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Ecological Impacts, Distribution and its Management Approaches of *Lantana camara* L. in Ethiopia: A Review Paper

Abesh Birhanu Morka

Abstract*: Lantana camara L. (Family: Verbenaceae) is one of the world's dangerous invasive alien species. This review paper aimed to review the ecological impacts, distribution, and management approaches of the invasive species of Lantana camara in Ethiopia. A comprehensive literature search was conducted across academic databases, including Google Scholar, Scopus, Web of Science, PubMed and Science Direct. Studies published between 2018 and 2024 were selected based on relevance and rigour, and their findings were synthesised into themes covering the ecological impacts, distribution, and management approaches of Lantana camara. The distribution of Lantana camara in Ethiopia is extensive, affecting many ecosystems, including cultivated and non-cultivated land, roadside areas, grazing areas, rural villages, riverbanks, wetlands, forests, and urban areas. They are introduced into a new country through either human or natural causes (such as winds, birds, animals, or water). Biodiversity loss, socioeconomic problems, agricultural losses, issues affecting human and animal well-being, and the invasion of national parks are the known impacts that Lantana camara poses in Ethiopia. Utilization of Lantana camara for several purposes, prevention of its further spreading into non-infected areas, use of fire, mechanical, chemical, biological control, and awareness creation are recommended to management policies that can bring solutions to the threats posed by the clear within the country. Then, the government of Ethiopia should frequently evaluate the distribution and socioeconomic impact of this species to take proper protection actions and to prevent further introduction and spread of the latana camara species in new areas that are not yet infested.

Keywords*: Ecological Impacts, Lantana Camara L., Invasion of Alien Species, Management, Ethiopia

Abbreviations:
IAPS: Invasive Alien Plant Species
IBC: Institute of Biodiversity Conservation
L.Camara L.: Latana Camara

I. INTRODUCTION

Invasion by invasive alien species is among the most significant global problems affecting ecosystems. Although this biological invasion is a natural process, the recent rapid rate of invasions is an anthropogenic phenomenon. It constitutes one of the most significant effects that humans have had on the Earth [6]. Invasive alien species pose a primary threat to biodiversity, human health, and all economic sectors, particularly in developing countries.

Like several other countries in the tropics, many aggressive alien species have been introduced to Ethiopia. Amongst the announced invasive alien species, 35 have been well-known so far. From the so far known invasive alien species *Parthenium hysterophorus, Prosopis juliflora, Eichhornia crassipes, Euphorbia stricta, Mimosa diplotricha, Xantium strumarium, and Lantana camara L.* are the primary ones, which are a pronounced concern in Ethiopia, affecting particular problems on biodiversity, agricultural lands, rangelands, national parks, waterways, lakes, rivers, power dams, roadsides, and urban green spaces with great economic and ecological consequences [6].

Among these, *Lantana camara* L. is one of the worst invasive species worldwide. It is an upright, hardy, and timeless perennial shrub, reaching heights of up to 5m. It is a species of flowering plant within the family of Verbenaceae. It is inborn to tropical and subtropical America and the West Indies. It is common as an attractive plant in all parts of the Vegetation of Ethiopia within an altitudinal range of 500-2500 meters above sea level [11].

The distribution of *Lantana camara* in Ethiopia is widespread, affecting many ecosystems, including cultivated and non-cultivated land, roadside areas, grazing areas, pastoral villages, riversides, wetlands, forests, and urban areas. It destroys an extreme amount of biodiversity [19].

L. camara has usually been purposely planted in various localities in Ethiopia as an ornamental shrub and has been rapidly spread by birds and animals that eat its fruits but cannot digest the woody seeds. In Ethiopia, it is one of the four major IAPSs that hurt the country's biodiversity. Therefore, this review aims to review the ecological impact, distribution, and management strategy of the invasive species *Lantana camara* in Ethiopia [6].

A. Overview of *Lantana Camara* L. in Ethiopia

i. Local Name of Lantana Camara L

Yewof kolo (Amhara); Hamaressa, rate kate, shimbero (Oromia); Burkaati, qarfa-weyn (Somolia) kaffe janga (Borna)

B. Declaration of the Problem

Biological invasion is the second most widespread threat to global biodiversity, following anthropogenic habitat loss and ecosystem destruction [18]. It is among the worst invasive alien species

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*Correspondence Author(s)
Abesh Birhanu Morka*, Department of Forest and Rangeland Plant Biodiversity, Ethiopia Biodiversity Institute, Assosa Biodiversity Research Centre, Assosa, Ethiopia Email ID: birhanuabesh12@gmail.com, ORCID ID: 0000-0003-2464-484X

categorised as universal. In Ethiopia, it is also recognised by the Environmental Policy and the National Biodiversity Strategy and Action Plan as a significant threat to the country's biodiversity.

Lantana camara L. can become the dominant understory shrub in agricultural areas, outcompeting other native species and reducing biodiversity. The allelochemicals that are produced in different parts of the plant can inhibit seed germination, initial growth, and biomass production in many plant species. It may also affect native vegetation indirectly through changes in soil properties [9]. In addition to the loss of biodiversity, interference with seed germination and early growth, *L. camara* can reduce the effectiveness of development by blocking irrigation canals, placing limitations on sustainable development, poverty mitigation, and food security within Ethiopia, even though *L. The camera poses a significant risk, given its limited attention, and is often* overlooked in Ethiopia.

The aim could be that the disaster impacts arising from this weed may often be considered not high enough to capture the attention of managers (since very little is known about the threats and dispersal of L. camara in Ethiopia), and/or the impact of this invasive alien species is often misinterpreted. Lantana has spread almost all over the country, but still, it is not much observed as a chronic environmental problem, except in a few parts of Ethiopia, such as Oromia and Somali regions.

C. The Objective of the Review Article

- To review the distribution, historical background, and general characteristic features of *Lantana camara* L.
- To review ecological impacts posed by *Lantana camara L.* on biodiversity in Ethiopia and
- To review the method of controlling the expansion of *Latan Camara L.* in Ethiopia.

D. Methodology

This review was conducted using a systematic and integrative approach to evaluate the Ecological Impacts, Distribution, and management approaches of *Lantana camara L.* in Ethiopia. The methodology was designed to ensure a comprehensive understanding of the current state of Lantana camera, its impacts, and potential pathways for sustainable development. The process involved several key steps.

E. Literature Search and Selection

A thorough literature search was conducted across multiple academic databases, including Google Scholar, Scopus, Web of Science, PubMed, and ScienceDirect, to identify relevant peer-reviewed articles, books, reports, and policy documents published between 2000 and 2025. Grey literature, including government reports, NGO publications, and conference proceedings, was also reviewed to ensure comprehensive coverage of the topic.

II. HISTORICAL BACKGROUND OF *LANTANA CAMARA L*

Lantana camara L. was introduced to the Calcutta Botanical Garden in 1809 from Sri Lanka as an ornamental plant bearing multi-coloured flowers. Due to its prolific seed production, it has spread to cultivated land. It has become a serious weed in pastures, wastelands, road sides, and forests, replacing local vegetation in most parts of India. This species was first recognized as a serious weed in forested areas near Madras in 1893. It had occupied 2,000 hectares in 1917, and by 1941, it had expanded to 40,000 hectares.

Plant invasion is a significant risk to species diversity worldwide during the 21st century, following habitat loss and degradation. Many species of IAP are introduced to their native countries worldwide, and a few of these become problematic. They are introduced into a country either through human or natural means (e.g., winds, birds, animals, water) [24]. Humans have transported thousands of plant species to areas far from their natural habitats, accidentally or intentionally (e.g., for agroforestry, horticulture, forestry, and animal farming purposes). However, invasions by IAPS are one of the most significant threats to the Earth's ecosystems and their services.

L. camara is a literature writer who indicated the natural occurrence of Lantana in Mexico, the Caribbean, and Tropical and subtropical Central and South America. The species was only widely dispersed around the world during the 19th and early 20*th* centuries. During the 18th century, Lantana became a preferred greenhouse plant, and many new varieties were propagated.

Reports on its geographical range indicate its presence in many Pacific Island nations. On the Pacific Rim, it occurs in Australia, New Zealand, China, Thailand, Cambodia, Vietnam, Malaysia, Indonesia, and the Philippines. In the Indian Ocean islands, it occurs on Mauritius, La Réunion, and Rodrigues.

Lantana flowers when the soil is moist and the air is warm and humid. Germination can occur at any time of the year, provided sufficient moisture is present. Initial seedlings grow slowly until their roots become established, after which they develop close stems that intertwine and begin to form thickets. It can reproduce from the base if the shoot dies, spreading the life of the individual plant.

The nectar attracts butterflies, bees, and other insects and pollinates the Lantana flower. About half of the flowers produce seeds, typically 1-20 seeds on each flower head. Mature plants can grow up to 12,000 seeds every year. Seeds are thought to remain viable for several years under natural conditions.

Studies on its seed dispersal mechanism have documented layering, in which stems send roots into the soil, allowing it to form dense stands quickly and spread over short distances. Additionally, birds and other animals consume and pass the seed in their droppings, potentially spreading it over considerable distances. The nursery trade also facilitates the invasive pathway to new localities. Local dispersal methods include digestion, excretion, and escape through gardens or waste disposal areas.

Lantana occurs in agricultural areas, disturbed areas, natural forests, grasslands, shrublands, urban areas, and wetlands. Many studies have documented the disturbance, decreased competition, and increased resource availability associated with fire and grazing as

promoters of Lantana invasions, whereas shedding is a limiting factor; however, some invasive populations are somewhat shade-tolerant. *L. camara,* also known as big-sage, white-sage, is a fast-growing woody thicket-forming shrub, native to tropical and sub-tropical South and Central America, and currently widely distributed in many countries, including Ethiopia.

Lantana camara is introduced into Ethiopia as an ornamental shrub often used as a privacy plant. Lantana is well-known in Ethiopia, particularly as a showy garden plant; for example, the horticultural society recommends planting it in home gardens in Addis Ababa. It has also seen 16 growing around home farmsteads as a live hedge along the nazareth Welenchiti road [12] [22].

A. Taxonomic Description of Latana Camara

Lantana camara L. is a small perennial plant that can grow to around 2 m tall and form dense bushes in a variety of environments [6]. It has small, cylindrical-shaped flowers, each with four petals, and is arranged in clusters at the terminal areas of its stems. Flowers come in various colours, including red, yellow, white, pink, and orange, which differ depending on the location within the inflorescence, age, and maturity. After pollination occurs, the colour of the flowers typically changes (from yellow to orange, pinkish, or reddish). This is believed to be a sign to pollinators that the pre-change colour contains a reward as well as being sexually feasible, thus increasing pollination efficiency.

Table-I: Description of Lantana Camara and its Parts

Plant Parts	Description
Steam	Four-angled, armed with recurved thorns
Leaves	Opposite, ovate to ovate-lanceolate, 2.5 to 10 cm long, 1.75 to 7.5 cm wide, acuminate, the margins are crenate to dentate, the upper surface is scabrous & rugose, and the lower surface is finely pubescent.
Petiole	2cm long
Inflorescence	A dense, axillary, flat-topped head-like spike, 1-3 cm across
Calyx	Cup-shaped, 1.2 - 2.2 mm long, with shallow two lobes, subtended by a bracteole
Corolla	Salver form, tube covered, 6-910ng, limb spreading, 4-8 mm across, yellow, orange, red or pink in the same head (generally yellow and pink on opening of corolla but changing to orange and red, sometimes blue or purple)
Petals	Four
Peduncle	2.5 to 7.5 cm long
Fruit	A drupe, globular, dark purple to black, 4-6 mm across at maturity, borne in clusters
Seed	One, about 1.5 mm long

B. Ecology of Lantana Camara L

Lantan camara L. is a weed of cultivated land, fence lines, pastures, rangelands, and waste places. It thrives in both dry and wet regions, often growing in valleys, on mountain slopes, and along coastal areas. It is a highly light-demanding species that thrives well on well-drained soils with sufficient moisture and in a climate with moderate temperatures, avoiding extremes of heat and cold (areas with 1250-3750 mm rainfall).

It can tolerate both humid and dry heat, but cannot survive very low temperatures. It is slightly shade-tolerant and can consequently become the dominant understory in open forestry or tropical tree crops. However, excessive shade, such as dense forests, inhibits its growth. It has low tolerance for marshy soils and saline soils and is susceptible to frost.

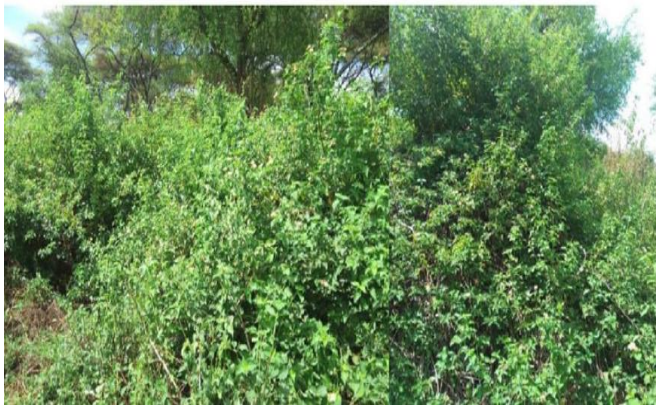
C. Ecological Distribution of Lantana Camara in Ethiopia

The dispersal of *L. camara* in Ethiopia is extensive, affecting many ecosystems, including cultivated and non-cultivated land, roadside areas, grazing areas, rural villages, riverbanks, wetlands, forests, and urban areas. It causes the loss of the maximum amount of biodiversity.

L. camara has usually been purposely introduced into various localities in Ethiopia (particularly urban settings) as an ornamental shrub and has been rapidly spread by birds and animals that eat its fruits but cannot digest the woody seeds [6]. It is commonly found in East and South Africa, where it occurs at altitudes below 2000m and often invades previously disturbed areas, such as recorded forests and areas cleared for agriculture [6].

Human-made and natural disturbances act together to help the introduction and spread of invasive alien species. *L. camara* is spread over sixty (60) countries in the world, viz, New Zealand, Mexico, Florida, Jamaica, and Brazil. It is stated in several African countries, including Ethiopia, Kenya, Uganda, Tanzania, and South Africa.

The different colours of *L. camara* flowers helped it to be cultivated for its ornamental purpose in Ethiopia. This process enables the plant to spread more rapidly than other weed plants. Its use for fencing also contributed to its dispersal within the country. The ability of *L. camara* to rapidly colonise areas of land that have been disturbed (in countries like Ethiopia, where activities such as logging and agricultural clearance are everyday occurrences) may also facilitate its dispersal [14].



[Fig.1: Photo Showing Level of Invasion by *Lantana Camara* from Aberamo District (Amba 14 Kebele Community Rangeland: - Photo Taken by Abesh Birhanu in Sep., 2024]

Although *L. camera* can originate in Ethiopia, like Adama [5], Jimma [6], Mekella [11], Gamo Gofa [15], Bahir Dar Wollega [4], Borna and Gujji; Deber Zeit, Dire Dawa, Harar, and Somail are the hotspot areas of the weed in Ethiopia [6] and Benishangule Gumize [23],

Lantana camara L. has biological attributes like a high production of fruits each year (prolific seed production) and duration of fruit production (which is throughout the year when

conditions are favorable such as adequate light and moisture), its ability to propagate vegetative by a process called layering where horizontal stems take root when they are in contact with moist soil [26], better competitive ability compared to native flora, widespread geographic range (wide ecological tolerance) [6] contributed to the success of its dispersal.

In addition to its biological attributes, the fast spread of its fruit by birds (which are predominant dispersers) (Swarbrick and animals that eat its fruits) may have contributed to its dispersal after its careful introduction into various localities of Ethiopia. Transportation of seeds by running water within the country may also contribute to their spread.

III.THE IMPACTS OF LATANA CAMARA L IN ETHIOPIA

A. Socio-Economic Impacts

Lantana camara was introduced to Ethiopia as an ornamental plant owing to its beautiful aromatic flowers. However, due to its productive seed production and easy dispersal, it escaped cultivation and became a pest, raising concerns in social, ecological, and economic contexts. Currently, it has spread almost nationwide. However, it is still not widely recognised as a chronic environmental problem, except in a few parts of Ethiopia, such as the Oromia and Somali regions.

Currently, there is little information obtainable on the spatial distribution of *Lantana camara* invasion and its potential geographic extent. Lantana is relatively inedible and poisonous to livestock, causing loss of appetite, frequent urination, dehydration, and yellowing of the inner mouth and eyes. Hairs are lost from the skin, the mouth and eyes swell and ulcerate, and animals may die in one or four weeks. The fruits are also poisonous to children. In some areas, lantana coverts provide a breeding ground for tsetse flies, which transmit the parasitic trypanosomes that cause an animal form of sleeping sickness.

According to Belayneh [8] [13], several problems associated with Lantana camara attacks include invading bushlands, quickly taking over valuable grazing lands, and its dense growth inhibiting grasses and other valuable forages under its canopy.

B. Agriculture Loss

In agricultural areas, *L. camara* can become the leading underwood shrub, crowding out other native species and reducing biodiversity. The formation of dense, thick L. camara can significantly slow down forest regeneration by preventing the growth of new trees. The different parts of lantana contain allelochemicals, mainly aromatic alkaloids and phenolic compounds, which can inhibit seed germination and early development of many plant species [7]. Lantana can also inhibit the growth of nearby plants by outcompeting them for soil nutrients [24] and altering the microenvironment (e.g., light, temperature) through the formation of dense canopies. Despite its recognition as one of the worst invasive alien species in the world, information on the ecological interference of lantana on the growth and establishment of native plants, especially on agronomic crops, is scarce in Ethiopia.

The opposing impacts of *Lantana camara* L. on agriculture have been studied in some parts of the world [6] [25]. It may have an indirect effect on crop production due to the heat, as it is favourable for many insect pests that can affect human health. In addition to its effects on root and shoot growth, biomass, and host for vectors, the weed can affect the mustering of cattle (by out-competing native pastures that are better feed for the cattle), thereby disturbing agriculture. Lantana may also affect agriculture by providing shelter for threatening wild animals, such as wild cats, hyenas (which can consume cattle, goats, and sheep), warthogs (which can damage crops), and others [3].

C. On Biodiversity Loss

Among the attackers that will have the most significant impacts are those that directly change ecosystems. They have cascading effects for resident biota (plants, animals, and micro-organisms). Exotics can disrupt ecosystems by altering system-level flows, the availability, or the quality of nutrients, food, and physical resources (e.g., living space, water, heat, or light). Many writings suggest that introduced ecosystems contribute to either increasing habitat complexity or heterogeneity, which tends to cause abundances and/or species richness to rise or decrease. Difficulty tends to have the opposite effect on ecosystem services.

Ecosystem services can be characterized into four main service area in general; (1) Provisioning service (e.g. food, freshwater, fiber, fuel, genetic resources, (2) Regulating services (e.g. air quality regulation, climate regulation, water regulation) (3) Traditional services are nonmaterial benefits, (e.g. aesthetic values, recreation/tourism, spiritual/ religious values, (4) Supporting services. Overarching, indirect, and occur on large temporal scales (e.g., photosynthesis, primary production, nutrient cycling [17].

IAPS pose threats to these ecosystem services; they pose a global threat to biodiversity conservation through their proliferation and spread, displacing or killing native flora and fauna, and affecting ecosystem services. They are particularly damaging in geographical or ecological islands, which are rich in endemic species. Invasive plants smother, outcompete, and displace indigenous species, changing the composition and function of entire ecosystems.

Lantana camara L. colonises disturbed sites, impacting croplands and range lands. It generates allelochemicals through the roots in the soil via root exudates [21]. These allelochemical inhibitors (like phenolic acids and alkaloids) inhibit the germination, growth, and yield of neighbouring plants through the mechanism called non-resource mediated interference, and this may adversely affect plant species diversity by displacing mature vegetation or limiting juvenile recruitment [16]. The other mechanism by which Lantana can affect biodiversity is through competition for resources (e.g., water, nutrients, sunlight). In addition to allelepathy, it has a fast growth rate and an inedible nature (due to its unpalatability, the weed experiences relatively little pressure from natural predators compared to those that have evolved in their native land, which favours

the weed in affecting biodiversity by competing out native species [3].

It readily invades pastureland, outcompeting palatable species, resulting in a decrease in carrying capacities and restricted access and movement of animals, humans, and vehicles. It is also unpalatable and, in large doses (approximately 1% of total body weight), is poisonous, causing skin lesions in sheep, particularly in cattle. Lantana is one of the known allelopathic weed plants in many parts of the world. For example, an experiment was conducted in Northern Ethiopia [6]. Accordingly, Lantana leaf powder significantly inhibits seed germination, speed of germination, shoot and root length, stem thickness, and biomass of wheat and maize.

D. Impacts on Human and Animal Health

The natural and severe impact of invasive alien species, such as L. camara, on human health is a global concern. *L. camara* is one of the potential invasive alien species that can pose a threat to human health. The effect of Lantana camara on human health can be direct or indirect. Feeding on the green fruit of Lantana has proven to be fatal, and this can be considered a direct consequence of *L. camara* on human health. However, this may not always be true, as children and adults often consume suitable fruits of *L. camara* without any ill effects in India. Additionally, in Ethiopia, Traditional healers have been using (such as leaves and stems) *L. camara* to treat various diseases in humans. These debated research findings may stem from the fact that some varieties are poisonous and some are not, but it is difficult to determine which varieties are toxic. Therefore, it is better to consider some forms as possibly poisonous.

Indirectly, *Lantana camara* can cause health problems in humans by providing shelter for malarial mosquitoes in bushes and Tsetse flies. In Ethiopia, the information on toxic plants like Lantana is uncommon. However, the findings of Reda and in the Tigray region, Northern Ethiopia, and [15] in Gamo Gofa zone indicated that *Lantana camara L.* is a constraint to both human and animal health. Moreover, the report of [4] showed that consumption of *L. camara* leaves in the Wollega Zone, Western Ethiopia, results in livestock toxicities (bloody urine). Additionally, in Cheffa (300 km north of Addis Ababa), research results have demonstrated that Lantana camara L. has negatively impacted the quality of livestock production.

E. Invasion in National Park Degradation

Infestation in national parks can unfavourably affect plant (by hurting native plant species and slowly reducing the endemic species) and wild animal biodiversity, and this finally may result in degradation of these protected areas and an increase in management costs [20]. Similarly, the spread of *L. camara* in Ethiopia's national parks has become a growing concern [1]. In other African countries, the findings of different researchers have similar results. According to African scholars, L. camara invasion in South Africa has been linked to a decrease in invertebrate diversity, the tourism industry, and industrial sites. The national parks in Zimbabwe [17], Kenya, Australia, and South Africa have been invaded by the weed.

IV. MANAGEMENT APPROACHES OF LATANA CAMARA L.

There are different management approaches to the IAPS of *L. camara* after the outbreak. Those efforts to *control L. camara* using Strategies are Mechanical, chemical, biological, and utilisation-based, as well as creating awareness among stockholders. Additionally, prevention methods and fire control are employed. An integrated approach is also required for adequate control.

A. Utilization of Lantana Camara

Unique among the likely options to succeed, *L. camara L.* invasion is through utilization. *L. camara can* be utilized to produce biogas, compost, especially vermicompost [6], and as a green manure. Plants at the pre-bloom stage should only be used; otherwise, while handling such material, dispersal may occur.

L. camara can be used to control root-knot nematode (due to its nematicidal properties) [15], protect seed potatoes from potato tuber moth damage during storage and protect Tomato (*Lycopersicon esculentum)* (due to its antibacterial activity) from bacterial wilt caused by Ralstonia solanacearum[8]

L. camara also has insecticidal properties on *Musca domestica* (house fly) and thus can be utilized as an insecticide. It can be used as a source for firewood [6] (and fuel briquettes, a clean energy source).

It has medicinal properties too.

In addition, it can be used to treat tick bites in livestock [2]. Currently, in India, *L. camara* is used as a craft material for weaving baskets and making furniture. It is also used as an input for paper production. Thus, utilization of *L. camara* for such resolution may help in its elimination and control in Ethiopia.

B. Fire

Even burning will reduce the capacity of invasive alien species to survive; however, initial kill rates are variable. This method will depend on the suitability of available fuel loads, litter moisture content, fire intensity, temperature, relative humidity, soil moisture, and season. Pasture re-establishment can then provide competition to inhibit *Lantana camara* seed germination.

Although *L. camara* L. burns readily during hot, dry conditions, even when green, moderate and low-intensity fires can promote the persistence and spread of its thickets, rather than reducing them, furthermore, the elimination of competing native plant species (native plant species that are not fire-tolerant) and increases in soil nutrients following burning (since burning can promote the release of nutrients from organic matter) can increase *L. camara* germination.

Care should be taken when using this method for *L. camara L* control and removal. The other limitation of this method is that it cannot be used in non–fire–tolerant vegetated areas, such as rainforests, wooded areas, or plantation areas. But this method is favourable for savannas (since plants in

savannas are fire-tolerant) [6].

C. Chemical Control

An additional, expensive, but effective method for managing L. camara is the use of Chemicals, but its effectiveness depends on plant size, time of application, and method of application. Numerous herbicide treatments can be used and are said to be effective when applied as a foliar spray or to the base of the stems and cut stumps. When applied as a foliar spray or to the base of the stems and cut stumps. According to different scholars, some herbicides (belonging to the phenoxy acid and benzoic acid) can be effective on *L. camara*. Like other management strategies, the use of chemicals requires careful application and regular follow-up.

D. Biological Control

Biological control can be careful relatively as the most excellent and most necessary control option for the control of *L. camara* L. because it will not be influenced by restrictions (because the other management options like mechanical and chemical are dependent on the land use, extent and density of the invasive populations, openness to invaded areas, economic value of land, and the associated costs). In addition, utilization of chemicals may not only be expensive and complicated but may also result in long-term environmental pollution and possible serious problems that may arise in the future [23].

Some biocontrol agents (insects) have been released periodically to manage *L. camara* biologically. The utilization of defoliating herbivores like Teleonemia scrupulosa Stål and Uroplata girardi Pic (since leaf defoliation can result in decreased seed production and dieback of leaves and some branches) can be used to remove and control *L. camara*.

In utilizing biological controls (like insects) one must make sure that natural enemies of those insects (insects which will feed upon them after the weed control or removal) are present in the area in which the method is planned to apply to them for the control of *L. camara* If not, utilization of biological control has also its own limitation (disadvantage).

E. Mechanical/Physical Control

Mechanical measures may minimize disruption to neighboring vegetation and be effective in killing the weed, but they also have their own limitation. The use of excavators and tractors, as well as ploughing by Oxen, may increase the difficulty in removing *L. camara.* Large areas may be occupied, and regrowth from stumps and/or increased seedling germination can occur in the disturbed soil. Mechanical measures can also make areas susceptible to soil erosion and other opportunistic weeds (since the measures may result in soil disturbance) unless proper care and follow-up are considered.

Although manual controls are expensive (e.g., bulldozers and tractors) and time-consuming (e.g., ploughing using Oxen) and cannot be used in areas where *L. camara* is not found in isolated clumps, they can provide some relief.

The use of bulldozers and tractors, in some cases, ploughing by Oxen, grubbing, the slashing of branches, and extensive digging of the root system are some of the mechanical measures that can be used to remove and control *L. camara* in Ethiopia.

Although mechanical measures, in general, may minimise disturbance to nearby vegetation and be effective in killing the weed, they also have their own limitations. The use of bulldozers and tractors, as well as ploughing by Oxen, may increase the difficulty in removing L. camara where large areas are invaded, potentially resulting in regrowth from stumps and/or increased seedling germination from the disturbed soil. Similarly, if care is not well-thought-out grubbing, the slashing of branches and extensive digging of the root system may also result in the establishment of coppicing from slashed branches of *L. camara* [7].

F. Awareness Creation for Stockholders

Currently, issues linked to invasive woody plants, such as L. camara, are mainly, and sometimes only, the concern of scientists and conservationists [20]. This may create difficulties or limitations in eradicating and controlling the invasive plants. *L. camara can invade any area in villages, towns, and cities, particularly in the vicinity of housing and other buildings, due to* its Morphological and ecological characteristics, unlike other weeds. So, societal awareness, consent, and participation are key to controlling and eradicating *L. camara.*

Consequently, to be effective in controlling the weed in Ethiopia, mass awareness programs should be organised by Universities, NGOs, the Environmental Protection Authority, and others to inform local people about the hazards of this harmful invasive weed. These can serve as an excellent source of knowledge about the dangers of *L. camara* and may help in its mechanical control (local people can be involved voluntarily during its uprooting) at an early stage in areas from which it originates. Additionally, if it is planned to save the national parks and biodiversity, and reduce the potential impact on agriculture, awareness creation programs should be organised annually throughout Ethiopia [7].

G. Prevention Methods

Avoidance of invasive alien species is the most effective control strategy because it minimises the risks (such as environmental) associated with the use of other methods (for example, chemicals) and reduces management costs [19].

According to CBD [10], prevention of invasive alien species includes regulating intentional introductions and minimizing accidental introductions (through the identification of potential high-risk species and corridors). The measures to prevent their establishment can be applied pre-border (before it leaves the source country), at the border (as it enters a country), or post-border (once it is already within a country). Even though pre-order and at the border prevention measures cannot be applied to prevent *Lantana camara* in Ethiopia (because the weed is already established within the country), post-border measures, such as Strict quarantine laws, should not transport the weed from the infested to the non-infested area within the country, this can be

effective in controlling and managing the spread of the weed into another location.

People should reduce the utilization of *L. camara* as an ornamental plant in the vicinity of their home or crop fields. This may also help in the prevention of *L. camara* in Ethiopia. Furthermore, at a regional level, each regional government must have a biosecurity plan that covers invasive plants like *L. camara* in its area (this may also help to reduce its spread into regions in which the weed is not currently found [7].

V. CONCLUSION AND RECOMMENDATION

Ethiopia boasts a diverse range of ecosystems that are home to a vast array of flora, fauna, and microbial species. However, there are pressures on ecosystem services and biodiversity loss due to habitat conversion, invasive species, unmanaged utilization of biodiversity resources, replacement of local varieties and breeds, and climate change and pollution. Invasive alien species, such as plants, are exotic and are introduced purposely or unintentionally outside their natural habitat, either naturally or through human activities. In new areas, invasive alien species inhabit native ecosystems, often having either positive or negative consequences for ecosystem services. Invasive alien species are found in all taxa, or groups of organisms, and are present worldwide in all ecosystems.

Recently, 35 invasive weed species have been identified in Ethiopia, posing negative impacts on native biodiversity, agricultural and rangeland areas, national parks, waterways, lakes, rivers, power dams, road sides, and urban green spaces, with significant economic and social consequences. Some of these species include mesquites (P. juliflora), parthenium weed (P. hysterophorus), water hyacinth (E. crassipes), lantana weed (L. camara), Acacia species, and other weeds, such as Orobanche and Cuscuta species, that are identified as major plant invaders. These IAPS are more pronounced in disturbed, arid, and semiarid vegetation ecosystems, such as Acacia-Commiphora woodlands, aquatic wetlands, agro-ecosystems, and rangelands in Ethiopia. IAPS have peculiar characteristics of invasiveness and distribution that outcompete native species, such as the number of seeds they produce, reproductive outputs, and some allelochemicals that inhibit the growth of other native species. As a result, they have impacts on biodiversity, social services, and health problems, both in humans and animals, in all ecosystems in the new areas. To ward off such threats, countries around the world, including Ethiopia, have their own strategies to control IAPS in their native ecosystems. But there are management blocks to implementing such strategies. Mechanical, chemical, and fire regimes, as well as biological control methods, are some methods used to manage the invasion of particular species, such as water hyacinth. The methods above have their own advantages and disadvantages for controlling IAPS. Prevention, integrated management strategies, and the utilisation of the species as a measure to control L. camara in Ethiopia are among the most effective management control measures. Therefore,

- It requires integrated, coordinated, and multi-stakeholder actions at multiple levels, involving the community, government, and development partners, to eradicate the invasive plant L. camara.
- Sustainable and multidisciplinary studies are needed regarding the history, properties of invasiveness, and impacts of the species in relation to ecological effects on ecosystems and socioeconomic consequences.
- Creating awareness among stakeholders about the history, cause, and effects of the Lantan camera is very important.
- Close monitoring and management of all natural and agroecosystems to mitigate disturbances and reduce the arrival and colonisation of IAPS.
- Secure quarantine measures need to be introduced in border areas where tourism, trade, and travel agents are flowing.
- Countries with IAPS share information and work together to control the transfer of IAPS from one to another.
- The society should be aware not to use the land for grazing or browsing more than its carrying capacity, as disturbance in the form of herbivory is found to be a significant factor facilitating invasion and encroachment of the species.
- Establishment of training on how to use the species to improve the biophysical and socio-economic environment. For example, planting it in eroded areas to rehabilitate regions, in erosion-prone areas to prevent erosion, and using it as a live fence around farmsteads and home gardens.
- Removing it before seed production is a significant means of encroachment into uninvited areas.
- Determination of the beginning level for decline in biodiversity and the identification of “management barriers” to invasion

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AUTHOR'S PROFILE

Abesh Birhanu Morka is an Associate Researcher in the Ethiopia Biodiversity Institute, Assosa Biodiversity Research Centre, Department of Forest and Rangeland Plant Biodiversity. He obtained his first degree in Applied Biology (BSc) from Bahir Dar University and his second Degree in Ecology and Conservation Biology (MSc) from Wollega University in 2014 and 2018, respectively. I have four years of experience working on the conservation of biodiversity and traditional medicinal plants, as well as Indigenous knowledge. He has published articles in peer-reviewed and significant Journals. I Have Published a total of six scientific papers in important scientific journals, as well as several review articles, seminars, and various scientific workshops.