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Prevention and Related Measures for Invasive Alien Plants in India: Policy Framework and Other Initiatives

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Introduction

Invasive alien species (IAS) are pathogens, plants and animals that are introduced into new areas where they are not part of the native flora and fauna, and because they are free of the natural enemies and/or competition found in their areas of origin, they spread or reproduce prolifically. Globally, they are a serious impediment to agricultural production and the conservation and sustainable use of biodiversity and other natural resources, often with significant irreversible impacts. Their costs include not only the direct costs of the agricultural and/or biodiversity loss they cause and the management needed to reduce their impacts, but also the indirect costs due to their impacts on ecological services, such as pollination, climate regulation and water purification. On a global scale, some of the most pernicious IAS are invasive alien plants, and many of these species are still spreading between and within countries (CABI, 2016); here, this situation is exemplified by India.

India's people and economy are heavily dependent on agriculture and India's vast natural resources. The country ranks among the world's megadiverse countries. India is

one the world's centres of crop diversity, and holds approximately 12% of the world flora, which includes 5725 endemic species of higher plants (Sharma and Brahmi, 2011). With increasing trade and movement of people, as well as agriculture (crops, livestock, forest products), India's natural biodiversity is under continuous threat from accidental or intentional introduction of invasive alien plants and other IAS. Although IAS have been identified as a major factor in natural resource management (Diwakar, 2003), reliable estimates of India's invasive flora are lacking (Khuroo *et al.*, 2012) and the impact of invasive plants on community structure and ecosystem processes is poorly understood (Mandal, 2011). Previous estimates of invasive alien plant numbers have not been based on reliable empirical data, which has serious implications for the management of plant invasions (Khuroo *et al.*, 2012). Two recent studies estimated that: (i) 173 species in 117 genera are invasive alien plants in India, which represents 1% of the vascular flora (Mandal, 2011); and (ii) 225 species (14%) of alien plant species in India are invasive, with another 134 (8%) having the potential to become invasive (Khuroo *et al.*, 2012). Even though these two studies do not

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agree completely, they do report figures of the same order of magnitude.

Apart from numbers, the impact of individual invasive alien plant species can be dramatic. Species frequently monopolize the environment and cause health hazards, reduce crop yields, increase labour costs and prevent the re-establishment of native species such as fodder grasses, shrubs and forest trees after land disturbance. In north-eastern India and the Western Ghats, invasive plants, including *Chromolaena odorata*, *Lantana camara* and *Mikania micrantha* infest extensive tracts of agricultural and forest land, displacing native flora and animals and even human activities (on this last point see, for example, Ramakrishnan, 2001). Interference with water flow and availability following invasion by waterweeds such as water hyacinth (*Eichhornia crassipes*) has led to decline in wetlands and associated wildlife. Parthenium weed (*Parthenium hysterophorus*) dominates the vegetation in town and city wastelands and is a potential allergen threatening human health.

In India, as in other countries, the development of appropriate national institutional and policy frameworks to address the increasing tide of invasive plants and other IAS has been complicated because of the traditional divide in responsibilities for the main two sectors at risk: agriculture and the environment (Griffin, 2003). In addition, there has been no commensurate increase in human resources and infrastructure facilities to handle the increased movement of IAS with trade (Sathyanarayana and Sathyagopal, 2013). The status of management of IAS in general in India has been reviewed by Mandal (2011) and Reshi and Khuroo (2012), while the review of IAS in India by Rana *et al.* (2004) includes an account of regulatory mechanisms. Efforts are also continuing to improve the export certification process and standards (Shah, 2008).

In this chapter, the focus is on the history and current status of the regulatory mechanisms and other initiatives in India that relate to preventive and related measures for invasive alien plants; the emphasis is on prevention because this is the most

cost-effective means of reducing the threats of these IAS (Wittenberg and Cock, 2001). Naturally, much of this is embedded in or stems from the country's general regulatory framework development and actions. Lastly, the chapter outlines the need for a national strategy on IAS. However, as the national regulatory framework has, by necessity, needed to harmonize with some binding international agreements and conventions that contain provisions on regulation, a brief overview of these is given first.

International Instruments Relating to the Prevention of IAS

There are many binding international instruments that include provisions for preventing the movement (intentional or accidental) of IAS, and these naturally include invasive alien plants; a complete review is provided by Shine *et al.* (2000). Three of the more important instruments to which India is a signatory are outlined here.

For trade, the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) is an international treaty that came into force in early 1995 under the World Trade Organization (WTO) and relates to prevention of the establishment or spread of alien pests (including invasive plants), diseases or disease-causing organisms of plants and animals into new geographical areas (WTO, 1995). The SPS Agreement aims to overcome impediments to market access that may result from pests and diseases by encouraging the 'establishment, recognition and application of common sanitary and phytosanitary measures by different Members'. The primary incentive for the use of such common international norms is that they provide the necessary protection based on scientific evidence, and at the same time improve trade flow.

The SPS Agreement recognizes the International Plant Protection Convention (IPPC; <https://www.ippc.int/en/>) as the organization mandated to develop International Standards for Phytosanitary Measures

(ISPMs), and the IPPC is the most relevant standard-setting body in the context of invasive alien plants. The standards that are relevant in the current context are listed in Table 8.1.

One of the major requirements of the SPS Agreement is for signatories to undertake pest risk analysis (PRA) for all the agricultural commodities traded (Khetarpal and Gupta, 2002). The entire procedure is a blend of inductive, deductive and expert opinion that facilitates the identification and characterization of risk. The guidelines for PRA as per ISPM 2 and ISPM 11, which elaborate the general requirements for a PRA, did not originally cover environmental impacts. However, ISPM 11 was revised in 2003 and 2004 to include the analysis of environmental risks and of living modified organisms (or LMOs; the term used in texts on the Convention on Biological Diversity, which equates, for most purposes, including ours, to the more generally used ‘genetically modified organisms’, or GMOs), thus widening the scope of the IPPC to include specific guidelines for assessing environmental risks due to the introduction of pests. In 2013, ISPM 11 was revised further to include PRA for plants as quarantine pests. The range of pests covered by the IPPC therefore extends beyond pests directly affecting cultivated plants and includes invasive plants and other species having indirect effects on cultivated plants and wild flora. The indirect effects include competition in natural or semi-natural environments and deleterious effects on other plant species/health in habitats/ecosystems. The inclusion of the analysis of environmental risks in a PRA ensures

the protection of the environment, ecosystem and wild flora (Gupta and Khetarpal, 2006).

From an environmental perspective, the Convention on Biological Diversity (CBD), which came into force in 1993, also has provisions on IAS. These are contained in Article 8(h) which states that ‘Each contracting Party shall, as far as possible and as appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species’ (Secretariat of the CBD, 2005). At the sixth meeting of the Conference of the Parties to the CBD (COP 6) the ‘Guiding Principles’ for the implementation of Article 8(h) were adopted (Decision V1/23) (CBD, 2002), but the Parties also recognized the contribution of existing international instruments covering standards (such as those of the IPPC) that are relevant to these Guiding Principles. In 2014, the IPPC became a member of the Liaison Group of the Biodiversity-related Conventions, which has facilitated a closer working cooperation between the CBD and the IPPC.

At the ninth meeting of the Conference of Parties to the CBD (COP 9), the Parties called for the consideration of IAS when developing policy frameworks for sustainable production and the use of biofuels (Decision IX/2), forest biodiversity (IX/5) and island biodiversity (IX/21), and set out detailed recommendations for improving IAS information systems through the Global Taxonomy Initiative (IX/22) (CBD, 2008).

Both the CBD and the IPPC broadly call for risk analysis/management that is based on transparency and non-discrimination, and

Table 8.1. International Standards for Phytosanitary Measures (ISPMs) cited in this chapter. Information from www.ippc.int/standards

ISPM No.	Title	Date of notification	Reference
2	Framework for Pest Risk Analysis	March 2007 (revised from 1995 version)	IPPC, 2007
11	Pest Risk Analysis for Quarantine Pests	April 2013 (revised from 2001, 2003 and 2004 versions)	IPCC, 2013a
15	Regulation of Wood Packaging Material in International Trade	June 2013 (revised from 2002, 2006 and 2009 versions; Annex 1 and 2 revised in 2013)	IPCC, 2013b
19	Guidelines on Lists of Regulated Pests	April 2003	IPCC, 2003

places emphasis on measures being minimally restrictive while managing the risks.

Many national agricultural departments may have little experience in dealing with alien crop pests, including plant pests (i.e. weeds), but in the international agricultural sector, the Food and Agriculture Organization of the United Nations (FAO), CABI and regional plant protection organizations (RPPOs) provide information on invasive species problems. For example, CABI provides technical support at the international and national levels, in the form of the identification of new alien species, provision of distribution maps and databases such as the Crop Protection Compendium (www.cabi.org/isc) and the Invasive Species Compendium (www.cabi.org/isc).

History and Current Status of Regulatory Mechanisms for Prevention of IAS in India

The effective prevention of IAS, including invasive alien plants, requires appropriate national laws as well as coordinated international action. The international agreements address components of the IAS problem, but comprehensive national legislation is needed for implementation in each country. As noted above, most regulatory mechanisms for invasive plants are contained in more general regulatory mechanisms.

Awareness of the importance of quarantine measures in India started in the early 20th century when in 1906 the Indian government ordered the compulsory fumigation of imported cotton bales to prevent the introduction of a Mexican species, the cotton boll weevil (*Anthonomus grandis*). As indicated earlier, the policy of using government authority to prevent the entry of dangerous exotic pests is based on the principle that it is preferable to undergo some inconvenience in an effort to exclude pests rather than to accept the expense of controlling them. The quarantine law was enacted for the first time in India in 1914 as the Destructive Insects and Pests (DIP) Act. A gazette notification entitled 'Rules for regulating

the import of plants etc. into India' was published in 1936. Over the years, the DIP Act has been revised and amended several times to meet the growing requirements of liberalized trade.

The DIP Act, 1914, provides for the following authorizations by the central and state governments:

- It authorizes the central government to:
 - prohibit or regulate the import into India or any part thereof or any specific place therein or any article or class of articles; and
 - prohibit or regulate the export from a state or the transport from one state to another state in India of any plants and plant materials, diseases or insects, likely to cause infection or infestation. It also authorizes the control of transport and carriage and gives power to prescribe the nature of documents to accompany such plants, plant materials and articles.
- It authorizes the state government to:
 - make rules for the detention, inspection, disinfection or destruction of any pest or class of pests or of any article or class of articles, in respect of which the central government have issued notifications; and
 - regulate the powers and duties of the officers whom it may appoint on its behalf.

The Act provides a penalty for persons who knowingly contravene the rules and regulations issued under the Act and at the same time protects from prosecution or other legal proceedings anyone acting in good faith.

In 1984, a notification was issued under the DIP Act, namely the Plants, Fruits and Seeds (Regulation of Import into India) Order, popularly known as the PFS Order, which was revised in 1989 after the announcement of the New Policy on Seed Development (NPSD) by the Government of India in 1988, which proposed major modifications for smooth quarantine functioning. The new policy covered the import of seeds/planting materials of wheat, paddy, coarse cereals, oil seeds, pulses, vegetables, flowers,

ornamentals and fruit crops. After the enactment of the NPSD in 1988, and the WTO Agreement in 1995, the import of agricultural commodities was allowed more freely. This led to the introduction of several new pests and diseases into the country. While liberalizing import though, care had been taken to ensure that there was absolutely no compromise on plant quarantine requirements. Thus, the PFS Order, 1989, was repealed by the Plant Quarantine (Regulation of Import into India) Order, 2003 (PQ Order) (Government of India, 2003) as a legislative attempt to comply with the SPS Agreement of the WTO.

In particular, the PQ Order, 2003, was brought into force as there was an urgent need to:

- fill the gaps in the existing PFS Order, including those pertaining to the regulation of the import of germplasm/genetically modified organisms (GMOs)/transgenic plant material, live insects/fungi, including biocontrol agents, etc.;
 - facilitate safe conduct of global trade in agriculture and thereby fulfil India's legal obligations under the various international agreements;
 - protect the interests of the farmers of the country by preventing the entry, establishment and spread of destructive pests, vectors and other noxious alien species, and also the national flora and environment; and
 - safeguard national biodiversity from threats from alien species invasions.
- restricted species whose import is permitted only with further declarations of freedoms from quarantine/regulated pests and subject to specified treatment certifications (Schedule VI); or
 - plant material whose import for consumption/industrial processing is permitted with a normal Phytosanitary Certificate (Schedule VII).
- The import of commodities with weed/alien species contamination as per Schedule VIII is prohibited.
 - There is a restriction on the import of packaging material of plant origin unless it is treated.
 - The provisions include regulating the import of:
 - soil, peat and sphagnum moss;
 - germplasm/GMOs/transgenic material for research;
 - live insects/microbial cultures and biological control agents; and
 - timber and wooden logs.
 - Permit requirement is enforced on imports of seeds, including flower seeds, propagating material and mushroom spawn cultures.
 - Additional declarations are specified in the Order for the import of agricultural commodities, specifically listing quarantine pests and 31 weed species.
 - Notified points of entry are increased to 130 from the previous 59. (The official entry points are the quarantine stations of the Directorate of Plant Protection, Quarantine and Storage, DPPQS.)
 - Certification fees and inspection charges are rationalized.

Under the PQ Order, 2003, apart from PRA being a precondition for all imports, the scope of plant quarantine activities was widened to incorporate additional definitions. The other salient features of the PQ Order are:

- Agricultural imports classified as follows are included:
 - prohibited plant species (Schedule IV attached to the Order);
 - restricted species where import is permitted only by authorized institutions (Schedule V);

By June 2017, 42 amendments of the PQ Order, 2003 had been notified to the WTO. These comprised: revising quarantine pest lists; the incorporation of ISPM 15 compliance (see Table 8.1); the recognition of irradiation treatment; pest free areas and cold treatments for fruit flies to allow import of fresh fruits; and revising the lists of crops under Schedules VI and VII to include 694 and 297 crops and commodities, respectively.

In 2007, the National Commission on Farmers recommended developing a National

Agricultural Biosecurity System characterized by high professional, public and political credibility through the integration of plant, animal and fish management systems on biosecurity based on risk analysis and management. It also recommended the establishment of synergies in the requirements of international agreements and national regulations across these sectors to avoid the duplication of resources. In response, a Core Group was constituted in 2008 by the then Department of Agriculture and Cooperation to formulate recommendations for the establishment of an Integrated National Biosecurity System. This Core Group, in its report submitted in 2009, recommended the establishment of the National Agricultural Biosecurity System, which would require new legislation that is more relevant in the context of the present scenario. An Agricultural Biosecurity Bill was thus drafted and submitted in 2013. This provided for the establishment of an Authority for the prevention, eradication and control of pests (including invasive alien plants) and diseases of plants and animals and unwanted organisms. Its task was to ensure agricultural biosecurity, meet the international obligations of India for facilitating the imports and exports of plants, plant products, animals, animal products and aquatic organisms, and the regulation of agriculturally important microorganisms, and deal with all matters connected therewith or incidental thereto. This bill is yet to be approved by the government.

Apart from the plant quarantine regulations, the Indian Biological Diversity Act, 2002, was drafted in line with CBD obligations (Government of India, 2002). There is a need to harmonize the regulations on trade and on access to planting material, particularly those on the assessment of the environmental risk of IAS and LMOs, and those concerning eradication and action plans. An analysis of the implications of both the WTO and the CBD obligations, and efforts at compliance, would contribute significantly to minimizing the introduction and establishment of IAS in the country (Khetarpal and Gupta, 2006).

Beside the above legislation, the Environment (Protection) Act (EPA) was enacted in India in 1986 to protect and improve the environment and prevent hazards to human beings, other living creatures, plants and property (Government of India, 1986). This was a response to the United Nations Conference on the Human Environment held in Stockholm in 1972, which urged all countries to take appropriate steps for the protection and improvement of the environment. Also in 1986, in order to exercise its powers under the EPA, 1986, the central government promulgated the Environment (Protection) Rules with the purpose of protecting and improving the quality of the environment and preventing and abating environmental pollution. In their various schedules, the Rules make relevant provisions for the 'management and handling of hazardous wastes, manufacture, rules for storage and import of hazardous chemicals, and rules for the manufacture, use, import/export and storage of hazardous micro-organisms and genetically-engineered organisms or cells'. They empower the central government to prohibit or restrict the handling of hazardous substances, including their export and import into or from different areas, either in qualitative or in quantitative terms, because of the potential damage to the environment, humans, other living creatures, plants and property. Both IAS and LMOs are covered under the EPA, 1986; however, it does not state in clear terms a framework for the restriction and prohibition of these potential threats to the environment.

Institutions that Currently Cover IAS Issues in India

In India, the Ministry of Environment, Forests and Climate Change (MoEFCC) is the nodal ministry for matters relating to biodiversity, and deals and negotiates with the CBD. The Ministry of Commerce and Industry, in cooperation with the Ministry of Agriculture and Farmers Welfare, is the nodal ministry for the implementation of the phytosanitary aspects of the SPS

Agreement of the WTO. It deals with the quarantine norms and standards to be set up at the national level as per international requirements for minimizing the risks associated with the transboundary movement of pests (plants, insects, nematodes and pathogens), along with agricultural commodities. So far, there is no clear-cut emphasis on IAS, although the subject is dealt with from time to time in several departments of these ministries. However, the MoEFCC, which had earlier accorded low priority to the implementation of the CBD's Article 8(h) in its national report submitted to the CBD (Desai, 1999), instigated initiatives to identify the IAS-related issues at the COP-MOP (Conference of the Parties serving as the Meeting of the Parties to the Biosafety Protocol of the CBD) meetings' series, given the deleterious impacts of IAS on the environment. The eighth meeting of the Conference of the Parties to the CBD (COP 8) in Brazil further highlighted the immediate need for gap analysis and in-depth review of the status of IAS in various member countries.

Prevention and Other Management Initiatives for IAS in India

Even though there is no exclusive national legislation or policy addressing the problem of IAS across sectors, historically there is a suite of enabling policies at the state or other administrative levels that contain elements of prevention and/or other management provisions (Kishwan *et al.*, 2007). Examples of these policies and acts are:

- the Madras Agricultural Pests and Diseases Act, 1919;
- the Travancore Plant Pests and Plant Diseases Regulation, 1919;
- the Coorg Agricultural Pests and Diseases Act, 1933;
- the Patiala Destructive Insects and Pests Act, 1943;
- the Bombay Agricultural Pests and Diseases Act, 1947;
- the Rewa State Agricultural Pests and Diseases Act, 1947;
- the East Punjab Agricultural Pests, Diseases and Noxious Weeds Act, 1949;
- the East Punjab Agricultural Pests, Diseases and Noxious Weeds Act as extended to Himachal Pradesh, 1949; and
- the Assam Agricultural Pests and Diseases Act, 1950.

It is of interest that the Coorg Agricultural Pests and Diseases Act, 1933 mentioned above was originally proposed (as the Coorg Noxious Weed Act, 1914) because of the invasion of coffee plantations by *L. camara*, followed by heavy forest fires, but it was not implemented until 1933 owing to World War I and its heavy cost to the British (see Kannan *et al.*, 2013, p. 1163).

A number of meetings have been held at the international level on IAS and related topics in the last 15 years, and those up to 2009 have been reviewed by Sharma *et al.* (2009). Moreover – and in light of the realization of the importance of IAS, the recent increase in volume of trade, and the exigencies posed by the WTO and the CBD – various meetings, workshops and seminars have been held in India to deliberate on the emerging issues and to bring together a number of organizations that have to cope with IAS issues, in order to share experience and to develop a strategy for their management. The proceedings and recommendations of these various meetings could act as an eye-opener for policy makers by bringing to their attention the fact that a large sector of the scientific community is aware of IAS; this may motivate them to take action at a policy level, which would go a long way towards tackling the current IAS problems.

The MS Swaminathan Research Foundation (MSSRF), Chennai, in collaboration with CABI, UK, organized the 'Conference on Management of Alien Invasive Species' on 2–5 December 2000. The conference addressed the growing threat of IAS and emphasized the need for research to accurately measure the socio-economic impacts of IAS, including those at community and landscape levels, to provide background information for their prevention and management. Also, immediate action was

proposed to eradicate or control biological invasions before their spread caused greater losses and incurred future costs for control. As a key recommendation of the conference, it was proposed that priorities should be set for research on social, economic and other impacts of IAS; the importance of implementing quarantine standards at the national and the state level was emphasized for preventing new invasions and spread within India. In addition, the conference designated various actions to be taken at local, state, national, regional and international levels.

As a sequel to the MSSRF conference outlined above, a brainstorming session was held at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi on 4 June 2001 to discuss 'Research Prioritization for Management of Alien Invasive Species'. These deliberations were focused mainly on the problems pertaining to different ecological habitats, including freshwater systems, mountains and plains (Khetarpal *et al.*, 2001). The exercise also identified various research institutes in the country that could take up work on different aspects of management of IAS and emphasized that a cross-sectoral approach was needed for developing a management model for them.

Several other meetings and symposia were organized on the subject between 2001 and 2003, including one on the 'Ecology of Biological Invasions' at the School of Environmental Studies, University of Delhi on 4–6 December 2003, which aimed to come up with a strategy for dealing with IAS. A workshop organized on 19–21 August 2004 by Banaras Hindu University, Varanasi, explored whether it was possible to predict invasions based on the susceptibility of an ecosystem, and the possibility of enhancing resistance to or recovery from IAS invasions, and then examined mechanisms for controlling the introduction and spread of IAS. The recommendations of all of these meetings should further help the government to tackle the problem in a holistic manner.

In terms of offering practical solutions to the problem of invasive plants, the 'Workshop on Alien Weeds in Moist Tropical Zones: Banes and Benefits', held at Kerala

Forest Research Institute (KFRI) in collaboration with CABI on 2–4 November 1999 (Sankaran *et al.*, 2001), recommended the development of an integrated weed management programme that included classical biological control. In particular, an application was proposed for the introduction of a host-specific exotic rust fungus, *Puccinia spegazzinii*, for the control of *M. micrantha*.

As a follow-up to the above recommendation, the implementation phase of a project on classical biological control of *M. micrantha* with *P. spegazzinii*, funded by the UK Department for International Development (DFID), began in 2003, with Assam Agricultural University (AAU), KFRI, the Indian Council for Agricultural Research (ICAR) and CABI as partners. Under this project, studies on rust multiplication and the screening of a variety of non-target plant species against the rust to assess the safety of its use were conducted at NBPGR, New Delhi, using the CL-4 level containment facility developed for the biosafety evaluation of GMOs (see Fig. 8.1). Based on the results of the combined screening by NBPGR (Sreerama Kumar *et al.*, 2016) and CABI (Ellison *et al.*, 2008) of 108 plant species belonging to 35 plant families, the Plant Protection Advisor to the Government of India granted permission for limited field release of the rust inoculum at two identified sites each in Kerala and Assam. With the release of *P. spegazzinii*, India became the eighth country in the world and the first in mainland Asia to deliberately and scientifically introduce a fungal pathogen for the biological control of an invasive plant (Sankaran *et al.*, 2008; Chapter 10, this volume).

In line with its obligations under the CBD, India established a National Biodiversity Action Plan in 2008. Among the Action Plan's objectives is regulation of the introduction of IAS and their management by: (i) developing a unified national system for the regulation of all introductions, including their quarantine checking, assessment and release; and (ii) improving the management of IAS species and restoring the ecosystems that have been adversely affected (Government of India, 2008). The operational



Fig. 8.1. The containment facility developed for the biosafety evaluation of genetically modified organisms at the NBPGR in New Delhi. Photo courtesy C.A. Ellison.

guidelines of the *Intensification of Forest Management* scheme (Government of India, 2009a) issued by the MoEFCC emphasize the need for the control and eradication of forest invasive species and provision of assistance to state-owned or supported research institutions to carry out research into the management or eradication of IAS. Notably, the legislation of the scheduled tribes and other traditional forest dwellers (Recognition of Forest Rights Act, 2006) also provides an enabling policy space for the participation of local communities in protection, as well as the management of protected areas, forests and biodiversity in general at the national level.

Currently in India, a multi-agency and multiprogramme approach, involving several ministries and agencies, is being followed for regulating introductions of and managing IAS. Major activities include regulation of the introduction of exotic living materials, and their quarantine clearance and release for research and direct use. In

general, the Ministry of Agriculture and Farmers Welfare deals with cultivated plants, fish and farm livestock, including poultry. It has sponsored projects on the eradication and management of invasive weedy plants, pathogens, pests and harmful fish. The MoEFCC deals with all forest and wildlife related IAS. In addition, it supports and coordinates programmes on the eradication, control measures and utilization of such species in different forest areas, conducts national surveys on their spread, prepares reports on the damage caused and undertakes restorative measures. There is, however, a need to develop a unified national system for regulation of the introduction and management of all IAS across the jurisdictions of all concerned ministries and relevant sectors.

Action points outlined in India's Fourth National Report to the CBD (Government of India, 2009b) to regulate the introduction of IAS and for the management of those already present include measures to:

- develop a unified national system for the regulation of all introductions and carrying out of rigorous quarantine checks;
- strengthen domestic quarantine measures to contain the spread of invasive species to neighbouring areas;
- promote intersectoral linkages to check unintended introductions and contain and manage the spread of IAS;
- develop a national database on IAS reported in India;
- develop an appropriate early warning and awareness system in response to new sightings of IAS;
- provide priority funding to basic research on managing invasive species;
- support capacity building for managing IAS at different levels with priority on local area activities;
- promote restorative measures of degraded ecosystems, preferably using locally adapted native species for this purpose; and
- promote regional cooperation in the adoption of uniform quarantine measures and containment of invasive exotics.

Developing a National Strategy for the Management of IAS in India

In order to develop a stepwise operational procedure for the management of invasive alien plants and other IAS, it is vital to understand their status, which can be classified as introduced and established, recently introduced, or not yet present but with the potential to be introduced (Khetarpal and Gupta, 2006). Overall, such a comprehensive management plan needs to be underpinned with a national strategy that includes scientific and technical considerations, and institutional and policy frameworks. The ultimate goal is the protection of agriculture and livestock, and the conservation or restoration of ecosystems. The goals and objectives for the national strategy should be realistic and result oriented.

The first step towards such a strategy would be to identify a cross-sectoral group

to advocate the development of an IAS programme. Next would be the identification and involvement of all stakeholders to address the IAS problem. Key persons need to be strategically involved, and conspicuous invasive species problems in the country can be used to generate public awareness. The formulation of the national strategy forms the third step after the initial assessment is done and stakeholders have been identified and involved. Ideally, a single nodal agency should be identified or created, but if many agencies are involved, the responsibilities and work involved need to be clearly defined and allocated between the agencies, and each should have complete administrative and technical powers for its own specific remits.

The legal and institutional frameworks for the prevention and management of IAS also need to be considered. Effective management requires appropriate national laws as well as coordinated international action based on jointly agreed standards. Many international agreements address components of the invasive species problem, but national legislation is needed for implementation in each country. Further, there is an urgent need to promulgate existing subnational legislation against important IAS that have been introduced/detected in the country in recent years and that are likely to spread fast. Schedules V and VI of the PQ Order, 2003, pertain to the specific requirements for quarantine pests, but the listing of regulated non-quarantine pests as per ISPM 19 (see Table 8.1) has to be instigated for IAS that have serious economic impacts and can gain entry through planting materials. Thus, the Schedules of the PQ Order, 2003, need to be amended by incorporating the list of regulated non-quarantine pests. A national standard on PRA for regulated non-quarantine pests, as developed for quarantine pests, should also be developed as a priority (Gupta and Khetarpal, 2004).

For the IAS already established in India, such as the plants *L. camara* and *M. micrantha*, there is a need for an intensive official control programme through integrated pest/weed management (IPM), with special emphasis on biological control. However,

caution must be exercised in introducing a biological control agent, and its host specificity must be thoroughly confirmed prior to release. In addition, the management of established IAS requires habitat restoration to be accorded importance (Murphy, 2001). In the case of recently introduced IAS (e.g. Singapore daisy, *Sphagneticola trilobata*; CABI, 2013), there is a need for early detection, which necessitates extensive surveys that may be site specific, species specific, or both, as the case may be. Based on its status as revealed by the survey, further actions to mitigate the impact of the IAS may need to be decided upon.

Lastly, a national council or agency needs to be identified to act as the nodal point on matters related to IAS. Such a council or agency would need members and experts from among the diverse stakeholders who would be able to: (i) draft regulations at both central and state levels and harmonize them with the international norms set by the WTO and the CBD; (ii) coordinate the activities of the stakeholders concerned with IAS, including area-specific surveys, and propose mitigatory measures; (iii) prepare a national management plan for IAS and review it periodically; (iv) collaborate with international agencies working on IAS; (v) facilitate the development of a Web-enabled national database on IAS; (vi) help in capacity building in the field of IAS; and (vii) generate funds through national and international sponsors and help in the reorientation of research projects in universities/ICAR institutes, etc.

Some steps have been taken towards the development of a national framework. The Department of Agriculture and Cooperation (DAC) of the Ministry of Agriculture and Farmers Welfare has proposed a National Policy for the Control of IAS under DAC's national Integrated Pest Management Programme to prevent and control the threat posed by IAS within the country. This policy uses the 15 Guiding Principles under the CBD as a basis. It would include the involvement of state governments, non-governmental organizations (NGOs), the private sector, research institutions and farmer self-help groups in the surveillance

and detection of invasive plants, pests and diseases, and in taking eco-friendly corrective measures within the IPM scheme.

Conclusion

With increases in trade, transport, travel and tourism, there is greater movement of people and commodities, and consequently a greater risk of the spread of invasive alien plants and other IAS. The developed and developing countries need together to address the global problems presented by these species. Identifying, and where possible, quantifying the importance of the pathways that lead to harmful invasions, and addressing the gaps in plant quarantine measures would help in building national capacity to tackle the problems.

Effective management requires not only a national legal framework but also concerted bilateral, regional or global action based on common objectives and jointly agreed international standards. Legislation and a regulatory mechanism are necessary to implement policy, set principles, rules and procedures, and to provide a foundation for global, regional and national efforts. Presently, there are more than 50 global and regional legal instruments (agreements, codes of conduct and technical guidance documents) dealing in one way or another with alien species (Shine *et al.*, 2000). International instruments are usually general in character, but the national legislation necessary to address invasive plants and other IAS should cover all of the issues concerned. The national framework should harmonize objectives and scope, standardize terminology, implement measures for prevention, support measures for early detection, provide management options that include biodiversity/habitat restoration, and promote compliance and accountability.

In India, at the national level, various aspects of invasive plant and other IAS problems are directly or indirectly considered as cross-sectoral themes. Furthermore, many research institutions and universities are well equipped in terms of both facilities and

expertise to take up the challenge posed by these species. To strengthen the drive for IAS management, it is a strategic policy decision to bring them under one umbrella of a nodal agency/council supported by a well-defined legislative mechanism. As in many developed countries, the responsibility for IAS control can be shared between various government agencies, provided there is effective coordination and linkage between these agencies and with clear-cut responsibilities are assigned. The lead responsibility may be given to one agency, such as an environment, agriculture or public health department, or to a specially established body. Apart from this, the legal framework should also promote active participation by the general public, so providing a culture of civil and administrative responsibility and accountability. In this context, the GISP (Global Invasive Species Programme) toolkit for the prevention and management of IAS (Wittenberg and Cock, 2001) gives comprehensive guidelines that can be adapted and adopted to suit the national set-ups in developing countries.

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