many public and private gardens (Queensland Government, 2004; Neena and Joshi, 2013). Garden plantings of *L. camara* pose a risk in two main ways: through the spread of seed by birds and mammals; and through the introduction of ‘enhanced’ genetic material into wild populations.

In general, *L. camara* though considered as a noxious woody weed, it has several uses, mainly in ornamental, hedge, and herbal medicine. There are series of research studies conducted on the exploitation of chemical constituents present in different parts of the plant species. The studies demonstrate that extracts from the leaves can be employed to combat antimicrobial, fungicidal, insecticidal and nematocidal problems. Its potential to serve as biocide has also

been illustrated in several researches (Begum *et al.*, 2004).

2.3. Theoretical Framework of the Study

Theoretical framework of the study is essential to understand people's perceptions and values for the role they play defining policy and management decisions. Additional to this it is apparent that perceptions, attitude and beliefs must be understood; as they are posited to influence human behavior (Ajzen and Fishbein, 1980), and therefore understanding individuals' perceptions and attitudes can help environmentalist better predict human behavior. The ability of perceptions and attitudes to predict behavioral intentions and actual behavior will continue to be a major focus of theory and research (Ajzen, 2001). The theory of reasoned action (TRA) developed by Ajzen and Fishbein (1977), and its extended version, the theory of planned behavior (TPB) (Ajzen and Madden, 1986; Ajzen, 1991) connect perception or attitude and behavior in a logical framework.

According to the TRA (1977), intention is the most important determinant of action. Sirivongs and Tsuchiya (2012) further disclosed that perceptions could affect stakeholders' intent to engage in environmental management. Behavioral intention refers to a person's intention to perform various behaviors. Intention in the TRA is specified as a function of attitude and subjective norms. In this model, attitude refers to the degree to which a person has a favorable or unfavorable evaluation of an object which is influenced by a person's beliefs or perceptions that performing a behavior will lead to a desired outcome, whereas subjective norms were defined as the perceived social pressure to perform or not perform the target behavior, and behavioral intentions were defined as the perceived likelihood of performing the target behavior. However, one factor that may limit the translation of intentions to behavior is one's ability to enact the desired behavior. As such, the Theory of Planned Behavior (TPB) updated the Theory of Reasoned Action to include a component of perceived behavioral control, which specifies one's perceived ability to enact the target behavior. In fact, perceived behavioral control was added to the model to extend its applicability beyond purely volitional behaviors.

2.4. Review of Studies on Households' Perception about IAS

In this section the researcher tries to review some of the previous studies undertaken on households' perception about IAS particularly *P. juliflora* and *L. camara* all over the world. But for the sake of simplicity those studies are categorized and presented below.

2.4.1. Studies on perception about IAS abroad

A study was made by Andreu *et al.* (2009) on the assessment of stakeholder perceptions and management of noxious alien plants in Spain. Regarding the magnitude of the impacts caused by noxious alien species, 35% of the cases were perceived as having a high impact on natural areas and 28.5% a low impact. In only 36% of the cases were invasive species perceived to cause a high impact and 25% a low impact, while in naturalized and casual species cases, 30% and 43% were causing a high impact, respectively. No significant differences were found between invasive and casual species in their perceived magnitude of impact. In addition, no significant differences were found between unmanaged and managed species in the ecological impacts they cause. Therefore, the type of ecological impact does not seem to be a criterion for management priorities.

Bharath *et al.* (2012) explored how the forest-dwelling Soliga community of South India views and explains biological invasions, and how local knowledge can inform scientific knowledge on biological invasions. He used an interview schedule with open-ended questions to solicit Soliga opinion on *L. camara* invasion. The Soliga cited three reasons for *L. camara* spread: its prolific fruit output and wide seed dispersal, change in fire management, and historical extraction of grass and bamboo. The Soliga believe that *L. camara* invasion has had negative effects on the ecosystem and their livelihoods. Tabling scientific knowledge with local knowledge has improved the understanding of *L. camara* invasion. The role of existing *L. camara* in colonizing neighboring areas, and the response of native tree communities to *L. camara* were common to both local and scientific sources. However, the Soliga view provides a more nuanced perspective of the *L. camara* -fire relationship (contextually based on *L. camara* density) with fires suppressing *L. camara* when *L. camara* density was low. This is

contrary to views held by foresters and biologists, that fires are uniformly detrimental and promote *L. camara*.

Rai *et al.* (2012) examined how rural people in the buffer zone of Chitwan National Park in Nepal perceive the effects of accidentally transported invasive plant species on their livelihoods. An ordinal logistic regression was used to understand the factors influencing the effects of the particular invasive plants. The research found that their perception of the impact of each species on their livelihood varies with factors such as the duration of the presence of invasive plants in the landscape, and household characteristics. The results of the ordinal logistic regression analysis indicate that the status of the invasive species has a significant and positive influence on the perceived effects of the particular invasive plants on rural livelihoods for all three species. However, socio-economic variables including proximity to the forest, occupation of respondents and user of the particular invasive species are significant determinants only in the case of the recently arrived species (*Mikania*). The control strategies practiced by the respondents were self initiated indicating there was no external support to control the spread of invasive plants. Because of the presence of all three species on the same piece of land, the control strategies were not specific to single plant species. Uprooting, cutting and burning were the major activities that rural households (84%) were carrying out in their farmlands and community forests. On the contrary, more than one-third (35%) of respondents suggested that there are “no control measures” for these species. Finally, the paper suggests a need for awareness raising programs and external support in rural communities, as the levels of social awareness is considered one of the challenges in controlling the invasion of exotic species in developing economies.

Another study in the list is the one undertaken by Elca (2013) in Baringo, Kenya about policy outcomes and community perceptions about *P. Juliflora*. The methodology for the study was a qualitative approach and, an inductive logic was used, drawing its inspiration from the core values of political ecology and political economy. Findings of Elca (2013) also indicate major changes in communities’ perception over time with outcomes of these interventions. Community members inter-viewed for this research stated that they appreciated the tree at the point when it was introduced since it was able to curb desertification, dust storms had

reduced, there was vegetation cover in the area and the temperatures had become much better. The appreciation of the tree started declining after it became invasive leading to loss of their livelihood, health problems as a result of the thorns as well as environmental impacts like the floods that were perceived to be as a result of the tree. This resulted in the communities' suing the government for its interventions that had later resulted to unintended consequences and even demanded for its eradication and compensation for their losses. This negative perception slowly changed back to appreciation of the tree after the communities were sensitized on how to exploit it tree for their economic and social benefits. This coupled with legalization of charcoal production has resulted to most of the community members earning a living from charcoal production.

Another study conducted by Petra (2016) on the title of beasts or beauties? Laypersons' perception of invasive alien species in Switzerland and attitudes towards their management. Linear regressions were used to test for influences of socio-demographic variables and study location on participants' characterizations of eight IAS and number of IAS correctly identified. The researcher was used ordinal regression to test for influences on participants' attitudes towards certain types of management. Result of this study shows that, almost all plants were perceived as beautiful and wanted. Aesthetic appeal and desirability of a species (attributed scores on the "ugly-beautiful" and "unwanted-wanted" scale, respectively) were positively correlated as were perceived nativeness, familiarity and ordinariness (scores on the "exotic-indigenous", "unfamiliar-familiar" and "extraordinary-ordinary" scale, all correlation coefficients between 0.15 and 0.46, all $p < 0.001$). Participants' aesthetic feelings were hardly influenced by education or expertise, but were more prominent in women and increased with age. Women are generally more in favor than men of visually appealing plants, while older people might have developed a gardener's view on plants. Feelings of familiarity, ordinariness and go native were positively correlated. Level of formal education did not influence participants' attitudes towards certain management types, while knowledge of IAS did.

2.4.2. Studies on perception about IAS in Ethiopia

Related studies had been carried out in the study areas. Mohammed (2012) conducted a research on households' perceptions about *P. juliflora* and its effect on Pastoral Livelihood Diversification Strategy" in Gewane Woreda, Afar National Regional state. The study used multinomial logit model and two step instrumental variable Tobit (ivtobit) model to assess the determinants of pastoral households' perception regarding *P. juliflora* and its effect on pastoral livelihood strategies, and determinants of livelihood diversification strategies respectively. And to measure perception of the household the researcher used likert scale. According to the descriptive result of this research 50.7% of pastorals or agro-pastoral perceives unlikely, 24% neutral and 25.3% likely about *P. juliflora*. Moreover, results of multinomial logit regression indicates that sex, age, market distance, TLU, extension service, participation on diversification, experience on farming and charcoal production, conflict, total household income, and hectare of land cultivated and total land owned by the household were found to be the major determinants of household perception with regard to *P. juliflora*.

Haregeweyn *et al.* (2013) made a study in Amibara district on the invasion rate, impacts and control measures of *P. juliflora*. Based on this study, by the year 2020, approximately 30.89 % of the study area is projected to be covered by *P. juliflora*. The expansion has affected human health, suppressed indigenous plants, and decreased livestock productivity. The management measures that have been implemented are not able to yield the desirable results because of the limited spatial scale, cost, and/or improper planning and implementation.

Another study was undertaken by Jema and Abdu (2013) to empirically evaluate the impact of a controversial alien species called *P. juliflora* invasion on the livelihood of agro-pastoral households selected from rural Dire Dawa Administration of Ethiopia. The major analytical concern of the study was to estimate the impact of *P. juliflora* invasion on agro-pastoral households' farm income using propensity score matching technique. Result of the study show that, after controlling for differences in demographic, socioeconomic and institutional characteristics of the sampled households, on average, invasion by *P. juliflora* has significantly decreased annual income of the agro-pastoral households from livestock and

their products sale by 780.74 Birr (28.82%) and increased average annual income from crop sale by 839.31 Birr (25.85%) though not statistically significant. Based on these results, the study recommends efficient use and/or eradication of *P. juliflora* to reverse its adverse effects on the agro-pastoral households in Dire Dawa Administration.

Solomon and Adane (2015) carried out the study to quantify ecological distribution, abundance and effects of *L. Camara* on different land uses and to assess the perception of local community concerning its impacts on environment and biodiversity of Abay Millennium Park, Bahir Dar, Ethiopia. The socio economic data was collected to assess the perception and awareness of the local people towards the species, and the data was collected through semi-structured questionnaires and participatory rural appraisal (PRA) interview. Results reveal that *L. Camara* has shown highest invasion (82.1%, grassland) and least invasion (34.6%, riverine forest); cultivated land being intermediate (57.5%). The socio-economic survey revealed that different respondents have similar view about how (it was purposely introduced), why (it was believed to be used as ornamental/hedge), and where (it was planted around the palace) the species was established in the study area. About 90% of the local people (farmers and agropastoralists) have negative attitude towards the species and they are highly supportive for its total removal, while some governmental employees (park development and agro-forestry experts) did not support its complete eradication, and have mixed attitude towards the species. They elaborated their reasons in that the plant has its own advantage for example; such species are ecologically successful and important in conserving genetic resources in the environment Solomon and Adane (2015).

2.5. Conceptual Framework of the Study

Social science research shows that human perceptions or attitudes and behaviors toward nature and natural resource management, such as invasive exotic species and their control, are multiple and diverse and are affected by psychological, cultural, and evolutionary factors (Kaplan and Kaplan, 1989; Gobster, 2011). In turn, underlying beliefs and perceptions about invasive species have been explained by individual or group demographics and knowledge and properties of the organism itself (e.g., aesthetic, charisma) (Bremner and Park, 2007;

García-Llorente *et al.*, 2011). Whilst Ajzen's model is widely accepted as being one best predictors of human social behavior, its ability to predict actual behavior is still limited by a number of confounding factors. From a conservation perspective Dickman (2010) highlights three key factors that contribute to the mismatch in common assumptions of behavior made by conservation managers and actual behaviors experienced. These are: perceptions of risk, disproportionate responses and social influences.

The way in which individuals and society understand and react to risk can be heavily influenced by social and cultural perceptions, values, history and the ideology surrounding that risk (Boholm, 1998; Sjöberg *et al.*, 2004; Dickman, 2010). These influences may cause an individual or society to perceive risk incorrectly. Furthermore, the individuals' perception of that risk and how they express it can then affect society by elevating the fear of damage in other people, regardless of their own personal experiences (Dickman, 2010). This clearly influences people's normative beliefs and in turn perceived social pressure with which to perform a behavior as described by Ajzen (1991).

It is clear then that people do not base their perceptions and attitudes solely upon facts and no amount of scientific evidence will ever be sufficient to bring about improvements in the management of a species if the species or management intervention does not resonate with public perceptions or attitudes and values. Thus providing mitigation alone to a natural resource damage issue will not mean negative perceptions or attitudes and behavior reduce concomitantly and to a proportionate degree (Dickman, 2010). In reality peoples' perceptions or attitudes and resulting behavior are results of not just personal experiences but also a wide variety of social factors that are rarely considered to the required level. These social factors range from simple socio-demographics (Majić and Bath, 2010; Kellert, 1985; Bjerke and Vitters, 2000; Ericsson and Heberlein, 2003; Kleiven *et al.*, 2004) to wider societal experiences, cultural norms, expectations and beliefs (Dickman, 2008). Specifically, Binggeli (2001) and Pasiecznik *et al.* (2001) propose that people's perceptions of invasive species depend upon whether or not their economic needs are met by the species. In the Indian province of Rajasthan, for example, local people's perceptions of *P. juliflora* were favorable during the early stages of its introduction. At that time, it was welcomed as a field boundary

marker and helped avert a significant fuel wood shortage. Peoples' perceptions changed later as the negative effects of the invasion such as colonization of agricultural land, its sharp thorns, suppression of grasses and crops became more pronounced. Income/wealth levels, dominant livelihood strategies/occupations and gender are also important determinants of how individuals perceive invasive species (Mwangi and Swallow, 2005).

Related to perception, Veitch and Mick (2001) also suggest other factors that influence people's perceptions of an invasive species. These include the extent of damage of the species to property and/or natural ecosystems (e.g. weeds in a crop, insects eating a crop, destruction of native trees), the physical appeal of the species, the opinions of powerful, charismatic and influential individuals and the media's portrayal and the costs of managing the species. From these review, it seems that people's perceptions are fundamentally shaped by the way their daily lives interface with the species and how it affects their livelihoods and local economies. An economically beneficial species will more likely be favored in as far as the costs of managing it do not exceed the discernible benefits.

Therefore, integrating risk perceptions with TPB can help further clarify interpretations and evaluations of potential hazards, which also affect the construction of perceptions and its factors. Under this integrated framework, according to this study examination of the conceptual framework, focusing on the direct relationship between perceptions and factors (natural environment, asset endowment, livelihood diversification, household characteristic and institutional factors).

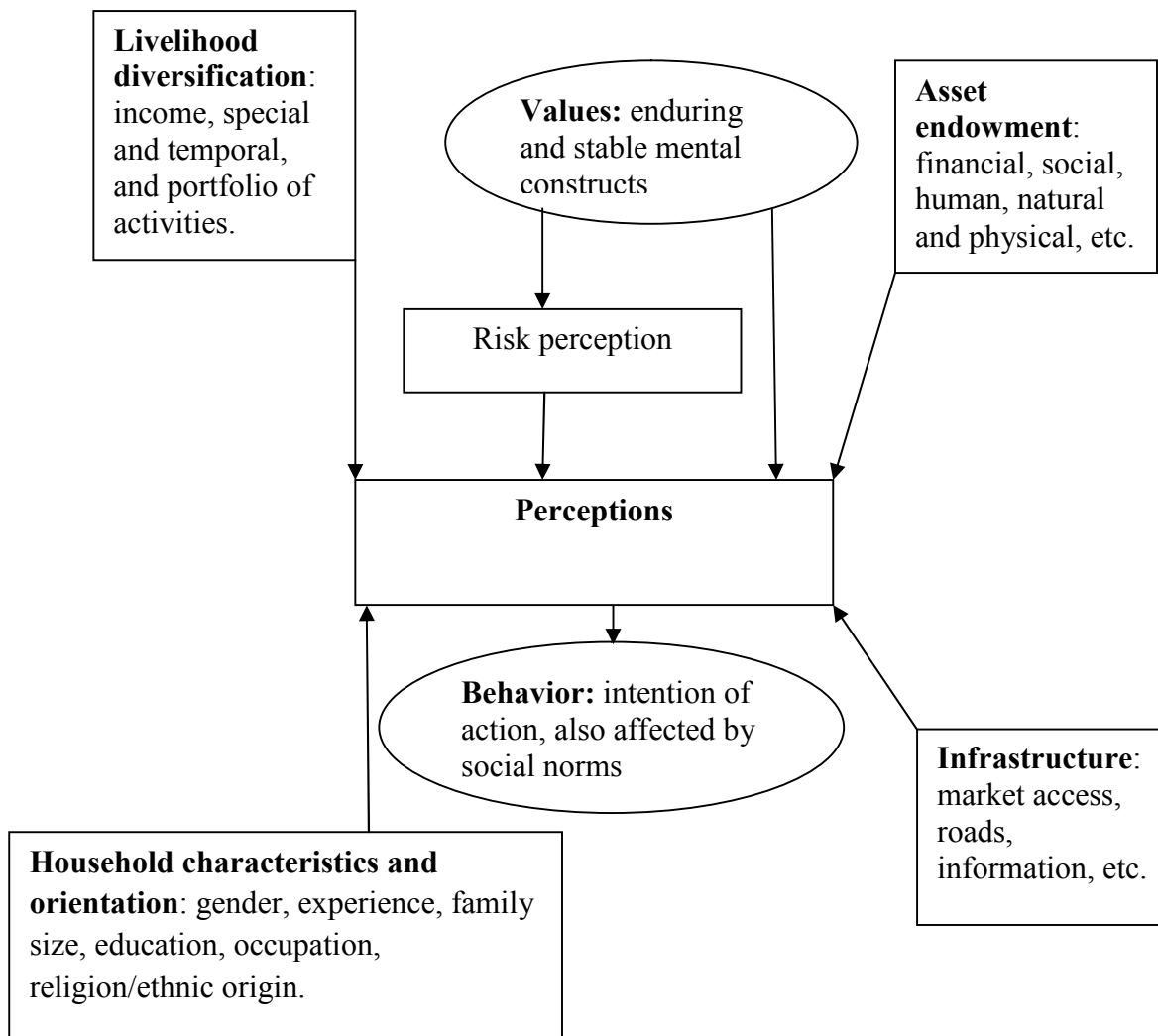


Figure 1: Conceptual framework of the study

Source: Barnes (2013)

2.6. Methodological Framework

Since human being is complex in nature, it is difficult to measure their perceptions, attitude, character and personality because of its subjective nature. However, it is necessary to analyze human behavior applying various research methods. Over the years, numerous methods have been used to measure character and personality traits of the human (Likert, 1932). It is very difficult to measure perception, attitude, character and personality in numerical form. The perceived need of this quantification lies in the necessity to transform an individual's

subjectivity into an objective reality (Joshi *et al.*, 2015). In qualitative research, there are the possibilities to explore human subjective feeling through follow up ideas, probe responses, and investigate motives and feelings (Bell, 1999). However, social scientists still rely on quantitative measures of perceptions, attitudes, character and personality traits (Boone and Boone, 2012) which is a crucial but difficult task. In the way of searching solution, Likert (1932) introduced the summative method to measure perceptions or attitudes which is now popularly known as Likert Scale and has been widely using as a tool to collect data specifically in survey research (Weng and Cheng, 2000).

Likert type data are commonly used to measure perceptions or attitudes providing a range of responses to a given question or statement. It is an essential tool in psychology and in social surveys, and is an ever-present method of collecting attitudinal data (Dittrich *et al.*, 2007). Typically, there are 5 categories of response: from strongly disagree to strongly agree, although there are arguments in favor of scales with 7 or with an even number of response categories (Jamieson, 2004). It can be combined the responses from the series of questions to create an attitudinal measurement scale (Boone and Boone, 2012). Likewise, the researcher of this study used different likert related questions (i.e. Likert scale) to measure perceptions.

Then after to assess the determinants of households' perceptions, response category will be changed to proportion by constructing an index based on sample household heads' perception measured using Likert scale. Perceptions of these households on invasive species would be putted between 0.2 and 1.

When the regression model has a limited dependent variable, it can be tricky to decide on the appropriate way to model it. One of the approaches for such type of dependent variable is to treat it as a binary response, and then run a logistic or probit regression. This will only work if the proportion can be thought of as a dichotomous, and the available data for the number of successes and failures. The second and simplest approach is to do a linear regression. The big problem with OLS regression is that the model can predict values that are not possible-values i.e. below 0.2 or above 1. The other problem is that the relationship might not be linear. Additionally, the weakness of such model (i.e. OLS) lies in the concentration of zero values

“observed” in the two limits. This will cause the fitted regression line to be too flat (Goldberger, 1964); consequently, coefficient estimates will be biased small (Cynthia and Yoram, 1986). Therefore, OLS is inconsistent with censored data, both under when estimating with the entire sample and with the uncensored subsample. The third approach is to treat the proportion as a censored continuous variable. Censoring means don’t have information both from below and/or above. It can also take account of interval censored data. If this approach is taken, it is important to run as a two limit Tobit model (Long, 1997).

Some of advantages of using Tobit model over OLS for limited dependent variable

Firstly, if we include the censored observations as $y = 0$, the censored observations on the left will pull down the end of the line, resulting in underestimates of the intercept and overestimates of the slope. Secondly, if we exclude the censored observations and just use the observations for which $y > 0$ (that is, truncating the sample), it will overestimate the intercept and underestimate the slope. Thirdly, the degree of bias in both will increase as the number of observations that take on the value of zero increases (Fernando, 2011).

However, the Tobit model uses all of the information, including info on censoring and provides consistent estimates. It is also a nonlinear model and similar to the probit model. It is estimated using maximum likelihood estimation techniques (Tobin, 1958). Therefore, a two limit Tobit model would be constructed for each objective.

Tobit Model

Tobit model originally developed by James Tobin, the Nobel laureate economist. It is also known as a censored regression model. Some authors call such models limited dependent variable regression models because of the restriction put on the values taken by the regressand. Statistically, we can express the Tobit model as

$$\begin{aligned} y_n^* &= \beta_n x_n + u_n \\ y_n &= y_n^* \text{ if } L_1 < y_n^* < L_2 \end{aligned} \tag{1}$$

$$= 0 \text{ otherwise}$$

The model is called Tobit because it was first proposed by Tobin (1958), and involves aspects of probit analysis – a term coined by Goldberger for *Tobin's Probit*. The likelihood function for the Tobit model takes the form:

$$L_n = \Phi \left[\frac{L_1 - \beta' X_n}{\sigma} \right]^{d_{n_0}} \left[\frac{1}{\sigma} \phi \left(\frac{y_n - \beta' X_n}{\sigma} \right) \right]^{d_{n_1}} \left[1 - \Phi \left(\frac{L_2 - \beta' X_n}{\sigma} \right) \right]^{d_{n_2}} \quad (2)$$

This is an unusual function, it consists of two terms, the first part corresponds to the classical regression for the uncensored observations (it is the pdf), and the second part corresponds to the relevant probabilities that an observation is censored (it is the cdf). Though linear least squares estimation of the tobit model is inappropriate, maximum likelihood estimation is no more difficult, and is preprogrammed in every contemporary econometrics computer program. The log-likelihood function for the above equation is:

$$\ln L_n = d_{n_0} \left[\frac{L_1 - \beta' X_n}{\sigma} \right] d_{n_1} \left[-\ln \sigma + \ln \phi \left(\frac{y_n - \beta' X_n}{\sigma} \right) \right] + (1 - d_{n_2}) \ln \left[1 - \Phi \left(\frac{L_2 - \beta' X_n}{\sigma} \right) \right]$$

The overall log-likelihood is made up of two parts. while.

Marginal Effects in the Tobit Model

The marginal effect is the effect on the conditional mean of the dependent variable of changes in the regressors. This effect varies according to whether interest lies in the latent variable mean $x\beta$ or the truncated or censored means.

1. Marginal effect on the latent dependent variable, y^* :

$$\text{Latent variable: } \frac{\partial E[y^* | x_n]}{\partial x_n} = \beta_n$$

Thus, the reported Tobit coefficients indicate how a one unit change in an independent variable X_n alters the latent dependent variable.

2. Marginal effect on the expected value for y for uncensored observations:

Truncated (at 0 and 1): $\partial E[y, 1 > y > 0|x] / \partial x_n = \beta_n \left\{ 1 - \lambda(\alpha) \left[\frac{x_n \beta}{\sigma} + \lambda(\alpha) \right] \right\}$

where $(\alpha) = \frac{\phi(\frac{x_n \beta}{\sigma})}{\Phi(\frac{x_n \beta}{\sigma})}$. This indicates how a unit change in an independent variable X_n affects uncensored observations.

3. Marginal effect on the expected value for y (censored and uncensored):

Censored (at 0 and 1): $\partial E[y|x] / \partial x = \Phi\left(\frac{x_n \beta}{\sigma}\right) \beta_n$.

3. RESEARCH METHODOLOGY

In this chapter, short descriptions of the study areas, sampling design, data sources and collection methods, methods of data analysis, variables definitions and hypothesis are presented.

3.1. Description of the Study Areas

The study was conducted in Amibara and Tulo districts of Afar and Oromia regions of Ethiopia respectively and their brief descriptions are presented below.

3.1.1. Amibara district

Amibara district is one of the six districts of zone three (Gebi Rassu), which is far from Addis Ababa at a distance of 250 kms and is located in the Afar Regional State in eastern Ethiopia at geographic coordinates of 09°13'–09°30' N and 40°05'–40°25' E. The district covers a total land area of 2,941 km² and a home of 40,175 inhabitants. Amibara district is where *P. juliflora* was presumed to be initially planted in the region, and the invasion has become seriously pronounced. The study area has a physiographic dominated by plains, with a slope range of 0–8% and altitude range of 665–815 meter above sea level. The main soil types in the area include Eutric Fluvisols, Eutric Cambisols, and Vertic Cambisols (MoA, 1997).

The climate can generally be described as arid to semiarid, with maximum and minimum temperatures varying from 25 to 42°C and 15.2 to 23.5°C, respectively, and an average annual rainfall of 560 mm (WAS, 2008). May and June are the driest months, whereas July through September is the main rainy season, during which flash floods originating from the highlands recurrently overtop the Awash River bank and damage the surrounding area.

There are eighteen kebeles (the smallest administrative units next to district in Ethiopia) under Amibara district; three urban and fifteen rural kebeles. Based on the 2007 census population

projection, the district had a total population of 76,649 people. Out of these, 37.7% were urban inhabitants, 51.96% agro-pastoralists and 10.34% pastoralists.

Transhumance pastoralism is the major production system in the study area, where cattle, camel, goats, and sheep are the dominant animals being reared. The cattle population of Afar State is approximately 1,620,147, with 131,832 of them found in Amibara district. Livestock are kept primarily for their products (milk, milk products, and meat) and income generation. Over 90% of the population depends largely on the milk from cattle, sheep, goat, and camels as their staple food. Furthermore, for the rural communities of the region including Amibara, livestock production is the most dependable portfolio for multiple purposes such as food consumption, income-generation, transport and asset reserves (Ilukor *et al.*, 2014).

3.1.2. Tulo district

Tulo district is one of the 309 districts in Oromia Regional State and it is one of the 19 districts in West Harerge Zone which is found in the north eastern part of West Harerge Zone located in the eastern part of Ethiopia. It is about 374 Km away from Addis Ababa and 48 Km away from Chiro town, the administrative seat of West Harerge zone. Tulo is surrounded by three districts of West Harerge zone and two districts of East Harerge zone. It shares boarder on the south with Mesella district, on the north with Doba district, on the west with Chiro district and on the east with East Harerge zone. Towns in Tulo include Hirna and Doba, where Hirna is the administrative seat of the district. The total area of the district is about 450 Km². According to the districts agricultural office report (2014), from the total land area of the district potentially cultivable land constitute 23337 ha, arable (cultivated) land 13280 ha, natural forest 524 ha, manmade forest (reforested) 2426 ha, uncultivable land (hills) 2805 ha, grazing land 253.3 ha and others 4737 ha. Attitudinally the district stretches from 1500 – 28000 masl. Topographically, the district includes lowlands, highlands and valleys.

Climatically, the district is classified into highland (dega) 43.3%, midland (woinadega) 53.7% and lowland (kola) 3%. Rain fall is bi-modal and ranges from 650 to 1200 mm, with an average annual rain fall of 750 mm. There are two rainy seasons, Belg and Meher. The *Belg*

rain extends from March to April while the *Maher season* is from mid-June to end of September. The temperature of the district ranges from 16 to 33⁰c. Hirna, Burka, Dabaso and Burka Recha rivers flow through the district. They have the potentials to irrigate about 1334 hectare of land.

Based on the 2007 Ethiopian population and housing census projection, the population of Tulo District in 2006 EFY is estimated to be 179,078 people of whom 87,627 (48.9%) are females. Among the total population of the district 18,413 (10.3%) are urban dwellers, of which 9,537 (51.8%) are males. The majority of the inhabitants, 78.72% are Muslim, while 20.04%, 1.09%, and 0.06% are Orthodox Christian, Protestant, and Catholic religion followers respectively. Among the different ethnic groups in the district, Oromo constitute the majority (78.67%), while 20.46% are Amhara. Other ethnic groups total less than one percent of the population. Afan Oromo is spoken as a first language by 79.61% of the population and 19.96% speak Amharic and the remaining 0.43% speaks all other primary languages.

The majority of the districts population (89.7%) lives in the rural areas. Therefore the main livelihood of the population is the sedentary mixed farming system, which is heavily dependent on crop and livestock production. According to the district's agricultural office's report (2014), the major food crops produced in the area are sorghum and maize. Haricot beans are also the dominant crop grown in all agro-ecological kebeles of the district, while barley and wheat is grown in the highland areas. Khat, coffee, sweet potato, potato and onion are the major cash crops grown in the area. Among the total 30 rural kebeles (Farmers' Association) inhabitants, 15 Farmers' Association (FAs) belongs to the sorghum, coffee, khat, haricot bean and livestock producer, and the rest 15 FAs belong to maize, barley, wheat, khat, sweet potato, potato, onion, pepper, tomato and livestock producer. Animal fattening and animal products are good sources of cash income to households of the district. Especially, the oxen fattening, which generate 20,000 birr – 47,000 birr per ox is one of the major cash income to the farmers, within two to three months of fattening period. This make Tulo district one of the areas that supply fattened Harar oxen for beef producers in Ethiopia in particular to Addis Ababa. According to the districts agriculture office report in 2005/2006 E.F.Y a total of

20,469 hectare of land has been planted with different crops and 221,293.4 quintal crops produced (cited in Gebeyehu, 2014).

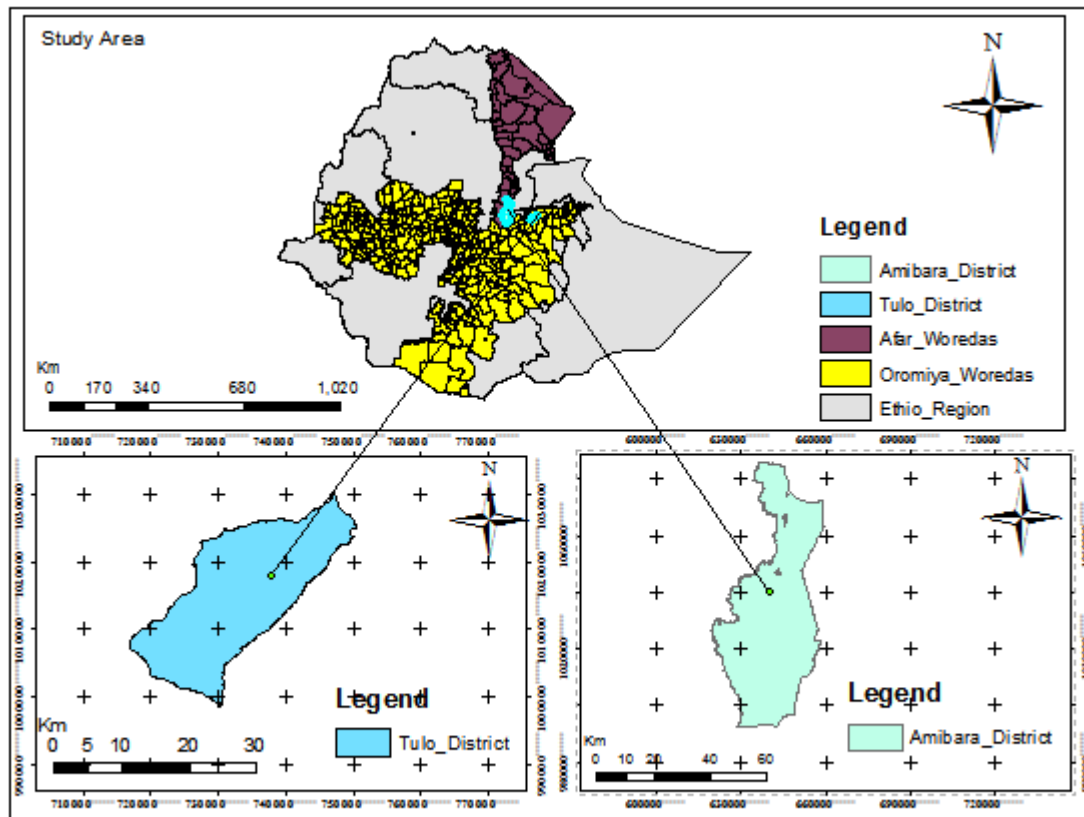


Figure 2: Map of the Study Area

3.2. Sample Size and Sampling Technique

The research followed two stages sampling procedure to select the required number of sample units. Amibara and Tulo districts were purposively selected since there is high invasion of *P. juliflora* and *L. camara* species in the area respectively. Firstly, out of 15 and 30 rural kebeles, 5 and 10 kebeles, were randomly and independently selected from Amibara and Tulo districts with the consent of community representatives and the districts experts on this issue, respectively. Secondly, 130 household heads were randomly and independently selected from each district's kebeles using Probability Proportionate to Size technique. In doing this, the

minimum sample size required for the study was determined by using Cochran's sample formula as indicated in equation (3).

$$n = \frac{(z)^2 * p(1-p)}{(e)^2} \quad (3)$$

$$n = \frac{(1.96)^2 * 0.5(1-0.5)}{(0.085)^2} = 130 \text{ Household heads}$$

Where, n is the required sample size; Z is confidence level, here Z= 1.96; p is the estimated proportion of an attribute that is present in the population which is assumed to be 50%; and e is margin of error (accepted level of precision by the investigator), in this case 0.085.

Table 2: Number of sample households from each kebele

District	Sample kebele	Total household heads	Sampled household heads	Percent age
Amibara	Serkamo	704	20	15.4
	Melka sedi	1091	31	23.8
	Halaydege	1161	33	25.4
	Kel'at buri	774	22	17
	Angelele	845	24	18.4
Total		4575	130	100
Tulo	Lubu-dhaqeb	822	14	10.8
	Odaa naga	617	10	7.7
	Burqa jalela	629	10	7.7
	Kirakufis	831	14	10.8
	Terkanfata	740	12	9.2
	Ragasis	925	15	11.5
	Hunde lafto	581	10	7.7
	Ifa-bas	830	14	10.8
	Qufanziq	1130	19	14.6
	Waltahi	718	12	9.2
Total		7823	130	100

3.3. Methods of Data Collection

In this study, both primary and secondary data were used. The data had of both quantitative and qualitative nature.

3.3.1. Primary data source

Primary data were collected from sampled respondents through semi-structured questionnaire. Thus data were collected on the demographic, socio-economic, institutional and attitudinal characteristics of rural households.

To gather reliable information, enumerators who know the local norms and customs, and language were selected and trained on how to collect the data using questionnaire. The survey instruments were also translated into local languages (*Afar aff* and *afan Oromo*) for respondents.

3.3.2. Secondary data sources

Secondary data were collected from written documents including those from pastoral and agricultural rural development bureaus and recent research works which were related to the study and study areas. It includes review of relevant journals, books, conference proceedings, academic theses and dissertations, reports from respective administrative layers. Different offices and individuals were contacted to secure additional information.

3.4. Methods of Data Analysis

Data were analyzed using both descriptive statistics and econometric model.

3.4.1. Descriptive statistics

Socio-economic characteristics of the respondents in the study areas were summarized and presented using descriptive statistics such as standard deviation, average, percentage and tables. ANOVA and Kruskal-wallis test were employed to check the existence of statistically significant difference between different perception categories in terms of household characteristics. Response measures taken by local communities against IAS were also described qualitatively.

3.4.2. Measuring perceptions

One of the objectives of this study was to examine households' perceptions in Amibara and Tulo districts towards the effect of *P. juliflora* and *L. camara* invasions respectively. The term "perceptions towards *P. juliflora* or *L. camara*" refers to a positive or negative set of beliefs that an individual may hold on these species. To quantify overall perceptions, a scale was constructed following the procedure suggested by Likert (1932). A scale consists of items that can be scored which represents both attitudinal direction and strength. Each individual item is carefully designed. The items are called perception or attitudinal statements which were written to be meaningful and interesting, even exciting to respondents. The statements were no more than 20 words long and written in simple, clear and direct sentences. Items were then attached to a five-point Likert scale ranging from "strongly disagree" to "strongly agree" with the mid-point being "indifferent". Positive items were scored from 1 to 5 respectively, whilst negative items were scored in reverse. Overall perception score for each district was independently calculated by using question number 30 and/or 31 of Appendix 7.1. and 7.2. A mean score across all items was calculated for each respondent taking into consideration any items not answered. Respondents' score were then summed and converted into a perception score ranging from 0.2 to 1. Finally, by using this index, perception was regressed up on hypothesized explanatory variables.

Perception index

Households' perceptions about *Prosopis* and *Lantana* were computed using weighted perception index. It will be computed by leveling a weight to each factor based on perception level perceived by sample households. Households' perception index about IAS is computed as the sum of perception level perceived by sample households for each factor to the number of variables that describes impacts of IAS.

Farmer's perception index is given as:

$$PI_Y = \frac{\sum_{j=1}^5 X_j}{V} \div 5 \quad (4)$$

Where,

PI_Y Indicates perception index for household head Y

X_j $J=1, 2 \dots 5$ variables used to indicate perception (likert item statement)

V is number of indicative variables (i.e. number of likert item statements)

Reliability of the Likert Scale

Basu (2016) mentioned that in calculating reliability of Likert type measurement Cronbach's alpha is better to use for interval nature of Likert data. Concerning literatures showed that in most of the cases Cronbach's alpha had been used to measure internal consistency or reliability of a psychometric instrument like Likert data. Additionally, experts suggest using the Cronbach's alpha test to provide evidence that the components of the scale are sufficiently inter correlated and that the grouped items measure the underlying variable (Sullivan, 2013). Cronbach's alpha is most widely and frequently used reliability index. It is a statistic and generally used as a measure of internal consistency or reliability of a psychometric instrument like Likert data. In other words, it measures how well a set of variables or items measures a single, one-dimensional latent aspect of individuals. A score of more than 0.7 is usually okay. However, some authors suggest higher values greater 0.90 (Stephanie, 2017).

3.4.3. Econometric Analysis

Two limit Tobit model

In this situation where the dependent variable is limited in its range; using ordinary least squares for such data is known to lead to biased and inconsistent parameter estimates given the censored nature of the data (Greene, 2003). This nature of the data prompted the use of a Tobit model, which yields consistent and asymptotically normal maximum likelihood estimators of parameters (Kennedy, 2003). The detailed structure of the model (i.e. two limit Tobit model) is given below:

$$y_n^* = \beta_n x_n + u_n \quad (5)$$

$$y_n = L_1 \text{ if } y_n^* \leq L_1$$

$$y_n = L_2 \text{ if } y_n^* \geq L_2$$

$$y_n = y_n^* \text{ if } L_1 < y_n^* < L_2$$

Where y_n^* (HHperc) is the latent variable (unobserved for values smaller than L_1 i.e. 0.2 and greater than L_2 i.e. 1) representing the perception level; x_n is a vector of independent variables, which include the factors affecting household perception; B_n is a vector of unknown parameters to be estimated; and U_n the disturbance assumed to be independently and normally distributed with 0 mean and constant variance.

The likelihood function for the n th observation ($n=1,2,\dots,N$) of the two-limit tobit model is given by:

$$L_n = \Phi \left[\frac{L_1 - \beta' X_n}{\sigma} \right]^{d_{n0}} \left[\frac{1}{\sigma} \phi \left(\frac{y_n - \beta' X_n}{\sigma} \right) \right]^{d_{n1}} \left[1 - \Phi \left(\frac{L_2 - \beta' X_n}{\sigma} \right) \right]^{d_{n2}}$$

Where $\Phi(\cdot)$ is the standard normal cumulative distribution function, $\phi(\cdot)$ is the standard normal probability density function, β is the vector of regression coefficients, σ is the standard deviation, X_n is the matrix of independent variables, and y_n is the observed value of the normally distributed dependent variable. For each observation, one of the exponents d_{nj} ($j=0, 1, 2$) will take a value of one, depending upon whether the value of the observed Y_n is equal to the lower limit, is in the interval between limits, or is equal to the upper limit, respectively, and all other exponents will take a value of zero.

The expected value of y_n in the interval between L_1 and L_2 is:

$$\int_{L_1}^{L_2} y \frac{1}{\sigma} \left[\frac{\phi((y - \beta' X_n)/\sigma)}{\Phi_{2n} - \Phi_{1n}} \right] dy,$$

Where Φ_{1n} and Φ_{2n} represent the cumulative distribution function of the standard normal, evaluated at $(L_1 - \beta' X_n)/\sigma$ and $(L_2 - \beta' X_n)/\sigma$, respectively. An alternative expression for

the conditional expectation which does not require integration over the dependent variable has been defined by Maddala (1983) as follows:

$$E(y_n | L_1 < y_n^* < L_2) = \beta' X_n + \sigma \frac{\phi_{1n} - \phi_{2n}}{\Phi_{2n} - \Phi_{1n}},$$

Where ϕ_{1n} and ϕ_{2n} represent the probability density function of the standard normal, evaluated at $(L_1 - \beta' X_n)/\sigma$ and $(L_2 - \beta' X_n)/\sigma$, respectively. Either expression may be used to estimate the change in the expected Value of y_n given a change in a conditioning variable X_{nk} .

3.5. Variables Definitions and Hypotheses

3.5.1. Dependent variable

The dependent variable for the two limit tobit model is household perception (HHperception) developed using households' response on different perception indicators (i.e. statements about the effects of the *P. juliflora* and *L. camara* invasion) by constructing an index whose value ranges between 0.2 and 1. As the index approaches towards one, the sampled household considered to have positive perception to the plants invasion; otherwise, negative perception.

3.5.2. Independent variables

Based on review of literature, the following hypotheses were made on the relationship between the dependent and the independent variables.

Age of the household head (ageHH): This is a continuous variable which refers to the household head's age in years. As the household head's age increases, it is assumed that individuals would be endowed with knowledge as to how to diversify his sources of income and how to use IAS in a better way. Hence, it was expected to have a positive effect on household perception (Fischer and van der Wal, 2006).

Gender of the household head (Gender): It is a dummy variable that takes a value of 1 if the household head is male and 0 otherwise. Colonization of invasive species has a greater impact on women. For one thing, female have greater responsibility in household chores including collection of firewood and searching feed for the small ruminants and newly born ones. Accordingly, women, who heavily depend on *P. juliflora* and *L. camara* for firewood and use their pod or leaf as feed, will likely enjoy greater benefits from thus invasive plants. Thus, it was hypothesized that households' perceptions would be negatively influenced by maleness (Veitch and Mick, 2001; Mwangi and Swallow, 2005; Fish *et al.*, 2010).

Education (EduHH): This is measured in years of formal schooling. As education level increases, it was assumed that an individual will have a skill to know more about the adverse effects of IAS on his day to day activity and livelihood. Therefore, it is hypothesized to negatively influence perceptions.

Family size (FamilyAE): This refers to the size of household members who live together under the same roof expressed in adult equivalent (AE). It was assumed that large family size provides sufficient labor to manage and utilize IAS plants and farming operation. Therefore, it was hypothesized that a household with large family size (AE) positively associate with household perceptions (Zeraye, 2008; Opiyo *et al.*, 2016).

Livelihood strategy (Diversn): It is a dummy variable taking one if household pursues pastoralism only and zero otherwise. The livelihood strategies pursued by the household affects the distribution of costs and benefits of living with *P. juliflora* among actors in society. Pastoralists would incur higher costs due to pasture depletion and farmland clearing. People pursuing livelihood strategies such as trading of *P. juliflora* products would accrue greater benefits. Hence, pastoral livelihood and perception are expected to be negatively correlated (Zeraye, 2008; Rai *et al.*, 2012; Mohammed, 2012; Wakie *et al.*, 2016).

Proximity to the bush land (Proximity): This is a continuous variable used as proximity to the bush land measured in kilometer to reach the nearest bush land products. Bush lands

consisting of grasses and trees (natural and planted) which uses as a source of fuel wood and fodder for cattles. Proximate users are more dependent on thus bush land products compared to their distant neighbors. Distant households experienced low-level of effects compared to respondents living in closer proximity to the bush lands. This relationship signifies that the infestation of invasive plants influences the bush land-dependent households' utmost as it influences the availability of bush land products by displacing native species (Sapkota and Oden, 2008; Rai *et al.*, 2012). Therefore, it was expected to be positively correlated with the dependent variable.

Livestock owned (tluliv): This represents the total number of livestock holding of a household measured in Tropical Livestock Unit (TLU) which was computed by appropriate conversion. The more livestock a household owns, the more culturally defined way of life the household would live. Since *P. juliflora* and *L. camara* invasion reduces household's livestock asset, it is unlikely perceived by pastoralists and farmers. Hence, it was hypothesized that a higher number of livestock ownership (in TLU) negatively affects the dependant variable (Binggeli and Desalegn, 2002; Zeraye, 2008; Mohammed, 2012).

Land holding (Landhold): It refers to the total land (in hectare) a household owns including farm and pasture land. Individuals would more likely to invest to eradicate and manage *P. juliflora* and *L. camara* existed in their own private land. As a household own more land, it obliges to incur higher cost to eradicate and manage thus invasive plants taking into account the level of invasion. So, households strongly disfavored the species. Therefore, land ownership negatively influence perception of the household about IAS (Binggeli and Desalegn, 2002; Mohammed, 2012).

Access to technology (technology): It was a dummy variable taking a value of one if the household have access to technologies that can ease use of IAS and zero otherwise. Technologies that help individual to ease the *P. juliflora* and *L. camara* products processing (i.e. pod crushing, fuel wood or charcoal production and timber production) will improve households' perceptions towards thus invasive species. Therefore, it was expected to have positive effect on households' perceptions about the invasion of IAS.

Extension service (Extension): This refers to the number (frequency) of contacts per year that the household head made with development agents. It is hypothesized that contact with extension agent is negatively related with households perceptions about IAS, thus improves households' awareness and knowledge about the adverse effects of invasion so that household develop negative perception and attitude against invasion about IAS. Additionally, DAs might not have adequate skill and knowledge about effective utilization of the IAS (Mohammed, 2012).

Total household income (IncomeHH): It refers to total income that household earned in birr from engaging in IAS product selling. The distribution of these costs and benefits would positively influence the perceptions of individuals about IAS. Those who obtained higher benefits relative to costs would more likely to favor the invasive species, while those whose costs are higher than benefits would strongly disfavor the species (Pasiecznik *et al.*, 2001; Mohammed, 2012; Elca, 2013).

Market distance (Mktdistance): It is a continuous variable used as proximity to the market center measured in kilometer to reach the nearest major wood product market place, in this case IAS products (charcoal, fuel wood and timber). Access to market may create opportunities to get information about market demand and supply, and sell agricultural and IAS products. Distant households from the market place disfavor the species compared to others as they are not able to benefit from marketing IAS products. Hypothetically, it was anticipated to have inverse relationship between market distance and households' perceptions about IAS (Mohammed, 2012; Opiyo *et al.*, 2016).

Farm Experience (Expcfarm): This is a continuous variable which is measured in years that a household head had spent on farm production. Experience on farming is expected to have a negative effect on households' perceptions about *P. juliflora* and *L. camara* invasions, since it discourages farming productivity via its negative effects (Mohammed, 2012).

Table 3 : Variable Definitions and Hypothesis

Description of variables	Code	Type	Expected sign	Measurement
Household perception	HHperc	Continuous		Perception level which is changed to proportion by using an index
Gender	Gender	Dummy	-	1= Male 0= Female
Age	AgeHH	Continuous	+	Number of years lived
Education level	EduHH	Continuous	-	Classes of education
Family size	FamilyAE	Continuous	+	Total number of family members in terms of adult equivalent
Livelihood strategy	Divern	Dummy	-	1= Only pastoralism 0 = Otherwise
Proximity to the bush land	Proximity	Continuous	+	Distance from the nearby bush land in Km
Livestock owned	Livtlu	Continuous	-	Number of cattle owned by the household in TLU
Land holding	Landhold	Continuous	-	Total area of land holding in ha
Extension service	Extension	Continuous	-	Number of extension contacts in a year
Access to technology	Technology	Dummy	+	1= Access to technology 0= otherwise
Total household income	IncomeHH	Continuous	+	Total household income per year in Birr
Market distance	Mktdistance	Continuous	+	Total distance from the center nearby market in Km
Farm experience on crop production	Expecfarm	Continuous	-	Number of years a household spent on crop production

4. RESULTS AND DISCUSSION

In this chapter, both descriptive and econometric model results are presented and discussed in comparison with the results of similar studies.

4.1. Household Characteristics

4.1.1. Characteristics of households in Amibara district

4.1.1.1. Demographic characteristics

Results presented on Table 4 indicate that, the sample respondents constitute 16 (12.30%) female and 114 (87.69%) male household heads. Further disaggregation of sex based on respondents perception about *P. juliflora* showed that out of the total female headed sample households, 11 (68.8%) disfavored *P. juliflora*, 4 (25%) were indifferent and 1 (6.2%) female headed sample household favored it. Out of the total male headed sample households, 106 (93%) disfavored the species and 8 (7%) were indifferent. Generally, out of the 130 sample household heads, 117 (90%) of them considered the species as bad, 1 (0.77%) as desirable (good) and the rest 12 (9.23%) were indifferent. Proportionally female household heads favored the species compared to male household heads and this observed perception difference between the two gender groups was statistically significant at 1% probability level.

With respect to marital status, 126 (96.9%) sample household heads were married, 2 (1.53%) were divorced, 1 (0.77%) was widowed and 1 (0.77%) was single. Perception wise, from 126 married household heads, 114 (90.5%) disfavored *P. juliflora*, 11 (8.73%) were indifferent and 1 (0.8%) favored it. From divorced household heads half of them i.e. 1 (50%) disfavored the species and half of them i.e. 1 (50%) was indifferent. The rest single and widowed household heads perceived the species as bad. The finding confirms that most of the respondents were married and they disfavored the species (Table 4).

Table 4: Descriptive statistics results (categorical variables) for Amibara district

		Household Perception								
Variable	Category	Bad		Indifferent		Good		Total		χ^2 - value
		Fre.	%	Fre.	%	Fre.	%	Fre.	%	
Gender	Female	11	68.8	4	25	1	6.2	16	100	8.7***
	Male	106	93	8	7	0	0	114	100	
Marital Status	Married	114	90.5	11	8.7	1	0.8	126	100	3
	Single	1	100	0	0	0	0	1	100	
	Divorced	1	50	1	50	0	0	2	100	
	Widow	1	100	0	0	0	0	1	100	
Total		117	90	12	9.2	1	0.8	130	100	

Note: *** indicates significance at 1% probability level.

Source: Own survey result

Descriptive results of continuous variables show that mean age of the household head was 39.13 years ranging from 22 and 99 years. Almost all (95%) sample respondents age fall below 64 years and this shows that most of them were within their productive age and actively involved in farm activities in the study area. With regards to perception category, the mean ages of sample household heads who disfavored, indifferent and favored *P. juliflora* were 38.4, 45 and 45.8 years respectively. Sample respondents' mean age difference between the three perception categories was statistically significant at 10% probability level (Table 5).

With regard to education level, in general, sample household heads have attended maximum of 10+3 class years and almost above 80% do not have formal education. The average family size of the household in terms of adult equivalent was 4.03 with a standard deviation of 1.45. The minimum family size was 1 and the maximum family size was 9.4 adult equivalent. Based on the ANOVA analysis, the mean family size difference between the three perception categories was statistically significant at 5% probability level (Table 5).

The average number of years that the household heads lived in the area was, on average, 38.50 years with a standard deviation of 11.64. The minimum years that the sample household heads lived in the study area was 5 years and the maximum was 99 years. The aforementioned scenario may indicate that most respondents were native to the area since the difference between average age of household heads and average year that households lived in the area is

too small. With regards to perception, sample household heads that perceived bad, indifferent and good about *P. juliflora* had lived in the study area on average for 37.7, 45 and 45.8 years respectively. And this mean difference in year of living in the study area among the three perception categories was statistically significant at 10% probability level (Table 5).

Table 5: Descriptive statistics results (continuous variables) for Amibara district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-value
		Bad	Indifferent	Good	Total				
Age	130	38.4	45	45.8	39.1	11.5	22	99	2.5*
Education	130	0.5	0	0	0.5	1.8	0	13	0.7
Year lived	130	37.7	45	45.8	38.5	11.7	5	99	2.9*
Family (AE)	130	3.9	3.3	5.1	4	1.5	1	9.4	3.9**

Note: * and ** indicates significance at 10% and 5% probability level respectively.

Source: Own survey result

4.1.1.2. Institutional factors

In Amibara district, the distance that sample households travel to the nearest market ranges from 3 km to 55 km with a mean of 27.61km. The study result shows that households who disfavor, indifferent and favor on average travel 28.8, 18 and 17.2 km respectively with statistically significant mean difference in terms of distance to the nearest market between the three perception groups at 10% probability level (Table 6). As Table 7 depicts, sample respondents home on average far away from the nearest bush land by 16.31 km. The minimum and maximum distances were 0.5 and 40 kms respectively with standard deviation of 10.22. Perception wise, sample respondents' who have bad, indifferent and good perception towards *P. juliflora* were have on average 16.4, 40 and 13.25 km proximity to the nearest bush land. Thus mean distance difference between the three perception categories was statistically significant at 5% probability level. Similarly, sample households were having on average six contacts per year and a maximum of 45 contacts with an extension agent. With regards to their perceptions, respondents that have bad and good perception towards *P. juliflora* have a mean of six and two contacts per year with DA respectively. Based on the ANOVA analysis, the mean difference in terms of extension contact between the two perception groups was statistically significant at 10% probability level (Table 6).

Table 6: Descriptive statistics results for institutional factors in Amibara district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-value
		Bad	Indifferent	Good	Total				
Market distance	130	28.8	18	17.2	27.6	17.8	3	55	2.5*
Proximity	130	16.4	40	13.2	16.3	10.2	0.5	40	3.3**
Exservice	130	6	0	2	5.7	6.7	0	45	2.4*

Note: * and ** indicates significance at 10% and 5% probability level respectively.

Source: Own survey result

As depicted in Table 7, out of the total sample respondents, 78 (60%) have access to irrigation while 52 (40%) did not have an access to it. With regards to perception category, from sample household heads who have access to irrigation, 75 (96%) disfavor and 3 (4%) are indifferent about *P. juliflora*. On the other hand, from non-irrigation user sample household heads, 42 (80.7%) disfavor, 9 (17.3%) are indifferent and 1 (2%) favor the presence of the species. The perception difference among irrigation users and non-users is statistically significant at 1% probability level (Table 7). Furthermore, 64 (49.23%) of the sampled household heads were using mobile for information exchange even though 66 (50.77) did not had mobile (Table 7). From mobile user sample household heads, 56 (87.5%) disfavor, 7 (11%) are indifferent and 1 (1.5%) favor the species. Again, from non-user household heads, 61 (92.4%) disfavor and 5 (7.6%) are indifferent about *P. juliflora* (Table 7). With regard to credit access almost all sample household heads in the study area (i.e. Amibara district) replied as they had no any access for formal credit around their environment (Table 7).

Table 7: Descriptive statistics results for access to irrigation and telephone in Amibara district

Household Perception										
Variable	Category	Bad		Indifferent		Good		Total		χ^2 -value
		Fre.	%	Fre.	%	Fre.	%	Fre.	%	
Irrigation access	No	42	80.7	9	17.3	1	2	52	100	8.2****
	Yes	75	96	3	4	0	0	78	100	
Telephone access	No	61	92.4	5	7.6	0	0	66	100	0.9
	Yes	56	87.5	7	11	1	1.5	64	100	
Total		117	90	12	9.2	1	0.8	130	100	

Note: *** indicates significance at 1% probability level.

Source: Own survey result

4.1.1.3. Household assets and farm characteristics

Livestock ownership was defined in terms of Tropical Livestock Unit (TLU), households who had considered *P. juliflora* invasion as bad and good have a mean of 31.8 and 20.32 TLU respectively while those who were indifferent about the species have 26.57 TLU in average. In general, sample household heads have on average 31.27 TLU with a range from 2.4 to 86.2 TLU (Table 8). Land owned by the sample households was 0.7 hectares, on average. The minimum and maximum land owned were 0 and 4 hectare respectively with a standard deviation of 0.7. With regards to perception, those household heads who perceived bad and indifferent about *P. juliflora* have an average land of 0.72 and 0.5 hectares respectively (Table 8). The average years of experience in crop production was 2.16 years with a standard deviation of 3.47 with a minimum of 0 and a maximum of 25 years experience in crop production. Since most of the Afar people were leading their life through a nomadic way of life, households' mean years of experience in crop production were too low and most of the people in the area are still pastoral. Perception wise, sample respondents that perceived bad and good about *P. juliflora* have an average crop production experience of 1.9 and 4.3 years respectively. Furthermore, according to the ANOVA analysis, there is a statistically significant mean difference in terms of farm experience among the three perception categories at 10% probability level (Table 8).

Table 8: Household asset and farm characteristics in Amibara district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-value
		Bad	Indifferent	Good	Total				
Expcrop	130	1.9	0	4.3	2.16	3.47	0	25	2.82*
TLU	130	31.8	26.57	20.32	31.27	11.39	2.4	86.2	0.77
Landhold	130	0.72	0.5	0	0.7	0.71	0	4	0.36

Note: * indicates significance at 10% probability level.

Source: Own survey result

4.1.2. Characteristics of households in Tulo district

4.1.2.1. Demographic characteristics

Descriptive statistical results of Tulo district indicate that, the sample respondents constitute 24 (18.5%) female and 106 (81.5%) male household heads. From 24 female headed sample households, 16 (66.7%) disfavored *L. camara*, 2 (8.3%) were indifferent and 6 (25%) favored the species. At the same time from 106 male headed sample households, 92 (86.8%) households disfavored the species, 3 (2.8%) were indifferent, and 11 (10.4%) had considered the species as good. Generally, out of the 130 sample households, 105 of them considered the species as bad but 17 households reflected desirable feeling (good) about the species and the rest 5 households portrayed themselves on indifferent/middle perception option. Similar to the results of Amibara district, proportionally female household heads favored the species compared to male household heads and the perception difference between the two gender groups was statistically significant at 5% probability level (Table 9).

With respect to marital status, out of 130 headed sample households 126 were married, 1 was divorced and 3 were widowed. Perception wise, from 126 married household heads, 105 (83.3%) disfavored *L. camara*, 4(3.2%) were indifferent and 17 (13.5%) favored it (Table 9). The rest all divorced and widowed sample household head respondents perceived the species as neutral (i.e. indifferent) and bad respectively. The finding confirms that most of the respondents were married and disfavored the species.

Table 9: Descriptive statistics results (categorical variables) for Tulo district

Household Perception										
Variable	Category	Bad		Indifferent		Good		Total		χ^2 – value
		Fre.	%	Fre.	%	Fre.	%	Fre.	%	
Gender	Female	16	66.7	2	8.3	6	25	24	100	5.5**
	Male	92	86.8	3	2.8	11	10.4	106	100	
Marital Status	Married	105	83.3	4	3.2	17	13.5	126	100	4
	Divorced	0	0	1	100	0	0	1	100	
	Widow	3	100	0	0	0	0	3	100	
Total		108	83.1	5	3.8	17	13.1	130	100	

Note: ** indicates significance at 5% probability level.

Source: Own survey result

At the same time descriptive statistical results of other household characteristics from Tulo district shows that mean age of the household head was 40.62 years with a range of between 20 and 85 years. Perception wise, mean ages of the sample household heads who disfavored, indifferent and favored *L. camara* were 40.54, 42 and 40.70 years respectively. Almost all (96%) sample respondents were in their productive age. The average family size of households in terms of adult equivalent was 4.45 with a standard deviation of 1.78. It had a minimum of 1 and maximum of 9.65 family sizes. With regard to perception category, an average family size of badly, indifferent and good perceived household heads were 4.5, 4.63 and 4.12 adult equivalent respectively. Based on the ANOVA analysis, there was no significant mean age and family size difference among the three perception categories (Table 10).

Similar to that of Amibara district with regard to education level, sample household heads' maximum level of education is 10+3 class years, but over half of them do have gone through formal education. With regards to their perceptions, sample respondents' who disfavored, indifferent and favored *L. camara* had attended 4, 4 and 3 class years, on average, respectively. And thus mean education differences between the three perception categories are statistically significant at 10% probability level (Table 10). The number of years that the household heads lived in the area was, on average, 40 years with standard deviation of 14.40. The minimum year that the household head lived in the area was 1 and the maximum was 75 years. Particularly, sample respondents' who dislike, indifferent and likely perceived *L. camara* were had on average 39.8, 42 and 40.7 years of living in the area (Table 10). Similar to the results of Amibara district, the above result may indicate that most respondents were native to the area since the difference between average age of household head and average year that households lived in the area is too small.

Table 10: Descriptive statistics results (continuous variables) for Tulo district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-Value
		Bad	Indifferent	Good	Total				
Age	130	40.54	42	40.7	40.6	14.4	20	85	0.02
Education	130	4.34	3.6	2.6	4	3.2	0	13	2.25*
Year lived	130	39.8	42	40.7	40	14.3	1	75	0.08
Family (AE)	130	4.5	4.6	4.1	4.5	1.8	1	9.6	0.7

Note: * indicates significance at 10% probability level.

Source: Own survey result

4.1.2.2. Institutional factors

In Tulo district, the distance that a sample household head travels to the nearest market ranges from 0.1 km to 25 km with a mean of 6.30 km and standard deviation of 6.32. The study result shows that households' average distance to the nearest market for who disfavored, indifferent and favored were 6.82, 3.1 and 3.95 kms respectively. The mean difference among the three perception categories in terms of distance to nearest market was not statistically significant (Table 11). Also the survey result presented in Table 11 shows that sample respondents' home proximity from the nearest bush land was 1.41 km, on average. The maximum distance was 20 km with standard deviation of 2.19. Concerning perception, sample respondents who disfavored, are indifferent and favored *L. camara* reside on average 1.37, 0.72 and 1.91 kms far from the nearest bush lands. Similarly, sample household's average contact with an extension agent was 3 with a maximum of 45 contacts per year. With regards to perception, all respondents that disfavored, favored and indifferent about *L. camara* were having same mean number of contacts with DAs (Table 11).

Table 11: Descriptive statistics results for institutional factors in Tulo district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-Value
		Bad	Indifferent	Good	Total				
Market distance	130	6.8	3.1	3.9	6.30	6.32	0.1	25	2.2
Proximity	130	1.4	0.7	1.9	1.41	2.19	0	20	0.7
Exservice	130	3	3	3	3	2.5	0	15	0.00

Source: Own survey result

Data from Tulo district also indicate that 57 (43.84%) households had the access to irrigation while 73 (56.16%) did not. This result shows that most of the farmers who were engaged in crop production did not have access to irrigation. With regards to perception category, from sample household heads who were irrigation users, 46 (80.3%) disfavored *L. camara*, 4 (7%) were indifferent and 7 (12.3%) favored the species. However, from non-irrigation user household heads, 62 (85%) disfavored *L. camara*, 1 (1.3%) were indifferent and 10 (13.7%) favored the species (Table 12). Furthermore, 71 (54.61%) of sampled households were using mobile for information exchange while 59 (45.39%) of households did not have mobile. Again, from sample respondents' mobile users, 62 (87.3%) disfavored *L. camara*, 3 (4.2%) were indifferent and 6 (8.5%) favored the species. From sample respondents' non-mobile users, 46 (78%) disfavored while 2 (3.4%) and 11 (18.6%) were indifferent and had good perceptions towards *L. camara* invasion respectively (Table 12).

Furthermore, according to the survey, 48 (36.92%) sample respondents had access to credit while 82 (63.07%) did not have access to credit. With regard to perception category, from sample respondents who had the access to credit, 43 (89.6%) disfavored *L. camara*, 1 (2%) were indifferent and 4 (8.4%) favored the species. Again from sample respondents who had not access to credit, 4 (5%) were different about *L. camara*; while 65 (79.2%) and 13 (15.8%) were had bad and good perceptions about the species respectively (Table 12). Similarly, with regards to the respondents who had not access to credit, more than half of them disfavored the species and even if there was a perception difference between credit users and non users it was not statistically significant.

Table 12: Descriptive statistics results for access to credit, irrigation and telephone in Tulo district

Household Perception										
Variable	Category	Bad		Indifferent		Good		Total		χ^2 - value
		Fre.	%	Fre.	%	Fre.	%	Fre.	%	
Credit access	No	65	79.2	4	5	13	15.8	82	100	2.22
	Yes	43	89.6	1	2	4	8.4	48	100	
Irrigation access	No	62	85	1	1.3	10	13.7	73	100	0.26
	Yes	46	80.7	4	7	7	12.3	57	100	
Telephone access	No	46	78	2	3.4	11	18.6	59	100	2.19
	Yes	62	87.3	3	4.2	6	8.5	71	100	

Total	108	83.1	5	3.8	17	13.1	130	100
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Source: Own survey result

4.1.2.3. Household assets and farm characteristics

On the other hand, in Tulo district with regards to livestock ownership in terms of Tropical Livestock Unit (TLU), households who had considered invasion by *L. camara* as bad, indifferent and good have on average 2.13, 2.41 and 2 TLUs respectively. In general, sample households in the study area had on average 2.12 TLU ranging from 0 to 8.47 TLU with standard deviation of 1.6 (Table 13). Land owned by sample household was 0.344 hectares, on average. The minimum and maximum land owned were 0.06 and 1.5 hectares respectively. Perception wise, sample households' who perceived *L. camara* as bad, indifferent and good have on average 0.33, 0.31 and 0.4 hectares of land respectively (Table 13). The average years of experience in crop production was 20.58 with a minimum of 2 and a maximum of 59 years in crop production which has a standard deviation of 13.40. Similarly those sample household heads that have bad, indifferent and good perception about *L. camara* have on average 20.64, 20.6 and 20.17 years of experience on crop production respectively. Furthermore, according to the ANOVA analysis, the mean difference in terms of livestock ownership, land ownership and crop production experience between the three perception categories were not statistically significant (Table 13).

Table 13: Household asset and farm characteristics in Tulo district

Variables	Obs	Mean				Std. Dev.	Min	Max	F-Value
		Bad	Indifferent	Good	Total				
Expecrop	130	20.64	20.6	20.17	20.58	13.40	2	59	0.01
TLU	130	2.13	2.41	2	2.12	1.60	0	8.47	0.14
Landhold	130	0.33	0.31	0.40	0.34	0.215	0.06	1.5	0.88

Source: Own survey result

4.2. Livelihood Strategy and Effects of IAS on Households' Livelihood

As discussed before invasive alien species (IAS), namely non-native species (including *P. juliflora* and *L. camara*) are causing economic and environmental harms. Enterprises and

important resources are affected, like trade, crop and livestock production, pasture land, forests, natural resources and biodiversity; as well as human and animal health (Zeraye, 2008). However, sampled rural households' were using invasive plants for various purposes. As depicted in Table 14, in general, all invasive plants (i.e. both *P. juliflora* and *L. camara*) were being used as a hedge, source of fuel wood and fodder for goats and cattle, particularly during the dry season, when other grass and fodder were not available. Thus farm households' response to invasive plants is to make the best out of the worst situation. They, therefore, use invasive plants as fodder, fuel wood, charcoal, construction material and fencing to adapt to the changing situation incurred due to the colonization of invasive plants.

Table 14: Uses of *P. juliflora* and *L. camara*

Species	Local names	Uses
<i>Prosopis juliflora</i>	Weyane, Dergi hara	Fodder (during winter season), fuel wood, charcoal, construction material, fencing
<i>Lantana camara</i>	Ye wef qolo, Bekaharkete, Tanzania	Fodder (during the winter mainly by Goats), fuel wood, fencing, medicine

Source: own survey result

Rural households in Amibara district involve in different sectors to earn money for covering their daily household consumption. According to the livelihood option that a respondent follow, 52 (40%) sample households were found to pursue pastoralism only but 78 (60%) of them pursued pastoralism and other livelihood strategies such as farming and different non/off-farm activities. Despite this division, households who pursued the same livelihood strategy had different perception about *P. juliflora*. Results presented in Table (15) show that among households that pursued pastoralism only, 44 (84.6%) perceived bad and 8 (15.4%) were indifferent about the effects of *P. juliflora* invasion. Also among households who pursued other livelihood strategies beside pastoralism, 73 (93.6%) disfavored the species, 4 (5.2%) were indifferent and 1(1.2%) perceived as good. However, the perception difference among the two livelihood strategy groups was not statistically significant.

In this study, specifically, the perceived effect of *P. juliflora* invasion on rural households' livelihood was assessed based on the alternatives from most harmful to most beneficial likert-item questions. Out of the total sample household heads, 92 (70.77%) said it is most harmful, 36 (27.69%) said harmful, 1 (0.77%) said beneficial and 1 (0.77%) said most beneficial to their livelihood (Table 15). Therefore, almost all (97.69%) sample household heads in Amibara district perceive the effects of *P. juliflora* invasion as harmful and have a significant negative impact on their livelihood.

In Tulo district, almost all sample respondents' livelihood was sedentary mixed farming. At the same time, specifically the perceived effects of *L. camara* invasion on farm households' livelihood was also assessed based on the alternatives from most harmful to most beneficial using a likert-item statement. Out of the total sample respondents, 65 (50%) said it is most harmful, 44 (33.85%) said it is harmful, 8 (6.15%) were indifferent, 12 (9.23%) said it is beneficial and 1(0.77%) said it is most beneficial to their livelihood. Likewise, most of sample household heads (83.85%) in Tulo district agreed that the effects of the species invasion as harmful for their livelihood (Table 15).

To conclude, sampled respondents in both districts perceived that the effects of invasive plants become more serious with their abundance and these species impair rural livelihood options and increase vulnerability. This is because the uses of the invasive plants are likely to be constrained as the basic pasture and bush land products including firewood and fodder they offer are mostly secondary rather than preferred since they are being used during the dry season, when there is a scarcity of good quality fodder.

Table 15: Effects of *P. juliflora* and *L. camara* on rural households' livelihood

Household Perception											
Variable	Category	Bad		Indifferen t		Good		Total		χ^2 value	–
		Fre.	%	Fre.	%	Fre.	%	Fre.	%		
Livelihood strategy	Not pastoralism	73	93.6	4	5.2	1	1.2	78	100	0.451	
	Pastoralism	44	84.	8	15.	0	0	52	100		

		6	4			
Effects of <i>P. juliflora</i> on livelihood	Most harmful	87	4	1	92	-----
	Harmful	28	8	0	36	
	Indifferent	0	0	0	0	
	Beneficial	1	0	0	1	
	Most beneficial	1	0	0	1	
Effects of <i>L. camara</i> on livelihood	Most harmful	65	0	0	65	-----
	Harmful	40	2	2	44	
	Indifferent	2	3	3	8	
	Beneficial	1	0	11	12	
	Most beneficial	0	0	1	1	

Source: Own survey result

4.3. Households' Perception about *P. juliflora* and *L. camara*

Households' perception towards the effects of IAS (i.e. *P. juliflora* and *L. camara*) invasions were measured using Likert scale through question number 30 and/or 31 of appendix 7.1. and 7.2. Results of the reliability index (i.e. Cronbach's alpha) show that the likert scales were an excellent to measure a unidimensional latent variable with an alpha value of 0.93 and 0.97 for both dependent variables with regard to both species, *P. juliflora* and *L. camara*, respectively. Results using the Likert scale measures are presented in Tables 16 and 17.

4.3.1. Households' perception about *P. Juliflora*

Households' perceptions index had a mean value of 0.37 (SE= 0.1, range 0.23 - 0.7). Following the works of Mohammed (2012) and Barnes (2013), this interval scaled dependent variable was grouped in to three categories (i.e. negative, indifferent and positive) for the purpose of making further discussion and descriptive statistics. According to the survey result presented in Table 16, the majority of respondents' perceptions were negative to indifferent with 90% of respondents (n=117) holding negative perceptions towards *P. juliflora* (score<3),

9.23% (n=12) are indifferent (score=3) and 0.77% (n=1) having positive perceptions (score>3) towards *P. juliflora*.

With regards to the present households' perceptions about the species (i.e. *P. juliflora*), majority of sampled respondents perceptions were bad. However, thus current perceptions towards the species are different from the perceptions at the time of *P. juliflora* introduction. Households' perceptions at the time of species introduction in the study area was registered as bad for 11 (8.46%) respondents, indifferent for 17 (13.08%) and good for 102 (78.46%) households. Based on the above result, most of the sample households' perceptions about *P. juliflora* during the species introduction were good and the reason for this might be households' shortage in awareness and knowledge about the upcoming adverse effects of *P. juliflora* invasion due to low abundance of the species in that time (Table 16). Beside this, through time in Amibara district, a perception shift was observed within sample households from positive to negative due to some negative impacts of the species on the rural community. As mentioned by the majority respondents some of the adverse effects are extinction of indigenous tree species and replaced by *P. juliflora*, reduction of grazing land and livestock population, roads blockage, and human health problem. With regards to the human health problem, one sample household head was told us about *P. juliflora* thorn piousness, as he said the thorn of "Weyane" tree is very dangers and its pain is like beating by the snake.

Table 16: Households' perception about *P. juliflora*

Variable	Category	Freq.	%		
Perception at the time of introduction	Bad	11	8.46		
	Indifferent	17	13.08		
	Good	102	78.46		
Current perception	Bad	117	90		
	Indifferent	12	9.23		
	Good	1	0.77		
Total		130	100		
	Obs	Mean	Std. Dev.	Min	Max
HHperceptionindex	130	0.37541	0.10062	0.23333	0.71020

Source: Own survey result

4.3.2. Households' perception about *L. camara*

In Tulo district, household perception index had a mean value of 0.40 (SE = 0.20, range = 0.2-1). According to the survey result presented on Table 17, majority of respondents' perceptions were negative to indifferent with 108 (83.0%) respondents holding negative perceptions towards *L. camara* (score<3), 5 (3.85%) respondents are indifferent (score=3) and 17 (13.08 %) having positive perceptions (score>3) towards *L. camara*.

According to the result depicted in Table 17, most of the current households' perceptions about *L. camara* were bad. However, most of sample respondents' perceptions at the time of species introduction in the study area was good but numerically it was registered as good for 104 (80%) respondents, indifferent for 6 (4.62%), bad for 12 (9.23%) households and only 8 (6.15 %) respondents did not know what was their perceptions at the time of *L. camara* introduction (Table 17). The reason for this might be lack of recognizing the adverse effects due to the low abundance of *L. camara* during the species introduction. Similar to the Amibara district, a perception change was observed within majorities' respondents from good to bad and this is due to some observed negative effects of *L. camara* on rural households' agriculture especially on land moisture i.e. it dries the land where it found copiously.

Table 17: Households' perception about *L. camara*

Variable	Category	Freq.	%		
Perception at the time of introduction	Bad	12	9.23		
	Indifferent	6	4.62		
	Good	104	80		
	Don't know	8	6.15		
Current perception	Bad	108	83.08		
	Indifferent	5	3.85		
	Good	17	13.08		
Total		130	100		
	Obs	Mean	Std. Dev.	Min	Max
HHperceptionindex	130	0.40	0.20	0.20	1

Source: Own Survey analysis

4.3.3. Introduction, abundance and spreading pattern of *P. juliflora*

Households' knowledge about *P. juliflora* was assessed using a knowledge self-assessment method (perceived knowledge). The survey result shows that 45 (34.6%) of sample respondents rate their knowledge about *P. juliflora* at a great deal, 8 (6.1%) of households had a fair amount of knowledge about *P. juliflora*, 55 (42.3%) of the households had some knowledge and only 18 (14%) of the households perceived as had very little knowledge about the species. With regard to sex, women's knowledge about *P. juliflora* is higher than men. About 94 % of women described themselves in the top three categories as knowing 'a great deal', 'a fair amount' or 'some' as opposed to only 83.78% men placing themselves in the same three categories. A Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the different levels of perceived knowledge about *P. juliflora*, $\chi^2(4) = 10.05$, $p=0.03$ (Table 18). Respondents' sources of information about *P. juliflora* were not all the sources listed in the questionnaire rather it was only from three sources. According to the survey, respondents' predominant source of information about *P. juliflora* was their own experience which accounts for about 74 (57%). In line with this, 49 (38%) households obtained information about the species from friends and family but only 7 (5%) respondents got information from agricultural experts i.e. DAs'. Finally, a Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the different sources of information at 1% probability level (Table 18).

The survey revealed that different respondents have different views about how, why, who and from where the species was introduced to the study area. Generally, 64% of sample respondents know that the plant was introduced first in Amibara irrigation project by a foreigner who worked in the project around Melka-werer town. The rest 36% households did not know from where the species comes from. On the other hand, 79% of the respondents know by whom *P. juliflora* was first introduced in the area which they perceive foreigners were agents to the introduction of the species but 21% of the respondents did not know by whom the species was introduced for the first time in their area (Table 18).

Households' knowledge about when *P. juliflora* was introduced is presented in Table 18. Majority (96.15%) of sample household heads know when it was introduced to the study area. Of these, 67 (51.5%) said that *P. juliflora* was introduced to the area 30 years ago, 36 (27.5%) said before 25 years, only 22 (17%) households said that it was introduced in the area 20 years ago and the rest 5 (4%) did not know when the species was introduced in the area. The Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the groups in this variable at 1% probability level. As the survey finding indicates that majority of the sample respondent 83 (64%) perceived combating desertification was the reason for introducing *P. juliflora* in Amibara district since the area was known with frequent drought. Beside this, since the area was known by arid and semi arid climate, 8 (6.1%), and 3 (2.3%) respondents perceived the purpose of introduction of *P. juliflora* to the area was for climate regulation, and soil conservation purposes. The rest 30 (23%) respondents perceived that *P. juliflora* was introduced for the purposes of fire wood and fodder and 6 (4.62%) respondents didn't know why *P. juliflora* introduced in their area. Thus, the above result indicates that most respondents perceived *P. juliflora* was intentionally introduced in the study area. A Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the various purposes of *P. juliflora* introduction at 10% probability level (Table 18).

Animals, human beings, flood and wind were the known agents for *P. juliflora* spread. According to survey results, majority (93.1%) of the respondents perceived that animal dung including livestock's' dung like boar, cattle and goat were the main agents for *P. juliflora* spread, but additionally with the above agent 2.3% and 4.6% of them perceived that human being, flood and wind were other means of *P. juliflora* invasion in their area respectively (Table 18).

All respondents in the study area replied that the abundance of *P. juliflora* is increasing due to some uncontrolled factors. Thus influencing factors for the alarming rate of the species invasion were animal mobility and ability of *P. juliflora* to resist harsh environment; even one sample respondent said that "this weyane (i.e. local name for *P. juliflora*) tree grows every where even over rocky areas or stones". Numerically as depicted in Table 18, most

respondents 68 (52.3%) believed that livestock mobility was the main factor for increasing the abundance of *P. juliflora* in the study area. After cattle fed the pod, seeds of *P. juliflora* delivered through excretion remain undigested by the animals' stomach which created a favorable condition for seed germination and spreading of *P. juliflora* in the area. Additionally, the amazing ability of *P. juliflora* to adapt and resist harshy environment mentioned by 52 (40%) sample respondents as the other factor for increasing rate of *P. juliflora* invasion and redistribution where as 10 (7.69%) did not know why the species increasing overtime in their area. According to Kruskal-Wallis H test, households' perception difference between the different reasons grouped under this variable was statistically significant at 1% probability level, $\chi^2(2) = 10.12$, $p=0.006$ (Table 18).

Table 18: Introduction and abundance of *P. juliflora*

Variable	Category	Household perception		
		Fre.	%	χ^2 -value
Knowledge	A great deal	45	34.6	10.05**
	A fair amount	8	6.1	
	Some	55	42.3	
	Very little	18	14	
	No response	4	3	
Source of information	Own experience	74	57	22.22***
	Friends and family	49	38	
	DAs	7	5	
Origin	Worer irrigation	83	64	12.90
	Donot know	47	36	
First agent	Forieners	103	79	5.31
	Donot know	27	21	
Year of introduction	>30 years	67	51.5	13.46**
	>25 years	36	27.5	
	>20 years	22	17	
	Do not know	5	4	
Purpose of introduction	Combat desert	83	64	10.56*
	Greening up region	8	6.1	
	Firewood and fodder	30	23	
	Rehabilitate soil	3	2.3	
	Do not know	6	4.6	
Agents	Animal dung	121	93.1	0.97
	Human being	3	2.3	

	Flood and Wind	6	4.6	
Abundance	Increasing	130	100	0
Reason for abundance	Animal mobility	68	52.3	10.12***
	Ability to resist harsh environment	52	40	
	Do not know	10	7.7	
Total		130	100	

Note: *, **, and *** indicates significance at 10%, 5% and 1% probability level respectively.

Source: Own Survey analysis

According to the survey result presented on Table 19, the spreading pattern of *P. juliflora* in the year 2015/16 was increasing. Numerically, almost all respondents 127 (97.7%) perceived that abundance of *P. juliflora* was rising from time to time at an increasing rate while the rest 3 (2.3%) believed as there is no difference. Again almost all sample respondents assume that *P. juliflora* was increasing during summer period. With regards to growing pattern of *P. juliflora* during winter season, 88 (67.7%) respondents perceived no difference, 34 (26.2%) household heads perceived increasing trend and 1 (0.8%) perceived decreasing trend where as the rest 7 (5.3%) did not notice the change in the spread of *P. juliflora* during winter season. A Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the different perceived growing patterns of *P. juliflora* during winter season, $\chi^2(3) = 31.53$, $p=0.0001$ (Table 19). Generally according to the above result, invasion of *P. juliflora* continues ever more in the area regardless of seasonal variability.

Table 19: Spreading pattern of *P. juliflora*

Variable	Category	Household perception		
		Fre.	%	χ^2 -value
Growing pattern at summer	Increasing	130	100	0
Growing pattern at winter	Increasing	34	26.2	31.52***
	Decreasing	1	0.8	
	No difference	88	67.7	
	Not noticed	7	5.3	
Growing pattern year	Increasing	127	97.7	0.338
	No difference	3	2.3	
Total		130	100	

Note: *** indicates significance at 1% probability level.

Source: Own Survey analysis

4.3.4. Introduction, abundance and spreading pattern of *L. camara*

The survey result presented in Table 20 showed that 98 (75.4%) of the respondents rate their perceived knowledge about *L. camara* by answering a great deal, 25 (19.2%) had a fair amount of knowledge about *L. camara*, 6 (4.6%) had some knowledge and only 1 (0.8%) had no knowledge about the species. With regard to sex, both genders had somewhat equal knowledge about *L. camara*. All sampled women described themselves in the top three categories as knowing ‘a great deal’, ‘a fair amount’ or ‘some’. At the same time, 99% men place themselves in the same three categories. Respondents obtained information about *L. camara* from not all of the sources listed in the questionnaire rather it was only from three sources such as from their own experience, friends and family, and DAs. According to the survey results, the predominant source, over half of the respondents’ source of information about *L. camara* was their own experience which accounts about 119 (91.5%). In line with this, 9 (6.9%) respondents’ sources of information were both friends and family but only 2 (0.8%) respondents’ sources of information were agricultural experts (i.e. DA’s) and others. A Kruskal-Wallis H test showed that there was a statistically significant difference in household perception between the different sources of information, $\chi^2(3) = 7.3$, $p=0.06$ (Table 20).

The survey results revealed that respondents have different views about how, why, who and from where the species (i.e. *L. camara*) was first introduced to the study area. Generally, there were different views about who introduced the species to the area. Individuals (human beings) were the only mentioned agent for the first time introduction of *L. camara* in the study area which took 54 (41.5%) sample respondents answer, while the rest 58.5% respondents didn’t have knowledge about who introduced the species to their locality. On the other hand, most of the respondents, 90 (69.23%) did not know from where *L. camara* was first introduced in their area and the rest 40 (30.76%) had different feelings about the origin of *L. camara* like some of them replied as it come from nearby desert areas, Tanzania, England and so on (Table 20).

Different households’ response about the time of *L. camara* introduction in to the study area is presented in Table 20. Majority of sample household heads 118 (90.8%) know when the

species was first introduced to the study area. Of these, 48 (40.67%) said that *L. camara* was introduced to the area before 25 years, 20 (16.94%) said before 20 years, 24 (20.34%) said before 15 years, 18 (13.85%) said before 10 years, 8 (6.15%) said before 5 years and the rest 12 (9.23%) households did not know when *L. camara* was introduced in to their area. According to Binggeli and Desalegn (2002), *L. camara* was introduced into Ethiopia as an ornamental plant due to its beautiful aromatic flowers. Yet, survey results indicate that majority of the respondents 63 (48.5%) perceived that *L. camara* was introduced to the area for the purpose of fencing around their farm and home, 12 (9.2%) of respondents replied that it was for the purpose of decorating the area, 10 (7.7%) replied that it was for shade and rehabilitating soil fertility, and the rest 45 (34.6) respondents didn't know the purpose for which *L. camara* was introduced to their locality (Table 20). Therefore, according to most respondents answer *L. camara* was introduced in their area for the purpose of gaining the perceived benefit.

As depicted in Table 20, birds, human being, flood, and wind were agents for the spread of *L. camara* in the study area. Almost all sample household heads agreed that *L. camara* was mainly spread by fruit-eating birds, as they spread seed in their droppings. According to the survey results, out of the total sample household heads 123 (96.15%) perceived birds dung and human being as the main agents of *L. camara* dispersal, but additionally animals, flood, and wind were other means of *L. camara* dispersion in the study area. Yet, 3 (2.4%) sample household heads did not know the reason for increasing trend of the species in their land. A Kruskal-Wallis H test showed that there was a statistically significant difference in households' perception between the various perceived agents of the species spread, $\chi^2(2) = 9.7$, $p=0.0078$ (Table 20). Survey result presented in Table 19 shows that 86 (66.2%), 39 (30%) and 5 (3.8%) of the sample respondents perceived that the abundance of *L. camara* was increasing, decreasing and no difference respectively. There were various factors for the increasing rate of the species invasion in the study area. As almost all sample respondents' answer, easy dispersal of *L. camara* pod by birds help the species to reach everywhere.

Table 20: Introduction and abundance of *L. camara*

Variable	Category	Household perception		χ^2 -value
		Fre.	%	
Knowledge	A great deal	98	75.4	0.26
	A fair amount	25	19.2	
	Some	6	4.6	
	Very little	0	0	
	Nothing	1	0.8	
Source of information	Own experience	119	91.5	7.35*
	Friends and family	9	6.9	
	DAs	1	0.8	
	Others	1	0.8	
From where	Various place	40	30.7	8.61**
	Donot know	90	69.3	
By whom	Individuals	54	41.5	0.90
	Donot know	76	58.5	
Year of introduction	>25	48	36.9	3.92
	>20	20	15.4	
	>15	24	18.6	
	>10	18	13.8	
	>5	8	6.1	
	Donot know	12	9.2	
Purpose of introduction	Fencing	63	48.5	
	Greenification	12	9.2	
	Shadow and Rehabilitate soil	10	7.7	
	Donot know	45	34.6	
Agents	Birds dung and human being	123	94.6	9.7***
	Others*	4	3	
	Donot know	3	2.4	
Abundance	Increasing	86	66.2	1.84
	Decreasing	39	30	
	No difference	5	3.8	
Total		130	100	

Note: *, **, and *** indicates significance at 10%, 5% and 1% probability level respectively.

Source: Own survey result

With regards to the spreading pattern of *L. camara* in the year 2015/16, 92 (70.8%) sampled respondents perceived that abundance of *L. camara* was increasing during summer season, but the rest 37 (28.4%) and 1 (0.8%) said that abundance of *L. camara* was decreasing and no

difference during summer season respectively. A Kruskal-Wallis H test showed that there was a statistically significant difference in households' perception between the different perceived growing patterns of the species during summer season, $\chi^2(2) = 6.19$, $p=0.04$ (Table 21). During winter season, out of the total sample respondents 47 (36.2%) perceived no difference, 42 (32.3%) perceived decreasing trend and only 41 (31.5%) perceived increasing trend. The survey findings about the whole year growing pattern of *L. camara* also confirmed that 122 (93.9%) sample household heads perceived the abundance of *L. camara* was rising from time to time at increasing rates while the rest 2 (1.5%), 5 (3.8%) and 1 (0.8%) perceived that it was decreasing, no difference and not noticed respectively (Table 21). Same with the spreading pattern of *P. juliflora*, in general, invasion of *L. camara* also continues ever more in the area regardless of seasonal variability especially at communal grazing lands and mountains yet at individually controlled farms even if it is expensive it was managed through frequent follow up by the farm households.

Table 21: Spreading pattern of *L. camara*

Variable	Category	Household perception		
		Fre.	%	χ^2 -value
Growing pattern at summer	Increasing	92	70.8	6.19**
	Decreasing	37	28.4	
	No noticed	1	0.8	
Growing pattern at winter	Increasing	41	31.5	0.93
	Decreasing	42	32.3	
	Decreasing	47	36.2	
Growing pattern year	Increasing	122	93.9	0.66
	Decreasing	2	1.5	
	No difference	5	3.8	
	Not noticed	1	0.8	
Total		130	100	

Note: ** indicates significance at 5% probability level.

Source: Own survey result

4.4. Management Options of *P. juliflora* and *L. camara* Invasion

4.4.1. *P. juliflora*

In Amibara district, all sample respondents are demanding eradication of *P. juliflora*, not least because its benefits are being far outweighed by its undesirable properties. According to these respondents, their primary livelihood options of livestock keeping and farming are in danger by the unchecked expansion of the invasive alien species. *P. juliflora* has been found in almost all land use or land cover types in the study area. The edible nature of the pods and its seed dispersal mechanisms by cattle, sheep, goats and wild animals and coppicing nature of the plant after stumping are some of the characteristics that facilitate its invasion (Hailu *et al.*, 2004; Berhanu and Tesfaye, 2006). At broad scale, there are basically three methods of prevention and management options (*i.e.*, mechanical, chemical and biological control), all of which can be used together within an integrated management programme (Wittenberg and Cock, 2005). However, to control further spreading and to remove it from the invaded areas, the local people have tried to use only some management options that are listed in Table 22. Mechanical control which was continuous hand clearing and uprooting of new seedlings from farm lands, grazing lands and around settlements areas by using local tools like “Qonchera”, axe, “zabiya” were the first options that most households 101 (77.69%) carried out in the study area. The other most effective but labor and cost intensive mechanical control method which was frequently mentioned by the respondents was removing of the plant from 10-15cm below the ground and use the land for crop production which was also described by Hailu *et al.* (2004). Moreover, burning was one of the methods that have been mentioned by 7.69% respondents to control the plant invasion. According to Berhanu and Tesfaye, (2006), burning of *P. juliflora* may kill very small seedlings but it encourages the coppicing ability of big stems of *P. juliflora*. Therefore, it should not be implemented for all ages of this plant.

4.4.2. *L. camara*

With regards to *L. camara* controlling mechanism, even if there is no any action that was yet taken by the regional government to control its invasion, households in the study area are

aware of the problem, and has substantial interest to control and manage the plant. *L. camara* though it is difficult to control, as it will coppice and form denser thickets if it is simply slashed, not uprooted. The edible pods, mostly by birds, also contribute for its long range dispersal mechanisms (Gentle and Duggin, 1998; Binggeli and Desalegn, 2002). In this study, majority of sample household heads (96.15%) have tried to use only physical methods (hand grubbing, uprooting, and cutting). These physical or mechanical techniques are in fact effective and mainly suited to small sized infestations. Additionally, action of burning and using as a firewood were also undertaken after the physical controlling mechanisms but according to sampled households there was no any attempt of utilizing (like for fire wood) the species as a management option.

Table 22: Methods used to control *P. juliflora* and *L. camara* invasions

Methods	Respondents (%)	
	<i>P. juliflora</i>	<i>L. camara</i>
Mechanical/Physical	77.69	96.15
Firing	7.69	
Nothing	7.69	3.85
No response	6.92	
Total	100	100

Source: own survey result

In general, actions in response to IAS's (i.e. *P. juliflora* and *L. camara*) invasion have concentrated on control and/or eradication attempts in individually controlled farms and homesteads, where individuals also have control over the benefits generated by their efforts. The communal grazing areas (i.e. pasture lands and mountains) that are jointly owned and used have seen very limited attempts at checking the spread of the species. Yet this resource is crucial for sustaining the livestock enterprise. As most of sample respondents' suggestion in Amibara district, individual households should be involved in clearing *P. juliflora* from their own fields, but with government assistance. On public lands especially pasture lands and mountains; almost all individuals in both study areas suggested that the Government should conduct or lead eradication efforts coordinating with a greater role from local communities, with some help from external factors, including government and non-governmental organizations. Nonetheless, no longer chemical, biological and integrated control methods were used in both study areas.

4.4.3. Households' preferences to manage invasions of *P. juliflora* and *L. camara*

As discussed above households' operations for controlling invasions of IAS (i.e. *P. juliflora* and *L. camara*) were under consideration at the time of this survey. Furthermore, to assess public willingness or preference, respondents were asked questions about the type of eradication or control measures that they would prefer to control the invasion of IAS. In both study sites, about 72-90% of the respondents favored complete eradication of IAS from both crop and grass lands, through application of chemicals or mechanical uprooting, and replacement with other trees that would be less invasive and thorn less. Numerically, results of the survey showed that 83 (63.85 %) of respondents preferred application of chemicals to control the invasion of *P. juliflora*, 35 (26.92 %) of them preferred physical way of controlling, 7 (5.38 %) of them chosen utilization and the rest 5 (3.85 %) households preferred biological method to manage invasions of the species. With regard to *L. camara*, about 74 (57.36 %) i.e. over half of respondents preferred application of chemicals, 21 (16.28 %) of them preferred mechanical methods, 7 (5.43 %) of them preferred biological methods and the rest 27 (20.93 %) of them preferred using of the species for different human need i.e. utilization method to control invasions of *L. camara*.

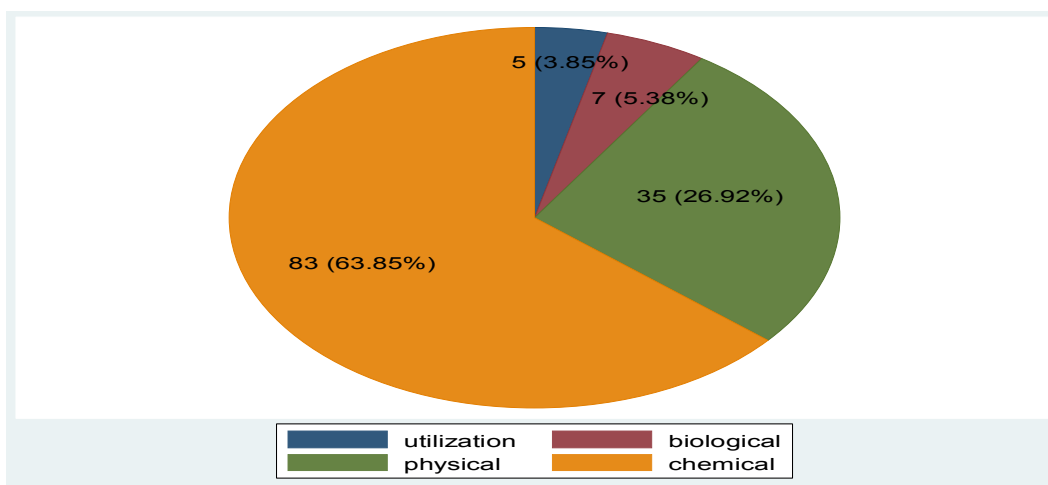


Figure 3: Households' preference to manage invasions of *P. juliflora*

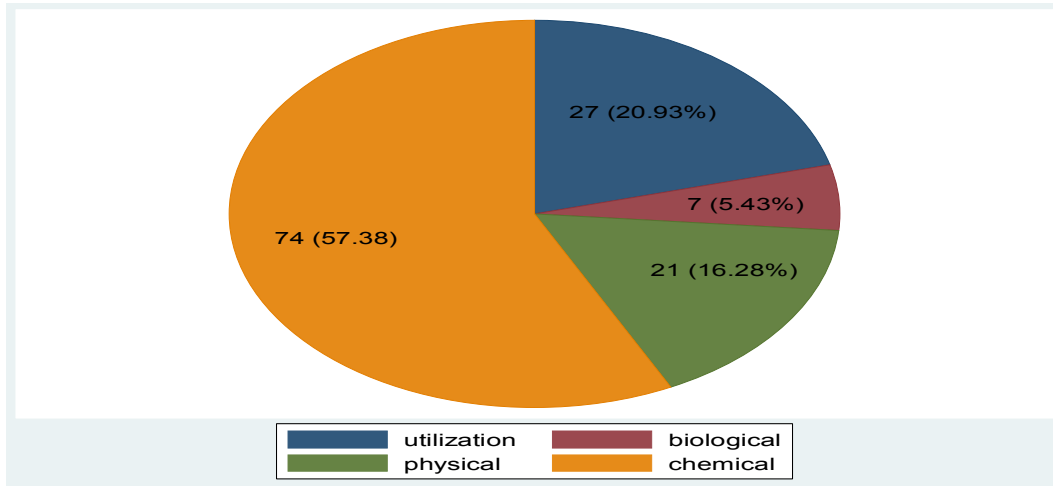


Figure 4: Households' preference to manage invasions of *L. camara*

4.5. Econometric Analysis

In order to identify the factors determining households' perception about effects *P. juliflora* and *L. camara* invasion in the study areas, a two limit Tobit model was estimated using Stata version 13.1.

4.5.1. Determinants of households' perceptions about *P. juliflora*

Tobit regression

Number of obs= 130

LR chi2 (13) = 88.14

Prob > chi2 = 0.0000

Log likelihood = 158.63

Pseudo R² = -0.3847

Table 23: Two limit Tobit regression results on households' perceptions about *P. juliflora*

Dependant variable	HHperceptionP			
Variables	Coef.	Std. Err.	t-value	p-value
Gender	-0.074***	0.020	-3.62	0.000
EduHH	-0.022	0.014	-1.59	0.114
FamilyAE	0.002	0.005	0.51	0.609

Diversn	-0.039***	0.014	-2.70	0.008
Tluliv	-0.000	0.000	-0.30	0.762
Landhold	0.004	0.013	0.33	0.744
Expccrop	0.002	0.002	1.29	0.199
Extension	-0.003***	0.001	-3.39	0.001
IncomeHH	1.63	1.65	0.99	0.325
Mktdistance	-0.003***	0.000	-3.62	0.000
Proximity	0.001*	0.000	1.67	0.098
Irrigusage	-0.0016	0.020	-0.82	0.414
Phoneusage	-0.001	0.014	-0.10	0.922
Constant	0.531***	0.039	-13.59	0.000
Sigma	0.071***	0.004		

Note: * and *** indicate significant at 10%, 5% and 1% probability level respectively.

The likelihood ratio chi-square of 88.14 (df=13) with a p-value of 0.00 tells us that our model as a whole fits significantly better than an empty model (i.e., a model with no predictors). In the table we see the coefficients, their standard errors, the t-statistic and the associated p-values. Results of two limit regression results presented in Table 23 indicate that gender, market distance, extension service, livelihood strategy and proximity to the bush land were found to be the major determinants of households' perceptions about the effects of *P. juliflora* invasion. The discussions about the significant variables are given as follows:

Gender: Gender of the household head was a statistically significant determinant (at 1% probability level) and negatively related with perception. It means maleness increases probability of households' negative perception by 0.96 percent compared to femaleness. The finding suggests that male household heads were more likely to perceive the species badly than female headed households since the daily activities of the latter like collection of firewood for cooking and feed/forage for livestock uses, may provide them with better perception about *P. juliflora* than the former because females are responsible for most of the household duties (i.e. in Afar, women do most of the household work including preparation of food, firewood collection and traditional house construction). Additionally, female household heads are benefiting from sale of *P. juliflora* products for their daily expenditure needs. The finding that female-headed households are more likely to have positive perception about the species than male, is consistent with prior expectations and results of other studies (eg. Veitch and Mick, 2001; Mwangi and Swallow, 2005; Wakie *et al.*, 2016).

Market distance: The coefficient for market distance is negative and significant at 1% probability level. When households' distance to the nearest market increases by one kilometer, it decreases the probability of households' positive perceptions about the effects of *P. juliflora* invasion by 0.08 percent. Access to market enables households' to participate in productive utilization of the species, the sign of the coefficient is also in line with the hypothesis and results of other studies (eg. Mohammed, 2012). Those who are far from the market disfavor the species as they were not able to benefit from sales of their *P. juliflora* products due to more money and time spent on distant market compared to the nearby ones.

Livelihood strategy: Livelihood strategy pursued by the households also an important determinant of how individuals perceive invasive species (Pasiecznik *et al.*, 2001; Binggeli, 2001). The livelihood strategy pursued by an individual was statistically significant at 1% probability level that negatively influences perceptions about *P. juliflora*. It means pastoralism increases probability of households' negative perceptions by 1.33 percent compared to not following only pastoralism. The result may reflect that households, who likely to diversify their livelihood other than being only pastoralism were more likely to perceive good about the effects of *P. juliflora* invasion while ranchers and pastoralists whose main livelihood strategy is livestock keeping perceive it negatively because of higher costs incurred due to depletion of valuable pastures and farmland clearing. The grass lands that are used by Afar pastoralists for dry season grazing were also described as the most invaded land-use categories by *P. juliflora*; therefore this invasion adversely affected households' whose livelihood depend on livestock rearing indirectly on thus grass lands (Wakie *et al.*, 2016). This result was also consistent with the findings of Binggeli (2001), Pasiecznik *et al.* (2001), Zeraye (2008), and Yohannes *et al.* (2015).

Extension service: An extension service was statistically significant at 1% probability level and had a negative effect on households' perceptions about *P. juliflora*. It means, when households' contact with extension agents increases by a unit, it increases probability of households' negative perceptions by 0.1 percent. The result suggest that extension agents were not aware about productive utilization as one controlling mechanisms of *P. juliflora*

invasion, or in other way, as invasion is above tolerable level, contact with DAs should increase households awareness about adverse effects of the species invasion so that household might develop negative perception against the invasion.

Proximity to the bush land: The coefficient for Proximity to the bush land was positive and significant at 10% probability level. The result tells us that as the household far from the nearby bush land by a kilo meter, probability of positive perceptions towards *P. juliflora* will increase by 0.03 percent meant households' becomes more satisfied when their home far from compared to those near to the bush land. This relationship signifies that the infestation of invasive plants influences the bush land-dependent household utmost as it influences the availability of bush land products by displacing native species. Even if the case was similar with non-infested areas, species diversity and richness of the woody vegetation in Gewane and Amibara were found to be very low. More specifically, in areas of high and medium *P. juliflora* invasion, the individuals or plants of other species were not available or recorded; therefore, *P. juliflora* might reduce this diversity further (Ilukor *et al.*, 2016). A result of this study is consistent with previous expectation and with also other studies like Sapkota and Oden (2008) and Ria *et al.* (2012).

Marginal effects of the Tobit model

There are three types of marginal effects that may be of interest in Tobit model. These are:

1. The marginal effects $Pr(a < Y_i^* < b)$ measures the effect of change in independent variables on probability of having perception.
2. The mean of the marginal effects of explanatory variables on expected value $E(Y_i^*)$ describe how the observed variable Y_i^* changes with respect to the total sampe.
3. The mean of the marginal effects of the truncated values $E(Y_i^* / a < Y_i^* < b)$ measures the changes in Y_i with respect to changes in the regressors among perceivers.

Table 24: Marginal effects of the Tobit model

Variable	Marginal effects		
	$\frac{\partial E(y^*)}{\partial x}$	$\frac{\partial E(y)}{\partial x}$	$\frac{\partial E(y 0 < y < 1)}{\partial x}$
Gender	-.0096006***	-.0728655***	-.0744527***
EduHH	-.0062194	-.0216216	-.0225695
FamilyAE	.0007244	.0025184	.0026288
Divern	-.0133078***	-.0376952***	-.0396124***
Tluliv	-.0000363	-.0001261	-.0001316
Landhold	.0011898	.0041362	.0043175
Expccrop	.0007382	.0025663	.0026788
Extension	-.0010574***	-.0036759***	-.0038371***
IncomeHH	4.46e-07	1.55e-06	1.62e-06
Mktdistance	-.0008669***	-.0030137***	-.0031458***
Proximity	.000393*	.0013661*	.001426*
Irrigusage	-.0043074	-.015705	-.0163654
Phoneusage	-.0003957	-.0013751	-.0014354

4.5.2. Determinants of households' perceptions about *L. camara*

Similarly, two limit Tobit regression results on the determinants of households' perception about the effects of *L. camara* invasion in the study area are presented in Table 25.

Tobit regression	Number of obs= 130
	LR chi2 (13) = 23.74
	Prob > chi2 = 0.0337
Log likelihood = 29.905	Pseudo R ² = -0.6579

Table 25: Two limit Tobit regression results on households' perception about *L. camara*

Dependant variable	HHperceptionL			
Variables	Coef.	Std. Err.	t-value	p-value

Gender	-0.103**	0.051	-2.02	0.046
AgeHH	-0.000	0.002	-0.24	0.811
EduHH	-0.011*	0.005	-1.96	0.052
FamilyAE	-0.025**	0.012	-2.02	0.046
MaritalS	-0.071*	0.040	-1.78	0.078
Tluliv	-0.006	0.011	-0.62	0.534
Landccprad	0.171**	0.084	2.04	0.044
Expccrop	0.001	0.002	0.39	0.697
Extension	0.005	0.006	0.83	0.406
Mktdistance	-0.004*	0.002	-1.86	0.066
Proximity	0.003	0.012	0.30	0.763
Phoneusage	-0.028	0.037	-0.76	0.448
Accesscredit	-0.014	0.035	-0.40	0.691
Constant	0.715***	0.099	7.19	0.000
Sigma	0.186***	0.011		

Note: * and ** indicates significance at 10% and 5% probability level respectively.

The likelihood ratio chi-square of 23.74 (df=13) with a p-value of 0.03 tells us that our model as a whole fits significantly better than an empty model (i.e., a model with no predictors). In the table we see the coefficients, their standard errors, the t-statistic and the associated p-values. The coefficients for gender, education level, family size, marital status, land holding and distance to nearby market were found to be the major determinants of households' perceptions about the effects of *L. camara* invasion. The discussions about the significant variables are given as follows:

Gender: Gender of the household heads was statistically significant at 5% probability level with negative influence on households' perception. It means maleness increases probability of households' negative perception by 9.6 percent compared to femaleness. The finding suggests that male household heads were more likely to perceive the species badly than females since the daily activities of the latter like collection of fire-wood for cooking and feed/forage for livestock uses, were providing them with better perception about *L. camara* than the former. The finding that female-headed households were more likely to perceive the species than male, therefore, was consistent with the hypothesis. Women, who are heavily dependent on *L. camara* for fuel wood, will likely, enjoy greater benefits from *L. camara* than men.

Education level: here education shows that negative sign and significant at 10% probability levels. When education level of the household head increases by one class, it increases probability of negative perceptions about *L. camara* invasion by 1.3 percent. But, this result opposed to some literatures' that assumed education improves skill on how to better control and utilize the species product (Garcia-Llorente *et al.*, 2008). The reason for this might be when the household head educated more, they are aware of the costs that incurred and harm the society due to the invasion of the species, or in other way, education might enable the household heads to be aware of the adverse effects more than their uneducated neighbors. This result is in consistent with results of Arbuthnot and Lingg (1975), Buttell and Flinn (1978) and Robertson and Samdahl (1989).

Family size: Family size was significant at 5% probability level with a negative effect on households' perception about *L. camara* invasion. The result implies that when households' family size increases by one in terms of adult equivalent, it increases probability of negative perceptions towards *L. camara* invasion by 2.9 percent. This result was contradicted with what assumed or hypothesized, the reason for this might be the high cost incurred by the family due to the availability of more labor to eradicate the species and to cover medicinal expenses for adversely infected family member. Therefore, the high cost they incurred might enforce them to feel bad about the species.

Land holding: Households' perceptions could also be influenced by hectares of land holding by the household. The coefficient for this variable is positive and significant at 5% probability level. A hectare increase in land holding will increase probability of households' positive perception towards the species by 19.8 percent. This is why, *L. camara* was predominantly used as a hedge around households' farm with continuous preventive action of controlling, not allowed to propagate inside the farm especially around Khat farms. Even some farmers in the area intentionally planted the species to use it as fence around their farm.

Market distance: The coefficient for market distance is negative and significant at 10% probability level. A one kilo meter increase in distance to the nearest market will increase probability of households' negative perceptions about the effects of *L. camara* invasion by

0.57 percent. Access to market enables households' to participate in productive utilization of the species, the sign of the coefficient is also in line with the hypothesis and results of other studies (eg. Mohammed, 2012). Those who are far from the market disfavor the species as they were not able to benefit from sales of their *L. camara* products due to more money and time spent on distant market compared to the nearby ones.

Marginal effects of the Tobit model

Table 26: Marginal effects of the Tobit model

Variable	Marginal effects		
	$\frac{\partial E(y^*)}{\partial x}$	$\frac{\partial E(y)}{\partial x}$	$\frac{\partial E(y 0 < y < 1)}{\partial x}$
Gender	-0.0967**	-0.0924**	-0.0718**
AgeHH	-0.0006	-0.0004	-0.0003
EduHH	-0.0131*	-0.0097*	-0.0073*
Mstatus	-0.0826*	-0.0615*	-0.0463*
FamilyAE	-0.0295**	-0.0220**	-0.0165**
Tluliv	-0.0080	-0.0060	-0.0045
Landhold	0.1982**	0.1475**	0.1111**
Expccrop	0.0011	0.0008	0.0006
Extension	0.0063	0.0047	0.0035
Mktdistance	-0.0057*	-0.0043*	-0.0032*
Proximity	0.0045	0.0033	0.0025
Phoneusage	-0.0330	-0.0248	-0.0187
Accesscredit	-0.0167	-0.0122	-0.0092

5. SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1. Summary

The main aim of the study was to examine households' perceptions about the effects of invasive woody species *P. juliflora* and *L. camara* in 15 randomly selected kebeles in Amibara and Tulo districts, Afar and Oromia regional states of Ethiopia respectively. To achieve the intended objectives, the researcher employed both descriptive and econometric analysis. The research design followed a two-stage sampling procedure. A total of 260 respondents, 130 respondents from each district, were selected randomly based on probability proportional to household size of the 15 selected kebeles. First, to measure household's perception about the invasive alien species a different Likert item statements (i.e. perception indicators) offered to sampled households to either agree or disagree with the statement on a 5-point Likert scale. The Likert scale measures the average intensity of perceptions or attitudes and represents the average degree of perceptions members hold. The level of respondent's perceptions toward invasive alien species was determined by dividing the grand mean perception score of all the items by the number of items (i.e. perception index). Secondly, to assess the factors influencing households' perception, perception index which was developed on the effects of the IAS was regressed up on hypothesized explanatory variables using two limit Tobit model.

With regard to the present household heads' perception about the species i.e. *P. juliflora*, out of 130 sample households 117 disfavored the species, 12 were indifferent and the rest 1 household heads had favored *P. juliflora* invasions. Household perception at the time of species introduction in the area was registered as not good for 11 respondents, indifferent for 17 and good for 102 household heads. A significant difference was observed with past and present perception of pastoralists or agro-pastoralists about the species. And the abundance of species increases than ever in the area regardless of seasonal variability. The survey result show that 45 respondents rate their knowledge about *P. juliflora* by answering a great deal, 8 respondent had a fair amount of knowledge, 55 respondent had some knowledge, and 18 respondents had very little knowledge about the species. Furthermore, 85.38% of sample

households took controlling measures to reduce *P. juliflora* invasion, of which 77.69% through mechanical method and the rest used firing as a reducing or controlling agent.

According to the survey results with regard to household heads' perceptions about *L. camara*, out of 130 sample households 108 disfavored the species, 17 had favored and the rest 5 respondents were indifferent about the effects of *L. camara* invasion. Households' perceptions at the time of species introduction was good in the study area with 104 respondents rating as good, indifferent for 6, not good for 12 household heads and only 8 respondents did not know their perception at the time of *L. camara* introduction. Even if it is not significant a difference was observed between past and present household heads' perceptions about *L. camara* invasion. And abundance of *L. camara* in the farm land was decreasing due to continuous response measure taken by the households but in general (i.e. including mountains and grass lands) its abundance was increasing than ever in the study area regardless of seasonal variability. Similarly, about 94.5% respondents' knowledge about the species was more than some amount and their primary source of information was their own experience with the species. Furthermore, 96.15% of sample household heads' took controlling measure towards *L. camara* invasion through mechanical method while the rest did nothing to control its invasion.

The empirical evidence on factors determining households' perceptions about the effects of *P. juliflora* invasion indicate that gender, market distance, extension service and livelihood diversification had a statistically significant and negative influence on households' perception about the species while proximity to the bush land had a significant and positive influence. On the other hand, with regard to *L. camara* the finding shows that gender, education level, family size and market distance had a significant negative influence on households' perception about the species. In contrast, the variable land holding had a significant positive effect on the dependant variable.

Even though more than 80% of the local people (farmers and agro-pastoralists) had a negative perception towards the species (both *P. juliflora* and *L. camara*) and they are highly supportive for their complete removal, minimum efforts have been made by the community

and government to control *P. juliflora* and *L. camara* invasion especially from communal lands. In Amibara district, the local chief and elders mobilized the community, including women and youth, to remove *P. juliflora* from communal areas in order to open up land for cultivation but it was not that much effective. However, all individuals interviewed in both districts and most individuals in the Tulo district have undertaken some form of control measures on their own land and around their homesteads by uprooting seedlings, cutting, and burning though the outcome is not satisfactory and effective especially in Amibara districts.

5.2. Conclusion and Recommendations

Empirical findings from this survey study have some feasible conclusions and policy implications which influence households' perceptions about the effects of *P. juliflora* and *L. camara* invasions. Therefore, the following conclusion and recommendations are forwarded.

In both study areas, sex had statistically significant and negative influence on households' perceptions about *P. juliflora* and *L. camara* invasions. This implies that female household heads have relatively good perception about the IAS (i.e. *P. juliflora* and *L. camara*) than male household heads. In Ethiopia, generally rural women have low status with huge workload at home and on the farm. More specifically, they are busy in searching feed, fetching water, collecting fire wood and preparing food for the family; also this is the reason for women to relatively favor IAS invasions because availability of such species at nearby areas might save their time and energy from searching fodder and wood products at distant area. However, gender influences rural communities' perceptions; accordingly capabilities on how environments are managed and used over time. Therefore, different programmes have to be launched to enhance the participation of women to attend in community decision making, training, and development works. Furthermore, it is important to take into account gender issues during problem identification, designing, implementing, and monitoring and evaluation of any intervention for effective and successful management of IAS.

Education was a statically significant variable which had negative effect on households' perceptions about the effects of *L. camara* invasions. Unlike sample respondents in Amibara

district, over half of sample respondents in Tulo district had enrolled in formal education even if it was in primary school. However, education is a key tool to understand the environment or to assess or obtain information about the environment i.e. about how to manage or utilize or cope up with difficult situation. Therefore, programmes have to be launched to increase households' enrollment in formal education.

Livelihood strategy had also a significant and negative influence on households' perceptions about *P. juliflora*. This is due to the high adverse effects of the species on livestock based livelihood system (i.e. pastoralism). Since it encroach pasture lands and replace native plants. By improving access to credit service, market infrastructure, and extension service, an alternative livelihood options can be generated and perceptions might be improved. Most importantly, government policy restrictions on charcoal making, transportation and selling of *P. juliflora* have its own justification. Nevertheless, it has overlooked the principle of "eradication by utilization". Therefore, regional government and concerned NGOs need to work on the improvement of pastoralist and agro-pastoralist knowledge in various dimensions of livelihood strategies using subsequent informal trainings and expansion of formal education in the area. Consequently, participation in different livelihood activities will have a likely effect on income distribution, pastoralist livelihood improvement and finally on households perceptions about *P. juliflora*.

Despite improved extension system is an essential element to improve awareness and to promote uses and controlling mechanisms of IAS for the rural households, results of the study revealed that extension service is a significant negative coefficient of perception. The possible reasons for this result are related with missing the target of extension service on IAS invasion control. Moreover, DAs have limited practical knowledge about *P. juliflora* and *L. camara* management and utilization. Therefore, the regional Pastoral Agriculture and Development Bureaus have to offer subsequent practical trainings at grass root level. Furthermore, the Bureau has to work in designing the extension system in a way that can upgrade practical skill of extension workers.

Bush land proximity would likely affect household perceptions about IAS. Households who live in nearby bush land areas acquainted with the adverse effects of IAS. Since the main products, required for rural livelihoods, offered by the species *P. juliflora* and *L. camara* are secondary (i.e. IAS does not adequately substitute products of replaced native species), an appropriate strategy to control the spread of invasive plants in the communal lands would be better. In the process of developing the strategy, households living near to those areas should be in the frontline because they are responding to the invasive species immediately both as a victim and a principal to utilize.

In both study areas, actions in responses to IAS (i.e. *P. juliflora* and *L. camara*) invasions have concentrated on control and/or eradication attempts in individually controlled farms and homesteads that is why invasions of *P. juliflora* and *L. camara* increasing at public lands like in pasture and mountain areas. Land tenure arrangements in particular, will influence households' willingness to invest their time and effort in management activities. Therefore, frequent trainings and education about the effects of IAS invasions on ecosystem and livelihood are vital for a successful management of invasive plants. In line with this, the effort should be designed to improve households' incentives to participate in the joint control of IAS at communal lands.

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7. APPENDICES

7.1. Appendix-I Conversion Factors and Model Diagnostic Tests

Table 1: Conversion factor for computing man equivalent

Group of years	Male	Female
<10	0	0
10-13	0.2	0.2
14-16	0.5	0.4
17-50	1	0.8
>50	0.7	0.5

Source: Storck *et al.* (1991) cited by Arega Shumetie. M.Sc. thesis presented in Haramaya University, 2010.

Table 2: TLU (Tropical Livestock Unit) values for Ethiopia

Animal type	TLU value
Camel	1
Sheep	.09
Goat	.09
Plough ox	1.10
Cow	.80
Heifer	.50
Bull	1.10
Calf	.20
Donkey	.36
Horse	.80
Mule	.80

Source: ILRI (International Livestock Research Institute) cited by Mohammed Jemaneh M.Sc. presented in Haramaya University

Table 3: Multicollinearity test^A

Variable	VIF	1/VIF
Sex	1.17	0.852488
EduHH	1.50	0.667321
FamilyAE	1.42	0.703906
Divern	1.34	0.744460
Tluliv	1.33	0.750948
Landccprad	2.27	0.439928
Expccrop	1.33	0.752294
Extension	1.48	0.674503
IncomeHH	1.79	0.557208
Mktdistance	3.57	0.280183
Proximity	1.96	0.510263
Irrigusage	2.48	0.403978
Phoneusage	1.40	0.715678
Mean VIF	1.77	

Table 4: Multicollinearity test^T

Variable	VIF	1/VIF
Sex	1.47	0.680232
AgeHH	4.35	0.229851
EduHH	1.29	0.773474
FamilyAE	1.88	0.532312
MaritalS	1.39	0.721489
Tluliv	1.18	0.847084
Landccprad	1.21	0.826163
Expccrop	4.37	0.228658
Extension	1.11	0.898317
Mktdistance	1.07	0.935757
Proximity	1.09	0.915178

Phoneusage	1.32	0.758557
Accesscredit	1.12	0.896154
Mean	1.76	

7.2. Appendix-II Semi-structured Questionnaire for Amibara District

Questionnaire for Household Interview on: Households' Perception about *P. juliflora*: The case of Amibara district of Afar National Regional States of Ethiopia.

Interviewed by: _____ Date ____ / ____ /2016 Time: ____ Signature _____

Checked by: _____ Date ____ / ____ /2016 Time: ____ Signature _____

Household Code	
District	
Name of Village	

PART ONE: SAMPLE HOUSEHOLDS BACKGROUND INFORMATION (USE CODEBOOK)

1. Name of the interviewee _____ if not the household head, your relationship to household head _____
2. Main occupation (income source) of the household (Code 1) _____
3. How long have you been in this occupation? _____ years.
4. Family members including the household head.

I.D. code	Age (yrs)	Sex (Code 2)	Marital status (Code 3)	Education Level (Code 4)	Occupation (Code 5)
01*					
02					
03					
04					
05					
06					
07					
08					
09					

10					
11					
12					

* Fill about the **household head** in I.D. 01. Note that family members refer to persons currently living in the same roof.

5. What is your household monthly expenditure in Birr per month? _____.
6. For how long have you been living here? 1. Born here 2. _____ years.

PART TWO: HOUSEHOLDS' PERCEPTION ABOUT PROSOPIS

7. Do you know what Prosopis is? 1. Yes 0. No
8. How much do you know about Prosopis?
1. Nothing 2. Very little 3. Some 4. A fair amount 5. A great deal
9. From where did you get information about Prosopis?
1. Direct/personal observations/experience
1. Friends and Family _____
2. Agricultural Office/development agent _____
3. Newspapers _____
4. Magazines _____
5. Radio _____
6. Television _____
7. Library or books _____
8. Talking to environmental specialists _____
9. Others _____
10. Using the lines to the right of your answers above please rank the items you have circled in order of amount of information [Starting with 1 = Most Information]
11. How do you describe the invasion of Prosopis in your area? 1. Low 2. Medium 3. High
12. How long Prosopis been in your area? _____
13. By whom and from where do you think Prosopis came to this locality? _____
-
14. How was it started invading the area (agent/means)? _____
-
15. For what purpose was Prosopis introduced in your area? (if you have more than 2 answers please rank in their level of priority starting with 1= most important)
1. Greening up/beautifying the area
2. Combat desertification
3. Preventing drought
4. Rehabilitate degraded soils
5. Supply firewood
6. Supply fodder

7. No response
8. Other specify_____
16. How was your perception about Prosopis at the time of its introduction?
1. Good 2. Not good 3. Fair 4. Don't know
17. What is your perception about the Prosopis now?
1. Good 2. Not good 3. Fair 4. Don't know
18. If your perception has changed, why?_____
-
19. How do you describe the abundance of Prosopis in your farm since the time of introduction?
1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all (I don't know)
20. If your answer to question no_19 is increasing; why do you think is the reason?_____
-
21. What is the growing pattern of Prosopis in your area?
i) During summer: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all
ii) During winter: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all
iii) Throughout the year: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all
22. Do you use Prosopis leaf/pod as forage for animal? 1. Yes 0. No
23. If your answer in question no_22 is 'yes', when do you use Prosopis leaf/pod as forage for animal?
1. When drought occurs
2. As supplementary forage
3. Always
24. Is Prosopis used as a safety net during time of hardship? 1. Yes 0. No
- 24.1. If yes, for what purpose?
1. Alternative fodder for cattle 2. Income source until found new employment 3. Both
25. Does drought occurs in your area? 1. Yes 0. No
26. If yes in question 25, how often_____
27. What were/are your coping strategies?_____
28. Which one of the following best describes the effect of Prosopis on your livelihood?
1. Most harmful 2. Harmful 3. Undecided 4. Beneficial 5. Most beneficial 6. No impact
29. What is your perception about the effects of Prosopis invasion?
1. Negative 2. Positive 3. Both negative and positive
4. No effect 5. I don't know

30. If y our answer to question no_29 is 1 or 3, which of the followings are the negative effects of Prosopis?

Effects	Perception Levels*				
	1	2	3	4	5
Invasion of wet and dry season grazing sources					
Invades farming land					
Competition for labor and expensive control methods					
Limiting seasonal mobility of herds					
Invades villages/ settlement areas					
Troubles herders for their site control of herds					
Blocking foot paths, puncture skins and cause injury					
Invades burial places					
Probable danger to household members and on livestock due to the thorn					
Host to predators, rustlers and mosquitoes					
The pod/leaf is probable danger for livestock health					
Inhibits under canopy growth of grasses and herbs					
Endangers indigenous tree species					
Narrowing/blocking cattle tracks					
Reducing surface and ground water availability					
Litters under water cause stringent smell					
Decrease plant diversity or biodiversity					
Land degradation					
Causes social/ethnic conflicts					
I negatively perceive the species					
Prosopis are ugly					
Prosopis does not deserve protection					

Note: *indicate that 1=Strongly Disagree 2=Disagree 3=Indifferent 4=Agree 5=Strongly Agree

31. If your answer to question no_29 is 2 or 3, which of the followings are the benefits of Prosopis?

Effects	Perception Levels ¹				
	1	2	3	4	5
Source of income from charcoal					
Source of income from fuel wood					
Charcoal for home consumption					
Barn (traditional mobile shelter) construction					
Temporary platform for resting					
For making traditional bed					
Shelter for wild life					
Fuel wood for home consumption					
Source of fodder for livestock					
Use as wind break or reduce wind speed					
Shade tree					
Hedge (live and dead)					
Fencing homestead					
House construction					
Nectar for bee keeping					
Protection of soil erosion					
Combat desertification					
Walking stick					
Enhances soil fertility					
Enhance biodiversity					
Has medicinal value					
Cultural values					
Has ornamental value					
Prosopis deserve protection					

Note: *indicate that 1=Strongly Disagree 2=Disagree 3=Indifferent 4=Agree 5=Strongly Agree

32. Do you manage Prosopis? 1. Yes 0. No

33. What traditional methods are used to avoid invasion or adverse effect of Prosopis?

34. In reducing density and/or invaded areas from cropland, which specific method do you prefer to implement?

1. Utilization

2. Biological

3. Physical

4. Chemical

5. Others (specify) _____.

35. Why do you prefer the method selected in question 34?

36. In reducing density and/or invaded areas from grassland, which specific method do you prefer to implement?

1. Utilization

2. Biological

3. Physical

4. Chemical

5. Others (specify) _____.

37. Why do you prefer the method selected in question 36?

PART THREE: FARM HOUSEHOLD CHARACTERISTICS

38. How many hectares of land do you own? _____ ha

39. How many hectares of cultivated land do you own? _____ ha

40. Livestock ownership and annual income gain

Type	Total owned	Number of livestock sale	Average amount sold per unit	Average amount incurred per unit	Net income gained
Cow					
Ox					
Camel					
Sheep					
Goat					
Donkey					
Hen					
Horse					
Honey production					
Others					

41. Type of crop produced and annual income gain

Type	Experience on farming	Area covered (hectare)	Total produced	Total cost incurred	Total amount sold	Net income gained
Sorghum						
Maize						

Haricots bean						
Barley						
Wheat						
Khat						
Coffee						
Potato						
Tomato						
Onion						
Green paper						
Sesame						
Sweet potato						
Watermelons (Habhab)						
Others						

42. Summary of annual income gain from different sources

No.	Livelihood strategy	Experience in years	Monthly	Annually
1.	Crop production			
2.	Livestock production			
3.	Labor selling/off farm activity			
4.	Trade			
5.	Land rent			
6.	Others			
	Total			

PART FOUR: SUPPORT SERVICES CAPITAL

43. Do you have any access for credit? 1. Yes 0. No

43.1. If Yes, how much did you receive credit from them? _____

44. Do they ask you collateral for credit access? 1. Yes 0. No

44.1. If yes, what is it? _____

45. Do you encounter any barriers for credit access? 1. Yes 0.No

45.1. If yes, describe it _____

46. Do you get cash income (government grant, pension, and local employment)? 1. Yes 0. No

47. Do you know any institution that provides training regarding to your livelihood? 1. Yes 0. No

48. Do you get an extension service? 1. Yes 0. No

48.1. If yes, from whom you get those services? 1. Development agent 2. Non-governmental entity 3. Relatives 4. Experienced local leaders 5. Research center

49. How often they contact you? _____
50. How many killo meters is the market far from your village? _____ km
51. Do you have the access to technologies that helps to use the Prosopis and Prosopis by products in a better way? 1. Yes 0. No
- 51.1. If 'Yes' what are those technologies and their function? _____

52. Do you use irrigation in your land? 1. Yes 0. No
- 52.1. If yes, for how long? _____ years.
53. Do you use phone for information exchange? 1. Yes 0. No
- 53.1. If yes, what kind of phone you use? 1. Home 0. Mobile

54. Estimate the coverage of Prosopis on pasture land/farm land and its cost

Land type	Total area owned (hectare)	Area invaded (hectare)	Cost incurred for Controlling per year
Pasture land			
Farm land			
Communal grazing land			
Communal farm land			

PART FIVE: ALTERNATIVE USES

55. What do you think is the beneficial side of Prosopis?

For domestic use _____

For commercial use _____

Others _____

56. What did you do before Prosopis was here? _____

57. Do you remember a time when this species was not here? 1. Yes 0. No

57.1. If yes, what other species did you use at that time? _____

58. Do you still use those other species? 1. Yes 0. No

59. Why did you change to the Prosopis? _____

60. Do you make any items from this plant (i.e. Prosopis) that you cannot make from other species? _____

61. What would you do if the plant (i.e. Prosopis) was not there anymore? _____

62. If there was a lot less, or very little of the species left, are there any other species you could use instead? _____

63. How far is the bush land from your home? _____ km

PART SIX: EFFECTS ON LAND USES

64. Are there areas in the landscape where Prosopis is, most common or prefers to grow?

1. Yes 0. No

64.1. If Yes, Where does it like to grow?

65. Are there areas in the landscape where you don't want Prosopis to grow? 1. Yes 0. No

65.1. If Yes, Where don't you want it to grow? _____

65.2. Why do you not want it to grow there? _____

66. Does Prosopis cause any problem to you, your household and other people? 1. Yes 0. No

66.1. If Yes, What problems does it cause? _____

67. Does this Prosopis grow in areas of special cultural significance? 1. Yes 0. No

67.1. If Yes, Where? _____

PART SEVEN: FUTURE

68. Do you think anything should be done about Prosopis in the future? 1. Yes 0. No

68.1. If 'Yes' what do you think should be done? _____

69. Do you have any other comments you would like to make? _____

Code Book

Code (1)	Code (2)	Code (3)	Code (4)	Code (5)
1. Pastoralism	0. Female	1. Married	0= Illiterate (No education)	1. Herder
2. Crop production	1. Male	2. Single	0*= Alternative Basic Education (ABE)(kumbaru)	2. Farmer
3. Agro-pastoralism (crop and animal production)		3. Divorced	1.If formal school, grade completed	3. wage worker
4. Trade		4.widow		4.petty trade
5. Salary employ		5.not together		5. No job
6. Share from clan land				6. Other

7. Other (specify)				
-----------------------	--	--	--	--

7.3. Appendix-III Semi-structured Questionnaire for Tulo district

Questionnaire for Household Interview on: Households' Perception about *L. Camara*: The case of Tulo district of Oromiya National Regional States of Ethiopia.

Interviewed by: _____ Date ____ / ____ /2016 Time: ____ Signature _____

Checked by: _____ Date ____ / ____ /2016 Time: ____ Signature _____

Household Code	
District	
Name of Village	

PART ONE: SAMPLE HOUSEHOLDS BACKGROUND INFORMATION (USE CODEBOOK)

1. Name of the interviewee _____ if not the household head, your relationship to household head _____
2. Main occupation (income source) of the household (Code 1) _____
3. How long have you been in this occupation? _____ years.
4. Family members including the household head.

I.D. code	Age (yrs)	Sex (Code 2)	Marital status (Code 3)	Education Level (Code 4)	Occupation (Code 5)
01*					
02					
03					
04					

05					
06					
07					
08					
09					
10					
11					
12					

* Fill about the **household head** in I.D. 01. Note that family members refer to persons currently living in the same roof.

5. What is your household monthly expenditure in Birr per month? _____.
6. For how long have you been living here? 1. Born here 2. _____ years.

PART TWO: HOUSEHOLDS' PERCEPTION ABOUT LANTANA

7. Do you know what lantana is? 1. Yes 0. No
8. How much do you know about Lantana? 1. Nothing 2. Very little 3. Some 4. A fair amount
5. A great deal
9. From where did you get information about Lantana?
1. Direct/personal observations/experience
 1. Friends and Family _____
 2. Agricultural Office/development agent _____
 3. Newspapers _____
 4. Magazines _____
 5. Radio _____
 6. Television _____
 7. Library or books _____

8. Talking to environmental specialists _____

9. Others _____

10. Using the lines to the right of your answers above please rank the items you have circled in order of amount of information [Starting with 1 = Most Information]

11. How do you describe the invasion of Lantana in your area? 1. Low 2. Medium 3. High

12. How long lantana been in your area? _____

13. By whom and from where do you think Lantana came to this locality? _____

14. How was it started invading the area (agent/means)?

15. For what purpose was Lantana introduced in your area? (if you have more than 2 answers please rank in their level of priority starting with 1= most important)

1. Greening up/beautifying the area

2. Combat desertification

3. Preventing drought

4. Rehabilitate degraded soils

5. Supply firewood

6. Supply fodder

7. No response

8. Other specify _____

16. How was your perception about Lantana at the time of its introduction?

1. Good 2. Not good 3. Fair 4. Don't know

17. What is your perception about the Lantana now? 1. Good 2. Not good 3. Fair 4. Don't know

18. If your perception has changed, why? _____

19. How do you describe the abundance of Lantana in your farm since the time of introduction?

1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all (I don't know)

20. If your answer to question no_19 is increasing; why do you think is the reason? _____

21. What is the growing pattern of Lantana in your area?

i) During summer: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all

ii) During winter: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all

iii) Throughout the year: 1. Increasing 2. Decreasing 3. No difference 4. Not noticed at all

22. Do you use Lantana leaf/pod as forage for animal? 1. Yes 0. No

23. If your answer in question no_22 is 'yes', when do you use Lantana leaf/pod as forage for animal?

1. When drought occurs

2. As supplementary forage

3. Always

24. Is Lantana used as a safety net during time of hardship? 1. Yes 0. No

24.1. If yes, for what purpose?

1. Alternative fodder for cattle 2. Income source until found new employment 3. Both

25. Does drought occurs in your area? 1. Yes 0. No

26. If yes in question 25, how often _____

27. What were/are your coping strategies? _____

28. Which one of the following best describes the effect of Lantana on your livelihood?

1. Most harmful 2. Harmful 3. Undecided 4. Beneficial 5. Most beneficial 6. No impact

29. What is your perception about the effects of Lantana invasion?

1. Negative 2. Positive 3. Both negative and positive

4. No effect 5. I don't know

30. If your answer to question 29 is 1 or 3, which of the followings are the negative effects of Lantana?

Costs / Effects	Perception Levels*					
	1	2	3	4	5	6
Allelopathic qualities reduces the vigor of native plant species and limits their productivity						
Invasion and loss of pasture in grazing areas						
Handling plant may cause skin irritation or allergic reaction						
Reduce productivity in orchards and interferes with harvesting						
Invades and reduce farming land						
Competition for labor and expensive control methods						
Limiting mobility of herds						
Invades villages/ settlement areas						
Troubles herders for their site control of herds						
Blocking foot paths, puncture skins and cause injury						
Invades burial places						
Host to pests, predators, rustlers and mosquitoes						
The pod/leaf is probable danger for livestock health						
Inhibits under canopy growth of grasses and herbs						
Endangers indigenous tree species						
Narrowing/blocking cattle tracks						
Reducing surface and ground water availability						
Litters under water cause stringent smell						
Decrease plant diversity or biodiversity						
Land degradation						
I negatively perceive the species						
Lantana is ugly						
Lantana do not deserve protection						

Note: *indicate that 1=Strongly Disagree 2=Disagree 3=Indifferent 4=Agree 5=Strongly Agree

31. If your answer to question no_29 is 2 or 3, which of the followings are the benefits of Lantana?

Benefits/Effects	Perception Levels*					
	1	2	3	4	5	6
Source of income in nursery sector as ornamental						
Source of income from fuel wood						
Source of organic matter for pasture renovation						
Provide perch sites and cover for birds						
winter food for many native birds						
Used as bio fuel and mulch						
Drought-tolerant plant so good candidates for landscape at desert area						
Fencing homestead						
Fuel wood for home consumption						
Source of fodder for livestock						
Act as hedge (live and dead)						
Shelter for wild life						
Used for weaving e.g. baskets						
Use as wind break or reduce wind speed						
Shade tree						
Nectar for bee keeping, butterflies and moths						
Protection of soil compaction and erosion						
Combat desertification						
Enhances soil fertility						
Enhance biodiversity						
Has medicinal value						
Going to the lantana forest is enjoyable						
Cultural values						
Has ornamental value						
Lantana deserve protection						

Note: *indicate that 1=Strongly Disagree 2=Disagree 3=Indifferent 4=Agree 5=Strongly Agree

32. Do you manage lantana? 1. Yes 0. No

33. What traditional methods are used to avoid invasion or adverse effect of Lantana?

34. In reducing density and/or invaded areas from cropland, which specific method do you prefer to implement?

1. Utilization

2. Biological

3. Physical

4. Chemical

5. Others (specify) _____.

35. Why do you prefer the method selected in question 34? _____

36. In reducing density and/or invaded areas from grassland, which specific method do you prefer to implement?

1. Utilization

2. Biological

3. Physical

4. Chemical

5. Others (specify) _____.

37. Why do you prefer the method selected in question 36? _____

PART THREE: FARM HOUSEHOLD CHARACTERISTICS

38. How many hectares of land do you own? _____ ha

39. How many hectares of cultivated land do you own? _____ ha

40. Livestock ownership and annual income gain

Type	Total owned	Number of livestock sale	Average amount sold per unit	Average amount incurred per unit	Net income gained
Cow					
Ox					
Camel					
Sheep					
Goat					
Donkey					
Hen					
Horse					
Honey production					
Others					

41. Type of crop produced and annual income gain

Type	Experience on farming	Area covered	Total produced	Total cost incurred	Total amount	Net income
------	-----------------------	--------------	----------------	---------------------	--------------	------------

		(hectare)			sold	gained
Sorghum						
Maize						
Haricots bean						
Barley						
Wheat						
Khat						
Coffee						
Potato						
Tomato						
Onion						
Green paper						
Sesame						
Sweet potato						
Watermelons (Habhab)						
Others						

42. Summary of annual income gain from different sources

No.	Livelihood strategy	Experience in years	Monthly	Annually
1.	Crop production			
2.	Livestock production			
3.	Labor selling/off farm activity			
4.	Trade			
5.	Land rent			
6.	Others			
	Total			

PART FOUR: SUPPORT SERVICES CAPITAL

43. Do you have any access for credit? 1. Yes 0. No

43.1. If Yes, how much did you receive credit from them? _____

44. Do they ask you collateral for credit access? 1. Yes 0. No

44.1. If yes, what is it? _____

45. Do you encounter any barriers for credit access? 1. Yes 0.No

45.1. If yes, describe it _____

46. Do you get cash income (government grant, pension, and local employment)? 1. Yes 0. No

47. Do you know any institution that provides training regarding to your livelihood? 1. Yes 0. No

48. Do you get an extension service? 1. Yes 0. No

48.1. If yes, from whom you get those services? 1. Development agent 2. Non-governmental entity 3. Relatives 4. Experienced local leaders 5. Research center

49. How often they contact you? _____

50. How many killo meters is the market far from your village? _____ km

51. Do you have the access to technologies that helps to use the Lantana and Lantana by products in a better way? 1. Yes 0. No

51.1. If 'Yes' what are those technologies and their function? _____

52. Do you use irrigation in your land? 1. Yes 0. No

52.1. If yes, for how long? _____ years.

53. Do you use phone for information exchange? 1. Yes 0. No

53.1. If yes, what kind of phone you use? 1. Home 0. Mobile

54. Estimate the coverage of Lantana on pasture land/farm land and its cost

Land type	Total area owned (hectare)	Area invaded (hectare)	Cost incurred for Controlling per
Pasture land			
Farm land			
Communal grazing land			
Communal farm land			

PART FIVE: ALTERNATIVE USES

55. What do you think is the beneficial side of Lantana?

For domestic use _____

For commercial use _____

Others _____

56. What did you do before lantana was here? _____

57. Do you remember a time when this species was not here? 1. Yes 0. No

57.1. If yes, what other species did you use at that time? _____

58. Do you still use those other species? 1. Yes 0. No

59. Why did you change to the Lantana? _____

60. Do you make any items from this plant (i.e. Lantana) that you cannot make from other species?

61. What would you do if the plant (i.e. Lantana) was not there anymore?

62. If there was a lot less, or very little of the species left, are there any other species you could use instead? _____

63. How far is the forest/grazing land from your home? _____ km

PART SIX: EFFECTS ON LAND USES

64. Are there areas in the landscape where Lantana is, most common or prefers to grow?

1. Yes 0. No

64.1. If Yes, Where does it like to grow?

65. Are there areas in the landscape where you don't want Lantana to grow? 1. Yes 0. No

65.1. If Yes, Where don't you want it to grow? _____

65.2. Why do you not want it to grow there? _____

66. Does Lantana cause any problem to you, your household and other people? 1. Yes 0. No

66.1. If Yes, What problems does it cause? _____

67. Does this Lantana grow in areas of special cultural significance? 1. Yes 0. No

67.1. If Yes, Where? _____

PART SEVEN: FUTURE

68. Do you think anything should be done about Lantana in the future? 1. Yes 0. No 72.1. If 'Yes' what do you think should be done? _____

69. Do you have any other comments you would like to make? _____

Code Book

Code (1)	Code (2)	Code (3)	Code (4)	Code (5)
Pastoralism	Female	Married	0= Illiterate (No education)	Herder
Crop production	Male	Single	0*= Alternative Basic Education (ABE)(kumbaru)	Farmer
Agro-pastoralism (crop and animal production)		Divorced	1.If formal school, grade completed	3. wage worker
Trade		4.widow		4.petty trade
Salary employ		5.not together		5. No job
Share from clan land				Other
Other (specify)				