Ethiopian Forestry Development

(Draft)Training manual on prevention and control of Invasive Alien Plant Species (IAPS) in Ethiopia

Editors

Tesfaye Gashaw

Kabtamu Girma

Tegene Tadese

Contributors

Dr Zewdu Eshetu

Mesfin Tsegaye

Mekonen Alemu

Compiled by Adugna Abebe

MSc

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Acronyms

IS…… Invasive Species

IAS……...Invasive Alien Species

IAPS…….Invasive Alien Plant Species

EDRR……Early Detection and Rapid Response

IUCN……International Union on Conservation of Nature

1 Introduction

Invasive species are indigenous or non- indigenous species that can heavily colonize a particular habitat. They are also widely distributed in all kinds of ecosystems throughout the world. IAS has the ability to establish, invade, out- compete natives and take over the new environment. They are now affecting every ecosystem types on the planet and they are the second greatest global threat to biodiversity after habitat destruction. They are pausing threats to ecosystems of the earth, and the services that they provide to humanity are under risk.

IASs have induced impacts on native species directly competing for resource such as: food and breeding sites indirectly by altering habitat and modify hydrology, nutrient cycling and other ecosystem processes. IAS are creating complex and far-reaching challenges that a threat to not only biodiversity, but also food security, health and economic development.

The problems of IAS in developing countries are higher than in developed nations. According to Lowe et al. in 2004, IUCN identified 81 IAS in South Africa, 49 in Mauritius, 44 in Swaziland, 37 in Algeria and Madagascar, 37 in Kenya, 28 in Egypt, 26 in Ghana and Zimbabwe and 22 in Ethiopia.`` These invasive alien species can create numerous problems on environment and the whole ecosystem. Therefore knowing about the invasive alien species help to manage and prevent them before the damage on environment, economic and social losses occurred by invasion.

2 Objectives of the training manual

The objective of this manual is to enhance the skill and knowledge of regional experts including stakeholders on the methods of prevention and control of Invasive plant species and thereby the trainees will be able develop and guide prevention and controlling mechanism of Invasive plant species in the country.

3 The scope

This Training Manual on Invasive alien plant species in Ethiopia is prepared mainly support the regions to use as a reference while providing trainings to the lower level structures (zonal and districts). It focuses on sharing knowledge and experiences to regions on control and prevention

of IAS. The purpose of this manual is to capacitate regional experts on the management of invasive species with the aim of reducing the negative impacts of invasive plant species in their respective zone and districts so as to maintain rich and fragile natural resources, communities and livelihoods.

4 Concepts of IAS

The majority of invasive species are alien, but it is important to note that native species may also become invasive, usually under altered environmental conditions such as grazing, cyclones, changes in nutrient regimes, colonization by an invasive species, or other alterations.

Invasive alien species (IAS) are animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment.

Invasive species a species that has established and spread or has the potential to do so outside of its natural distribution range, and which then threatens ecosystems, habitats and/or other species, potentially causing economic and/or environmental damage, or harm to human health.

5 Terminologies

There are seven terms (native, nonnative, introduced, established, invasive, nuisance, and range change) that are applicable across invasive taxa, understandable, typically interpreted correctly, and useful for describing most situations regarding invasive species. An alien species those threaten ecosystems, habitats or species include:

- Alien species that escape from human control go beyond the intended physical boundaries and cause environmental damage;
- Covers alien species that remain under human control but damage native ecosystems. Such damage is linked to species being alien, but not to invasiveness.

The definition of terms to use for Invasive Species is;

- **Native:** A species that occurs naturally in a specified geographic area.
- **Nonnative:** A species that does not occur naturally in a specified geographic area.
- **Introduced:** A species brought to a new geographic area intentionally or unintentionally by humans.

- **Nuisance:** An individual or group of individuals of a species that causes management issues or property.

IAS can be established species having a self-sustaining and reproducing population in a specified geographic area without the need for human intervention. This can be applies to both native and nonnative species. Invasive Alien species that (a) is nonnative to a specified geographic area; (b) was introduced by humans (intentionally or unintentionally), and (c) does or can cause environmental or economic harm or harm to humans.

Part 2

6 Historical perspective of IAPS in Ethiopia

Ethiopia has great geographic diversity, and macro and micro climatic variability. However, there are threats to its biodiversity by habitat conversion, invasive species, unsustainable utilization of biodiversity resources, replacement of local varieties and breeds, climate change and pollution, demographic change, poverty, and lack of awareness and coordination. IASs are found in different parts of the country mainly invading dry lands and wetlands. The distribution of IAPS in Ethiopia is indicated in different regions across the country.

In Ethiopia; disturbed ecosystems, along road sides, agricultural lands, and grass lands, in vegetation ecosystems: Desert and semi-desert, *Acacia-commiphora* woodland and bush land, freshwater lakes, lake shores, marshes, swamps and flood plain vegetation, dry Evergreen Afro-montane forest and grassland complex, and Acacia wooded grassland of the central rift valley are under threat of IAPS. Many evidences prove that disturbances in the natural ecosystems provide the great opportunities to the alien invaders to establish themselves. The frequency of the alien herbal plants increased in the areas of human interference such as forest fragmentation. Moreover, population pressure, over-stocking, overgrazing and deforestation have facilitated the disturbance of the Ethiopian ecosystem and enhanced the effect of weed invasion by threatening biodiversity of the country.

Biological invasions are attracting extensive attention from ecologists because of their significant ecological impacts and economic costs worldwide. They are increasingly recognized as a key problem of conservation of biological diversity (Reichard and White, 2003). Invasion by plant

species poses a major threat to native plant communities and alters fundamental structures and functions of ecosystems.

Recently, it has been proofed that some invasive alien plant species (IAPS) are spreading at an alarming rate and exerting negative impacts on agricultural lands, rangelands, national parks, waterways, lakes, rivers, power dams, roadsides and urban green spaces in Ethiopia (EARO, 2003). Plant invasion is a strong threat to the species diversity around the world during the 21st century after habitat loss. Large number species of IAP are introduced to native country in the world and few of these become problematic; they are introduced in to a country either through human or natural (e.g. winds, birds, animals, water). Thousands of plant species have been transported by humans to areas far from their natural habitats; accidentally or intentionally (e.g. agro-forestry, horticulture, forestry, and animal husbandry purposes). However, invasions by IAPS are one of the largest threats to the ecosystems of the earth, and the services.5 few aggressive IAPS which are threatening biodiversity in Ethiopia and elsewhere in the world are discussed in the following sections.

6.1 The process of IAPS

Invasion processes involve the successful overcoming of several challenges: a potential invader must survive, transported from its place of origin, become established in the new site, persist and reproduce until a sustainable population is formed that eventually expands. The ability to successfully overcome these stages depends not only on the species' own characteristics, but also on the characteristics of the invaded habitat that determine its susceptibility to invasion, the establishment of effective relationships with local dispersal agents and the particular conditions at the time of the arrival of the prop gules.

6.2 Invasion Vectors and pathways

6.2.1 Vectors

They are the transfer mechanisms responsible for the introduction and spread of invasive species in a certain area by physical means or agents. It is possible to compare the different vectors of introduction that operate in a particular area in terms of their potential to transport species of high risk of invasion efficiently and, once identified, to establish strategies of prevention, early detection and rapid action.

6.2.2 Pathways

The pathways are the means and routes by which invasive species are introduced into new environments and can generally be classified as either natural or man-made.

a) Natural pathways (self-introduction on their own) include
- ❖ Wind,
- ❖ streams (including marine debris), and
- ❖ Other forms of natural dispersal that can bring species to a new habitat.

b) Man-made (human assistance) pathways are those which are created or enhanced by human activity.

7 Pathways of introduction (causes)

7.1 Intentional introductions

Intentional introduction is the result of a deliberate movement of a species by humans outside of its natural range. Intentional introductions as a whole should not be labeled as either good or bad. A specific intentional pathway can only be judged by the positive or negative impact of the specific organisms that are moving along that means.

7.2 Unintentional introductions

Unintentional introduction is the inadvertent or accidental movement of species as a byproduct of some other human activity. The unintentional pathways are the movement of non-native species is an indirect byproduct of human activities.

8 Types, nature and characteristics

To be invasive, it should meet the following:

- ❖ A species must adapt to the new area easily;
- ❖ It must reproduce quickly;
- ❖ It must harm property, the economy, or the native plants and animals of the region.

Invasive species are any species that are non-native and harm the local ecosystem. When these non-native plants and animals establish themselves in our local ecosystems, they out-compete and remove species that have evolved specifically to live there.

9 Impacts of IAPS

Environmentally invasive alien species can cause environmental degradation through numerous problems, such as

- Acting as predators,
- hindering the growth of native species,
- altering habitats,
- causing physical and chemical changes to the soil,
- competing for food and space,
- hybridizing with native species,
- Introducing new parasites and diseases.

Socially invasive plant species can directly or indirectly affect the food security of local residents and increase vulnerability to hazards and risks. In areas where they spread, invasive species can destroy natural pasture, displace native trees, and reduce grazing potential of rangelands.

Economically invasive alien species can affect crop production, animal husbandry, human health and biodiversity. Moreover, invasive alien species have adversely impacted numerous industries, such as fisheries, tourism, and water production.

10 Geographical distribution, description, and management of IAPS in Ethiopia

There are more than 35 IAPS identified in Ethiopia. Some of these IAPS include: *Prosopis juliflora*, *Parthenium hysterophorus*, *Water hyacinth* (*Eichhornia crassipes*), *Lantana camara*, Acacia species, and Orobanche and Cuscuta species that are identified as major plant invaders. Recent surveys found also emerging plant invaders such as *Cryptostegia grand flora*, *Parkinsonia aculeate*, *Mimosa diplorotricha*, *Mimosa pigra,* and *Agrimonies mexicana* and *Nicotine glauca*. However, we are briefing in detail five of the most devastating from the above stated.

10.1 Prosopis juliflora

10.1.1 Overall features

A. Description:

Prosopis juliflora is a thorny shrub 3-5 m or tree growing up to 15 m height. It has a thick rough grey-green bark that becomes scaly with age. The plants are often multi-stemmed and furnished with abundant large and very sharp thorns measuring up to 5 cm. The tree is deeply rooted. It is regarded as one of the worst weeds in Australia because of its invasiveness, potential for spread, and economic and environmental impacts. There are four species and several hybrids of Prosopis, which are all collectively known as mesquite.

Figure 1 the single tree of Prosopis juliflora that is invading large areas in Ethiopian Rift valley.

B. Use:

Most of the plants of the genus Prosopis are considered useful for growing dry areas. The main produce from these plants is quality wood for, timber, seeds for human and animal food, and other products. It is a highly esteemed fuel wood source in several places, a valued tree for shade, and is also used as timber and forage (Saini et al., 2013). The stem of prosopis helps to produce house/office furniture and farming tools. In addition to the above mentioned uses, *P. juliflora* is also used to control soil erosion.

C. Impacts

Prosopis's economic impacts raise from its habit of forming dense, impenetrable thickets which combined with its large thorns, prevent livestock accessing watering holes and make gathering difficult. Mesquite also reduces the productivity of pastoral country by taking over grasslands and using valuable water resources. Other nuisances from mesquite include damage to animal hooves and vehicle tiers from thorns, and the poisoning of livestock which consume excessive amounts of seed pods.

Environmental impacts include land erosion resulting from the loss of grassland habitat that supports native plants and animals; and the provision of safe refuges for untamed animals such as pigs and cats. Its thorns, which grow along tendrils/vines/ to 7-10 cm in length, have caused problems to the communities living in these areas, particularly children stepping on thorns.

It is also replacing native Acacia and affecting the biodiversity of the areas invaded. Its pods have a high sugar content, which causes teeth decay in animals ingesting them.

In addition, seeds pass easily through the digestive tract of livestock without harming the animals, thereby bringing about a further spread of the plant and rise of dense stands of Prosopis covering the most fertile areas.

D. Distribution

These plants originate from the western hemisphere and have been introduced into several countries of Africa, Asia and Australia over the last century. It is introduced in Ethiopia in the late 1970s at Goro nursery- Dire-Dawa. Prosopis was planted over large areas until 1982, continued by the Food for Work Programme from 1986 to 1988. This species is now commonly found in Afar, Oromia, Amhara, Somali, Dire-Dawa regions and Sothern Nations and Nationalities. Nowadays, it is repeatedly reported to be one of the invasive and problematic trees in the Afar Region and progress to Rift Valley of Ethiopia.

E. Management

There are different interventions required for Prevention of Prosopis establishment, removal of Prosopis, restoration, rehabilitation and use of cleared areas containment and prevention of further spread. On the other hand different interventions will be required for;

- highly invaded areas,
- moderately invaded areas, and

- Areas at risk of invasion.

In some areas it is appropriate to utilize the biomass once it is removed. There might also be the case for controlled utilization of biomass from areas that are temporarily contained. The use of biomass can bring economic benefits to local communities, government and businesses; however a dependence on these benefits should not be encouraged because ultimately, the resource (the Prosopis) will be eradicated. Then decisions need to be made through a participatory consultation process of different actors.

Based on the national strategy, the interventions that should be used in the different areas are;

- Raising public awareness on the dangers of Prosopis;
- Strengthening national and regional research extension programs on Prosopis;
- Monitor and evaluate progress of national Prosopis management efforts;
- Prevention of new introductions or establishment of Prosopis

There are three components of early detection and rapid responses (EDRR)

a. Early detection – establishing mechanisms for ensuring that new invasions are identified, notified and action taken.
b. Rapid assessment – the context and scale of the new invasion should be assessed – maps and other information on the invasion will be collected.
c. Rapid response – a systematic effort will be made to eradicate the new invasion as quickly as possible and before it becomes widely established.

11 Mechanisms/methods of eradication

In areas where Prosopis species have already spread over very large areas other Prosopis management methods such as preventive and containment are seldom feasible as management options. Control, in conjunction with restorative habitat management, may then be the only realistic recourse. The aim of a control programme is to reduce the abundance and density of infestations, and to keep harmful impacts of an invasion down, as far as possible, to within manageable limits (Gordon and Arne, 2013). In general there are three types of control methods; Mechanical, chemical and biological control strategies.

A. Mechanical control methods

Mechanical control options include the physical felling or uprooting of plants, often in combination with burning (Van wilgen et al., 2001). Manual and mechanical control methods involve the removal by hand, or with tools, implements, or machines of an infestation's individual invaders.

B. Chemical control

Chemical control methods, involving the judicious use of approved herbicides, can improve the efficacy of manual and mechanical clearing activities. Applying systemic herbicides to cut tree-stumps or to incisions made in the bark of trees or shrubs (in a procedure known as frilling) will, on spreading through the vascular tissue of treated invaders, eventually kill the targeted trees or shrubs.

C. Biological control

Biological control has in recent decades gained acceptance in many countries as the most cost-effective and reliable means of managing large infestations of invasive alien plant species. Bio control involves the deliberate, closely-monitored introduction of one or more species of highly specialized alien organisms that hail from the original home range of the invading plant species, and which physiologically are adapted to feeding exclusively on or attacking exclusively plants of that species (Gordon and Arne, 2013). Bio control does not eradicate the alien plant invader, but rather weakens its competitiveness with native plant species, suppressing its density and environmental impacts, so allowing the native vegetation to recover (Gordon and Arne, 2013).

D. Control by Utilization

Conventional Prosopis control methods particularly by mechanical and chemical means, have been expensive and ineffective (McConnachie et al., 2012; Sato, 2013). As a result the strategies that aim to minimize costs and maximize economic benefits are being sought in several developing countries. Therefore; it could be argued that utilization of Prosopis is the best option to control invasion of many invaded areas (Tessema, 2012; Wakie et al., 2012)

12 Parthenium hysterophorous (Congress grass)

A. Description

Parthenium hysterophorus is a much-branched, short-lived (annual), upright (erect) herbaceous plant that forms a basal rosette of leaves during the early stage of growth. It usually grows 0.5-1.5 m tall, but can occasionally reach up to 2 m or more in height. It is known for its notorious role as environmental, medical, and agricultural hazards.

Figure 2 Picure of Parthenium hysterophorus

B. Habitat:

The habitat of Parthenium hysterophorus is a weed of semi-arid, subtropical, tropical and warmer temperate regions. It is found in riparian zones (banks of watercourses), on roadsides, along railways and in pastures, seasonal floodplains, grasslands, open woodlands, waste areas, disturbed sites, lawns, gardens and crops.

C. Uses:

Recently many innovative uses of this previously notorious plant have been discovered. Parthenium hysterophorus confers many health benefits, via;

- ✓ remedy for skin inflammation,
- ✓ rheumatic pain,
- ✓ diarrhea,

- ✓ urinary tract infections,
- ✓ dysentery,
- ✓ Malaria and neuralgia.

  Remark: These should be studied well and identified as medical plant before using it.

- Impacts:

Along with severe negative effects on human and animal health and crop production, it also causes harm to ecosystem functioning by reducing the native plant species biodiversity. However, its impacts on native plant species, especially in pasture communities, are less known.

D. Distribution

Parthenium hysterophorus L. is a native plant of sub-tropical America and it is rapidly invading in the North-Western Indian Himalaya (Himachal Pradesh), from last two decades onwards. Here, it is invaded up-to 2000 m altitude from mean sea level and drastically effecting native plant resources in the invaded habitats.

Ecologically, it is introduced to Ethiopia accidentally in the 1970s when drought induced famine triggered a massive multinational relief effort. It was first reported from Ethiopia in 1988 at Dire-Dawa and Harerge, Eastern Ethiopia and subsequently found near Desse, Northeastern Ethiopia as well.

E. Management

Biological control by Mexican beetle (zygogramma bicolorata) in India is known. Based on well documented success by Mexican beetle, Zygogramma bicolorata Pallister (Coleoptera: Chrysomelidae) in other countries where they were introduced, beetles were imported in 1982 from Mexico to Bangalore.

Chemically Parthenium in waste land can be controlled by use of glyphosate (1 to-1.5%) for total vegetation control but if grasses are to be saved, metribuzin (0.3 to 0.5%) or 2,4-D (2-2.5 kg a.i) can be used.

However, control of parthenium has been tried by various methods, but no single management option would be adequate to manage parthenium, and there is a need to integrate various management options.

Successful management of this weed can only be achieved by an integrated approach with biological control as the key element.

13 Eichhornia crassipes (Mart.) Solms in A. DC. (Pontederiaceae)

A. Description:

Eichhornia crassipes is a free water-floating aquatic plant that has invaded aquatic areas throughout the eastern and southern portions of the United States. Plants can grow to 3 ft. (1 m) in height. The leaves are oval to elliptical, thick, up to 6 in.

Figure 3 Picture of Water hyacinth (Eichhornia crassipes)

Eichhornia crassipes grows;

- In shallow temporary ponds,
- wetlands and marshes,
- sluggish flowing waters and large lakes,
- Reservoirs and rivers.

It is thought to be native to the Amazon River Basin. Plants can tolerate extremes of water level fluctuation and seasonal variations in flow velocity, and extremes of nutrient availability, pH, temperature and toxic substances. It possesses specialized growth habits, physiological characteristics, and reproductive strategies that allow for rapid growth and expansion in

freshwater environments. Water hyacinth has spread rapidly throughout the tropics and subtropics.

Some of the use or benefits that can be derived from the plant include;

- Biogas and biofuel production,
- medicinal functions,
- vermicomposting,
- compost production, and
- Bioremediation.

Water hyacinth has a variety of negative impacts once introduced into a freshwater environment. It forms dense, impenetrable mats which clog waterways, making boating, fishing and almost all other water activities, impossible.

It also reduces biodiversity by crowding out native plants at the water's surface and below.

B. Distribution:

Water hyacinth is native to South America and it is originally from the Amazon Basin its entry into Africa, Asia, Australia, and North America was facilitated by human activities and lack of naturally occurring enemies.

It introduced in to Kenya (1957), Lake Victoria in East Africa, and began to cause problems in 1990. Zimbabwe (1937), Mozambique (1946), Rwanda and Burundi colonized in the late 1950s, Tanzania were infested in 1955 and 1959, Zambia (1960s), Uganda (1988- 89), Malawi (1996). Water hyacinth has also spread to West Africa and Cameroon (1997-2000), Nigeria (almost all water bodies).

Water hyacinth in Ethiopia has also been marked on a large scale in many water bodies of the Gambella area, in Blue Nile Watershed, Lake Tana, in rift valley of Ethiopia, Lake Ziway and Lake Abaya vicinities.

14 C. Control Methods/Mechanisms

C.1 Mechanical control

Mechanical control includes harvesting by hand or machine. The use of machinery to remove WH from water bodies is the most effective non-polluting control method, especially in critical areas such as hydro-electric dams and ports. The main advantage to the use of mechanical harvesting is the simultaneous removal of nutrients and pollutants from the water body, and may therefore act as a means of slowing or even reversing eutrophication.

Water Hyacinth can be removed by raking or seining it from the pond's surface.

C.2 Biological Management Options:

Since water hyacinth is the main food source for the Neochetina beetle, they are commonly used as a biological management factor for the plant. Methods to keep the Mexican beetle from expanding to the nearby areas are monitoring and management. Monitoring and management of can be done through taking plant samples with suspected infestation can be fragmented by hand and placed in Berlese funnels to extract any larvae or adults of Neochetina eichhorniae feeding on the plant (Tipping et al. 2014). Impact of the insect on the plant can be quantified based on changes in plant parameters such as production of biomass, production of flowers, and density (number of plants per unit area.

C.3 Chemical

Chemical herbicides are the principal means of control when an immediate solution to a WH problem is needed

15 Lantana camara

A. Description

Lantana camara is a species of flowering plant within the verbena family, native to the American tropics. It is a very adaptable species, which can inhabit a wide variety of ecosystems; once it has been introduced into a habitat it spreads rapidly; between 45ºN and 45ºS and more than 1,400 meters in altitude. It is tiny 5-lobed flowers in dense hemispherical clusters (to 2” diameter) bloom summer to fall. Flower colors include white, yellow, orange, red and purple, often mixed in the same cluster. Ovate, toothed, dark green leaves (to 4” long) are rough-wrinkled above. Leaves are aromatic when bruised.

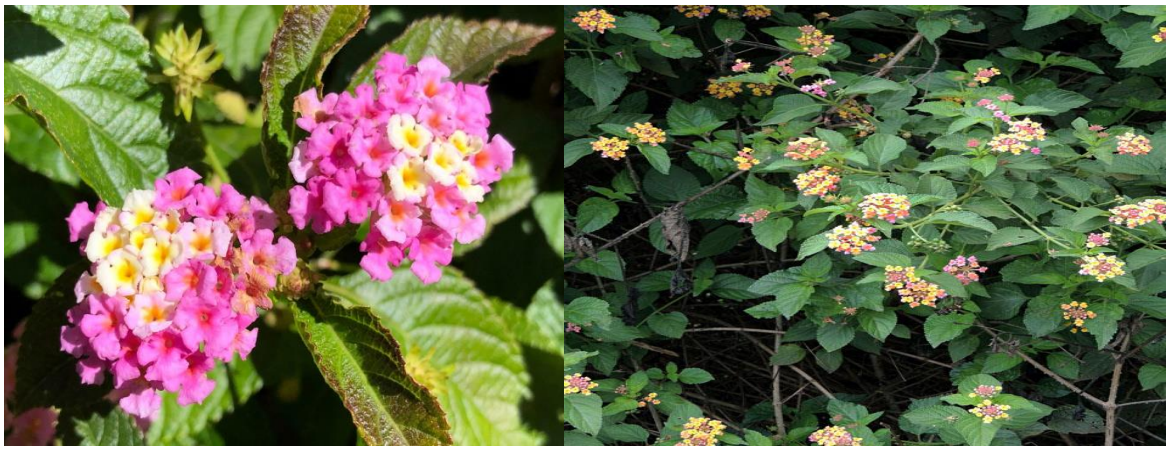

Figure 4 Lantana camara at its flowering stage

Lantana camara occurs along roadsides, in degraded lands, in riparian zones (banks of watercourses), along fence lines and in pastures and parklands, in plantations, forest edges and gaps and is now seen invading native vegetation in woodlands and savannas (notably in protected areas).

Lantana does best in full sun and hot temperatures in well-drained soil. It is easy to grow and is heat, drought and sun tolerant. Too much water and fertilizer will reduce bloom. In containers, fertilize once a month during the growing season.

Ecologically, Lantana camara (Lantana) is an invasive species of South American origin, and it is visibly widespread in Amurum Forest Reserve (AFR) Jos-Plateau, central Nigeria. Presently, there is no baseline study on Lantana and its spread despite its conspicuous presence within AFR.

According to a published medical review on medicinal properties of lantana, its leaves are used for treating malaria, chickenpox, asthma, ulcer, swelling, eczema, tumor, high blood pressure, bilious fever, sores, measles, fevers, colds and high blood pressure. Lantana camara L. is an invasive alien shrub of worldwide significance due to its impacts on biodiversity. It can alter the soil properties of invaded ecosystems and, as a result, affect management outcomes.

Locations within which Lantana camara is naturalized include Africa, Australia, India, south-eastern Asia and many oceanic islands with warm climates.

The distribution of Lantana camara in Ethiopia is great and many ecosystems are affected by this species are cultivated and non-cultivated land, road side, grazing area, rural villages, river side, wetlands, forest and urban areas .

B. Management

Established pastures can be burnt to control significant lantana regrowth, and any small patches can be spot sprayed with a registered herbicide or grubbed out.

In forested areas herbicides are recommended to control regrowth, typically requiring three follow-up sprays after the initial control effort.

For single-stemmed lantana, basal bark spraying and cut-stump methods also give good results at any time of year (but best when the plant is actively growing). On multi-stemmed varieties, obtain best results by carefully applying herbicide to each stem.

The root-feeding flea beetle, Long tarsus sp. (Coleoptera: Chrysomelidae: Alticinae), was studied as a potential biological control agent for Lantana camara L.

16 Prediction/Forecast of IAPS and outcomes

There is currently much worldwide interest in predicting distributions of invasive species, and many organizations will be faced with questions of whether and how to embark on such a task, or how to interpret predictions that others have provided. The geographic spread and proliferation of Invasive Alien Plants (IAPs) into new ecosystems requires accurate, constant, and frequent monitoring particularly under the changing climate to ensure the integrity and resilience of affected as well as vulnerable ecosystems.

The methods of risk mapping, climate matching, niche mapping and predicting potential distributions will all mean the same thing: a model or process that aims to produce a map of areas that are likely to be suitable for the species. The advantages of these maps are obvious: species can be screened for those likely to become invasive, monitoring programs can target areas most likely to be infested, and arrangements can be established for cost-sharing between jurisdictions over a large region and so on (Brunel et al., 2010; Cook et al., 2007; Richardson & Thuiller, 2007).

Modeling the geographic spread and proliferation of invasive alien plants (IAPs) using multi-source data and multiple predictive models is another way of prediction. Predicting which alien plant species will become invasive is important to mitigating their impact.

17 Management of IAPS

As IAPS have the potential to significantly impact national biodiversity, obstruct signage and line of sight at junctions, and damage road infrastructure, is outlining its requirements in this Standard for the management of the species most likely to be encountered on existing and proposed national roads.

17.1 Prevention:

Prevention of introductions is the first and most cost-effective option. Exclusion methods based on pathways rather than on individual species provide the most efficient way to concentrate efforts at sites where pests are most likely to enter national boundaries and to intercept several potential invaders linked to a single pathway.

Three major possibilities to prevent further invasions exist:

1) Interception based on regulations enforced with inspections and fees,
2) Treatment of material suspected to be contaminated with non-indigenous species, and
3) Prohibition of particular commodities in accordance with international regulations.

Deliberate introductions of non-indigenous species should all be subject to an import risk assessment. The strategies to prevent the further spread of invasive species are;

a. starting with strictly enforced quarantine procedures to avoid further introductions and take measures to prevent the spread,
b. The best methods of Prevention is clean your bags and boots after each climb, and
c. throw out food before you travel from place to place,
d. Don’t release aquarium fish and plants, live bait or other exotic animals into the wild.
e. Cleaning up ballast water is the most effective way to prevent new invasive species in the Lakes.

17.2 Early warning and rapid response (EDRR)

Early detection of a potential invasive species is often crucial in determining whether eradication of the species is feasible. The possibility of early eradication or at least of effectively containing a new colonizer makes investment in early detection worthwhile. Early detection in the form of surveys may focus on a species of concern or on a specific site.

Species-specific surveys are designed, adapted or developed for a specific situation, taking into consideration the ecology of the target species. Site-specific surveys are targeted to detect invaders in the vicinity of high-risk entry points or in high value biodiversity areas. Even the best prevention efforts cannot stop all invasive species. Early detection, rapid assessment and rapid response are a critical second defense against the establishment of invasive populations.

Early detection and rapid response (EDRR) increases the likelihood that localized invasive populations will be found, contained, and eradicated before they become widely established. EDRR can slow range expansion, and avoid the need for costly long-term control efforts. Effective EDRR depends upon the timely ability to answer critical questions such as:

- What is the species of concern, and has it been authoritatively identified?
- Where is it located and likely to spread?
- What harm may the species cause?
- What actions (if any) should be taken?
- Who has the needed authorities and resources?
- How will efforts be funded?

Successful Early Detection and Rapid Response Programs include

- potential threats are being identified in time to allow risk-mitigation measures to be taken;
- new invasive species are being detected in time to allow efficient and environmentally sound decisions to be made;
- responses to invasions are effective and environmentally sound and prevent the spread and permanent establishment of invasive species;
- adequate and timely information is being provided to decision-makers, the public, and to trading partners concerned about the status of invasive species within an area; and
- Lessons learned from past efforts are being used to guide current and future efforts.

17.3 Eradication and control

When prevention has failed, eradication is the preferred course of action. Eradication can be a successful and cost-effective solution in response to an early detection of a non-indigenous

species. However, a careful analysis of the costs and likelihood of success must be made, and adequate resources mobilized, before eradication is attempted.

Successful eradication scheme/program includes the following:

a. Mechanical control, e.g. hand-pulling of weeds or handpicking of snails,
b. Chemical control, e.g. using toxic baits against vertebrates,
c. Habitat management, (e.g. grazing and prescribed burning), and
d. Hunting of invasive vertebrates. However, most eradication programmes need to employ several different methods.

Each programme must evaluate its situation to find the best methods in that area under the given circumstances.

Management of the invasive species that are established on different areas suffers from a lack of resources relative to the size of the problem, and resources are often devoted to long-term control, whereas a large initial investment in eradication or biological control might produce a more cost-effective result in the long term. Given the excessive costs and failures of past control attempts and the limitations associated with individual techniques, the new approach to involve integrating all control methods together with grazing management systems to minimize impacts over the long term. Integrating all control methods involves;

- Chemical control,
- Biological control ,
- Mechanical control which is relatively inexpensive but gives varying results with different species, Fire which is inexpensive and can provide excellent control especially if used strategically after mechanical control and
- Grazing management such as quarantine, exclusion from seed pods or destocking, to promote regrowth of grasses for fuel and to compete with seedlings.

In Ethiopia several mechanical control methods have been investigated for management of IAS, including mechanical removal, felling and burning of uprooted trees of species, ranging from blade ploughing to grubbing and chaining, are aimed at removing as much of the root system as possible to prevent the tree reshooting.

Mechanical control has varying levels of effectiveness depending on the size and species of the plant, but will kill different IAS if the roots can be removed to a depth.

A biological control programme was initiated against IAS in different countries. To date the programme has focused on seed feeding insects which could theoretically regulate expansion of the weed while allowing it to persist and be exploited for its useful assets and services.

Herbicides are among the most effective and resource-efficient tools to treat invasive species. Most of the commonly known invasive plants can be treated using only two herbicides

- Glyphosate (the active ingredient in Roundup™ and Rodeo™) and
- Triclopyr (the active ingredient in Brush-BGone™ and Garlon™).

The last step in the sequence of management options is the control of an invasive species when eradication is not feasible. The aim of control is to reduce the density and abundance of an invasive organism to keep it below an acceptable threshold. There are numerous specific methods for controlling invasive species. Many of the control methods can be used in eradication programmes, too. Mechanical control is highly specific to the target, but always very labour-intensive. In countries where human labour is costly, the use of physical methods is limited mainly to volunteer groups. Chemical control is often very effective as a short-term solution.

The major drawbacks are;

- the high costs,
- the non-target effects, and
- The possibility of the pest species evolving resistance. In comparison with other methods,

Classical biological control;

- when it is successful,
- is highly cost-effective permanent,
- self-sustaining and
- Ecologically safe because of the high specificity of the agents used.

Biological control is particularly appropriate for use in nature reserves and other conservation areas because of its environmentally friendly nature and the increasing instances of prohibition of pesticide use in these areas.

Integrated pest management, combining several methods, will often provide the most effective and acceptable control.

18 Barriers for management of IAPS

There are many impediments to the adequate prevention and management of IAPs. In addition to the difficulty of sustaining active management interventions and monitoring their success, common obstructions to management may include;

- a lack of: motivation and awareness of the seriousness of the threat to an area;
- knowledge about what resources are available and how to implement prevention,
- early detection and management programmes;
- equipment, technology and other tools to map and control IAPs;
- available person-hours (allocation of staff and/or volunteers); and
- Sustained funding for continued monitoring and control are estimated to be barriers of IAS management.

The Environmental Policy of Ethiopia contains ten sectoral and ten cross-sectoral policy elements. The IAS issues have been explicitly articulated in the following policy sections: Forest, Woodland and Tree Resources; Genetic Species and Ecosystem Biodiversity; and Water Resources Conservation. The policy section on Environmental Impact Assessment (EIA), Environmental Education and Awareness, and Tenure and Access Rights to Land and Natural Resources have implication to the IAS prevention and management. However, IAS prevention, management and eradication are not clearly articulated in the environmental policy of Ethiopia, the IAS issue has largely remained to being narrowly perceived simply as another pest and/or weed problem.

The policy directives that state the need to enact legislation to protect, conserve and sustainably utilize the biological resources in Ethiopia, movement, exchange of genetic resources to be governed by the laws and regulations, to reduce the pressure on and avoid degradation of the biological resource have implication to the IAS prevention and management. However, this

policy has an implication to the need to prevent and control any impact of IAS on biodiversity as IAS is the major threat to conservation and sustainable utilization of biodiversity.

The prevention of threats as well as the conservation and development of forest resources have an implication to IAS control and management.

The control of IAS requires multi-sectoral approach, however, reports show that threats of invasive plants in Ethiopia have been less studied and some appear to be off the limit to control showing the insufficient institutional capacity and limited focus in the research, monitoring and control of IAS supported by appropriate policy.

Invasive alien species could prevent governments and industries from selling some types of food products, selling “living” commodities and using certain kinds of containers. These make them barriers to international trade and economic growth and become barriers to Sustainable development. In free trade areas, removal or liberalization of border controls may facilitate the movement of potentially invasive alien species between different countries and ecosystems.

In general, lack of public and media awareness capacity, resource and information constraints supported by fragmented legal and institutional frameworks lead to absence of strategic approach.

Inconsistent laws to address agricultural-environment, marine-public health concerns, poor coordination between agriculture, border protection, fisheries, environment, public health, tourism, and other agencies. These gaps and the low levels of stakeholder engagement, compliance, and enforcement become barriers to IAS control.

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