

Invasive Alien Species in Sri Lanka

TRAINING MANUAL FOR MANAGERS AND POLICY MAKERS



INVASIVE ALIEN SPECIES IN SRI LANKA

Training Manual for Managers and Policy Makers



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for Managers and Policy Makers.**

Biodiversity Secretariat,

Ministry of Mahaweli Development and Environment

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WHAT IS THIS BOOK ABOUT?

Many species are introduced to areas outside of their natural range, and are hence non-native, but not all of these will become invasive. Many will not be able to adapt to the new environment at all, and may eventually die-off. Most plants consumed by Sri Lankans originate from other parts of the world. Even today, hundreds of new plant and animal species are brought to Sri Lanka for various purposes. This process is not confined to Sri Lanka as it happens all over the world.

What happens to these introduced species? Some species are confined to human habitats such as home gardens, botanical gardens or farmlands, or end up in fish tanks or cages as pets. A few of them are able to escape, from where they are intended to be confined, and mix with other species and habitats. Although most of these species are not able to survive in such new environments, a very small portion of them manage to persist in their new homes. Out of this small portion of species, a blend with the natural ecosystems and maintain their populations, without causing harm to native biodiversity. Some of them grow rapidly in human settlements, especially in farmlands, and cause damage to agricultural crops and livestock. These are known as pests and weeds. Lastly, a very small number of introduced species are able to survive, colonize and disperse beyond their areas of introduction and beyond their purpose of introduction, by suppressing man-made and natural ecosystems, and replacing native plant and animal species. Such species are known as Invasive Alien Species (IAS).

There are a number of invasive alien plant and animal species in Sri Lanka. They are currently causing the loss of millions of rupees to our economy in several ways. They are also suppressing our unique biological diversity and ecosystems. The aim of this manual is to provide valuable information on IAS, and to provide guidelines on identification and management practices.

This book is especially designed to cater to the managers and policy makers who are responsible for the management and control of IAS. It is anticipated that this descriptive manual will share a wide range of knowledge relevant to the design and practice of effective invasive alien control programmes.

Did you know?

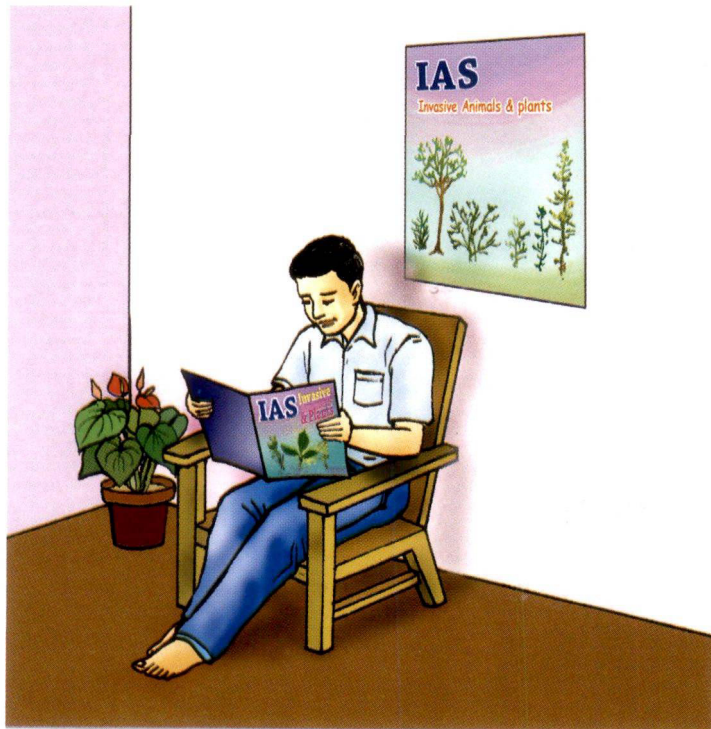
Invasive Alien Species (IAS) negatively impact the global economy, cost billions of dollars to countries in losses from agricultural production, and cause trillions of dollars of environmental cost worldwide, annually.

INTRODUCTION TO INVASIVE ALIEN SPECIES (IAS)

What are IAS?

As explained in the previous chapter, Invasive Alien Species (IAS) are recognized as one of the leading threats to biodiversity, and also impose enormous costs on agriculture, forestry, fisheries and other human enterprises, as well as on human health. Among the many definitions for IAS, the following description has been adopted by the Convention of Biological Diversity (CBD) as the widely accepted definition: **“Invasive Alien Species (IAS) are species whose introduction and/or spread outside their natural past or present distribution threatens biological diversity.”**

Two facts are embedded in the above definition, which we would like to highlight. The first main fact is that the species should be introduced or non-native. To put it more simply, invasive alien plants or animals should come from another country (beyond geographic boundaries), region or ecosystem to a new country, region or ecosystem. An example would be a lion being taken from Africa to America. The second fact is that such an alien species should be a threat to native biological diversity. These two factors together form an IAS.



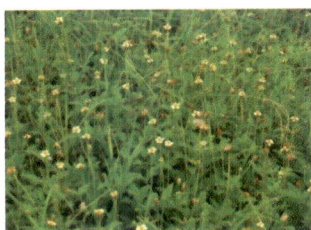
ALIENS, INVASIVES, PESTS, WEEDS AND IAS

There are many introduced plant and animal species in home gardens, roadsides, farmlands and even in natural habitats. Can all those species really be considered invasive? It is very difficult to draw a sharp line between IAS and weed/pest species. Basically, as explained in the previous section, most introduced species, including weeds and pests, are not IAS. Occasionally, such species may affect the economy, human health, agriculture and even native biodiversity to some extent. However, some pest and weed species are considered to be IAS and some IAS are also considered to be pests and weeds.

As clearly explained in the definition, species which have an impact on native biological diversity are considered IAS. As such, most weeds that grow in agricultural lands are not considered to be IAS, as here they do not greatly affect native biodiversity. Additionally, even a native species can be considered a weed or a pest if it damages crops, livestock or human beings. In most cases, weeds and pests are seasonal and can therefore be controlled with simple weed and pest control systems.

IAS damage native biodiversity through various ways. Some invasive alien plant species directly invade and alter natural ecosystems (for example *Prosopis juliflora* in Bundala National Park and *Ulex europaeus* in Horton Plains National Park). Some species affect semi-natural habitats or suppress the natural succession of the ecosystems. For example, species such as (*Panicum maximum*) invade disturbed areas and suppress the growth of pioneer species that naturally grow in disturbed ecosystems.

SOME COMMON WEEDS THAT ARE NOT CONSIDERED AS IAS IN SRI LANKA



Tridax procumbens



Euphorbia hirta



Stachytarpheta indica

INVASIVE ALIEN SPECIES IN THE SRI LANKAN CONTEXT

Sri Lanka is home to a unique biodiversity due to its varied climatic and topographical conditions. Our biological diversity is seen to be facing many threats, of which IAS have resulted in major impacts on biodiversity both globally and locally. The impacts of these species are immense, insidious, and most often irreversible. The costs of these biological invasions are enormous in both an economic and ecological sense. In Sri Lanka, the majority of the invasive alien plant species has been imported and introduced via agricultural and horticultural purposes and have established themselves in natural, semi-natural and human settlements. Many invasive alien animal species introductions are accidental. For example the Clown knife fish (*Chitala ornata*) and the Tank cleaner (*Pterygoplichthys disjunctives* & *P. paradalis*).

IAS have invaded almost all terrestrial and inland aquatic ecosystems of Sri Lanka. Horton Plains National Park, known as the highest plateau in the country, is being invaded by *Ulex europaeus* and Rainbow trout (*Oncorhynchus mykiss*). Mean while forests and other habitats in the sub-montane region have been invaded by *Clusia rosea* and *Psidium littorale*; wet lowland areas by *Alstonia* (*Alstonia macrophylla*) and *Clidemia hirta*; wet zone marshes and flood plains by *Annona glabra* and *Dillenia suffruticosa*; dry lowlands by *Opuntia dillenii* and *Prosopis juliflora*; wet zone rivers, canals and marshes by Knife fish (*Chitala ornata*), and Tank cleaners (*Pterygoplichthys disjunctives* & *P. paradalis*)

You may be wondering why it is that Cats (*Felis catus*), Dogs (*Canis familiaris*) and Water buffalos (*Bubalus bubalis*) are listed as potential IAS in Sri Lanka. This is because there are wild cat species in Sri Lanka which belong to the same genus as domestic cats, such as the Jungle cat (*Felis chaus*) and the Rusty-spotted cat (*Prionailurus rubiginosus*), which are much similar in size to the domestic cat. Thus, there are some records of hybridization (*cross breeding*) occurring between domestic cats and wild cats, which ultimately have contributed to the depletion of health of wild cat populations in Sri Lanka. Furthermore, the domestic cat is a known predator of many native small mammals, birds, reptiles as well as many species of invertebrates. Dog populations that live around forests and other natural habitats are known to have killed native wild animals, including Black napped hare (*Lepus nigricollis*), Mouse deer species (*Mosciola spp.*), Spotted deer (*Axis axis*) and many others. Additionally, there is the possibility of dogs spreading diseases, such as rabies, to Jackals (*Canis aureus*). There is also some evidence of hybridization between Water buffalo (*Bubalus bubalis*) and Wild buffalo (*Bubalus arnee*). All of these serve to deplete native species.



Prosopis juliflora invasion in Embillakala Lagoon in Bundala National Park



Dillenia suffruticosa invasion in agricultural lands in Poddiwela, Galle District

IMPACTS OF IAS

Agriculture

Crop Loss: One of the most prominent impacts of invasive species is the direct loss of crops due to infestations.

Decline in value of Rangeland/Farmland: Invasive plants impact on agriculture by decreasing the forage value of rangelands and decreasing the productive area of farmlands.

Depletion of Water Resource: IAS (such as Water Hyacinth) can reduce water quality and flow, as well as the damage on fisheries.

Economy

- Control or management of many introduced species is costly and is often labour intensive
- Crop damage and the decrease of productive lands cause economic losses.

Health and Social Issues

- Some invasive aliens cause health issues. Introduced species can bring previously unreported diseases. Native plants which are of medicinal value can be threatened by IAS.
- Most invasive plants disturb the scenic beauty of the area and can directly or indirectly create concern and stress among local communities and badly affect the tourism industry.

Biodiversity and Ecosystem

IAS can transform the structure and species composition of ecosystems by dominating the ecosystems and suppressing or excluding native species. For example, *Lantana camara* (Gandapana) secretes toxic chemicals into the soil to suppress the surrounding plants. This also affects animals, like elephants, that feed on those plants.

IAS IDENTIFICATION METHODS

There are two documents published by the Ministry of Mahaweli Development and Environment to help in identifying IAS. Invasive plants or animals can be identified using the provided Pictorial guide. If anyone comes across any suspected IAS, and is unable to identify it there and then, it is advisable that the species be photographed or sketched for later identification by a specialist or by using a descriptive guide (Fig 2 and fig 3).

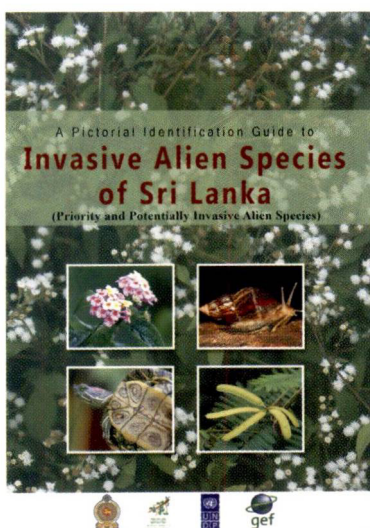


Figure 2: Pictorial Guide

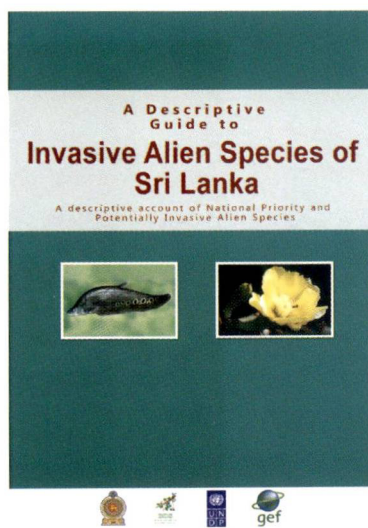


Figure 3: Descriptive Guide

FOR INVASIVE PLANTS

When taking photographs, it is essential that the photographs capture most of the characteristics of the plant, so that a specialist can identify it later solely by the photographs themselves. Therefore, it is important that the habit (form in which the plant grows), the leaves, a close up of the flowers and fruits (if present) of the plants are photographed.

If a camera is unavailable, you can make a rough sketch of the plant, noting all the important features.

Another option is to collect a specimen of the plant. For this purpose, a good representative sample containing all available parts of the plant (i.e. fruits, flowers and buds, as well as bark and leaves, etc.) should be taken along with detailed notes on the plant and its surroundings (i.e. location information: GPS coordinates, district, nearest town, area, access roads, etc.).

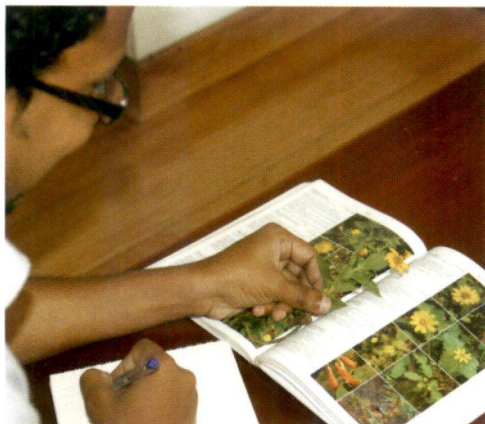
However, it should be noted that prior permission is required from the authorities (Forest Department, Department of Wildlife Conservation) to collect any plant specimen from any protected area in Sri Lanka (Conservation Forests, National Parks, Strict Nature Reserves etc.).

A collected specimen can be dried by pressing it between newspaper sheets using a weight. The dried specimens, photographs or sketches can then be identified by at the National Herbarium of Sri Lanka, any local University or by the Species specialists at the IUCN Sri Lanka country office (see the list in page 30).



Wedelia: (*Sphagneticola trilobata*); A good quality picture helps to identify IAS

Important tools that can be used for the identification of invasive alien plants



You can use the field guide or descriptive guide for direct identification of invasive plant species.

The illustrations, photographs and descriptions provided in the field books will help you to identify plants by yourself.



If you have a camera you can take good quality photos of leaves, flowers, fruits and plant habit.

Photographs will help you identify plant species using guides. You can also show them to others when visiting relevant institutes or when meeting with experts.



Producing a rough sketch while marking/annotating the colours of the plant will also help you identify the species.

You have to ensure your illustration will help identify the shape of the leaves, fruits and flowers

Figure 4: Methods for identifying Invasive Alien Plant Species

FOR INVASIVE ANIMALS

If you choose to take photographs, it is essential that the photographs capture most of the characteristics of the animal so that a specialist can identify it later by the photographs alone. Therefore, it is important that the whole body (shape) and a close up of the mouth or special features (if present) of the animals are photographed.

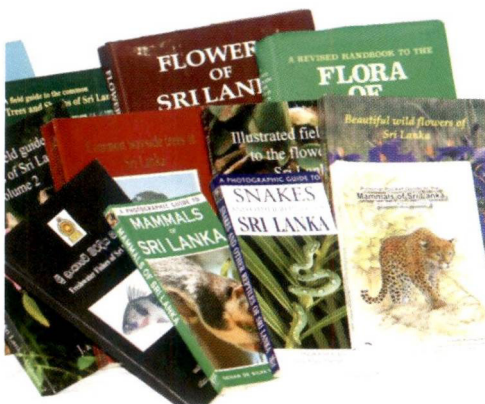
If a camera is unavailable, make a rough but detailed sketch of the animal with all the important features and colours marked.

It is also important to note the location where the particular animal was observed (GPS coordinates, District, closest town, area name and the access roads). The photographs or sketches can later be identified by at the Zoology Section of the National Museum of Sri Lanka or at any local University, or by the Species specialists at the IUCN Sri Lanka country office. Alternatively, you can identify animals by comparing your photographs or sketches to with descriptive guides.



Red eared slider turtle - (*Trachemys scripta*)

Important tools that can be used for the identification of invasive alien animals



You can use a field guide or descriptive guide for direct identification of invasive animal species.

The illustrations, photographs and descriptions provided in the field books will help you to identify animals by yourself



If you have a camera, you can take good quality photos of the body shape and any other special features on the legs, mouth, tail etc.

Photographs will help you identify animal species using guides. You can also show them to others when visiting relevant institutes or when meeting with experts.



Producing a rough sketch while marking/annotating the colours of the animal will also help you identify the species.

You have to ensure your illustration will help identify the shape of the body and other special characteristics.

Figure 4: Methods for identifying Invasive Alien Animal Species

MANAGEMENT OF IAS IN SRI LANKA

Management of IAS is not a simple task. A continuous and strong workforce is required to deal with these species at multiple levels. As indicated in the IAS Management and Guiding Principles in the Convention on Biological Diversity (CBD), a broad approach is needed from prevention and containment, to total eradication, depending on the given situation. The table below describes the CBD principles for IAS management:

The Three Tier management approach for managing IAS at the country level:

1. Prevention of IAS introductions between and within states is generally far more cost-effective and environmentally desirable than measures taken for IAS introduction and establishment.
2. If an IAS has been introduced, early detection and rapid action are crucial to prevent its establishment the preferred response is one to eradicate the organisms as soon as possible.
3. Where eradication is not feasible or resources are not available, containment and long-term control measures should be implemented.

(CBD Guiding Principle 2)



PREVENTION

It is obvious that prevention is the first and most important action in the IAS management process. As an island nation we are in a good position to control the introduction of IAS. The export and import of live animals, plants and planting material should be rigorously monitored in order to prevent the entrance of unwanted species to Sri Lanka. Pre-entry risk assessment will help to assess the risk level before the introduction of non-native species or review the risk level of already released species which occur naturally but are still not considered as IAS (e.g. some of the non-native weeds). Large amounts of data and information are needed for pre-entry risk assessments and most of such information can be obtained via websites which are devoted to IAS, weeds, pests and non-native species around the globe. It is vital to identify non-native species that can become invasive in Sri Lanka and to ban or control their import. Already, the importation of certain species of fish (e.g. Piranhas - carnivorous fish species) is banned under this concept in order to prevent the entrance of possible invasive species. Although such measures fall under higher policy level decisions and actions, there are certain actions that can be done at the local level to prevent invasive species from invading our natural and semi-natural ecosystems. The table below describes national and local level prevention actions that can be taken together with the manager/management body responsible for each action.

Action	Responsibility
Prevent importation of banned and possible invasive plant and animal species	Department of Wildlife Conservation Forest Department Department of Fisheries and Aquatic Resources Department of Agriculture Sri Lanka Customs
Prevent unwanted disposal or accidental escape of live exotic animals (pet fishes, birds, reptiles, mammals) into natural habitats	Department of Wildlife Conservation Forest Department Department of Zoological Gardens Police Department Local Authorities Universities and other research institutes Department of Fisheries and Aquatic Resources
Prevent the possibility of accidental introduction of invasive species through exotic seeds, planting materials and ornamental plant trade.	Department of National Botanical Gardens Department of Agriculture Department of Agrarian Development Department of Export Agriculture Sri Lanka Customs Universities and other research institutes
Prevent the possibility of accidental introduction of invasive species through aquaculture	Department of Fisheries and Aquatic Resources National Aquaculture Development Authority
Prevent the local level introduction of invasive species into new areas	Department of National Botanical Gardens Department of National Zoological Gardens Police Department Local Authorities Department of Wildlife Conservation Forest Department
Raise awareness on the importance of IAS prevention	Biodiversity Secretariat, Ministry of Mahaweli Development and Environment Department of Agriculture Department of Agrarian Developments Department of Education Central Environmental Authority Department of Irrigation Mahaweli Authority of Sri Lanka Coast Conservation & Coastal Resources Management Department Universities, National Institute of Education and other research institutes such as IUCN

EARLY DETECTION AND RAPID ACTION

It is inevitable that the introduction of alien species into Sri Lankan territory will take place occasionally, due to various factors. Prevention is not always possible. Therefore the next level/tier of management of IAS should be considered at the national as well as regional level. Looking at what detrimental effects could be caused by these IAS, early detection and treatment of such species has proven not only to be effective but also an ecologically sound management approach.



Strong inventories together with effective monitoring programs would provide the necessary information required to carry out these precautionary measures. Carrying out inventories provide baseline information on aspects such as distribution, presence and non-native plant populations. These also provide essential information needed to carry out planning and budgeting together with setting priorities. Early detection and rapid actions can be applied at two levels: at the national and at the regional level.

NATIONAL LEVEL

National level early detection and rapid response programmes should be focused on new introductions of alien species. It is important to keep an eye on possible invasions by alien species in different habitats and ecosystems. National park and forest officers, agricultural officers, officers attached to local governance bodies, estate managers, researchers as well as the general public can act as the early detection teams for the entire nation.



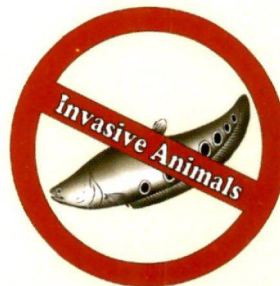
REGIONAL LEVEL

Regional level early detection and rapid response programmes are needed to prevent the invasion of a region by already established IAS from other regions or ecosystems of Sri Lanka. It is important to stop further invasion of species into new regions and ecosystems to minimize the damage caused by already known species. Identification of the spreading mechanism of IAS is vital to stop local invasions by such species.



GUIDELINES FOR EARLY DETECTION AND RAPID ACTION

- Identify the possible alien species that can be invasive to Sri Lanka based on international experience, and make available the list to relevant stakeholders.
- Record all non-native plant and animal species in the locality, especially in vulnerable areas such as wetlands, grasslands, abandoned lands, agricultural lands, roadsides, newly deforested areas, etc.
- Continuously monitor the national parks, forest reserves, estates, agricultural lands and other areas over time for possible invasions.
- Share the information with relevant government and research organizations.
- Organize and help others to implement total eradication programmes before such an invasion progresses to the next level.
- Monitor and maintain the area continuously to completely suppress the invasive species.



Case Study

Early detection of Giant Mimosa in the Colombo District

The Giant Mimosa (*Mimosa pigra*) is possibly one of the country's worst invasive alien plant species, spreading in the middle catchment of the Mahaweli region. It is almost impossible to totally exterminate the Giant Mimosa population in the Mahaweli region. Thus, the only option is to manage the populations, which may cost millions of rupees annually. A few newly established Giant Mimosa populations have been recorded in the Colombo district. It is possible that these populations may have become established through the contaminated sands coming from the Polonnaruwa and Mahiyanganaya area, where Giant Mimosas have extensively invaded. These small populations, which are newly established, in the Colombo district can be completely eradicated by a rapid action programme if done at this stage. However, if it spreads to other areas such as in flood plain marshes of the Lower Kelani River, it will be more difficult to eradicate, manage or control.



Early detection of Giant mimosa population in Kaduwela; Colombo District

ERADICATION, CONTROL AND CONTAINMENT OF IAS

If an IAS is established, then viable management options are needed in accordance with the situation. Eradication is more possible at the early detection period. However for well-established IAS populations, control and containment are usually the only options.

Eradication is the elimination of the entire population of an IAS, including any resting stages, in the managed area. When prevention has failed to stop the introduction of an alien species, an eradication programme is the preferred means of action. Prior to this means of action, a careful analysis of the costs (including indirect costs) and likelihood of success must be made together with adequate resources mobilized before eradication is attempted.

Eradication programmes involve several control methods, which will be listed below. Successful eradication plans, which have been used so far, have been single method of eradications.

- **Mechanical control:** Involves direct removal of the species by hand or with appropriate machines or firearms or traps
- **Chemical control:** Involves the use of herbicides, insecticides and rodenticides, which primarily affect the target species. These are delivered in a way that avoids the potential problem of resistance development over time and do not accumulate in the food chain
- **Sterile male releases:** This is usually combined with a chemical control
- **Habitat Management:** Involves measures such as prescribed burning, grazing and other activities
- **Hunting of invasive invertebrates**

If an eradication process is feasible, it is the preferred choice for action against an IAS. The advantage of using this measure of action as opposed to a long-term control is the opportunity for complete rehabilitation to the conditions prevailing prior to the invasion of these species. A well-designed and realistic eradication approach needs to be developed to achieve the required goal. In most cases, well established populations and large areas of infestation are unsuitable for eradication programmes. Therefore, the best chances for successful eradication of these species are during the early phase of invasion, while the target populations are small and restricted to a small area.

The chances for success can be improved by identifying a period when the target species are particularly vulnerable. Improvements in eradication technology, eradication experience and improved knowledge of the basic ecology of these invaders will improve eradication attempts in the future.

BASIC CRITERIA TO CARRY OUT A SUCCESSFUL ERADICATION PROCEDURE;

- The programme needs to be scientifically based.
- Eradication of all individuals must be achievable.
- Continued support by the public and all stakeholders must be ensured before hand.
- Sufficient funding must be secured for an intensive programme.
- Small, geographically limited populations of non-indigenous species are the easiest to eliminate.
- Immigration of alien species must be zero.
- All individuals of the population must be susceptible to the eradication technique used.
- Development and use of field methods will almost certainly need to be an iterative process.
- Effective team management and motivation is needed.
- A technique to monitor the species at very low densities, at the end of the programme, needs to be designed to ensure detection of the last survivors
- A monitoring phase should be part of the eradication programme to ensure eradication has been achieved
- Methods to minimize the chances of re-invasion and early detection of the eradicated species, should it re-establish, need to be in place

Controls and containments are the only options for well-established and widely distributed invasive species. Such programmes will cost millions of rupees, are highly labour intensive and need long term continuous monitoring. As such, the assessment of the economic efficiency of competing alternative strategies may be needed. Two major tools that are used to assess economic efficiency are Cost/benefit Analysis and Cost Effectiveness Analysis.

Cost/benefit Analysis:

Is a widely used economic tool that can be applied to see if the total benefits of a particular intervention in managing IAS would offset the costs of implementing it. It also provides a framework to measure net social benefits, with or without intervention scenarios. Among the key criteria used on evaluation of competing alternatives are the benefit/cost (B/C) ratio, net present value (NPV) and internal rate of returns (IRR). Tools such as sensitivity analysis can be used to capture uncertainty involved with benefit and cost estimates.

Cost Effectiveness Analysis:

This serves as an alternate tool in identifying the minimum cost solutions amongst a number of alternative strategies of management. Total costs can be calculated for different target levels taking all benefits and costs of respective strategies into consideration. Also, partial cost-effectiveness analysis could be performed on selected approaches, depending on the data availability.

CONTROL METHODS

There are a number of specific methods proposed for the control of invasive species. It is important to recognize and understand the complex nature, ecology and the importance of local conditions. Thus general statements about suitable control methods for groups of alien species, in specific habitats, should be approached with great caution.

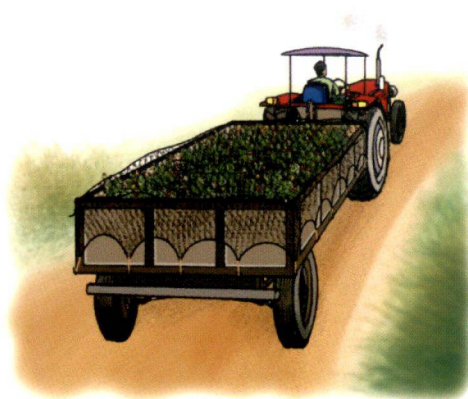
The most successful invasive species control programmes have been achieved with species-specific methods.

BEST PRACTICE GUIDELINES FOR ERADICATION, CONTROL AND CONTAINMENT OF IAS

- The programme should be planned based on scientific methods and should follow legal, policy and ethical considerations. Post-entry risk assessments will help to assess the risk level of already established IAS, and provide basic guidelines on management of such IAS. It is important to carryout post-entry risk assessments periodically against all known IAS.
- Consider other factors such as soil erosion and landslides before removing invasive alien plants in a vulnerable area.
- Some rare native animal species may hide, perch, feed or rear their juveniles inside or on invasive plants. It is better to move such animals, especially less mobile species, elsewhere before commencing the removal work. Always follow the safety measures when transporting invasive species to burning or dumping sites.



Unsafe transport of IAS



Safe transport of IAS

- Some species may have to be burned in order to cease regrowth. In such occasions, always follow safety measures.



Safe burning of IAS

- There exist IAS biological control and chemical / poisoning methods. With these, great care is required and risk assessments should be conducted before introducing such methods to IAS control.
- It is advised to pre-plan and follow-up with habitat restoration and continuous monitoring programmes within the IAS control and management programme. Destruction and removal is only one half of an IAS management program. The other half is habitat restoration.

Pre-entry risk assessment and Post-entry risk assessment of IAS

Pre-entry risk assessment of IAS is a scientifically developed methodology which can be used to assess the invasiveness of non-native species before the introduction of such species or at the early stage of introduction. On the other hand post-entry risk assessment can be used to assess the status of already established species. Both pre and post entry risk assessments provide vital information for IAS management. The first IAS risk assessment (pre and post) of Sri Lanka was carried out by the National Invasive Species Specialist Group (NISSG) in 2009.

LEGAL ASPECTS

Laws, Acts, Ordinances related to control of IAS

Sri Lanka is a signatory to both international and regional agreements related to trade. Some of these international agreements include the World Trade Organisation (WTO), South Asian Free Trade Area (SAFTA) as well as international conventions related to IAS such as the Convention of Biological Diversity (CBD), International Plant Protection Convention (IPPC) and International Convention for the Prevention of Pollution from Ships (MARPOL 73/78). Regionally, the main legal enactments that have assisted in the control and eradication of IAS are listed below. These laws can only be used in relation to specific types of IAS. It is important to mention that no single enactment deals with all the different types of IAS. However, approval has now been granted to develop an act in order to prevent the entry of IAS and to control those already present.

- **Fauna and Flora Protection Ordinance (No. 02 of 1937 as amended);** Its intention lies in the protection, conservation and preservation of the fauna and flora of Sri Lanka and the commercial exploitation of these species. Importation of animal eggs, spawn, or larvae of any animal could only be done under the authority of a permit; this applies to all species of animals with the exception of domestic animals such as – cattle, sheep, goats, asses, horses, dogs, cats, mules, domestic pigs and domestic fowl reared as poultry. These provisions have the same effect as if they were part of the Customs Ordinance.

- **Fisheries and Aquatic Resources Act (No. 02 of 1996);** Its intention is to manage, regulate, conserve and develop the fisheries and aquatic resources. This is done through the Minister in charge of Fisheries and Aquatic Resources together with the Minister in charge of Trade who can prohibit or regulate the importation of fish or aquatic resources. Twenty four (24) species of fish are already prohibited from being exported.

- **Plant Protection Act (No. 35 of 1999);** Its intention is to prevent the introduction and spread of any organism injurious or harmful to plants or destructive to plants found in Sri Lanka. This law is mainly implemented to prevent entry of any plant or animal that may become a pest or invasive, or a potential threat to plant life. When there is reason to believe that a certain pest is being harboured in any premises, the Director General (DG) of Agriculture can direct an inspection to ascertain the situation. The Minister of Agriculture is able to prohibit entry of Quarantine Pests.

- **Marine Pollution Prevention Act (No. 35 of 2008);** The intention of this Act is to prevent, control and reduce pollution in the territorial waters. Provisions can be used to bring necessary regulation to control and regulate the release of ballast waters in the seas of Sri Lanka or to treat them in a specific way before releasing them into waters.

- **National Policy on Invasive Alien Species in Sri Lanka, Strategies and**

Action Plan - 2016; Implemented by the Ministry of Mahaweli Development and Environment; with the support of other responsible stakeholder agencies (i.e. Forest, Irrigation, Agriculture, Agrarian Services, Wildlife Conservation Departments, Mahaweli Authority, Department of Fisheries and Aquatic Resources, Sri Lanka Customs etc.)

The main objectives are; (i). to minimize the risk of IAS on the Biodiversity, Ecosystem, Economy and Society (ii). make aware all stakeholders on national position and priorities (iii). Contribute to the global efforts to control IAS.

This policy comprise of four main trust areas: (i). Prevention, (ii). Early Detection & Rapid response, (iii). Containment Control and Eradication, (iv). Restoration of Ecosystems

- **National Wildlife Policy of 2000;** Implemented by the Department of Wildlife Conservation to promote ecosystem-based management of protected areas, including the eradication of IAS, which is subjected to thorough consideration of the environmental impacts. This policy is aimed at regulating the importation of alien organisms, including genetically modified organisms to minimise risks towards the integrity of Sri Lanka's biodiversity

- **National Environmental Policy of 2003;** Implemented by the Ministry of Environment through which environmental management systems will be encouraged to be flexible so as to adapt to changing situations (e.g., climate change, IAS and genetically modified organisms) and adopt the precautionary principles.

- **National Agriculture Policy of 2007;** Implemented by the Ministry of Agriculture which strictly adheres to plant protection regulations in order to prevent alien weeds, insect pests and diseases from entering the island.

LIST OF INVASIVE ALIEN PLANTS IN SRI LANKA

National Invasive Alien Plant list

(According to the 2015 risk assessment)

	Species	Common name	Year & reason for introduction
01	<i>Prosopis juliflora</i>	Mesquite	1880, ornamental
02	<i>Salvinia molesta</i>	Salvinia	1930's, educational
03	<i>Eichhornia crassipes</i>	Water hyacinth	1905, ornamental
04	<i>Panicum maximum</i>	Guinea grass	1801-1802, Fodder
05	<i>Clusia rosea</i>	Autograph tree	1886, ornamental
06	<i>Typha angustifolia</i>	Hambu pan	Unknown
07	<i>Lantana camara</i>	Lantana	1826, ornamental
08	<i>Annona glabra</i>	Pond apple	Unknown, Grafting stock
09	<i>Austroeupatorium inulifolium</i>	Austroeupatorium	Unknown
10	<i>Dillenia suffruticosa</i>	Shrubby Dillenia	1882, ornamental
11	<i>Cuscuta campestris</i>	Cuscuta	Probably through contaminated grains
12	<i>Alstonia macrophylla</i>	Hard milkwood	Forestry and timber
13	<i>Leucaena leucocephala</i>	White leadtree	1980, fodder and soil improvement
14	<i>Clidemia hirta</i>	Soap bush	1894, ornamental
15	<i>Parthenium hysterophorus</i>	Parthenium	1980s, accidental
16	<i>Mimosa pigra</i>	Giant Mimosa	1980s, strengthening river banks
17	<i>Opuntia dillenii</i>	Prickly pear cactus	Ornamental
18	<i>Ulex europaeus</i>	Common gorse	1888, ornamental
19	<i>Sphagneticola trilobata</i>	Creeping ox-eye	Ornamental
20	<i>Cestrum aurantiacum</i>	Orange cestrum	1899, ornamental



1. Mesquite
2. Water hyacinth
3. Lantana

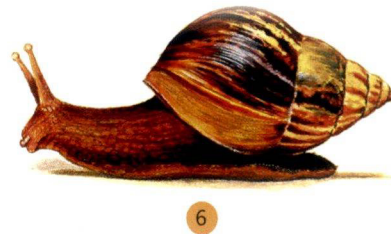
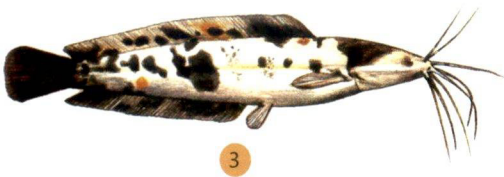
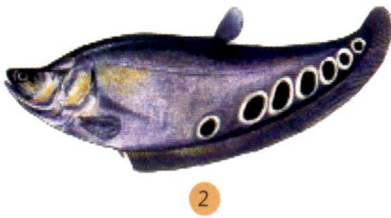
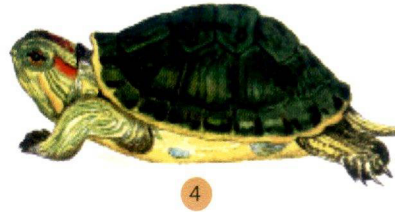
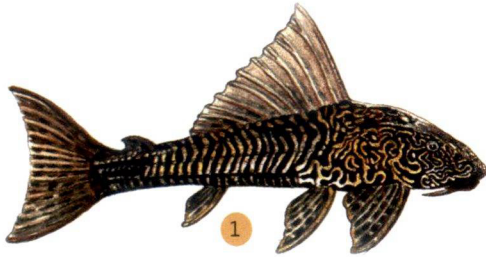
4. Soap bush
5. Prickly pear cactus
6. Common gorse

LIST OF INVASIVE ALIEN ANIMALS IN SRI LANKA

National Invasive Alien Animal list

(According to the 2015 risk assessment)

	Species	Common name	Year & reason for introduction
01	<i>Oncorhynchus mykiss</i>	Rainbow trout	1889, sport fish
02	<i>Pterygoplichthys disjunctivus</i>	Scavenger	1990s, escaped from aquariums
03	<i>Pterygoplichthys pardalis</i>	Scavenger	1990s, escaped from aquariums
04	<i>Chitala ornata</i>	Clown knife fish	1990s, escaped from aquariums
05	<i>Clarias batrachus</i>	Marble cat fish	Unknown, escaped from aquariums
06	<i>Trachemys scripta</i>	Red eared slider turtle	1980s, accidental though the pet trade
07	<i>Pomacea spp.</i>	Apple snail	1970s, aquarium industry
08	<i>Lissachatina fulica</i>	Giant African land snail	1990s, deliberate



1. Scavenger Fish
2. Clown knife fish
3. Marble cat fish

4. Red eared slider turtle
5. Apple snail
6. Giant African snail

PLACES WHERE FURTHER INFORMATION CAN BE OBTAINED

Further information on invasive alien plants and animals can be obtained from the following institutions.

PLANTS

Department of National Botanic Gardens

Peradeniya, Sri Lanka.

<http://www.botanicgardens.gov.lk/>

Department of Botany-Faculty of Science

University of Peradeniya

Peradeniya, Sri Lanka.

<http://www.pdn.ac.lk/sci/botany/>

Department of Crop Science-Faculty of Agriculture

University of Peradeniya

Peradeniya, Sri Lanka

http://www.pdn.ac.lk/agri/dept/crop_home.php?dep=Department of Crop Science#

Department of Plant Sciences-Faculty of Science

University of Colombo

Colombo 07, Sri Lanka.

<http://science.cmb.ac.lk/departments/plant-sciences/>

Plant Protection Service

P.O.Box 22

Gannoruwa

Peradeniya.

<http://www.agridept.gov.lk/index.php/en/institutes/325>

Forest Department

82, Rajamalwatta Road

Battaramulla.

<http://www.forestdept.gov.lk>

ANIMALS

Zoology Division-Colombo National Museum

Sir Marcus Fernando Mawatha

Colombo 07, Sri Lanka.

<http://www.museum.gov.lk/>

Department of Zoology, Faculty of Science - University of Colombo

Colombo 07, Sri Lanka.

<http://science.cmb.ac.lk/departments/zoology/>

Faculty of Veterinary Medicine and Animal Science-Faculty of Agriculture University of Peradeniya

Peradeniya, Sri Lanka

<http://www.pdn.ac.lk/vet/>

Department of Zoology and Environmental Management-Faculty of Science University of Kelaniya

Dalugama, Kelaniya, Sri Lanka

<http://www.kln.ac.lk/science/depts/zoology/>

National Animal Quarantine Service-Animal Quarantine Office

41, Morgan Road

Colombo 2

PLANTS AND ANIMALS

Faculty of Agriculture-University of Peradeniya

Peradeniya, Sri Lanka

<http://www.kln.ac.lk/science/depts/zoology/>

Post Graduate Institute of Agriculture University of Peradeniya,

Old Galaha Road,

Peradeniya.

<http://www.pdn.ac.lk/agri/>

Postgraduate Institute of Science University of Peradeniya

Peradeniya, Sri Lanka

<http://www.pgis.lk/>

National Aquatic Resources Research and Development Agency (NARA)

Crow Island

Colombo 15

<http://www.nara.ac.lk/>

IUCN Sri Lanka Country Office

No. 53 Horton Place

Colombo 07, Sri Lanka

http://www.iucn.org/about/union/secretariat/offices/asia/asia_where_work/srilanka/

Department of Wildlife Conservation

No. 811A Jayanthipura,

Battaramulla.

<http://www.dwc.gov.lk/index.phplen/>

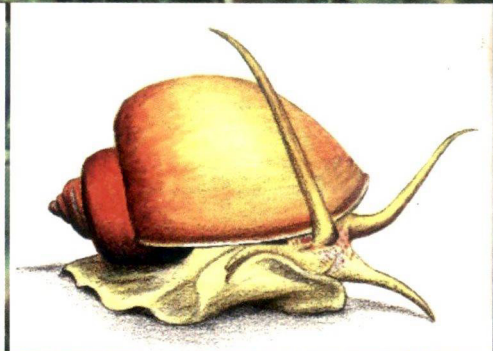
USEFUL WEB LINKS

- <http://www.iasrilanka.info/>
- <http://www.cbd.int/invasive/>
- <http://www.issg.org/>
- http://ec.europa.eu/environment/nature/invasivealien/index_en.htm
- <http://www.issg.org/database/species/search.asp?st=100ss>
- <http://www.invasive.org/>
- <http://www.doi.gov//invasivespecies/index.cfm>

LIST OF PUBLICATIONS IMPORTANT FOR THE STUDY OF IAS

- Ashton, M. S., Gunatilleke, S., & Zoysa, N. d. (1997). *A field guide to the common trees and shrubs of Sri Lanka*. Colombo: WHT Publication (Pvt.) Ltd vii, 431p. ISBN, 969179493.
- Bambaradeniya, C., Ekanayake, S., & Gunawardena, J. (2001). Preliminary observations on the status of alien invasive biota in natural ecosystems of Sri Lanka. Paper presented at the workshop on Alien Invasive Species, Global Biodiversity Forum-South and Southeast Asia Session, Colombo. IUCN Regional Biodiversity Programme, Asia, Colombo, Sri Lanka. October 1999, Colombo, Sri Lanka.
- De Costa, W. A. J. M., Hitinayake, H. M. G. S. B., & Dharmawardena, I. U. (2001). A physiological investigations into the invasive behaviour of some plant species in a Mid-Country forest reserve in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 29(1 & 2), 35-50.
- Epa, U. P. K. (2006). Alien Invasive Snail, *Pomacea* spp. in Sri Lanka. In R. C. Joshi & L. S. Sebastian (Eds.), *Global advances in ecology and management of Golden Apple Snails* (pp. 319- 324). Nueva Ecija, Philippines: Philippine Rice Research Institute.
- Gunasekera, L. (2009). *Invasive plants: a guide to the identification of the most invasive plants in Sri Lanka*. Sarasavi prakashakayo, Sri Lanka.
- Haluwana, N., & Madawala, H. (2014). Changes in plant diversity and composition across forest edges bordered by *Austroeupatorium inulifolium* invaded grasslands in the Knuckles Conservation Area, Sri Lanka. *Ceylon Journal of Science (Biological Sciences)*, 42(2), 29-43.
- IUCN SSC Invasive Species Specialist Group (2010). Global Invasive Species Database. Available at <http://www.issg.org/database/welcome/>.
- Lowe, S., Browne, M., Boudjelas, S., & De Poorter, M. (2000). 100 of the world's worst invasive alien species: a selection from the global invasive species database: Invasive Species Specialist Group Species Survival Commission, World Conservation Union (IUCN), Auckland, New Zealand.
- Marambe, B. (2001). Alien invasive plants in Sri Lanka: current concerns and future perspectives. (Ed. Balakrishna P.) Paper presented at the Report of workshop on Alien Invasive Species, Global Biodiversity Forum-South and Southeast Asia Session, Colombo. IUCN Regional Biodiversity Programme, Asia, Colombo, Sri Lanka. October 1999.
- Marambe, B., Silva, P., Ranwala, S., Gunawardena, J., Weerakoon, D., Wijesundara, S., et al. (2011). Invasive alien fauna in Sri Lanka: National list, impacts and regulatory framework. In C. R. Veitch, M. N. Clout & D. R. Towns (Eds.), *Island Invasives: Eradication and Management*. (pp. 542). Gland, Switzerland and Auckland, New Zealand: IUCN, The Centre for Biodiversity and Biosecurity.
- Marambe B, Silva P, Wijesundara S & Atapattu N (Eds) (2010): *Invasive Alien Species – Strengthening Capacity to Control Introduction and Spread in Sri Lanka*. Biodiversity Secretariat of the Ministry of Environment, Sri Lanka. 191 pp.

- McNeely, J. A., Mooney, H. A., Neville, L. E., Schei, P., & Waage, J. K. (Eds.) (2001). *Global strategy on invasive alien species*. Gland, Switzerland and Cambridge, UK: IUCN.
- Mordan, P., Naggs, F., Ranawana, K., Kumburegama, S., & Grimm, B. (2003). *A guide to the pest and exotic gastropods of Sri Lanka* (pp. 10). London, United Kingdom 10 pp.: Department of Zoology, The Natural History Museum, London.
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- Ranwala, S., Marambe B., Wijesundara S., Silva P., Weerakoon D., Atapattu N., Gunawardena J., Manawadu L. and Gamage G. (2011): Post-entry risk assessment of invasive alien flora in Sri Lanka: Present status, gap analysis and the most troublesome alien invaders. *Pakistan J Weed Science* 18: 863-871
- Welcomme, R. L. (1988). International introductions of inland aquatic species: Food & Agriculture Org.
- Wittenberg, R., & Cock, M. J. W. (2001). Invasive Alien Species: A Toolkit of Best Prevention and Management Practices. In R. Wittenberg & M. J. W. Cock (eds.) *CAB International*. Wallingford, Oxon, UK.
- Wickramathilake, B., Weerasinghe, T., & Ranwala, S. (2014). Impacts of Woody Invader *Dillenia suffruticosa* (Griff.) Martelli on Physio-chemical Properties of Soil and, Below and Above Ground Flora. *Journal of Tropical Forestry and Environment*, 3(2), 66-75.
- Wijesundara, S. (2008). Major invasive plant species in different climatic zones of Sri Lanka, *Proceedings of National Symposium on Invasive Alien Species*, Colombo, Sri Lanka.
- Wijesundara, S. (2010). Invasive Alien Plants in Sri Lanka. In B. Marambe, P. Silva, S. Wijesundara & N. Atapattu (Eds.), *Invasive Alien Species – Strengthening Capacity to Control Introduction and Spread in Sri Lanka* (pp. 27-38). Colombo, Sri Lanka: Biodiversity Secretariat of the Ministry of Environment, Sri Lanka.



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