

# THE ECOLOGICAL DOMINO EFFECT: INVASIVE SPECIES AND ECOSYSTEM COLLAPSE

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## Abstract

Biological invasions by Invasive Alien Species (IAS) constitute a severe global crisis, acting as a primary driver of biodiversity loss and ecosystem collapse. In India, the rapid spread of IAS such as *Lantana camara*, *Prosopis juliflora* and *Chromolaena odorata* currently threatens over two-thirds of the nation's natural areas. Driven by globalization, climate change and habitat degradation, these invasions initiate cascading failures that significantly compromise ecosystem resilience. Beyond ecological degradation, IAS impose a staggering socio-economic burden, costing the Indian economy an estimated \$127.3 billion to \$182.6 billion over the last six decades. They severely impact agricultural productivity, deplete pastoral forage and increase public health risks. However, managing these species presents a complex paradox; many marginalized rural communities have adapted to depend on certain invasive plants, such as *Prosopis juliflora* for fuelwood and *Lantana sps.* for crafts. Consequently, blanket eradication campaigns could inadvertently threaten local livelihoods and trigger social issues. To combat this multifaceted threat, researchers and policymakers advocate for a paradigm shift from reactive eradication to adaptive, community-integrated management. Ultimately, addressing the invasive species crisis demands a holistic approach that harmonizes strict biosecurity policies with climate adaptation strategies, ensuring both the protection of vulnerable biodiversity and the socio-economic stability of dependent communities

**Keywords:** invasive species, ecosystem collapse, biodiversity loss, ecological disruption, biological invasion, ecosystem resilience

## Introduction

What if a single plant or animal could silently collapse an entire ecosystem? This question is no longer hypothetical in the modern era of ecological change. Across the world, the introduction of non-native species into new environments has triggered profound and often irreversible transformations in natural and managed ecosystems. These organisms, commonly referred to as Invasive (Non-native or alien) species, which are non-native to a given geographical location, reproduce freely and have the potential to establish, spread rapidly and outcompete native flora and fauna, thereby damaging the environment, economy and human health (Mack et al., 2000). Their success is largely due to the reduced pressure from the natural predators and their high adaptability. Once established in a new environment, the domino effect begins. They get into competition with native species. If they outperform native populations, it leads to a decline in the native population, that further disrupts the food web and destabilizes the local ecology and it might lead to

ecological collapse. It is like a cascading chain of ecological disruption. Such a collapse could alter the soil health, water quality and other environmental parameters, eventually impacting human well-being. They are not just an ecological threat, but also impact the economy, public health and the One Health framework. Given the serious consequences, knowledge of invasive species and their spreading mechanism is required in the development of effective management strategies to prevent ecological damage and to restore ecological stability.

## What are Invasive Species?

Invasive species are those species that expand, establish and reproduce beyond their own native geographical location and are in competition with natives for resources. Their introduction is largely anthropogenic, either intentional or accidental. If they are introduced once, they can rapidly establish themselves in the given area. Not all the non-native species are invasive. Non-native or exotic means they exist outside of their own location, whereas invasive

means they are spreading aggressively and cause ecological and environmental disturbances. Some of the common Invasive species of flora and fauna are tabulated below:

**Table 1:** Common invasive species of India

S.No.	Common Name	Scientific Name	Type / Ecosystem
1.	Water Hyacinth	<i>Eichhornia crassipes</i>	Flora (Aquatic Weed)
2.	Lantana	<i>Lantana camara</i>	Flora (Terrestrial Shrub)
3.	Congress Grass / Carrot Weed	<i>Parthenium hysterophorus</i>	Flora (Terrestrial Weed)
4.	Siam Weed / Bitter Bush	<i>Chromolaena odorata</i>	Flora (Terrestrial Shrub)
5.	Mesquite / Vilayati Keekar	<i>Prosopis juliflora</i>	Flora (Terrestrial Tree)
6.	Mile-a-minute Weed	<i>Mikania micrantha</i>	Flora (Climbing Vine)
7.	Touch-Me-Not / Sleeping Grass	<i>Mimosa pudica</i>	Flora (Terrestrial Weed)
8.	Goat Weed	<i>Ageratum conyzoides</i>	Flora (Terrestrial Weed)
9.	Butterfly Fern / African Payal	<i>Salvinia molesta</i>	Flora (Aquatic Fern)
10.	Dodder	<i>Cuscuta spp. (C. chinensis, C. campestris)</i>	Flora (Parasitic Weed)
11.	African Catfish / Thai Magur	<i>Clarias gariepinus</i>	Fauna (Freshwater Fish)
12.	Common Carp	<i>Cyprinus carpio</i>	Fauna (Freshwater Fish)
13.	Mozambique Tilapia	<i>Oreochromis mossambicus</i>	Fauna (Freshwater Fish)
14.	Mosquito Fish	<i>Gambusia affinis / G. holbrooki</i>	Fauna (Freshwater Fish)
15.	Amazon Sailfin Catfish	<i>Pterygoplichthys pardalis</i>	Fauna (Freshwater Fish)
16.	Giant African / Apple Snail	<i>Achatina fulica</i>	Fauna (Mollusc)
17.	Cotton Mealy bug	<i>Phenacoccus solenopsis</i>	Fauna (Freshwater Fish)
18.	Papaya Mealy bug	<i>Paracoccus marginatus</i>	Fauna (Insect)
19.	Yellow Crazy Ant	<i>Anoplolepis gracilipes</i>	Fauna (Insect)
20.	Spotted Deer / Chital	<i>Axis axis</i>	Fauna (invasive in Islands)



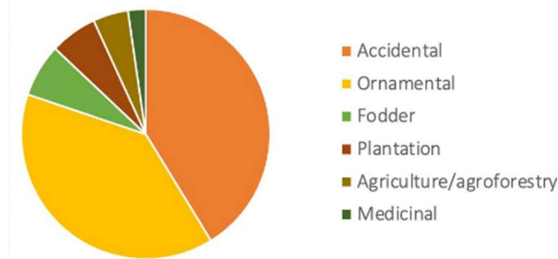
**Fig. 1:** Common invasive floral species seen in India

**How Do Invasive Species Enter an Ecosystem**

In today's highly connected world, human activities have enabled species to move across continents within a matter of hours, making people the primary drivers of exotic species introductions. Some introductions are deliberate, carried out for perceived benefits such as agriculture, ornamental purposes or biological pest control. However, these efforts often produce unintended consequences when introduced species establish and spread beyond control. In many cases, introductions occur unintentionally, with organisms transported through international trade,

cargo shipments, packaging materials, the pet trade or by travellers. A notable example is *Parthenium hysterophorus*, which was accidentally introduced into India in 1956 through contaminated grain imported from the United States. Since then, it has become a major environmental and public health concern, causing pollen allergies in humans while negatively affecting agriculture, livestock productivity and biodiversity, resulting in significant economic losses (Adkins and Shabbir, 2014). Similarly, *Lantana camara* was introduced during the colonial period as an ornamental plant but has

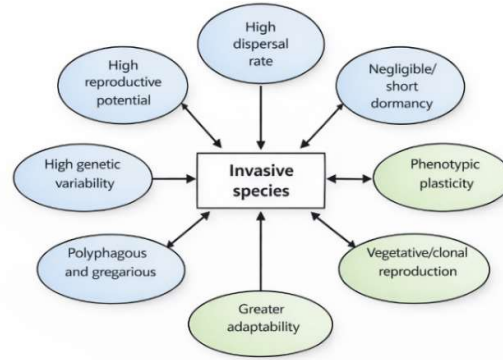
since spread widely across India as a persistent invasive weed. Another example linked to the pet trade is the red-eared slider turtle, a popular pet species that has become invasive in many regions, where it competes effectively with native turtles for food and basking sites.



**Fig. 2:** Introductory pathways of Invasive species (Banerjee *et al.*, 2021)

**What makes them so successful?**

Following the introduction of a new species, its success largely depends on its ability to survive and establish in the new environment. Characteristics of invasive species (Fig. 3) include rapid reproduction and growth, high dispersal ability, broad ecological tolerance (generalists), phenotypic plasticity and a distinct lack of natural predators in their new habitats. One of the most critical factors influencing this success is the absence of natural predators. In their native habitats, species evolve alongside predators and parasites that regulate their population size. However, when introduced into a new ecosystem, these natural controls are often absent, allowing the species to reproduce rapidly and expand its population. Environmental suitability also plays a significant role. When climatic and habitat conditions favour the introduced species, it can spread aggressively and outcompete native organisms occupying similar ecological niches. Native species, which continue to face predation and other ecological pressures, often lack evolutionary adaptations to defend against the invader. This imbalance can lead to a decline in native populations and disrupt ecological interactions, ultimately affecting the stability of the entire food web. This process is well explained by the *Enemy Release Hypothesis*, which suggests that species introduced into a new environment experience reduced pressure from their natural enemies. As a result, they can allocate more energy toward growth and reproduction, giving them a substantial competitive advantage over native species (Keane and Crawley, 2002).



**Fig. 3:** Characteristics of invasive species

**The Ecological Domino Effect**

The ecological domino effect begins when non-native species enter a new environment where favourable conditions and the absence of natural predators allow rapid establishment. Once established, these species become invasive and compete with native organisms for resources within the same ecological niche. Native species often lack the adaptations needed to cope with new competitors, leading to population decline. This decline triggers a chain reaction in the food web. Predators may decrease due to reduced prey availability, while shared prey populations may also decline because of overconsumption by invasive species. These cascading effects gradually destabilize ecosystem functioning. Over time, prolonged invasion can alter soil health, water quality and nutrient cycles. Some invasive species may also produce toxins or spread diseases, affecting agriculture, livestock and biodiversity. Ultimately, the introduction of a single species can lead to ecological imbalance, economic losses and threats to human well-being.

**Impacts on Ecosystems**

- Biodiversity Loss and Species Extinction
- Disruption of Food Webs and Trophic Dynamics
- Alteration of Ecosystem Functions and Biogeochemical Cycles
- Habitat Degradation and Landscape Homogenization
- Allelopathy and Chemical Interference
- Genetic Pollution
- Reservoirs for Pathogens and Diseases

Over a longer period of time, these invasive species can alter the habitat and structure. Alter the wildlife, soil health and nutrient cycle. In some cases, it alters the microbial functions that change soil parameters like pH, water holding

capacity and other parameters. Alters water quality, sedimentation rate and hydrological cycles. These altered environmental factors may not be suitable for other species that are not directly related to the affected species, which further changes the ecosystem. These ecological disruptions ultimately affect ecosystem services, the benefits humans derive from ecosystems, such as clean water, fertile soil, pollination and climate regulation. As these services decline, the consequences extend beyond nature to directly impact human livelihoods and well-being.

For instance, the Nile perch (*Lates niloticus*) was introduced to Lake Victoria (Africa) in the 1950s to boost fisheries, acting as a massive predator. This caused an ecological crisis, leading to the extinction of hundreds of native cichlid species. This demonstrated how a single species can trigger a trophic cascade and ecosystem collapse. (Goldschmidt et al., 1993). Cane toads (*Rhinella marina*) were introduced in Australia to control sugarcane Beetles in 1935 but they became invasive and killed native predators by toxic secretions making the prey population grow uncontrollably, which led to ecological imbalance. (Shine, 2010). In the Indian context, a very well-known example is of *Lantana camara*, which was introduced to India as an ornamental plant, that now covers over 13 million hectares. It threatens 40% of Indian tiger habitats and native biodiversity by choking vegetation, altering soil and poisoning livestock. It is one of the world's worst invasive stories. (Sharma et al., 2005). Water hyacinth (*Eichhornia crassipes*), which was introduced as an ornamental flower, but it became an invasive aquatic weed covering over 200,000 hectares of Indian wetlands, rivers and ponds. Causing massive environmental damage by creating dense mats that deplete oxygen, block sunlight and destroy biodiversity. The problem

persists to haunt fish farmers. (Villamagna and Murphy, 2010). Red-Eared Slider (*Trachemys scripta elegans*) are well known pet, but also considered as one of the world's 100 worst invasive species.

Several well-documented cases illustrate how introduced species can trigger severe ecological disruption. The Nile perch (*Lates niloticus*) was introduced into Lake Victoria in the 1950s to enhance fisheries, but its role as a dominant predator led to the extinction of hundreds of native cichlid species, demonstrating a classic example of trophic cascade and ecosystem collapse (Goldschmidt et al., 1993). Similarly, cane toads (*Rhinella marina*) were introduced into Australia in 1935 to control sugarcane beetles. Instead, their toxic secretions killed native predators, allowing prey populations to expand unchecked and causing widespread ecological imbalance (Shine, 2010). In India, *Lantana camara*, originally introduced as an ornamental plant, has spread across more than 13 million hectares and now threatens a large proportion of tiger habitats and native biodiversity by suppressing vegetation, altering soil conditions and poisoning livestock (Sharma et al., 2005). Another major example is water hyacinth (*Eichhornia crassipes*), introduced for ornamental purposes but now infesting over 200,000 hectares of Indian water bodies. Its dense growth reduces oxygen levels, blocks sunlight and damages aquatic biodiversity, posing persistent challenges for fisheries and aquaculture (Villamagna and Murphy, 2010). The red-eared slider (*Trachemys scripta elegans*), a popular pet turtle, is also recognized globally as one of the world's most invasive species due to its strong competitive ability in natural habitats. Some of the common adverse effects of these invasive species are given below in table

Species Name	Adverse Effects
<b>Water Hyacinth</b> ( <i>Eichhornia crassipes</i> )	It blocks waterways, limits boat traffic, swimming and fishing. It prevents sunlight and oxygen from reaching submerged plants, severely reducing aquatic biodiversity. It chokes ponds, lakes and rivers and invades paddy fields, making them unproductive.
<b>Lantana</b> ( <i>Lantana camara</i> )	It overruns cultivable lands, forests and pastures and suppresses the regeneration of native species by competing for scarce nutrients. It is poisonous to livestock like cattle, buffalo, sheep and horses and poses a serious fire hazard in deciduous forests.
<b>Congress Grass</b> ( <i>Parthenium hysterophorus</i> )	It supplants native flora and inhibits the germination and growth of several crop plants. It causes severe health issues such as asthma, bronchitis, dermatitis and hay fever in humans and livestock. It also acts as a host for crop pests and diseases.
<b>Siam Weed</b> ( <i>Chromolaena odorata</i> )	It replaces native ground vegetation and creates a potential fire hazard during dry seasons. It rapidly reduces grazing areas and is poisonous to cattle.

<b>Mile-a-minute</b> ( <i>Mikania micrantha</i> )	It climbs over forest trees, masking their photosynthetic surfaces and suppressing undergrowth and tree seedlings. This reduces the yield of cash crops, creates nuisances in forestry operations and prevents forest regeneration.
<b>Mesquite</b> ( <i>Prosopis juliflora</i> )	It degrades native ecosystems and causes major negative impacts on regional ecology. It also blocks access to pasture and water, forcing marginalized households to travel far for daily needs.
<b>Touch-Me-Not</b> ( <i>Mimosa pudica</i> )	It has become a widespread pest that negatively impacts forest plantations, croplands, orchards and pastures.
<b>African Payal</b> ( <i>Salvinia molesta</i> )	It forms dense vegetation mats that reduce water flow, light and oxygen levels, which negatively affects the abundance of freshwater fish and submerged aquatic plants.
<b>African Catfish</b> ( <i>Clarias gariepinus</i> )	It is a voracious predator that can wipe out entire food chains by attacking and eating fish of its own size. It also negatively impacts native amphibian populations by preying on tadpoles.
<b>Mozambique Tilapia</b> ( <i>Oreochromis mossambicus</i> )	It negatively impacts locally adapted indigenous species by competing with them for food and habitat niches.
<b>Common Carp</b> ( <i>Cyprinus carpio</i> )	It reduces water clarity and destroys or uproots the aquatic vegetation that serves as a habitat for a variety of other species.
<b>Mosquito Fish</b> ( <i>Gambusia affinis</i> / <i>G. holbrooki</i> )	It is highly predatory and eats the eggs of economically desirable fish. It preys on and endangers rare fish and invertebrate species.
<b>Giant African Snail</b> ( <i>Achatina fulica</i> )	It threatens crop systems and native ecosystems through direct herbivory of native plants, resource competition, disease spread
<b>Yellow Crazy Ant</b> ( <i>Anoplolepis gracilipes</i> )	It drives biodiversity loss and causes broader economic and health hazards within the fragile ecosystems it invades.
<b>Cotton Mealybug</b> ( <i>Phenacoccus solenopsis</i> )	It severely affects cotton crops and causes significant agricultural yield losses.
<b>Papaya Mealybug</b> ( <i>Paracoccus marginatus</i> )	It destroys huge crops of papaya, heavily impacting agricultural production

Table 2. Adverse effects of these invasive species

### Management Strategies, Policy Framework and Future Directions

Prevention remains the most cost-effective approach for managing invasive species, requiring strong border control, quarantine systems and early detection to limit establishment and spread. Mechanical methods such as cutting and removal are commonly used but are labour-intensive and often ineffective without habitat restoration. Chemical control using herbicides and pesticides can suppress invasive species but carries risks of environmental contamination and must be carefully regulated. Biological control involves introducing natural enemies to reduce invasive populations, though strict safety testing is essential to avoid unintended impacts. An integrated management approach that combines multiple control methods offers the most sustainable long-term solution. Effective management is also supported by national and international policies that promote coordinated action, early detection and biodiversity protection, along with active community participation in monitoring and control efforts. Looking ahead, climate change is expected to increase the risk of new invasions by expanding suitable habitats,

making advanced tools such as biotechnology and predictive modelling increasingly important for early detection and planning. Ultimately, sustainable ecosystem restoration through habitat rehabilitation and support for native species is critical for maintaining long-term ecological stability.

### Conclusion

Invasive species shows how a single ecological problem can take a form of disaster. It all starts with the introduction of non-native species on the ground where it doesn't belong. If it got established and start growing aggressively, it can have major impact on environment, economy and health. In today's interconnected world, it doesn't take much for the spread of non-native species, which means we must be observant and act to manage this time bomb. Effective management is a necessary, for protecting biodiversity, early detection and prevention. It is essential for sustaining stability and securing the future of life, on Earth. As global trade and climate change accelerate these biological invasions, there is an urgent need for both local community action

and unified global policies to protect our planet's fragile biodiversity.

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