Review Article

Invasive insects outbreaks in India during the 21st century-threat and management

Abstract

Alien species are non-native or exotic organisms that occur outside their natural adapted habitat and dispersal potential. The alien species become invasive when they are introduced deliberately or unintentionally outside their natural habitats into new areas where they express their capability to establish, invade and outcompete native species. Globalization has increased international agricultural trade; the movement of seeds and planting materials has enhanced the risk of introducing alien pests into India. Free trade propelled by economic liberalization has intensified the movement of goods across frontiers and geographic barriers without much quarantine, enhancing chances of introduction of exotic pests into agroecosystems. If not accompanied by the natural enemies that keep them in check in their native range, these species can multiply in large proportion and cause damage to economically important plant species and crop plants. Invasive Alien Species (IAS) are recognized as one of the greatest threats to the country's ecological and economic well-being. These species cause enormous damage to biodiversity and the valuable natural agricultural systems.

Keywords: Invasive, alien species, agroecosystem, natural enemies

Introduction

Alien species are non-native or exotic organisms that occur outside their natural adapted habitat and dispersal potential. 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 [1]. These invasive pests are widely distributed in all kinds of ecosystems worldwide and include all categories of living organisms. Globalization has increased international agricultural trade; the movement of seeds and planting materials has also enhanced the risk of introducing alien pests into India. If not accompanied by the natural enemies that keep them in check in their native range, these species can multiply in large proportion and cause damage to economically important plant species and crop plants. One of the best opportunities we have to reduce the impact of invasive alien species is to prevent them from becoming established in the first place and to understand how they manage to move or be moved outside of their native range.

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Features of invasive species

Invasive species tend to be hardy, long-lived, voracious, aggressively pervasive, very resilient, rapid growth, generalized diet, ability to move long distances, and prolific breeding [2]. Invasive alien species have invaded and affected native biota in virtually every earth's ecosystem. They occur in all major taxonomic groups, including viruses, fungi, algae mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds, and mammals. Invasive species can transform the structure and species composition of ecosystems by repressing or excluding native species, either directly by out-competing them for resources or indirectly by changing the way nutrients are cycled through the system. They cause negative impacts on the ecosystem, biodiversity, health, economics, other aspects of human welfare, and decline agricultural yield.

Pathways for entry and establishment

Natural Movement

Between approximately 150,000 to 130,000 years ago, much of North America was covered by ice. During these periods, plants and animals were pushed well beyond their natural range by the advancing ice and the changing climate. When the climate warmed, and the glaciers began to recede, these same species slowly followed the glaciers north and established new habitats. It is thought that many mammal species moved from Asia to North America. At the same time, the native range of any species may change naturally with changes in climate and landform.

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Unnatural or human-assisted movement

The problems we are experiencing today with invasive alien species are caused mainly by unnatural species movement where a plant, animal insect, or disease organism are moved outside its natural range into an area or ecosystem that they would not usually be able to get to on their own. Human activity has been the primary means of new species entering newer ecosystems and countries today.

Dreaded invasive alien insects

A recent study showed that about 1300 species of invasive insect pests and pathogens had been introduced into 124 countries [3]. In Southeast Asia, 677 alien insect species are reported, including almost all insect orders, but most belong to Coleoptera, Hemiptera, and Lepidoptera insect orders [4]. In India, 173 invasive species include 54 terrestrial plants, 56 aquatic organisms, 47 organisms having agricultural importance, and 14 organisms of the island ecosystem [5].

These alien pests find the new habitat ideal and conducive for breeding and establishment without any restriction through natural regulating factors like natural enemies that keep these species under check in their native range. Managing such invasive species is ideally attempted through classical biological control involving the introduction of effective exotic natural enemies from the native range of the introduced pests to re-establish the lost balance between the pests and the natural enemies.

Even though dealing with these alien pests is a huge task, the entomologists at NBAIR have successfully dealt with all the introduced alien pests. In the XII Plan, there is a need to recruit more entomologists at NBAIR to successfully manage the alien pests which are likely to gain entry into India.

List 1: List of Invasive Pests in India during 21st Century

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Sr No	Common Name	Scientific Name	Native	First report	Host Plant	Year
1	Eucalyptus Gall Wasp	*Leptocybe invasa* (Fisher & La Salle)	Australia	Karnataka	*Eucalyptus spp.*	2001
2	Erythrina Gall Wasp	*Quadrastichus erythrinae* (Kim)	Panama-Central America	Thiruvanantapuram, Kerala	*Erythrina stricta Roxb.*	2005
3	Cotton Mealy bug	*Phenacoccus solenopsis* (Tinsley)	USA	Punjab	Cotton	2006
4	Papaya Mealy Bug	*Paracoccus marginatus* (Williams and Granara de Willink)	Mexico and Central America	Coimbatore, Tamil Nadu	Papaya	2008
5	Madeira Mealy bug	*Phenacoccus madeirensis* (Green)	Neotropical region South America	Bandipur National park, Karnataka	*Cestrum nocturnam*	2012
6	Jack Beardsley Mealy bug	*Pseudococcus jackbeardsleyi* (Gimpel and Miller)	Neotropical region South America	Tamil Nadu	Papaya, Banana, Custard Apple, Hibiscus	2012
7	Lantana Mealy bug	*Phenacoccus parvus* (Morrison)	South America	Bangalore, Karnataka	*Crysanthemum sp., Amaranthus sp.,*Tomato, Capsicum	2012
8	Rose Aphid	*Wahlgreniella nervata* (Gillette)	North American	Bangalore	Rose	2014
9	Tomato Pin Worm	*Tuta absoluta* (Meyrick)	South America (Peru)	Pune, Maharashtra	Tomato, Potato, Eggplant	2014
10	Western Flower Thrips	*Frankliniella occidentalis* (Pergande)	Western half of North America	Bangalore	Tomato, Groundnut, Cotton, Tobacco	2015
11	Rugose Spiraling White Fly	*Aleurodicus rugioperculatus (*Martin)	Mexico	Coimbatore, Tamil Nadu	Coconut, banana, Apple	2016
12	Fall Army Worm	*Spodoptera frugiperda* (Smith)	Western hemisphere tropics from US to Argentina	Karnataka	Maize, Sugarcane, Sorghum	2018

13	Woolly whitefly	*Aleurothrixus floccosus*	Neotropical		Guava, *Citrus* species	2019
14	Neotropical whitefly	*Aleurotrachelus atratus*	Neotropical		*Cocos nucifera* and *Dypsis lutescens*	2019

1. Blue gum chalcid, *Leptocybe invasa* Fisher and La Salle (Eulophidae: Hymenoptera)

The blue gum chalcid is a gall-inducing wasp native to Australia. It has become a pest of planted eucalypt forests in various parts, including Kenya, Morocco, New Zealand, Tanzania, and Uganda. It was reported from Mandya during 2001 in planted forests and nurseries of *Eucalyptus camaldulensis* Dehnh and *E. tereticornis* Smith.

Hosts: *Eucalyptus camaldulensis*; *E. tereticornis*; *E. grandis*; *E. deanei*; *E. globules*; *E. nitens*; *E.botryoides*; *E. saligna*; *E.gunii*, *E. robusta*; *E. bridgesiana*; *E. viminalis*.

Ovipostion: Eucalyptus gall wasp lays eggs in the bark of shoots or the midribs of leaves

Damage: *L. invasa* lays eggs in the bark of shoots or the midribs of leaves. The eggs develop into minute, white, legless larvae within the host plant. Damage is caused when the developing larvae produce galls on the leaf midribs, petioles, and twigs (Plate 1). The galls can cause the twigs to split, destroying the cambium. Small circular holes indicating exit points of adults from pupae are common on the galls. Repeated attacks lead to loss of growth and vigor in susceptible trees. Severely attacked trees show gnarled appearance, stinted growth, lodging, dieback, and eventually tree death [6].

Plate 1. Galls produced by *L. invasa* on the leaf midribs

Biological control: *Quadrastichus mendeli* and *Selitrichodes kryseri* are promising parasitoids.

2. Erythrina gall wasp (EGW) *Quadrastichus erythrinae* Kim (Eulophidae: Hymenoptera)

EGW is an invasive insect pest on *Erythrina spp*. in major black pepper (*Piper nigrum* L.) areas of Kerala and Karnataka. EGW was first reported damaging *Erythrina* spp. in Taiwan in 2004 and first recorded in India from the southern districts of Kerala, including Thiruvananthapuram district in 2006. Later, it was observed on *Erythrina* spp. in Pune, Satara, Sangli and Kholapur districts of Maharashtra, Belagavi and Dharwad districts of Karnataka during the same year.

Nature of damage: Shoots become swollen, forming many thick-walled glob galls (Plate 2). After feeding within the galls, the larvae pupate, and the adult wasp cut exit hole through plant gall material to emerge.

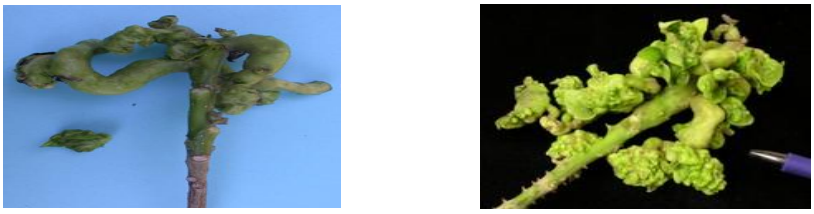

Plate 2. Swollen shoots of Erythrina by EGW

There is no severe incidence in Kolar, Mandya, and Ramnagar has been reported because promising parasitoid like *Aprostocetus gala* (Plate 3) was recorded with 7 to15 percent parasitization [7].

Plate 3. *Aprostocetus gala* on EGW

3. **Papaya mealybug:** *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae)

It is native to Mexico; the infestation was first recorded in India during 2007 on papaya, at Coimbatore, Tamil Nadu. By 2009, the pest assumed the major pest status across the country and caused massive damage to mulberry, tapioca, jatropha, cotton, and several fruits, flowers, and plantation crops in Tamil Nadu, causing 90 percent damage. In June 2010, the occurrence of papaya mealybug in Karnataka on Mulberry in the area of Chamarajanagar was reported. The incidence was seven percent, and the intensity was recorded to be 42.9 percent. It was confirmed that the pest has just made its entry from Talawadi in Tamil Nadu through infested mulberry cuttings [8,9].

Nature of damage: Nymphs and adults of *P. marginatus* suck the plant sap and weaken it (Plate 4). The leaves become crinkled, yellowing, and withering. The honeydew excreted by the bug and associated black sooty mold formation impairs the photosynthetic efficiency of the plant.

Plate 4. Nymphs and adult of *P. marginatus* on papaya fruit and leaf

Economic loss: Nearly 576 ha of papaya in Coimbatore districts had been affected. There are 60 plant species as hosts for Papaya mealybug, the pest has spread to almost all ecological niches in India through the transport of infested papaya fruits. Fortunately, the pest had been successfully managed through the intervention of classical biological control wherein *Anagyrus loecki*,

Pseudleptomastix mexicana and *Acerophagus papaya* were imported from the USA (Plate 5). Predators like *Cryptolaemus montrouzieri*, lacewings, hoverflies and *Scymnus sp*. also play an essential role in managing this pest in the cotton ecosystem [10].



Plate 5 i) *Anagyrus loecki* **ii) *P. Mexicana*** ***iii) A. papaya***

4. Cotton mealybug, *Phenococcus solenopsis* Tinsley (Hemiptera: Pseudococcidae)

Cotton mealybug is native to Central America; In India, the first incidence of *Phenacoccus solenopsis* in cotton was reported from Punjab in 2006. The widespread damage it caused in the country in 2006 has been of utmost concern to the entire continent. Cotton mealybug poses a significant threat to cotton cultivation all over the country and causes significant economic damage. The pest has invaded all cotton-growing areas in the country.

Economic loss: Mealybug was noticed to appear on cotton crop in India from 2003-04 onwards [11]. This coincided with the introduction of Bt. cotton, its rapid adoption by the farmers, effective control of the bollworms and reduction in pesticide use. The pest became a threat to Bt cotton by 2006 and 2007 in Punjab, Haryana, Rajasthan, Gujarat and Maharashtra [12] and caused significant losses in cotton production. In Punjab the losses caused by the mealybug were estimated to be Rs. 159 crores to cotton growers during kharif season 2007 [13].

5. Coconut hispine beetle, *Brontispa longissima* Gestro (Chrysomelidae: Coleoptera)

It is native to Indonesia and first introduced to India from Sri Lanka in 2009 through the movement of infected planting material. The pest has been expanding in areas around Southeast Asian countries, and it was found in Myanmar in 2004, followed by the Philippines in 2005. The host of this pest are betel nut palm, coconut, African oil palm, bottle palm.

Biological control: Removing coconut and other palms to prevent the beetle from spreading. *Asecodes hispinarum and Tetrastichus brontispae* as in Plate 6 [14].


Plate 6 i) *Asecodes hispinarum* **ii) *Tetrastichus brontispae***

6. Tomato leafminer: *Tuta absoluta* Meyrick (Gelichiidae: Lepidoptera)

It is native to South America and was initially observed in Pune on tomato plants during October 2014. The infestation of *T. absoluta* ranged from low to high (up to 15 mines/plant) in different tomato

fields surveyed in six districts of Karnataka State viz., Bengaluru, Kolar, Chikkaballapur, Ramanagar and Tumkur. The percent infestation was to the tune of 87 percent [15,16].

Nature of Damage: After hatching, young larvae of *T. absoluta* immediately mined into tomato leaves, apical buds, stalks, or fruits. Feeding resulted in inconspicuous mines (blotches), galleries on leaves, and pinhole-sized holes on fruits from the stalk end generally covered with frass. Larvae mainly attacked leaves, creating blotch/leaf mines visible from both leaf sides. The mines have dark frass visible inside, and the mined areas turned brown and dried over time.

Plate 7. Leaf mining by *Tuta absoluta* larva

Alternate hosts of *Tuta absoluta* are Tomato, Potato, Eggplant, Pepper, Tobacco and other solanaceous plants and weeds.

Egg parasitoids: *Trichogramma exiguum*, *Trichogramma nerudai*, *Trichogramma pretiosum* [17].

Larval Parasitoids: *Goniozuz nigrifemur* (Bethylidae), *Apanteles spp*. (Braconidae) *Bracon spp*. (Braconidae), *Chelonus sp*. (Braconidae) and *Dineulophus phthorimaea* (Eulophidae).

Management: Immediately after the occurrence of *Tuta absoluta* in 2014, (DPPQS), GOI, a nodal agency for quarantine along with (ICAR) monitored the pest status in India. In 2015, CIBRC, part of DPPQS, made adhoc recommendation of a few insecticides

- Chlorantraniliprole 10.26% OD @ 0.3 ml/L,
- Cyantraniliprole 18.5% SC @ 0.3 ml/L,
- Flubendiamide 20%WG @ 0.3 ml/L,
- Indoxacarb 14.5% @ 0.5 ml/L
- Imidacloprid 17.8%SL @ 0.3 ml/L)

Monitoring: Identify pest occurrence and take timely control measures. (Ex. Pest Control (India) Pvt. Ltd; Epheromone IPM Solutions etc.). Trapping of 20-50 moths/trap immediate action should be taken.

Cultural methods: Do not use seedlings from pest-infested areas. Two months gap between two crops to avoid carryover population. After ploughing, cover the soil with plastic mulch or perform solarisation and remove the alternate weed host *viz., Datura sp.* (Datura) and *Nicotiana glauca* (Tree tobacco) **Western Flower Thrips, *Frankliniella occidentalis* (Pergande) (Thripidae: Thysanoptera):** It is native to the Southwestern United States; in India first reported from Bangaluru on tomato [18]. WFT transmitted Tomato spotted wilt virus.

Host: Variety of hosts including groundnut, cotton, tobacco, vegetables (eggplant, tomato, carrot, peas, capsicum), fruits (grapes, apple, peach), ornamentals (gladiolus, hibiscus, roses).

Biocontrol agents of Western Flower Thrips [19].

i. ***Amblyseius swirskii*:** Feeds on both first and second instar larvae. Tolerates higher temperatures than *Neoseiulus cucumeris*. Feeds on pollen in the absence of prey.
ii. ***Neoseiulus cucumeris*:** Most widely used predatory mite for western flower thrips. Feeds on the first instar larvae.
iii. ***Orius spp.*:** Feed on larvae and adults of western flower thrips.
iv. ***Stratiolaelaps scimitus*:** Adults may kill up to 30 prey, including western flower thrips pupae.

7. Jack Beardsley mealybug, *Pseudococcus jackbeardsleyi* Gimpel and Miller (Hemiptera: Pseudococcidae)

It is native to Central and South America; it was recorded in India from Tamil Nadu in 2012on papaya and distributed throughout the Neotropical region and in southern Asia and found in association with papaya mealybug and cotton mealybug. It is a polyphagous pest feeding upon 93 plant species of vegetable, fruit, and ornamental crop species [20].

Host Plants: Pepper, Eggplant, Tomato, Tropical fruit trees, Tropical shrubs, Ornamentals.

Plate 8: i) *P. jackbeardsleyi* (Ventral view) ii) *P. jackbeardsleyi* (Dorsal view)

Management: *P. solenopsis* and *P. marginatus*, fast establishment on weeds and ornamental crops. *P. beardsleyi* very slow establishing species and is expanding slowly. Under check by local natural enemies, *Cryptolaemus montrouzieri*, *Spalgis epius* and some species of gnats. Coccinellid, *Cryptolaemus montrouzieri* Mulsant are some natural emenies [21].

8. Madeira mealybug, *Phenacoccus madeirensis* Green (Hemiptera: Pseudococcidae)

It is native to the Neotropical region and found in Pakistan, Philippines, Vietnam, Thailand, and Japan. It is the latest invasive mealybug in India and was first recorded from Karnataka. It is a highly polyphagous pest, attacking 152 plant species in 46 families, including many agronomic and horticultural crops in both indoor and outdoor productions [22].

Host Plants: Cotton, tomato, potato, brinjal, tapioca, mulberry, acalypha, *Hibiscus rosasinensis, Lantana camera* and *Clerodendron viscosum*

Plate 9:- Madeira mealybug

Natural Enemies: Parasitoids: *Allotropa sp, Anagyrus sinope, Anagyrus qadrii (*Predominant*), Anagyrus sloeckii, Anagyrus amnestos* [23]

Predator: *Cacoxenus persipicax, Cryptolaemus montrouzieri* and *Scymnus* sp.

Anagyrus amnestos (Hymenoptera: Encyrtidae): Promising parasitoid of the invasive Madeira mealybug. Parasitism rate ranged 17–40% within 24 hours, each female parasitoid producing a range of 58–71 offspring over her lifetime at an average female: male ratio of 2:1. *A. amnestos* preferred parasitizing second instar and adult of *P. madeirensis* [24].

10. Lantana mealybug: *Phenacoccus parvus* Morrison (Pseudococcidae)

It is native to South America and spreaded in Africa, tropical Pacific region of Australia, Southern Asia and China. It was first reported from India in Bangalore on China Aster *Callistephus chinensis* [25]. It is a pest of more than 50 species of host plant belonging to 26 families. It is also a promising biocontrol agent for *Lantana camera* in Queensland and Australia.

Plate 10: Lantana mealybug

11. Rugose Spiraling White Fly *Aleurodicus rugioperculatus* Martin (Aleyrodidae)

It is native to Belize, Guatemala, and Mexico and spread to 22 other Central and South American countries, including Florida, USA. It was first reported from India in the Pollachi area of Coimbatore district, Tamil Nadu in Coconut farm. India is the only country in the oriental region where this whitefly has been introduced [26,27].

Host Plants: Coconut, banana, apple and several ornamental crops. Coconut and banana are the most common and preferred hosts. More minor infestations were seen on guava, citrus, mango, sapota, okra, custard apple, jatropha, and hibiscus [28].

Fig 11: Damage

Damage: Egg spirals of rugose spiraling whitefly on the underside of leaves. Presence of heavy white, waxy material. Presence of sticky honeydew around the whitefly-infested area. Black sooty mold formation. Leaf damage [29].

Management

Biological control: *Encarsia guadeloupae* Viggiani, *Encarsia dispersa, E. noyesi, Alueroctonus vittatus, Nephaspis oculata and Menochilus sexmaculatus* [30]. *E. guadeloupae* (Hymenoptera: Aphelinidae) parasitized 40 to 70% banana [31] and 20–60% on coconut in Tamil Nadu and Kerala has been reported [26].

12. Fall Armyworm: *Spodoptera frugiperda* (Smith) (Lepidoptera, Noctuidae)

It is native of the Western hemisphere tropics from the U.S.A to Argentina and spread to Africa in the 2016 on maize crop. In India, it was first reported from Karnataka in Chikkaballapur, Hassan, Shivamogga, Davanagere and Chitradurga district in 2018 [32,33].

Hosts in India: Maize and sorghum in southern Karnataka and sugarcane in Maharashtra. Within only six months, almost 50 percent of the country, including Mizoram, Maharashtra, Karnataka, Tamil Nadu, Andhra Pradesh, Chhattisgarh, Madhya Pradesh, Gujarat, and West Bengal, FAW infestations has been reported. It prefers young maize plants and attacks all stages of the maize plant, whereas foliar consumption is major; under heavy infestations, it also feeds on maize ears. The foliar damage appeared as ragged feeding and moist sawdust-like frass found near the whorl and upper leaves of the plant.

Management

Monitoring: Pheromone traps @ 5/acre

Cultural Measures: Deep ploughing, timely sowing and avoiding staggering sowings. Intercropping (eg. Maize + pigeon pea/black gram/green gram). Bird perches @ 10/acre (up to 30 days). Sowing of 3-4 rows of trap crops (eg. Napier). Clean cultivation and balanced use of fertilizers.

Mechanical control: Hand picking, applying dry sand and ash into the whorl, mass trapping (traps @ 15/acre).

Biological control [34]

- *In situ* protection of natural enemies by habitat management
- Augmentative release
- *Trichogramma pretiosom*
- *Telenomus remus* @ 50,000/acre
- Biopesticides: *Metarhizium anisopliae* @ 5g/litre , *Nomuraea rileyi* @ 3g/litre, *Bacillus thuringiensis v. kurstaki* @2g/L(or) 400g/acre

Chemical control:

- 5% NSKE / Azadirachtin 1500 ppm @ 5ml/l of water.
- Emamectin benzoate @ 0.4 g/l of water
- Spinosad @ 0.3 ml/L of water
- Thiamethoxam 12.6% + lambdacyhalothrin 9.5%@ 0.5 ml/l of water
- Chlorantraniliprole 18.5% SC @ 0.3 ml/l of water

Companies producing Pheromone traps: ISCA Technologies, California, U.S.A, Russell IPM and Pherobank.

Whereas in India are Pheromone Chemicals, Hyderabad, Green Revolution (Kolhapur, Maharashtra), Innovac Bioscience Private Limited (Vadodara, Gujarat), Land Marshal Chemical Industries (Guntur, Andhra Pradesh).

International Scenario

The Convention on Biological Diversity (CBD), adopted in 1992, incorporates provisions regarding alien species that threaten ecosystems, habitats, or species. The International Plant Protection Convention (IPPC), which has existed since the 1950s, aims to prevent the introduction and spread of plant pests. National plant protection services and the governing body of the IPPC, the Interim Commission on Phytosanitary Measures (ICPM), recognized that the aim of the CBD to prevent the introduction of alien species corresponds in large measure to the aim of the IPPC. In 2003, the ICPM adopted supplements to two international standards for phytosanitary measures. To

avoid conflicting developments within the IPPC and the CBD regarding invasive alien species and plant pests, the secretariats of the two conventions have established a Memorandum of Cooperation and developed a joint work plan as was called for by the Conference of Parties to the CBD at its seventh meeting. A comparison between these guiding principles and provisions of the IPPC shows strong correspondence and considerable overlap.

Suggestions/ future threats/ management [35].

The spread of invasive alien species is creating complex and far-reaching challenges that threaten both the natural biological riches of the earth and the well-being of our people. While the problem is global, the nature and severity of the impacts on society, economic life, health, and natural heritage are distributed unevenly across nations and regions.

Some aspects of the global IAS problem require solutions tailored to nations' specific values, needs, and priorities, while others call for consolidated action by the larger world community. Preventing the international movement of invasive alien species and coordinating a timely and effective response to invasions requires cooperation and collaboration among governments, economic sectors, non-governmental organizations, and international treaty organizations.

At the national level, consolidated and coordinated action is required. This could be part of a national biodiversity strategy and action plan, with close involvement of the economic sectors and identifying people responsible for operative actions involving potential IAS as a key prerequisite. The capacity and expertise to deal with IAS are not yet sufficient in many countries. Therefore further research on and capacity building around the biology and control of IAS and biosecurity issues needs to be given attention and priority.

A global information system regarding the biology and control of IAS is also required. Tools, mechanisms, best management practices, control techniques, and resources must be provided and exchanged. Such a proposed system is currently developed as part of the Global Invasive Species Information Network (GISIN) and is intended to link to the Clearing House Mechanism of the Convention on Biological Diversity. Awareness-raising and education regarding IAS should be given high priority in action plans, and the development of economic tools and incentives for prevention are urgently needed.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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