Invasive Alien Species: The Indian Scene

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The international importance of invasive alien species (IAS) is highlighted by the Article 8h of Convention on Biological Diversity (CBD), 1992, which emphasizes on prevention of the introduction of species which threaten other species, habitats or ecosystems. A Global Invasive Species Programme (GISP) was launched to assemble and identify practices for the prevention and management of IAS. Among the various international instruments, CAB International plays a key role to provide technical support at international and national level in identification of new alien species, publication of distribution maps and databases. In India, invasive weeds infest extensive tracts of agricultural and forest land. Various aspects of control of alien weeds and pests are being dealt with by a number of authorities. Recently, several initiatives have been taken at national level to identify specific actions to mitigate the threat of IAS. The present study highlights the national and global status, regulatory mechanisms and management options of invasive aliens. A national strategy for their management in line with the 15 Guiding Principles given by CoP 5 and 6 has been proposed with several steps involved in its mode of implementation. Legislative measures like the Destructive Insects and Pests Act (1914) have been reviewed and the Plant Quarantine Order (Regulation of Import into India) 2003 has been enforced from January 1, 2004 and Environment (Protection) Act (1986) has also been reviewed and amended periodically, but still there is a lack of cohesive policy and action plan to deal with IAS. An overview on the national system for management of IAS has been proposed involving all the stakeholders to deal with biological invasions in a step-wise manner and future line of action recommended.

Key Words: Alien, Invasive Species, Regulation, India

Among the major threats faced by India to its native species of plants and animals (and their habitats and ecosystems), the one posed by the invasive alien species is truly scaring since it is considered second only to that of the habitat loss. This has happened largely because the natural barriers such as oceans and mountains that once prevented/restricted the movement of species have been rendered ineffective by the increased volume of trade and international transport over the past few centuries, ending millions of years of biological isolation. Non-native ('alien species') may be brought deliberately, in authorized or unauthorized manner, or they may enter by accident through 'hitch-hiking' in containers, ships or cars, 'hidden' in soil or just 'carried away' by wind.

In this paper the problems faced by India due to invasive non-native species are discussed and various measures including prevention of their entry, their early detection and eradication and control are considered to limit their further spread and mitigate their negative impacts with special emphasis on plant species. Overall focus is on regulating and managing the intentional and unintentional introductions that may pose biosecurity threats, and biological risks to natural ecological systems or to the well-being of humans, animals or plants inhabiting the affected areas.

Invasive Alien Species

'Alien Species' refer to non-native or exotic organisms that occur outside their natural ranges and dispersal potential. In other words, they inhabit areas that they cannot occupy without direct or indirect introduction or care by humans. This term also covers any parts, gametes or propagules of such species (species, subspecies, or lower taxa) that might survive and subsequently reproduce in their newly found 'homes'. Species carried suddenly to new environments may usually fail to establish and survive but they may also thrive and become invasive in some cases.

'Invasive Alien Species' (IAS) denote those 'alien species' that have been moved (often aided by humans) outside their natural habitats to new areas where they have established themselves and invaded the new environments acting as an agent of change by competing with and overcoming the pre-existing native flora and fauna. Found in all categories of living organisms and all types of ecosystems, these are widespread in the world. Plants, mammals and insects (along with their associated pathogens and pests) comprise the most common types of invasive alien species in terrestrial environments.

Many alien species are non-invasive and support our farming systems and other human livelihoods in

a big way. In fact, nearly half of our food and other cultivated plants have come from other countries. Only those alien species that cause substantial negative impacts to the environment, ecosystems, habitats, native biodiversity, economies, and human health are considered the "Invasive Alien Species". Farmers still dread the invasion by migratory locust swarms devouring their field crops. Devastating effects of exotic aquatic weeds like water hyacinth (*Eichhornia crassipes*) and great nuisance value of aggressive exotic land species like Lantana (*Lantana camara*) and congress grass (*Parthenium hysterophorus*) are well known. More recently, the carnivorous 'African Catfish' (also called 'Thai Magur') has hit the diversity of native fish species in many parts of the country.

Many biologists are still trying to elucidate the capability of invasive species to aggressively invade new areas in the hope that incipient invasions may be predicted and stopped. Several explanations have been proposed in this context. A major contributing factor appears to be that the invading organism has been relieved of the pressures of its predators/ parasites that keep its population under check in its native habitat, enabling it to proliferate unhindered in its new territories. In addition, it may be biologically "very hardy", characterized by a short generation cycle and a varied diet. A common feature of many invasive species is that they often thrive in an ecosystem that has already been disturbed by humans or some other factor(s). Whatever the precise causes, the consequences of such invasions may mean severe alteration of habitats and disruption of natural ecosystem processes with catastrophic impact on the native species.

Intentional and Accidental Introductions

The introduction of alien species may be through both intentional and accidental means either deliberately for commercial or recreational purposes (e.g., crop plants and their varieties; fish for aquaculture; pasture species for rangelands; ornamental or other horticultural species; exotic animals for zoological gardens) but there are also unintentional introductions of weeds, insect pests and pathogens), and other species, through traded commodities, especially of agricultural produce, timber, livestock, etc.

Most of the deliberate introductions have proved to be of immense value in serving human needs, more so for agricultural and forestry purposes. The great bulk of human dietary needs in most parts of the world are currently met by species that have been introduced from elsewhere (Hoyt, 1992). More than half of the plants now commercially grown in India, for example, are introductions from other lands in recent or remote past. Many among them got so naturalized and diversified here that local people find it difficult to believe that they have travelled here from far away places. A case in point is the sorghum and pearl millet crops that have their origin in Africa. Likewise, it is difficult to imagine an Africa without cattle, goats, maize, and cassava, or a North America without wheat, soybeans, cattle and pigs, or a Europe without tomatoes, potatoes, and maize - all introduced species. Species introductions, therefore, are an integral part of agricultural biodiversity in virtually all parts of the world. Increasing concerns for maintaining the health of these introduced species also led to the introduction of additional alien species for use in biological control programmes based on the import of natural enemies of insect pests and pathogens from the areas of their origin.

Much of the work to date on IAS has focused attention on their biological and ecological characteristics, the vulnerability of ecosystems to such invasions, and the use of various means of control against the invaders. The time has come to extend these considerations to cover other aspects such as global trade, settlement patterns, agriculture, economics, health, water management, climate change, genetic engineering and many other relevant fields (Drake et al., 1989).

Threats to Biological Diversity

Every IAS that becomes established in a new environment alters the composition of native biological communities in some way. These alterations can disturb the structure and functioning of the invaded ecosystems with profound socio-economic impacts.

Four aspects of the exotic invasives are noteworthy. Firstly, people are largely responsible for moving organisms or their reproductive/ vegetative parts from one place to another, especially through modern global transport and travel. Secondly, while some species are capable of invading well-protected/ undisturbed ecosystems, IAS more often seem to invade habitats that have been already altered by humans, such as the agricultural fields, grazing lands, abandoned mining areas, human settlements, and roadways. The degradation of natural habitats, ecosystems and

agricultural lands (for example, loss of vegetation cover and soil, pollution of land and waterways) that has occurred throughout the world has made it easier for some alien species to establish and become invasive since they are 'colonising' species that benefit from the reduced competition that follows habitat degradation. Thirdly, alien species are often intentionally introduced for direct or indirect economic benefits without proper risk assessment regarding their becoming invasive later on in situations favourable to them. Fourthly, the negative consequences of IAS affect various strata of communities quite differently, the deprived sections bearing the burden more than others.

A perusal of the literature reveals that the scope and cost of biological alien invasions by microorganisms, aquatic plants, land plants, aquatic invertebrates, land invertebrates, fishes, reptiles and mammals is global and enormous, in both ecological and economic term (Khetarpal, 2002). The ecological cost is the irretrievable loss of native species and ecosystems. In addition, the direct economic costs of IAS run into many billions of dollars annually. Arable weeds reduce crop yields and increase costs; weeds degrade catchment areas and freshwater ecosystems; tourists and homeowners unwittingly introduce alien plants into wilderness and natural areas; insect pests and pathogens of crops, livestock and forest trees reduce yields and increase control costs. Environmental and socio-economic impacts of harmful IAS are already evident in many countries as widely experienced in the case of alien aquatic weeds like water hyacinth (*Eichhornia crassipes*) and water lettuce (*Pistia* spp.) that are increasingly choking waterways and degrading freshwater ecosystems and terrestrial weeds as lantana (*Lantana camara*) and congress grass (*Parthenium hysterophorus*) which occupy agricultural and barren lands.

Recent Global Developments

Despite enriching effect of biodiversity at the local level, the evidence shows negative effects of many introductions on species and genetic diversity at both the local and global level. Such introductions can lead to severe disruption of ecological communities (Drake *et al.*, 1989; Zaret and Paine, 1973; Mooney and Drake, 1987), and heavily influence the genetic diversity of indigenous species. Some protected areas established to conserve native species have been profoundly affected by introduced species and wherever the direct cause of extinction is identifiable, introduced species head the list. Globally, almost 20 per cent of the vertebrates thought to be in danger of extinction are threatened in some way by invasive species (Table 1). Increased international trade is now considered as having the massive potential to cause introductions of more harmful exotic species (Jenkins, 1996).

Table 1. Threatened terrestrial vertebrate species affected by introductions in the continental landmasses of the different biogeographic realms and on the islands

Taxonomic group	Mainland areas		Islands (Insular areas)	
	%	(n)*	%	(n)*
Mammals	19.4	(283)	11.5	(61)
Birds	5.2	(250)	38.2	(144)
Reptiles	15.5	(84)	32.9	(76)
Amphibians	3.3	(30)	30.8	(13)
Total for all groups Considered	12.7	(647)	31.0	(294)

* Total number of threatened terrestrial vertebrate species
Source: Macdonald *et al.* (1989)

The emerging general global picture depicts a tremendous mixing of native and alien species in most parts of the world. The future is expected to bring considerably more ecological shuffling as people influence ecosystems in various ways, not the least through both purposeful and accidental introduction of species. This shuffling/ re-shuffling will have both winners and losers although the overall effect is likely to be a global loss of biodiversity at species and genetic levels (McNeely, 2001).

International Legal Instruments

Key international legal instruments, that address the threat of IAS, include the United Nations Convention on the Law of the Sea, the Convention on Biological Diversity, the Ramsar Convention on Wetlands and other multilateral environmental agreements, as well as instruments developed for the plant, animal and human health sectors, or to address particular vectors, such as the International Plant Protection Convention (IPPC) and instruments developed under the Office International des Epizooties (OIE) and specialized agencies such as the Food and Agriculture Organization (FAO), the International Civil Aviation Organization (ICAO), the International Maritime Organization (IMO) and the World Health Organisation (WHO).

Prevention is treated inconsistently across existing multilateral environment agreements (MEA), the level

ranging from strong[1] to weak[2]. Most of the instruments provide no indicators of where prohibitions or restrictions should be imposed, unless their scope is limited to protected areas. No procedures are established for cooperation with countries that are the source/ origin of alien species that may impact on biodiversity. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is the only multilateral environmental agreement to mandate species-specific reciprocal controls between States of export and import.

The Convention on Biological Diversity requires Parties "as far as possible and as appropriate, [to] prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species" (Article 8(h) (CBD, 2002). The Convention contains no specific requirements of how this is to be done, though non-binding, 15 Guiding Principles have been recommended (CBD, Cop 6, 2002).

The Convention on the Law of the Sea requires Parties to take all measures necessary to prevent, reduce or control pollution of the marine environment resulting from the intentional or accidental introduction of alien or new species to a particular part of the marine environment, which may cause significant and harmful changes thereto (Article 196). Regionally, environmental protocols developed under the UNEP Regional Seas Programme contain specific requirements to prevent introductions to marine and coastal ecosystems (Eastern African region, Wider Caribbean region, South-East Pacific and Mediterranean).

- **Instruments to Protect Plant, Animal and Human Health**

Some of the earliest instruments that address the threats of IAS aim at controlling the introduction and spread of insect pests and diseases in order to protect human, animal and plant health. For example, the IPPC provides a framework for international cooperation to secure common and effective action to prevent the introduction of pests of plants and plant products, and to promote appropriate measures for their control. The IPPC was revised in 1997 primarily in response to the adoption of the 1995 WTO Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement"). However, the IPPC concerns only with pests classified as "injurious to plants or plant products". This wording covers alien organisms that could damage wild plants but not explicitly those that may harm ecosystem functions or/ plant genetic diversity.

The Office International des Epizooties develops standards and guidance on pests and diseases of animals (but not animals themselves as pests). Standards are set out in the International Animal Health Code for Mammals, Birds and Bees, including on import risk analysis and import/export procedures, and in the International Aquatic Animal Health Code, the aim of which is "to facilitate trade in aquatic animals and aquatic animal products".

The 1995 WTO Agreement on the Application of Sanitary and Phytosanitary Measures is relevant to alien species characterized as pests or diseases. A WTO member may adopt national measures to protect human, animal or plant health/life from risks arising from the entry, establishment or spread of pests, diseases, or disease-causing organisms and to "prevent or limit other damage" within its territory from these causes.

The 1969 WHO International Health Regulations, amended in 1973 and 1981, aim at ensuring the maximum security against the international spread of diseases. The goals are to: (i) detect, reduce or eliminate sources from which infection spreads; (ii) improve sanitation in and around ports and airports; and (iii) prevent dissemination of vectors. These Regulations are being revised and modernized to adapt to changes in disease epidemiology and control and to substantial increases in the volume of international traffic.

- **Instruments to Address Risks from Transport**

No binding standards apply to international transport, though some countries have moved ahead and adopted legislation in this area. IMO has adopted Guidelines (voluntary) for the Control and Management of Ships' Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens.[3] Mandatory international regime to regulate and control ballast

1. Prohibition under AEWA and the Alpine Convention Protocol, strict control under the Convention on Migratory Species and the Bern Convention.

2. The ASEAN Agreement, " Endeavour to regulate, and where necessary, prohibit...".

3. Annex to resolution A.868 (29), 20th IMO Assembly, 1997, which updates the 1993 IMO Guidelines for Preventing the Introduction of Unwanted Aquatic Organisms and Pathogens from Ships' Ballast Waters and Sediments Discharges (IMO Assembly Res. A.774

water is under preparation. The Cartagena Protocol on Biosafety includes provisions for handling, transport, packaging and identification (Article 18).

- **Provisions Relating to Intentional Introductions**

A major gap exists in relation to the introduction of alien species into freshwater systems. The work programme on the biodiversity of inland waters under the Convention on Biological Diversity (decision IV/4) recommends that Parties should develop inventories and impact assessments of alien species in such ecosystems and mitigate negative consequences of such species on inland water ecosystems especially at the watershed, catchment and river basin level. The FAO Code of Conduct for Responsible Fisheries provides some guidance, for example, for pre-introduction discussion with neighbouring States when non-indigenous stocks are to be introduced into transboundary aquatic ecosystems. It calls for harmful effects of non-indigenous and genetically altered stocks to be minimized especially where significant potential exists for spread into other states or country of origin. The FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents has been adopted as an international standard under the IPPC. However, there are no binding instruments on deliberate introductions.

The Cartagena Protocol on Biosafety includes provisions for advance informed agreement by the receiving country for living modified organisms for intentional introduction into the environment (Articles 7–10).[4]

- **Standards for Risk Assessment**

There are no legally binding international guidelines for risk assessment of invasive alien species *per se*. General guidelines, including those recently developed for aquatic animals, do exist for assessing the risk of introduction and spread of exotic animal disease and plant pests, including weeds. The Cartagena Protocol on Biosafety includes provisions for the management of risks posed by living modified organisms (Article 16), and includes a list of points to be considered in risk assessment.

For WTO members, national measures for prevention of alien species that may affect international trade must be consistent with WTO principles and rules, as expressed through the SPS Agreement. Where an international standard is set by an organization recognized under that Agreement, States should base national measures on that standard. The SPS Agreement currently recognizes standards set by IPPC (pests of plants and plant health), OIE (pests and diseases of animals) and Codex Alimentarius Commission (food safety and human health). This excludes taxa that are pests in their own right but are not vectors of disease or injury to plants, plant products and animals. The mandates of the three organizations are broad enough to cover certain environmental and societal impacts, but no standards (adapted to date) take these dimensions adequately into account. However a working group under the IPPC is exploring the option of incorporating such environmental criteria into its standards for risk analysis.

The lack of reliable, consistent and comprehensive data is possibly the biggest challenge in the successful application of risk assessment to invasive alien species. This is particularly true for biological baseline data and economic impacts. These gaps exist both in the type and the quantity of data available, compared to what is required for comprehensive risk assessments to be undertaken. In addition, lack of coordination in data collection programmes may yield data that cannot be used to form a comprehensive picture of the situation. Poor accessibility to information also hinders the majority of countries in their development of representative tools and procedures.

CBD Approach to Invasive Alien Species

The impact of these invasive species is being addressed in many ways including eradication, control, mitigation of their impacts combined with legislation and guidelines at national, regional and international levels. It is recognized as a cross-cutting issue within the Convention and priority attention is being given to geographically and evolutionarily isolated ecosystems as represented by small islands. The Conference of Parties (COP) to CBD has referred to alien species in a number of its decisions while recognizing the importance of the Global Invasive Species Programme (GISP) calling on it to develop a second phase of its activities and requested the Global Environment Facilities (GEF) and other bodies to provide financial support for this purpose. The Invasive Species Specialist Group (ISSG), a global group of 146 scientific and

4. *A simplified procedure applies for LMOs intended for direct use as food or feed, or for processing (Article 11).*

policy experts on invasive species from 41 countries and a part of the Species Survival Commission (SSC) of the International Union for Conservation of Nature. And Natural Resources (IUCN) also provides advice on threats from invasives and control or eradication methods.

Parties have been invited to develop country-driven projects at both national and supra-national levels to address alien species and to incorporate the issue into their biodiversity strategies and action plans. Parties have also been urged to carry out a number of actions regarding alien species, including application of the interim guiding principles, undertaking of case studies, development of mechanisms for transboundary, regional and multilateral cooperation, and development of education, training and public-awareness measures. The COP has also resolved that the GEF should provide adequate and timely support for country-driven projects at national, regional and subregional levels addressing the issue of alien species.

While reaffirming the priority to full and effective implementation of Article 8(h), COP-6 (held in The Hague in April 2002) urged the Contracting Parties, other Governments and relevant organizations to promote and implement the 15 Guiding Principles. It has also urged the Parties, Governments and relevant organizations to promote and carry out research and assessments on:

- The impact of invasive alien species on biological diversity;
- The socio-economic implications of invasive alien species particularly the implications for indigenous and local communities;
- The development of environmentally benign methods to control and eradicate invasive alien species, including measures for use in quarantine.
- The costs and benefits of the use of biocontrol agents to control and eradicate invasive alien species;
- Means to enhance the capacity of ecosystems to resist or recover from alien species invasions;
- Priorities for taxonomic work through the Global Taxonomy Initiative; and
- Criteria for assessing risks from introduction of alien species to biological diversity at the genetic, species and ecosystem levels.

Review of Case-studies

Sixty case studies, based on experiences, had been received by CBD as of October 2000. An analysis of the main issues, emerging from these case studies, is presented below, broken down into six main areas: prevention, detection, eradication, containment, control and general issues/points.

Prevention

Attempts to develop tools to predict whether a species is likely to become invasive have had some success. In some cases, it may be possible to identify that a species is highly likely to be invasive, for example, because it has been invasive in a similar habitat. Saying with certainty that a species will not be invasive appears to be more difficult as the case studies include examples where predictions about behaviour were incorrect. For this reason, it can be concluded that a precautionary approach would be to treat every alien species as potentially invasive until there is evidence to indicate that it is not.

The case-studies indicate that species in their natural environment may exhibit quite different characteristics when they are translocated elsewhere. Therefore, while behaviour in the originating environment may indicate potential problems, it is unlikely to be an indicator of safety. In many cases, species that became invasive outside of their natural range did not show invasive characteristics in their natural environment.

Detection

The guiding principles recognize that early detection is an important component of any prevention/eradication approach. Information document UNEP/CBD/SBSTTA/INF/3 sets out a range of ways in which the rate of early detection can be increased. Several case studies show that the ability to undertake eradication successfully is often dependent on early action. In addition, case studies show that rapid response to an invasion may be essential to prevent irreversible damage occurring. The case-studies and information document UNEP/CBD/SBSTTA/INF/3 include examples where early detection can be achieved through formal monitoring/surveillance programmes, as well as through less formal means, including public reporting of new species.

Several case studies indicate that the ability to

mount a rapid response would be greatly enhanced if there already existed:

- A clear allocation of responsibilities to agencies with the ability to undertake the work;
- Authority to take actions already established (e.g. the use of certain types of poisons may have already been approved through the normal process, ready for when they are needed, or relevant laws may be in place);
- Established funds, or access to a fast-track funding process;
- The ability to undertake actions that would not normally be allowed (e.g. blocking the movement of goods and vehicles, destroying private property) where such actions are needed to respond to an emergency;
- Clearly understood and established procedures for responding to new incursions that outline who is responsible for taking initial actions, rules for gaining additional government funding, how decisions will be taken on an appropriate response, and what actions can be taken to prevent further spread.

Eradication

Eradication is recognized in the guiding principles to be the preferred method for dealing with invasive alien species if prevention is not successful. The guiding principles recognize that this depends on it being cost effective. The case studies include examples where eradication was difficult and expensive. They also include examples, however, where eradications were successful and cost-effective, and show that our knowledge base and capacity to undertake eradication is increasing.

Containment

Containment is a useful approach and the case studies provide a number of circumstances where this approach has been employed. These include its use as a temporary measure while long-term measures are being decided, to prevent the spread of the species to new areas, or to allow localized eradication without the cleared area being immediately re-invaded.

Control

There is a wide range of control measures available that can be used to mitigate the impacts of invasive alien species. The most frequently mentioned methods are mechanical removal, biological control, poisoning, and trapping. However, the case studies provide a variety of other options, including the development of physical barriers to the movement of species and changing the nature of potential vectors. In addition to the success stories, the case studies include failed programmes, which also provide valuable information for other Parties.

Some case studies showed that where an area is subject to more than one invasion, the removal of one species may result in changes in the populations of the other species that may then result in a greater overall problem for biodiversity. This would suggest that it is important for the planning of a control programme to include consideration of the likely effects of the programme on other invasive alien species present in the area.

Information document UNEP/CBD/SBSTTA/6INF/3 suggests biological control may be a valuable option, but not without risks. The case studies include both successful use of biological control, and problems created by poorly designed projects. Careful research and assessment is necessary in any proposed biological control programme.

General Points/Issues

A number of case studies documented the direct economic costs of alien species invasions. The economic costs of some of these invasions were very high. Identifying costs was cited in some cases as a major factor in gaining support for prevention and management programmes. Most of the economic studies focused on alien species in the primary production sectors, rather than those affecting biodiversity, but these species often also have biodiversity impacts. The economic costs of alien species included the following:

- Direct and indirect costs of prevention, eradication or control (including delays to the movement of goods and passengers);
- Direct effects on economic sectors (e.g. agriculture, forestry, shipping);
- Effects on human health, resulting in lost productivity and medical costs;
- Indirect costs to the economic sector, for example from loss of markets or damage to the tourism industry.

Some case studies indicated that prevention, eradication and control can be very costly, and, hence,

prioritizing of actions was an important element to allow scarce resources to be targeted to where they would achieve optimal benefit.

The case studies show that alien species may threaten many sectors of society and there is need for integration between the sectors to increase the cost-effectiveness of alien species work. Key sectors mentioned were health, agriculture, forestry, fisheries, aquaculture, tourism, shipping, and construction. Several case studies exemplified how public attitudes to alien species problems can greatly influence the effectiveness of prevention, eradication and control programmes. Public-awareness campaigns in some cases were reported to have greatly enhanced public understanding of the impacts of alien species, and the practicalities and risks of various management options.

Almost all the thematic national reports identified a lack of resources as a major limiting factor for alien species response work. Some case studies included examples of the use of community and international volunteers in detection and management programmes. These case studies suggest that the use of communities and volunteers may represent a significant untapped resource for other programmes.

The case studies included examples showing that cooperative efforts between countries provided major benefits, and in some cases was essential for the effective treatment of the problem. The reasons for cooperative arrangements varied, and included the following:

- Countries share biodiversity that was threatened;
- Countries were the source of the alien species, and the site of the invasions (this was particularly relevant for biological control work);
- Countries faced similar problems, and sharing of experiences or cooperative development of new information or techniques benefited both;
- Countries had political relationships, for example, a donor-recipient relationship;
- Activities (for example, management of border-control arrangements) needed to be operated at a regional level;
- Mitigation effort in one country was considered to be fruitless because of the threat of constant re-invasion from a neighbouring country that was not carrying out mitigation actions.

Review of National Reports on Implementation of Article 8(h) of CBD

By the end of January 2002, a total of 65 reports had been received from the Parties to CBD including 13 reports from Asia, 17 from Africa, 9 from Central and Eastern Europe, 8 from Latin America and the Caribbean and 19 from the Group of Western and Other States. The differences among regional groups of Parties in the implementation of the Article 8(h) are not remarkable. However, some regional groups of Parties are further advanced in legislation and policy and programme development than other groups of Parties. Generally the Parties of all groups are at a similar level of implementation, which may be attributed to the fact that the issue of alien species is relatively new and the work on various aspects of the issue is still ongoing within CBD or other relevant forums.

Judging from the responses concerning identification of alien species, risk assessment and measures taken, it is clear that more needs to be done for a full implementation of the Article 8(h), though a number of Parties have made some progress in scientific research, monitoring, legislation and planning. Some Parties have identified the following as constraints for implementation of the Article 8 (h): weak capability of research, inventorying, risk assessment and monitoring; lack of measures to control unintentional introduction; inconsistency of policy among relevant sectors and industries; weak information exchange and cooperation among the Parties at the regional level; and lack of regulatory and technical tools.

At the national level, most countries have at least a minimal system in place for regulating alien species introductions. Except for a few countries, these are rarely comprehensive and they were not designed to conserve biodiversity against invasion impacts (except, possibly, in a limited way for protected areas).

Quite often, suitable tools are in place but underused. Competent authorities usually have general powers under quarantine/agricultural legislation to adopt import/movement regulations for designated 'noxious weeds' and to require farmers and landowners to control such weeds. However, implementing regulations are not always issued promptly or publicized and applied.

Effective prevention also depends on restricting further imports and internal movements of alien species that present invasion risks: this is important to support

containment strategies and prevent spread to other areas. This is potentially a gap under the IPPC whose provisions apply only where the species concerned is designated as a quarantine pest and thus subject to official control where an invasive alien species is not regulated as a plant pest by an individual country, IPPC provisions do not apply (Gupta and Khetarpal, 2004). The IPPC provisions do not appear to support restrictions on pests with environmental impacts.

Invasive Alien Species in India

Plant diversity in India is remarkably rich largely because of the vast variations in soil, altitudinal and climatic conditions. About 46,000 plant species have been documented here, of which nearly 17,000 are vascular while *ca* 5,000 among them are endemic (Nayar and Sastry, 1987). Indian flora is considered a part of the Indo-Malayan sub-kingdom under the paleotropical kingdom.

High mountain ranges in the North and presence of sea on three sides of the Indian sub-continent provide favourable situation for the preservation of unique flora. Although these natural barriers have protected the indigenous flora yet the land mass connections in the north and the west have provided migratory routes to many exotic elements from North-East Africa or West Asia, and South-West China. As a result, a large number of species have come to India from the surrounding countries and their great influence on the flora of India is evident (Chatterjee, 1940).

Exotic weeds have established in India ever since the arrival of Portuguese who introduced several economically important plants brought from Brazil, Mexico, parts of Africa and other places on their commercial route (Sankaran *et al.*, 2001). They introduced many ornamental and medicinal plants also. In the process, seeds of many obnoxious weeds also got mixed up and they firmly established here and spread widely. These weedy species seem to have been aided to some extent by shifting agriculture, faulty pasture practices, establishment of townships and colonies, and mass shifting of labourers from one region to another for construction or plantation work.

It is estimated that 18% of Indian flora comprises invasive aliens, of which about 55% are American, 10% Asian, 20% Asian and Malesian and 15% European and Central Asian species (Nayar, 1977). Tropical weedy species, in general, have proved to be aggressively invasive in nature endangering the native flora. Notable examples include *Eupatorium odoratum*, *E. adenophorum*, *Acanthospermum hispidum*, *Parthenium hysterophorus*, *Mikania micrantha*, *Erigeron karvinskianus*, *Conyza bonariensis*, *Flaveria australasica*, *Tithonia diversifolia*, *T. tagetiflora*, *Synedrella nodiflora*, *Crassocephallum crepidioides*, *Xanthium strumarium*, *Tridax procumbens*, *Amaranthus spinosus*, *Cassia tora*, *C. occidentialis*, *Cannabis sativa*, *Chenopodium ambrosioides*, *Nicotiana plumbaginifolia*, *Alternanthera pungens*, *Gomphrena celosioides*, *Euphorbia prostrata*, *E. geniculata*, *Jatropha gossypifolia*, *Oxalis richardiana*, *O. cernua*, *O. corymbosa*, *Scoparia dulcis*, *Argemone mexicana*, *Lantana camara*, *Croton bonplandianum*, *Hyptis suaveolens*, *Peristrophe bicalyculata*, *Calotropis* spp., and several grasses. They have over-run the native vegetation in many parts of India.

Of these, the recently introduced *Parthenium hysterophorus* (commonly referred to as 'rag weed', 'Santa Maria', 'white top', 'congress grass' or 'carrot weed') has become the greatest menace to natural flora in the plains. This weed, first reported from Poona (Rao, 1956), has spread amazingly fast across agricultural fields, fallows, railway lines, roadsides, aquatic situations, forest-cleared areas and even forested areas is believed to have entered India in the early 1950s. It is the most dominant and obnoxious weed today invading almost all habitats and supplanting the native flora.

Similarly two species of *Eupatorium* namely *E. ordoratum* and *E. adenophorum* have become quite adventive in comparatively open forests, fallows and roadsides on hills of Himalayan region as well as in parts of Western Ghats. At lower elevations, *Mikania micrantha* has become a great menace to forests of northeast India where this weedy species climbs over forest trees masking the photosynthetic surface of host plants, suppressing forest undergrowth as well as tree seedlings and creating nuisance in forestry operations. It is another example of a recently introduced tropical American species that has become a dominant element of the flora in most parts of North-east India. Another weed that has been naturalized in a remarkably short span of time is *Croton bonplandianum*, a South American weed that arrived here around 1900.

A large number of exotic weeds of the Asteraceae family, in particular, have become naturalized in India

impacting negatively on the distribution of native flora. *Ageratum conyzoides*, like other tropical American weeds, is an adventive species that occupies wastelands, agriculture fields, and forestlands in India. *Ageratina adenophora,* a native of tropical America and Mexico, that entered India around 1900, has also become an aggressive weed at higher elevations throughout the tropical belt in the Himalayas and also in Nilgiris in South India. *Chromolaena odorata,* native to tropical America and Mexico that arrived here around 1900, became the most dominant weed in and around Karapura, Kakanakote and Heggadadevana Kote forests replacing all other ground vegetation including the noxious *Lantana*. It has become particularly aggressive in the higher elevations as well as in the sub-Himalayan states. It is said that it was first introduced in northeast India (Rao and Suryanarayana, 1979), particularly in tea plantations and has been introduced to south India by plantation labourers returning to Kerala.

Although, the spread of alien weeds depends to a large extent on disturbance of the native habitat, there are many instances that indicate that invasion of weeds like *Ageratina, Chromolaena*, *Mikania* and *Parthenium* can proceed even without continuing disturbance. Nevertheless, disturbed habitats are being created at a much faster pace than ever before in the country. Botanists need to assess the species that have become extinct or rare in different biogeographic regions of the country due to the introduction of exotic weeds. Alien species are also known to cause major economic losses in agriculture, forestry and several other segments of Indian economy and these losses should be systematically assessed through appropriate criteria and indicators.

The distribution and economic impact of alien invasive weeds, insect pests and pathogens in India has been recently reviewed (Khetarpal, 2002). At global level, some rough estimates, based on some simplistic and selective criteria, indicate economic and environmental losses to exceed US $ 115 billions per year (Pimentel *et al.*, 2001).

Some Experiences

*Water Hyacinth (**Eichhornia crassipes**)*

Native of tropical South America, it has become naturalized throughout the tropics, growing gregariously and inhabiting stagnant or slow-moving waters. It was introduced in India from Brazil in the beginning of the 20th century due to its ornamental appeal. It is a free-floating or surface perennial and one of the worst aquatic weeds that presently occurs all over the globe. Large bladder-like swollen petioles cause the plant to float high and it is easily blown about by wind making it a very troublesome weed. It is a serious threat to wetlands biodiversity, particularly in West Bengal where it is estimated to infest over 15,000 ha of once clear water surface choking ponds, lakes and rivers. The affected areas enlarge alarmingly in monsoon months. In certain areas this weed has also invaded paddy fields making them unproductive.

In West Bengal, the eradication of water hyacinth has been made compulsory by legislation within notified areas. Special water hyacinth weeks are organized during which people in groups clear infested areas. In Assam, provisions have been made in Municipal and Local Self Government Acts to enforce land holders to eradicate this weed. The Madras Agricultural Pests and Diseases Act 1919, makes the destruction of the weed obligatory on the part of the owner or holder of the land, channel or pond. In Uttar Pradesh, the state government has assisted in the removal of water hyacinth through grants for compost making.

In view of the amazingly quick spreading ability of this weed, eradication can be effective only when the chances of re-infestation are totally blocked. Its primary sites of occurrence are inland waters and, hence, greater attention needs to be paid to them. Numerous methods for its eradication have been tried but without much success. Recent focus seems to be on finding ways and means of utilizing its biomass.

*Lantana (**Lantana camara**)*

Out of the four important species of lantana in India, *Lantana camara* is considered to be the most noxious pest. It is a prickly perennial shrub. A native of tropical America and introduced in this part of the world as an ornamental and hedge plant in the beginning of 19th century, it is now completely naturalized here and found throughout India. Due to its prolific growth habit and wide adaptability, lantana has overrun large areas including cultivable and waste lands, forests, grazing and pasture lands and even plantations. Worst affected areas are parts of Deccan, Coorg, Wynaad, Nilgiris and lower hills of Western Ghats. It has also invaded parts of Uttar Pradesh, Uttaranchal and Assam. Lantana also poses serious fire hazard in deciduous forests because of its ability to burn even when green.

Another highly invasive alien species, namely, *Chromolaena odorata*, which is a climber, is reported to be replacing lantana in parts of Karnataka. Studies in these areas have revealed the negative impact of this species on biodiversity conservation and the livelihoods of local people who depend largely on natural forest resources (Poulsen, 2001).

Measures to eradicate lantana or even to check its spread have not succeeded largely because too little was done, and that also too late. It has high regeneration potential, and the sporadic efforts to control have not yielded the desired results. Uprooting of this species and its replacement by planting fodder trees has potential application in plains but this approach is not feasible in hilly terrains. Chemical control appears to be effective but it is not practicable view of huge costs involved and also environmental risks. Biological control, using lantana eating insects like *Telenemia*, has had some success but has not been tried on a large scale in carefully selected situations. The management approach based on utilizing this species locally and also on commercial scale, holds some promise but remains to be tested on a large scale.

*Mesquit (**Prosopis juliflora**)*

This species is native to west tropical and sub-tropical North and South America where climate ranges from the arid to semi-arid conditions. It was introduced in India through seed obtained from the Kew Botanical Garden, and the earliest records of its cultivation in the Indian subcontinent date back to 1877. Then Nawab of Radhanpur introduced it in the Rann area of Kachchh in 1900. State Forest Department started planting this species on coastal area in 1953 as part of the Desert Immobilization Programme. Plantations were carried out extensively for checking the spread of desertification towards mainland and for establishing a shelterbelt. Unexpectedly, this species invaded the vital grasslands in Banni and other areas that were grazing ground of chinkara, wild ass, bluebull and black buck as well as prime habitat of grassland birds including bustards and cranes. Within five decades, this invasive exotic has colonized progressively more areas in Saurashtra, Kachchh and North Gujarat. Remote sensing data show an area of around 43,000 ha occupied by mesquit in Little Rann of Kachchh (Singh *et al.*, 1999). Its colonization has brought major impact on the ecology of the region since its dense impenetrable cover does not permit the growth of other species underneath.

*The Congress Grass (**Parthenium hysterophorus**)*

Widely distributed in native America, this is one of fast spreading and most dreadful weeds in India. It is an annual, prolific seeder with high dispersal ability. Commonly referred to as 'Rag weed', 'Santa Maria', 'White top', 'Congress grass' or 'Carrot weed', it has become the greatest menace to natural flora in the plains. This weed, believed to be accidentally introduced in India through the import of foodgrains from USA and was first reported from Poona (Rao, 1956), has spread amazingly fast across agricultural fields, fallows, railway lines, roadsides, aquatic situations, forest-cleared areas and even forested areas. It is the most dominant and obnoxious weed today invading almost all habitats and supplanting the native flora.

Infestation of *Parthenium* is posing a serious problem in agricultural crops and vegetables, its spread being reportedly to be more in irrigated crops like sugarcane than under rainfed conditions (survey conducted by the Maharashtra State Government). Some host specific natural enemies of *Parthenium*, such as *Zizogramma bicolorata*, appear to be helpful in checking its growth in field trials. In some parts of Maharashtra and Karnataka states, a leguminous undershrub (*Cassia uniflora*) has been reported to have effectively replaced *Parthenium* by inhibiting its germination and preventing its establishment due to phenolic leachates and also because of its longer lifespan (Joshi, 1991).

Introduction of Exotic Trout Fishes and Carps

India is very rich in fish diversity with 2118 species documented from 8 aquatic ecosystems across the country. Over 350 species among them are considered to be of exotic origin. Introduction of tilapia, the Chinese carps (silver carp and grass carp) and the common carp have greatly helped the country in enhancing production in composite fish culture and adding substantially to the meager income of fish farmers. The larvicidal exotic fish, *Gambusia affinis*, has similarly helped in eradication of malaria.

Exotic fish stocks and species are still being introduced for increasing aquaculture production, boosting sport fishery and supporting aquaria and ornamental fish trade. Brown and rainbow trout fish, for example, were introduced in northern upland stream

(cold water) ecosystems in the beginning of 20th century to encourage amateur sport fishery combined with delicious food. These virgin streams accepted trout as welcome additions attracting thereby eager anglers from far and near.

Competing with the native species (like rohu, catla, mrigal and snow trout) for food and habitat niche, the exotic species appear to have negatively impacted upon the locally adapted indigenous species, often reducing their effective population size and causing genetic drift and loss of genetic variation in them. Other possible adverse genetic effects may arise from inter- and intra-specific hybridization among the native and exotic fish species resulting in introgression and contaimination/homogenization of the gene pool and ultimately the loss of adaptation to the local environment.

Accidental entry of silver carp in Govindsagar and its subsequent dominance over the native catla and mahseer fisheries is a shocking experience. Tilapia has similarly been reported to have adverse effects on indigenous species in Vaigai reservoir in Tamil Nadu. Another aquacultural species, the bighead carp, and a very recent intruder, the African catfish (also called Thai magur) seem to have posed even far greater threats to native fish fauna.

Key Actors and Major Stakeholders

A large number of primary and secondary stakeholders are concerned with the possible impact of invasive alien species that threaten ecosystems, habitats, species and natural base resources. Regeneration of renewable natural biological wealth, the pace of area development programmes and livelihoods security are also of immense interest. The Ministry of Agriculture of Government of India is the nodal governmental agency for dealing with this subject in the country and also for liaising with the FAO and other international/ regional organizations on relevant programmes and activities. There are several other union ministries/ departments that have jurisdiction over different components of this complex and cross-cutting thematic area. This subject is also of high priority to the state governments since agriculture and forestry are on the concurrent list of items. In addition, there are numerous other stakeholders including research organizations, developmental agencies and civil society organizations besides the farming and local communities who are the primary stakeholders but happen to be weak in asserting their rights. Their listing, though far from being exhaustive, is given as follows:

Nodal Central Ministry:

Agriculture

Departments:

Agriculture & Cooperation

Agricultural Research & Education/ ICAR Animal Husbandry & Dairying

Other major Central ministries/ departments:

Environment and Forests

Science & Technology/ Biotechnology

Health & Family Welfare

Commerce

Ocean Development

Mines

Tourism and Culture

Tribal Affairs

Finance/ Revenue (Customs)

Industry

Planning and Programme Implementation

State Ministries:

Agriculture

Forests

Environment

Other organizations:

State Agricultural Universities and Traditional Universities

ICAR and CSIR Research Institutes

Development Agencies

Non-Governmental Organisations

Farming and other local communities

Regulation of the Import of Plants and Animals

Authorities

Nodal Authority: Union Ministry of Agriculture

Plants (including seeds and propagation materials): Department of Agriculture & Cooperation, under advice of Plant Protection Advisor.

- Bulk Import for Commercial Use/Consumption: Directorate of Plant Protection, Quarantine & Storage, Faridabad.
- Samples for Research: National Bureau of Plant Genetic Resources, New Delhi.

Animals (including fish and other aquatic species):

Directorate General of Foreign Trade under advice of Animal Husbandry & Dairying

Department/Animal Husbandry, Commissioner to the Government of India.

Fishes (and other aquatic species)

Fisheries Development Commissioner to the Govt. of India

Animal Husbandry & Dairying Department

Plant Quarantine:

Plant quarantine is legal enforcement of measures that collectively aim to prevent the introduction of exotic pests through imported seeds, plants and plant material and to contain the spread of exotic pest that are accidentally got introduced to the country by implementing the provisions of The Destructive Insects & Pests Act, 1914 and the regulations issued there under. There is one National Plant Quarantine Station at New Delhi, 4 Regional Plant Quarantine Stations at Amritsar, Calcutta, Chennai, and Mumbai and 24 Plant Quarantine Stations (earlier referred as minor stations) functioning at various sea ports/airports and land borders.

Structure

Central Sector Scheme "Plant Quarantine Facilities in India"

Objectives:

- To prevent introduction of exotic pests inimical to Indian Fauna and Flora, and
- To assist the foreign Governments' as an international obligation, making arrangements for issuance of Phytosanitary Certificates for exportable plants/plant materials.

Salient features:

- Enforcement of Destructive Insects & Pests Act, 1914, and the Plant Quarantine Regulations entitled "The Plants, Fruits and Seeds (Regulation of Import into India) Order, 1989" issued thereunder, now revised as Plant Quarantine (Regulation of Import into India) Order, 2003.
- Regulation of import of plants and plant materials including seeds, fruits, soil, living insects, fungi, etc.
- Quarantine inspection/treatment and release of the imported materials if found free from exotic pests, or otherwise deport/destroy.
- Issuance of Phytosanitary Certificates for exportable agricultural commodities in compliance with the provisions of International Plant Protection Convention, 1951 of FAO.

Pattern of assistance:

100% grant by Ministry of Agriculture, Government of India

Implementation:

The statutory provisions under DIP Act, 1914 and Plant Quarantine (Regulation of import into India) Order, 2003 are implemented through 29 Plant Quarantine Stations situated at 10 international airports, 10 seaports and 9 land frontiers.

Person to be contacted:

The Joint Secretary
Plant Protection Division
Department of Agriculture & Cooperation
Krishi Bhawan, New Delhi 110001.

Date of start/duration: 1948

Implementation status:

The powers delegated under DIP Act, 1914 & Plant Quarantine (Regulation of import into India) Order, 2003 are implemented by the officers & staff of 29 Plant Quarantine Stations situated all over the country at all international airports/ seaports & land frontiers.

Issuance of Import Permit

No consignment shall be imported into India without a valid import permit issued by the Competent Authority as stated below.

(a) Bulk import of seeds / plant materials for sowing, planting and propagation:

Plant Protection Advisor to the Government of India

(b) Import of seeds/plant material for consumption:

Plant Protection Advisor to the Government of India

(c) Import of germplasm/ research and breeding materials:

The Director, National Bureau of Plant Genetic Resources (NBPGR) is authorised to issue permits for import of germplasm/ research and breeding material for public/ private sector in the country including institutions and organisations of Indian

Council of Agricultural Research (ICAR), State Agricultural Universities (SAU) and International Crop Research Institute for Semi Arid Tropics (ICRISAT).

Forest Research Institute, Dehradun: For forest plants.

Botanical Survey of India, Kolkatta: For the remaining plants of economic and general Interest.

Authority for Post Entry Quarantine

Plant materials:

Plant Protection Advisor for bulk imports

Director, NBPGR, for small samples imported for research

Animal materials:

Animal Husbandry Commissioner/ Animal Quarantine Unit

Domestic Plant Quarantine:

Under the DIP Act, Directorate of Plant Protection, Quarantine and Storage, Faridabad headed by the Plant Protection Advisor to the Government of India (under the Ministry of Agriculture) is responsible for enforcing domestic quarantine, regulating the inter-state movement of plant and plant materials to prevent the further spread of dangerous pests and pathogens still restricted in their distribution in the country. There is domestic qurantine regulations for nine pests and pathogens at present.

Institutional Support

Directorate of Plant Protection, Quarantine and Storage

The Directorate of Plant Protection, Quarantine and Storage (Dte of PPQS), established in 1946 with Plant Protection Advisor to Government of India as its head under the Ministry of Agriculture, is the apex plant protection organisation in the country having the following key functions:

- To enforce Plant Quarantine Regulations issued under The Destructive Insects and Pests Act, 1914 and amendments issued there under to prevent introduction & spread of exotic pests
- To implement the provisions of The Insecticides Act, 1968 and rules framed there under for effective control over use of pesticides
- To fulfill international commitment and obligations in respect of locust control and phytosanitary measures
- To introduce and popularize innovative plant protection technologies such as integrated pest management (IPM) practices
- To impart training in areas of plant protection technology, pesticide quality testing & pesticide residue analysis etc.
- To coordinate and liaise with State/Union Territory Governments in all matters relating to plant protection

The Directorate implements five central sector schemes in the area of plant protection viz., expansion of plant quarantine facilities, integrated pest management programmes, implementation of Insecticide Act, locust control and training in plant protection.

National Bureau of Plant Genetic Resources (NBPGR), New Delhi

NBPGR is the nodal institution for germplasm exchange in India at the national, bilateral and international levels. It has been authorized under PFS Order 1989 (now PQ Order, 2003) to undertake quarantine clearance of the germplasm of agri-horticultural crops imported in small quantities for research use. The NBPGR issues import permit for germplasm materials on application from both public and private sectors. This Bureau has a separate Division of Plant Quarantine for this purpose that is serviced by highly trained scientific and technical specialists working in well equipped laboratories with the latest technology. It has developed a national networking system that has insect-proof screen houses and environment controlled green houses located at New Delhi, Hyderabad and Bhowali (Khetarpal *et al.*, 2001).

Legal Backup

This section lists a number of the major legal authorities of the Government of India that deal with invasive species. It does not represent a complete or definitive list of all legal authorities on invasive species but includes those most relevant ones to this subject. Some international agreements are also briefly described that are concerned with the impact of IAS.

Legal Authorities Available to the Union Ministry of Agriculture:

- The Destructive Insects and Pests Act, 1914 (as amended upto 2001)
- The Plants, Fruits and Seeds Order, 1989 (and Amendments, 2001)

- The Seeds Act, 1966 (and the Seeds Rules, 1968)
- EXIM Policy 2002-2007
- Indian Livestock Importation Act, 1898 (and amendments, 2001)
- The Fisheries Act, 1897 (along with State Fisheries Acts)
- The Protection of Plants Varieties & Farmers Rights Act, 2001

Learning from the experience of other countries, a plant quarantine legislation was passed on 3 February 1914 by the Governor General of India, named "Destructive Insect and Pests Act 1914 (DIP Act)". This Act empowers the Central Government to:

- Prohibit or regulate the import into India of any article or class of articles likely to cause infection to any crop;
- Prohibit or regulate the export from a State or the transport from one State to another in India, of any article or class of articles likely to cause infection to any crop;
- Make rules prescribing the nature of documents which shall accompany any article or class of articles, the export or transport of which is subject to the conditions imposed or which shall be held by the consignor or consignee thereof, the authorities which may issue such documents and the manner in which these documents shall be employed.

This Act authorizes the State Governments to make rules for detention, inspection, disinfection or disinfestation of any article or class of articles in respect of which a notification has been issued and for regulating the powers of the officers whom it may appoint in this behalf. It also provides for penalty for persons who knowingly contravene the rules and regulations issued under this Act. Plant quarantine rules and regulations have been framed by the Government under the provisions of the DIP Act.

Responding to emerging requirements, a comprehensive Plants, Fruits and Seeds (Regulation of Import into India) Order 1984 was promulgated by the Government in exercise of the powers conferred by sub-section (1) of section 3 of the DIP Act. Following the announcement of the 'New Policy on Seed Development' by the Government of India in October 1988 liberalising the import of seeds and other planting materials for the benefit of Indian farmers, PFS Order 1989 was issued by the Government in suppression of the 1984 Order. The PFS Order 1989 works in conjunction with the DIP Act authorize the Union Ministry to regulate the importation and movement of field crop, pasture and forage, or vegetable seed that may contain noxious weed seeds. Provisions under these Acts authorize the government authorities to prohibit or restrict the importation or interstate movement of any plant, plant product, biological control organism, noxious weed if the Competent Authority, Plant Protection Advisor and others, determines that the prohibition or restriction is necessary to prevent the introduction into India, or the dissemination within India, of a plant pest or noxious weed. A plant pest is any living stage of any of the following that can directly or indirectly cause damage to, or cause disease in any plant or plant product: a protozoan, nonhuman animal, parasitic plant, bacterium, fungus, virus or viroid, infectious agent or other pathogen. A noxious weed is a plant or plant product that can directly or indirectly injure or cause damage to crops (including nursery stock or plant products), livestock, poultry, or other interests of agriculture.

Plant Quarantine

The DIP Act and PFS Order emphasise the plant quarantine requirements and specifically authorize the Plant Protection Advisor (and others to whom the authority is legally delegated) to hold, seize, quarantine, treat, apply other remedial measures to destroy or otherwise dispose of any plant, plant pest, noxious weed, biological control organism, plant product that is moving (or has moved) into or through India or interstate, if the Ministry considers it necessary in order to prevent the dissemination of a plant pest or noxious weed that is new to or not known to be widely prevalent or distributed within or through out India.

These Acts also authorize the Ministry to order an owner, or an agent of the owner, of a plant, biological control organism, plant product, plant pest or noxious weed to treat, destroy, or otherwise dispose of those items. In addition, when a State is unable or unwilling to take the necessary action to prevent the dissemination of a plant pest or noxious weed, the Union Ministry has the authority to declare an extraordinary emergency and take appropriate actions. They also specifically authorize the Union Ministry to develop integrated

management plans for noxious weeds for the geographic region or ecological range where the noxious weed is found in India.

In addition, these Acts authorize the Union Ministry to cooperate with other Ministries, States, national governments, local governments of other nations, domestic or international organizations, domestic or international associations, and other persons to carry out their provisions.

Animal Quarantine

The Ministry's authority to regulate the importation and interstate movement of invasive animal species derives primarily from the "Livestock Importation Act 1898"(and its amendments upto 2001). The animal quarantine requirements under them authorize the Competent Authority (Animal Husbandry Commissioner/ Fisheries Development Commissioner/ Animal Quarantine Division) to promulgate regulations and take measures to prevent the introduction and dissemination of communicable diseases and pests of livestock and poultry. The animal quarantine rules authorize the Competent Authority to regulate the importation and interstate movement of all members of the animal kingdom, domestic and wild, except man, for the purpose of regulating communicable diseases and pests of livestock and poultry. Under these rules, the Competent Authority is authorized to seize, quarantine, and dispose of animals, animal products, or other material that can harbor disease or pests of livestock or poultry that are moving or are being handled, or have moved or have been handled, in interstate or foreign trade if they are infected with or exposed to a communicable disease of livestock or poultry.

Fishes are not included in the Wildlife (Protection) Act. The main available legal instrument covering fishes is the Indian Fisheries Act, 1897 that was enacted to protect aqua resources and also covered direct and indirect revenue earning. States have also enacted their Fisheries Acts and framed rules and regulations for implementation. Provisions of the Indian Livestock Importation Act, 1898 (and amendments, 2001) have been extended to cover fishes also.

Legal Authorities Available to the Union Ministry of Environment and Forests:

- The Forest Act, 1927
- The Wildlife (Protection) Act, 1972 (Amendment Act, 1991)
- The Forest (Conservation) Act, 1980
- The Wildlife (Protection) Act, 1972 and subsequent amendments up to 1993
- The Environment Protection Act, 1986
- The Coastal Regulation Zone Act, 1991
- The Environment Impact Assessment Notifications Act, 1994

The Ministry is required to develop and maintain a forest management plan for each administrative unit of the National Forest Management System. Forest plans establish forest-wide and area-specific management direction and may include management direction relating to the control of invasive species. The other Acts, pertaining to the protection of environment, also empower the Competent Authority to frame relevant rules and regulations and also to issue directions to States when necessary.

Legal Authorities Available to the Union Ministry of Commerce and Industry

- The Import and Export (Control) Act, 1947
- Foreign Trade (Development and Regulation) Act, 1992
- EXIM Policy 2002-2007

Provisions under these regulatory measures work in conjunction with the above -mentioned legislations enacted by different Ministries.

Leadership Role and Coordination

The Ministry of Agriculture is the nodal agency and is expected to provide the leadership and also coordinate the regulatory actions among all the concerned ministries and departments/ agencies in liaison with the State Governments. It is also the nodal Ministry regarding linkages with FAO, OIE, IPPC and other regional and international organizations concerned with genetic resources for food and agriculture. It is also responsible for quarantine operations in the country for plants and animals.

Ministry of Environment and Forests is the nodal agency for matters related to biodiversity, habitats and ecosystems and has links to CBD, CITES, CMS and Ramsar Convention. Ministry of Commerce and Industry, in cooperation with the Ministry of Agriculture, is the nodal ministry for implementation of the WTO-SPS Agreement on the Application of Sanitary and Phytosanitary Measures.

There is no clear focus on invasive alien species though several ministries and departments are primarily or partially dealing with them. Jurisdiction, authority and responsibilities seem to be overlapping with little accountability. Negotiations on this subject under the auspices of CBD are handled by the Ministry of Environment and Forests in association with the Ministry of Agriculture. Low priority is reflected in the National Report submitted to CBD on the implementation of Article 8h (Alien Species). There is an obvious need for perspective planning and proactive lead role, both at national and international levels.

An Operational Overview of the National System

Measures for Prevention

Actions to prevent or minimize the entry of unwanted alien organisms are preferred considering the technical difficulties and high costs of detecting, eradicating or containing the introduced species that become invasive. Hence, high priority is being accorded to prevention measures in India. Tools for prevention include prohibitions and permits (especially for deliberate introductions), quarantine measures (especially for incidental introductions on commodities), and destruction of the unwanted species through biological control and physical or chemical means. Since such controls are transboundary by nature, international cooperation is therefore vital. International instruments play an important role in providing a generally accepted regulatory framework for preventive measures taken at the national level.

The use of import and export controls to prevent introduction of pests is long established in India. National plant and animal health services and customs authorities play a key role in implementation of border controls, import restrictions and other quarantine measures.

Quarantine systems theoretically cover all introductions that can involve the transfer of pests but in practice there are wide variations in the scope and administrative working. Serious constraints are faced regarding legal authority, inspection facilities, taxonomic capacity, access to information, and human and financial resources. These controls are located in the Ministry for Agriculture but their implementation involves active participation of several other ministries/ departments/ agencies. Although all sectors involved in these operations are expected to be appropriately engaged and accountable, yet, the coordination between agencies remains far from being effective.

To sum up notwithstanding all the available regulatory provisions, the prevention and early detection measures for invasive alien species have not proved to be fully effective. The entire system works on the voluntarily disclosures at the designated ports of entry with hardly any strict checking system in place. The Directorate of Plant Protection, Quarantine and Storage, the nodal authority, does not have the powers of 'search and siege'. These powers rest only with the Customs authorities and if they intercept any seed/ planting materials noticed by them in the accompanied baggage of incoming passengers and pass them on to the quarantine officials for examination and due clearance. Regulatory system for the intentional introductions for research appears to operate effectively but this component forms just a small part of the total inflow of biological materials in the country. The national system has recently been strengthened under a UNDP Project and it remains to be seen how the entry of all plants and animals (including fish and other aquatic organisms) can be regulated under a unified, autonomous and statutory, national authority with assured funding and operational facilities.

Measures for Early Detection

The tools available for the early detection of invasive alien species include general surveillance or collation of information, site-specific surveys (for example, through trapping at likely entry points to ascertain the distribution of a known invasive or to detect a particular pest through trapping), monitoring, taxonomic identification, and public-awareness campaigns.

A significant and fast developing tool is the use of information systems for regulatory purposes. The series of publications, brought out by NBPGR, on plant pathogens and pests not known to occur in India is relevant here (Sharma *et al.*, 1990; Lal and Kapur, 1992). While there is consensus on the need to enlarge databases on known and potential invasive species and to make this information accessible as part of global capacity-building on invasive alien species, it must be recognized that some kinds of information may have commercial or political implications.

Infrastructure for the early detection of invasive alien species is being strengthened rapidly in India.

Monitoring for pests is particularly active programme. Early detection relies mostly on workers on the ground (farmers, extension staff), research organisations, field naturalists, NGOs and members of the public. Public-awareness schemes together with education and reporting mechanisms can contribute significantly to early detection and monitoring of alien species.

The IPPC, OIE and Codex Alimentarius support the establishment of surveillance systems as part of national frameworks and provide a basis for emergency action. Under the IPPC, elements include identification of pests already present and identification and surveillance of areas that are pest-free or from which a pest has been eradicated. In practice, national and regional capacity and also the funding are critical to effective surveillance.

Nationally, monitoring and early warning systems are still weak due largely to lack of information about species already present (baseline data) and lack of accessible information systems. Weak institutional linkages limit the ability of environment, veterinary, phytosanitary and health authorities to cooperate on prompt action.

To sum up, the lack of a national database on this subject is the major limitation. Access to information, held by the governmental system, is very limited and linkage with lead institutions and non-governmental agencies is weak. Surveillance at the field level for some prioritized species/ pathogens is in operation but its working and linkages need to be monitored and reviewed. Public education and awareness on this topic remains extremely low. Detection of species is weaker for lower taxonomic categories. Coverage of pathways is still inadequate, notably for the alien freshwater aquatic species. Finally, the networking and early warning systems leave much to be desired to be effective.

While terrestrial systems are mostly supported by the measures developed under agricultural conditions, particularly for weeds and insects, all major plant pathogens are not adequately covered by the existing capacities and merit greater attention. Awareness of some diseases and of certain taxa such as nematodes, flatworms and snails is gradually building up. Animal pathogens are well covered but only to the extent that the invading species is on the list of international notified diseases.

Aquatic weed control is now getting more attention because of public outcry. Likewise some progress has been made with invasive fish species and aquatic animal pathogens also. Best practices regarding introductions and transport of alien fish species need to be given more attention. The recent inclusion of aquatic animal (fish, shrimp and other) diseases among officially notified diseases are expected to reduce the spread of pathogens to natural populations surrounding aquaculture and adjacent processing sites.

Measures for Eradication and Control of IAS

Where an alien species has become invasive, options to prevent its establishment and spread include eradication (where feasible and cost-effective), containment or long-term control measures, and measures to mitigate the impacts of invasive alien species. Integrated pest management (IPM) technologies have been developed, most strongly for the management of insect pest problems in agriculture. These technologies have been directed for a complex of pests that affect a particular crop system. Good progress has been made in implementation but only for a few selected species.

Eradication requires prior effective surveillance on the distribution of the IAS, containment to prevent its spread, a good understanding of the biology of the target organism, and sufficient funding for training and follow-up measures to prevent re-invasion. Eradication is more likely to be successful in the early stages of invasion. Even so, total eradication of an established alien species is often difficult to achieve as experienced in several weedy species.

The aim of controlling invasive alien species has been either to contain the species within a geographical area or to suppress the overall abundance of the species to a level where it no longer causes any significant economic, social or ecological damage. Control measures for either containment or suppression fall into the following categories:

- Physical or mechanical (e.g., mechanical harvesters, hunting, trapping);
- Chemical (e.g., herbicides, insecticides);
- Biological [this includes a number of tools: the introduction, conservation or augmentation of natural enemies, the application of microorganisms as a biopesticide, host plant resistance (HPR), and

other tools such as behaviour modifying chemicals like pheromones, male sterile release and fertility control];

- Habitat management (e.g. crop rotation, nutrient management);
- Integrated pest management, utilizing combinations of the above four main measures.

To sum up the national legislative measures are weaker on eradication and control than on the prevention on the entry of exotics. Other constraints include poor institutional linkages, narrow mandates and lack of a strategic framework for remedial action. Prerequisites like surveillance on the distribution of the pest, proper understanding of the biology of the target organism and a risk analysis are found mostly wanting. Control measures for either containment or suppression of noxious weeds like Lantana, Parthenium and water hyacinth have not achieved notable success, primarily due to fragmented efforts that permit regeneration. While many tools exist for control of some invasive species, more work on generating technical knowledge and developing new methods is required for several other taxa. There is an urgent need for developing a national programme with identified institutional support.

Mitigation of Impacts and Adaptation Measures

Strategies to control the impacts of established invasive alien species have included reduction or elimination of the invasive species and their spread through mitigation measures, such as eliminating the invasive alien species completely, containment (keeping the invasive alien species within regional barriers); or suppression (reducing population levels of the invasive alien species to an acceptable threshold), that would curtail the extent, duration and impacts of the invasion (NISC, 2001).

It is now appreciated that the mitigation of impact would be most effective when it employs a long-term, ecosystem approach rather than an approach directed to controlling invasive species in isolation (Ramakrishnan and Vitousek, 1989).

Restoration may involve reintroduction or re-establishment of populations of native species and/or enhancement of native biodiversity and the structure and functions of the habitats or ecosystems that have been degraded as a result of invasion by alien species (Ramakrishnan, 1991). Restoration techniques, based on detailed information on invasive species biology and ecology, site assessments, beneficial plantings and monitoring of the effects of disturbances such as fire and flooding, have allowed the recovery of some terrestrial habitats/ecosystems to nearly their states before invasions (Sankaran *et al.*, 2001).

There is need to develop guidance for restoration work. This could be based on best practices for appropriate uses of native and desirable non-native species, the best available techniques for restoring habitats/ecosystems, as well as management practices that promote regeneration of native species and habitats/ecosystems (MSSRF-CABI, 2000).

To sum up attempts at predicting impacts have generally been unsatisfactory. There is a need for better and wider quantification and measurement of what invasive species do. In the context of preserving biodiversity, such studies are urgently needed. Data from countries where a species has previously invaded and been controlled can provide useful information on approaches to management. In addition, best practices for restoration of degraded ecosystems with the help of native species need to be documented and promoted.

Critical Gaps

Policy Support

Overall policy support to deal with the challenges posed by the invasive alien species in India is weak, particularly considering that this country is more vulnerable due to its vast porous borders, diverse agro-ecological zones and rich native biodiversity. This general perception is reflected by the low key at which India participates in international inter-governmental negotiations on this subject. This inference also emerges from India's national report submitted to CBD on the implementation of Article 8(h): Alien Species. Three one-page sketchy case studies contributed by India with a view to sharing knowledge in this area have made a poor impression as they seem to ignore the wealth of information available in the country. Other developing countries expect India to play a lead role in these negotiations in view of the enormous scientific expertise and also experiences available here on this topic.

Setting of Priorities

Programmes and activities bearing on the prevention (including regulation of introductions and quarantine measures), containment, control and management of

invasive alien species and also on mitigation of their impact require a more balanced approach and prioritization, particularly in terms of responsibilities and fund allocation.

Database

The major limitation to work on IAS is the lack of national database on intentional and accidental introductions in the country and their distribution. Access to information on different key aspects is restricted, particularly from the governmental sources. Several websites developed by some government departments, in an effort to promote awareness about their activities, are of limited help as most of them are either not updated or remain inaccessible.

Lines of Command

Authority to deal with different components of biodiversity (plants, animals, aquatic species, insect pests and pathogens) is fragmented in tight compartments with weak linkages and ineffective coordination and monitoring mechanisms. This leaves serious gaps and also leads to unavoidable overlaps.

Legal protection

There is no legal power of search and seize delegated to the quarantine staff as these entirely rest with the customs staff who often work with little orientation training or even proper briefs on invasive species. For example, not much effective actions have been taken to prevent unauthorized introduced fishes and punish the person/ organization violating the provisions of the Livestock Importation Act. Strengthening of State Fisheries Acts to include authority to prohibit sale of illegally introduced exotic fishes is needed.

Structural Limitations

Massive effort to strengthen the plant quarantine system with assistance from the UNDP notwithstanding, the quarantine component covering animal and aquatic species appears to have limitations of effective networking with the plant side. There is an obvious need for developing a unified national system with strong linkage with the relevant State Departments. Leadership role appears to be missing in this subject of national importance. There is also an imbalance in programmes since major focus of import regulation and quarantine operations remains on crop weeds, insect pests and pathogens of agricultural importance.

Quarantine Effectiveness

Enforcement of quarantine regulations at all the major disembarking ports needs to be improved and streamlined to make them more effective. Role of the Designated Inspection Authorities is very crucial and requires coordination and monitoring. A separate 'Living Organisms Quarantine Declaration Card', like the one used for 'Customs Declaration Card', needs to be introduced for the passengers disembarking in India enabling them to declare any plant materials/ seeds/ animals/ aquatic organisms brought by them as accompanied baggage. All these items should then be subjected to quarantine check and clearance. All State Governments should have separate quarantine wings/ units to effectively implement the domestic quarantine regulations.

Domestic Quarantine

Only nine insect pests/ pathogens have been covered at present under domestic plant quarantine regulations. There are, however, a number of other serious pests/ diseases that are still localized and not covered under these regulations. Even in the case of these nine pests, domestic quarantine is not being enforced properly with the result that these pests continue to spread to more areas/ states in the country. There appears to be no serious concern as yet on alien species invading and dominating public places, forest areas, freshwater systems and wastelands.

Awareness

The level of awareness on this subject remains low, particularly among the political leadership, policy makers and managers. There is an urgent need to organize public opinion and undertake campaigns on a war footing towards eradication/control/ management of top 10 invasive species in the country and restoration of the affected habitats/ecosystems. This requires collection and analysis of data on socio-economic impact of the alien species in major areas of their occupation so as to relate the problem to local people/ communities.

Law Enforcement Problems (The Case of Bighead Carp and African Catfish/ Thai Magur):

Based on the reports of various State Governments, state fisheries departments and followed by detailed field studies and a survey of fish farmers and fish traders, the National Bureau of Fish Genetic Resources

concluded that the culture of two unauthorized exotic fish species, namely, the Bighead Carp and Thai magur (also called African Catfish), was spreading under captivity in different parts of the country.

This survey also revealed that the Bighead carp, believed to arrive illegally from Thailand via Bangladesh more than 15 years back, was becoming more popular than even the widely cultured Silver Carp (one of the Chinese Carps) that was introduced legally earlier to boost fish production and fish farmers' income.

Since its introduction in 1975 at the Thu Duck Aquaculture Station in South Vietnam, the African catfish (also called Thai magur in India) has spread to Cambodia, Laos, China, Thailand, Bangladesh and India covering a large part of Asia. Deep concerns expressed about its negative impact on the indigenous fish fauna notwithstanding, the fact remains that culture of this species and its hybrids is also spreading rapidly.

Although the Indian scientists, environmentalists and NGOs decry the unauthorized introduction of these two invasive alien species in the country, yet, the way to stop their entry and spread into Indian waters is yet to be found.

The National Committee to oversee and regulate Introduction of Exotic Aquatic Species in Indian Waters discussed the issue of "unauthorized introduction of exotic magur and bighead carp" in its first meeting held on 9 October 1997, under the Chairmanship of Joint Secretary (Fisheries), and recommended as follows:

"The Ministry of Agriculture should write to all the States/ UTs to take immediate steps to destroy the existing stock of exotic magur and bighead which have been introduced into the country without official sanctions. All hatcheries may be identified and destroyed by the concerned States. It was stressed that exotic magur (*Clarias gariepinus*) should not establish in the natural environment and cross with the endemic species *Clarias gariepinus*. A strict controlling measure should also be adopted to avoid spread of exotic disease(s) from *Clarias gariepinus* to the endemic fishes."

The Fisheries Development Commissioner wrote to the Secretary (Fisheries), State Governments vide DO No.31016/1/96-FY dated 19 December 1997 requesting that necessary action may be taken immediately on this recommendation.

This order was challenged by C. Sebastian and others before the Hon'ble High Court of Kerala claiming that the two exotic fishes were very high yielding and commonly cultured throughout India for the last 15 years and destroying their stocks would bring losses to fish farmers. The Hon'ble Court directed the Government to provide all available relevant scientific data. This direction has been complied with and the matter stands there.

This case illustrates some of the problems encountered in implementation of the measures aimed at prevention, detection, eradication and mitigation of the impact of invasive alien species offers lessons to be learned.

Recommendations

The challenges posed by invasive alien species in India are enormous, both in dimensions and intensity. In marked contrast to this alarming situation, level of preparedness and response of the Central and State Governments appears to be inadequate. There is no unified national system geared to address the problems created by biological invasives and the authority/ responsibilities dealing with plants, animals, fishes and other aquatic species are rigidly compartmentalized. A holistic approach to face the prevailing and impending threats is missing and, above all, participation of key players and major stakeholders in decision making and problem solving is either lacking or ineffective. There are, however, examples of good work done in some areas but they do not seem to be part of a planned national effort. Some suggestions are offered here with a view to stimulating fresh thinking on this subject and drawing attention to some pivotal aspects of the national system that require re-orientation.

Role of the Central Government

- Overall authority regarding regulation of imports (of plants and livestock) and quarantine;
- Leadership, perspective planning, coordination and monitoring;
- National system development, infrastructure, database, institutional support, linkages;
- Early Warning and Watch: Detection, containment, quick response and monitoring;
- Legislation and enforcement;
- Capacity building and research support (Developing technologies to manage IAS);
- Education and public awareness;
- Fund mobilization; and

- Regional and international cooperation (also inter-governmental negotiations/ national reporting).
- **Establishing 'Unified Command for Plant and Animal Quarantine':**

A proposal for establishment of an autonomous Quarantine Authority of India.

Authority for import and quarantine of plants and seed materials is presently with the Plant Protection Advisor to the Govt. of India, Department of Agriculture & Cooperation, who heads the Directorate of Plant Protection, Quarantine & Storage. Director, National Bureau of Plant Genetic Resources, working under ICAR, shares the delegated responsibility for import of germplasm of agri-horticultural crops. Authority for import and quarantine of livestock (including fishes and aquatic species) rests with the Department of Animal Husbandry & Dairying with technical advice of the Animal Husbandry Commissioner and Fisheries Commissioner.

The plant quarantine activities in the country are presently regulated through implementation of Plant Quarantine (Regulation of Import into India) Order, 2003 (implemented from 1.1.2004) notified under the DIP Act, 1914 while the animal quarantine is regulated through implementation of the provisions under the Livestock Importation Act 1898 (as amended upto 2001).

Being the signatory to the International Plant Protection Convention (IPPC), India is obliged to have a National Plant Protection Organisation (Central Regulatory Agency) responsible for meeting international obligations relating to phytosanitary measures. Effective functioning of such a regulatory agency enjoins upon its necessary financial and administrative flexibility. Hence, an urgent need has been felt to establish an autonomous authority under the Government of India to undertake the scientific requirements of pest risk analysis, development of national standards, domestic and national quarantine, etc. A proposal to establish a **Plant Quarantine Authority of India** for this purpose is under discussion but it needs to be made more comprehensive covering quarantine measures in respect of animals and aquatic organisms (including fish) also. Accordingly, a recommendation is being made here to enact legislation for establishing an autonomous Quarantine Authority of India.

- **Setting up 'National Invasive Species Advisory Committee': A Proposal**

Considering that the scope of dealing with invasive alien species is multi-dimensional and requires multi-disciplinary inputs, there is an urgent need for establishing a broad-based National Invasive Species Advisory Committee to advise the Government on this subject and to work for the following objectives:

- To provide national leadership on invasive species;
- To see that the Central efforts are coordinated and effective;
- To promote action at local, State and ecosystem levels;
- To identify recommendations for international cooperation;
- To facilitate a coordinated network to document and monitor invasive species;
- To develop a web-based information network;
- To provide guidance on invasive species for Central Government agencies; and
- To prepare the National Invasive Species Management Plan.

Role of State Governments

- Assert their partnership right in preparation of the National Action Plan on IAS;
- Play the Area Commander's role in all Central Government's field programmes dealing with invasive alien species;
- Establish Surveillance, Early Warning and Quick Response System dealing with IAS;
- Strengthen their plant quarantine capacity and assist the Central Government in enforcing regulations of domestic quarantine;
- Enlist progressively greater involvement of *Panchayati Raj* (local self-government) institutions with capacity building activities;
- Mobilize funds based on proposals for field programmes and preparation of Case Studies;
- Involve local institutions and consultants in demonstrative restoration of the ecosystems;
- Organise Bio-Security Campaigns for disinfestation of the invaded areas;
- Support socio-economic studies, monitoring work and public awareness campaigns in partnership

with civil society organizations and self-help groups.

Role of Institutions

- Providing expertise, research backup and policy inputs;
- Extending research, technical and technological support;
- Developing and strengthening linkages;
- Conducting socio-economic studies;
- Developing case studies;
- Organising workshops and discussion meetings;
- Providing consultants/ subject matter specialists;
- Leading the effort on restoration of ecosystems and mitigation of negative impacts; and
- Project based mobilization of funds, particularly from international funding agencies.

Regional and International Cooperation

International Agreements and Authorities:

India cannot succeed in facing its invasive species problems unless it plays a leadership and proactive role in regional and international cooperation, and also in intergovernmental negotiations on this subject in different international forums.

Conclusions

India is highly vulnerable to the invasions of aggressive alien species in view of its vast ('porous') borders, wide spectrum of climatic and soil conditions, rich native biological wealth, endemic repository of wild relatives of cultivated plants, weak enforcement of biodiversity and environmental protection laws, ineffective implementation of regulatory measures for import of living organisms (plants, livestock, fishes and other aquatic species, insects and accidental introduction of virulent pathogens), expanding tourism and liberalization of trade. National system to respond to the prevalent and impending threats of IAS is still weak with notable shortcomings and gaps. It has, however, the scientific strength and capability to face these challenges provided that the priorities are set rightly at various levels, required funds are mobilised and the actions are taken without further delay with full administrative support and political will. The Central and State Governments and various ministries/ departments must work together for this purpose in active partnership with lead research institutions and civil society organizations and with effective involvement of local people and *Panchayati Raj* institutions. It is also desirable that campaigns for clearance of already heavily infested areas and restoration of invaded ecosystems be linked to Government's 'Food for Work' Programme in case a real headway is to be made in this direction.

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