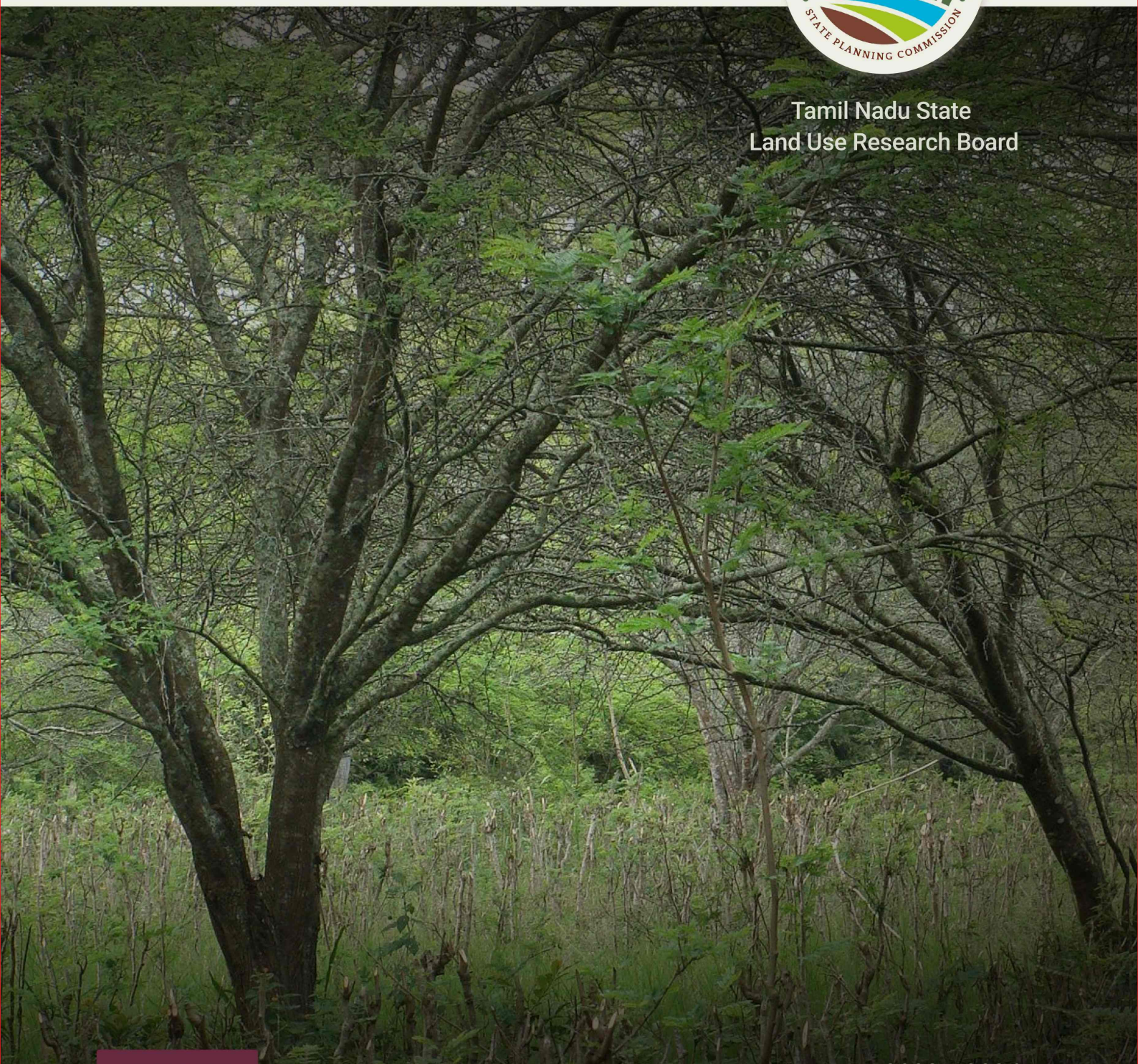
Government of Tamil Nadu
State Planning Commission

Tamil Nadu State
Land Use Research Board



REPORT

2023 - 2024

International Workshop on the Management of Forest Invasive Species in Tamil Nadu

International Workshop

on

Management of Forest Invasive Species in Tamil Nadu

Tamil Nadu State Land Use Research Board,
State Planning Commission

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Foreword

The role of forests in the environment, biodiversity, livelihood, tourism, health, and various other aspects is widely acknowledged and appreciated. Efforts are being made to protect and conserve forest resources.

Ecological disruptions resulting from biotic invasions are increasingly recognized as a significant threat to global sustainability. Invasive Alien Plant Species (IAPS) are a major driver of biodiversity loss, consequently altering ecosystem services and socio-economic conditions through various mechanisms. These non-native plants and animals, once established in local ecosystems, often outcompete and displace species that have evolved to inhabit those areas. These invasive plants have a detrimental impact on forest resources, degrading the soil, causing erosion, and resulting in a loss of native vegetation.

In this context, the compendium titled "Management of Forest Invasive Species in Tamil Nadu" was compiled based on the discussions during a workshop conducted by Tamil Nadu State Land Use Research Board (State Planning Commission) in February 2023. The workshop aimed to serve as a platform for knowledge sharing and capacity building to enhance invasive species management within the state. Emphasis is placed on the need for research studies to support the sustainable management of Forest Invasive Species. The potential for strengthening management lies in the integration of geospatial technologies for mapping and monitoring the spread of these invasive species.

The State Planning Commission has taken into consideration the existing modalities and monitoring protocols within the state concerning Forest Invasive Species. This document is expected to complement the Tamil Nadu Policy on Invasive Plants & Ecological Restoration (TNPIPER) and serve as a guiding manual, providing direction to departments on strengthening institutions and implementing appropriate interventions for invasive species management within the state.

Vice Chairman,
State Planning Commission

Executive Summary

Invasive alien species have gained global recognition for their profound impact on our economies, environment, ecosystems, human health, and biodiversity. These species pose a significant threat to the health of the forests in our country. To address this pressing issue, the State Planning Commission, in conjunction with the Tamil Nadu State Land Use Research Board and the Forest College & Research Institute, orchestrated the "International Workshop on Management of Forest Invasive Species" in February 2023 at Mettupalayam. This workshop brought together a diverse group of participants, including esteemed organizations such as the government departments, Wildlife Institute of India, IFGTB, KRFI, SACON, civil society organizations, industrialists, farmer communities, tribal communities, and students.

The purpose of this compendium is to heighten awareness about the imminent threats posed by invasive species to our ecosystems, biodiversity, economies, and the well-being of our communities. It serves as a comprehensive guide intended for policymakers, researchers, conservationists, and stakeholders alike. Its primary objectives are twofold: first, to elucidate the multifaceted challenges presented by invasive alien species, and second, to offer a framework for the development and implementation of effective strategies for their prevention, monitoring, and control.

This compendium delves into a wide range of themes that emerged during the workshop, encompassing critical areas such as Forest Invasive Species Spread & Threat Eradication, Management strategies, Experiential insights from the field, international perspectives, and best practices in the Management of Invasive Species. Furthermore, it highlights the imperative need for forest landscape restoration and its implications for wildlife and biodiversity. Additionally, it explores avenues for value addition and livelihood opportunities that can arise from responsible management practices. Legal and policy considerations form an integral part of this compendium, offering insights into the regulatory frameworks in place and suggestions for improvement.

Within these pages, the State Planning Commission provides a comprehensive overview of the current status and existing strategies within the State. It also presents a policy brief outlining the "Tamil Nadu Policy on Invasive Plants and Ecological Restoration." This policy aims to not only mitigate the threat of invasive alien plant species but also advocates for ecological restoration—a holistic approach to safeguarding our natural heritage. It emphasizes the importance of preventing, detecting, controlling, managing, and eradicating invasive species while simultaneously restoring ecological balance.

This compendium stands as a testament to our commitment to addressing the challenges posed by invasive alien species comprehensively and collaboratively. It is our hope that the insights and strategies presented herein will pave the way for a more resilient and sustainable future for our ecosystems, economies, and communities.

Contents

Status of Forest Invasive Species in Tamil Nadu & Suggestions to Improve the Management of Invasive Species

1. Introduction

India occupies approximately an area of 32,67,500 Sq. kms and ranks 7th among the largest countries in the world. This country is endowed with rich biological diversity and stands 6th amongst the 12 mega biodiversity nations of the world (MoEF, 2009). It is also one of the primary centers of origin of cultivated plants and domesticated animals.

Existence and establishment of endemic flora and fauna has been limited by geographical barriers (including; mountains, oceans, deserts, etc.) which tends to cause failure in disseminate their seeds, fruits, spores and other propagules. A major competition to the "Native flora" of any geographical region is imposed by the human made introduction of "Introduced species". Species, namely Acanthospermum hispidum, Ageratum conyzoide, Cassia tora, Cuscutare flexa, Datura metel, Parthenium hysterophorus, Lantana camara, Prosopis juliflora, etc. have established as introduced species in India (Reddy, 2008). In due course of time some of them have been tremendously successful in partial to complete elimination of the native species, thereby affecting the distribution and abundance of the native vegetation. This well-established non-native species are called Invasive Alien Species.

2. Invasive Alien Species & Forest Invasive Species

a. Invasive Alien Species

Alien species are non-native or exotic organisms that occur outside their natural adapted ranges and dispersal potential. Many alien species support our farming and forestry systems in a big way. However, some of the alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express the capability to establish, invade and outcompete native species. International Union for Conservation of Nature and Natural Resources (IUCN) defines Alien Invasive Species as an alien species which becomes established in natural or seminatural ecosystems or habitat, an agent of change, and threatens native biological diversity. These invasives are widely distributed in all kinds of ecosystems throughout the world, and include all categories of living organisms. Nevertheless, plants, mammals and insects comprise the most common types of invasive alien species in terrestrial environments. The threat to biodiversity due to

invasive alien species is considered second only to that of habitat destruction. Invasive species cause loss of biodiversity including species extinctions, and changes in hydrology and ecosystem function. Differences between native and exotic plant species in their requirements and modes of resource acquisition and consumption may cause a change in soil structure, its profile, decomposition, nutrient content of soil, moisture availability, etc. Invasive species are thus a serious hindrance to conservation and sustainable use of biodiversity, with significant undesirable impacts on the goods and services provided by ecosystems. Biological invasions now operate on a global scale and will undergo rapid increase in this century due to interaction with other changes such as increasing globalization of markets, rise in global trade, travel and tourism. For effective management of invasive species, knowledge about their ecology, morphology, phenology, reproductive biology, physiology and phytochemistry is essential.

b. Forest Invasive Species (FIS)

Over the past few decades, a significant number of Forest Invasive Species (FIS) have been introduced to India, either knowingly or unknowingly, without considering the consequences, which are further categorized as floral (weeds and plants with national and regional distribution), entomological (insects), and pathogenic (fungi). Around 111 FIS have been identified across these categories. Many invasive species have naturalized in India and are used for various purposes, including medicinal uses, religious sentiments, furniture, and composting. The FIS may also cause economic or environmental harm or adversely affect human health. In particular, they impact adversely upon biodiversity, including decline or elimination of native species - through competition, predation, or transmission of pathogens - and the disruption of local ecosystems and ecosystem functions.

Forest invasive species (FIS) not only reduce the productivity of forests but also cause significant losses to agricultural production and commercial activities, such as the cultivation of medicinal plants. FIS can block water bodies and water transport ways, affecting local communities and wildlife habitats in forests and wetlands. Effective management of FIS is necessary to prevent further damage to the environment and local economies. Weeds are also considered as Forest Invasive Species. In case of Tamil Nadu forests, few species of weeds are known to cause severe damage to the ecosystem as they reduce the native floral diversity in the parts of forests.

Weeds of an invasive nature that grow in forest vegetation form a significant category of FIS, including both indigenous and exotic taxa. India has a rich weed flora, and these plants create management problems that adversely affect productivity, incurring heavy costs in preventive and damage control measures. It can be challenging to distinguish between native and exotic species, as they often grow intermixed. However, exotic invasive species are usually confined to areas that are managed or influenced by humans and their dispersing agencies.

3. Distribution of Invasive Alien Species – Indian and Global Perspective

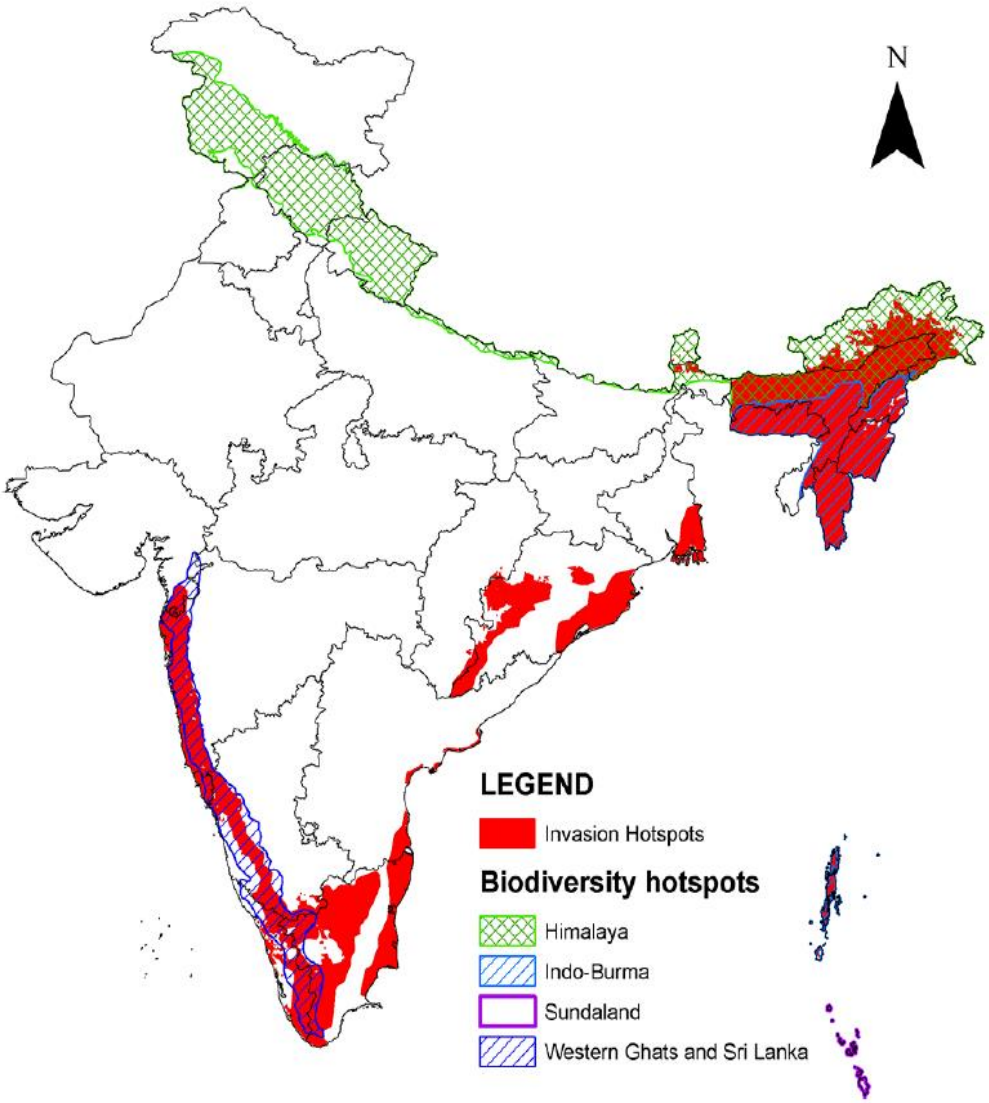
Globally, 6075 plant species are known to be invasive in different parts of the world (Wills 2017). Studies in India indicate that about 8.5% of the plant species in India are alien to the country (Khuroo*et al.* 2012), and includes, at present, at least 756 cultivated aliens, 1388 other alien species, and 25 cryptogenic species (Pant *et al.* 2021). The 1388 alien species include 220 invasive alien species, 237 naturalized species (Inderjit *et al.* 2018) and 931 casual alien species. A large number of alien species including invasive aliens, casual aliens, and naturalized species occur within the state of Tamil Nadu.

Recent entry of Invasive Alien Species in India:

In recent years, five new species of Invasive Alien Weeds namely *Ambrosia trifida* (Giant Ragweed), *Cenchrus tribuloides* (Spiny Burr Grass), *Cynoglossum officinale* (Houndstongue), Solanum carolinense (Horsenettle), *Viola arvensis* (European field Pansy) have entered in India, especially in Chhattisgarh, Odisha, West Bengal, Maharashtra, Kerala, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu and Madhya Pradesh. The seeds of these five FIS have been carried along with wheat imported in 2006-07 from Europe, Russia, Australia, Canada, Hungry, France, Argentina, Romania, Netherlands, Kazakhistan and Bulgaria and was distributed in above ten states through public distribution system (PDS). The surveillance of these weeds in the states is going on at large scale to check the expected losses as had been experienced earlier due to invasion of weeds like *Parthenium hysterophorus, Lantana camara, Eicchornia crassipes* etc.

Distribution of Invasive Alien Plant Species in Tamil Nadu:

As per a recent comprehensive review (Pant *et al.* 2021), 2503 vascular plant species have been reported as alien species of India. This include 756 cultivated aliens and 1747 other species of which 1388 were categorized as alien, 334 re-categorized as native, and 25 as cryptogenic (regions of origin unknown). Further, from the list of 1388 alien species identified, 220 were categorized as invasive alien plant species by consulting the GRIIS database, 237 as naturalized aliens (Inderjit *et al.* 2018) and the remaining 931 species were categorized as casual aliens (Khuroo*et al.* 2012). A recent compendium of plants of Tamil Nadu recorded a total of 6,723 taxa (species), of which 4,264 are native species found in the wild and the remainder 2,459 species are non-native alien species, comprising nearly 36.6% of the state's flora, a majority of which are cultivated and ornamental plants (Narasimhan and Irwin 2021). Tamil Nadu has always been a hot-bed of introduced species since colonial period.



Map: *Invasion hotspots in India delineated by Adhikari et al. (2015).*

Increased urbanization, presence of a considerable number of ornamental plant collectors and specialized plant nurseries catering to the needs of the public favor the presence of a high number of cultivated [alien] plants. However, they also go one to state (Narasimhan and Irwin 2021) that, to our knowledge the cultivated [alien] plant list of Tamil Nadu included in this compendium is not complete as the exotics continue to get imported into the state through flourishing horticultural trade. Besides known invasive alien species, many these alien species under cultivation or horticultural use are potential invasive species, as already witnessed by examples such as Opuntia spp., This indicates the extent and seriousness of the invasive alien plant species problem in the state of Tamil Nadu.

An analysis of invasive alien plant species in India through ecological niche modelling identified invasion hotspots in the country (Adhikari *et al.* 2015). As can be seen from the map above. The State of Tamil Nadu, including the Western Ghats are among the chief invasion hotspots in the country.

4. Area under invasive alien species in Tamil Nadu

The Policy published by Tamil Nadu Forest Department states that an accurate published estimates of area under invasive alien species across the entire state of Tamil Nadu are presently unavailable. The few estimates that are available cover only a small number of invasive alien species that are widespread or well-known enough to have attracted the attention of researchers and managers in the past. Available estimates tend to be approximate and confined to areas within Forest Divisions under the control of the TN Forest Department. The policy also says about the recent efforts to compile area under major invasive alien species in the Forest Divisions of Tamil Nadu:

I. Expert Committee constituted by Honorable High Court of Madras, Madurai Bench

The expert committee constituted under the Honorable High Court of Madras circulated a questionnaire to all Forest Divisions to report back their estimates at the Range level of the area under 17 listed Invasive Alien Species (and any others) in their Respective Divisions. According to this report, the area under 5 major invasive alien species were as follows: Lantana camara (185,000 ha), Prosopis juliflora (56,000 ha), Acacia mearnsii (wattle, 22,400 ha), Senna spectabilis (2,400 ha), and Opuntia sp. (2,300 ha), together affecting a total area of 268,100 ha.

II. Invasive Alien Species Policy drafting committee (present committee)

Estimated Area under some major invasive alien plant species in Tamil Nadu Species	TNFD estimate of HC committee (ha)	TNFD estimate of Policy Draft committee (ha)
Acacia wattles	22,400	16,110
Chromolaena odorata	11,532	46,057
Eucalyptus	6,780	2,029
Lantana camara	1,85,000	1,66,152
Opuntia sp.	2,300	-
Parthenium hysterophorus	12,150	47,583
Pinus sp.	2,700	-
Prosopis juliflora	56,000	19,937
Senna spectabilis	2,400	20,174
Total	3,01,262	3,18,041

(Source: TN PIPER)

An effort was made by the policy drafting committee to compile estimates of area under seven major invasive alien plant species of TN from various Forest Divisions of the state. As per this effort, compiled division-wise, there is about 3,18,000 ha. affected by seven invasive alien species. Although both datasets are compiled by the TN Forest Department from various divisions, the significant differences in estimates from these two sources as tabulated below suggest that these figures should be taken as broad approximations.

5. Diversity of Invasive Alien Species in Tamil Nadu

The State of Tamil Nadu has a significant number of alien, casual alien, naturalized, and invasive alien species. Almost all attention has been on invasive alien species that are non-native to India (National invasive alien, as defined here), with much less attention paid to State invasive aliens and Ecoregional invasive aliens. Based on the available information from various sources, the policy also provides a comprehensive list of species for the purposes of the documentation which will help to strategize the action plan and management.

1. Narasimhan *et al.* 2009 reported a large number of National invasive alien plant species within the state of Tamil Nadu. This study reported 1226 alien species in Tamil Nadu, including 756 cultivated species, 200 invasive alien species, and 56 cultivated species that also occur as escapes. Since their definitions do not strictly match with the definitions used here, the categorization of these species as naturalized and casual alien is not available.
2. According to the TN ENVIS center online portal, 1274 alien species occur in Tamil Nadu, of which 998 plants occur under cultivation, and 276 species are either potentially invasive or have turned invasive.
3. Sixty prominent invasive alien plant species in India, included several species known to be invasive in Tamil Nadu (Kohli *et al.* 2012). In Tamil Nadu, 47 invasive alien species from Western Ghats (Rao and Sagar 2012) and 7 major invasive from the southern Eastern Ghats were reported (Parthasarathy *et al.* 2012).
4. The ILORA database (Pant *et al.* 2021) lists 449 plant species whose occurrence within Tamil Nadu is known from existing literature and confirmed by occurrence records. Of these, 150 species were reclassified as native species. The remaining 299 alien species, included 133 invasive alien species, 93 Casual Alien species, 70 Naturalized species, and 3 Cryptogenic species.
5. Additionally some studies have also identified additional species as invasive aliens in Tamil Nadu

- ✓ Robusta coffee (*Coffea canephora*), a cultivated species, is known to be invasive, including into closed-canopy forests adjoining plantations (Joshi *et al.* 2009).
- ✓ *Montanoa hibiscifolia* is another recently confirmed invasive alien species found in the Nilgiris and the Anamalai (Udhayavani and Ramachandran 2017).
- ✓ The African umbrella tree (*Maesopsis Mini*, grown as shade in coffee plantations, is known to be invasive in forests adjoining plantations (Parthasarathy *et al.* 2012, Joshi *et al.* 2015).

6. Based on the list of invasive alien species and reference to other sources, including the IUCN 100 of the World's Worst Invasive Species, and their relative prevalence and intensity of known invasion in Tamil Nadu, the following 23 Priority Invasive Alien Plant Species are identified for the state:

1. Acacia wattles
2. Antigononleptopus
3. Calopogoniummucunoides
4. Cenchrus clandestinus
5. Cestrum nocturnum/aurantiacum
6. Chromolaena odorata
7. Cytisus scoparius
8. Eucalyptus sp. (Palani Hills)
9. Ipomoea carnea
10. Lantana camara
11. Leucaena leucocephala
12. Ludwigia peruviana
13. Maesopsis eminii
14. Mikania micrantha
15. Montanoa spp.
16. Mucuna bracteata
17. Opuntia spp.
18. Parthenium hysterophorus
19. Pontederia crassipes
20. Prosopis juliflora
21. Senna spectabilis
22. Sphagneticola trilobata
23. Ulex europaeus

6. Details on some of the common Forest Invasive Species in Tamil Nadu

Lantana camara is an invasive weed that has taken over large areas of community and reserve forestlands, especially in the fragile Western Ghats and Himalayan region. Its rapid spread has had a significant impact on agriculture and forestry, inhibiting the regeneration of important plant species and reducing crop and pasture yields. This weed also increases harvesting costs and requires heavy expenditure to manage and restore infested lands. Afforestation efforts are particularly affected, as Lantana competition can lead to loss of

stand and slower growth rates, requiring frequent weeding and further increasing costs.

Parthenium weed controlling is a challenging task as it produces a large number of seeds and can germinate easily in various environmental conditions. The weed poses a significant threat to agriculture because it competes with pastures, reduces their carrying capacity, and has an allopathic effect. Additionally, the weed has detrimental effects on human and animal health, causing respiratory problems, severe dermatitis, and tainted milk.

Eupatorium glandulosum is a weed found in both the southern and northern temperate regions, and its proliferation is often linked to ecological disturbances. This fast-spreading weed is particularly problematic in the Western Ghats, where it impedes the regeneration of other plant species and has replaced valuable flora in some areas. It typically grows in disturbed soil and thrives in goat-travelled paths, earning it the local moniker of "goat weed." Unfortunately, the plant has no known local or commercial use, which has allowed it to spread rapidly in denuded and forested lands.

Ulex europaeus is a serious fire hazard to private property in the Western Ghats and poses a significant threat to the region's watersheds, which provide a substantial amount of drinking water. This invasive weed also endangers agricultural and grazing lands. Thickets of Ulex europaeus are difficult to penetrate due to their persistent spiny litter, making them particularly troublesome. As a result, the weed requires careful management to prevent its spread and minimize its negative impact on the local ecosystem.

Acacia mearnsii was introduced in the Western Ghats, particularly in the Nilgiris, to provide fuelwood to rural communities and help save the shola forests, which had been degraded in the past by human activities. It was also planted in tea gardens to provide shade for the tea plants. However, the tree has now become a menace in the Nilgiri Hills as it has spread and covered much of the shola forests. The invasive nature of this species, combined with its profuse regeneration, has hindered the regeneration of the shola forests. As a result, careful management is required to prevent further spread and minimize the impact of Acacia mearnsii on the local ecosystem.

Cytisus scoparius, which was originally introduced from European countries for ornamental purposes in the Western Ghats, has now become a menace in the Nilgiri Hills, particularly in the shola forests and grazing lands. This invasive species reduces the regeneration of shola species and invades grasslands, leading to decreased production of grass for the cattle of Nilgiris. Cytisus scoparius spreads rapidly in areas affected by forest fires or other biotic interferences, exacerbating the problem. To prevent further spread and minimize its impact on the local ecosystem, careful management of this species is required.

Appendix II has posters with information about other common forest invasive species in Tamil Nadu.

Lantana camara

Parthenium

Eupatorium glandulosum

Ulex europaeus

Acacia mearnsii

Cytisus scoparius

7. Conditions that favor the spread of Invasive species

Understanding how invasive plants get propagated is critical for developing sound management plans. Anthropogenic disturbances have not only led to the global expansion of FIS, but also have drastically shaped the invasion mechanisms. The basic mechanisms behind the FIS success and impacts should be adequately understood for the ecological/ health risk assessment of FIS. The reason of success of the FIS in diverse environments, is complex, and needs to be investigated in the context of specific FIS. In this respect, a species-specific mechanism for elucidating the spread of alien plants is necessary as they show differential invasive potential in tune with their ecosystem attributes.

Also, studies on the role of plant-microbe/insect interactions (both mutualist and antagonist) are necessary for elucidating the mechanisms of FIS spread. Nutrient enrichment in both the terrestrial and aquatic ecosystems plays a vital role in the success of FIS in new habitats; for example, an increased level of nitrogen in soils is found to help *Bromus tectorum*, (annual cheat grass), to outcompete the native flora. Further, interesting research observed that the FIS impacted soil carbon pool/local climate mirrored differences in the traits of the FIS and the natives.

Domestic livestock can transport seeds long distances by ingesting and passing seeds in dung or by the attachment of seeds to skin and fur.

8. Ecological Impact of Invasive Alien Species in Natural Forest Ecosystems

A large number of exotics are naturalized, affecting the distribution of native ecosystem and a few among them have evidently altered the vegetation pattern of the country (Dogra *et al.*, 2009). In recent years, invasion by exotic species has come to be considered a leading cause of native species decline and habitat degradation. The invasion of natural communities, particularly conservation areas, by introduced plants constitutes one of the most serious threats to biodiversity and has been shown to profoundly alter ecosystem structure and function and aesthetic value of many habitats around the world. Invasive alien species create a host of harmful effects to native environments that include displacement of native species (Anderson, 2005; Cohen and Carlton, 1998), degradation or elimination of habitat (Council, 2005; Rogers and Biggs, 1999), alteration in soil properties (Nichols and Williams, 2006; Szaro *et al.*, 1998), degradation or elimination of wildlife forage (Williams, 2001), adversely alter fire regime (D'antonio and Vitousek, 1992; Metz *et al.*, 2011; Varner *et al.*, 2009) and pose a considerable threat to endangered species (Wilcove *et al.*, 1998).

Invasive species often cause the disease to wild and domesticated animals, and physical injuries. Degradation of wildlife forage creates a complex effect on carnivore's food chain (Chambers *et al.*, 2007).

Invasive plants disrupt the ecosystem processes such as nitrogen cycling, alteration in soil properties and below ground mutualisms between native species and mycorrhizae. The increase in nutrient levels in sites invaded by exotic plants was a consequence of litter accumulation (Ali and Al-Rawai, 2007). The suppression of grass and other native species would result in enormous economic and ecological impacts on Biodiversity. As a result of this, our country may lose such most important conservation areas with rare, diverse and endemic species and natural heritage.

Plant invasion, an important area of ecological research, has received a significant amount of attention from ecologists during the last few decades (Dogra *et al.*, 2009). A large number of exotics are naturalized, affecting the distribution of native ecosystem and a few among them have evidently altered the vegetation pattern of the country. There is an apparent need for a regional and national authentic database on invasive alien species for monitoring the spread and their impact in various regions and for devising applicable management strategies (Dogra *et al.*, 2009).

The invasive alien species cause a wide range of impact on different classes of diversity, richness, crop fields, loss of nutrient component and environmental services to larger extent. Some of the studies have also shown that due to growth and development of invasive

species can lead to genetic variation in regional populace through hybridization and also often obstructs in plant pollination interaction. The studies done globally on invasive plants has revealed that there is low richness and diversity of local plants in the invaded occupied sites but on other hand it is also increased the primary production in those localities reported that previously, the invasive alien plant species proliferate mainly along way side or open forest cover areas or boundaries in the Indian Himalayan region. In the last few decades, it has been seen due to fast urbanization through forest range so many of alien species have started occupying woodland and mountainous ecosystems.

Important Ecological Impacts

Impact/ effect	References
Replacing medicinal plants and fodder grass	Bughani and Rajwar (2005)
Constraint of seed growth and development	Bhardwaj et al.(2014)
Preferring other invasive species over endemicspecies	Dobhal et al. (2011)
Adapt of natural habitats	Dar and Reshi (2015)
Some of the studies showed the effects on natural environment, but others mainly concentrated on agricultural ecosystems	Batish et al. (2007, 2009); Katoch et al.(2012)
Dropping in nutrient level of the soil	Bhatt et al.(1994)
Depletion various ecological parameters of native species like frequency, density and abundance	Tripathi et al. (1981); Kandwal et al. (2009)

The Western Ghats known to be one of the biodiversity hotspots of Indian subcontinent, where invasive alien species are spreading at a faster rate and becoming one of the major threats for the native diversity and environment. The invasion of ruderal habitat by this alien species has made extended conscription pattern abetted by disturbed habitat, favorable physical factors like temperature, moisture, light and nutrient level, high populace size that can be observed even afterward of seedling mortality and allelopathic action of its aqueous foliage percolate.

Impacts of plant invasion on environment, ecosystem services and economy

Biotic invaders resulted in the homogenization of biota at a global scale and thereby affected the environment and ecosystem services indirectly. Socio-economic impacts of invasion are mainly visualized through human health assessment. The FIS, particularly 100 flora and fauna invaders as per, which affect the environment and economy of both terrestrial and aquatic ecosystems.

9. Environmental impacts of the Forest Invasive Species

Ecosystem functioning is perturbed due to FIS to a greater extent in the Islands than in the mainland. It has been demonstrated that FIS affect the ecosystem functioning through three basic mechanisms,

a. reduction in the diversity of native plants and animals,
b. remarkable changes in physico-chemical characteristics of soils (mostly through allelopathy), and
c. enhancement in ecosystems response towards altered fire regimes.

Intense competition between FIS and native flora for critical resources regulating ecosystem functioning may lead to the 'invasion melt down'. The invasion meltdown hypothesis states that the establishment of one invasive species in a new environment makes it easier for other non-native species to invade. It is also worth mentioning that the first impact of FIS, i.e., reduction in biodiversity is quite uniform across the globe. Alien invaders are also known to adversely affect the wildlife. For example, *Spartina alterniflora* replaces native macrophytes (*Phragmites australis* and *Scirpusma triqueter*) in wetlands of China, which eventually leads to the decline in avian fauna due to the movement and feeding restrictions.

Nutrient enrichment/eutrophication in the oligotrophic lakes leads to increase in the numerical strength of FIS. Similarly, FIS tend to spread at rapid rate, consequent upon the expansion of natural fire regime, which may also have adverse impacts on the ecosystem functioning. FIS have also been found to alter the fire regimes in several terrestrial ecosystems that result in a huge socio-economic loss. The invasive species can invade the aquatic systems through certain novel physiological characteristics (e.g. high biomass, deep roots and high evapo-transpiration) and can thus impede water flow, making it un-fit for drinking and irrigation. They also tend to increase the flood frequency by narrowing the stream channels and altering soil attributes (e.g. decreased water holding capacity and increased soil erosion), which eventually harms the riparian native plant communities, besides having the human health implications. Plant invaders like *Tamarisk*, lead to economic loss around US$52 million annually, *Castor canadensis* (beavers) also perturbs water quality and increases the flood risk.

Invasive species are also known to affect quantity of surface and ground water. *Prosopis pallida*, a N-fixing invasive species in arid regions of Hawaii Island exploits groundwater resources to a level that alters the soil's environment. Some FIS exploit an enormous amount of water, which can compound the impact of water scarcity and bring a paradigm shift in socio-ecological regimes.

FIS are also reported to alter the soil stability resulting in soil erosion. Invasions by noxious invasives, like spotted knapweed (*Centaurea stoebe*), leafy spurge (*Euphorbia esula*) and cheat grass (*Bromus tectorum*) may have profound impact on the soil quality of the grassland ecosystems. *Acacia dealbata*, an invasive of Mediterranean ecosystem, reduces the native plant diversity by adversely affecting the soil chemistry and microbial functioning. Enhanced soil N favored the *Flaveria bidentis*, over the competing non-native *Amaranthus retroflexus* and the native *Bidens* sp. *Flaveria bidentis* was assumed to modulate the elevated soil N for its growth while interacting with the other non-native/native plants.

Impacts of the Invasive Alien Species on ecosystem services

Many FIS are well known for their influence on ecosystem services *viz,* aesthetic, recreational, cultural and regulatory. Since invasives tend to impede the water navigation, they are known to impact adversely the recreation and tourism services. Restrictions on sale of ornamental invasive species to avoid their harmful effects on environment have also been reported. Many FIS are also known to impact the regulatory ecosystem services [such as hazards mitigation (e.g. landslide), water treatment, pest management, pollination, climate change, etc.)], which are inextricably linked with agriculture and forestry.

The invasion of *wattle and Prosopis juliflora has* adversely affected the environment and economy. It has also affected the livelihood of local people through reduction in fodder and livestock health. Since the cultural values are confined to a specific community, their economic quantification is difficult. The cultivation of multi-purpose trees and shrubs is encouraged widely in order to boost bioenergy and industrial sectors. Although, multi-purpose plants provide several benefits to humans, the introduction of FIS as a multipurpose species [e.g. introduction of *Prosopis* sp.] has profoundly affected the ecosystem services.

10. Economic impacts of the Invasive Alien Species in Indian and Global context

A recent study has shown that as many as 10 invasive alien species, out of the 330 that are known to be invasive in India, have cost the economy $127.3 billion in the last 60 years. The study points to glaring knowledge gaps in costs incurred by these species to the Indian economy. As many as 330 species are declared invasive out of more than 2000 alien species in India and the costs of $127.3 billion as documented in the study comes from only 10 of

these 330 species, making India the second topmost invasion-cost bearing country.

The study adds that the costs of FIS in India are severely underestimated by anywhere between 20 and 10,000 times less compared to what would be expected considering all other countries with invasion costs. Highly-fragmented data and wide knowledge gaps, which contribute to the underestimated costs, mainly arise because many invasive species, regions and affected sectors are underrepresented.

As for the sectors impacted by such invasive species, more than 99% of costs are attributed to multiple sectors without a proper break-up. Among the one per cent costs which specify afflicted sectors, most costs come from anthropocentric sectors such as fisheries, agriculture, health, social welfare, and administration. The costs related to forests and other non-anthropocentric ecosystems are almost absent. Because of these knowledge gaps it is unsure "who the worst offenders are in terms of their economic impacts and the geographic regions where they are causing maximum economic offense and the ecosystems that require urgent attention." While an economic lens is applied to measure climate impacts, the same treatment for taking stock of the impacts of invasive species is still underexplored. Additionally, the effects of climate change are more tangible than invasive species and both issues are often lumped together. However, researchers point out that synergies do exist between climate action and tackling the spread of invasives.

The climate change will worsen the spread of invasive species that tend to show a robust resilience to warming and spread across landscapes. The plants show robust resilience to climate change, provide valuable information on sensitive sites prone to future invasion. Such prior information helps develop prevention and control measures to contain the infestation.

Invasive species are emerging as a severe threat, especially to natural and agricultural landscapes. Their presence promotes wildfires in natural landscapes, hinders the regeneration and expansion of native species and their natural habitats; and reduces natural resources for the tribal people living in forest fringe areas and depending on numerous non-timber forest produce. Another threat is transportation, especially in tourist hotspots, which, along with wind, birds and wildfires, drive the dispersal of invasive species that mostly spread along roadsides, agriculture fields and across natural landscapes

Several invasive species, introduced for human welfare are known to create environmental and economic havoc. Therefore, people's perception about FIS as well as their local ecological knowledge can be an effective approach to categorize the FIS impacts. The invasion of aquatic macrophytes like *Eichhornia crassipes* (water hyacinth) has become havoc for human welfare as it reduces water quality, water capacity, water flow, fish production and also the eco-tourism potential.

In African context, an FIS of high risk i.e. *Opuntia stricta*, was evaluated to cause the economic loss of US$ 500–1000 per household per year through participatory rural appraisal (PRA) technique. Further, in the agriculture sector of African countries, alien invaders were evaluated to result in an economic annual loss of US$ 1 billion by causing damage to agriculture crops.

The socioeconomic and ecological damage to the natural environment caused by FIS have been conservatively estimated to exceed 1.4 trillion United States of American Dollar (USD) annually, or roughly five percent of the global economy. Economic impact from introduced species can thus carry a heavy price tag (Anderson, 2005).

Some of the common invasive species in the forest are known to have economic value for the products and derivate extracted from these species. State Planning Commission has analyzed this utilization part of the invasive species based on the discussions with experts from farming community, civil society, organizations, academia, and industrialists. Brief details on the utilization of the common invasive species found in Tamil Nadu is available in the Appendix I under section - Theme 5 which discusses on the Value addition and livelihood opportunities.

11. Need for Forest Invasive Alien Species Management & Strategy

Even though invasive alien species are a recognised threat to biodiversity – one that merits its own biodiversity target – the term 'invasive alien species' (or simply 'invasive species') remains foreign to many. 'Alien' refers to species that have been introduced to regions outside their native range. This is not unusual.

Many of the crops we grow, fruits we eat, fibers we use and animals we tend have their origins elsewhere. People have always moved species around, intentionally or inadvertently. A subset of introduced species however can sometimes become problematic, causing untold ecological and economic damage. These so-called 'invasive species' are a rapidly growing problem in a fast globalizing world where, with increasing trade and travel, the rates of species introduction to new environments is now historically unprecedented.

Invasive species threaten biodiversity and ecosystem processes, with direct and indirect impacts on human wellbeing. They suppress native biodiversity and cause local extinctions. They alter wildlife habitat.

They affect livelihoods directly by suppressing species that people depend on (e.g., non-timber forest products, 'NTFP') and by encroaching on private and commonly held agricultural and grazing land. They affect livelihoods and wellbeing indirectly by altering hydrology, damaging soils, affecting the provisioning of ecosystem services, and due to costs incurred in their control or management.

In the Western Ghats, for example, lantana (*Lantana camara*), a Central and South America shrub that was introduced to India in 1809 as a garden ornamental, has spread extensively. In Karnataka's Biligiri Rangaswamy Temple Tiger Reserve, Soliga farmers have suffered from reduced abundances of NTFPs, such as *amla*, which they harvested for supplementary income. Lantana also affects regeneration of other forest plants on which the wild herbivores are dependent upon. And boar raids of millet and maize crops have drastically increased associated with the spread of lantana.

In 2001, economists attempted to estimate the costs of damages caused by invasive species to agriculture and forestry. They put this figure at about $91 billion a year in India alone. This is an underestimate at best and does not account for the costs of invasive species management and control, let alone the costs of local species extinctions, alterations in ecological functioning and reduction in ecosystem services. Yet it is indicative of the magnitude of damage caused by invasive species.

12. Measures taken to manage invasive species

In the last decade, there have been efforts to compile lists of invasive plant species in India and to study the impacts of invasive species in different parts of the country. In 2009, the Indian Council for Forestry Research and Education set up a Forest Invasive Species Cell to develop capacities for invasive species management and to create a database on invasive species. This cell appears to have ceased to exist since. An integrated forest protection scheme was devised to include the management of invasive species. The last tiger census conducted by the National Tiger Conservation Authority included a survey of the distribution of a subset of invasive plants in tiger landscapes across the country. And the 12th five-year plan proposed a national invasive species monitoring system. These efforts, though welcome, remain isolated initiatives.

There exists a number of different legislations relating to invasive species. Some of these were enacted long before invasive species were a global concern but have since been amended to include invasive species. An indicative, though incomplete, list includes the Plant Quarantine (Regulation of Import into India) Order 2003; The Destructive Insects and Pests Act, 1914 (and amendments); Livestock Importation Act 1898 and the Livestock Importation (Amendment) Ordinance, 2001; Environment Protection Act 1986; and The Biological Diversity Act 2002.

So also, a number of different agencies charged with preventing the introduction of invasive species and for management and control of invasive species. These include the Ministry of Environment Forests and Climate Change, the National Bureau of Fish Genetic Resources, the Plant Quarantine Organisation of India and various departments of the Ministry of Agriculture. This situation "everybody's responsibility, therefore nobody's responsibility" is far from ideal. The country really needs a single, comprehensive legal and policy framework

on invasive species and a single nodal agency responsible for its coordination and implementation.

Mega diverse country like India needs a coordinated national effort to make an inventory and document invasive species not just a list of alien species, but also the pathways by which they were introduced, the ecological characteristics that make them invasive, and their ecological and economic impacts. This will enable us to better monitor and regulate the most likely routes by which species arrive, as well as enable a risk assessment of potential invasive species prior to introduction. Given the time lag between species introduction and invasion, a comprehensive documentation would also enable pre-emptive assessment of alien species yet to become invasive.

Such a national effort is too big task for any one agency to carry out, but it could be achieved as was done in Europe with the Delivering Alien Invasive Species Inventories for Europe: if government agencies, universities, and government and non-governmental research institutes join hands.

Despite the measures taken at the national level, the Government of Tamil Nadu has taken some efforts to act on invasive species and eco-restoration of the affected areas. Some of the recent efforts are – a pilot project was sanctioned by the Government for removal of 4 major invasive species such as Prosopis juliflora, Lantana camara, Senna Spectabilis and Wattle to an extent of 700 Ha. At a cost of Rs.535.21 Lakhs for the year 2022-23. Further, the invasive species are also being removed under various schemes such as NABARD, TN CAMPA, SADP, Project Tiger and Project Elephant etc. during 2022-23. Total Extent of invasives removed in Tamil Nadu as per the efforts taken, during 2022-2023(up to 28.02.2023), the invasive species were removed over a total extent of 2969.29 Ha. and further removal is in progress.

S.No.	Name of the species	Invasive cleared (in Ha.)
1.	Lantana Camara	1449.09
2.	Prosopis juliflora	803.20
3.	Senna Spectabilis	306.00
4.	Wattle	395.00
5.	Euphatorium	14.00
6.	Parthenium hysterophorus	2.00
	Total	2969.29

As another pioneering initiative as per the directions of Hon'ble High Court of Madras, Tami Nadu Forest department had issued orders for removal of Senna Spectabilis and to be handed over to Tamil Nadu Newsprint and Papers limited (TNPL) spread over the Nilgiris Biosphere Reserve area at a conservation charge of Rs.350/- per ton. Which is to be utilized for eco restoration of the habitats. Based on the above orders, 645 Ha. Of Senna Spectabilis from Sathya Mangalam Tiger reserve and 60 Ha. from Mudumalai Tiger Reserve have been allotted to the Tamil Nadu Newsprint and Papers limited (TNPL) for removal.

Tamil Nadu Policy on Invasive Plants and Ecological Restoration (TN PIPER)

Following the announcement made on the floor of legislative Assembly on 03.09.2021, "Tamil Nadu Policy on Invasive Plants and Ecological Restoration (TNPIPER)" has been framed which is one of the first policy on invasives in India. The Policy aims at identification, prevention of spread, developing appropriate control and eradication of all invasive alien plant species in terrestrial and wetland ecosystems of Tamil Nadu. The vision and the objectives of the TNPIPER are,

Vision

To prevent, detect early, control, manage, and eradicate invasive alien plant species along with ecological restoration of natural habitats, and enhancing knowledge base through research and monitoring in the lands of Tamil Nadu

Objectives

- ✓ To develop a comprehensive policy framework for invasive alien plant species control and management in terrestrial and freshwater ecosystems along with ecological restoration of habitats in Tamil Nadu
- ✓ To identify and list invasive alien plant species of Tamil Nadu, demarcate, and assess the area infested, and priorities problematic invasive alien plant species for appropriate removal or control measures
- ✓ To link invasive alien plant species management with appropriate methods and measures for ecological restoration of natural habitats to revive native ecosystems and species of Tamil Nadu
- ✓ To identify the best practices and Standard Operating Procedures for removal, disposal, and elimination of priority invasive alien plant species in Tamil Nadu
- ✓ To strengthen the management response and identify appropriate legal and institutional mechanisms

The policy uses the following eight principles to provide a framework to define, plan, execute, and measure all aspects of invasive alien species removal and ecological restoration efforts

1. Principle of avoidance/prevention

The introduction of any new alien species, not currently occurring within Tamil Nadu, must be prohibited, if it is a known invasive in other regions of India or in any other part of the world. No introduction of any other alien species should be permitted in the state unless: (a) there are strong economic reasons (e.g., new crop) or environmental reasons (e.g., biological control) for their introduction, and (b) no alternative species is available among the native species of Tamil Nadu that can perform the same or similar function, and (c) the species is conclusively found to be safe after thorough screening, risk assessment, quarantine, and multi-year trials with phyto-sanitary measures in representative ecosystems, conducted and published by an independent research body.

2) Principle of safety and precautionary approach

For casual and naturalised alien species for which present information suggest that they are not invasive or for which no information is presently available on their invasiveness, a bio-safety and precautionary approach will be adopted aiming to minimize their further spread along with monitoring to detect early signs of invasion if any.

3) Principle of removal with restoration (R&R)

Removal of invasive alien plant species and ecological restoration should go together. No removal should be carried out without a clear plan for ecological restoration to revive the corresponding local native ecosystems (whether grassland or forest or wetland). Such invasives removal and ecological restoration should be designed in a context-specific manner. For instance, it is important to assess in a site-specific manner the existing regeneration of native species, the correct target original native ecosystem, and carry out ecological restoration in a manner that tackles all alien species found on the site and not just one or two problem species.

4) Principle of minimal intervention

For ecological restoration to be effective, disturbances related to the intervention should be minimal such as to prevent further invasion or secondary invasion of disturbance adapted alien species. This 11 implies avoiding heavy machinery such as earth movers and bull-dozers, massive earthworks, check dams, and concretization. The principle aims to achieve as natural a state as possible with minimal disturbance or artificial structures, and better potential for recovery of native species.

5) Principle of prioritization of invasion front

Efforts to remove, control, or eradicate invasive alien species should as far as possible priorities areas at the invasion front (where invasion is just entering into a natural ecosystem). These areas are more feasible and important, as well as have higher potential for recovery of native vegetation from remnant native plants in the area.

6) Principle of continuous implementation, research and monitoring

Tackling invasive alien plant species requires sustained and long-term efforts that are both scientifically informed and implemented. Implementation should therefore also go hand-in-hand with continuous systematic research and monitoring. Results of such research and monitoring should be used in an adaptive management framework and be disseminated to create awareness and expand the knowledge base on invasive alien plant species.

7) Principle of promotion of native species

The protection and propagation of native plant species of Tamil Nadu shall be encouraged as far as possible in all areas including botanical gardens, agroforestry areas, forest nurseries, government and college campuses, and public lands. The Tamil Nadu Forest Department nurseries may be strictly restricted to growing native plant species only and completely avoid all alien species.

8) Principle of tolerance

While all invasive alien species should be tackled, this policy recognises that not all alien or exotic (non-native) species are necessarily harmful. Species that are known to be relatively benign and are naturalised and non-invasive in nature (e.g., gulmohar, Delonix regia, and tamarind Tamarindus indica), shall not be targeted for removal or control measures in cultural landscapes (urban areas, farms etc.), while they may be included in removal and restoration efforts within natural areas such as Wildlife Sanctuaries, Tiger Reserves, and National Parks.

Planning for Invasive Alien Species Management

The management of invasive species encompasses the prevention, mitigation, containment and restoration activities which needs meticulous planning of operational and administrative tasks. Better way of planning is to organize the tasks into an annual/ periodic work cycle which would serve as an easy record of reference for those responsible for implementation but may not be part of the planning process. The thumb rule shall be that invasive plant eradication activity at any infested site should be continuously monitored and invariably

succeeded by ecological restoration at the site without any delay or time-gap to derive the desired result. The systematic planning process herein is referred to as the Invasive Removal and Restoration Planning (IRRP). The IRRP will involve several stages:

A. Preparation of IRR Plan: Mapping of invasives, stratifying and selecting area, identification of benchmark sites or reference ecosystems to guide restoration, re-vegetation planning, local work study, demarcation of work area, preparation of plan of operation

B. Plan Approvals: Plan approvals to be sought and obtained as required for pro-rata, work area, benchmark sites, native plant nursery, and periodic plan of operations (PPO)

C. IRR Implementation: Implementation of invasives removal, survey of native vegetation in benchmark sites, native plant nursery establishment, ecological restoration after removal, setting up monitoring photo points, periodic plan and calendar of operations

D. Continuous Monitoring Plan: Continuous long-term monitoring using photo-points, quadrat sample plots, perambulation survey, and assessment by evaluation committee, record keeping and mid-course-correction.

Though Tamil Nadu has come up with a dedicated policy on invasive alien species and Eco-restoration, the policy has to be converted in to action points and implemented on war-footing basis. Having understood the gravity of the issue caused by the invasive species in the biodiversity rich forests of Tamil Nadu, the State Planning Commission decided to come up with immediate action points as recommendations to effectively manage the invasive plant species reported in Tamil Nadu.

13. International Workshop on Management of Forest Invasive Species

State Planning Commission in association with Tamil Nadu Forest College and Research Institute planned to organise a workshop by inviting organisations at international level, national and state level, subject matter experts, success stories of other state forest departments, research organisations, civil society, industries and other stakeholders.

Need for the International Workshop on Management of Forest Invasive Species

The International Workshop on Management of Forest Invasive Species in Tamil Nadu was conceived to be necessary for several reasons, including:

1. Forest Health: Invasive species can pose a significant threat to forest health and biodiversity, leading to negative impacts on ecosystem services and local livelihoods. This workshop can provide a platform for forest managers, researchers, and

policymakers to discuss effective strategies for managing invasive species in forest ecosystems.

2. International knowledge sharing: Invasive species are a global problem, and managing them requires international cooperation and collaboration. This workshop can bring together experts and stakeholders from different countries to share their experiences and knowledge on invasive species management.
3. Capacity Building: The workshop can provide an opportunity for capacity building, including training and sharing of best practices in invasive species management. This can help build the skills and knowledge of forest managers and other stakeholders to better manage invasive species in their respective regions.
4. Policy aspects: Effective management of invasive species requires the sound policies and regulations. This workshop was expected to facilitate discussions on policy development and implementation to improve invasive species management at the national and international levels.

Overall, the International Workshop on Management of Forest Invasive Species in Tamil Nadu aimed to provide a platform for knowledge sharing and capacity building to improve invasive species management in the state.

The Tamil Nadu State Land Use Research Board, State Planning Commission, Chennai, and the Forest College & Research Institute organized an "International Workshop on Management of Forest Invasive Species" on February 2nd and 3rd, 2023 in Mettupalayam. The workshop aimed to address the following objectives:

- To improve knowledge, initiatives, institutions, and structures required to address the impacts of forest invasive species in Tamil Nadu.
- To identify effective ways of removing invasive species and suitable methodologies to recover forest land, and to assess the extent of capacity development and technical assistance required to achieve this.
- To develop and implement integrated approaches for managing the impacts of forest invasive species in Tamil Nadu, engaging stakeholders and the community.
- To identify suitable methods for carrying out the massive exercise of removing and restoring forest land at the state level, including analysing the possibility of using MGNERGA workers, rural SHGs, Joint Forest Management committees, and other means.
- By addressing these objectives, the workshop aims to contribute to the effective management of forest invasive species in Tamil Nadu, promoting biodiversity conservation, ecosystem services, and sustainable livelihoods.

The following were the themes identified to be discussed during the workshop.

Theme 1	Overview of Forest Invasive Species – Spread & Threat
Theme 2	Eradication and Management strategies – Experience from the field
Theme 3	International perspectives and best practices in Management of Invasive Species
Theme 4	Need for forest landscape restoration – Wildlife issues and threats to biodiversity
Theme 5	Value addition and Livelihood opportunities
Theme 6	Policy and legal issues

Brief summary on the presentation made by the experts, field officers, research and various other organisations is enclosed in the Appendix I. Panel discussion on the final takeaways from the detailed discussions was also organised. With all the information that was gathered up during this workshop and after a detailed discussion with the subject matter experts, the State Planning Commission has come up with certain recommendations which are summed in the next section.

14. Recommendations

14.1. Dedicated Institutional mechanism

For an effective invasive species management, clear strategies need to be embedded with adequate legislation and policy. Participation of different actors from all possible sectors including researchers and public needs to be ensured. Further, an effective enforcement mechanism and regular monitoring is required for a long-term sustainable management.

Establishment of state level invasive cell with regular staff and experts for consultation is needed along with allocated budget to carry out the planned activities, to implement the strategies and to monitor the progress as per the management plans. The roles and responsibilities of the agency and staff need to be formulated with the help of international, national and regional experts. The nodal agency is necessary to ensure the following,

- To develop state level strategy and to guide the divisions to prepare local management plans
- Coordinating the efforts of all stakeholders involved in action to effectively manage the invasive alien species within and outside the forest areas in the state.
- To monitor and evaluate the coordinated actions

- To developing protocols and guidelines for invasive alien species of Tamil Nadu
- Shifting focus from alien to native species
- The agency should ensure Consumers' perspective should be included in the policy framework
- Formation of a state invasive species strategy and action plan
- To develop a coordinated and multisectoral network of different stakeholders to prevent future introductions and to develop a mechanism to impose trading ban (both international and domestic) for species that have already been introduced and/or escaped in the wild. Develop Standard operating procedure of the system built on the existing biosecurity infrastructure
- Strengthen response capacities through scientific research and knowledge sharing
- Ensure public compliance and effective implementation of the eradication programs.
- The agency needs to leverage its key resources toward developing an effective communication strategy, increasing public awareness, and ensuring their compliance with the legal framework.
- The agency should also promote citizen science initiatives, which can be a valuable tool for real time observations and data enrichment on invasive species

14.2. Periodical Assessments on invasive species

At present accurate state-wide estimates of area under invasive alien species and intensity of invasion is not present. There is a need for a state level assessment of the invasive species within the forest and at the forest fringe areas. On a priority basis, the department has to be carried out this assessment in partnership with reputed organisations. The possible approaches that can be used for this purpose are,

a. Remote-sensing based estimation along with ground truthing done by field level assessment

Analysis of satellite imagery and other remote sensing data can be used to estimate areas under invasion and priorities areas for restoration. Remote sensing has long been favored as a tool for invasive alien species mapping, specifically for plants, due to its ability to provide synoptic views over large geographical extents. This provides an advantage over field surveys, especially in the area which is difficult to access (Bolch, E.A. *et al.* (2020)).

State level zonation maps of invasive species spread has to be made using geo spatial technologies.

b. Biennial survey of invasive alien plant species

A biennial survey of invasive alien plant as envisaged by the TNPIPER policy will also be able to provide valuable evidence of distribution, prevalence and more accurate estimates of area under various invasive species in the State.

c. Use of Citizen Science

Citizen science has grown to be a very popular and effective way to involve large numbers of interested people in large-scale monitoring surveys and documentation. Portals such India Biodiversity Portal, iNaturalist, eBird, other digital apps, and many other citizen initiatives have been very effective in documenting biodiversity and monitoring distribution and changes in the abundance of species. The Tamil Nadu Forest Department along with the Keystone Foundation, Kotagiri, and ATREE, Bengaluru, have also developed and used a mobile app for monitoring invasive plant species in the Nilgiris as a citizen science effort. Citizen science should therefore be leveraged for Invasive Alien Plant Species monitoring in the state.

d. Field Research and monitoring studies

Systematic and rigorous field research on alien and invasive alien plant species should be fostered, **encouraged** and conducted by research institutions (government and NGOs), academic institutions or the research wing of the TN Forest department. Long-term research and ecological restoration studies should be, in particular, supported and encouraged.

In addition to the assessment of the affected areas, periodical surveys need to be carried out to identify the invasive species-free zones which are near to the highly infested areas, and measures need to be in place to maintain the pristine status by protecting the areas from livestock and vehicle movements from the nearby infested areas.

It is recommended to create an invasive database at the state level using the GIS platform. The database along with a dashboard can act as a tool which can be used to develop the management plan and annual plan of operations to effectively manage the invasive alien species in the forests of Tamil Nadu.

14.3. Development of strategy and Management plans

Developing a comprehensive understanding of the invasive species present in the forest division, their impacts, and the resources required for its effective management is highly essential to effectively plan operations for the eco-restoration. Adequate documentation is required at local level (at the level of forest division).

14.3.1 Strategy

- State level strategy has to be developed based on the policy and local management plans with time bound targets – short term and long-term goals has to be prepared at the earliest possible to streamline the action on invasive species in the forest areas.
- Developing a clear standard operating plan and a long-term plan for restoration and management of invasive species affected areas is critical to ensuring the success of eradication and restoration efforts and to protecting the health and biodiversity of forest ecosystems.
- Restoration of invasive species eradicated areas is an important aspect of invasive species management that requires a landscape-level approach and a focus on habitat improvement to restore ecosystem functioning and enhance the resilience of the ecosystem.
- Implementing long-term management strategies that are sustainable and cost-effective. This may include the use of natural or biological control methods. Appropriate measures to control and eradicate invasive alien plant species must always be supported by rigorous research and monitoring, along with proper ecological restoration of natural habitats.
- Collaboration among foresters, scientists, wildlife experts, NGOs, and other stakeholders is crucial for successful invasive species management. Each group brings a unique perspective and set of skills that can be used to develop effective management strategies.
- Sustainable management and maintenance with community involvement and engagement. By involving local communities in the management and maintenance of eradicated areas, there is a greater sense of ownership and responsibility, which can lead to greater success in maintaining the eradication efforts over the long term.
- The strategy developed should ensure that the actions prescribed in the management plan shall be in coherence with the existing plans like working plan, wildlife management plan, tiger conservation plan, wetland management plan or any other plans as mandated by the law.
- Protocols for forest surveillance for alien species on a periodic basis need to be developed.

The strategy for low infested area and high infested area has to be devised separately.

a. Low infestation areas

- Organize awareness campaign for the people living in and around the infested habitat
- Appropriate removal methods shall be carried out with the help of locals.
- Training to locals on the control methods, surveys and eco-restoration activities
- Local level monitoring committee needs to be set up to monitor the sensitive habitats
- Members in the committee need to be educated and frequently trained about removal methods and Eco restoration.
- Technical guidelines and practical manuals shall be prepared and circulated to the committee members in the local language
- Educate and explain to the locals about the importance of fencing/restricted access of people, livestock and vehicles in the non-infested areas.

b. High infestation areas

- A more coordinated and collective response is required in the highly infested areas. Community level action shall be encouraged.
- Control of high infestation requires high level of integrated management approach. The approach should also ensure the safe disposal of the collected/removed biomass. The methods used shall ensure environmental friendliness of the control methods (National Strategy on Prosopis juliflora management 2017).
- Value addition of the removed biomass, utilisation of the derived products, alternate livelihood for locals in these activities shall also be considered.
- Eco restoration should be given priority than removal of the invasive species because this helps to ensure regeneration of the local native species, avoids regrowth of the invasive species and supports local biodiversity.
- Local level monitoring committee shall be set up which is actively involved in all the planned activities.

14.3.2 Management Plan

- Creating a management plan that takes into account the specific needs of the ecosystem, including the identification of potential conflicts and opportunities for collaboration. The management plan has to be more of eco-restoration plan which includes removal of the invasive plants, activities for the regeneration of the native

plants, augmenting local water resources, soil conservation activities and other allied activities.

- Preventing the reproduction of invasive species is also an important component of invasive species management. This can be achieved through a range of measures, such as physical removal of individuals or populations, the use of barriers or exclusion methods, or the application of biocontrol agents.
- The management plan has to be developed at the division level based on the intensity, diversity and the distribution of the invasive species. Actions will be different based on the three parameters related to the invasive species – intensity, diversity and distribution.
- A priority removal of invasive species from the major livestock grazing and transport routes is needed. Entry of livestock to the highly infested areas needs to be avoided and an awareness campaign on the impacts of FIS as well as the role of livestock and vehicle movement on the spread of invasive species needs to be elaborated to the locals.
- The collective management/eradication process needs to be carried out only in the appropriate time/season. The time of collection needs to be announced well in advance to the locals by the appropriate authorities.
- Prevent the entry of public, livestock, vehicle by isolating the area with proper fencing and the information needs to be circulated among the residences and other stakeholders. Collection and transport of seeds from the infested areas need to be prevented. However, the collection of seed for alternate livelihood activities shall be permitted for which a protocol has to be developed.
- Application of proper integrated management strategies after due consultation with experts needs to be localised based on the prevailing conditions before it is implemented.
- A local community level (SBB, BMC, panchayat) monitoring is needed to update the current status of the reinvasion process. Continuous monitoring in the cleared areas needs to be ensured by the authorities/managers.
- Before implementing a management and control programme, it is better to work out the cost and benefit analysis and ensure about the realized and desired outcomes.
- Researchers highlighted that control methods need to be selected based on their control efficiency and the undesirable effects caused by the adopted methods (e.g. chemical control method). In most of the cases, integrated management method is the best option.
- Besides, once the invasive species are controlled/eradicated from the habitat, it is

essential to restore the infested habitats with native species (Genovesi and Shine, 2004; USDA.2004; Priyank et al 2013). It is the mandate of the state level Nodal agency to prioritize the targeted species and the habitat/ecosystem for the management at region and division levels.

14.4. Monitoring and Evaluation

- Developing and implementing effective monitoring and evaluation systems to measure the success of the management plan.
- Developing sustainable mechanisms for subsequent management and maintenance to prevent the problem from returning. This involves ongoing monitoring and surveillance to ensure that the eradication has been successful and to detect any potential re-infestations early on.

14.5. Capacity building

- Sharing knowledge and best practices to increase the effectiveness of invasive species management efforts.
- Capacity building and training can help stakeholders effectively manage invasive species, while exempting weeds from forest produce may be one potential approach to reducing invasive species invasion. However, it is important to take a comprehensive and ecosystem-based approach to invasive species management to ensure the protection and conservation of native ecosystems and biodiversity.
- International and National cooperation shall help in knowledge sharing and gaining expertise.
- Capacity building and refresher training of agencies involved in regulation and quarantine in state borders, airports, sea ports etc., to fortify and prevent any unauthorised or ignorant admission of any invasive species of flora and fauna and their propagules.

14.6. Financial mechanism

- The management of invasive species is considered to be expensive and involves high labour cost which have been an interruption in management of these invasive species. Eradication and biological control studies have shown that eradication methods for invasive species are effective only if they are completed at initial stage of propagation. Most of the studies have suggested integrated control measures to be successful but this requires huge capital.
- Convergence of schemes can help the state to optimise the financial need. In some

states, MGNREGA Scheme is utilised to remove invasive species. Invasive alien plant species management and ecological restoration activities can be included under Mahatma Gandhi National Rural Employment Guarantee Act and scheme (MGNREGA). This will boost availability of funds and manual labour available for the work, besides providing livelihood opportunities and helping in creating local assets such as native plant nurseries, watershed protection and revival.

- Simplified and streamlined mechanisms to accept funds from Corporate Social Responsibility need to be developed apart from other innovative funding mechanisms.
- The decision on the agency to bear the cost of implementation of the action plan and activities prescribed under the management plan, either solely by the government or by the industries, should be taken with high priority on case basis. While both these strategies have their own merits, the experiments from the TNPL using senna spectabilis species for paper production (described in section 12) can be converted as a business model and made replicable in other areas as well.

14.7. Research and Development

- The agency should also encourage research activities to identify native species with more consumer benefits, since unavailability of suitable alternative options mostly hinder the promotion of native species. For example, high annual water use by alien Eucalyptus species, which have been widely used for afforestation programs and community economic development in the arid and semi-arid regions in India, threaten dryland water and livelihood security. A recent study has found that native Azadirachta indica A. Juss., with similar benefits and acceptability in the community, can be used for replacement initiatives in these regions (Everard, 2020).
- Research activities should be promoted to conduct comparative assessments between native and alien species by considering both economic and ecological perspectives, build baseline data, and ensure effective and timely communication of the findings with the local communities and relevant stakeholders.
- The agency should also identify research gaps and encourage active participation of the scientific community in furthering the research activities and policy discussion. Notably, knowledge of pathways and vectors of IAPS spread should be considered in the NISSAP to prioritize species for management actions.
- Research on fast growing native species specific to that geographical region has to be initiated. Mass propagation of native species shall be encouraged. Avenue to develop tissue culture techniques for native bamboo and grass species can be initiated. Technical support from international or national research organisations shall be obtained. The nodal agency in association with the research wing of the forest

department can work to establish a "Centre of Excellence for Invasive Species Management". The Centre can take up all research activities on priority basis.

15. Limitations

Though there is a sufficient capacity and good awareness on subject of invasive species and its management, the state governments in India have not been able to show success in effectively managing the issue. There are multiple limitations and challenges that are prevailing presently which has to be addressed scientifically in parallel while taking up measures to fight against the invasives species.

- At the policy and legislative level, there seems to be a suite of enabling policies, even if there is no exclusive national legislation or policy addressing the problem of Invasive alien species. The legislation of the scheduled tribes and other traditional forest-dwellers (Recognition of Forest Rights Act 2006) also provides an enabling policy space for the participation of local communities in protection as well as management of protected areas, forests and biodiversity in general. The act strongly urges local communities to ensure the protection of ecologically sensitive areas, regulate the access to community NTFPs, and stop any activity which adversely affects wild animals, forests and biodiversity. Such provisions have to be used to the best for the management of infested areas in the forest in adherence to the Wildlife Protection act 1972, Management plan or Tiger Conservation plan.
- Early detection challenges - Studies clearly established that even the best prevention efforts cannot completely stop all invasive species. Obviously, early detection and rapid response play a crucial role and are one of the best cost-effective steps after prevention. Early detection minimizes the impacts of invasion and most of the time helps in complete eradication. However, early detection is quite challenging because the invasion in new areas happens over a period of time and detection of plant is possible only when they start to colonise the new area.
- Research on genetics of FIS - Examining the ecology and genetic make-up of the FIS is required for developing suitable management strategies. The utility of genomic approaches for determining invasion mechanisms through analysis of gene expression, gene interactions and genomic rearrangements that are associated with invasion events. But the genetic research has not been attempted at this level and it has not been integrated with the management plan.
- Need for legal instruments - In India, economic costs towards management of FIS are yet to be done in details. Three imperatives are evident at this juncture, namely: developing policies with sound biological rationales ensuring the effective biodiversity conservation affect; accelerating the implementation action on the ground urgently; and ensuring the legislative frameworks which are adequate to support the policies.
- Time intensive process - Current control methods are expensive, lengthy, and risky

because total eradication is required to prevent reestablishment. Effective site-eradication procedures require multi-year treatments, continued monitoring, and follow-up treatments. All infestations on adjacent lands should be treated to prevent reinvasion. Infestations along railway tracks and roads are rarely treated for eradication, thus those areas act as nodes of propagation.

- Need of a Platform for scientist and conservationist - Scientists and conservationists need to work together to address the scourge with vigor and urgency drawing on examples and best practices from around the world and adapting them to the Indian context. Researchers need to categorize alien species according to the level of threat and rate of spread in each of the bioclimatic zones (e.g. Robertson*et al.*41). After the classification, broad and replicable management strategies need to be developed based on a range of options related to (a) early detection, (b) control and removal, and (c) ecosystem management and monitoring of IAS.

16. Conclusion

Management of invasive alien plant species is a complex subject that needs a focused and dynamic approach based on studies and field experiences. The phenological and ecological character of the alien species in established or a new territory are subject to modification, both temporally and spatially and hence information updates from field managers and researchers, and synthesis of relevant literature are most essential for developing action plans. An understanding of changes in spatial and temporal distribution and abundance of invasive alien plant species is crucial. The State Planning Commission urges the department concerned to identify the baseline, carry out assessment using standard scientific methods using geospatial technology and to develop a strategy using the decision support system. The policy TNPIPER has tried to incorporate current scientific understanding, available literature, and field experiences, but as comprehensive scientific information and practical experience on all the above aspects are as yet limited, this forms a limitation.

However, the state government and the forest department deserve appreciation for pioneering in rolling out a policy exclusively for invasive species management in forest areas through the lens of ecological restoration. Effective implementation necessitates deep understanding of the invasive problem, collaboration with various stakeholders both governmental and non-governmental, frequent sharing of knowledge and experiences, and substantial investment of time and finance. This policy on invasive alien plant species of Tamil Nadu addresses only the terrestrial alien invasive species of flora alone, leaving aside the faunal part as well as the non-forested and marine invasive problem. Dedicated efforts to address these should also be taken up on priority basis in order to conserve the native natural biodiversity.

APPENDIX

Appendix I

Highlights of the Workshop

The International Workshop on Management of Forest Invasive Species was organised jointly by Tamil Nadu State Land Use Research Board, State Planning Commission and Forest College and Research Institute, Tamil Nadu Agricultural University during 2nd and 3rd February 2023 at Mettupalayam.

The workshop was attended by Dr.J.Jeyaranjan, Vice Chairman, SPC, Prof. R. Srinivasan, Full-time member, Prof. M.Vijayabaskar, Additional Full time Member, Dr. T.R.B. Rajaa, MLA & Member SPC, Prof Sultan Ahmed Ismail, Member, SPC, Mr. Subrat Mahapatra, IFS, HOFF, Tamil Nadu Forest Department, Tmt. Sudha, IFS, Member Secretary (FAC), SPC, Mr. I. Anwardeen, IFS APCCF, Dr.Geetalakshmi, VC TNAU, Dr. K.T. Parthiban, Dean FCRI, Dr. N. Krishnakumar IFS (Retd), Chairman Research KFRI, officials for Tamil Nadu Forest Department and State forest departments of Karnataka, Kerala, Maharashtra, Uttarakhand, other line departments, organisations like Wildlife Institute of India, IFGTB, KFRI, SACON, etc, civil society organisations, industrialists, farmer communities, tribal communities and students.

Theme 1

Overview of Forest Invasive Species – Spread & Threat

Presenter 1: Dr. C.R. Babu, Professor Emeritus, Centre for Environmental Management of Degraded Ecosystems, University of Delhi

Management of Invasive Species in any ecosystem should start with a thorough assessment of the extent of Invasive species. Inventorying the number of Invasive species threat to the ecosystem should be monitored on a continuous basis in order to have an early and effective management strategy in place. In Tamil Nadu, there are 50 Forest Invasive Species of which around 20 are listed as major threat to the ecosystem and the process of eradication has been initiated for the top six species.

He highlighted various methods of removal of Invasive Species and the pros and cons involved in each of the method and its implications.

- Biological Method - Using insects and pathogens was cost effective but the rate of replication was much slow to keep pace with the rate of spread of the Invasive Species.
- Chemical Method - Costly and species specific, but poses great danger and threat to the environment and ecosystem.
- Physical method - Manual method of removal of Invasive Species. Highly feasible and flexible method for removal of different invasive species.

After removal, it is mandatory to study the re-invasion or secondary invasion of the species in the eradicated areas. He emphasized the need for developing protocols for removal of Forest Invasive Species and separate monitoring methods for its management.

Presenter 2: Dr. K.V. Sankaran, Coordinating Lead Author, IPBES& Former Coordinator APFISN

Title: Invasive alien species - Impacts, costs and trends

The speaker shared the information on the impact of FIS in Asia and Africa and the need for in-depth studies and regular monitoring. The impact of FIS on terrestrial habitat and biodiversity loss on ecosystem scale to be studied to maintain the ecological cycle.

Impact of invasive alien species

Affects all ecosystems across the globe and occurs even in Antarctica (the grass *Poa annua*). Fewer impacts were recorded in very cold, very dry or flooded habitats and No invasions known so far in the cryosphere and deep sea. Impacts exasperated by changes in climate, land-use pattern and pollution.

Researchers have documented that over 70 per cent of the impacts are negative which far outweigh the positive impacts and around 17 % impacts were found to be neutral.

Further, information on impacts available for different FIS, countries, regions and ecosystems is grossly incomplete particularly from Asia and Africa. There exists a huge data gaps especially on the impacts of invasive microbes and fungi & invasion in marine habitats. It has been reported that about 10% of all alien species known are invasive.

Most impacts caused by invasive alien invertebrates and fishes. Native plant species are worst affected compared to other taxa. Most negative impacts on nature known from terrestrial habitats; invasive alien plants cause significant negative impacts in terrestrial habitats.

Negative impacts

1. Loss of biodiversity - Population decline and local extinction of native species, affects growth, species richness, evenness, composition and causes threat to rare and endangered species.
2. Affects ecosystems services provided by nature.
3. Invasives are also found to cause economic damage through yield loss, damages to infrastructure, disrupt navigation, management costs, non-market values etc
4. Invasives also have negative impact on human and animal health like allergy, zoonotic diseases etc., and are also found to spread human and animal diseases.
5. They are also found to affect the quality of life though reduction in human food supply, affecting the provision of materials, labor, etc.,
6. Alters ecosystem processes though:
    - Physical and chemical changes in the ecosystems
    - Affecting the hydrology, primary productivity and natural decomposition process.
    - Drastic changes in the nutrient cycling, fire regimes, water availability in the natural ecosystem.
    - Modifications in the soil structure and profile are also found in certain ecosystems.
    - Problems due to soil erosion in the invaded areas were also recorded.

FIS have monopolized the resources for native plants. Excessive growth of FIS blocks irrigation canals; prevents access to water and fodder for livestock and wild animals. They smother native plants, causes death of vegetation, and found to cause pollution, competition, predation, hybridization, parasitism, toxicity in the natural ecosystem.

Globally, both negative and positive impacts due to FIS are known more from the Asia-Pacific region. Species extinction hot spots due to FIS are also more in these regions.

Further, he highlighted that the cost involved in the annual maintenance and huge economic loss due to FIS. Management costs are highest for terrestrial ecosystems and in the absence of appropriate management measures of the invasives, the yield loss can be 100 per cent in agriculture and it has been estimated that about 71 per cent of natural grazing land will be lost in South Africa. The yield loss in annual crops have been estimated as 12 per cent in USA and around 30 per cent in India.

Invasion by alien species – current status and trends

Over 5000 FIS recorded across the globe (In spite of the data gaps especially from Asia and Africa). Over years, there is a huge rise in the number of FIS and the numbers would continue to rise significantly despite concerted attempts at its management. The invasions will increase significantly especially in tropical and subtropical forests – mainly due to land use changes. Apparently, these forests are also the least studied for invasion by alien species.

The most widespread invasive species are vascular plants; the number of invasive plants is also the highest compared to other invasive alien species. Majority of the FIS is recorded from terrestrial ecosystems compared to aquatic and marine systems. The most widespread Invasive Species across Asia are *Chromolaena odorata, Lantana camara, Eichhornia crassipes, Pistia stratiotes, Mikania micrantha, Parthenium hysterophorus, Mimosa diplotricha, Mimosa pigra, Prosopis juliflora, Salvinia molesta*and *Xanthium strumarium*

Impending threats to India

1. Miconia calvescens

Origin: Rain forests of Central and South America. One among 100 of the world's worst FIS documented so far. Shrub/small trees, leaves dark green above and bright purple below. Mostly sighted in pastures, forest borders, road sides, disturbed areas, riparian zones, scrub/shrub lands, and planted and natural forests.

Threat: Forms dense thickets causing species extinction. The shallow root system exacerbates soil erosion and landslides.

2. Piper aduncum

Origin: West Indies and Tropical America

Shrubs or small trees, to 7 m tall. Inflorescence a spike.

Invades agricultural areas, forest margins, roadsides and clearings.

Threat: Aggressive invader that can form dense thickets out-competing native species and decreasing native biodiversity.

Recognizing the serious concern about the impact of Invasive Species and the struggle involved in eradication of the same, it's time to initiate collaborative action along with foresters, Scientists, Wildlife experts and NGOs for Invasive Species Management and eradication.

Strengthening of Funding support – Inventorying, assessment, management, eradication and value addition necessitates huge investments and hence appropriate funding support is essential to strengthen the activities.

Theme 2

Eradication and Management strategies – Experience from the field

Presenter 1: Mr. D. Venkatesh, IFS – Director, Mudumalai Tiger Reserve

Title: Eradication & Management (Wattle & Senna)

Invasive Alien Species

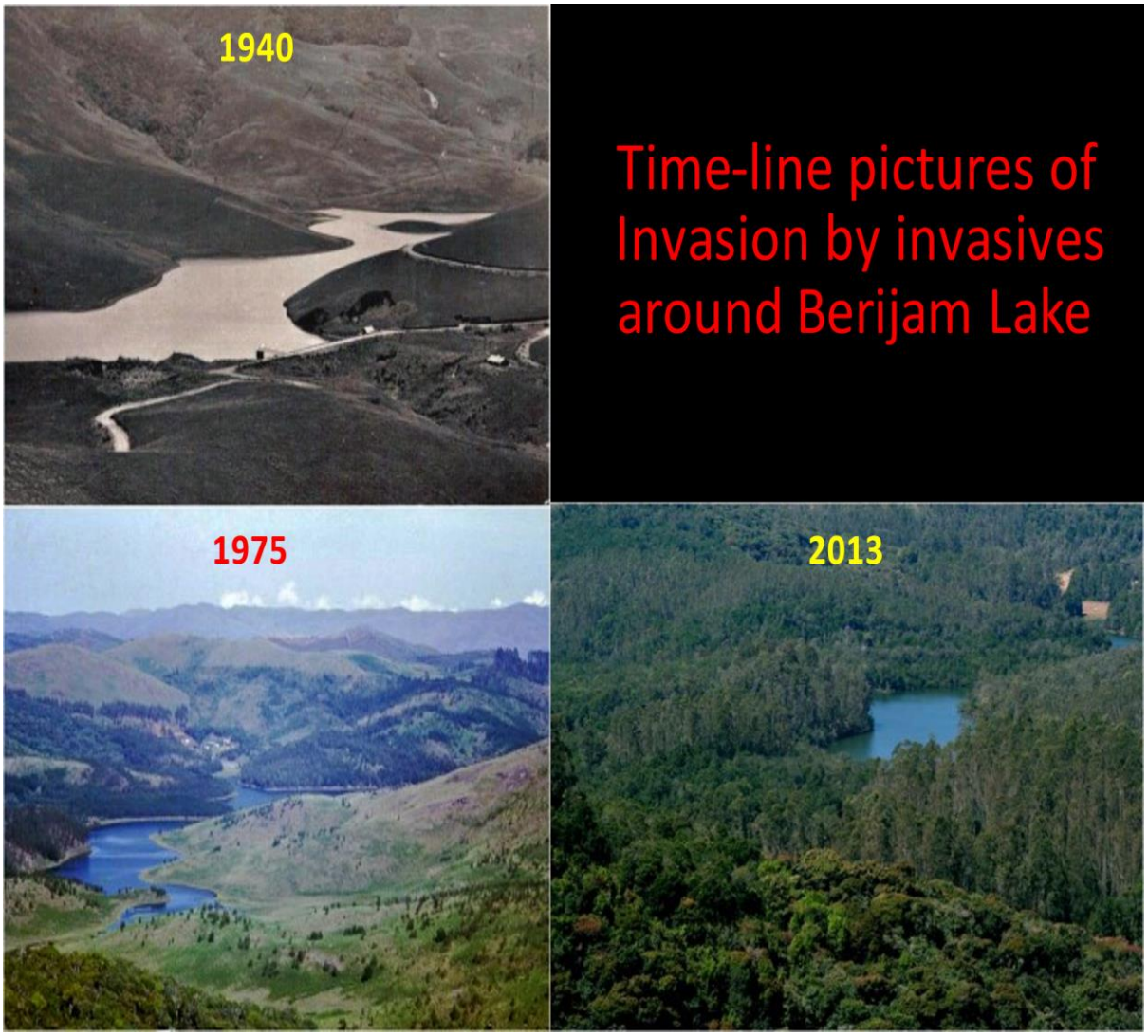
Internationally accepted definition by scientists: species that moved from one part of the world to another through human intervention are introduced and when they spread and cause economic or environmental damage they are termed INVASIVE or INVASIVE ALIEN SPECIES.

Acacia mearnsii was introduced in Kodaikanal hills during 1883. It was raised as hedge plant during the earlier time. The first large scale wattle plantation was taken up during 1945-46. Main objective of wattle introduction were:

1. To meet growing needs of Tannin Industries
2. To supply pulpwood to the Industries
3. To meet the local demand of fire wood by reducing the pressure on valuable forests

Conflict between Wattle and Flora

- The primary effect of plantation species, especially in the dense Wattle stands, is the complete extirpation of the grassland ecosystem and its destructive effects on the ecosystem.
- Following this, now Wattle has started spreading in Shola Pockets causing severe damage to the natural forest.
- Wattle introduction has resulted in an increase in soil acidity and tannin content in the water bodies. Further, the success story of eradication of Invasive Species and introduction of native shola species in Berijam Range to the tune of 100 ha was presented during the workshop. Special mention was made regarding the usage of eradicated wattle and senna by the TNPL.



Tannin in Wattle Bark

Removal of Wattle in Kodaikanal Division

- 100 ha. area cleared during 2014 in Madikettan Shola of Berijam Range under Tamil Nadu Biodiversity Conservation and Greening Project (TBGP).
- Removal of Wattle patches fringing the existing Shola forests has been taken up.

Regeneration in the cleared areas

Carexbaccans -a favoured grass of the Indian Bison

Daphniphyllum macropodum saplings in cleared area. The most common Shola species under Wattle

Management of Senna spectabilis

Coppice Growth from cut stump

Young shoots emerging from cut branches

Cut Stumps covered with poly bags

100 % Debarking of Stump

The speaker stressed the need for an exclusive legislation for Invasive Species management in wildlife protected areas and indicated that out of 500 and odd Protected Areas, in India, invasives have been studied in detail only in about 20 Protected Areas of the country.

Presenter 2: Mr. R. Kirubashankar, IFS – Deputy Director Sathyamangalam Tiger Reserve

Title: Management of Prosopis juliflora in Sathyamangalam Tiger Reserve

The major threatening Invasive Species in Sathyamangalam Tiger Reserve (STR) were Prosopis juliflora with an area under invasion of 8000 to 12000 ha and Lantana camara and Senna spectabilis with a total area of 730 ha. In STR, Prosopis removal works were taken up in an area of 950 ha. during the past 10 years.

The post removal operations include disposal of cut materials and restoration of the removed area.

Disposal of removed FIS in STR

Restoration of the eradicated areas in STR

Untreated area *Treated area*

The speaker made a detailed presentation on the experiences of removal of *Prosopis juliflora* in STR and post removal operations including disposal of cut materials, restoration of invasive species removed area, maintenance and steps initiated for its long-term monitoring.

Presenter 3: Smt. Deep J Contractor, IFS –Director Biligiri Rangan Tiger Reserve (BRT), Mysuru

Title: Invasive Species Management in Biligiri Rangan Tiger Reserve

The speaker made an elaborate presentation on the eradication of *Lantana camera* in Biligiri Rangan Tiger Reserve (BRT). *Lantana camara*, a thorny shrub, belonging to the family Verbenaceae.

Lantana camara a native of Central and South America. The high alkaloid content in the leaves make them unpalatable to herbivores. FIS normally outcompetes the native vegetation and prohibits regeneration.

Manual Eradication of Lantana camara at BRT using manpower available with MNREGS

Value added products of Lantana camara at BRT

It was indicated that almost 55-60 per cent of the vegetation has been replaced by Invasive Species like Lantana over last 30 years. Manpower available with the MNREGA scheme was effectively used for manual eradication with active participation from the local tribal people. Compensatory Afforestation Fund Management and Planning Authority (CAMPA) funds were also effectively used for the management of Invasive Species.

The CSR funds were sourced for value addition of the eradicated material into handicrafts and for exploring the opportunities for large-scale utilization of the material such as particle boards and similar other items.

Title: Eradication and Management Strategies: Experiments by Kerala Forest Department

The major Invasive Species of Kerala state are Senna, Wattle and Lantana. *Cassia* (Senna) *spectabilis* is a greater menace in the moist areas of the Lower Nilgiris. Lantana camera is spread in the entire forest areas of South Western Ghats. *Mimosadiplotricha*, *invisa*; Giant sensitive plant: Neotropical in distribution is very common in southern Western Ghats. *Pteridium aquilinum*, Eagle Fern is totally inedible and has reduced the habitat quality for gaur. The seeds of *Parthenium hysterophorus.* (American native) spreads up to 2 km through winds.

In Kerela, management activities of Invasive Species include clearing the vegetation and planting with native species in the eradicated areas. The department has initiated steps to retain seedlings of native species for gap planting in the future course.

Further, the success stories of eradication of invasive species in Tamil Nadu and Kerala was discussed during the presentation.

Experiments and initiatives by Kerala Forest Department

I. Thrissur- Wadakkancherry (Land resumed from HNL- Hindustan Newsprint Limited)
II. Punalur Division (Acacia extracted areas)
III. Marayood Sandal Division (Black wattle & Lantana infested areas)
IV. Periyar Tiger Reserve (Removal of woody invaders from grasslands)
V. Shola – Pazhathottam (Removal of Black Wattle from grasslands)
VI. Wayanad WLS (Senna eradication from the Sanctuary)

Case study - I

Eco restoration of the land resumed from HNL at Wadakkancherry

Extent of area was 172 ha.

- Broadly the area can be divided as:

  Type 1. 5 Ha of Mature Acacia plantation & 9 Ha Mature Eucalyptus

  Type 2. Area with native seedlings and trees of height up to 20 feet

  Type 3. Area with natural vegetation and scattered Acacia trees

  Type 4. Area with profuse regeneration of Acacia

Species Present in the area

1. Macaranga peltata	2. Alstoniascholaris
3. Trema orientalis	4. Holarhinaantidysentrica
5. Moringtatingtoria	6. Mallotusphilippenensis
7. Bombax ceiba	8. Butea monosperma
9. Bridelia retusa	10. Strychnosnux-vomica
11. Ficus hispida	12. Gliricidiasepium
13. Helecteresisora etc.	14. Xanthophylumrhetsa

Treatments done

Type 1. 5 Ha of Mature Acacia plantation 2016

The 2016 plantation of *Acacia auriculiformis*clear felled and auctioned. The slash were only heaped and not burnt. Area planted with fast growing species like *Macaranga peltata*, *Gmelina arborea*, *Artocarpus* etc.

Type 2. Area with native seedlings and trees of height up to 20 feet.

These patches were devoid of Acacia trees or seedlings. Native saplings were suppressed by weeds and climbers. Slash felling without removing natural regeneration done. Gaps planted with native species, any Acacia found girdled.

Type 3. Area with natural vegetation and scattered Acacia trees

Slash felled without removal of natural regeneration. Uprooting acacia seedlings done, Girdled isolated Acacia trees. Clear felled small patches of large Acacia trees. Gap planting using *Gmelina arborea*, *Macaranga peltata*etc.

Type 4. Area with profuse regeneration of Acacia

This area had good density of small sized seedlings of Acacia. Profuse Acacia regeneration as undergrowth. Those were cleared and replanted with native species

Monitoring and Evaluation- Indicators of Success

Elimination of Acacia and Eucalyptus was done in 500 ha site. Survival rate of the trees planted were monitored continuously. Increase in species diversity (Flora and Fauna) was observed. Regeneration of Native Species was also noticed in some areas. Biomass productivity was observed in the study area. Increase in Ground Water Level was noticed from the measurements made in the open wells. Reduction in Weed abundance could be seen. Employment opportunities and income to local communities though these activities. Availability of NTFP for the local communities was assured.

Case Study–II

Eco restoration initiatives in Acacia extracted areas in Punalur division

Removal of Acacia species: Activities done

1. Selective Removal of Exotic species

Removal through uprooting	Applicable up to 3 months of its germination (seedlings).
Clear knife weeding	Sapling stage
Cutting/ Girdling	Poles/Trees
Climber cutting	Removal of climbers that inhibit the growth of natural species

2. Prevention of fire

Avoid heaping and burning as pre planting operation.

Avoid fire tracing (Fire break can be adopted)

Treatments Done

1. Enrichment planting in open area with suitable fast growing native species
2. Soil working around the existing natural species (limited to seedlings only)
3. Staggered trenches (Contour trenches) 0.5 x 0.5 x 1 m
4. Brush wood check dams.

1.	Teak (Tectona grandis)	(2 m x 2 m)
2.	Anjili(Artocarpus hirsutus)	(3 m x 5 m)
3.	Malaveppu(Melia dubia)	(3 m x 3 m)
4.	Elavu(Bombax ceiba)	(3 m x 3 m)
5.	Matti (Ailanthus excelsa)	(3 m x 3 m)
6.	Ungu(Pongamiapinnatta)	(3 m x 3 m)
7.	Kumbil(Gmelina arborea)	(3 m x 3 m)
8.	Peelivaka(Albizia odorattissima)	(3 m x 3 m)

Case study – III

Eco-restoration initiatives in black wattle infested areas in Marayoor Sandal Division

Mechanized uprooting of Lantana. The wattle trees with girth size up to 15 cm uprooted. The branches of wattle were chopped by using shredding machine. The wattle trees with girth size up to 15 cm uprooted. The left over tree parts and humus with wattle seeds were removed for assisting the regeneration of grass species and shola species. Planting was also done by collecting seedlings of shola and grass land species from adjacent forest.

Case study – IV

Eco-restoration initiatives in woody vegetation infested grasslands in Periyar Tiger Reserve.

Treatment Methods

1. Removal of woody species

- Seedlings: No specific operation for seedlings.
- Establishment of seedlings will be controlled in fire tool management.
- Saplings: Cutting and removing.
- Sapling were cut and removed as close as to collar.
- Tree: Girdling for trees.
- Bark removed completely at a height 90cm to 1 m from base. The width of girdling is 30 cm.
- Power saw used for marking the edges of girdling to ensure the wound should touch the sap wood.

2. Fire Tool Management

- Controlled burning will be done in specific intervals.
- Frequency of Fire:
- First 5 years: Burning every year
- Second 5 years: Burning Alternate years
- Third 5 years: Burning once in a three years.
- Required Manpower
- A team of 10 people can burn a block in one day.

3. Weed Management:

- Uprooting of weed will be done every year before the monsoon.
- Funding source: CAMPA

Girdling of Trees

Case study – V

Eco-restoration Initiatives in Black Wattle infested areas of Shola NP

Treatment Plan

- Soil conservation
- Contours aligned with dead and deceased wooden materials after knife weeding
- Contour tracing
- Planting

Planting

- Digitariasanguinalis
- Paspalum dilatatum
- Cynodondactylon
- Chrysopogonnodulibarbis
- Spacing 0.6 x 0.6 m
- Locally available species

Case study – VI

Eco-restoration Initiatives in Senna infested areas of Wayanad Wildlife Sanctuary

Extent of *Senna spectabilis* invasion in Wayanad Wildlife Sanctuary

Extent of *Senna spectabilis* abundance/Km^2				
Scattered/ Isolated	Low	Medium	High	Total
90.46	7.15	7.64	18.61	123.86

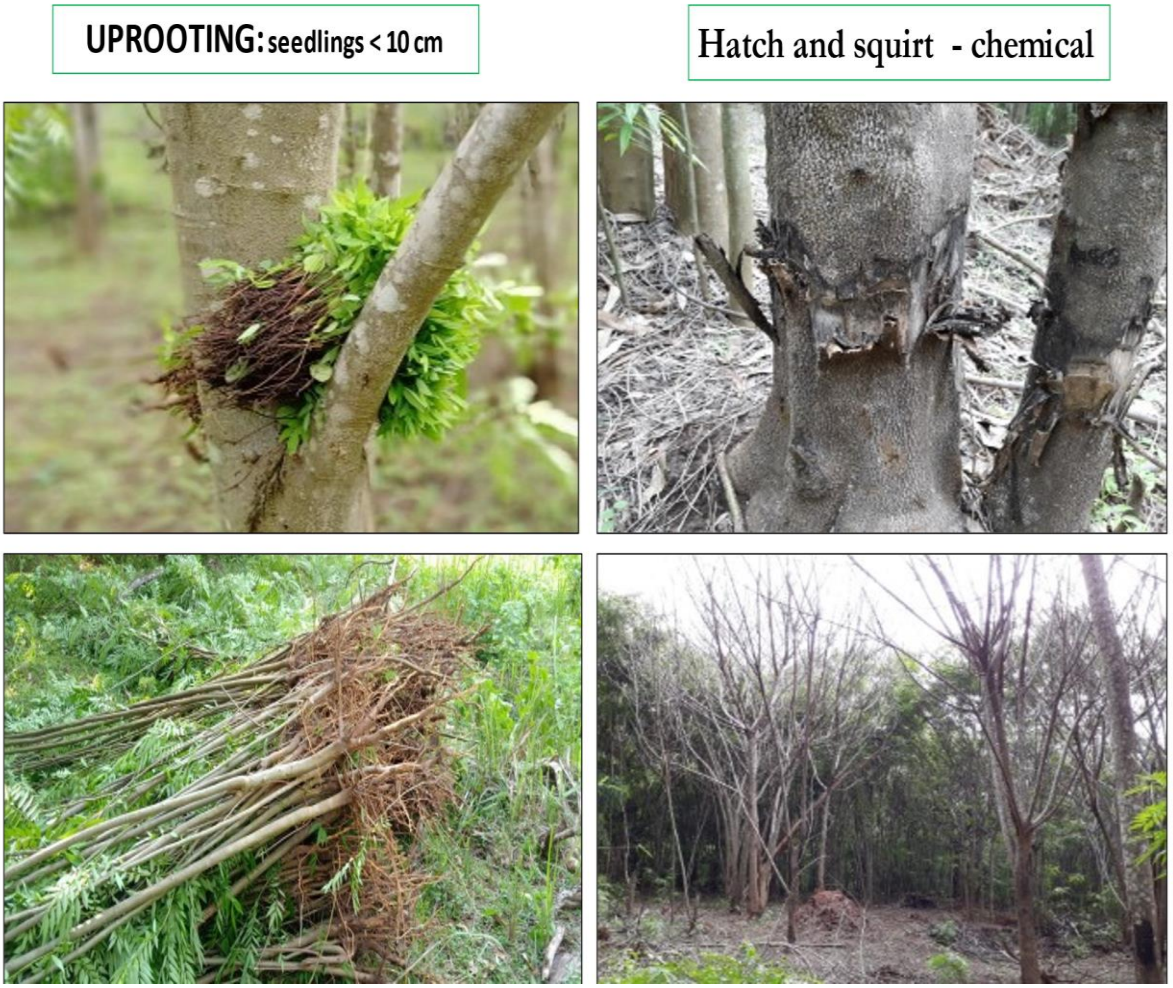
Kerala Forests and Wildlife Department & Ferns Nature Conservation Society - 2023

The results show that an area of 123.86 square kilometers (more than 35 % of the sanctuary) is occupied by *S. spectabilis* in 2022-2023. The degree of invasion is very high in Tholpetty and Muthanga ranges of the sanctuary.

KFRI studies- Experiment on control measures

- Cut-stump treatment : Removal by cutting at ground level in every 2 month interval
- Cut- stump treatment and herbicide application : Removal by cutting at 1 m and 0.5m above the ground level and applying Glyphosate (45%) at the cut surface (medium sized trees)
- Ring barking and herbicide application : Removal of bark 5cm wide around the trees at 1 ft above ground level and application of Glyphosate (Large trees)
- Removal by cutting at the collar region (Small trees)
- Removing/ pull out by excavator

- Debarking: From collar region upto1 meter trees
- Cut the tree and bark striping
- Hatch and squirt - chemical
- Cut from the base and cover with soil
- Hand pulling: Removal by manual uprooting small seedling



Eradication of invasive species were attempted in four southern states of India, the outcome of the deliberations insisted on sustainable mechanisms need to be developed for subsequent management and maintenance of the eradicated areas.

Theme 3

International perspectives and best practices in Management of Invasive Species

Presenter 1: Dr. Malavika Chaudhary – Asia coordinator - CABI

Title: Success Stories from CABI's Experience

The presenter emphasised that stakeholder engagement, best practice solutions, community approach and Knowledge management are the four key components in the Invasive Species eradication process and highlighted the action on Invasives – both flora and fauna need to be accelerated in India.

Invasive Species - Arrive in a new area: alien, non-native. Intentional introduction in agriculture, aquaculture etc., Unintentional introductions through contaminants/hitchhikers in commodities, etc. Natural spread – Fall Army Worm can fly 100s km/night with the wind. The risk of invasives is increasing due to Trade, Travel, Tourism, Climate change.

Speaker further emphasised the importance of developing capacities to respond to threat of invasives. Further, she presented the following Tools and Approaches adopted by CABI for successful management of Invasive Species,

- Horizon scanning – A systematic examination of information to identify potential pest threats and risks, allowing for better preparedness, and the incorporation of risk mitigation into the policy-making process.
- Pest risk analysis tool (online & offline) – Generates a list of potential pests for a commodity

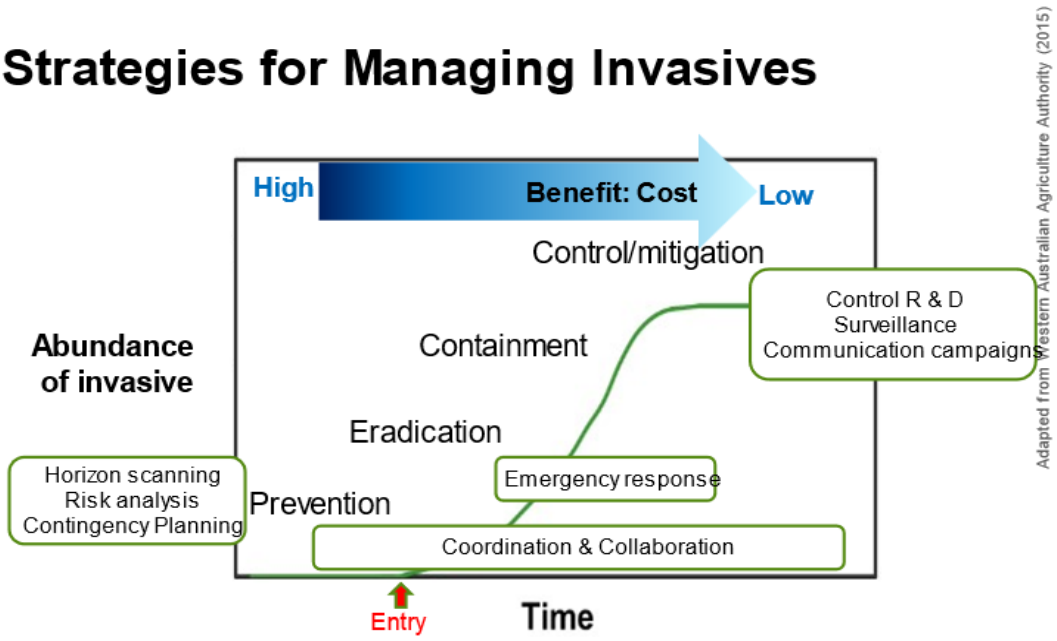
The speaker recommended Invasive Species eradication through contingency planning by emergency response, based on molecular identification, sharing of information and research by coordination, collaboration and communication campaigns.

Integrated landscape management would be adopted for management of the woody weeds. Early detection, risk analysis and rapid response to the invasives would yield desired results in the management and monitoring of invasive species.

Way Forward

- Horizon scanning, risk analysis, contingency plans for early deduction. Prevention is most cost-effective.

- Early detection and rapid response to invasions.
- Integrated Landscape Management
- Biological control - Local production of the bio control agents for augmentation.
- Promotion of Biopesticides among the farmers. Communicating to farmers regarding invasives and their management.
- Close alliance with private sector and agro dealers. Coordination and collaboration among different stakeholders.
- Learning from past experiences to be better able to respond to the next invasive species.



Presenter 2: Dr.T.V. Sanjeev, Member APFISN & Senior Principal Scientist, KFRI Title: About APFISN & Stories on FIS

The speaker mentioned the collaboration between the source and sync in the ecosystems which are the key to reduce the spread of invasive species. Additionally, collaboration with source countries can help to identify and monitor existing populations of invasive alien species, develop and deploy early warning systems, and assist in the development of control and eradication strategies of invasive species.

STEPS OF BIO-CONTROL

- Understanding species interactions
- Overseas exploration in countries of origin

- Biology/ host range studies
- Petition for agent release
- Rearing/ field release
- Establishment and impact assessment
- Redistribution and long-term assessment

Lantana camara L., is a pantropical weed affecting pastures and native forests in over 60 countries worldwide and the weed can suppress native forest regeneration, reduce native plant species richness, increase fire, and out-compete native vegetation via shading and allelopathy.

Miconia is originally from central America where it must compete with other fast-growing tree species and there are many insects' fungi and parasites that help to keep miconia FIS growth in check. But when miconia was brought to Hawaii, those organisms didn't come with it that allowed miconia trees to dominate and smother Hawaiian forests.

Researchers wanted to find a way to reduce miconia FIS dominance, so they went back to its home to find insects and parasites that evolved with it. They found a caterpillar and its adult butterfly that were not eating other types of plants. So they brought them to a secure laboratory, and were placed in cages with a range of plants they might come across in Hawaii.

Miconia calvescens

Euselasia t chrysippe

They were tested to ensure that they will not eat miconia and will not survive without it. The miconia caterpillar passed all these tests, so it's called host specific. The caterpillar doesn't kill miconia but reduces the plant's ability to dominate, which helps the watershed and native species

Forest as a sink of Invasion

Lantana, Lantana camara L., is a pantropical weed affecting pastures and native forests in over 60 countries worldwide

Lantana can suppress native forest regeneration, reduce native plant species richness, increase fire, and out-compete native vegetation via shading and allelopathy

Further, the speaker has recommended management strategies for Senna through uprooting (Small saplings), Weed puller (Larger saplings) and Girdling (Adult trees). The presenter insisted that the eradication of invasive species should not be taken up without a restoration plan. Exotic species should not be used for afforestation in any of the landscapes. He also highlighted that conservation measures on sky islands needs to be carried out effectively and efficiently to protect hilly terrain and hill tops.

Uprooting of small Saplings

Debarking the outer bark

Horizon scanning could be effectively used for invasive species management. Prevention of reproduction of invasive species could be an effective measure to prevent further spread.

Theme 4

Need for forest landscape restoration – Wildlife issues and threats to biodiversity

Presenter 1: Dr. Ramesh Krishnamoorty, Scientist F, Wildlife Institute of India

Title: Forest Landscape Restoration: opportunities and strategies from Central India

The presenter reiterated the restoration and management on larger land scape needs to be carried out based on state of degradation (1.Destroyed, 2.damaged, 3.degraded) of the forest ecosystem. He suggested larger landscape management through devising temporal plan and study of ecological impacts of the Invasive Species. The restoration components should include Protection, Disturbance removal & augmentation.

Conservation-Management Issues and Threats

S.no.	Ecosystem	Issues/Threats
1	Terrestrial Ecosystem	Small scale extractive disturbances (fuelwood collection, NTFPs collection) Livestock grazing Fire Invasive and exotic species Human-Wildlife Conflict Threats to breeding and nesting sites
2	Aquatic Ecosystem	Fishing Water scarcity Water demand and loss Exotic fish species Water quality Threat to spawning sites
3	Riparian Ecosystem	Small scale extractive disturbances (fuelwood collection, NTFPs collection, fishery etc.) Livestock grazing Invasive and exotic species Erosion, unstable banks Threats to breeding and nesting sites

Restoration/Conservation opportunities through Biodiversity Conservation, Community Engagement and Integrated Management were discussed. Removal of Invasive Species will lead to Restoration and in the process the need is to rely on strategies rather than philosophy.

A detailed presentation was made on the restoration experiences from the Central India landscape.

Presenter 2: Dr. K. Sankar, Former Director SACON

Title: Need for Landscape Restoration: Wildlife Issues and Threats to Biodiversity

A comprehensive presentation was made on the status of tiger population in India and the western ghats in particular. Corridor restoration is an important measure for reducing the human-wildlife conflicts.

The challenges in corridor restoration in a landscape including Invasive Species invasion, prey predator base, habitat suitability, forest protection etc. were also deliberated during the workshop. The removal of Invasive Species is an important measure for protecting the key stone species and restore the habitat suitable for wildlife Restoration of invasive species eradicated areas need to be addressed at landscape level with specific focus on Habitat Improvement.

Exhibition on value added products from Invasive Species

An exhibition was arranged to gain hands on experience on value addition aspects of invasive species removed from forest areas. Demonstrations on conversion of *Lantana camera* biomass into briquettes, *Prosopis juliflora* billets into activated charcoal through carbonization, usage of senna in pulping process and wood gasification technology were conducted. Various value-added products developed from *Lantana camera* by the forest dwellers and NGOs were also exhibited. Seeds of one hundred native trees were displayed for quick reference. Posters pertaining to invasive species in India were also displayed in the exhibition.

Theme 5

Value addition and Livelihood opportunities

Presenter 1: Dr.K.T.Parthiban, Professor (Forestry) & Dean, FC & RI, Mettupalayam

The presenter elaborated on the wood demand of the country and Tamil Nadu and highlighted the use of eradicated Invasive Species biomass for value addition (solid wood 70 lakhs to 90 lakhs of the biomass). Developing institutional mechanism for biomass utilization and marketing can facilitate effective use of the removed material.

The speaker enlisted the possible value addition opportunities available for Lantana, Senna, Prosopis, *A.mearnsii* through briquetting, pulping, dendroenergy, carbonisation, gasification etc.

1.1 Lantana camara

Area occupied by *Lantana camara* in Tamil Nadu: 1,84,802 ha

Briquettes made of Lantana camara has Calorific value of 3102.58K Cal /kg

1.2 Senna spectabilis

Area occupied by *Senna spectabilis* in Tamil Nadu: 2,395 ha

Basic Density	461 kg / m3
Specific gravity	**0.410**
Moisture content	**38.8%**
Holocellulose	**66.6%**
Veneer recovery	**91.5%**

1.3 Prosopis juliflora

Area occupied by *Prosopis juliflora* in Tamil Nadu: 56,388 Ha. It is a fast growing, salt and drought tolerant tree. It has been established as an invasive weed in Africa, Asia, Australia and elsewhere.

Prosopis - Chips and Briquettes

1.4 Acacia mearnsii

Area occupied by *Acacia mearnsii*in Tamil Nadu: 2,395 Ha

1. 1.*Acacia mearnsii*, invasive leguminous tree native to Australia
2. Distributed in the forests of sub-tropical and warm temperature regions in Tamil Nadu.

Utility- specialty timber, pulpwood, firewood and tannin extract.

Portion of Tree	% Tannins
Barks (dry)	38.6
Leaves only	4.9
Leafless twigs	3.6
Upper stem	0.4
Stem base	1.6
Roots	12.7
Pods	21.6

Presenter 2 – Mr. V. Renganathan, Director, Nippon Woodgas Private Ltd, Bangalore

Title: Carbon capture, Clean energy by removing Invasive Trees and Presiding employment

The speaker highlighted the use of Prosopis for energy generation with the associated benefits and industrial applications. He shared the experience of biochar application in soil health management.

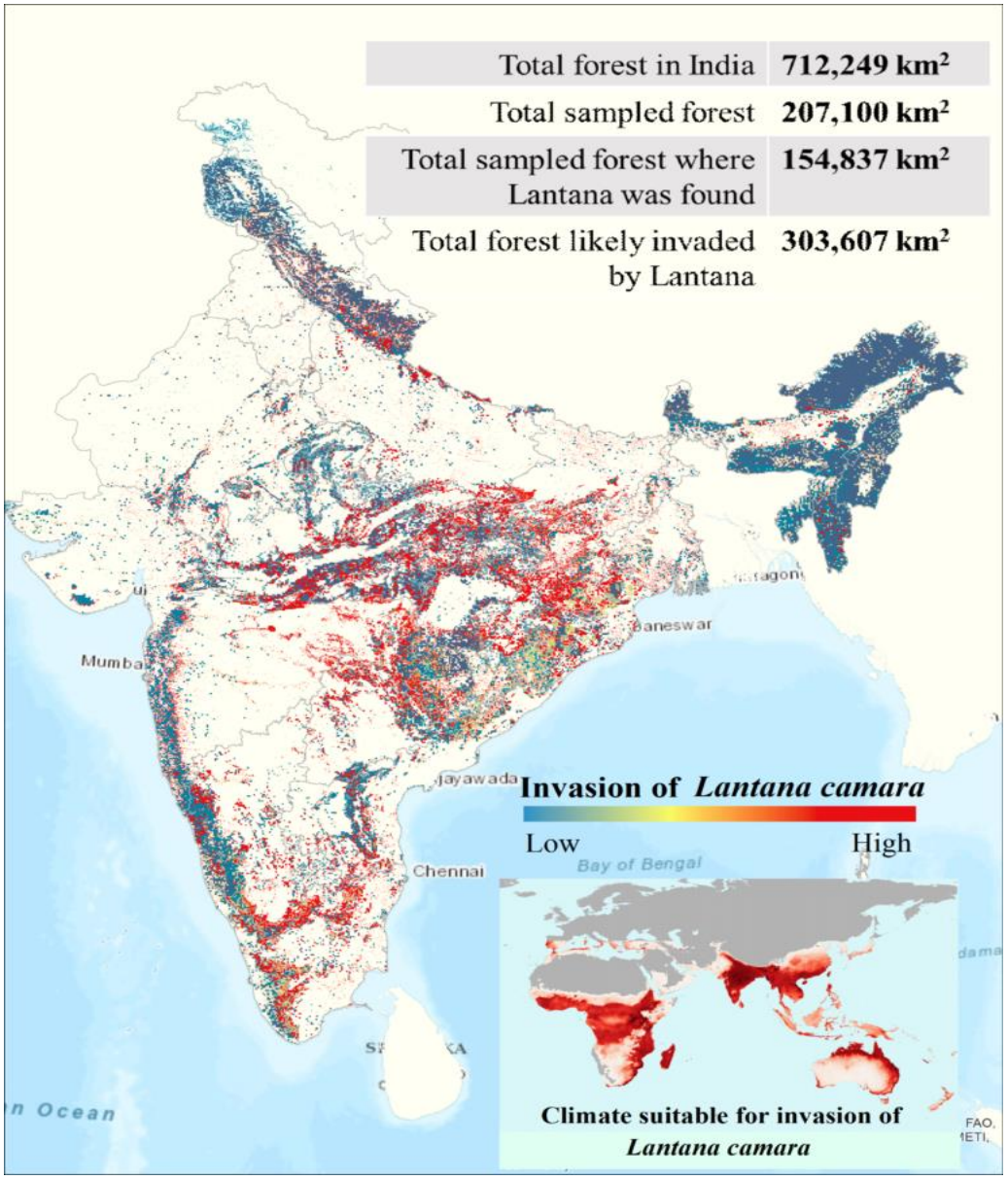
Presenter 3 – Mr. Subash Gowthaman, Trustee, Shola Trust, Nilgiris

Title: Cleaning invasive lantana from Forest – creating a circular economy from Lantana

The presenter insisted to go for uprooting of lantana to avoid further coppicing. Profuse seedling in Lantana **needs** to be minimized. A complete and comprehensive assessment of lantana in NBR should be taken up.

Lantana problem and removal challenges

- Toxic and inedible for all other animals, so significant biodiversity reduction occurs in forests (Sharma *et al.* 1981) and increasing human-wildlife conflict as animals are pushed outside forests.
- Allelopathic properties – puts out chemicals that inhibit the growth of other plants, so only lantana takes over entire forests (Achhireddy& Singh 1984)
- If cut, it coppices vigorously and grows back faster and stronger, so has to be removed with roots (Sharma *et al.* 2005).
- Soil disturbance has to be minimal, as a vibrate seed-bank remains viable under the soil and will germinate if disturbed. Also propagates well vegetatively from pieces of the plant left on ground (Parsons & Cuthbertson 2001, Swarbrick*et al.* 1998).
- Thorny plant making movement and removal is a major challenge, with huge removal cost of Rs. 1Cr/sqkm.



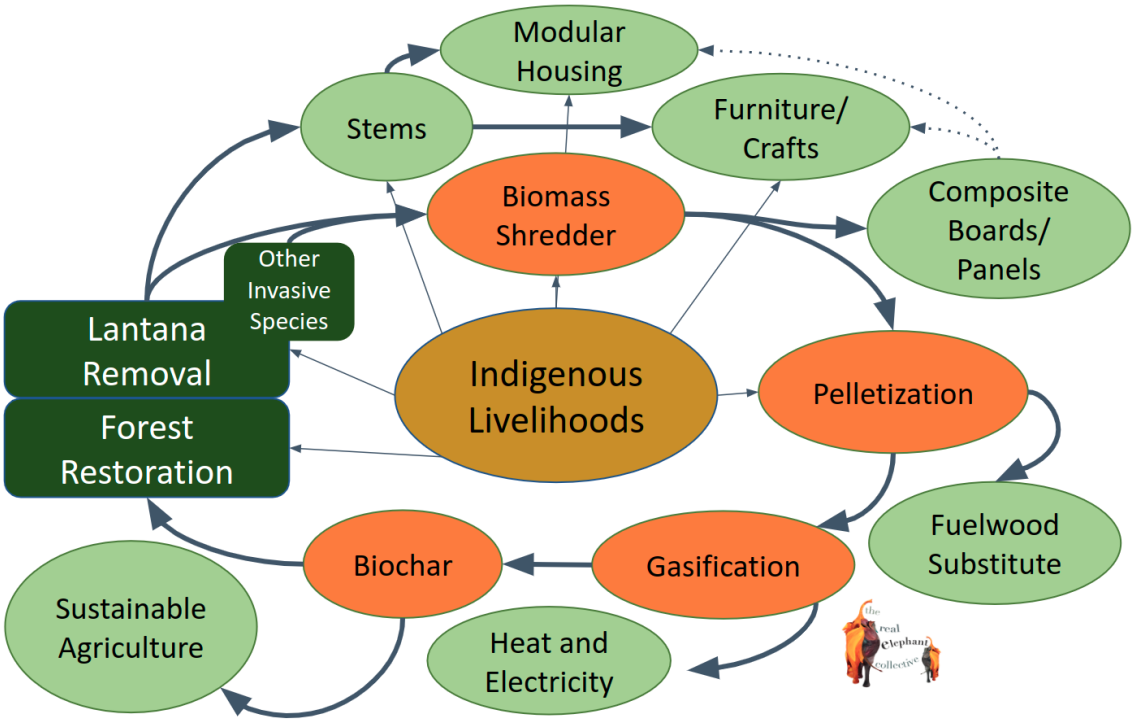
(Mungi et al. 2020)

At National scale, total Lantana infestation is over 3L sqkm, viz. more than 4 times the combined area of all Tiger Reserves in the country.

- Can cost up to 160,000 crores to remove all this and restore the landscape.
- Traditional Manual removal mechanism is not feasible and new methods have to be developed.

A novel concept of lantana circular economy by involving local institutions, monitoring and evaluation was introduced during the presentation.

A circular "Lantana Economy" is Revolving around Forest Restoration and Indigenous Livelihoods

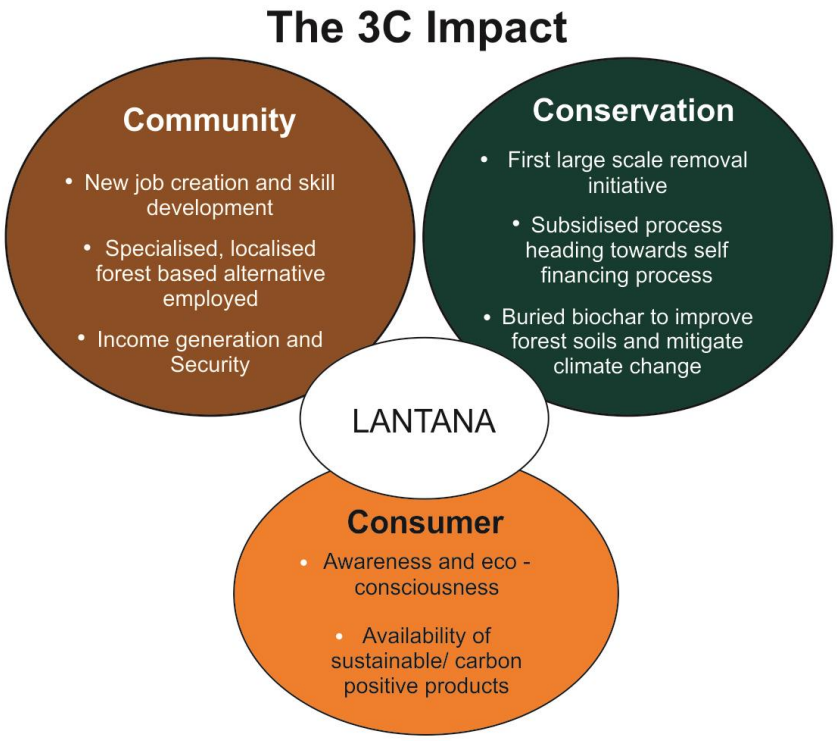


Detailed presentation was made on the value-added products from Lantana such as handicrafts and the income generation for local people and throw light on high value products of lantana like modular housing, lighting, composites, palletization and gasification etc.

Lantana Elephant Sculptures – high value art products – being made since 2016, traveling around the world in prolific public exhibitions

Modular housing used as COVID Isolation huts in remote tribal villages

He explained the mechanical ways adopted for removal of Lantana and opined that restoration of the invasive species eradicated locations was a big task and great challenges were involved in the process.



Presenter 4 – Mr. Annadurai, M/s. Santhosh Machineries, Attur

Title: Tree Biomass Processing

The speaker introduced the use of advanced machineries for eradication of Invasive Species and value addition of the removed materials like briquettes. Customized machineries could be designed suiting to the needs of different invasive species and their application in field level removal and management.

Presenter 5 – Mr. Thamotharan, DEO, VazhthuKattuvom Project, Erode

The presenter highlighted the concept of participatory growth plan by involving local people for removal and value addition of lantana. A comprehensive presentation was made on "Iyarkaiyin Sirpam" project that focused on providing skill development to local people for making value added products from lantana and the success of Community enterprise group in marketing of the products developed by tribal communities.

Iyarkaiyin Sirpam

Enriching the livelihood of tribes by encouraging entrepreneurship in Forest product value addition.

Iyarkayin Sirpam bridges a crucial gap by promoting their in-situ livelihood by enabling them to be entrepreneurs through value addition to forest produces. Value addition to "Lanatana Camara", an invasive species found prevalent in the forest by converting them to exquisite handicrafts and economically viable briquettes which are used as fuel in Boilers in Industries.

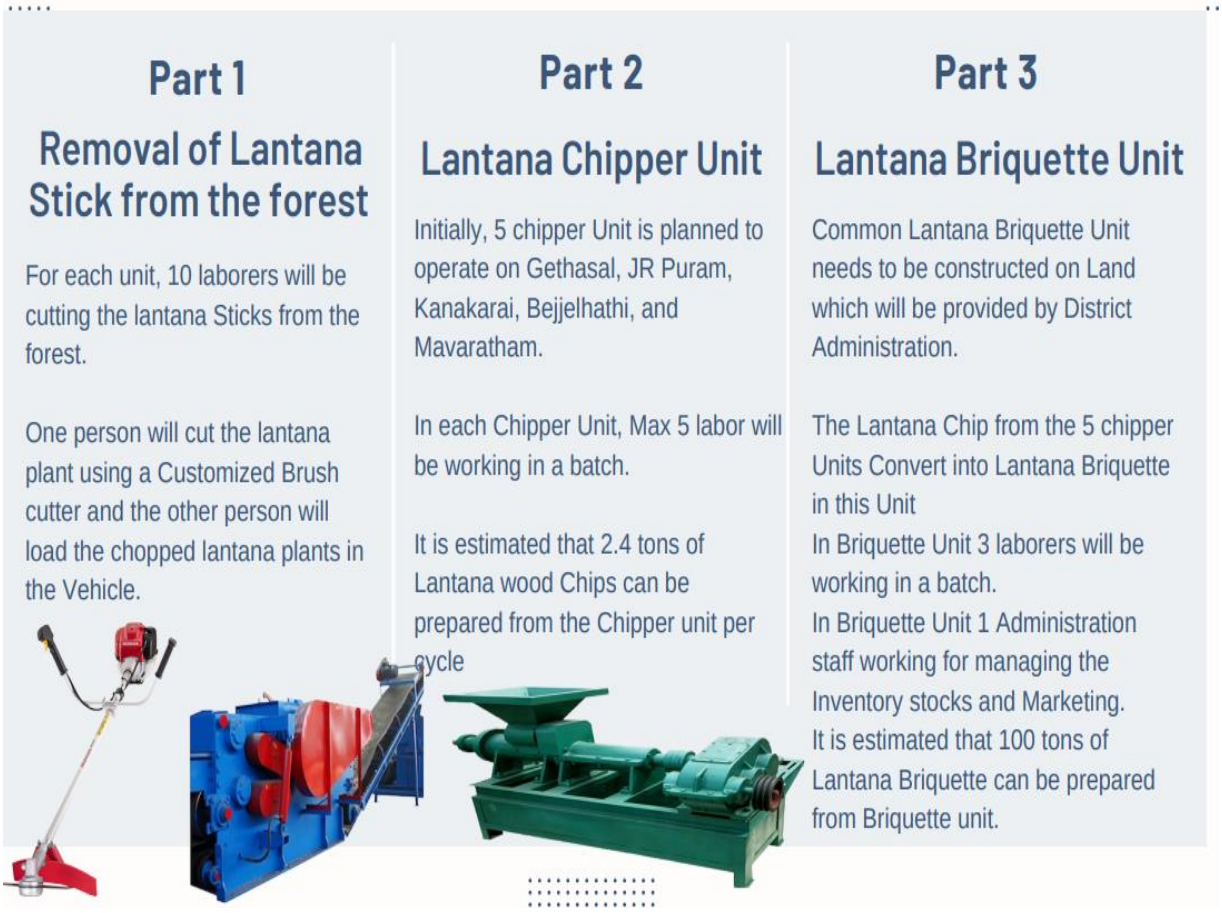
Identification of Lantana Craft enterprise possibilities

Tamil Nadu VazhndhuKaattuvom Project (TNVKP)TNVKP has identified that, there is a possibility of forming lantana craft furniture making Enterprise in Thalavadi block. On Focus Group Discussion (FGD) TNVKP has imparted 30 days skill training to the interested 30 artisans from 10.11.2021 to 9.12.2021 through Community Skill School. As a result of training, they can make furniture such as Chair, Table, Dustbin, Pen stand, Sofa, Cloth box, Flower Vase, Corner Stand, Shoe Rack, Book shelf, Tea-poy etc. in small scale.

In Thalavadi block, TNRTP has formed an Enterprise Group with 30 members for Lantana Craft Furniture making. Current Bank Account was opened to manage their business transactions. To meet out the initial expenditure of Enterprise Group, a start-up grant of Rs.75,000/- was provided by TNVKP.

Hasanur Tribal Lantana Camara Enterprise Group have empanelled with TRIFED-South for supplying their produces. The trained Enterprise Group members are making various types of Lantana craft Furniture such as Chair, Table, Dustbin, Pen stand, Sofa etc. A mutual agreement for marketing was made with furniture association for supplying of Lantana Camara Furniture and also, the products are selling at Aatral Erode (An outlet of District Supply and Marketing Society (DSMS)). A marketing flyer has been prepared and circulated to furniture associations, industries and individual companies for exploring the market opportunities. Lantana Camara Furniture has been supplied to ROPES India, Madurai and TRIFED, Coimbatore.

Lantana Elephant making training was given by SHOLA Trust, Cuddalore from 26.12.2022 to 03.01.2022. They provided Rs.500/- per person during the training to improve the artisan's skill as well as increase their livelihoods.



Expected Output of the Project

- It is estimated that 5 acres of Lantana Shrub will be removed from the forest area of Thalavadi block every month. 4 to 6 Tonnes of Lantana Shrub can be eradicated per acre.
- In a Chipper Unit, a Minimum of 20 Tonnes of Lantana Chips can be made per month. 1 ton of Lantana wood chips costs Rs.3000 to 4000 based on the Moister content.
- In Briquette Unit, 25 Tonnes of Briquette can be made per week. 1 ton of Lantana Briquette costs Rs.6000 to 7000 based on the caloric value of Briquette.
- By implementation of this project, the Lantana Camara weed shrub will be eradicated in due course.
- This will provide, in-site sustainable regular income to the forest dwellers, predominantly tribal in the Thalavadi block.
- In addition to that, their living standard will be improved by getting regular employment and guaranteed wages. Also, the Economic condition of this block will be improved.

Presenter 6 – Dr. Godwin Vasanth Bosco, Naturalist and Restoration, Practioner, Nilgiris

Title: Importance of forest and grass land restoration

The importance of restoration after Invasive species removal in Nilgiris was prioritized during the presentation. There are over 650 plants in the grass lands and the ecological role played by grasses were also emphasized during the presentation. The presenter discussed about the hindrances caused by the invasive (Kikiyu grass) that affects restoration of grasslands. He also shared his experiences of growing 85 native species in nurseries and reintroduction for restoration. Various techniques used for restoration such as tree guards, planting tall seedling etc. were also detailed in the presentation. Use of native grasses, shrubs and trees with proper protection techniques for restoration can aid in successful restoration of grass lands, amidst the influence of invasive species.

Selection and propagation of mature plants that can withstand exotic invasions

4ft to 10 ft tall shola trees

Concluding Remarks:

Exploiting commercial utilization of the eradicated material within the frame work of law. Long term plan for restoration and management of Invasive species affected areas. Clear Standard Operating Plan must be devised for eradication and restoration of Invasive species affected areas within the forest areas.

Theme 6

Policy and legal issues

- Highlights on statistics of Invasive species in Tamil Nadu
- Highlighted the principles for management of Invasive Species.
- Categorized FIS as Invasive alien/Exotic invasive/ non-native invasive/ non indigenous invasive
- Invasive removal & restoration planning
- Political & social complications
- Need of a Clearcut definition of various terminologies related to Invasive Species.

Presenter 1: Mr. S. Anand IFS., Deputy Director, SMTR, Theni

The speaker Insisted for the promotion of native species and explained the problem of invasive species. Highlighted restoration was difficult in individual owned areas and exorbitant costs were also involved. He also added that secondary invasions need to be taken in account while planning for restoration of the area.

Presenter 2: Mr. Srinivasan Kasinathan

The speaker made a detailed presentation on Invasive species like *Maesopsis Mini* currently being used as shade tree in coffee plantations need to be removed and native shade species need to be recommended. He emphasized that thorough study needs to be conducted before introducing a species for any purpose including a shade tree.

Legal – Preventing introduction of alien species into the country through strong quarantine laws

Policy – Need to implement even outside forests and protected areas (involving stakeholders) to prevent species like *Maesopsis Mini* and *Senna spectabilis*

Management – In some cases, complete removal may be inadvisable and can cause secondary invasions: requires phased approach and ecological restoration follow-up measures

Presenter 3: Mr. Vetriselvan

The presenter discussed the need of a Clearcut definition of various terminologies related to Invasive Species. The policies once framed could be brought as law for effective implementation.

Climate change can facilitate Invasive Alien Species as:

- New species, that may become invasive, will be entering regions due to climate change,
- species hierarchies in ecosystems will change, leading to new dominants that may have invasive tendencies, and
- climate induced stress in an ecosystem will facilitate invasive pathways.

He highlighted that with rise in temperature regime, new species may be introduced and strict and vigilant monitoring is highly essential the forest ecosystem will change based on temperature and precipitation. He highlightSed the impact of climate change and invasive species in forest regeneration and ecosystem functioning.

Concluding Remarks

Principles of tolerance – Some species are environmentally and economically important that such species are to be considered. Capacity building and training should be provided for the stakeholders. Weeds to be exempted from forest produce to reduce invasive species invasion.

PANEL DISCUSSION ON STRATEGIES TO MANAGE FOREST INVASIVE SPECIES:

Chairman:	Panellists
Prof. M. Vijayabaskar Additional Full Time Member, SPC	**Dr.N. Krishnakumar, IFS Retd,** Chairman, Research Council, KFRI
	Mr. I. Anwardeen, IFS, APCCF (Working Plan)
Prof. Sultan Ahmed Ismail Member, SPC	**Dr.K.T Parthiban**, Dean (Forestry), FC&RI
	Mr.OsaiKalidasan, Member, State Wildlife Board
	Dr. Samir Kumar Sinha, Chief Ecologist, Wildlife Trust of India (WTI)

Dr.K.T.Parthiban, Dean (Forestry) deliberated regarding the main strategies for the management of invasive species which are to identify the exact area where the management practice should begin, its landscape (based on the forest types), sustainable eradication and linking of the whole technology-based value chain process (VAP). He also added that financing from NABARD and other banks also can be arranged for the industries that are in need of woody biomass as raw materials.

Dr. N. Krishna Kumar, I.F.S., the former PCCF (HoFF) of Tamil Nadu Forest Department expressed that he was associated with the "All India Coordinated Programme on Invasive Species which involved nine institutions. He reflected the need for scientific ideas on the restoration of the present forests, caution while handling invasive species, and the funds to eradicate must be collected from Bank/NABARD and industries as they are in need of raw materials. He also expressed that restoration forestry should be balanced with productive science and a good extension programme.

Mr.I.Anwardeen, I.F.S., APCCF (Working plan) emphasized that knowledge and science are for human welfare. The strategic plans placed for discussion were that there should be no confusion between ecological ethics and environmental characteristics. He also mentioned to undue the hurry for the removal of invasives and allow for restoration through natural regeneration. Certain points like having a clear-cut plan like the removal of mature trees in the first place, monitoring the carbon loss, generation of money through the removal of species and the utilization of money generation should be diverted for conservation and monitoring the restoration.

Mr.Sameer Kumar Sinha, an expert from Wildlife Trust of India expressed that invasive species are an ecological problem and requires ecological solution, hence we must focus on restoration integrity. He projected a comprehensive policy which has an accessible plan with

a focus on objectives, areas of invasion, indicators and risks. He also articulated to focus on eradicating invasives in the herbivore habitats in a sustainable manner and also create awareness among students.

Mr. Osai Kalidas, OSAI NGO indicated the Invasives pose the biggest challenge in conserving forests (1/5th of land). He stated that the invasive plant policy by the Tamil Nadu Government is moving towards providing the solution for invasives and people should understand the need for it. He also spoke about the selection of indigenous trees for urban planting instead of exotic species.

Appendix II

Posters on common forest invasive species

Acacia mearnsii De Wild.

TAXONOMICAL CHARACTERS

Kingdom	: Plantae
Clade	: Tracheophytes
Clade	: Angiosperms
Clade	: Eudicots
Clade	: Rosids
Order	: Fabales
Family	: Fabaceae
Sub family	: caesalpinioideae
Clade	: mimosoid clade
Genus	: Acacia
Species	: Acacia mearnsii

Fig 1 : Parts of *Acacia mearnsii*

INVASIVENESS

- Loss of biodiversity,
- Reduction of surface stream flow
- Increase in erosion
- Loss of recreation opportunities
- Nitrogen pollution
- Loss of grazing potential.

Botanical Description

- An erect, unarmed, evergreen shrub or tree mostly 3 to 10 meter tall. All parts finely hairy
- Growth tips golden-hairy.
- Leaves are dark olive green, finely hairy, double compound.
- Vigorous nitrogen fixing species that has precocious and prolific seed production.
- It is hard to control because of its ability to form root suckers.
- Leaflets are short. Leaflets are 1.5 to 4 mm and are crowded.
- Flowers are pale yellow or cream, spherical flower heads in large, fragrant sprays.
- Fruits are dark brown parts, finely hairy, usually markedly constricted.

A) Effect on environment

Reduce the richness of the species, increased nutrient cycling and nitrogen cycling rates, reduces the water holding capacity

B) Effects on ecology

Restricts the movement of wild animals, disturbs the natural feeding behaviour of wild animals, tannin content in the species leads to allelopathy which affects the chemical composition of the

Harmful Effects of *Acacia mearnsii*

ORIGIN

- Southeastern Australia, from southern New south Wales
- Southern Victoria to southeastern Australia and Tasmania

ERADICATION

- Eradication may not be completely desirable when considering the importance to rural livelihoods.
- It must be viewed as an integral component of land-use planning and incorporated into already existing social and rural development programs.
- Mature trees can be killed by a combination of felling and burning. The seedlings must be hoed out manually.

Reference - Bashar, H.K., Juraimi, A.S., Ahmad-Hamdani, M.S., Uddin, M.K., Asib, N., Anwar, M.P. and Rahaman, F., 2021. A Mystic Weed, Parthenium hysterophorus: Threats, Potentials and Management. Agronomy, 11(8), p.1514.

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Chromolaena odorata- An invasive alert

Taxonomical Characters

Kingdom: Plantae
Clade: Tracheophytes
Clade: Angiosperms
Clade: Eudicots
Clade: Asterids
Order: Asterales
Family: Asteraceae
Genus: Chromolaena
Species: *C. odorata*

Figures: Parts of *Chromolaena odorata L.*

Do You Know ?

Family : Asteraceae
Synonyms : *Eupatorium odoratum*
Common name : Siam weed, bitter bush
Plant type : Shrub
Height : 5m
Flowering : Dec to Jan
Seed production : Jan to March
Seed dispersal : By wind
Soil type : Well drained soils.

Botanical Description

- *Chromolaena odorata* is a rapidly growing perennial herb.
- It has soft stems but the base of the shrub is woody.
- The plant is hairy and glandular and the leaves give off a pungent, aromatic odour when crushed.
- The leaves are opposite, triangular to elliptical with serrated edges.
- Leaves are 4–10 cm long by 1–5 cm wide (up to 4 x 2 inches). Leaf petioles are 1–4 cm long.
- The white to pale pink tubular flowers are in panicles of 10 to 35 flowers that form at the ends of branches.
- The seeds are achenes and are somewhat hairy.
- They are mostly spread by the wind, but can also cling to fur, clothes and machinery, enabling long distance dispersal.
- Seed production is about 80,000 to 90,000 per plant. Seeds need light to germinate. The plant can regenerate from the roots. In favorable conditions the plant can grow more than 3 cm per day.

Harmful Effects of *C. odorata*

A) Human health

C.odorata causes skin problems and asthma in allergy prone people. In the implication of pyrrolizidine alkaloids, the pyrrolizidine alkaloids have been associated with a severe type of liver disorder known as veno-occlusive disease. In this disease, the hepatic vein becomes clogged, blocking off the blood supply to the liver.

B) Effects on Livestock

Chromolaena odorata contains carcinogenic pyrrolizidine alkaloids. It is toxic to cattle. It can also cause allergic reactions. Recent research has shown the plant is larvicidal against all major mosquito vectors. The alkaloids in the flowers are said to have killed goats which ate the flowers

C) Effect on Crops

It is a considerable problem in commercial tree plantations as it suppresses the growth of young pine and eucalypt trees and allows fire and also promote wild land fire.

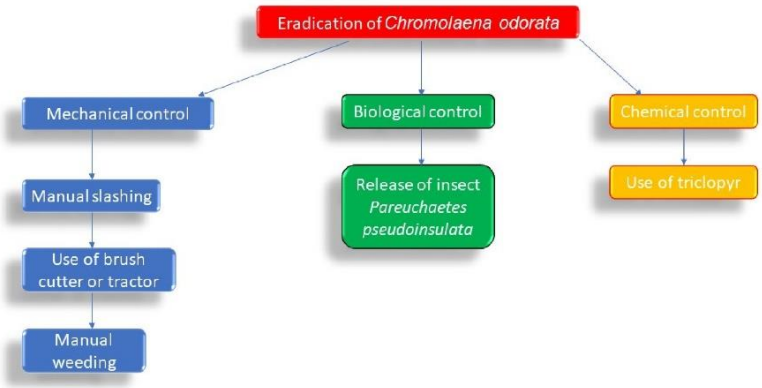
D) Other effects

It prevents regeneration of tree species in areas of shifting cultivation. It affects species diversity. It is also considered as a considerable threat to conservation and ecotourism, as it has first invaded natural area , reducing the biodiversity of grasslands, savannahs and forests.

Origin & Introduction

1. Native of tropical central and south America.
2. Introduced to

- Asia in the middle of 1800's
- Africa in 1937 &
- Micronesia in 1960's



https://www.fao.org/agriculture/crops/thematic-sitemap/theme/biodiversity/weeds/listweeds/chr-odo/en/

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Eichhronia crassipes – An Invasive Bane

Taxonomical Characters

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Liliopsida
Order	:	Pontederiales
Family	:	Pontederiacea
Genus	:	Eichhornia
Species	:	*crassipes*
English Name	:	Water Hyacinth

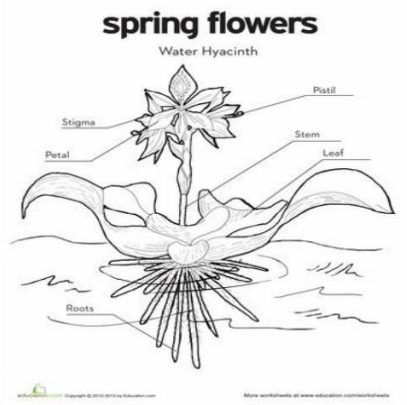


Fig 1 : Parts of *Eicchornia crassipes*

Do You Know ?

Origin –Native to South America
Distribution – North America , South America , Eastern Africa , and Asia
Pollinators – Wind or Insects
Conservation Status – Legislation
Local Names – Meteka

Botanical Description

- Water Hyacinth is a free floating freshwater perennial.
- Leaves are emergent, ovate, and 4-5 inches in diameter.
- Leaf stock are bulbous and spongy.
- Flowers are with 6 petals , one with a yellow diamond shaped patch outlined with a deeper purple.
- Flowers emerge from single spike containing 8-15 flowers.
- Roots are dark and feathery, growing upto 3 ft. long.
- Egg shaped seeds are ribbed and cointained in a membranous capsule.

Origin

- *Eichhornia* orginated from Amazon Basin , South America.
- *Eichhornia* has spread mainly to the tropics and sub trioics since the 1800s.

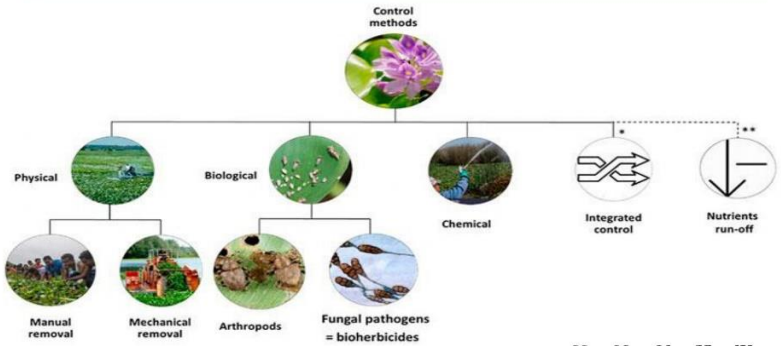
Harmful Effects of *Eichhornia crassipes*

A) It can damage ecosystem services, reduce habitat and biodiversity, and negatively impact agriculture, tourism and recreational opportunites.

B) It can completely cover lakes and wetlands, outcompeting native aquatic species, reducing oxygen level for fish, and creating ideal habitat for disease carrying mosquitoes.

C) It forms dense , impenetrable mats which clog water ways, making boating, fishing and almost all other water activities, impossible.

D)It can increase flooding in rivers and canals by forming dams.



Reference – Bashar, H.K., Juraimi, A.S., Ahmad-Hamdani, M.S., Uddin, M.K., Asib, N., Anwar, M.P. and Rahaman, F., 2021. A Mystic Weed, Parthenium hysterophorus: Threats, Potentials and Management. Agronomy, 11(8), p.1514.

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Lantana camara -Perilous Invasive Noxious Weed

Taxonomical Characters

Kingdom : Plantae
Phylum : Tracheophyta
Class : Magnoliopsida
Order : Lamiales
Family : Verbenaceae
Genus : Lantana
Species : ***Lantana camara Linn***
English Name: Shrub Verbena or Red sage

Lantana camara Linn

Do You Know ?

Distribution – India: Shivalik hills, Central India, and Southern Western Ghats
Pollinators – Abiotic: Wind and Water , **Biotic:** Birds, Bees, Butterfly and Thrips
Conservation Status – Least Concern
Local Names – Unni Chedi (Tamil)

Origin and Arrival

- **Native to Tropical America**, Lantana camara was brought to **India by the British as ornamental plants**
- Arrived in India as an ornamental plant in the **early 1800s**, lantana has escaped from gardens and taken over entire ecosystems, now occupying **40 percent of India's tiger range alone**.
- It has spread from its native range to **around 50 countries**, where it has become an invasive species.

They can alter ecosystem structure and function, trophic structure, resource availability and downgrade biodiversity of natural landscapes.

Lantana camara is one such invasive alien species and considered by IUCN as one of the world's 100 most invasive species, and among the world's 10 worst weeds.

IMPACT ON ANIMALS

Lantana camara is a shrub containing toxic triterpenes which cause **hepatic degeneration** in cattle, producing signs of photosensitization, jaundice, rumen stasis, and depression.

EDHAPIC IMPACT

Lantana disrupts succession, decreases biodiversity, and can reduce vigour of native plants due to allelopathy.
It typically forms dense thickets, suppressing native vegetation and seedlings through shading, nutrient competition and smothering

ERADICATION

The most common methods used in India for the control of Lantana in forests are:
Hand pulling
Slashing/Chopping of the stems
Burning
Manual grubbing with substantial removal of the root system

Reference:
A framework for management of Lantana camara in India - Neena Priyanka, M.V. Shiju , P K Joshi -Proceedings of the International Academy of Ecology and Environmental Sciences, 2013, 3(4): 306-323.
Lantana Camara -Stephen Johnson From the book Encyclopedia of Biological Invasions Pg – 428 © 2019 University of California Press, Berkeley

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Parthenium hysterophorus – An Invasive Bane

Taxonomical Characters

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Magnoliopsida
Order	:	Asterales
Family	:	Asteraceae
Genus	:	Parthenium
Species	:	*Parthenium hysterophorus L.*
English Name	:	Carrot Grass

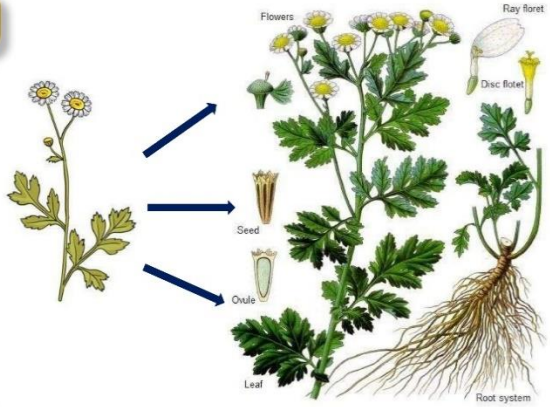


Fig 1 : Parts of *Partenium hysterophorus L.*

Do You Know ?

Origin –Native to Central America and Caribbean area.

Distribution – India: Assam, Bihar, Gujarat, Madhya Pradesh, Maharashtra, Manipur, Rajasthan, Odisha, Uttar Pradesh; Tropical America

Pollinators – Bees

Conservation Status – Legislation

Local Names – Congress Grass, Gajar Ghas, Coimbatore chedi, Congress pacha.

Botanical Description

- *Parthenium hysterophorus* is an annual herbaceous plant that reproduces mostly through seeds.
- After sprouting, the young plant has a basal rosette of bright green and finely lobed leaves that measure about 8–20 cm in length and 4–8 cm in breadth.
- During unfavorable conditions, the rosette stage can continue to grow up to a maximum of 2.5 m long.
- Both leaves and stems have short and fluffy hair or trichomes, four styles of which have been recognized and considered for their taxonomic significance.
- The flower heads are terminal and somewhat hairy; they consist of several small white capitula-shaped florets.
- Usually, each head has five productive ray florets, although occasionally six or eight.
- Thousands of branches, which develop in separate clusters, produce compressed black seeds about 2 mm in size.

Origin

- *Parthenium* was found in the Gulf of Mexico, the USA, the West Indies, and Central America.
- *Parthenium* has now invaded 46 countries and regions

Harmful Effects of *P. hysterophorus*

A) Human health

Cause skin diseases, allergies, malarial infection-related fever, Skin infections, allergies, eczema, allergic rhinitis, dark spots, burning, swelling around the eyes, Diarrhea and shortness of breath

B) Effects on Livestock

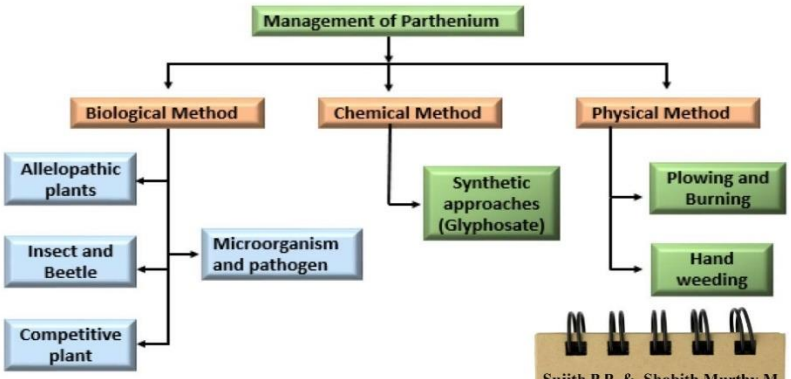
Parthenium decreases livestock productivity by reducing the amount of forage. Also affect grazing animals' welfare, milk production, and meat quality, develop atrophic eruptions, alopecia, skin depigmentation and anemia. Death, rashes on the body and udders, alopecia, loss of skin pigmentation, allergic skin reactions, dermatitis, diarrhea, anorexia, and pruritus are all possible outcomes if they come in contact on regular basis.

C) Effect on Crops

Allelopathic impacts on crop development and establishment. As a result of *P. hysterophorus* expansion, native and non-native species have been hampered or replaced. Allelochemicals are formed by *P. hysterophorus* leaves and discharged into the soil by leaching or decomposition, and they affect plant growth directly or indirectly by affecting the soil's physico-chemical characteristics..

D) Other effects

A huge number of national parks, tourism sites, and industrial sites may be affected by Parthenium, and wild animals may suffer the consequences. Most national botanical gardens of India is affected by this weed growth.



Reference – Bashar, H.K., Juraimi, A.S., Ahmad-Hamdani, M.S., Uddin, M.K., Asib, N., Anwar, M.P. and Rahaman, F., 2021. A Mystic Weed, Parthenium hysterophorus: Threats, Potentials and Management. Agronomy, 11(8), p.1514.

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Prosopis juliflora

Taxonomical Characters

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Magnoliopsida
Order	:	Fabales
Family	:	Fabaceae
Genus	:	*Prosopis*
Species	:	*Prosopis juliflora*
English Name	:	Iron wood

Do You Know ?

Origin –Native to Mexico, Central and Northern South America

Distribution – India: Except Jammu and Kashmir, Himachal Pradesh, Sikkim, Arunachal Pradesh

Forest Type: Tropical Thorn Forest

Conservation Status – Not Extinct

Local Names – Prosopis, Mathenge, Mesquite, Alagarroba, Ironwood Eterai

Botanical 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. The stems are shaped in a "mild zigzag" way with one or two stout **thorns** at each turn of the stem.
- Leaves, are twice-compound (**bipinnate**) with mostly two, sometimes more pairs of **pinnae**, 6-8 cm long, 12-25 pairs of **oblong leaflets** per **pinna**, 6-16 mm long, 1.5-3.2 mm wide.
- The flowers are fragrant golden-yellow, dense **spikes** about 5-10 cm long. The fruit of P. juliflora is a **cylindrical** or slightly irregularly curved green **pod** which turns yellow upon ripening. It is 10-20 cm long, sweet to taste and contains 10-20 hard oval or **elliptic** seeds (2.5-7 mm long) that are difficult to extract.
- Prosopis juliflora thrives in most soils including; sandy, rocky, poor and saline soils within an altitude range of 300-1900 m above sea level. where it has deep taproots which help to access sub-surface waters.

Harmful Effects of *Prosopis juliflora*

Prosopis juliflora **can be a very aggressive invader and replaces native vegetation and takes over rangelands. Negative effects include complete loss of pasture and rangelands for both domestic and wild ruminants, losses due to access to water and the destruction of fishing nets by the thorns, and illness and death of livestock due to eating**

P. juliflora **pods and being pierced by the sharp and stout thorns. Other impacts are loss of cropland, the costs of repairing tyres punctured or destroyed by thorns, and doctor's bills for treating thorn wounds. Dense stands of P. juliflora can block irrigation channels, obstruct roads and block smaller trails completely affecting access to pasture, croplands, water sources and fishing areas.**

Livestock, particularly cattle, can become ill when they are almost exclusively fed with pods. Symptoms can be facial contortions and constipation, sometimes resulting in death.

It cannot even shelter birds as it produces less oxygen and more carbon dioxide. If it does not have sufficient water it begins absorbing groundwater. And if there is no groundwater, it starts absorbing humidity from the surroundings. It can also turn the groundwater poisonous.

ERADICATION

Mechanical removal refers to using machines and tractors to remove, rather uproot, Prosopis trees.

Reference – CABI Invasive Species Compendium online data sheet. Prosopis juliflora (mesquite). CABI Publishing 2011. www.cabi.org/ISC. Accessed March 2011.
GISD (2010). Global Invasive Species Database online data sheet. Prosopis juliflora (shrub). www.issg.org/database. Accessed March 2011.
Henderson, L. (2001). Alien weeds and invasive plants. A complete guide to declared weeds and invaders in South Africa. Plant Protection Research Institute Handbook No. 12, 300pp. PPR, ARC South Africa. NB- related but different species than P. juliflora.

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Senna spectabilis – An Invasive Bane

Taxonomical Characters

Kingdom	:	Plantae
Phylum	:	Tracheophyta
Class	:	Dicotyledons
Order	:	Fabales
Family	:	Fabaceae
Genus	:	Senna
Species	:	*Senna spectabilis*
English Name	:	Golden wonder tree

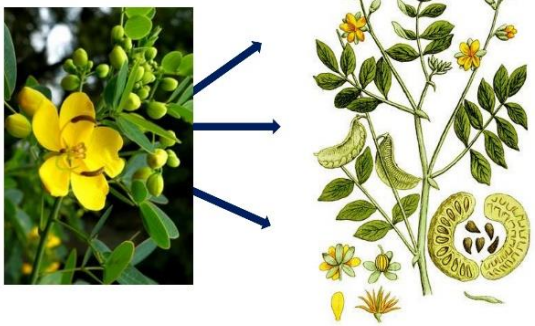


Fig 1 : Parts of Senna spectabilis

Do You Know ?

Origin –South and central America
Distribution – naturalized include southern USA, Malaysia, Puerto Rico, southern and eastern Africa.
Pollinators – Bees
Conservation Status – Legislation
Local Names – Spectacular cassia, mhomba (Kiswahili), mwenu (Kikuyu); calceolaria shower, cassia, pisabed, yellow shower

Botanical Description

- *Senna* includes herbs, shrubs, and trees.
- The leaves are pinnate with opposite paired leaflets.
- The inflorescences are racemes at the ends of branches or emerging from the leaf axils.
- The flower has five sepals and five usually yellow petals.
- There are ten straight stamens. The stamens may be different sizes, and some are staminodes.
- The fruit is a legume pod containing several seeds
- The number of species is estimated to be from about 260 to 350.
- The type species for the genus is *Senna alexandrina*.
- About 50 species of *Senna* are known in cultivation.

Origin

- Senna is native to much of tropical America
- *Senna spectabilis* is a common garden ornamental plant that also invades; forest margins, savanna, riverbanks, roadsides, waste ground and plantations.

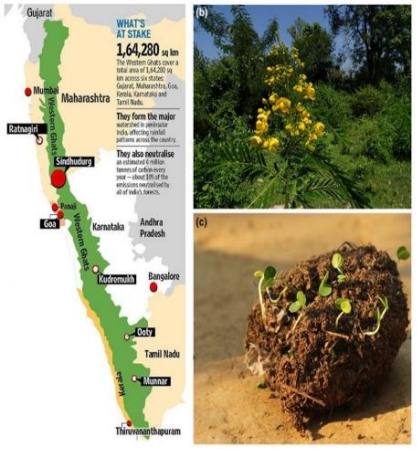
Harmful Effects of Senna spectabilis

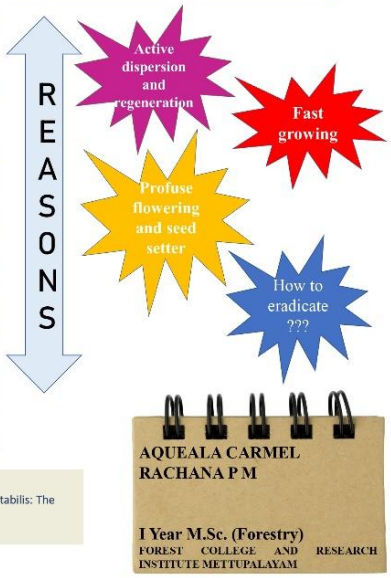
A) Allelopathy
B)Monoculture formation
C) Supress regeneration of native species
D)Habitat alteration or ecosystem change
E) Soil erosion
F) Reduction in crop yield and reduction in native flora and fauna

Senna spectabilis can invade disturbed forests, forest edges and gaps where it can establish and suppress the regeneration of native species.

AFFECTED AREA

Satyamangalam tiger reserve, Bandipur, Nagarhole, Mudumalai, Satyamangalam, Meghamalai – Tiger reserves
Nilgiris Biosphere Reserve
Attappady, Wayanad – Kerala
Bhadra Tiger Reserve – Karnataka
Coimbatore forest division





WCS India; News room blog Senna spectabilis : The Alien green; 2019
EIACP newsletter on biological invasion; volume 3, No 3; January 2023; Senna spectabilis: The progressive invasive threat of Western Ghats.

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Leucaena leucocephala – Devil in disguise

Taxonomical Characters

Kingdom : Plantae
Phylum : Tracheophyta
Class : Eqisetopsida
Order : Fabales
Family : Fabaceae
Genus : Leucaena
Species : *Leucaena leucocephala*
Common Name : Pearl wattle

Leucaena leucocephala (with floral and fruiting character)

Do You Know ?

Origin –Native to Central America
Distribution – All over India; Asia – Pacific region
Pollinators – Birds, wind
Local Names – Wild tamarind, Horse tamarind, White leadtree, Pearl wattle, Jumbay, tan-tan

Botanical Description

- *Leucaena leucocephala* is a fast growing, evergreen, thornless shrub, reaching a height of 5 m to 20 m.
- It has a deep taproot and is highly branched.
- Leaves are bipinnate, bearing numerous leaflets 8 mm to 16 mm long.
- The inflorescence is a cream coloured globular shape producing clusters of flat brown pods, 13 to 18 mm long containing 15-30 seeds.
- Young leaves are bipinnate, with glands visible (one is arrowed) in the branches of the secondary rachis.
- self-fertile and produces prodigious quantities of seed from the first year, more or less continuously throughout the year.
- Hairy anthers distinguish *Leucaena leucocephala* from all other mimosoid legume genera.

Adverse Effects of *Leucaena leucocephala*

1. Ecological impacts
The sps richness in invader sites is found to be lower than in uninvaded sites. It alters the balance of interactions between the local species. It has brought negative ecological consequences in different regions such as hindering reforestation affecting vegetation and threatening native sps.

2. Effects on Livestock
Virtually all parts of Leuceana contains contains toxic amino acids and mimosine. **Mimosine** which has adverse effect on growth, reproduction and health of animals. Mimosine may cause alopecia in young cattle.

3. Effect on Crops
It is a widespread invader with putative allelopathic effects on other species. When intercropped with few species, it has significant allelopathic effects on germination, root- shoot and growth of lateral roots.

4. Other effects
Trees topple over in the rain like skittles, causing widespread damage to streets and neighbourhood. In urban areas, it is an especially unwanted species, growing along arid roadsides, in carparks, and on abandoned land.

Integrated management: Once established, *Leucaena* is difficult to eradicate. It resprouts vigorously after cutting. Cut stumps need to be treated with diesel or other chemicals.
Also, as it produces seeds profoundly, seeds need to be destroyed.

Origin

- *L.Leucocephala* was found in the southern Mexico and Northern Central America.
- It has now invaded almost throughout the tropics.

Reference – Sastry, M.S. & Singh, Rajendra. (2008). Toxic effects of subabul (Leucaena Leucocephala) on the thyroid and reproduction of female goats. Indian Journal of Animal Sciences. 78. 251-253.

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The Management of Forest Invasive Species in Tamil Nadu

Invasive alien plant species are a major driver of biodiversity loss, posing significant threats to the health of the forests in our country.

This report is an outcome of the **'International Workshop on the Management of Forest Invasive Species',** which was organised by the State Planning Commission in conjunction with the Tamil Nadu State Land Use Research Board (TNSLURB) and Forest College & Research Institute.

The purpose of this report is to heighten awareness on the threats posed by alien invasive species and to offer a framework for the development and implementation of effective strategies for their prevention, monitoring and control. It serves as a comprehensive guide for policymakers, researchers, conservationists and stakeholders alike.

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