LOCAL COMMUNITIES' PERCEPTIONS ON LANTANA CAMARA AND MANAGEMENT RESPONSES IN EAST USAMBARA, TANZANIA

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ABSTRACT

Lantana camara is one of the alien invasive species introduced to East Usambara about 100 years ago. The species is locally increasing in abundance and spatially advancing to new areas threatening the livelihoods of local communities and biodiversity in nearby Amani Nature Reserve. This study assessed local communities' perceptions on *Lantana camara* focusing on its origin, pathways, socio-economic impacts and management responses in East Usambara. Data was collected through household survey where semi structured questionnaire was randomly administered to 130 household heads in seven villages. Results showed that about 97% of the respondents were very knowledgeable about invasion and pathways of *L. camara* but surprisingly, about 99% of respondent regardless of age categories perceived *L. camara* to be a native shrub. At an early stage of *L. camara* invasion, 20% of respondents perceived the species to be "bad" but the negative perception increased to 76.2% of respondents at the late stage of invasion. About 77% of the respondents argued that *L. camara* invasion has harmful effects on their livelihoods. Furthermore, 38% of respondents preferred the species to be controlled, 34% stated nothing should be done and 22% preferred prevention of *L. camara* invasion and only 7% of respondents proposed the species to be completely eradicated. study concludes despite considerably large proportion of respondents (33.8%) were comfortable with current *L. camara* cover and they had no intension of reducing the level of invasion but generally results indicate the need for more sustainable management measures that will see *L. camara* coverage not exceeding the current levels in less invaded areas while at the same time, reduce its cover in the heavily invaded areas. The study recommends that local communities should be empowered with knowledge on invasion pathway so that they can control *L. camara* invasion to reduce the negative impacts on livelihoods.

DECLARATION

I, Gasto Vicent Mushi, by my signature below, I declare and affirm to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of my registration and that it has neither been submitted nor being concurrently submitted to any other institution.

Gasto Vicent Mushi — Date

(MSc. Candidate)

The above declaration is confirmed by:

Dr. Charles J. Kilawe — Date

(Main Supervisor)

Prof. George C. Kajembe — Date

(Co- Supervisor)

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To my adorable daughter Lucimaria for being the source of encouragement in my life, I pray our Almighty God bless her forever. To all Tanzanian students in SHULE ZA KATA Secondary Schools who are struggling day and night to make it to the University, I want this work to be a light that will ignite hope and efforts in studying hard knowing that it is possible to come from SHULE ZA KATA and graduate Master's degree anywhere in the world.

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LIST OF ABBREVIATIONS

IAS	Invasive Alien Species
L. camara	*Lantana camara*
SUA	Sokoine University of Agriculture
TAFORI	Tanzania Forest Research Institute

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Invasive Alien Species (IAS) have been introduced worldwide due to the perceived by communities; economic, environmental or aesthetic values. Some accidental introductions have also occurred through time, however introduction of new species is not always beneficial and one of the problems linked to this is the possibility of these species becoming invasive thereby altering ecosystem processes or causing problems to livelihoods (Mack *et al.,* 2000). IAS can be defined as non-indigenous species that adversely affect, economically, environmentally or ecologically habitats where they have been introduced, either accidentally or deliberately, outside their normal past or present distribution (CBD, 2010). Invasive alien species are found in all taxonomic groups and can affect all types of ecosystems (CBD, 2010). IAS, along with climate change, land use change and changes in the Nitrogen and Carbon cycles, are identified as top four drivers of global biodiversity loss, their relative importance depends on the Eco-region being considered. Furthermore, IAS including *L. camara* can affect productive landscapes by reducing crop yields, reducing grazing lands and affecting provision of ecosystem services by altering hydrology, fire regimes, nutrient cycling, and other ecosystem processes. Evidence suggests that ecosystems with low diversity are more susceptible to invasion than species-rich systems, however this is contentious.

L. camara, a notorious global invader has spread rapidly in many of the 60 regions of the world to which it has been introduced (Day *et al.*, 2003) and is listed among the world's one hundred worst invasive species (Lowe *et al.*, 2000) also is one of the most conspicuous invaders in savannah ecosystems worldwide (Foxcroft *et al.,* 2010). In a recent global review of invasive trees and shrubs, *L. camara* was found to be one of

the most widespread invasive alien woody shrub species globally, being recorded as invasive in 12 out of 15 regions assessed (Richardson and Rejmánek, 2011). *L. camara* has invaded large expanses of land in Tanzania where it threatens habitats of the wild animals and affects bird habitats by altering community composition and also pose a big threat to human activities and health. For example, *L. camara* harbours pests that affect human health by providing shelter during the day for tsetse flies (Glossina sp.), which are vectors for African sleeping sickness (Mack and Smith, 2011). In East Usambara, *L. camara* is an Invasive Alien species and it has wide ecological tolerance and surviving successfully in different soil types and displays explosive expansion in areas invaded through achieving exponential population growth and rapid dispersal. The wide spread of this plant is facilitated by moving seeds through running water, dispersal by birds and animals after eating and excreting undigested seeds. *Lantana camara* is used by communities in East Usambara as hedge and ornamental plant, vegetation for reducing and controlling soil erosion and also provide animal fodder and in some areas used as firewood, mulch and herbal medicine (Dua *et al.,* 2010). This indicates that people may view the species differently within an area; it is dependent on human perception. What is considered to have adverse effects by one stakeholder may be considered beneficial by another. So the species can only be judged as an invasive alien within a specific spatial, temporal, economic, environmental and cultural context.

1.2 Problem statement and justification

Lantana camara, an invasive terrestrial weed is such a species which has caused huge repercussions to the native composition of terrestrial ecosystems where it has been introduced. Its invasion is implicated with widespread loss of native species diversity via recruitment, limitation, competition, and alteration of ecosystem structure and function (Dobhal *et al.,* 2009 Sharma *et al.,* 2005; Kohli *et al.,* 2006). Not only is the geographic

range of *L. camara* escalating in various regions, but the density of infestations within its range is increasing and has been acknowledged and recognized as a potential threat in many regions (Sharma and Raghubanshi, 2006; Kimothy *et al.*, 2010; Lüi, 2011). In its new ecosystems, *L. camara* become predator (Drenovsky *et al.,* 2012), competitor (DiVittorio *et al.*, 2007), parasite (Holmes *et al.*, 2009), hybridizer (Corbin and D'Antonio, 2004; Prentis *et al.,* 2008; Cordell and Sandquist, 2008), and cause diseases to native and domesticated plants and animals (Ehrenfeld, 2006; Chambers *et al.,* 2007; Van Kleuenen *et al.,* 2010). Besides all these, it creates a host of harmful effects to native environments including displacement of native species (Anderson, 2005), alteration of soil properties (Nichols and Williams, 2006), degradation or elimination of wildlife forage (Williams, 2001), adversely alter fire regimes (Varner *et al.,* 2009; Metz *et al.,* 2011) and pose a considerable threat to endangered species (Moore and Conroy, 2006). Studies on *L. camara* invasion includes Zavaleta (2000) who estimated economic impacts of tamarisk (Tamarix sp.) in western USA, Van Wilgen *et al.* (1996) who examined costs and benefits of invasive plant species at a regional scale in South African fynbos vegetation, and Le Maitre *et al.* (2002) who concluded that control programmes were justified after a cost-benefit analysis of management of invasive plants in four catchment areas across South Africa. In a more ambitious study, Pimental *et al.* (2001) estimated total costs of invasive exotic species in six nations, the US, the UK, Australia, South Africa, India and Brazil to be more than US$336 billion per year (Pimental *et al.,* 2001).

Despite the economic importance of many invasive species, to date most published work has concentrated on the biological aspects of invasions (Di Tomaso, 2000, Grosholz, 2002, Willis and Hulme, 2002). This is an omission as the process of invasion by Invasive Alien Species is both a social and natural process. People make choices that augment or diminish the chances of species becoming invasive, largely via intentional introductions

to support economic activities including agriculture, gardening, and international trade (Bright, 1999; Reaser, 2001; Wittenberg and Cock, 2001).

Given *L. camara* global status as a species of considerable concern, it is not surprising that it has been extensively studied. Much of the available knowledge of the species has accumulated recently, and is predominantly focused on biological invasion, control efforts and management (Bhagwat *et al.,* 2012), ethno pharmacology, (Ali-Emmanuel *et al.,* 2003) and phytochemistry (Kumar *et al.,* 2011) more often on ecological aspects than on social perceptions and attitudes of the people (Van der Wal *et al.,* 2015). Mack (2001) revealed that IAS is the result of human values, decisions and behaviours and suggested that focusing on human belief systems, and behaviour that follows, might be a more effective long-term strategy for IAS management than concentrating only on ecological factors. Perception can become different, especially between those with vested interests in growing *L. camara* as ornamental, hedge, firewood, mulch, herbal medicine, avoidance of erosion or trading in their products, and the conservationists. Thus, perceptions regarding *L. camara* can differ and are highly dependent on goals that people pursue and both costs and benefits to local people livelihoods and environment. A better understanding of the underlying values in invasive species perception can help to elucidate current difficulties in invasive species management. This type of information is relevant for making decisions on the feasibility of management actions and for informing the general public about invasive species control and involvement in prevention-oriented measures (Andreu *et al.,* 2009).

It can therefore be hypothesized that, the success of invasive species management efforts depends on people. The importance of perceptions and ecological views is apparent in cases where public opposition can cause delay or even terminate control efforts targeted

at a particular IAS. Perceptions explain subjective way in which individuals or group of people experience and understand their environment and associated processes. Therefore perceptions are a crucial part of the appraisal of the management strategies for invasive alien species and in shaping policy and procedure that are both effective and accepted by interested parties. However there are widespread beliefs that all plant species are desirable, because they are assumed to promote rainfall, stabilize catchments, sequester carbon, and provide shade and habitat for wildlife. On the contrary, invasive alien species are described as undesirable because of their negative impacts on biodiversity and ecosystem services (Van Wilgen, 2012). A variety of opinions between those holding conflicting views is also constantly changing, adding to the complexity of the subject. These opposing interests lead to explicitly call for research on local communities' perceptions in order to gather public support for invasive aliens species control programs (Fischer *et al.*, 2011). Therefore this study was designed to assess perception of local commnities' on the spread and impacts of *L. camara* in East Usambara, Tanzania.

1.3 Objectives

1.3.1 General objective

To assess local communities' perceptions on *Lantana camara* and management responses in East Usambara, Tanzania

1.3.2 Specific objectives

i) To assess local communities' perception on knowledge about *Lantana camara* invasion, origin and spread;

ii) To assess local communities perceptions on socio-economic impacts of *Lantana camara* invasion ; and

iii) To examine local communities' management response to *L. camara* invasion.

CHAPTER TWO

2.0 LITERATURE REVIEW

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

2.1 Perception

Perception or attitude can be defined in different ways as:

- Expressions of inner feelings that reflect whether a person is favorably or unfavorably inclined to some object or situation
- Perceptions can also be regarded as "Opinions"
- Perception can also mean "An enduring disposition to consistently respond in a given matter"

Attitude or perception has three components including:

a) Affective component: The feelings or emotions toward an object
b) Cognitive component: Knowledge and beliefs
c) Behavioral component: Predisposition to action, intentions, and behavioral expectations

2.2 Theoretical framework of the study

People's perceptions on nature haven been explained in the visions of nature concept (Van den *Born et al.*, 2001). It comprises of three different components: (1) images of nature (what is nature?) including images of the type of balance in nature, (2) values of nature (why is nature important?) and (3) images of the human–nature relationship (how should people relate to nature?). The first component, images of nature, addresses

people's understanding of what nature is. Aspects shaping people's images of nature unfolded in literature are the absence/presence of humans, autonomy of natural processes and degree of wildness (Buijs, 2009; De Groot, 2012; De Groot and De Groot, 2009; Van den Born, 2008). The study by Vanderhoeven *et al.* (2011) showed that horticultural professionals and nature reserve managers with different perceptions (or images) of nature had different levels of concern for non-native species. Images of nature also comprise images of balance in nature; i.e. beliefs regarding how fragile or how robust nature is. Thompson *et al.* (1990) described four myths of nature (i.e. unstable, with thresholds, stable and indifferent) based on cultural theory of risk. In this theory, followers of each myth have an accompanying view regarding the management of nature (Thompson *et al.,* 1990). Recent applications to environmental risk perception have proved it to be a useful concept in understanding environmental beliefs and nature perception (Grendstad and Selle, 2000; Steg and Sievers, 2000; Storch, 2011). A study that linked myths of nature and perception of risks related to water management showed that respondents who thought of nature as stable were, in general, less concerned about non-native species than respondents with an unstable and thresholds view (Fath and Beck, 2005). However, non-native species were ranked low relative to the other risks included in the study.

The second component, values of nature, is the reason why nature is perceived to be important. Prevailing concepts are those of instrumental (or functional) values and the intrinsic value of nature (the value nature has irrespective of its utility) (Van den Born *et al.*, 2001). For example, people who value nature because of its functionality for humans may have a different perspective on non-native species than people who highly value the authenticity of nature (Van den Born and De Groot, 2009).

The final component is images of the human–nature relationship. Early attempts by philosophers such as Passmore (1974) and Barbour (1980) to classify images of relationships between humans and nature date back to the 1970s and 1980s. This has evolved into a qualitative and quantitative research field discerning between four classifications of human–nature relationships (De Groot *et al.,* 2011; De Groot 1992; Kockelkoren 1993; Van den Born 2008):

i. Mastery over nature: humans stand above nature and are allowed to maximize exploitation of nature to benefit human society as detrimental effects of human actions can easily be overcome by economic growth and technology;
ii. Stewardship of nature: humans stand above nature but have a responsibility towards future generations or God to take care of nature;
iii. Partnership with nature: there is an equal relationship between nature and humans who work together in a dynamic process of interaction and mutual development;
iv. Participant in nature: humans are part of nature, not just biologically, but also with a sense of (spiritual) belonging.

In previous studies, these images of the relationship between humans and nature were found to act as predictors for preferred river management styles (De Groot 2012; De Groot 2009). The question of how to respond to biological invasions also addresses images of the relationship between humans and nature; therefore, visions of nature are relevant in understanding perceptions of non-native species and support for invasive species management.

2.3 Invasive alien species

Invasive species pose an increasing environmental problem across the globe, but to date socio-economic perspectives on this problem have been limited. It is important to note

that not every exotic plant species become invasive weeds. Only a few of the introduced plant species form viable stands/populations and even fewer naturalize to their new environments. It has been estimated that only one or two percentage of introduced exotic plants becomes invasive weeds (Groves, 1986). However, it is difficult to predict whether a plant species has the ability to spread irrepressibly. A common phenomenon with introduced plant species is the so called 'time lag', where the plants only start to show invasive trends after a period of so many years to many decades (Hughes, 1994; Mooney and Cleland, 2001).

Invasive Alien species are increasingly recognised as having important impacts on landscapes, ecosystems services and levels of biodiversity (Mack *et al.,* 2000; Cronk and Fuller, 2001; Baskin, 2002; Grosholz, 2002). These impacts are not all negative; Invasive Alien plant species bring both costs and benefits to the local people and environment. Costs are incurred if the exotic species inhibit effective functioning on local social and ecological systems, such as when invasive species become weeds within agricultural or forestry systems, inhibit vital ecosystem functions or affect animal or human health (DiTomaso, 2000; Bax *et al.,* 2001; McNeely *et al.,* 2001; Pimental *et al.,* 2001). Ecosystems level change can also deplete peoples' sense of the value of place. On the other hand these species may bring benefits and many of the traits that lead to species becoming invasive, including hardiness and high fecundity, are also likely to increase their usefulness. As a result exotic species can form the base of many economically important resource management systems such as agriculture, horticulture, forestry and landscape gardening.

2.4 *Lantana camara*

L. camara is a complex of many horticultural hybrids and a few wild *Lantana* species (Sanders, 2006). As originally described by Linnaeus in 1753, the genus *Lantana* contained six species from South America and one from Ethiopia (Ghisalberti, 2000) however, between 40 and 150 species and sub-specific entities are currently recognized (Day *et al.*, 2003; Stirton, 1977). As popular ornamentals, numerous hybrid forms were later distributed worldwide (Howard, 1970; Morton, 1994; Stirton, 1977). The dominant parents of the hybrid forms are considered to be *L. camara, L. subsp. aculeata* from the West Indies and *L. nivea* Vent. Sub sp. *mutabilis* from southern Brazil (Sanders, 2006). In its native range *L. camara* grows in small bunches in moist habitats. 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 now a cosmopolitan weed and has been declared as a noxious weed in many parts of the world (Benggeli *et al.,* 1998; Goulson and Derwent, 2004). It is particularly a weed of the tropics and sub-tropics naturalized in approximately 60 countries (Day *et al.*, 2003).

2.4.1 Species traits

Due to extensive breeding intra and inter-specific hybridization, *L. camara* displays high morphological variation (Binggeli, 2003; Spies, 1984). For example over 50 varieties are recognized in South Africa alone (Spies and Stirton, 1982). Morphological and ecological characteristics that have contributed to its successful spread includes prolific flowering and production of fleshy fruit throughout the year (Euston-Brown *et al.,* 2007; Gujral and Vasudevan, 1983), features that are particularly important as frugivorous birds are important dispersal vectors. Endozoochory (i.e. the dispersal of seeds after passage through the vertebrate gut) has been shown to increase seed germination rates and vigor

(Jordaan *et al.*, 2011). *L. camara* also reproduces vegetatively and possibly also via self-fertilization. Vegetative reproduction occurs by a process called layering, in which horizontal stems and cuttings take root when in contact with moist soil or leaf litter (Walton, 2006).

Conflicting reports of self-compatibility in *L. camara* exist. Mohan Ram and Mathur (1984) and Neal (1999) considered the species to be self-compatible, albeit dependent on insect pollination. However, some varieties are unable to self-pollinate under laboratory conditions (Barrows, 1976). Due to extensive horticultural selection it is likely that self-compatibility may also be affected by polyploidization (Vardien *et al.*, 2012).

2.4.2 Physical description of *L. Camara*

It is a heavily branching shrub that grows 3–4 m high as clumps. 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. The leaves are 2–10 cm long with toothed edges, bright green on the upper surface and pale 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 Lantana 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.

2.5 Impacts of *Lantana camara*

2.5.1 Negative impacts of *Lantana camara*

The invasion history of *L. camara* is well documented in some countries but poorly in others including Tanzania. *L. camara* has been reported to cause a wide range of negative impacts around the world (Day *et al.*, 2003; Sharma *et al.*, 2005) (Table 1). In many of these countries *L. camara* was introduced as an ornamental plant, a hedge plant, or for use in traditional medicine or mulch (Ghisalberti, 2000).

Table 1: Distribution, introduction dates, and associated impacts of *Lantana camara* in different regions of the world. * Estimates of invaded areas are listed where available

Region	Initial/early introduction records	Associated negative impacts and extent of invasion
Australia	First reported in1841 (Van Oosterhout *et al.*, 2004)	Allelopathic suppression of indigenous plant species (Gentle and Duggin, 1997; Osunkoya and Perrett, 2011), poisonous in agricultural areas (Culvenor, 1985); consumption of fruit by humans have resulted in death (Morton, 1994) *4million ha (Holm *et al.*, 1991)
Bangladesh	Introduced early 19th century (Bansal, 1998)	Allelochemicals inhibit germination and initial growth of agricultural crops such as Oryza sativa and Triticum aestivum (Hossain and Alam, 2010)
Hawaii	First reported as early as 1898 (Thaman, 1974)	Loss of large expanses of native vegetation (Diaz, 2010) *160,000ha (Holm *et al.*, 1991)
India	Introduced early 19th century (Thakur *et al.*, 1992)	Harbors malarial mosquitoes (Day *et al.*, 2003); affects bird community structure by decreasing bird diversity (Aravind *et al.*, 2010), problematic in tea plantations (Holm *et al.*, 1991) *13.2millionha of pasturelands (Singh, 1996)
Indonesia	Not known	Problematic in tea plantations and a serious weed in coffee plantations and rice fields (Nanjappa *et al.*, 2005)
Israel	Introduced as an ornamental, exact date unknown (Danin, 2000	A threat to local flora in EnGedi and common in date plantations in Jordan-Dead Sea–Arava Rift Valley (Danin, 2000)
Kenya	Not known	Replacement of native pastures; threatening the habitat of sable antelope (Walton, 2006)
Rwanda	Not known	Harbors tsetse flies (Day *et al.*, 2003)
South Africa	First recorded in 1858 in the old Cape Town Gardens (McGibbon, 1858)	Death of livestock and humans reported (Wells and Stirton, 1988), decreased invertebrate diversity (Samways *et al.*, 1996), regeneration via allelopathy (Van Wilgen *et al.*, 2001) *70,000ha condensed area (Le Maitre *et al.*, 2000)
Tanzania	Not known	Thickets provide breeding ground for tsetse flies, vectors of trypanosomiasis (Leak, 1999; Day *et al.*, 2003).
Uganda	Not known	Thickets provide breeding ground for tsetse flies, vectors of trypanosomiasis (Leak, 1999; Day *et al.*, 2003).

Source: Vardien *et al.(*2012)

2.5.2 Positive impacts of *Lantana camara*

L. camara though being a noxious weed has several uses, mainly as 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. The studies reveal that extracts from the leaves can be used to combat antimicrobial, fungicidal, insecticidal and nematicidal problems. Its potential to serve as biocide has also been illustrated in several researches (Begum *et al.*, 2004; Dharmagadda *et al.*, 2005). Furthermore *L. camara* thickets can offer a substitute habitat for a range of animals, including bandicoots, whip birds, quail, wrens, birdwing butterflies and brush turkeys, where it has replaced the natural understory vegetation. In addition, provides a refuge for wild animals such as cats, pigs, rabbits, foxes and wild dogs, which compound the negative impacts on native plant and animal populations.

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. However, this management technique should be treated with caution as there is a potential for seed spread into breaks and disturbed sections of the rainforest, further affecting 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. In 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 treated with care. There must be the capacity 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.

2.6 Perception on *Lantana camara*

To understand perception on *Lantana camara* two theories are being intergrated to obtain aclear picture on fctors which affects the perception of people on IAS. Human perceptions toward invasive alien species such as *Lantana camara* and their control, are multiple and diverse and are affected by many things which inclufes, psychological, cultural, evolutionary factors and the effects that IAS have on the livelihood of the communities. 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; Garc´ıa-Llorente *et al.*, 2011). Nevertheless, humanists and social scientists have found that a few core principles and cognitive structures, including values systems and risk perceptions, are fundamental components that frame subsequent attitudes and help explain ultimate behavior toward invasive species (Churchill *et al.*, 2002; Fischer and van der Wal, 2007; Norgaard, 2007).

Cognitive hierarchy theory (CHT) organizes values, attitudes, and behaviors as a system and has been commonly applied to support natural resource management (Fulton *et al.*, 1996; McFarlane and Boxall, 2003; Whittaker *et al.*, 2006). Values are the CHT's central focus and are understood as enduring and fundamental beliefs that influence attitudes and guide behaviors (Rokeach, 1973). Attitudes, in turn, are numerous and flexible constructs based on several beliefs and value trade-offs that involve preferences or evaluations in

specific situations (Fulton *et al.*, 1996). In the CHT framework, behaviors are understood as intention of action and as being directly influenced by attitudes.

Despite its theoretical strengths in linking values, attitudes, and behavior with environmental management actions, the CHT does not explicitly incorporate other important factors such as risk perceptions. In confronting difficult decisions, cognitive psychology studies have demonstrated that people frequently make judgments based on a set of mental strategies or heuristic rules that reduce complex mental tasks to simpler ones. Furthermore, risk management perceptions are influenced by common mental mechanisms, such as evaluation of potential threats and lack of institutional or personal trust. Currently, cultural cognition theory, based on the early works of Douglas and Wildavsky (1982), informs the integration of these 2 theories and shows that individuals also form their risk perceptions about IAS such as *Lantana camara* based on their cultural backgrounds and personal values (Kahan and Braman, 2006). Regarding environmental risk perceptions, Slimak and Dietz (2006) found that an individual's values and fundamental beliefs explain how the individual perceives potential risks. Therefore, integrating risk perceptions with CHT can help further clarify interpretations and evaluations of potential hazards, which also affect the construction of attitudes and its factors (Lazo *et al.*, 2000).

Under this integrated framework, shows that there is a bi-directional relationship between the natural environment, asset endowment, livelihood diversification and household characteristic or orientation, In addition, there is a relationship of infrastructure affecting perceived risks and a fuzzy relationship of perceived risk affecting infrastructure.

The term fuzzy relationship is not defined by the authors; however, it appears to mean an undecided relationship. The conceptual framework also has relationships between the factors identified.

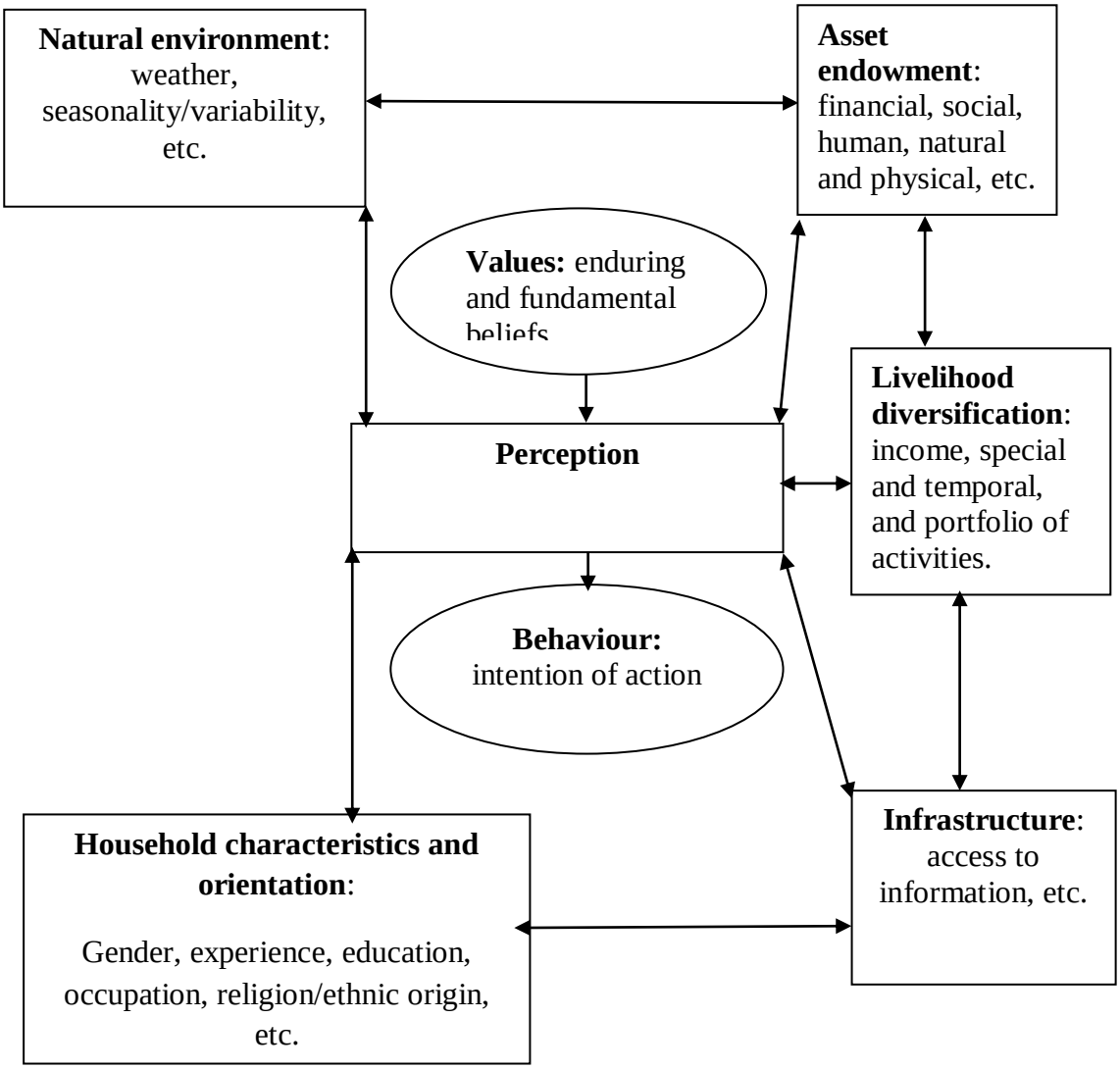

Figure 1: Integrated conceptual framework to understand social perception of invasive species and its factors created by integrating cognitive hierarchy theory (CHT) and risk perception theories

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Description of the study area

This study was conducted in East Usambara whereby seven villages (Shebomeza, Mlesa, Mbomole, Sakale, Mghambo, Mikwinini and IBC-Msasa) found within and in the periphery of Amani Nature Forest Reserve were selected. The villages are located between longitude 30^0 30' and 38^0 50' E and latitude 4^0 40' – 5^0 15' S at an altitude range of 250 - 1506m above sea level (Fig.1). The village were purposively selected due to the presence of *L. camara* invasion at various stages of invasions.

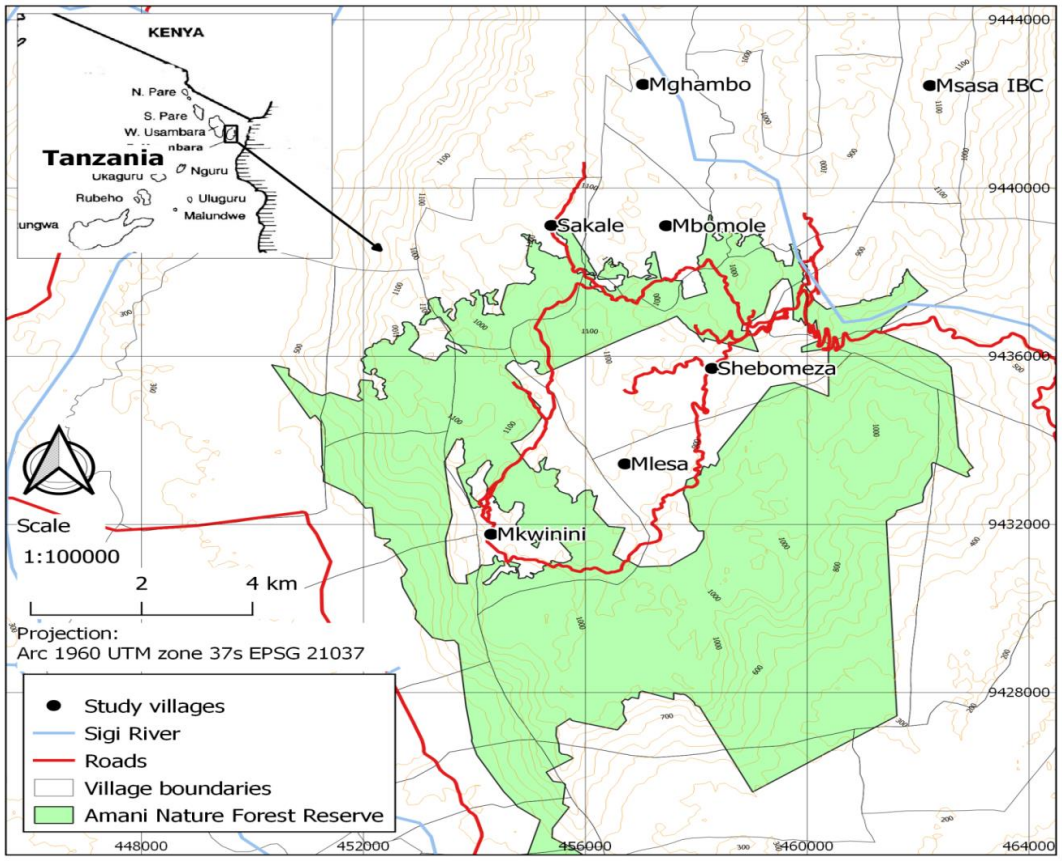

Figure 2: A map showing study villages and Amani Nature Reserve in the East Usambara, Tanzania

The mean annual rainfall is 1918 mm and the mean annual temperature is 20.6 ºC. Lowest temperatures are found in relatively wet places. There are distinct local microclimates, which are referred to as exceptional mistiness and general wetness. Proximity to the Indian Ocean has a cooling effect, and temperatures in the East Usambaras are 4-5 ºC lower at 700 m, and 2-3 ºC lower at 500 m than those in other parts of Tanzania at similar altitudes. The forest itself creates a remarkably cool microclimate, and the relative humidity is high throughout the year. Rainfall in the East Usambaras is very variable and the microclimate changes distinctly from place to place. The mean annual rainfall is highest near southern escarpment (2300 mm) and lower in north (1650 mm). From January to March climate is hot and dry. During long rains (March-May), temperature falls and the mountains receive 45% of the total annual rainfall. From June to September the climate is rather dry and cool until short rains start (normally in October to December) and the temperature increases

3.2 Socio-economic activity

The oldest form of land use in the East Usambaras is a combination of shifting cultivation with livestock keeping. The main source of income is trading in cash crops, working on tea estates, involvement in petty business, dairy farming and agricultural trade. The main cash crops are sugarcane (*Saccharum officinarum L.*), black pepper, cardamom, cloves (*Syzygium aromaticum L.*), cinnamon (*Cinnamomum verum* J. Presl or *C. zeylanicum* Bl.), coffee (Coffea spp.), groundnut and beans. The main subsistence crops are maize, cassava, beans and cocoyams (*Colocasia esculenta L.*). The most commonly grown fruits are bananas, coconuts, oranges (*Citrus sinensis L.* or *C. aurantium L.*) and avocados (*Persea americana Mill.*); cocoa is also produced. The most common other tree species planted on the farms are typically *Grevillea robusta, Eucalyptus saligna, Tectona grandis*

L.f. (teak) and *Cedrela odorata*. In East Usambara land is inefficiently cultivated and poorly managed, and even very steep slopes are often completely cleared.

3.3 Study design

The study adopted a mixed methods design integrating qualitative and quantitative research methods due to the interdisciplinary nature of the subject under investigation. Mixed methods is defined by Bickman and Rog (2009) as a research design in which the investigator collects and analyzes data, integrates the findings and drawing inferences and narratives using both qualitative and quantitative approaches in a single study. The authors highlighted the following strengths of mixed methods;

i) It enhances the comparison of divergent aspects of a similar phenomenon.

ii) Mixed methods enables the researcher to integrate various methods hence compensate for weaknesses of one approach.

iii) A holistic overview of the subject under investigation is attained. This is because various aspects about it are complemented.

iv) According to Hen *et al.* (2009) mixed methods ensures comprehensive investigation on a subject or phenomenon by focusing on different methods of data collection, analysis and result presentation.

While qualitative features dominated the study, quantitative approaches were employed in data analysis and interpretation. Quantitative methods were used to extract information on the socio-economic characteristics of local people, examining their perceptions and factors informing their decisions. The qualitative data were obtained from in-depth interviews with Household members through questionnaires.

3.4 Sampling frame, sampling design, sample size and data collection

Purposive and random samplings were employed. Purposively the study was focused in East Usambara based on its relevance due to *L. camara* invasion and spread rather than for generalization purposes. In this study there were two observation units; the first observation unit included three villages which are found within the ANR vicinity, Shebomeza, Mlesa and Mikwinini whereas the second observation unit were four villages outside the periphery which were Sakale, Mghambo, Mbomole and IBC- Msasa. Bailey, (1994) found that a sample size of 30 from one observation unit is considered adequate and as acknowledged by Mbeyale (2007). A sampling frame is a list that identifies the target population in this study, a total of 130 household were randomly selected from the village registry book with the record of all villagers whereas 70 households were considered from the first observation unit and 60 households from the second observation unit were considered for the purpose of this study in order to get all scenarios on perceptions of the local communities' about the *L. camara* invasion and spread. The characteristics of the villages and respondents are summarised in (Table 2).

Table 2: Characteristics of the study villages

Villages	**Shebomeza**	**Mlesa**	**Mbomole**	**Sakale**	**Mghambo**	**Mikwinini**	**IBC-Msasa**
Main livelihood strategies	Farming (37%), Livestock keeping (63%)	Farming (47%), Livestock keeping (53%)	Farming (37%), livestock keeping (63%)	Farming (60%), Livestock keeping (40%)	Farming (70%), Livestock keeping (30%)	Farming (50%), Livestock keeping (50%)	Farming (80%), Livestock keeping (20%)
No. of respondent	30	30	30	10	10	10	10
Sex –M	15	18	14	4	4	7	6
Sex –F	15	12	16	6	6	3	4
Land size (ha)	1 722	5 295	674	977	641	1 364	788
Average *L. camara invasion*/person (acre)	2.33	2.30	1.90	1.60	1.90	1.40	2.10

Field data collection on perception of the local communities on *L. camara* invasion was obtained using standard questionnaire designed for Wood Weeds project. A pre-test was conducted with a subset of the selected sample to test the validity of the questionnaire in data collection in terms of clarity of the questions. Feedback and comments from the survey were instrumental in improving the efficiency of the data collection tools. The questionnaire had questions related to origin, spreading mechanism and pathways, social-economic and environmental impacts and local communities' management responses to the invasion of *L. camara* (See Appendix 1 for more details). However the questionnaire was translated into national language (*Kiswahili*) for easy understanding by the respondents. Likert scale was used to approximate the perceptions of the local people on the effects of *Lantana camara* to the livelihoods. Respondents were asked to rate their perception to each of the statement describing either positive or negative effect of *L. camara* depending on how the respondents perceived the effects of *Lantana camara* using a six-point Likert scale (1 strongly disagree, 2 disagree, 3 neutral/undecided 4 slightly agree 5 agree and 6 strongly agree).

3.5 Data Analysis

The objective of data analysis is to summarize collected data and make them useful for informed decision making. Both quantitative and qualitative analysis methods were used in this study.

3.5.1 Descriptive statistical analysis and content analysis for quantitative and qualitative data respectively

The primary data from questionnaire were coded and entered in a Statistical Package for Social Sciences (SPSS) computer program version 16.0 where descriptive and inferential statistics were employed, using the analytical tools such as frequency and chi-square,

embedded in the (SPSS), to analyse the socio-economic data. The output tables were exported to excel spread sheet from where descriptive statistics (frequencies, percentages, and measures of central tendencies) were derived. Results were then presented in form of graphs, and frequency tables for easy interpretation. The qualitative information obtained from the interviews and direct observations were however transcribed through content analysis.

CHAPTER FOUR

4.0 RESULTS

4.1 Local communities' perceptions on knowledge of invasion, origin and spread of *Lantana camara*

Irrespective of the villages about 97% of the respondents perceived to be very well-informed/knowledgeable about *L. camara* invasion in East Usambara (Table 3).

Table 3: Respondents' perceptions on knowledge about *L. camara* invasion in East Usambara

Question	Response	Name of the Village							
		Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)	Total n=130 (%)
How informed do you think you are about *L. camara* invasion?	Very little informed	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.8
	Some amount	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.8
	A fair amount	0.0	0.0	0.0	0.0	3.3	0.0	3.3	1.5
	Very well informed	100.0	96.7	100.0	100.0	96.7	100.0	93.3	**96.9**
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Furthermore there was small difference between farmers and Livestock keepers on perception on the knowledge of *L. camara* invasion (Table 4).

Table 4: Perceptions on knowledge about *L. camara* invasion in relation to household occupation

Question	Responses	Main occupation (income source) of the household	
		Farming n= 62 (%)	Livestock keeping n=68 (%)
How informed do you think you are about lantana invasion?	Very little informed	0.0	1.5
	Somehow informed	1.6	0.0
	Fairly informed	0.0	2.9
	Very well informed	98.4	95.6
Total		100.0	100.0

However, in light of Chi-square tests there was no significant relationship between the level of knowledge on *L. camara* invasion and the occupation that household pursue at 95% significance level (Table 5).

Table 5: Chi-Square tests for knowledge on *L. camara* invasion in relation to household occupation

Chi-Square Tests	Value	Df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3.858[a]	3	0.277
Likelihood Ratio	5.395	3	0.145
Linear-by-Linear Association	0.487	1	0.485
N of Valid Cases	130		

a. 6 cells (75.0%) have expected count less than 5. The minimum expected count is .48.

Majority of the respondents reported that *L. camara* has been around in East Usambara for many years (over 100 years) irrespective of the villages and the species have been named locally as “Mvuti” nevertheless few respondents reported the species to have invaded their farms in a period not exceeding six years (Table 6).

Table 6: History of *L. camara* invasion in study villages

Question	Responses	Name of the village						
		Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)
When Lantana started invading in your area?	Long time (more than 100 years)	100	96.7	100	100	100	100	96.7
	One year ago	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Six years ago	0.0	3.3	0.0	0.0	0.0	0.0	3.3
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0

The recent invasion is of important consideration as it indicates that *L. camara* invasion is still progressive and if efforts are not made to curb the invasion its repercussions' to the ecosystem services and livelihoods of local communities in East Usambara will continue and become more severe. Moreover majority of the local communities (99.2%) despite of their age categories were not aware that *L. camara* was an introduced alien species and thus considered it as a native shrub (Table 7).

Table 7: Origin of *L. camara* in East Usambara

Question	Responses	Age of the respondent				
		20-30years n=12 (%)	31-40 years n=26 (%)	41-50 years n=37 (%)	Above 50 n=55 (%)	Total n=130 (%)
Who brought this species here?	Introduced	0.0	3.8	0.0	0.0	0.8
	Natural shrub	100.0	96.2	100.0	100.0	99.2
Total		100.0	100.0	100.0	100.0	100.0

Study further revealed local communities perceived *L. camara* to spread through different mechanisms and pathways, from vegetative propagation to birds. Droppings from birds were perceived as the main pathway for invasion and this indicates that *Lantana camara*

can spread over a long distance very rapidly through birds' droppings since birds can travel over long distances in a short time. Other dispersing agents were Wind, Water, Animals and Humans (Table 8).

Table 8: Pathways for *L. camara* spread and invasion

		Name of the village							Average n=130 (%)
Question	Responses	Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa N=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)	
How does it start invading the area? (agent/ means)	Birds	80	70.0	100.0	80.0	66.7	90.0	66.7	73.8
	Wind	0.0	16.7	0.0	20.0	6.7	0.0	13.3	10.0
	Water (surface runoff)	0.0	6.7	0.0	0.0	20	0.0	6.7	7.7
	Animals	20.0	3.3	0.0	0.0	3.3	0.0	10.0	5.4
	Human	0.0	3.3	0.0	0.0	3.3	10.0	3.3	3.1
Total		100	100	100	100	100	100	100	100

4.1.1 Overall perception of local communities about *L. camara* invasion

Majority of the respondents (40.8%) agreed that *L. camara* invasion is high in the area. However variability in *L. camara* invasion is also observed in the study area (Table 9).

Table 9: Overall perception about *L. camara* invasion in the study area

Question	Responses	Name of the village							
		IBC-Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)	Total n=130 (%)
How do you describe the invasion of *L. camara* in your area?	Low	30	23.3	20	40	23.3	50	10	23.8
	Medium	70	40	30	30	36.7	20	10	31.5
	High	0	36.7	50	0	40	10	80	40.8
	No L. camara	0	0	0	30	0	20	0	3.8
Total		100	100	100	100	100	100	100	100

With regards to growing pattern of *L. camara*, all respondents in the study area perceived increasing trend in growth of *L. camara* when there is no attempt made to curb the spread and invasion. However, during dry season the growing pattern of *L. camara* was perceived to be decreasing (94.6%) which indicates that *L. camara* growth is hindered by seasonality (Table 10).

Table 10: Growing pattern during dry season

Question	Responses	**Name of the village**						
		Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)
How do you describe the growing pattern of *L. camara* in your area during dry season?	Increasing	10	6.7	10	0	0	0	3.3
	Decreasing	90	93.3	90	90	100	100	93.3
	No difference	0	0	0	10	0	0	3.3
Total		100	100	100	100	100	100	100

4.2 Local communities' perceptions on socio-economic impacts of *L. camara* invasion

An overall assessment showed that on average about 73% (N=130) of the respondent's perceived *L. camara* to have harmful effects on their livelihoods (Table 11).

Table 11: Perceived impacts of *L. camara* invasion on livelihoods

		Name of the villages							
Question	Responses	IBC-Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebomeza n=30 (%)	Average n=130 (%)
Which one of the following best describes the effect of Lantana on your livelihood?	Very harmful	0	6.7	0	0	0	0	3.3	2.3
	Harmful	60	86.7	60	70	66.7	80	73.3	73.1
	Undecided	0	3.3	10	10	26.7	0	13.3	11.5
	Beneficial	40	3.3	30	20	6.7	20	10	13.1
Total		100	100	100	100	100	100	100	100

Perception of local communities about *L. camara* impacts changed at various stages of invasion. During the early stages of invasion, about 20% of the respondents perceived the species as "bad" to their livelihoods but number of respondents with this perception changed to 76.2% at late stage of invasion (Fig. 3).

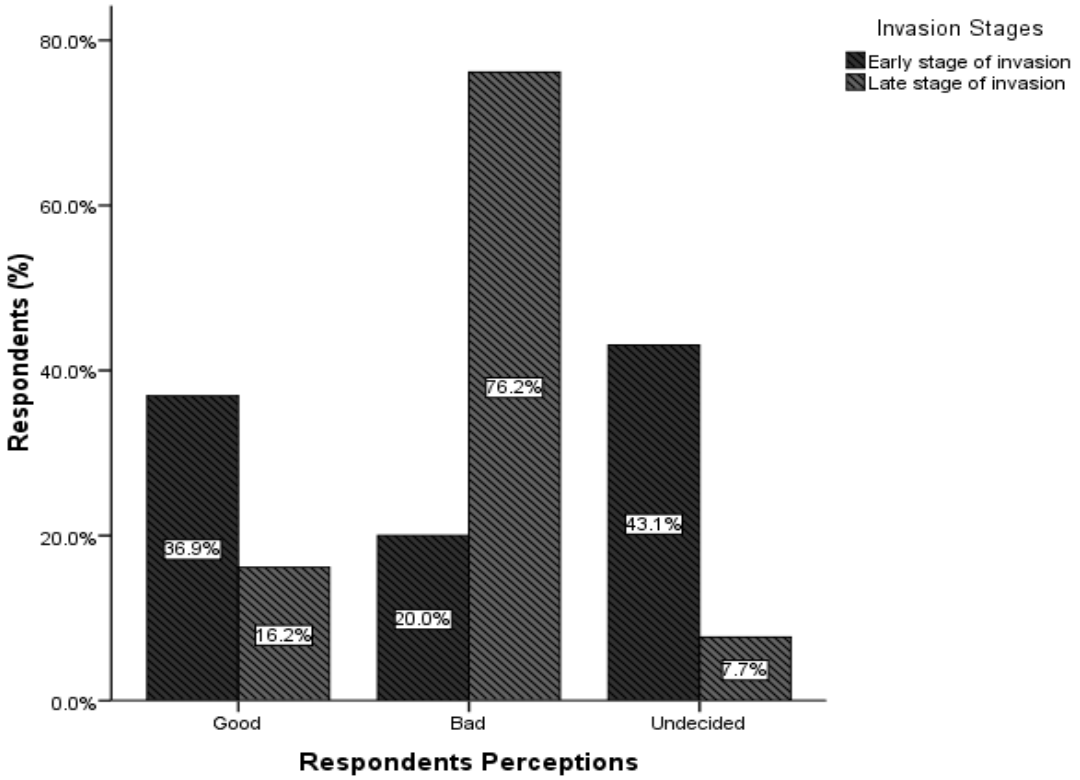

Figure 3: Change in perceptions of local communities during early and late stages of *L. camara* invasion

4.3 Management responses for *L. camara* invasion in East Usambara

Finding from this study revealed that, there was variability in the perceived preferred management responses for *L. camara* invasion. On average, the majority (37.7%) of the respondents preferred *L. camara* to be controlled whereas comparably large number of respondents (33.8%) said nothing should be done about the species (Table 12).

Table 12: Management options for *L. camara* in different villages

Questions	Responses	Name of the Village							
		Msasa n=10 (%)	Mbomole n=30 (%)	Mghambo n=10 (%)	Mikwinini n=10 (%)	Mlesa n=30 (%)	Sakale n=10 (%)	Shebo meza n=30 (%)	Average n=130 (%)
What do you think should be the management options for *L. camara*?	Control	40.0	16.7	60.0	60.0	43.3	30.0	40.0	37.7
	Do nothing	20.0	43.3	30.0	20.0	26.7	60.0	33.3	33.8
	Prevention	40.0	13.3	10.0	20.0	26.7	10.0	26.7	21.5
	Eradication	0.0	26.7	0.0	0.0	3.3	0.0	0.0	6.9
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

CHAPTER FIVE

5.0 DISCUSSION

5.1 Local communities' perception on knowledge about lantana camara invasion, origin and spread

Findings showed that majority of the respondents (97%) were knowledgeable about *L. camara* invasion in East usambara. But, about 99% of respondents were not aware that *L. camara* was alien. Moreover, most of the respondents reported to have found *L. camara* around since when they were born and that *L. camara* has been around in East usambara for long time (over 100 years) to the extent that the species has been known locally as "Mvuti". However, few respondents reported *L. camara* to have invaded their farm in recent time, about six years. The recent invasion is of important consideration as it indicates that *L. camara* invasion is still progressing and if efforts are not made to curb the invasion repercussions' to the ecosystem services, biodiversity and livelihoods of local communities in East Usambara will continue and become more severe. The findings are particularly important because they show its people's perceptions which guide their decisions and actions' regarding particular IAS which either increase or decrease its invasion and this findings resonates with findings by (Bright, 1999; Reaser, 2001; Wittenberg and Cock, 2001) who reported people make choice which either diminish or augment the chance of species to become invasive.

5.1.1 Invasion pathways and mechanisms

Study revealed that *L. camara* spread through different pathways and mechanisms from vegetative propagation through layering, in which horizontal stems, roots and cuttings take root when in contact with moist soil or leaf litter to by birds through the droppings.

Birds were identified as the major dispersal agent and since birds can travel over long distances in a short time *L. camara* can spread over a distance very rapidly.

Wind was considered mainly instrumental in the dispersal of *L. camara* seeds from the parent plant and its spread is limited to short distances. Moreover, surface run offs was consider to further *L. camara* invasion since it was observed *L. camara* cover to be linearly dense along the roads and paths. The study carried by Sharman *et al.* (2005) showed that *L. camara* invades a wide range of habitats but grows best in open disturbed ecosystems, forest edges and roadsides as the result of deposition by surface run offs. Transportation of *L. camara* seeds by human was also considered as the pathway in the invasion process of *L. camara* nevertheless majority of the respondents considered it as the least in *L. camara* seed dispersal. This option was considered a possibility during farming activities, pasture collection and transportation and in such cases, the movement of *L. camara* seeds from parent plant mostly covers a limited distance, generally within the homesteads or farms. Unless dispersed further by other agents, this pathway was considered to have a limited capability of enhancing invasion especially into the less invaded areas.

5.2 Local communities' perceptions on socio-economic impacts of *L. camara* invasion

Results shows that on average majority of the respondents (73.1%) perceived *L. camara* impacts to be harmful to their livelihood whereas (13.1%) perceived it to be beneficial, (11.5%) had no opinion about the impacts of *L. camara* to the livelihood and (2.3%) stated the impact to be very harmful. However adverse effects of *L. camara* are diverse depending on the ecosystem service and livelihood strategy they impact.

Harmful effects of *L. camara* on farming: Being invasive, *L. camara* was reported to invade farmlands, particularly when left idle without regular disturbance/farming. This increases farming costs during farm preparation and also during weeding and was acknowledged as the most severe effect in farming activities. Furthermore *L. camara* was reported to cause disturbances during farm preparation, making farming laborious and causing skin bruises. Moreover *L. camara* was perceived to be detrimental to crops since it was believed to inhibit growth of crops through shading and allelopathic effect of which it was reported where *L. camara* flourishes crops and other native plant can't thrives as well. Study by Sharma *et al.* (2005) reported similar observation whereas *L. camara* wasconsidered to affect economic viability of 14 major crops around the world including coffee, tea, rice, cotton, oil palm, coconut and sugarcane, in part due to its allelopathic properties, which reduce productivity of crop plants.

Harmful effects of *L. camara* on livestock production: It was considered that where *L. camara* thrives, no other native species survives. The most probable explanation for this was that it forms a thicket limiting light penetration for other native species of grasses to survive. Also there was a believe among the respondents that it may be allelopathic, releasing chemical substances, which inhibit the growth of native grass and it was identified as major causes of reduction in availability of fodder**.** Furthermore it was reported that livestock fed on matured *L. camara* and its seeds encounters health defects including blotting, loosing fur resulting to wounds, urinating blood, and compromising quantity and quality of the milk in lactating Cow.

Furthermore there was change in perception about *L. camara* at various stages of invasion. During early stage of invasion about (20%) of the respondents perceived the species as "bad" to their livelihoods but this perception changed to (76.2%) at late stage

of invasion (Figure 3). Results suggested that perception was influenced by values and stages of invasion. During the early stage *L. camara* was considered as easy to slash/clear and uproot and could be used as alternative source of fodder for Cattle. This perception change drastically when *L. camara* has established and form dense thicket stands that are impenetrable and start to impacts the livelihoods of people and ecosystems services negatively. Studies suggest that Lantana invasion affects local biodiversity and all four categories of ecosystem services provisioning, regulating, supporting and cultural (Breman *et al.*, 2012; Shaanker *et al.*, 2010; Henderson, 2007 and Australian Government Report 2011). At late stage of invasion *L. camara* was considered to alter ecosystem functioning and structure, causing loss of native species diversity, making farming activities laborious and costly, adversely affecting livestock production by reducing quality and quantity of milk if consumed by lactating Cows, also causing blotting and Cows to loose fur consequently resulting to wounds, competing and inhibiting growth of crops and grasses through shading and allelopathic effects consequently reducing farm yields and availability of fodder and providing shelter and breeding ground for disease vectors such as mosquitoes where as it was reported as *L. camara* cover increase also mosquito population increases, this opinion resonates with findings by (Day *et al.*, 2003; Leak, 1999; Hossain and Alam, 2010; Holm *et al.*, 1991; Wells and Stirton, 1988) who postulated in their studies that *L. camara* stand provide breeding ground for Tsetse flies which is the disease vector for trypanomiasis.

However there were several benefits perceived to be derived from *L. camara*. Matured steam of *L. camara* can be used for different purposes including toothbrush and as alternative source of wood fuel for household. Also the plant was considered to have medicinal values although this was proved to be contentious as the knowledge was not

shared among all respondents and to some people it was new knowledge. Other perceived benefits were alternative source of fodder and source of green manure.

5.3 Management responses for *L. camara* invasion in East Usambara

Livelihoods of majority of the respondents are negatively affected by Invasion of *L. camara* but only about (7%) of the communities wanted the species to be eradicated. Majority of the respondents (37.7%) wanted the species to be controlled. Local communities reported traditional method used in controlling *L. camara* invasion was mechanical removal which involves slashing and uprooting, with few respondent suggesting use of fire as management tool for *L. camara*. All respondents had no any knowledge about biological control of *L. camara* and also there was no chemical reported to be used in controlling the species. Studies conducted in Australia, India and South Africa where substantial efforts to eradicate and control *L. camara* have been made shows that Control measures of Lantana include fire, mechanical removal, chemical and biological control or their combination (Bhagwat *et al.*, 2012). Biocontrol appears to be the most prominent method in Australia (Forest Commission New South Wales 1959-1983); and in South Africa reports suggest mechanical removal as preferred method (Department of Forest 1980). In India, a combination of methods except chemical control is used with a majority of reports indicating mechanical removal including the use of domestic elephants to uproot *Lantana* as the preferred method (Bhagwat *et al.*, 2012). However results further indicates that large number of respondents (33.8%) was comfortable with current *L. camara* coverage, nevertheless it was evident sustainable management measures that will see *L. camara* coverage not exceeding the current levels in less invaded areas while at the same time reducing its coverage in the heavily invaded areas are needed.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS

This chapter presents conclusions based on the findings as well as recommendations of the study.

6.1 Conclusion

Invasion and spread of *L. camara* is influenced by values and perception of the local communities. The study indicates that local communities in East Usambara are aware of *L. camara* invasion but didn't know if the species was alien. However invasion pathways and mechanism are well understood. Furthermore *L. camara* was considered to have both positive and negative impacts on ecosystem services and livelihoods but the adverse impacts to outweigh its positive impacts. Moreover there was change in perception about *L. camara* impacts at various stages of invasion. At an early stage of *L. camara* invasion, only about 20% of respond perceived the species to be "bad" but the negative perception increased to 76.2% at the late stage of invasion. Invasion of *L. camara* negatively affect the livelihoods of the majority of respondent (76.7%) but only about 6.8% of the local communities wanted the species to be eradicated. Majority wanted the species to be controlled. Considerably Large proportion of respondents (33.8%) were comfortable with current *L. camara* cover and they had no intension of reducing the level of invasion but generally results indicate the need for more sustainable management measures that will see *L. camara* coverage not exceeding the current levels in less invaded areas while at the same time, reduce its cover in the heavily invaded areas.

6.2 Recommendations

The study recommends the following:

i. Awareness creation about the origin and pathways of *L. camara*

ii. Local communities should be empowered by knowledge on pathways of *Lantana camara* invasion so that they can control *L. camara* and thus reduce the negative impacts on livelihoods.

iii. More research should be conducted to understand level of *L. camara* cover at which net negative impacts become displayed

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APPENDICES

Appendix 1: **Research Questionnaire**

SOKOINE UNIVERSITY OF AGRICULTURE (SUA)
COLLEGE OF FOREST, WILDLIFE AND TOURISM
DEPARTMENT OF ECOSYSTEMS AND CONSERVATION

Gasto V. MUSHI (Msc. Ecosystems Science and Management)

Research Title: PERCEPTION BY THE LOCAL COMMUNITIES ON SPREAD AND IMPACTS OF LANTANA CAMARA TO THEIR LIVELIHOOD IN EAST USAMBARA, TANZANIA

Phone: +255656439955 E-mail: gastormushi2016@gmail.com

My name is Gasto V. Mushi a Postgraduate student at Sokoine University of Agriculture, pursuing Msc. Ecosystems Science and Management. I am conducting a research on perception by the local communities on spread and impacts of *Lantana camara* to their livelihood in East Usambara, I kindly ask you to participate in this research.

CONFIDENTIALITY

I am going to ask you some very personal questions; your answers are completely confidential. Your honest answers to this question will help me to understand the perception of people on the spread and impacts of *Lantana camara* around this area and will assist Policy makers and institutions in the management of *Lantana camara*.

Questionnaire for Household

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

Checked by: __ Date ____/___/2016 Time ___:____ Signature

Household Code	
District	
Name of Location/Village	
Clan/Tribe Name	
GPS coordinates	

Part A: Background Information (Use Codebook)

Name of the interviewee_____ if not the household head, your relationship to household head_____

Main occupation (income source) of the household (Code 1) _____

How long have you been in this occupation? _____ Years.

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)	Religion (code 6)
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.

What is your household monthly expenditure in Tsh. per month?_____.

For how long have you been living here?

Born here

……..years.

Part B: Households' perception about Lantana

How much do you know about Lantana?

Nothing

Very little

A fair amount

A great deal

From where do you get information about Lantana? (tick where appropriate)

Friends and Family

Agricultural Officers/development agent

Newspapers

Magazines

Radio

Television

Library or books

Talking to environmental specialists

Others (Specify)

Please rank the items you have selected above (question no.8) in order of amount of information obtained[Starting with 1 = Most Information]

How do you describe the invasion of Lantana in your area?

Low

Medium

High

When Lantana started invading in your area? _____

How does it start invading the area (agent/means)?

_____

_____

_____

14. Why Lantana Invade 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.Other

specify_____

_____

_____

15. What was your perception about Lantana at the time of its early Invasion in your area?

Good

Not good

Fair

16. What is your perception about the Lantana now?

Good

Not good

Fair

17. If your perception has changed,

why?_____

_____

_____

18. How do you describe the abundance of Lantana in your farm since the time of early stages of invasion?

Increasing

Decreasing

No difference

Not noticed at all (I don't know)

19. If your answer to question no_18 is increasing (a); what do you think are the reasons?

_____

_____

_____

20. How can you describe the growing pattern of Lantana in your area?

During dry season:

Increasing

Decreasing

No difference

Not noticed at all (I don't know)

During wet season:

Increasing

Decreasing

No difference

Not noticed at all (I don't know)

Throughout the year:

Increasing

Decreasing

No difference

Not noticed at all

21. What do you think are the main factors influencing lantana invasion and spread in your area?

_____

_____

_____

22. What do you think is the main reason influencing lantana population in your farm?

_____

_____

23. Do you use Lantana leaf/pod as forage for animal?

Yes

No

24. If your answer in question no_23 is 'yes', when do you use it?

During drought

As supplementary forage

Always

25. Is Lantana used as a safety net during time of hardship?

Yes

No

If yes, for what purpose?

Alternative fodder for cattle's

Source of Income

Both (a&b)

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

Very harmful

Harmful

Undecided

Beneficial

Very beneficial

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

Negative

Positive

Both negative and positive

No effect

I don't know

If your answer to question 27 is (a) or (c) which of the followings is the negative effect of Lantana?

Effects	Perception Level 1					
	1	2	3	4	5	6
Under storey competitor for forestry						
Allelopathic qualities reduces the vigor of native plant species and limits their productivity						
interferes with harvesting						
Loss of pasture in grazing areas						
Poisoning of Livestock by plants						
Seeds are poisonous if ingested						
Handling plant may cause skin irritation or allergic reaction						
Interferes with the mustering of cattle causing death of						

stock by poisoning						
Reduce productivity in orchards						
Harbors Pests						
Invasion of wet and dry season grazing sources						
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 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						
Disrupts succession and Decrease plant diversity or biodiversity						
Land degradation						
I am interested on having a rule for controlling invasion of the species						
I negatively perceive the species						
I do not want to know more about Lantana						
Lantana is ugly						
Lantana don’t deserve protection						
I do not like having Lantana in the trees where I live						
I would rather avoid places where there is lots of Lantana						

If your answer to question no. 27 above is (b) or (c), which of the followings is the benefit of Lantana?

Effects	Perception level 2					
	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						
vital wet season food for many native birds						
Used as bio fuel and mulch						
Drought-tolerant plant so good candidates for xeriscaping						
Fencing homestead						
Fuel wood for home consumption						
Source of fodder for livestock						
Act as hedge (live and dead)						
Shelter for wild life						
Making baskets and Temporary platform for resting						
For making traditional bed						
Use as wind break or reduce wind speed						
Shade tree						
House construction						
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 forest (lantana) is enjoyable						
Cultural values						
Has ornamental value/Watching Lantana is exciting						
It is god’s creature and should be protected						

Part C: Management of Lantana

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

_____

_____

29. How much do you know about biological control of invasive weeds?

Nothing

Very little

Some

A fair amount

Much information

30. Please tick one box for each statement where you think appropriate. [One circle on each line]

	True	False	Don't know
Biological control of invasive weeds is a deliberate introduction of a natural enemy from the origin of the weed			
Biological control of invasive weeds takes long time to establish			
Biological control of invasive weeds is a common method of controlling weeds in Tanzania			
Biological control of invasive weeds is cheaper of other methods			
Biological control of invasive weeds does not require studies of the host range of the natural enemy			
The natural enemy can be from anywhere where the weed exist			
No need for approval of agents by government regulatory agencies before implementing this control method			

31. How much do you know about biological control of lantana?

Nothing

Very little

Some

A fair amount

Much information

32. What is your perception about biological control of invasive weeds (Lantana)?

Positive

Negative

Both positive and negative

Neutral

Don't know

33. In reducing density of infestation and/or invaded areas, which specific method do you prefer to implement? (Please select only one choice)

For Cropland

Utilization

Biological

Physical

Chemical

Others (specify) _____

For Grassland

Utilization

Biological

Physical

Chemical

Others (specify) _____

34. Why do you prefer the method selected above?

For Cropland

_____

_____

For Grassland

_____

_____

35. What kind of management mechanisms/strategies you follow to control the invasion of Lantana?

For Cropland

Sustainable management within the invaded area.

Preventive actions.

For Grassland

a) Sustainable management within the invaded area.

b) Preventive actions.

36. If your answer for question 35 above is (a), what measures have you taken so far? (Multiple responses are possible)

1. Local mechanical followed by land cultivation or grassland restoration
2. Local chemical followed by land cultivation or grassland restoration
3. Local utilization of Lantana
4. 1 and 3
5. 2 and 3
6. Biological control using insects
7. Adaptation to Lantana impacts
8.Others_____

37. If your answer for question 35 above is (b), what measures have you taken so far? (Multiple responses are possible)

1. Prevention of livestock mobility outside Lantana invaded areas
2. Prevention of any other way of human- or animal- assisted seed dispersal
3. Early detection and rapid response of new Lantana infestations outside the invaded area
4. Biological control using seed feeding insects.
5. Others_____

Part Iii: Farm Household Characteristics

38. Is there conflict of interest among households members on Lantana products?

Yes

No

If yes, what is the main cause of conflict? _____

39. Does drought occurs in your area?

Yes

No

If yes in question 39, how often_____

40. What were/are your coping strategies?

_____

_____

41. How many livestock do you have?_____

42. How many hectares of land do you own? _____ha

43. How many hectares of cultivated land do you own? _____ha

44. 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					
Sheep					
Goat					
Hen					
Honey production					
Others					

45. 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						
Beans						
Clove						
Banana						
Coffee						
Potato						
Tomato						
Onion						
Green paper						
Sesame						
Sweet potato						
Watermelons						
Ginger						
Others						

46. Summary of annual income gain from different sources

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

Part D: Support Services Capital

47. Do you know any institution that provides credit?

Yes

No

48. If yes, how much did you receive credit from them? _____

49. Do they ask you collateral for credit access?

Yes

No

If yes, what is it? _____

50. Do you encounter any barriers for credit access?

Yes

No

If yes, describe it

_____

_____

51. Do you get cash income (government grant, pension, and local employment)?

Yes

No

52. Do you know any institution that provides training?

Yes

No

If yes, do you get any vocational training which is helpful for your livelihood strategy?

Yes

No

53. Do you get extension service?

Yes

No

If yes, from whom you get those services?

Development agent

Non-governmental entity

Relatives

Experienced local leaders

Research centre

54. How often they contact you?

_____

55. How many kilometres is the market far from your village? _____km

56. Do you have the access to technologies that helps to use the Lantana and Lantana by products in a better way?

Yes

No

If 'Yes' what are those technologies and their function?

_____

_____

57. Do you use technology that save time, minimize cost of production and improve productivity?

Yes

No

58. What are those technologies? Describe them

59. Do you use irrigation in your land?

Yes

No

If yes, for how?

60. Do you use phone for information exchange?

Yes

No

If yes, what kind of phone you use?

Home

Mobile

61. Estimate the monthly expenditure for phone _____Tsh.

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

Land type	Total area owned (ha)	Area invaded (ha)	Cost for controlling Lantana Camara
Pasture land			
Farm land			
Communal grazing land			
Communal farm land			

Part E: Alternative Uses

63. What do you think is the benefit of Lantana?

For domestic use

_____

_____

For commercial use

_____

_____

Others

_____

_____

64. What did you do before it was here?_____

_____

65. Do you remember a time when this species was not here?

Yes

No

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

67. Do you still use those other species? _____

68. Why did you change to the Lantana? _____

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

_____

_____

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

_____

_____

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

_____

_____

72. How far is the forest/grazing land from your home? _____km

Part F: Effects on Land Uses

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

Yes

No

If Yes, Where does it like to grow? _____

74. Are there areas in the landscape where you don't want Lantana to grow?

Yes

No

If yes, where don't you want it to grow?

---

75. Why do you not want it to grow there?

_____

_____

76. Does Lantana cause any problem to you, your household and other people?

Yes

No

If Yes, What problems does it cause?

_____

_____

Part G: Cultural Value

77. Is this Lantana used for any cultural or spiritual purposes?

Yes

No

If yes, can you tell us what is it?

_____

_____

78. Does this Lantana grow in areas of special cultural significance?

Yes

No

If Yes, can you tell us where?

_____

_____

Part H: Future

79. Do you think anything should be done about Lantana in the future?

Yes

No

If 'Yes' what do you think should be done?

_____

_____

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

_____

_____

Code Book

Code (1)	Code (2)	Code (3)	Code (4)	Code (5)	Code (6)

Pastoralism	1.Male	Married	1.university /college	Herder	1.Muslim
Crop production	Female	Single	Secondary education	Farmer	2. Christians
Agro-pastoralism (crop and animal production)		Divorced	3. primary education	3. wage worker	3.Orthodox
Trade		4.widow	4. informal education	4.petty trade	4. Other specify
Salary employ		5.not together	5. Illiterate (No education)	5. No job	
Share from clan land				6.Other (specify)	
Other (specify)					