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Prevention and Management of Invasive Alien Species:
Proceedings of a Workshop on Forging Cooperation throughout South and Southeast Asia

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The workshop was co-chaired by Drs. Sutat Sriwatanapongse and Banpot Napompeth on behalf of the Royal Thai Government, Dr. Jeff Waage on behalf of GISP, Mr. Ted Osius on behalf of the U.S. Government, and Dr. Jamie K. Reaser on behalf of the U.S. Government and GISP. The members of the Steering Committee included Ms. Kanchana Aksorn-Aree (U.S. Embassy, Bangkok), Mr. Michal De Tar (U.S. Embassy, Kathmandu), Ms. Alexis Gutierrez (U.S. National Invasive Species Council), Dr. Banpot Napompeth (Thailand Biodiversity Centre), Mr. Ted Osius (U.S. Embassy, Bangkok), Dr. Nirmalie Pallewatta (University of Colombo/GISP), Dr. Jamie K. Reaser (U.S. National Invasive Species Council/GISP), Dr. Dana Roth (U.S. Department of State), Mr. Jay Pal Shretha (U.S. Embassy, Kathmandu), and Dr. Jeff Waage (Imperial College, Wye and GISP).

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South and Southeast Asia

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South and Southeast Asia Recommendations for Minimizing the Spread and Impact of Invasive Alien Species

August 2002, Bangkok, Thailand

The delegates[1] of the *South and Southeast Asia Regional Workshop on the Prevention and Management of IAS: Forging Cooperation throughout South and Southeast Asia*, co-hosted by the Royal Thai Government[2] in collaboration with the Government of the United States of America and the Global Invasive Species Programme (GISP), have concluded that problems of invasive alien species (IAS) are causing significant ecological, economic, and social damages and pose ongoing threats to all countries within the region. They, therefore, recommend that the following actions related to the prevention and management of IAS be taken:

1. Establish coordination mechanisms and information exchange systems at national, regional, and international levels by the creation of IAS National Focal Points and through the Convention on Biological Diversity's (CBD) Clearing-house Mechanism (CHM);

2. Ensure political commitment in terms of policy, legislation, enforcement, and implementation of activities to prevent and manage IAS initiated through national and regional strategies and action plans;

3. Initiate assessments of problems related to IAS and develop early warning and monitoring systems;

4. Encourage appropriate and relevant research on IAS issues;

5. Provision adequate financial and technical support from relevant national, regional, and international assistance agencies to address IAS;

6. Build capacity in terms of human resource development and technology transfer to address IAS;

7. Promote community participation and involvement in efforts to address IAS;

8. Encourage partnerships between public and private sectors in activities to address IAS;

9. Promote awareness of IAS issues by convening workshops and seminars, as well as conducting publicity events and media campaigns; and

10. Ensure the sustainability of IAS prevention and management activities in the region by developing long-term programmes of action.

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[1] Representing Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, India, Indonesia, Laos, Malaysia, Maldives, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam, and the ASEAN Regional Centre for Biodiversity Conservation (ARCBC), CAB International (CABI), International Plant Protection Convention (IPPC) Secretariat, Food and Agriculture Organization (FAO), IUCN-World Conservation Union, South Asian Cooperative Environment Programme (SACEP), and Japan National Institute for Environmental Studies

[2] Represented by the Office of Environmental Policy and Planning (OEPP) of the Ministry of Science, Technology and Evironment, Thailand Biodiversity Centre (TBC), and National Science and Technology Development Agency (NSTDA)

Contents

1. Background

1.1 Rationale for strengthening cooperation in South and Southeast Asia

Invasive Alien Species (IAS) are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health. They are one of the most significant drivers of environmental change worldwide, consequently placing constraints on environmental conservation, economic growth, and sustainable development. The globalisation of trade, travel, and transport is greatly increasing the rate at which IAS are moving around the world, as well as the diversity and number of species being moved. At the same time, changes in land use and climate are rendering some habitats more susceptible to biological invasions.

South and Southeast Asia are united by common cultural, social, ecological, economic, and political features that define the essence of 'Asia.' However, this vast region with its large number of countries also encompasses a wide diversity of cultures, economies, and ways of life. Major ecosystems of Asia span deserts, mountains, tropical moist and dry forests, grasslands, very large riverine and deltaic systems, fresh and brackish water systems, and marine environments. All of these ecosystems are threatened by habitat loss, degradation, climate change, pollution, and the invasion of IAS. The issue of preservation of the natural environment is one of the key unifying problems that draws countries of South and Southeast Asia together. Of these problems, the issue of IAS requires the greatest cooperation among governments and across sectors. With the exception of countries that have very large land masses or scattered territories where biological invasions may be between ecosystems of the same country, most biological invasions occur across national borders, from one geographic region to another.

The problems posed by IAS in Asia and the rest of the world are not new. Societies have suffered from the impacts of IAS as long as humans have intentionally and unintentionally moved organisms around the world. Clearly, it is a problem that will have to be managed in perpetuity. What is relatively new, however, is the scale of the problem and its impacts -- at no time in history has the diversity and volume of IAS, and the rate at which IAS are spreading around the world been greater. IAS that threaten agriculture, human, and animals health have become particularly significant problems in Asia.

Article 8(h) of the Convention on Biological Diversity (CBD) calls on member governments to "as far as possible and appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species." However, national and international responses to the IAS problem have thus far been insufficient to counter their increasing toll on natural resources and society. One of the most significant barriers to policy development and implementation has been a lack of awareness of the causes and consequences of biological invasion.

The governments of South and Southeast Asia have already taken some steps towards mitigating the impacts from IAS to biodiversity (see national reports in Pallewatta et al. 2003[3]). These include efforts to address IAS within their National Biodiversity Strategies and Action Plans (NBSAPs) and national level meetings to assess the status of IAS, and develop national plans to address them. Because national efforts alone are inadequate to manage problems that transcend jurisdictional borders, the countries of the region have also engaged in international IAS activities. For example, the IUCN's Asia Regional Biodiversity Programme (see section starting page 65) organized a workshop on IAS as part of the

[3] Pallewatta, N., J.K. Reaser & A. Gutierrez. 2003. Invasive alien species in South-Southeast Asia: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

South and Southeast Asia regional meeting of the Global Biodiversity Forum in 1999 in Colombo, Sri Lanka. This workshop facilitated the exchange of information on the status, trends, and impacts of IAS. There are also programmes for the prevention, eradication, and control of IAS in ballast water in Singapore. At the 6th meeting of the Convention on Biological Diversity's (CBD) Subsidiary Body on Scientific, Technical, and Technological Advice, SBSTTA (Montreal, March, 2001), governments from South and Southeast Asia joined with other Parties to address IAS as a cross-cutting theme.

Although it has become increasingly clear that IAS pose a major threat to biodiversity, economies, and human health throughout Asia, the capacity of the region to address this threat has remained quite limited. In particular, it is evident that many tools and strategies adopted for prevention, eradication, and control of IAS, and the large body of scientific and technical information relating to IAS in other parts of the world, are not readily available in parts of South and Southeast Asia. Furthermore, while there is much be gained globally from the lessons learned by some Asian countries in combatting IAS, this opportunity remains largely untapped.

Asia is experiencing a significant increase in economic activity within the region, and between it and other parts of the world. Adoption of increasingly liberal trade policies (e.g. emergence of preferential trade agreements) and higher volumes of tourism will undoubtedly facilitate more biological invasions. The risk that these alien species will cause significant harm is exacerbated by a considerable lack of awareness of the severity of the IAS problem (especially among policy makers), as well as seriously inadequate technical support.

It was within this context that the South and Southeast Asia regional workshop on IAS was organised by the Global Invasive Species Programme (GISP) and partners in 2002 in Bangkok, Thailand. This meeting was one of six regional IAS workshops held by GISP and the U.S. government in 2001-2004. The others included: the Baltic/Nordic region (May 2001), South America (October 2001), Southern Africa (June 2002), the Austral Pacific region (October 2002), and West Africa (rescheduled for March 2004). Each meeting has resulted in a regional statement, meeting report (including draft regional action plans), and development or strengthening of regional directories of information resources on IAS.

1.2 Workshop design

Objectives

Each regional IAS workshop had three primary objectives:

1. to raise awareness of the IAS problem and opportunities to manage it;

2. to strengthen and expand cooperation between sectors (especially agriculture and environment), among governments, and between governmental and non-governmental entities; and

3. to lay the groundwork for the development of a comprehensive regional strategy to address IAS.

In order to meet the objectives, the workshop had three introductory sessions in plenary to review the issue and relevant regional mechanisms, three working group sessions to forge cooperation and outline a regional strategy, and a final plenary discussion to develop a regional statement and recommendations and define next steps (see agenda in Appendix 3.2).

Participants

The South and Southeast Asia regional workshop was attended by 62 participants and observers (Appendix 3.3), many of whom were high-level policy officials in the environment and agricultural sectors. Nineteen Asian governments were represented at the workshop: Afghanistan, Bangladesh, Bhutan, Brunei Darussalam, India, Indonesia, Laos, Malaysia, Maldives, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand, and Vietnam. Regional and international organisations represented were the ASEAN Regional Centre for Biodiversity Conservation (ARCBC), CAB International (CABI), the Global Invasive Species Programme (GISP), International Plant Protection Convention (IPPC) Secretariat, Food and Agriculture Organization (FAO), IUCN-World Conservation Union, South Asian Cooperative Environment Programme (SACEP), and Japan National Institute for Environmental Studies. The Government of Thailand was represented by the Office of Environmental Policy and Planning (OEPP) and National Science and Technology Development Agency (NSTDA) of the Ministry of Science, Technology and Environment, and the Thailand Biodiversity Centre (TBC). While the governments and organisations of the South and Southeast Asia region already recognise the need for regional cooperation on IAS issues, and have worked together in the past through bodies such as the Convention on Biological Diversity (CBD) and International Plant Protection Convention (IPPC), never before had so many different sectors come together to develop a comprehensive approach to IAS prevention and management.

Outcomes

This report is one of two complementary documents arising from the South and Southeast Asia regional workshop. The second is a compilation of national reports on IAS submitted by participating countries, which will serve as a regional resource directory of information on IAS issues, policies, programmes and key people within South and Southeast Asia. The *South and Southeast Asia Recommendations for Minimizing the Spread and Impact of IAS*, a third outcome, form page 5 of this report.

1.3 Workshop approach and structure

The workshop was designed to inspire a cross-sectoral approach to the IAS problem, bringing together participants from agricultural and environmental ministries and organisations. In addition to government officials, a small number of observers were invited from inter-governmental and non-governmental agencies. Participants were expected to contribute to help raise current levels of IAS awareness, share strategies for a prevention and management of IAS in their countries, and identify practical opportunities for cooperation and better use of existing bodies, resources, and institutions within the region. All of the GISP-US workshops emphasised the need to develop regional information tools and clearing-house mechanisms, as well as improve co-ordination and information exchange and strengthen linkages between scientific organisations and natural resource management agencies within the region.

Defining the issues at the global and regional scale

After the welcome and opening remarks (see agenda in Appendix 3.2), the first morning of the meeting was devoted to presentations by technical experts on the causes and consequences of IAS problems, the Global Invasive Species Programme and its tools for best practice and prevention of IAS, networking for information exchange and co-ordination, legal instruments for addressing IAS, and opportunities for international co-operation in research.

South and Southeast Asia regional perspectives

The afternoon session consisted of subregional overviews (continental and insular) of the status and trends of IAS. The presenters were each asked to address the questions below for a specific subregion:

- *What is the status of the IAS problem?*
- *What are the most significant challenges to addressing the problem?*
- *What are the needs and opportunities for cooperation throughout South-Southeast Asia?*

See pages 47-64 for summaries of these papers.

Regional and international organisations work on IAS in Asia

During the afternoon of the first day, representatives from regional and international agencies operating in Asia participated in a series of panel presentations that provided information on ongoing IAS and existing resources within the region. The questions addressed by the panelists included:

- *What programmes already exist for addressing IAS issues within the region?*
- *What are the needs for programme linkages, expanded programmes, and/or new programmes?*

All presentations on the first day were designed to provide the participants with an overview of the multi-faceted problems caused by IAS and prospects for their amelioration. This session is summarized on pages 65-73.

Working groups on regional cooperation

The second day commenced with an introduction to the structure and functioning of Working Groups on regional co-operation. Participants then divided into one of two groups (according to insular or continental South and Southeast Asian setting), each addressing the questions listed below:

- *What do we want the region to achieve collectively?*
- *What are the challenges to achieving regional cooperation?*
- *What are the necessary elements for a strategy to facilitate regional cooperation?*

In the afternoon session, the two working groups considered the following questions:

- *How can we promote collaboration/cooperation within existing frameworks?*
- *What are the existing resources that can be utilized to achieve regional cooperation?*
- *What additional resources are needed?*
- *Who needs to be involved, when, and where?*

Preparation of a draft regional statement was carried out in the evening of the second day, discussed further and finalized for the plenary at the concluding session of the workshop. The agenda of the third and final half day of the workshop aimed to explore and articulate actions for regional cooperation on IAS, both immediate as well as in the longer term. The working groups addressed the following questions during their last morning session:

- *What are the steps to establish regional collaboration and promoting action?*
- *What are the steps that can be taken immediately and who should take them?*
- *What is at least one action that each participant will pledge to take soon after the meeting?*

Final plenary session

The concluding half day commenced with presentations of overviews from the two working groups and concluded with discussion and finalization of the regional statement from South and Southeast Asia (see page 5). The afternoon was spent on a most informative visit to the grounds of the Thai Royal Palace to view the Royal Chitralada Projects, which demonstrate the potential for small scale and efficient uses of Thailand's natural resources in an equitable manner that engages community members.

A summary of the working group findings can be found on pages 74-83.

2. Presentations and contributions

2.1 Summary of opening remarks

The workshop was opened by *Mr. Darryl N. Johnson, Ambassador of the United States* to Thailand and *Dr. Saksit Tridech, Deputy Permanent Secretary, Ministry of Science, Technology* and *Environment, Royal Thai Government* who stood in place of Dr Sunthad Somchevita, Permanent Secretary of the Ministry of Science, Technology and Environment.

Welcoming the participants, Ambassador Johnson said that IAS posed a significant threat to the well-being of humans, and while these species have crossed borders for centuries, the faster speeds of travel and large volumes of international commerce, including tourism, were accelerating the rates of spread. Factors such as changes in land use and climate were also making some environments more suitable for IAS. He referred to the huge economic cost of IAS in the US (more than US $100 billion annually) and cited several examples of IAS that have caused severe damage in Southeast Asia. Among these was the golden apple snail (*Pomacea canaliculata*) brought to Taiwan from South America as a potential high-protein food source. However, the snail has attacked rice crops in Japan, China, the Philippines, Vietnam, Malaysia, Indonesia, Laos, and Thailand, and may be spreading in other Asian countries. He acknowledged the presence of delegates from nineteen governments and twelve international and non-governmental organisations and said that it was a clear sign the governments of the region considered this issue a high priority for regional cooperation. Ambassador Johnson said that governments around the world now face the same challenge "to decide how to live in an increasingly fast-paced and borderless world without destroying unique ecosystems, damaging crops, or threatening human health." He hoped this event would be a catalyst for long-term regional and global efforts to combat IAS.

Dr. Saksit Tridech welcomed the participants on behalf of the co-hosts of the meeting, and stressed the importance of IAS to Thailand and other countries in Asia. He said the region had suffered great impacts of IAS, especially on agriculture, and highlighted the large amount of research and technology advancement that had been carried out to combat introduced pests in this sector. The Royal Thai Government has recognised the importance of addressing IAS by establishing a Working Group on Alien Species in 1997, in the Office of Environmental Policy and Planning (OEPP) under the Ministry of Science, Technology and Environment (MOSTE). Dr. Tridech stressed the need to develop approaches that would prevent and minimize opportunities for introductions of IAS. He was particularly pleased to see so many governments prepared to take a regional approach to IAS issues in an increasingly inter-dependent world. He hoped that participants would be able to gain much from the visit to the Royal Chitralada projects which demonstrated the commitment of the Royal Palace to exemplary and wise use of Thailand's natural resources. He concluded by offering best wishes for a productive workshop and a pleasant stay in Thailand.

2.2 Papers presented at the workshop

2.2.1 Defining issues at the global and regional scale

Invasive alien species: problem definition, causes, and consequences

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Problem definition

Globalisation has created a situation in which even the most prosperous countries in the world are now economically dependent on the goods and services provided by other countries (Levintin & McMahon, 1996; Bright, 1999). Increasingly, these global markets are not only driven by needs, but also by desires for "more"- things that are "new," "better," "different," or "exotic." Nearly every imaginable good and service is now traded internationally. While globalisation has brought social and economic benefits to many people, it has also brought new challenges, and IAS are among the most significant. At no time in history has the rate of biological invasion, nor diversity and volume of invaders been so high and the consequences so great (Bright, 1998; McNeely et al., 2001).

Under the Convention on Biological Diversity, CBD (2002), *invasive alien species* "means an alien species whose introduction and/or spread threaten biological diversity." Like most definitions of IAS, this one is context-specific. Other definitions (e.g. National Invasive Species Council, 2001[5]) also address impacts to economic and human health sectors. An *alien species* "refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce" (CBD, 2002). These organisms are sometimes called "exotic," "non-native," or "non-indigenous species." *Vectors* (or "modes") are the means by which IAS are relocated. Some vectors consist of equipment specifically designed for trade and transport (e.g. cargo containers). Other vectors are not so obvious. For instance, seeds might be translocated when they adhere to the bottom of a suitcase. *Pathways* are routes by which IAS are moved from one location to another. Because they follow the patterns and trends of globalisation, pathways are ever-expanding and changing.

In most instances, the translocation of biological organisms does not present a problem as the organisms do not survive in their new conditions without deliberate care, or their populations are small and easily managed (Mack et al., 2000, Mack et al., 2001). However, about 1 out of every 1000 organisms is introduced into a new environment where it thrives and becomes invasive (Williamson & Brown, 1986, Williamson, 1996). Introductions can be of several types. *Intentional introductions* of IAS occur when non-native organisms are introduced into the natural environment for specific purposes (e.g. agriculture, aquaculture, forestry, recreational fishing, gardening) or released with the intent to "do good" or relieve care-givers of responsibility (i.e. freeing former pets, research subjects, etc.) and later cause harm.

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Unintentional introductions take place when harmful non-native species are imported as "hitchhikers" on people and products and disperse into the environment (e.g. insects infesting wood packaging materials) or when they escape from captivity (McNeely, 2001).

There is no "perfect" science to predict which introduced species will become invasive. However, there are a few broadly-defined characteristics that are likely to give an organism an advantage, including rapid growth rate, strong dispersal capabilities, large reproductive output, and broad tolerance for such environmental conditions as moisture, temperature, and acidity. Numerous researchers have attempted to determine the specific characteristics that contribute to the success of invaders, and develop tools to predict invasions (Kolar & Lodge, 2002; Rejmanek & Richardson, 2002). Parties to the CBD (2002) and other international (McNeely et al., 2001) and national (National Invasive Species Council, 2001) bodies have recognised the urgent need for risk analysis frameworks that will better enable prevention and management of IAS. Due to the nascence of the issue, however, and the numerous biological and socioeconomic variables involved, the capabilities of predictive models and risk assessment frameworks based on them remain limited (National Research Council, 2002).

Causes

International trade, travel, and transport - the 3Ts - are the major drivers of biological invasion (McNeely et al., 2001). "More - Faster – Further" have become the slogans of economic growth. In 2001, world import and export markets were valued at US$6270 billion and US$6155 billion, respectively (World Trade Organization, 2002). People also increasingly travel the world for business and pleasure. Commercial services (including travel, transport, and other services) totaled US$1443 billion in imports and US$1458 billion in exports worldwide in 2001 (World Trade Organization, 2002). Despite good intentions, developed countries occasionally facilitate the introduction of IAS to other countries through development assistance programmes, military operations, famine relief projects, and international financing. Land-use and climate change can also facilitate invasion by making habitats more challenging for native species and more hospitable to IAS (Mooney & Hobbs, 2001). Because disturbed habitats often favor rapid colonizers, they are particularly vulnerable to the invasion of alien species (Bright, 1998, Baskin, 2002). From the perspective of the IAS, it does not matter whether the environmental changes are natural or human-induced.

Consequences

Every country has been invaded by IAS, and society is paying the consequences. The costs of biological invasion are measured not just in currency, but also unemployment, damaged goods and equipment, power failures, food and water shortages, environmental degradation, loss of biodiversity, increased rates and severity of natural disasters, disease epidemics, and lost lives (Bright, 1998, McNeely et al., 2001). Not only do IAS have obvious immediate and long-term impacts, effectively addressing the problem can require natural resource managers to invest substantial resources in management operations and work to restore ecosystems in order to re-produce their goods and services.

While the impacts of IAS are typically classified as environmental, economic, and human health-related, these categories should not be regarded as mutually exclusive. IAS often have synergistic and cascading impacts, influencing numerous aspects of environmental and human well-being over long periods of time.

Environmental

IAS are one of the most significant drivers of environmental change globally (Sala et al., 2000; McNeely, 2001; McNeely et al., 2001). In the United States, IAS now rank second to habitat conversion as a cause of species endangerment and extinction (Wilcove et al. 1998). Even the best-protected natural areas are not immune to the invasion of alien species (Chapin, 2000; Simberloff, 2000; Simonson et al., 2001; Parkes et al., 2002; Tye et al., 2002; O'Dowd et al., 2003).

The decimation of native species in Guam by the brown tree snake *Boiga irregularis* illustrates the potential for a single IAS to cause significant and permanent losses to biodiversity in a relatively short time frame. The snake, which is native to northern Australia, Papua New Guinea, and the Solomon Islands, was accidentally introduced to the Pacific island of Guam in the 1940s, probably in military transports. Within sixty years it spread throughout the island, reaching numbers as high as 12,000 per square mile in some forests. It has eliminated nine of the island's eleven native land bird species (Savidge, 1987), adversely impacting other fauna, such as native lizards (Fritts, 2001).

A single ecosystem can suffer numerous invasions, with resultant changes in its structure, function, and ability to provide natural resources. Much of the developing world is just beginning to observe significant impacts of IAS in their ecosystems. In contrast, some ecosystems in the developed world, such as the eastern forests of the United States, have been suffering losses from IAS for centuries (e.g. near-extinction of American chestnut, *Castanea dentate*, as a result of root rot, *Phytophthora cinnamomi*, and blight, *Cryphonectira parasitica*). This is due in large part to the long history of trade and transport between regions with similar climate – such as between the eastern U.S. and Europe (Bright, 1999; Baskin, 2002).

Economic

IAS can also take a heavy financial toll on governments, industries, and private citizens. A recent study estimates that IAS cost the U.S. more than US $100 billion a year (Pimentel et al., 2000) and at least this much in six other countries combined (Pimentel et al., 2001). There are, however, remarkably few quantitative studies of the socio-economic impacts (Perrings et al., 2000, but see Pimentel, 2002 for case studies of international costs). Worldwide, the losses to agriculture have been estimated at between US $55 billion and nearly US $248 billion annually (Bright, 1999). The impact and management costs of a single species can carry a price tag in the millions. For example, the golden apple snail *Pomacea canaliculata*, introduced from Latin America as a high protein food source, caused losses to Philippine rice crops during the 1980s of approximately US $1 billion (Naylor, 1996). Formosan termites *Coptotermes formosanus*, introduced from East Asia, cost an estimated one billion dollars annually in property damage, repairs and control measures in the southeastern United States (Suszkiw, 1998). The European gypsy moth *Lymantria dispar* was introduced into North Carolina in 1993 and eradicated four years later at a cost of approximately US $19 million (U.S. Army Corps of Engineers, personal communication). The U.S. Department of State contributes more than US$10 million annually to control the sea lamprey *Petromyzon marinus* in the Great Lakes shared by the U.S. and Canada (U.S. Department of State, personal communication).

Costs from IAS are also incurred when specific commodities or transport systems are affected. Because trade disputes may arise over "pest risks" (Jenkins 1996), the spread of IAS increases the probability that countries will not be able to:

- Sell certain food products because their trade and transport may spread destructive pests and highly infectious diseases that kill agricultural crops, livestock, or people;
- Sell certain types of other commodities (e.g., horticultural products, seeds, and pets) because countries fear they will escape into the environment, causing irreversible harm and requiring expensive, long-term control; or
- Use certain types of shipping containers because their trading partners fear that, upon arrival, they will inadvertently release pests that will destroy agricultural, forestry, or fisheries systems or the natural environment.

Health

IAS can impact the health of humans and other species. Pathogens and parasites may themselves be IAS or may be introduced by invasive vectors (e.g. mosquitoes such as *Aedes aegypti*; Bryan, 1996; Bright, 1998). Plague *Yersinia pestis*, particularly that known as the bubonic plague, provides a well- known historical example. The pathogen, native to parts of Asia, Africa, and the Middle East, spread into Europe and other areas along with alien rats (*Rattus* sp.) and other animals harboring infected fleas, which might also be alien (e.g. *Xenopsylla cheopis*, Oriental rat flea). The "Black Death" is reported to have claimed more than 130 million human lives (Butler, 1983; Thomas, 1997). The karnal bunt fungus *Tilletia indica,* which infects wheat crops, and the viral foot-and-mouth disease (FMD), a pathogen of cattle and other ungulates, are of recent concern to crop and livestock industries (Enserink, 2001; Meyerson & Reaser, 2002). Cholera, *Vibrio cholerae*, and some of the microorganisms that can cause harmful algal blooms, are relocated and released in the ballast water carried by large ships (Wilson, 1995). Other high-profile diseases caused by invasive pathogens include malaria (*Plasmodium* spp.), dengue fever (*Flavivirus* sp.), and the human immunodeficiency viruses that cause Acquired Immune Deficiency Syndrome (AIDS).

Food and water shortages induced by IAS can have negative consequences for all living organisms, but are particularly problematic in the developing world (McNeely et al., 2001). When certain pesticides are used to eradicate or control IAS, people and the ecosystems on which they depend can often be placed at risk (Parker, 2001).

Addressing the problem

Approaches for preventing and managing the spread of IAS are discussed in other chapters, and about 100 case studies can be found in the Global Invasive Species Programme's *Toolkit* (Wittenberg & Cock, 2001). Here I define the goals and outline the general processes. Goals for addressing the problem of IAS include:

Prevention: Keeping an IAS from being introduced into a new ecosystem. Ideally, this usually means keeping alien organisms from entering a new country.
Early detection: Locating IAS before they have a chance to establish and spread. This usually requires effective, site-based inventory and monitoring programmes.
Eradication: Killing the entire population of IAS. Typically, this can only be accomplished when the organisms are detected early.
Control: The process of long-term management of the IAS' population size and distribution when eradication is no longer feasible.

Control and eradication methods can take one or more of three forms (see below). Integrated pest management (IPM) is their combined application:

⇒ Mechanical control: The physical removal of organisms – pulling weeds, for example. The process requires a long-term investment of human resources.

⇒ Chemical control: The use of chemicals to kill organisms – poisons for wildlife and herbicides for plants, for example. The process can be quite costly and typically requires repeat applications.

⇒ Biological control: The introduction of a highly specific predator, parasite or pathogen that will attack the IAS. This process is not likely to result in eradication of the organism but often can reduce the population of the IAS to tolerable levels. The initial costs associated with research and development may be high, but the long-term costs once applied are low and relatively little maintenance is required.

Restoration: The process of re-establishing natural populations and ecosystem functions. In theory, this increases the ecosystem's resistance to future invasions (Mueller-Dombois, 1981).
These goals are best accomplished through a strategic, holistic approach incorporating the following:

- Risk assessment and risk management
- Research
- Inventory and monitoring
- Policy and regulation
- Information management
- Education and outreach
- International cooperation and capacity building

International cooperation and capacity building are crucial, as IAS are an international problem by their very definition. However, these processes are probably the "weakest link" in any country's efforts to minimize the spread of IAS.

Challenges

The prevention and control of IAS presents scientific, political, and ethical challenges (McNeely, 2001) as invasion is a process that is often complex, resulting in considerable scientific uncertainty (Bright, 1998; Mooney & Hobbs, 2000; Mack et al., 2001). Implementing effective prevention and control measures can be costly and require new policy approaches, as well as significant advances in ecological knowledge and natural resource management (Shine et al., 2000; McNeely et al., 2001; Wittenberg & Cock, 2001).

Scientific

The process of invasion is often quite complex. It can involve any number of individuals from any taxonomic group of organisms, any ecosystem, and numerous pathways and vectors (McNeely et al., 2001). There is considerable uncertainty in both the process and the outcome. We do not have an adequate ability for prior determination of which species will become invasive under what circumstances. Interactions among species are often unpredictable. Alien species thought to be benign have on occasion suddenly become invasive, even after a significant amount of time since their introduction – known as the "time lag" phenomenon (National Research Council, 2002).

Political

IAS are not only moved, they move themselves. They can walk, run, hop, fly, or swim across jurisdictional boundaries or be borne there by wind and water currents. Thus, once IAS become established within one country, they pose a threat to an entire region, as well as trading partners and every country along a trading pathway.

There are more than 40 international agreements, as well as numerous codes of conduct that directly address IAS (Shine et al., 2000). However, few countries consider IAS a top priority and have invested in the development of well-coordinated policies and programmes to address the problem. Developing countries that recognise the gravity of the situation and want to take immediate action are hampered by a lack of scientific, technological, and financial resources. Efforts of most governments to address IAS problems are poorly coordinated and neighboring countries are often unaware of each other's policies and practices (National Invasive Species Council, 2001).

Ethical

Efforts to manage IAS have been hindered, and in some cases halted, on ethical grounds. Many animal rights groups oppose the eradication and control of IAS, especially large mammals (Low, 1999, Genovesi & Bertolino, 2001). Human health concerns arise over the application of certain pesticides, such as the use of DDT to control introduced species of mosquitoes in malaria-infested regions (Bright, 1998; Parker, 2001). Some scientists and environmental groups believe that potential biological control agents pose risks of invasion that may exceed those of the IAS already in place (Ouder, 1996; Strong & Pemberton, 2000). There are also instances where different sectors of society place different values on alien species. What some people see as beneficial, others might view as undesirable. Such conflicts of interest are not uncommon and are often associated with intentional introductions (Hattingh, 2001; Reaser, 2001).

Opportunities

Human health, food and water security, social stability, and long-term economic gains all depend upon a healthy environment. IAS are thus a problem facing the "developed and developing worlds." Because every country is an exporter and importer of goods and services, every country is also a facilitator and victim of the invasion of non-native species. The patterns and trends of invasion will continue to follow the patterns and trends of international commerce and the movement of people. Every country, even the most economically wealthy, needs to raise their capacity to minimize the spread and impact of IAS.

Although the prevention and control of IAS present scientific, political, and ethical challenges, the problem can be dramatically reduced through concerted action. Stakeholders need to be made aware of the problem and motivated to address it. Scientifically-based information and effective tools need to be provided to policy makers and resource managers so that well-informed decisions can be enacted. Co-operative programmes need to be forged among governments and other institutions to enable the problem to be addressed in a strategic, holistic, and timely manner.

No programme to minimize the spread and impact of IAS will be successful, however, unless it effectively addresses the factors that ultimately drive invasion processes. *IAS are a by-product of human values, beliefs, and behaviours*. They are a symptom of a society that is choosing immediate gains over long-term, irreconcilable losses. We must recognise that the way in which we choose to conduct business and live our daily lives will either magnify or minimize the problem (Reaser, 2001).

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Overview of international instruments addressing invasive alien species

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This paper provides a brief overview of international instruments relevant to IAS and outlines:

⇒ the rationale for international action on IAS;
⇒ the scope of existing treaties and guidelines that address IAS in the context of biodiversity, aquatic ecosystems, plant, animal and human health, transport, and international trade;
⇒ constraints in existing frameworks and recent policy developments; and
⇒ frameworks for regional and subregional coooperation in the South-Southeast Asian region.

Why are IAS an international legal issue?

The causes and impacts of biological invasions are often international by definition. Through trade and transport pathways, countries both send and receive non-native species. Species may also be translocated within countries to areas or islands where they are not currently present and become invasive in this new location. For these reasons, unilateral action by a few States can never be enough to prevent unwanted introductions. Cooperation is essential at all jurisdictional levels.

Policy, legal, and technical tools need to address the range of pathways through which non-native species are moved (see Box 1).

How does the international regulatory framework address IAS issues?

Nearly fifty internationally-agreed legal instruments or guidelines deal with some aspect of the introduction, control, and eradication of IAS. These instruments set out the policy or technical norms that should form the baseline for national legal frameworks. They fall into three broad categories*:*

⇒ the longest-established agreements focus on controlling the introduction and spread of pests (some of which are IAS, others are not) and diseases to protect human, animal, and plant health through the establishment of quarantine systems. A series of quarantine agreements now mandate and govern sanitary (human health), zoosanitary (animal health), and phytosanitary (plant health) measures to control introductions for such purposes.

Box 1. Examples of pathways for intentional or unintentional introductions of non-native species

- trade and movement of goods (non-native species translocated in containers, planting media, untreated wood packaging, some food products)
- movement of people, including for tourism, through air, road, rail and sea transport
- shipping and boating (ballast water, sediment, hull fouling, anchors)
- aviation (in cargo and on and in the aircraft itself)
- postal and courier services (including biological material purchased via the internet)
- mariculture and aquaculture (fish, molluscs, and crustaceans introduced for production)
- food fish (release on non-natives)
- agriculture (crops and livestock) (direct introductions)
- hunting and fishing (game species and live fish and bait introduced for sport and restocking, movement of equipment)
- aquaria (deliberate discards, discharge of organisms with waste water)
- release of pets or other domestic animals
- horticulture and gardening (dispersal of material from gardens, ponds etc.)
- habitat restoration and landscaping (use of non-native genotypes of native plants, escapes)
- waste disposal and overflow (discharges of untreated effluent to aquatic systems)
- infrastructure development, interbasin transfers of water (dam removal, canals)
- movements of vehicles/equipment during development, famine relief, and military operations
- note: non-native species may be carrying pathogens and parasites.

⇒ biodiversity-related treaties are concerned with IAS for their possible impacts on native species and ecosystems. Some focus specifically on marine and/or inland water ecosystems; and

⇒ most recently, technical guidelines and codes of conduct aim to minimize risks associated with a limited number of transport and trade-related pathways.

Existing instruments have been developed by different multilateral bodies at different times with different objectives, for implementation by different national agencies and sectoral stakeholders. This affects how they refer to IAS, down to the terms, definitions, and procedures used. Most national systems reflect these sectoral differences and have overlaps, gaps, and result in little contact between IAS specialists in different departments and agencies.

Conservation and sustainable use of biological diversity

The Convention on Biological Diversity (CBD) is the only global instrument to provide a comprehensive basis for measures to protect all components of biodiversity against those non-native species that are invasive. Article 8(h) 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."

Other CBD provisions that should be taken into account when implementing IAS measures relate to strategic and cross-sectoral planning, regulation, and management of potentially damaging processes and activities, involvement of local populations and the private sector, incentives, environmental impact assessment, transboundary notification, and emergency planning.[6]

CBD institutions have prioritized IAS issues in recent policy-making. In 1998, recognizing the problems IAS pose to indigenous and local communities and their negative effects on local and national economies, the Conference of the Parties (COP) designated non-native species as a cross-cutting issue to be taken into account in each thematic work program and identified geographically and evolutionarily isolated ecosystems, including islands, as needing special attention because of their vulnerability to biological invasion.

Box 2. Resolution VIII/18 (Invasive Species and Wetlands) urges Ramsar Parties to:

- address the problems posed by IAS in wetland ecosystems in a decisive and holistic manner, making use as appropriate of the tools and guidance developed by various institutions and processes, including relevant guidelines or guiding principles adopted under other conventions;
- undertake risk assessments of alien species which may pose a threat to the ecological character of wetlands, taking into account the potential changes to ecosystems from the effects of global climate change, and applying the guidance available in Ramsar's *Risk Assessment Framework*;
- identify the presence of IAS in Ramsar sites and other wetlands; the threats they pose to these sites' ecological character, including the risk of invasions by such species not yet present within each site; and the actions underway or planned for their prevention, eradication or control;
- when developing and implementing national IAS strategies and responses, recognise that terrestrial IAS can threaten and affect ecological character of wetlands (e.g., lowering of water tables, alteration of water flow patterns) and ensure that appropriate measures to prevent or control such invasions are in place;
- prior to moving water between river basins, examine carefully the potential environmental impacts due to invasive species;
- work closely with their counterpart national focal points for CBD, U.N. Convention to Combat Desertification, UNESCO Man and the Biosphere Program, International Maritime Organization and others in developing and implementing national IAS policies, strategies and management responses
- ensure that IAS prevention, eradication and control are fully incorporated in national legislation and national wetland and biodiversity policies, strategies and action plans, applying the Ramsar *Guidelines for reviewing laws and institutions to promote the conservation and wise use of wetlands* (Ramsar Handbook 3) and *Guidelines for developing and implementing National Wetland Policies* (Ramsar Handbook 2).

[6] Respectively Art.6(a) and (b), Art.8(l), Art.10, Art.11 and Art.14 of the CBD.

In 2002, after extensive preliminary work, the sixth meeting of the COP adopted Decision VI/23 on *Alien species that threaten ecosystems, habitats and species*. This decision:

⇒ reaffirms the importance of national and regional IAS strategies and sets out detailed recommendations for the content of national strategies and action plans;

⇒ urges closer international and regional cooperation and specific measures for capacity building, assessment, information and tools;

⇒ urges Parties, other governments, and relevant organizations to promote and implement the *Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species* annexed to the decision.

Information on other biodiversity instruments (including CMS and CITES) is available in the *Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species* (see References).

Aquatic and marine ecosystems and resources

The emphasis on prevention is particularly important in aquatic and marine systems because IAS can be particularly hard to detect and can disperse rapidly, making eradication or control extremely difficult. Introductions of non-native species to marine ecosystems are covered in a general way by:

⇒ the United Nations Convention on the Law of the Sea (UNCLOS). Parties should take all measures necessary to "prevent, reduce, or control pollution of the marine environment resulting from the intentional or accidental introduction of non-native or new species to a particular part of the marine environment, which may cause significant and harmful changes thereto" (Article 196);

⇒ instruments developed under the United Nations Environment Programme (UNEP) Regional Seas Programme, e.g. the Protocol for the Conservation and Management of Protected Marine and Coastal Areas of the South-East Pacific (Paipa 1989).

IAS in coastal and inland wetlands were addressed by the Conference of the Parties to the Ramsar Convention on Wetlands in November 2002 (see Box 2).

Introductions of IAS into inland water systems have very little coverage under binding instruments, except for the 1997 Convention on the Law of Non-navigational Uses of International Watercourses (not in force). Most existing bi- and multilateral watercourse treaties do not reference this risk.

Instruments for the protection of plant, animal and human health

International instruments and institutions for the protection of plant, animal, and human health are an important part of the international regulatory framework, because the interests they protect may be adversely affected by non-native animals, plants, and micro-organisms (e.g. viruses, bacteria, and fungi) that become invasive.

Plant health

The International Plant Protection Convention[7] (IPPC) provides a framework for international cooperation to prevent the introduction of pests of plants and plant products and to promote appropriate measures for their control. It deals with the spread of pests between countries and phytosanitary measures within a country (see the International Phytosanitary Portal (IPP) at http://www.ippc.int for further information). It is not explicitly a trade or environmental treaty, but is directly relevant to IAS issues that fall within its scope.

The IPPC defines "pest" as "any species, strain or biotype, animal life or any pathogenic agent injurious or potentially injurious to plants or plant products," e.g. fungi, bacteria, phytoplasmas, viruses and invasive plants. It covers both direct and indirect damage by pests to plants, defined broadly to include natural flora as well as cultivated plants. Alien organisms that meet the definition of "pest" are covered, as are biological control agents used to control pests in this broad context. Official IPPC definitions can be found in the International Standard for Phytosanitary Terms (ISPM) # 5 "Glossary of Phytosanitary Terms," which is revised annually.

Until the 1990s, the IPPC mainly focused on phytosanitary certification with an almost exclusively agricultural focus. In 1997, it was revised to provide for the development of international phytosanitary standards (ISPMs) recognised within the multilateral trading system. ISPMs are not binding *per se* on World Trade Organization (WTO) members, but Members that do not comply with available standards must base national measures on risk assessment. Existing ISPMs cover matters such as pest risk analysis, import and release of exotic biological control agents, guidelines for the establishment of pest free areas and guidelines for pest eradication programmes. The most recent standards[8] are beginning to take greater account of environmental implications, which could provide an important bridge with the work carried out under the CBD.

The IPPC provides for national mechanisms that are well-suited to prevention, early detection, and control of IAS. Each IPPC party is required to:

⇒ establish a National Plant Protection Organization (NPPO);

⇒ adopt legislative, technical and administrative measures to prevent introduction/spread of pests;

⇒ establish a single official contact point to facilitate the exchange of official information;

⇒ undertake pest risk analysis, in the absence of an ISPM, to provide technical justification for a national phytosanitary measure;

[7] 1951, revised in 1979 and 1997 (latest revision not yet in force, but countries have agreed to starting implementation due to its imminent acceptance).

[8] In 2003, the IPPC's Interim Commission on Phytosanitary Measures (ICPM) approved standards on the analysis of environmental risks and the coverage of taxa that impact unmanaged as well as agricultural systems: see Supplement on *Analysis of environmental risks* to ISPM No.11 (*Pest risk analysis for quarantine pests*, 2001) and IPPC Supplement No. 2 on *Guidelines on the understanding of 'Potential Economic Importance' and related terms including reference to environmental considerations* to ISPM No.5 (*Glossary of Phytosanitary Terms*). ISPM 3 (Code of Conduct for the Import and Release of Exotic Biological Control Measures, 1996) is currently being revised. Proposals for consideration include its expansion to better address intentional introductions of biopesticides, soil enhancers, pollinators and sterile insects for purposes of pest control and the enhancement of its RA component.

⇒ carry out surveillance of growing plants, including both areas under cultivation (e.g. fields, plantations, nurseries, gardens, greenhouses and laboratories) and wild flora, and of plants and plant products in storage or in transportation, particularly with the object of reporting the occurrence, outbreak and spread of pests, and of controlling those pests;

⇒ provide for the protection of endangered areas and the designation, maintenance and surveillance of pest free areas and areas of low pest prevalence;

⇒ establish export certification systems to ensure that exported products comply with the import requirements of trading partners;

⇒ establish inspection procedures and treatments (when appropriate), and

⇒ establish an official process for the implementation of the ISPMs.

Implementation is facilitated by nine regional plant protection organisations (RPPOs), including the Asia Pacific Plant Protection Commission (APPPC). RPPOs are beginning to develop regional phytosanitary standards to facilitate regional harmonization of trade-related measures consistent with the WTO-SPS Agreement (see below).

Animal health

Animal health issues are addressed by the Office International des Epizooties (OIE), which develops standards and guidance on pests and diseases of animals (but not on animals themselves as pests). The International Animal Health Code for Mammals, Birds, and Bees and the International Aquatic Animal Health Code set out standards on import risk analysis and risk management measures for specific diseases and are updated annually. The OIE has an Ad Hoc Working Group on risk analysis for aquatic animal diseases and a long-established Working Group on Wildlife: this addresses wildlife management and reintroduction issues that have an animal disease dimension, but has not covered related habitat and ecosystem issues.

Human health

Human health can be affected by alien species providing hosts for diseases. One example is the West Nile virus apparently introduced to New York, U.S. via an imported alien bird and then transmitted to local mosquitoes. Because the virus can decimate bird populations and affect other species including humans, it is a serious concern for many countries represented at this Workshop.

The World Health Organization (WHO) has developed International Health Regulations[9] to prevent the international spread of human infectious diseases, which are currently being updated due to changes in disease epidemiology and the increase in international traffic. Codex Alimentarius (a joint FAO/WHO initiative) deals with food safety and is responsible for international standard setting in this regard.

Technical guidance for certain transport sectors

There is a growing emphasis on the need for technical guidelines or codes of conduct to address specific pathways in a more detailed and practical way than treaty negotiation permits.

[9] Geneva, 1969; amended in 1982.

The International Maritime Organization (IMO), through its Maritime Environmental Protection Committee (MEPC), has focused on prevention efforts to minimise IAS introductions via ships' ballast water. It supports the development of a mandatory legal regime to avoid unilateral responses by individual states in such an international industry, but began by adopting voluntary *Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens*[10] to assist governments, ships' masters, operators and owners, and port authorities to establish common procedures to minimize the risk of introducing harmful aquatic organisms and pathogens from ships' ballast water and associated sediments.[11] The MEPC has also approved a technical circular on design measures for ballast water and sediment options in new ships (MEPC 47th session, London 4-8 March 2002). The IMO Council[12] has now convened a Diplomatic Conference for early 2004 to finalise the the draft IMO *International Convention for the Control and Management of Ships' Ballast Water and Sediments.*

The IMO, Global Environmental Facility (GEF), and U.N. Development Programme (UNDP) have jointly developed the GloBallast Programme[13], a global technical cooperation programme to assist developing countries to tackle the transfer of harmful aquatic organisms in ships' ballast water and to prepare for the implementation of the future convention. This Programme ran from 2000-3 and has been extended until 2004. A favourable mid-term evaluation[14] found that stakeholder participation and support has been impressive and that the project has created a solid foundation of support for the future IMO Convention.

There are no internationally-agreed prevention measures for hull-fouling as an IAS vector, although CBD Decision VI/23 §7 called on the IMO to develop mechanisms to minimise this as a matter of urgency.[15] The IMO International Convention on the Control of Harmful Anti-Fouling Systems on Ships (2001) provides for the global phase-out of tributyl tin (TBT) in paints, but this ban is designed to reduce chemical pollution of the marine environment and could even lead to a significant increase in the number of introductions of invasive fouling species such as ascidians.[16]

The International Civil Aviation Organization (ICAO) recognises that civil air transportation represents a potential pathway for IAS introduction (e.g. the brown tree snake, *Boiga irregularis*, to Guam). Contracting States have been urged to take mutually supportive efforts to reduce the risk of introducing potential IAS via this pathway to areas outside their natural range.[17] In 2002, the ICAO surveyed 188 States to gather data for an assessment of whether civil aviation is a "significant"/"high-risk" pathway for unintentional introductions. The questionnaire covered possible vectors (aircraft structure, cargo, passengers, baggage, packaging, mail) and control measures based on education (brochures, airport notices, quarantine declaration on arrival cards), physical intervention (detector dogs, disinfection of aircraft, searches of passengers, baggage and/or cargo), enforcement and surveillance. The Secretariat's preliminary analysis of the 47 responses shows that about half of the States aware of IAS problems in their respective countries consider that air transport is a contributing factor (the other half lacked the

[10] Annex to Resolution A.868 (20), 2Oth IMO Assembly, 1997.
[11] At least seven countries and three ports have now enacted legislation requiring ships calling at their ports to comply with the Guidelines, e.g. Australia, Canada, Chile, Israel, New Zealand, Portugal, the USA, some States within the USA and some ports around the world, such as Buenos Aires (Argentina), Scapa Flow (Scotland) and Vancouver (Canada).
[12] 89th session, 25-29 November 2002.
[13]The GEF/UNDP/IMO *Global Ballast Water Management Programme for the Removal of Barriers to the Effective Implementation of Ballast WaterControl and Management Measures in Developing Countries.*
[14] Vousden, D. & B. Okamura. 2003. *GloBallast Project Independent Mid Term Evaluation: Final Report* (31 March 2003).
[15] Note that IMO, the International Council for the Exploration of the Sea (ICES) and the International Oceans Commission have recently established a Study Group on Ballast and other Ship Vectors (first meeting in Vancouver, 24-25 March 2003).
[16] These are also found in submerged man-made structures in ports, harbours and marinas with appropriate salinity and can tolerate high levels of pollution and considerable variations in temperature (*Ballast Water News* Issue 12 Jan-March 2003).
[17]ICAO General Assembly Resolution A33-18, adopted at the 33rd Session, Montreal 2001.

data to respond). The detailed analysis will also cover species-specific information provided by States. The ICAO Council will then determine whether an ICAO prevention strategy is necessary: the matter will be considered by the ICAO Assembly in 2004.

Technical guidance for fisheries and aquaculture

Aquaculture and mariculture operations present a known risk of unwanted introductions (escapes, parasites, and disease). Some technical guidance has been adopted to establish principles and standards and provide best practice guidance for this rapidly growing industry.

Through the Food and Agriculture Organization (FAO), the Code of Conduct for Responsible Fisheries was adopted in 1995.[18] The Code provides guidelines for the responsible introduction, production and management of fish species under managed conditions. It urges States to adopt measures to prevent or minimize harmful effects of introducing non-native species or genetically altered stocks used for aquaculture into waters.

The 1994 Code of Practice on the Introductions and Transfers of Marine Organisms was issued by the International Council for the Exploration of the Sea and the FAO's European Inland Fisheries Advisory Commission. It establishes procedures and practices to diminish the risk from intentional and unintentional introductions of marine alien species into marine and freshwater ecosystems.

Relationship of existing instruments with the multilateral trading system

Alien species are introduced through trade intentionally (imported products) or unintentionally (e.g. as by-products, parasites and pathogens of traded products, hitchhikers and stowaways in vessels, vehicles, or containers that deliver products or services). National measures to minimize unwanted introductions - quarantine and border controls on live species, commodities, packaging and other vectors - therefore have a direct interface with the multilateral trading system and need to be consistent with applicable rules and disciplines adopted within the WTO framework.

Multilateral environmental agreements do not directly address international trade aspects of alien species control, except CITES - to a limited extent. The non-binding FAO Code of Conduct for Responsible Fisheries recommends that States develop international agreements for trade in live specimens where there is a risk of environmental damage *inter alia* in importing States.[19]

In contrast, the IPPC, OIE, and Codex Alimentarius have a formal relationship with the multilateral trading system, following the conclusion in 1995 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement). The SPS Agreement provides:

⇒ that 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.[20]

⇒ for the use of international standards as a basis for national protection measures that affect trade. The aim is ensure that national measures have a scientific basis and are not used as unjustified barriers to international trade. The Agreement recognises standards set by three organisations: IPPC

[18] Guidance developed under this Code includes *Precautionary approach to capture fisheries and species introductions* and *Aquaculture Development* (FAO Technical Guidelines for Responsible Fisheries 2/1996 and 5/1997).
[19] Section 11.2.10.
[20] Abridged from Annex A, Definitions.

(pests of plants and plant health); OIE (pests and diseases of animals and zoonoses); and Codex Alimentarius Commission (food safety and human health).

⇒ for key principles (reflected in the revised 1997 IPPC Agreement) that include consistency in the application of appropriate levels of protection, least trade restrictive alternatives, acceptance of equivalent but different SPS measures and transparency through advance notification of measures.

Consistent with these principles:

⇒ countries may take action when necessary to protect plant/animal health by preventing introduction or carrying out eradication/containment;

⇒ such action should be based on the appropriate level of protection for that country;

⇒ pest risk analysis is to be used in the development of measures;

⇒ countries should base national measures on international standards where available. Where no international standard exists or a higher protection level is sought, the State concerned must justify a national measure through scientifically-based risk assessment; and

⇒ emergency (or provisional) measures are permissible without such analysis, when situations require urgent action or there is insufficient information on which to base action. However, such measures must be reviewed for their scientific justification and modified as appropriate.

Progress and remaining constraints

Terminology

Many different terms are used for alien species generally (non-indigenous, alien, exotic, foreign, new), the subset that cause damage (pest, weed, harmful, injurious, invasive, environmentally dangerous) and the concept of "introduction." The need to clarify concepts and terms is widely acknowledged, internationally and nationally. Biodiversity-related instruments prior to the CBD Guiding Principles contain few definitions of key terms and concepts. In contrast, the FAO/IPPC Glossary of Phytosanitary Terms provides for standardized use of terms at international, regional and national level and is updated annually. Some key IPPC terms (e.g. "quarantine pest") are roughly comparable but not identical to IAS in the CBD sense. In 2003, the ICPM adopted guidance[21] on the interpretation of the term "economic importance" in the IPPC and ISPMs. This notes that the IPPC has historically maintained that the adverse consequences of plant pests, including those concerning uncultivated/unmanaged plants and wild flora, are measured in economic terms, but recognises that the term "economic" has resulted in some misunderstanding of IPPC's focus. The new Guidelines clarify that pest risk analysis can account for environmental concerns in economic terms using monetary or non-monetary values;

[21] Supplement No. 2 on *Guidelines on the understanding of 'Potential Economic Importance' and related terms including reference to environmental considerations* to ISPM 5 (*Glossary of Phytosanitary Terms*).

⇒ market impacts are not the sole indicator of pest consequences; and

⇒ members have the right to adopt phytosanitary measures with respect to pests for which the economic damage caused to plants, plant products or ecosystems within an area cannot be easily quantified.

⇒ for a plant pest to have "potential economic importance," it must have a potential for introduction in the area subject to pest risk analysis, the potential to spread after establishment, and a potential harmful impact on plants (e.g. loss of crop yield or quality, damage to ecosystems, habitats or species, or some other specified value such as recreation, tourism or aesthetics).

At the operational level, it is very important for quarantine and environmental personnel to develop a common approach to terms used in these sectors.

Taxonomic coverage

Biological invasions may be generated by all taxonomic groups at all taxonomic levels. Internationally, only the CBD covers IAS in relation to all levels of the biodiversity hierarchy. Nationally, biodiversity laws that regulate introductions tend to be limited to higher taxa of non-native animals and plants and rarely go below the species level.

Sanitary and phytosanitary instruments potentially cover all taxonomic groups and lower taxonomic categories, but only to the extent that these are injurious to plant or animal health as defined by the IPPC or OIE. The IPPC's trigger for pest classification is "injurious to plants or plant products." This covers alien organisms that could damage wild plants, but not explicitly those that may harm ecosystem function or plant genetic diversity.

Ecosystem/biome coverage

Invasion processes affect all ecosystems, but the impact of particularly aggressive species is especially severe on the structure and function of vulnerable and isolated ecosystems, including small islands, certain lakes, and mountain areas. Guidance is needed to assist countries and regions to develop appropriate frameworks for vulnerable ecosystems.

Coverage of pathways and vectors

Many pathways and vectors are still not covered by international rules or guidance. For transport, only one shipping-related vector (ballast water) has been addressed: equivalent measures to minimize hull fouling are urgently needed. Aviation-related guidance is voluntary and is limited to civil aviation. Land transport is not formally regulated to minimize transfer risks. For inland waterways, there seems to be no guidance on water-borne transport or risks associated with dam removal or canal linkages connecting drainage basins or coasts.

Material moving outside conventional trade pathways (e.g. in development assistance, humanitarian programmes, military operations) falls outside the regulatory framework. A preliminary report on *International Assistance Programmes as pathways for the introduction of invasive alien species*[22] found that serious and under-documented IAS problems still result from such programmes. More concerted work is needed in international funding and technical agencies to assess the nature and

[22] Source: unpublished report by CABI Bioscience compiled on behalf of GISP.

severity of associated IAS risks and to support development of better prevention methods and stronger national and international quarantine systems.[23]

Quarantine systems are theoretically broad enough to cover all introductions that can involve the transfer of pests (e.g. passengers, mail, Internet transactions, means of transport). However, national systems vary widely in capacity and resources (inspection facilities, taxonomic capacity, access to information). Many smaller nations lack the resources to operate comprehensive quarantine and risk assessment systems. Moreover, national systems mainly focus on international boundaries and rarely cover movements between regions of the same country except for high-risk agricultural and forestry pests. This is a very serious deficit.

Prevention, eradication and control

All existing instruments mandate prevention, recognizing the technical difficulties and costs of detecting, eradicating, or containing introduced species after they have become invasive. However, frameworks tend to be weaker on monitoring, eradication, and control for IAS that impact biodiversity, when compared with those that affect agriculture and forestry.

Internationally and nationally, the use of import and export controls to prevent introduction of pests is long established. National plant and animal health services and Customs play a key role in establishing and implementing border controls, import restrictions, and other quarantine measures.
However, some developing nations lack the technical capacity or resources for adequate quarantine systems and may not be able to meet the standards and requirements of agreements within the multilateral trading system. There are wide variations in the national capacity levels and assessment and control procedures of different trading partners within Asia. This can place countries at risk from others in the same region that do not apply such stringent measures. This is another reason why regional technical support is particularly important for the South and Southeast Asian region.

Effective prevention also requires the restriction of further imports and internal movements of IAS. This is important to cut off supply, support containment strategies, and prevent spread to other areas. Measures of this kind are often restricted to agricultural and forestry pests.

Institutional coordination and synergy

Cooperation between key organisations has expanded significantly over the last five years. The CBD has endorsed closer cooperation with the FAO, WHO, IMO, OIE, Codex Alimentarius, UNESCO and relevant treaty secretariats. The 3rd Joint CBD-Ramsar Work Plan (2002-2006) provides for collaborative actions with GISP, IUCN, and the World Conservation Monitoring Centre (WCMC) to increase the availability of information and guidance on aquatic IAS. In February 2003, the CBD and IPPC Secretariats agreed a Memorandum of Understanding that recognises their overlapping objectives, calls for strengthened cooperation between secretariats and identifies areas for collaboration. There is no equivalent mechanism between the CBD and the OIE, but the OIE has expressed support for the development of closer cooperation (B. Vallat, pers.comm.).

[23] Decision V/25 (Biological diversity and tourism) includes as some of the potential impacts of nature-based tourism the increased risk of introduction of alien species by tourists and tourist transportation and the spread of pathogens from humans or companion animals to wild species.

Increased engagement of non-State actors

There is growing acceptance of the need to engage trade, transport, and other stakeholders in IAS prevention and management, and to harness their ingenuity in finding solutions and alternatives. The development of codes of conduct and of best practice should be promoted, although voluntary measures of this kind will not necessarily be enough to tackle difficult IAS issues.

In the marine sector, the shipping industry contributes through the International Chamber of Shipping and the International Association of Independent Tanker Owners to the *GloBallast* Global Ballast Water Management Programme which gives practical guidance for the implementation of the IMO voluntary guidelines on board ships.

In the pet and ornamental fish sector, some trade associations participate actively in CBD and CITES discussions relevant to IAS. A small number of trade organisations have developed voluntary codes of conduct for national application, usually directed at the point of retail (e.g. pet shops, garden centres).

Frameworks for regional and subregional cooperation in the South and Southeast Asian region

At the regional and sub-regional level, there has been very little Asia-specific focus on IAS to date. This section outlines existing institutions and initiatives through which regional cooperation and programmes on IAS could be effectively and efficiently developed.

⇒ *Association of Southeast Asian Nations (ASEAN)*

ASEAN was established in 1967 and now has ten member countries: Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand and Vietnam. Their combined population exceeds 500 million people. Other Asian nations (e.g. China, India, Japan, South Korea) cooperate increasingly closely with ASEAN through the ASEAN Regional Forum set up in 1993 and other initiatives. India and China are separately developing frameworks for economic cooperation with ASEAN which would liberalise trade and potentially create the world's largest regional trade unit. The ASEAN Vision 2020 (adopted in 1997) aims to work towards a world class standards and conformance system to facilitate the free flow of trade while meeting health, safety and environmental needs.

ASEAN regional initiatives on the environment are guided by the Ha Noi Plan of Action (2000-4) which sets out 15 objectives for enhanced regional cooperation on: (a) Land and Forest Fires and Transboundary Haze; (b) Nature Conservation and Biodiversity; (c) Coastal and Marine Environment; (d) Global Environmental Issues; and (e) other environmental issues. An ASEAN Working Group has recently been established on Nature Conservation and Biodiversity. In addition, the ASEAN-EU Regional Centre for Biodiversity Conservation (ARCBC) has been established in the Philippines to implement activities to enhance the capacity of ASEAN in strengthening biodiversity conservation in ASEAN, through networking, applied research, database and information management, training and technical assistance (see MacKinnon, this volume).

ASEAN countries have adopted a biodiversity-related treaty which specifically addresses IAS. The ASEAN Agreement on the Conservation of Nature and Natural Resources (Kuala Lumpur, 1985) requires Parties to endeavour to regulate and, where necessary, prohibit introduction of alien species (Art.3(3)).

⇒ *South Asian Association for Regional Cooperation (SAARC)*

SAARC's members are Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan and Sri Lanka, all primarily agricultural countries. SAARC established an Agricultural Information Centre (SAIC) in Dhaka in 1989 to share information for the advancement of agriculture, livestock, fisheries and forestry. This functions as the regional information centre for South Asia and has established linkages with international information networks such as AGRIS and CARIS.[24]

⇒ *South Asian Cooperative Environmental Programme (SACEP)*

SACEP was established in 1982 under the aegis of the United Nations and is based in Sri Lanka. Its members are the seven SAARC member nations, Afghanistan and Iran. SACEP promotes and supports conservation and management of the natural and human environment in the South Asia region and implements projects funded by the UN and other multilateral or bilateral agencies. It has developed a strategy and action plan for environmental cooperation in the region.

⇒ *South Asian Seas Action Plan*

SACEP also provides the secretariat for the South Asian Seas Action Plan (1995). The Plan supports National Action Plans and pilot programmes to implement the UN's Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA). The non-binding GPA lists IAS as a potential threat to marine ecosystems but does not provide specific guidance for addressing the problem.

⇒ *East Asian Seas Action Plan*

The Action Plan for the Protection and Sustainable Development of the Marine Environment and Coastal Areas of the East Asian Region was adopted in 1981 by Indonesia, Malaysia, Philippines, Singapore and Thailand. The decision-making body is the Coordinating Body on the Seas of East Asia (COBSEA) and the secretariat is hosted by the UN Regional Co-ordinating Unit for marine environmental matters in East Asia (EAS/RCU). COBSEA has adopted a series of Action Plans for management, conservation, restoration and sustainable use of the marine environment of the East Asian seas, also endorsed by Australia, Cambodia, China, Korea and Vietnam. The most recent Action Plan also covers monitoring and environmental assessment, technology transfer, environmental governance and reduction of pollution from land-based activities.

⇒ *Asia-Pacific Economic Cooperation (APEC)*

APEC was established in 1989 to facilitate economic growth, cooperation, trade and investment in the Asia-Pacific region. It has 21 Member Economies from both sides of the Pacific Basin. Asian member economies include Brunei Darussalam; People's Republic of China; Hong Kong, China; Indonesia; Japan; Korea; Malaysia; Philippines; Russa; Singapore; Chinese Taipei; Thailand; and Vietnam. APEC has not focused on IAS issues generally, but supports research and information tools that could contribute to regional capacity-building and IAS information exchange (e.g. the APEC Virtual Centre for Environmental Technology Exchange[25]). There are now APEC Study Centres in 19 member economies (100 universities and research centres across the region).

[24] www.fao.org/agris
[25] http://www.apec-vc.or.jp

A new development within the APEC framework relates to marine IAS. The APEC Marine Resources Conservation Working Group, led by Australia and Chile, is developing a regional management framework for APEC economies for the control and prevention of introduced marine pests (IMPs).[26]

In APEC economies, little is known about IMP or practical measures to prevent and control introductions. A consultancy has been carried out by Australia's CSIRO[27] Centre for Research on Introduced Marine Pests and the Inter-America Centre for Sustainable Ecosystems Development on:

- Management capabilities and approaches

This found that institutional arrangements are fragmented in most countries, baseline surveys of marine pests and capacity to detect incursions are very limited and vector management is unbalanced. The main focus is on ballast water and aquaculture, whereas there are few or no management measures in place for recreational boating, dredging, fishing boats or hull fouling.

- Priorities and hazards for APEC economies

Hazard levels are variable. Ballast water and biofouling are the most important vectors and international shipping, aquaculture and biodiversity are the most threatened values. Commercial shipping and trading partnerships are the most important factors affecting pathway strength.

- Considerations for an APEC management framework

Effective management can be achieved by economies working collectively and maximising opportunities for management at the pre-border, border and post-border levels. The Consultancy identified the need to build awareness of IMP problem in APEC economies, develop appropriate information systems and tools, and develop and adapt current institutional structures in individual economies and the region as a whole.

An APEC Workshop in 2001, including representatives from 15 APEC economies, International Maritime Organisatio, APEC working groups on Fisheries and Transportation and stakeholders from shipping, industry, aquaculture and environmental management, developed elements for a draft IMP management framework[28]. These include:

- Risk assessment and cost benefit analysis
- Risk management: development of common requirements, protocols, procedures and management frameworks for specific risks
- Establishment of legislative/policy basis for management
- Identification of focal point in each economy;
- Timeline and proposals for cooperative projects
- Regional communication and recognition that IMP are a global issue

A second workshop will be held in Chile in 2003 to develop a framework for APEC leaders' consideration.

[26] This information is drawn from a presentation made by Warren Geeves (Assistant Director, Marine and International Section, Environment Australia) at the GISP Austral-Pacific Workshop (October 2002).
[27] Commonwealth Scientific and Industrial Research Organisation.
[28] A Risk Management Framework – for APEC Economies –for use in the Control and Prevention of Introduced Marine Pests (Hobart, Australia, 12-15 November 2001).

Conclusion: key steps for regional and national cooperation

The existing instruments summarised above give rise to significant national obligations and commitments. Effective and practical institutional and legal frameworks are needed as well as a stronger political commitment for regional coordination and cooperation on IAS.

The following are priority issues *at regional and sub-regional levels* :

⇒ *develop a holistic focus on pathways as well as intentional introductions*

Pathways and pathway actors need to be identified as part of integrated pathway management. The expertise of relevant trade and industry sectors should be harnessed through stronger contacts with vector-responsible groups, such as timber and plant traders, aquarium and sport fish traders, transporters and so on. The region/sub-region is a good level to develop contacts with target groups.

⇒ *promote stakeholder and community participation*

Stakeholders involved in or affected by alien species-related activities need to be engaged and, where appropriate, made accountable. Appropriate education and communication strategies need to be developed, tailored to different target audiences and groups, including enforcement personnel. For socio-cultural reasons, it is particularly important to strengthen the role of local authorities, local communities and indigenous peoples in IAS detection and management.

⇒ *collect, share and manage information to support early warning and rapid response*

⇒ *develop regional dialogue and strengthen institutions*

Broad-based coordination means building links with counterparts across borders, throughout the region and with trading partners. The need for a sound ecological approach to IAS that includes agriculture justifies increased cooperation between regulatory agencies and key sectors. Regionally-agreed negotiating positions, measures and standards may carry greater weight in global fora than unilateral measures.

At the *national* level:

- decisions should be taken at the right level by the right body, taking into account the affected communities of interest;
- there should be clear lines of authority and appropriate associated accountabilities;
- there should be appropriate public input into decisions but this should be designed to ensure it does not impose unreasonable costs or prevent effective action;
- there needs to be the ability to take rapid decisions in emergencies;
- the responsible institution should have adequate stability of function and resources to enable long-term programmes to be run.

⇒ *review and develop strategy and tools*

A review of existing policy, legal and institutional arrangements makes it possible to identify gaps and inconsistencies and any necessary improvements. The review process may be an integral part of developing an national IAS strategy or action plan.

Sectoral agencies whose programmes and projects have IAS implications should assess these implications in consultation with affected stakeholders. Strategic environmental assessment of policies, programmes and projects that may provide new IAS pathways – e.g. transport infrastructure, inter-basin hydrological links and new trade agreements and practices - is central to prevention.[29] Such approaches can make it easier to identify some types of risk and take avoidance or mitigation measures early on.

⇒ *make better use of existing measures and expertise*

Environmental impact assessment (EIA) regulations and criteria may need to be expanded to cover activities and processes involving IAS. Operating licence requirements should apply to premises where potential IAS are held in containment or captivity, to minimise the risks of escapes.

There may be scope to streamline regulatory procedures, so that permit applicants do not have to make multiple applications to different regulatory authorities. Complex systems tend to be less transparent and can deter compliance.

Existing tools may be under-used, e.g. competent authorities often have powers under quarantine/ agricultural legislation to require land owners to control noxious weeds or nuisance species, but these species lists may not be regularly updated.

⇒ *Develop incentives and funding tools*

Research carried out by GISP found that there are few deterrents to the export, import or use of IAS (i.e. traders and users are often not the ones affected by the consequences of a harmful introduction). There are also few incentives for importers and other users to use locally-available native species or to manage land to prevent biological invasions.

Few countries have mechanisms to generate sustainable funding for public investment in IAS prevention and control programmes. This is a serious deficit, particularly for developing countries, and calls for priority research into innovative new approaches.

[29] The CBD COP has called for use of impact assessment and strategic environmental assessment in the alien species context (Decisions V/18 and VI/23).

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Detailed technical and advisory material is available from international organisations, governments, and specialist bodies working on IAS issues, including IUCN, GISP and the FAO which has legal and technical expertise with regard to IAS in agriculture, forestry and fisheries. A list of key websites is given in Appendix 3.1.

An introduction to GISP and best practices for prevention and management of invasive alien species

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Introduction to the Global Invasive Species Programme (GISP)

In this paper, I will present a general introduction to GISP, its history and current activities, highlighting its development of a toolkit of best practices for invasive alien species (IAS) prevention and management. For all these, I will concentrate on experience gained through GISP which may be useful to the South and Southeast Asian regions.

Alien species introductions into Asia have been considerable and important. The development of Asian agriculture, particularly in the tree crop sector, has depended on alien crops. Such crops from other parts of the same region, such as rice, sugar, soya, citrus and many pulses have been important to food production and security, as have crops from other continents, e.g. maize, wheat, potatoes and cassava.

Only a very small fraction of alien species undergo population explosions and expansion that make them invasive (Williamson & Brown, 1986; Williamson, 1996). What makes this kind of biological pollution so damaging is its innate capacity to self-regenerate and self-spread to new areas. Historically, IAS have been best known as threats to agriculture, as exotic pests, weeds or plant and animal diseases. More recently, in the latter half of the last century, the role of IAS in conservation emerged, with evidence that alien species could displace native species, particularly localized, rare endemic species such as those on islands. Even more recently, we have come to understand that the impact of IAS goes beyond production systems and biodiversity conservation to include effects on ecosystem function (McNeely et al., 2001). IAS can alter water availability, fire regimes, ecological succession, food chains and possibly even climate (Mooney & Hobbs, 2000). In Asia, floating alien water weeds affect water flow, evaporation and fauna, while alien trees and grasses can reduce water levels and affect fire regimes (Mooney & Hobbs, 2000, Wittenberg & Cock, 2001).

These impacts affect all communities, but are particularly severe on the rural poor and development programmes to assist them, including sustainable agriculture, restoration of degraded lands, reforestation and health programmes. IAS are not simply an agricultural and environmental challenge, they are a development challenge as well.

In all these areas, the range of taxa which are now known to be invasive and damaging is growing, well beyond familiar agricultural pests, to include such groups as worms, frogs, jellyfish, and algae, including poorly known biota of invasive marine species. Further, the introduction of all these taxa appears to be accelerating with the increase in global trade. This creates not only a greater volume of introductions, but a greater range of species due to new sources of imports, as well as improved success of survival due to faster, more protected transport (e.g., airplanes, sealed containers). Through both intentional and unintentional introductions, the problems of IAS are growing in this region and others.

The Global Invasive Species Programme (GISP) has its origin in recent environmental concern about IAS, associated with Article 8(h) of the Convention on Biological Diversity (CBD, 1992) which asks parties to "*prevent the introduction of, control or eradicate those aliens species which threaten ecosystems, habitats or species.*" An international conference in 1996 in Norway, attended by 80 governments and experts on IAS, concluded that many countries had poor awareness of IAS problems and their prevention and management, and identified an urgent need for a global strategy. Further, this UN-Norway Conference on Alien Species identified IAS one of the top threats to biodiversity conservation, perhaps second only to habitat destruction (Sandlund et al., 1996).

GISP Phase I products:

Biological and socioeconomic syntheses	***Policy and management synthesis***	Other products
Invasive Species in a Changing World. 2000. H.A. Mooney, R. J. Hobbs (eds.) Island Press, Washington, D.C.	***A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species***. Shine, C., N. Williams, L. Gundling. 2000. IUCN Environmental Law Centre.	***Global Invasive Species Database*** http://issg.appfa.auckland.ac.nz/database (Coordinated by IUCN/ ISSG)
The Great Reshuffling: Human Dimensions of Invasive Alien Species. McNeely, J.A. (ed.). 2001. IUCN, Gland, Switzerland and Cambridge, UK.	***A Global Strategy on Invasive Alien Species.*** McNeely, J.A., H.A. Mooney, L.E. Neville, P. Schei, J.K. Waage (eds.). 2001. IUCN, Gland, Switzerland and Cambridge, UK. www.gisp.org	***100 of the World's Worst Invasive Alien Species - a selection from the Global Invasive Species Database***. Lowe, S. et al. http://issg.appfa.auckland.ac.nz/database/species/search.asp?st=100ss&fr=1&sts (IUCN/ISSG)
The Economics of Biological Invasions. 2000. C. Perrings, M. Williamson, S. Dalmazonne (eds). Edward Elgar Publishers.	***Invasive Alien Species: A Toolkit of Best Prevention and Management Practices***. Wittenberg, R., M.J.W. Cock. 2001. CAB International, Wallingford, Oxon, UK. www.gisp.org	
A Plague of Rats and Rubbervines: The Growing Threat of Species Invasions. Baskin, Y. 2002. Island Press, Washington, D.C.	***Invasive Species: Vectors and Management Strategies.*** 2003. Ruiz, G.M. and J. T. Carlton, (eds). Island Press, Washington, D.C.	
Invasive Alien Species: a New Synthesis. Mooney, H.A., J. McNeely, L. E. Neville, P.J. Schei, J.K. Waage (eds). Island Press, Washington, D.C. (in press)		

The concept for GISP was developed at this meeting, and emerged later as a voluntary network of scientists, managers, lawyers, economists, environmentalists and policy specialists, organized around a programme of workshops, studies and publications on key IAS issues. GISP was developed under the auspices of three international organisations with experience in IAS problems: the Scientific Committee

on Problems of the Environment (SCOPE), the World Conservation Union (IUCN) and CAB International (CABI). Funding was provided by GEF for an initial programme with an emphasis on developing country needs, and additions funds were contributed by governments and foundations.

The outputs of GISP so far have largely been publications and meetings, directed at professionals (e.g. texts on IAS and economics, global change, legal and institutional frameworks, human dimensions), policy makers (global strategy), governments (toolkit of best practices) and the general public (Table 1).

At a Synthesis Meeting in Cape Town in 2000, 48 governments, international organisations and NGOs and representatives from the private sector met to review and finalize the outputs of GISP and design its future programme. Subsequently, in 2001, GISP was invited to be an international thematic focal point for invasive alien species in the Convention on Biological Diversity (CBD), and established a Partnership Network, encouraging governments and other organisations to participate in GISP, contributing national expertise and receiving in turn the outputs of GISP studies and projects. These outputs have now been distributed to thousands of stakeholders around the world.

During this process, GISP has made observations regarding the status of the IAS problem internationally. Firstly, awareness of IAS issues has been very poor at the national and international level, and remains so, although this has begun to change. Understanding and capacity varies enormously between countries. Highly "invaded" countries like Australia, New Zealand and the U.S. have considerably more capacity than Europe or many tropical countries. There is also enormous variation between sectors: the agricultural sector has considerably more experience in regulation, prevention and management than the environment or trade sectors, both newly engaged with IAS issues under the CBD and WTO, respectively.

There is, therefore, a need for inter-departmental integration at the national level, which this meeting has been designed to address. Many countries have shared problems, promising very substantial economies through regional cooperation. At the international level, there is a need for better coordination and harmonization of conventions and protocols which related to IAS (e.g. CBD, IPPC, OIE, WTO), with a particular need to "fill gaps" not currently covered. For instance, gaps in regulations and policy regarding the introduction of species into freshwater aquatic systems, both at the international and national levels, may be a reason why these ecosystems experience currently high levels of damaging invasions (see Shine, this volume).

GISP has now launched a second phase of operation, based on recommendations of the Synthesis Meeting. This will, as before, involve specific working groups of volunteer specialists, and will focus on six areas:

- Law and policy
- Global information management
- Evaluation and assessment
- Education, communication, outreach
- National and regional facilitation and co-operation
- Pathway management

The series of regional workshops, of which this South and Southeast Asia Regional Workshop is the fourth, is one of the outputs of the Education, Communication, and Outreach Working Group.

For the rest of this paper, I will concentrate on an output related to national and regional facilitation, namely the production and adaptation of *Toolkit of Best Prevention and Management Practices for Invasive Alien Species* (Wittenburg & Cock, 2001).

Best prevention and management practices for IAS

The "Toolkit" was developed to provide national programmes and other relevant parties with the best, most current understanding of prevention and management, drawn from the experiences of different countries and sectors. An initial consultation was organized in 1999 in Kuala Lumpur, Malaysia to bring together IAS experts, representatives from countries with well-established IAS programmes, and representatives from developing countries without these. This workshop designed a structure, which was then completed by synthesizing experiences into a text and collecting over 100 case studies on IAS prevention and management, successful and unsuccessful, to illustrate this.

The Toolkit contains a short section on developing a national strategy and programme, followed by a more detailed text on prevention and management. Rather than summarize this second part here, I will highlight some key lessons learnt from this exercise, and relate them to logical steps in IAS prevention and management.

A simple representation of IAS management would involve a number of sequential options. An IAS threat could first be prevented by stopping the intentional or accidental introduction of an IAS. If such a species does, however, enter a country and establish a population, there is the possibility that it could be detected early in its establishment and eradicated. Failing this, the IAS will spread, probably beyond the limits where eradication is a feasible option. Then, the only options available are to control the species to some desired level, or to "live with it."

Prevention has generally proven to be the preferred option for IAS management, particularly as it will often be far more economical than subsequent eradication or control options. Risk assessment methods, developed for agricultural IAS under the auspices of the IPPC, provide an excellent means to prioritise which potential IAS should be particularly targeted for prevention. However, current risk management methods need to be modified to include not only economic risks, e.g. to crop production, but environmental risks as well. Some integration of environmental impact analysis and risk assessment is, therefore, optimal.

For the many diverse taxa of "environmental IAS" affecting biodiversity and ecosystem services, impact assessment methods are still very poorly developed and the risks associated with particular kinds of organisms are not as well known as with "agricultural IAS." In this situation, the best available information on risk is the experience of a particular species as an alien in another country. While there are exceptions, alien species which become serious IAS in one country outside their area of origin are likely to be invasive in similar ecosystems elsewhere. Unfortunately, many countries do not have information on these environmental IAS in other parts of the world, and distribution of this information will be enormously valuable. For instance, in Asia, a number of countries are aware of the serious impact of alien water weeds like *Salvinia molesta* and *Eichhornia crassipes*, while others, unaware of this threat, are actively distributing, or even producing commercially and exporting, these plants.

Ultimately, we would like all nations to have import and border controls capable of preventing the introduction of all potential IAS. In reality, many national programmes are struggling to prevent even serious, known agricultural invasives, due to the rapid increase in trade and the inability of under-financed regulatory and quarantine services to cope with this. In this situation, perhaps the best way of reducing serious new invasions is to identify and address the key pathways along which our most serious IAS are travelling. A good example of this is to be found with marine IAS. Identification of ships' ballast water and hull fouling as major vectors of invasion for many species of marine organisms has allowed a focused effort to limit this risk of shipping. Military activity and food aid represent other

key pathways of invasions, particularly into countries which may be particularly vulnerable to IAS, which could be targeted and "closed" relatively easily.

The early detection and eradication of newly established IAS is a profoundly under-utilized approach, relative to prevention and control measures, and is therefore worthy of more serious consideration. It requires regular surveys by well trained staff who know what species may be invading what habitats or production systems. However, there is the potential to inform and empower local government and the general public to be vigilant about new IAS, thereby mobilizing an enormous and inexpensive workforce for IAS management. Early detection systems rely heavily on adequate national systematic expertise to identify new species and distinguish natives from aliens (in some ecosystems, e.g. coastal marine zones, taxonomy is often so poor as to not be able to determine what species are native or alien). This is why issues of improving taxonomy and managing IAS are so closely linked. All early assessment systems require carefully thought out contingency plans to implement quickly when an unwanted alien is detected. Often, time is of the essence. Some invasive taxa have very short "lag periods" between introduction and explosive growth and spread – this is the case for many animal diseases. However, others, like some invasive weeds and some (but not all) insects, will persist at low numbers for a long period, even decades, allowing better opportunities for detection and eradication.

Eradication is, of course, not always feasible, even with small, initial populatons.of IAS. Experience has shown that eradication is most likely when it is based on sound scientific information about the growth rates and spreads of the species, and the efficacy of control methods. It must be clear that the species can be completely eradicated – eradication often becomes much more difficult with the few remaining individuals to be found, trapped or removed. Also, there must be no immigration of new individuals into the eradication area. Given that these technical considerations are met, the other major element of successful eradication is strong policy and public support. Funds must be adequate for a campaign which sees the process through to its end, whatever the cost or time. Public support may be difficult to maintain, for this reason, and also because some eradication methods, such as the trapping, poisoning or shooting of invasive mammals, may be unpopular with the public.

A range of methods are available for eradication or control of IAS. Eradication has depended largely on mechanical or chemical methods, such as collecting, trapping and poisoning. These have the advantage of being precisely targeted, but can be expensive. In the case of chemical control, environmental risks may apply to widespread use of chemicals.

Where eradication proves impossible, mechanical and chemical control may be used in recurrent control efforts, to bring IAS populations to non-damaging levels (e.g. pesticides applied to crop pests). Habitat management may also be used to reduce IAS populations. In Asia, for instance, goats are used in plantations to remove alien weeds, while fish in rice-fish systems may be manipulated for control of golden apple snail.

Such methods may be considered a form of biological control, but this term is also applied to the introduction of specific alien natural enemies to safely and permanently suppress populations of an alien species. Biological control of this kind has been most successful against insects and weeds to date. Returns on investment can be very high, but success is hard to predict until an introduction is made, and this can be expensive due to the need for extensive safety testing to ensure the biological control agent will only affect the target species.

New technologies are emerging for IAS management, offering hope for many currently intractable problems. For instance, invasive mammals are very difficult targets, because of their intelligence, the risks of biological control (e.g. pathogens) to other animals including humans, and public aversion to killing animals. In this case, new biotechnologies may be valuable. Scientists in Australia have

engineered specific, mild viruses of target mammals to cause sterilization by inducing autoimmunity in the female mammal to her own eggs. In this way, the population declines without any substantial harm to individuals. However, the field release of genetically-engineered mammalian viruses still has many safety hurdles to cross.

Overall, there exist a range of prevention and control methods for IAS, which have the potential for application or adaptation to the new IAS problems emerging today. New technologies are badly needed, as are sufficient resources to adequately address this problem. We may need to live with many well-established problems, and the best advice to governments in developing IAS prevention and management may be to focus on preventing new and serious problems, and eliminating or controlling recently established problems where there is a good chance of success and precedents elsewhere.

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Invasive alien species in Southeast Asia

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Introduction

Invasive alien species (IAS) are causing billions of dollars worth of damage in SE Asia as well as causing displacement and, in some cases, extinction of hundreds of native species. Yet, despite the scale of the damage, the prominence given to management of IAS in the Convention on Biological Diversity (CBD), and the many international protocols and initiatives to tackle this issue (see Shine, this volume), almost no attention is paid to this threat in SE Asia and there are few national programmes to combat established IAS or reduce the risk of more being introduced. Equally shocking is the fact that whilst some IAS have become established accidentally, the bulk were deliberately introduced.

The data sheets held on SE Asian countries by the Global Invasive Species Database[30] also fail to reflect the great extent or urgency of the problem. Hundreds of species are involved, rather than the few species per country documented in the database.

The rate of introduction of alien species is greatly increasing with the globalisation of trade, travel, and tourism. Moreover, the opportunities for invasion are becoming more numerous as more natural areas are transformed by rapid development (McNeely et al., 2001).

Some major culprits

Almost all lakes and fresh-waterways of the region are clogged with such species as water hyacinth *Eichhornia crassipes*, water lettuce *Pistia stratiotes*, and yellow burhead *Limnocharis flava*. These species impede boat transport and fishing activities, as well as causing eutrophication and loss of productivity. Clearing these weeds annually involves very high labour costs.

Most lakes of the region have become invaded by introduced fish such as tilapia *Tilapia mossambica*, which now even inhabits saline estuaries, Thai catfish *Clarias batrachus*, bighead *Aristichthys nobilis*, grass carp *Ctenopharyngodon idella*, snakeheads *Channa* spp. and even goldfish *Cyprinus carpio*. Almost all endemic lake fish of the Philippines are already extinct as a result of such introductions. Losses of indigenous fish in major fisheries such as in the Tonle Sap in Cambodia have huge economic impacts.

In addition to many pantropical weeds that have become very aggressive, such as Siam weed *Eupatorium (Chromolaena) odoratum*, sensitive plant *Mimosa pudica* and grasses such as Japanese blood grass *Imperata cylindrica*, there are many ornamental plants spreading out of control across the region. These include bush lantana *Lantana camara*, trumpet creeper *Caesalpinia pulcherrima* and especially climbing plants that can smother the original vegetation such as blue trumpet vine

[30] http://www.issg.org

Thunbergia grandiflora, morning glory *Ipomea carnea* and *I. cairica*, mile-a-minute vine *Mikania micrantha*, paper flower *Bougainvillea spectabilis*, and the edible Thai vine *Coccinea indica*.

Exotic coloniser shrubs such as false matico *Piper aduncum*, catclaw mimosa *Mimosa pigra*, and prickly pear *Opuntia monacantha* now cover huge areas of the region. The undergrowth of important nature reserves and parks in Luzon, Philippines, which should be covered in endemic palms and shrubs are dominated by the admittedly attractive South American shrub *Pachystachys coccinea*, in no way inhibited by the lack of its natural pollinators, the hummingbirds.

Foresters have consistently introduced alien trees for plantations. There is often a short-term advantage in planting a species in a place where its natural pests and diseases are absent. In some cases such species spread out of control, displacing natural vegetation and profoundly changing the natural ecology. Examples include the Chinese super-tree *Paulownia tomentosa*, listed as invasive in many countries; several introduced conifers that have become established in the region, and the spread of Australian eucalypts and acacias. Both ear-leafed acacia *Acacia auriculiformis* and big-leafed acacia *A. mangium* grow well in SE Asia, and spread naturally over cleared and burned areas. These species create conditions of great flammability, and themselves thrive on regular fire episodes in lands where natural forest fires were almost unheard of. As the "haze" fires now burn annually in Borneo and Sumatra, so these species are spreading at the expense of native species and transforming those islands into firescape monsoon forests.

Introduced American bullfrogs *Rana catesbeiana* and marine toads *Bufo marinus* have spread right across the region, competing with and actually devouring local endemic amphibia along the way.

When it comes to impacts on native species, introduced mammals rival other IAS. Ship-spread rats *Rattus rattus* and *R. norvegicus* have eliminated local bird species on small islands, competed with indigenous rodents and also are disease sources and major agricultural pests. The wild pig *Sus scrofa* has spread through the region, causing huge agricultural losses and outcompeting the indigenous forest pigs of the bearded pig (*barbatus, celebensis*) group. Domestic cats *Felis cattus* and dogs *Canis familiaris* have done untold damage, especially on islands that formerly lacked significant mammal predators such as Sulawesi, parts of Philippines and many small oceanic islands. Humans also seem to have spread the common palm civet *Paradoxurus hermaphroditus* in early times.

The tree sparrow *Passer montanus* and house crow *Corvus splendens* have spread across the region as a commensals of man and become serious grain and urban pests, respectively. The Java sparrow *Padda oryzivora* has become an established pest in many areas, even though it remains endangered and rare in its native Java. Exotic parrots such as lesser yellow-crested cockatoo *Cacatua sulphurea* and rainbow lorikeet *Trichoglossus haematodus* have even become established in some areas and have become noisy local pests in some cities.

Invasive invertebrates introduced to the region include American cockroach *Periplaneta americana*, which has become a terrible household pest, yellow crazy ants *Anoplolepis gracilipes* which have caused havoc among some native fauna, red fire ants, nematode worms and avian malaria. Introduced African giant snail *Achatina fulica* and golden apple snail *Pomacea canaliculata* for human consumption have been ecological disasters. These species are mostly not appreciated as foods in the region but are now dominating many ecosystems and causing huge losses as agricultural pest species. Other snails spread the serious disease, eastern schistosomiasis.

Even more difficult to notice and control are the many microrganisms such as wood rot fungi that become introduced with timber shipments, other fungal pests and viral and bacterial diseases.

The scale of damage and losses

Economic assessments of the levels of damage caused by IAS in USA result in figures of tens of billions of $US per year. These costs are seen in loss of production in agriculture and forestry, fishery losses, costly eradication programmes to eliminate undesirable species and diseases. The clean up costs of one species of *Tamarix* is estimated at US $4 billion (Pimentel et al. 2000). Similar costing exercises are almost totally absent in the SE Asian region, but given the size of the region, the total human population and the greater direct dependence of the population on biodiversity and primary production systems, it is clear that the damage to ecosystems and economies must also be counted in billions of US$ per annum.

Vulnerability

Examining patterns of invasion enables us to make some generalisations. Some ecosystems are more vulnerable than others. Freshwater systems, small islands, areas with high numbers of local endemic species, and areas undergoing major landcover transformation are particularly vulnerable and need special vigilance and protection. For instance, logged or secondary forests are far more prone to IAS than intact primary forests.

Equally, we can recognise that certain types of organisms that have a greater chance of becoming IAS. Vigorous "r-selected" coloniser species with fast reproductive rates and good dispersal ability are very dangerous. Such species include many grasses, climbers, coloniser shrubs and trees with wind dispersed seeds. Parasitic and carnivorous animals are also dangerous. Introduction of close relatives of indigenous species are highly prone to result in genetic pollution of the local form.

Why do we continue to introduce new species?

There are many reasons why alien species are introduced, but a few major ones are (McNeely, 2001):

- Accidents due to weak controls, laws and quarantine procedures;
- Irresistible urge to try to improve on nature;
- Lack of local species to meet specific needs (e.g. good fibre or ornamental properties);
- Short term or long term production superiority of exotic varieties (often due to lack of local pests and diseases); and
- Easier accessibility to alien seed than local species, due to lack of development of local germplasm over much of the world.

Why do local agencies pay so little attention to the problem?

- Failure to recognise long-term and indirect costs of introductions;
- Costs of biological invasions are not be borne by the importer, who generally shows a profit;
- Weakness of systematics and lack of awareness of problem. Lack of recognition of local versus alien species, such that people do not notice that they are surrounded by aliens;
- Some problems, such as spread of diseases, crop pests, grain losses to rats and domestic pests such as cockroaches are recognised as major economic losses, but not generally recognised as being caused by IAS;
- Weakness of laws and control measures resulting from the lack of awareness as to the true scale of the problem;
- Unwillingness to interfere in "commercial development," and
- Over-concern over the hyperbole of genetically modified orgasnisms (GMOs), without realising that IAS is a more immediate and serious threat.

Conclusions

- The scale of threat from IAS has been consistently under-appreciated in the Southeast Asian region, but is clearly enormous. IAS is probably the second greatest threat to biodiversity after loss of habitat.

- Each country should be encouraged to take the problems of IAS more seriously than at present. Large countries must recognise that there are internal biodiversity boundaries. For instance, Sulawesi plants introduced into Maluku can become IAS even within the same country.

- Countries should be more interested in the measures taken by land neighbours and should have the right to comment and see information on IAS for which they may be the next target. They should undertake surveys and research to assess the extent to which they are already invaded by alien species and assess the economic implications of these invasions. The findings of such studies need to be much more widely broadcast, and in particular must be brought to the attention of government planners and regulators, so that actions to control or eradicate IAS and limit further introductions can be justified and implemented.

- National databases about IAS should be established on websites. International programmes such as GISP can assist in collating such data into easily accessible international databases. A good example of a national database can be found on http://www.chinabiodiversity.com. Such databases should contain lists of noticed IAS, details of their biology, case studies, evaluations of damage, results of control or eradication measures. They should also serve an outreach function to broadcast awareness.

- Most of the regulations limiting introduction, field trials and releases of new organisms into the environment would be the same for alien species and genetically modified organisms. Therefore, GMO regulations should not be developed independently of IAS controls. Such controls start at limiting the export of non-sterile biological materials to export controls, field trials, field release, and continued monitoring and if necessary control and eradication.

- National programmes should be introduced including tax incentives to promote the use of native germplasm rather than introduced species for horticulture, urban greening, parks, recreational areas including parks, golf courses, roadside trees, and forestry.

The ASEAN Regional Centre for Biodiversity Conservation (ARCBC) is developing ASEAN-wide species databases on the web, and can include a clearinghouse for regional level data on IAS. We remain willing to discuss with GISP and focal countries how this can be organised. ARCBC is also devoting one edition of the magazine "ASEAN Biodiversity" to this topic and can also assist regional efforts in terms of training and research.

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Invasive alien species: opportunities for international research collaboration

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This paper was unfortunately unavailable at time of going to press.

2.2.2 Sub-regional overviews

South Asia (continental) perspective: invasive alien species in India

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Introduction

During the last decade invasive alien species (IAS) have been identified as the major factors directly affecting India's natural resource management, placing constraints on the protection of watersheds and native flora and fauna, for example. The taxa causing the most damage in India include insects, mites, molluscs, weeds, and pathogens. Examples are listed below:

Insect species

⇒ Coffee berry-borer *Hypothenemus hampei:* In India, the infestation of coffee berry-borer was first noticed in the Gudalur area, Nilgiris district, Tamil Nadu in 1990. The beetles were recovered from berries of *Coffea arabica* (CVS 795 Canvery hybrid). In all probability, *H. hampei* was introduced from neighbouring Sri Lanka through coffee beans brought by the Sri Lankan Tamil refugees. The coffee berry-borer entered and spread to Wayanad (Kerala) and Kodagu district of Karnataka by 1993. At present, it is estimated that an area of 39,000 ha in these three districts is infested, with significant losses estimated at $US 300 million per annum.

⇒ Serpentine leaf miner *Liriomyza trifolii*: The leaf minor was first reported from India in 1991. It is likely that it was imported from the United States or the United Kingdom into India along with cut *Crysanthemum* flowers in 1988-89. It has spread rapidly and widely in the states of Karnataka, Andhra Pradesh, Maharastra, Gujarat, and in Delhi. It was found to occur commonly on cotton during 1991 in Karnataka and in subsequent years has been recorded in Tamil Nadu and Andhra Pradesh, typically on cotton. It has also attained the status of a serious pest in vegetable crops, especially tomato and cucurbits. In India, it has been recorded from 55 hosts including cotton, tomato, cucurbits, ornamental, pulses, and oilseeds.

⇒ Subabul psyllid *Heteropsylla cubana*: The psyllid probably dispersed on high westward wind currents and reached India in 1988 from Sri Lanka. In India, it was first reported from Chengalpattu (Tamil Nadu) and subsequently from Tamil Nadu. It is also possible that besides high altitude winds, the passengers in airplanes and ships might have played a role in introduction and dispersal of this species. At present, it has spread to Bangalore (Karnataka), Pune, Nagpur (Maharastra), Khammam (Andhra Pradesh), and Nepanagar (Madhya Pradesh). This pest is spreading so fast that it has already covered whole of peninsular India. It has become a serious threat to subabul, a major plant preferred for social agro-forestry in India.

⇒ Spiraling whitefly *Aleurodicus dispersus*: Spiraling whitefly was first reported on cassava in 1993 from the Trivandrum district of Kerala (Palanisamy, 1995). Later, it was recorded on tapioca, rubber and 99 other hosts, and has become a serious pest on guava, pomegranate, banana, and ornamental crops.

⇒ Silverleaf whitefly *Bemisia tabaci* – B- biotype: Occurrence of silver leaf whitefly in India was first noticed in 1999 in Kolar district (Karnataka). Although no direct evidence is available, it is believed that it was introduced through imported rose cuttings from Israel. The pest is still confined to Karnataka but has appeared in a severe form on vegetable crops, especially tomato. It is feared that the species might spread fast to other regions on several crops.

⇒ Codling moth *Cydia pomonella*: It is believed that the codling moth was introduced to the Ladakh region (Jammu and Kashmir) from Pakistan. First reported in 1989, it has now spread to the adjoining state of Himachal Pradesh, and has become a serious pest of apple and other temperate fruits (walnut, peach, pear, apricot).

⇒ Potato tubermoth *Phthorimaea operculella:* It was accidentally introduced in India during 1900 along with seed potato from Italy. It is now well established all over India, and is regarded as the most destructive pest of potato, in both fields and storage.

⇒ Diamond-back moth *Plutella xylostella*: This species was first reported in 1914 on crucifer vegetables. It has attained the status of a serious pest of cole crops (cabbage/cauliflower) and has spread throughout India.

⇒ Woolly aphids *Eriosoma lanigerum*: In India, this IAS may have been introduced in 1909 along with nursery stocks imported from England. It was first noticed in the Shimla area and has since spread to all apple-growing areas. It is a serious pest on apple and other temperate fruits.

Invasive alien plants

⇒ Lantana *Lantana camara*: Introduced to India during 1809 from Central America, *Lantana* has replaced several forage grasses in the terrestrial ecosystems including hilly regions, plains, and open forests. This species has greatly reduced the forage/grass production in India, and affected cattle grazing in many regions.

⇒ False ragweed *Parthenium hysterophorus*: This species was introduced to India in 1956 with imported milo (red wheat) from Mexico, and has since invaded very rapidly disturbed habitats throughout the country, especially urban environments, rail tracks, and roadsides. It has also become a problem in fields in Mahrastra, Karnataka, and Madhya Pradesh.

⇒ Canary grass *Phalaris minor*: This plant causes the most serious invasive problem in wheat cultivation. It was introduced in 1966 along with the large-scale import of wheat seed from Mexico and the United States. The cost of control using herbicides is Rs 500 crores per annum in northwest India.

⇒ Water hyacinth *Eichhornia crassipe*s: Introduced in 1914 from Brazil, it is a serious problem in water channels, reservoirs, canals, rivers, ponds, and hampers water transport, irrigation, and fish culture. It also creates breeding sites for mosquitoes. In India, satisfactory levels of biocontrol using a weevil (*Neochatina* spp.) have been achieved through a field-to-field release method.

⇒ Honey mosquite *Prosopis juliflora*: Introduced in 1877 from the United States, this IAS has invaded abandoned housing sites. The cost of reclaiming land invaded by this weed either for agriculture or housing is prohibitive, and is therefore a serious economic concern.

⇒ Siam weed *Chromolaena odorata*: Introduced from the United States in 1951, it has since spread and displaced several plant species. In the northern hills of Tamil Nadu, it is threatening the existence of thatch grass (*Cymbopogon* sp.).

⇒ Water fern *Salvinia molesta*: Introduced from South America during 1955-1958 to Kerala, it has become a major problem in backwaters and rice paddies. A phytophagous weevil has provided satisfactory biological control.

Invasive pathogens and parasites of plants

Information available is summarised in the Table below.

Organism	***First detected***	***Origin***
Bunchy top of banana	1959	Sri Lanka
Blight of chickpea	-	Middle East
Banana streak virus	1995	-
Peanut stripe virus	1987	-
Sunflower downy mildew	1984	-
Potato golden nematode	1977	United Kingdom
Apple scab	1974	Europe
Cotton leaf curl virus	1995	Pakistan

Other invasive alien species

⇒ Coconut mite *Aceria* (*Eriophyes*) *guerreronis*: In India, this IAS was first reported from Ernakulam district in Kerala in 1997. Recent surveys indicated that the pest has not only spread to adjoining districts such as Alleppey, Kottayam and Trissur, but is also fast spreading to adjacent Tamil Nadu (Pollachi) and Karnataka (Bangalore), and has reached alarming population sizes, causing serious concern to coconut growers. Recently, it has been recorded from Andhra Pradesh. The spread of this mite usually occurs through the wind. However, it also spreads through transportation of affected nuts. The pest has assumed the status of a severe coconut pest in India.

⇒ Fluted scale *Icerya purchasi*: The fluted scale or cottony-cushion scale in India was first reported in 1928 from Nilgiris and Madurai district (Tamil Nadu). It is believed that the IAS entered with imported budwood or flowering plants like apple cuttings imported from Sri Lanka. It has spread to Tamil Nadu, Karnataka, Kerala and Maharastra, and has been recorded on 38 hosts, including *Acacia* spp., *Casuarina* spp., *Citrus*, and *Rosa* spp.

⇒ San Jose scale *Quandraspidiotus perniciosus*: This IAS is believed to have entered Kashmir along with flowering plants like quince (*Cydonia* sp.) in 1922. It is now considered a serious pest of apple in northwestern India, including Jammu and Kashmir, Himachal Pradesh, Uttaranchal, Tamil Nadu, Karnataka, West Bengal, Sikkim, Assam, and Meghalya.

⇒ Green scale *Coccus viridis*: This IAS was noticed in South India for the first time in 1889 on coffee. It has spread and established itself in southern India (Karnataka, Tamil Nadu, Kerala) and has attained the status of a serious pest on coffee, citrus, guava, mango and orange.

⇒ Giant African snail *Achatina fulica*: The invasion of *A. fulica* from East Africa to India through human agencies dates back to 1847 when Benson carried living specimens from Mauritius to Calcutta where they became naturalised. In 1907, it multiplied in large numbers and spread to other regions in West Bengal, Bihar, Orissa, Assam, Madhya Pradesh, Maharastra, Kerala, Tamil Nadu and Karnataka. It has attained serious pest status on garden and ornamental plants. In 1946-47, it appeared in epidemic proportions from Balasore (Orissa) and caused severe damage to vegetable crops and rice paddies.

Management efforts and agencies

In India, plant protection is the joint responsibility of both the central and State governments. At the central level, there are two relevant departments in the Ministry of Agriculture – the Department of Agriculture and Cooperation (DAC) and Department of Agricultural Research and Education (DARE) - which are concerned with plant protection outreach and research, respectively. The DAC is responsible for framing policies and programmes for execution and implementation with the help of State governments, which have adequate infrastructure and functionaries up to village and block level to carry out extension and development programmes, including plant protection and pest management. DARE is mainly responsible for research and education, and has an autonomous high-level council known as the Indian Council for Agricultural Research (ICAR), presided over by the Honourable Union Agriculture Minister. ICAR is one of the best known research organisations in the world, with more than 90 research institutes, national research centres, research directorates which include approximately 30,000 scientists engaged in multi-disciplinary research such as crop husbandry, plantation crops, animal husbandry, and dairy farming, fisheries, and aquaculture. There are also approximately 32 State Agricultural Universities (SAUs) and over 100 universities engaged in biological science research.

In addition, the Ministry of Environment and Forests, Department of Science and Technology, Ministry of Human Resource Development, and Department of Bio-Technology also undertake and assist in research, development, and extension activities in plant protection.

There are a few non-governmental organisations (NGOs), like the Swaminathan Research Foundation, Chennai and Ramakrishna Mission, Kolkata which are actively engaged in research/extension work in pest management including IAS. The pest management efforts are, however, coordinated by the Department of Agriculture (DAC) (Ministry of Agriculture) at the central level through the Directorate of Plant Protection, Quarantine and Storage in close cooperation with ICAR and State governments. The Directorate also implements the Destructive Insects and Pests (DIP) Act of 1914 and the Plants, Fruits and Seeds (import regulation into India) Order of 1989.

The DAC organises discussions with the ICAR and other related departments at regular intervals to advance strategies and programmes to address serious pest problems, including IAS. The DAC also organises national conferences and zonal conferences during both Kharif and Rabi crop seasons to discuss and plan out crop production programmes. Priorities for management of pest species are decided on the basis of criteria such as: the crop, pest species, areas affected, economic importance, available technology, and feasibility of management approaches.

Scientists are engaged in research in well-equipped multi-disciplinary laboratories at the ICAR research institutes and in universities. The ICAR headquarters in New Delhi coordinates all research efforts on plant protection and management strategies, including international cooperation. The DAC through the Central Directorate of Plant Protection, Quarantine and Storage, coordinates with State governments for implementation and execution of extension and development programmes at the national level and also

coordinates with international agencies, including a wide range of intergovernmental organisations for implementation of relevant programmes.

In summary, India has a multi-agency, multi-departmental, multi-disciplinary, and multi-programme approach for pest management, including management of IAS. There is no single national-level agency to coordinate work on IAS.

Integrated pest management: a strategy

India has adopted an integrated pest management (IPM) approach as the cardinal principal and foundation of its plant protection strategy, with a view to minimizing the use of toxic chemicals and promote sustainable agriculture and forestry. The IPM approach tends to be more environmentally benign and seeks to employ all available techniques, skills, methods, and practices in a harmonious manner. In India, considerable headway has been made in the use of IPM in rice, cotton, oilseeds, and vegetables for control of IAS. A large IPM Farmers Field Schools (FFSs) Programme was launched in 1994, wherein 30,000 extension staff and 3,000,000 farmers have been exposed to IPM approaches.

Conclusion

IAS pose threats of epidemic proportions, reduce agricultural productivity, reduce biodiversity, contribute to trade barriers, lead to intensive pesticides use, and threaten food security. Both national and local governments must address the prevention and management of IAS by establishing a separate organisation wholly devoted to this important issue. These problems will become even more pressing and the necessary responses more urgent as international trade expands under the WTO regime.

Invasive alien species in insular South Asia

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Introduction

This paper summarizes the published information on the IAS in insular South Asia (particularly to the Maldives and Sri Lanka), strategies adopted to overcome their negative impacts, and the need for the development of a regional strategy to tackle the problems of IAS in the region.

Sri Lanka

IAS have caused significant losses of biodiversity, especially in island communities. As Sri Lanka is an island with a rich biodiversity and numerous endemic species, the threat of IAS is very real. Although the IAS issue was neglected during the past in Sri Lanka, there is a growing concern at present and efforts have already been made to identify IAS in the country, as well as generate public awareness of the causes and consequences (Marambe, 1999, 2000; Bambaradeniya et al., 1998; Bambaradeniya et al., 2001; Marambe et al., 2001).

Macroeconomic policies such as free market policies, liberalization of the financial sector, and the increasing share held by private sector in the national economy - all of which were pursued by successive governments in Sri Lanka since the late 1970s - have facilitated an increase in entry of IAS to the country (Marambe et al., 2001). These include intentional trade in living organisms, as well as the unintentional movement of organisms by tourists, on products, in shipping containers, and associated means of transport. Urbanisation and infrastructure development, which are two of the most visible processes of development in the country, have also facilitated the spread of IAS by modifying natural environments (Marambe et al., 2001).

Humans have been moving plants across the world for centuries. Species such as tea, rubber, and coffee have been introduced to Sri Lanka as food crops. Many other species have been introduced to the botanical gardens for the impressive ornamental characteristics of foliage and flowers. Some of these introduced species have become accepted components of the local flora. However, there are species that have become management problems in new habitats due to their continuing and inexorable spread. Most of these species have proven themselves to be unwanted species, threatening the diversity of natural habitats or generating a range of problems associated with agricultural activities. Examples of invasive weed species in Sri Lanka include: water fern *Salvinia molesta*, water hyacinth *Eichhornia crassipes*, giant sensitive plant *Mimosa pigra*, congress weed *Parthenium hysterophorus*, lantana *Lantana camara*, balsam of Peru *Myroxylon balsamum*, gorse weed *Ulex europaeus*, mesquite *Prosopis juliflora*, alligator weed *Alternanthera philoxeroides*, Ipil-ipil *Leucaena leucocephala*, madeira vine *Anredera cordifolia*, and wild sunflower *Tithonia diversifolia*. Among the faunal populations, feral buffalo *Bubalus bubalis*, tank cleaner *Hypostomus plecostomus*, clown knife fish *Chitala chitala*, and tilapia *Sarotherodon mossambicus* are among the dominant IAS in recorded in the country (see Marambe et al. in the accompanying national reports volume for further details).

Policies and provisions

The threat of IAS to local flora and fauna in Sri Lanka, particularly in the agriculture sector, has been well understood from early times. Several legislative provisions were enacted in Sri Lanka in the early 20th century to safeguard plants and animals against the threats of alien species. The Water Hyacinth Ordinance of 1909 includes provisions to prevent introduction and dissemination of the aquatic weed. The Plant Protection Ordinance of 1924 has provisions against the introduction into Ceylon (now Sri Lanka) of weeds, pests, and diseases injurious to or destructive of plants, and it provides for sanitation of plants brought into Ceylon. This Ordinance was amended in 1956 and 1981 and totally revised in 1999 (No. 35) to make adequate provisions to cope with current trends on the movement of flora and fauna due to increased international trade and traffic. The Fauna and Flora Protection Act, amended in 1964 and 1970, includes provisions for establishment and maintenance of national reserves, national parks, and jungle corridors, thus ensuring conservation of the native biological diversity of the country. The Department of Agriculture revised the policy on import of seeds and planting materials to Sri Lanka in 1991. This, together with the New Seed Act of 1999 which is pending approval, would help enable Sri Lanka to overcome the threats of IAS that could enter the country's ecosystems through international trade.

These legislative enactments provide considerable legal support for Sri Lankans to control and eradicate IAS. However, the areas covered by these enactments are limited and do not meet the total requirement for action against IAS. The Plant Protection Ordinance of Sri Lanka aims at preventing introduction of exotic pests (insects, diseases and weeds), which are harmful to agricultural, horticultural, and forestry industries. However, quarantine laws place less emphasis on plant species that can have serious negative effects on biodiversity of natural habitats of Sri Lanka. Thus, it is clear that development of an appropriate legislative framework is a pre-requisite for effective IAS prevention and control.

Sri Lanka is a signatory to the Convention on Biological Diversity (ratified in 1994), and the Biodiversity Secretariat of the Ministry of Environment and Natural Resources of Sri Lanka serves as its focal point. Accordingly, several attempts have been made by Sri Lankan authorities to overcome threats posed by IAS to natural, as well as agricultural, ecosystems. These attempts have engaged numerous stakeholders in governmental, non-governmental, and private sector organisations. Creating awareness among the general public and policy makers has been considered as a high priority in issues related to IAS. Awareness campaigns have been held at national and regional levels with a good coverage given by the newspapers, and national radio and television channels. The Ministry of Environment and Natural Resources plays an important role in these activities, providing necessary financial assistance and other logistical support. Resource persons for these awareness programmes come from State departments, universities, and the non-governmental organisations. Currently, the Ministry of Environment and Natural Resources is in the process of preparing a national strategy to tackle the problems of IAS in Sri Lanka.

The Maldives

As in Sri Lanka, the majority of biological invasions in the Maldive islands has taken place as a result of increasing the international travel and trade. The islands of Maldives have been at the crossroads of several maritime nations since ancient times. Major factors contributing to the invasion of IAS include: lack of local resources and the consequent requirement that nearly all the food is imported; expansion of tourism, fisheries, and agriculture of the country; and the influx of planting materials from neighbouring countries. Inefficient quarantine regulations further these problems. Among the IAS in agricultural and terrestrial ecosystems, the impacts of plant pathogens and insect pests have raised serious concerns (Shafia & Saleem, 2002). The following organisms have been identified as IAS that have caused significant habitat and financial losses in the Maldives: the pathogen that causes the citrus canker *Xanthomonas campestris*, which killed the majority of the local lime variety (*Citrus aurantofoli*a) in 1980s, the stem borer *Batocera rufomaculata*, introduced to the country in 1990s which attacts jack (*Artocarpus* spp.), and the fringle nettle grub *Darna nararia*, introduced in the late 1990s which damaged coconut palm (*Cocus nucifera*) plantations, as well as the banana streak virus, bract mosaic virus and a bacterial pathogen (*Erwinia* sp.) which has damaged banana (*Musa* sp.) plantations.

Policies and provisions

Several attempts have been made by the Government of Maldives to manage the threats posed by IAS. The control and management measures adopted by the government with the assistance of the Food and Agricultural Organization (FAO) of the United Nations in 1990s have resulted in significant reduction in the spread of the fringle nettle grub *Darna nararia* in coconut plantations. The government of the Maldives has banned the importation of coconuts and vegetative parts of coconut palms to avoid importation of IAS that could threaten the ecosystems of the country (Shafia & Saleem, 2002). In addition, as the coral reefs are an important resource to the country's economy, the government has imposed laws and regulations to ensure that environmental impact assessments be conducted prior to implementation of the any marine development projects. Reef monitoring, protected area management, protected species management, and reef resources management are some of the attempts made by the national govenrment in association with local, regional, and international agencies to overcome the threats of IAS to the marine environments.

As a Party to the CBD, Maldives has identified several IAS action plans in its National Biodiversity Strategy and Action Plan (NBSAP), formulated in 2001 (Shafia & Saleem, 2002). However, the island nation will continue to face serious threats of IAS as long as the ports of entry to the country remain

largely unregulated. Some of the important recommendations that have been made in the Maldive's NBSAP include: formulation of quarantine laws and other regulations to control the import of IAS; adoption of risk assessment techniques developed by international organisations for identification, entry, establishment and control of potentially harmful species; establishment of suitable quarantine facilities at entry points; and establishment of appropriate measures for conservation of native biological diversity when transferring species within the country from one locality to another.

Conclusions

IAS problems are a national security issue and should be made a priority to be addressed using a holistic approach. The problem of IAS has grown and continues to grow as trade expands. However, resources to deal with the problem have not kept pace. Thus, the policy makers of the island nations in South Asia, such as Sri Lanka and Maldives, must put management of IAS high on the list of resource management priorities, and see that every natural and agricultural ecosystem with IAS has a management programme in place. National programmes should be coordinated through a regional strategy that helps countries minimise the movement of IAS through international commerce and tourism, especially in the context of trade agreements such as the South Asia Preferential Trade Agreement and South Asia Free Trade Agreement.

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Invasive alien species of insular Southeast Asia

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Invasive alien species of continental Southeast Asia: the case of Thailand

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Introduction

Thailand has no single or centralized national authority responsible for prevention and management of invasive alien species (IAS). This responsibility is divided among different ministries such as the Ministry of Agriculture & Cooperatives (MOAC) in the Department of Agriculture (DOA) for plants, insects, plant pathogens, and biological control agents; Department of Livestock Development (DOLD) for microorganisms and animals of livestock and veterinary importance; Department of Fisheries (DOF) for fish and aquatic animals and plants (freshwater and marine); Royal Forest Department (RFD) for other plants, shrubs, trees, wildlife and endangered animals listed under the Convention on International Trade in Endangered Species CITES; Ministry of Public Health (MOPH) in the Department of Medical Science (DOMS) and the Department of Communicable Disease Control (DOCDC) for microorganisms and causal agents of epidemiological importance; Ministry of Commerce (MOC) for the import and export of certain kinds of flora and fauna. While plant quarantine is under the Department of Agriculture, animal quarantine is under the Department of Livestock Development, both of which are under the Ministry of Agriculture & Cooperatives.

The issues of IAS have become more urgent in Thailand and are one of the major concerns of the country (although it will only ratify the CBD in 2004). Following the UN/Norway Conference on Alien Species in Norway (July 1996 ; see Waage this volume), the National Environmental Board Sub-committee on the Convention on Biological Diversity decided to establish a Working Group (WG) on Alien Species in January 1997. This was situated in the office of Environmental Policy and Planning (OEPP) - the official CBD national focal point, under the Ministry of Science, Technology and Environment (MOSTE), which also functioned as the secretariat of the WG. The OEPP also serves as the secretariat of the CBD Subcommittee, which is chaired by the permanent secretary of MOAC.

The WG on Alien Species is chaired by the executive director of the National Biological Control Research Centre (NBCRC) and co-chaired by the deputy secretary-General of OEPP. It is a joint venture between Kasetsart University and the National Research Council of Thailand (NRCT). Members of the WG consist of representatives of the secretaries' various ministries and boards. The Working Group on Alien Species had the following tasks :

- Compile information on the status of alien species in Thailand;
- Compile information and conduct investigations on the biology, ecology and impacts of alien species in Thailand;
- Prepare guidelines and measures for the control and eradication of those alien species affecting and causing economic damage;
- Prepare guidelines to regulate the introduction of alien species including genetically modified organisms (GMOs); and
- Undertake any task assigned by the CBD Subcommittee.

Inventories

Under the WG on Alien Species, Thailand has accomplished a considerable amount of work, such as preparing inventories of alien species which take into account both invasive and alien species that have proven to be more beneficial than harmful. Although the number of known alien species of microorganisms, plants and animals in Thailand is still far from being reasonably estimated, these inventories reflect, at the very least, the extent to which the alien species exist within the country. Some of the major inventories that have been undertaken thus far include:

- Endemic and alien microorganisms of livestock and veterinary importance prepared by the National Institute of Animal Health, DOLD, and MOAC. Based on culture collections maintained at the institute, researchers estimate that 19 of 168 virus/virus strains are alien, while 135 of 274 bacterial strains or serotypes, and one out of 31 protozoa are of foreign origin;

- The National Biological Control Research Centre (NBCRC) of Kasetsart University and the National Research Council of Thailand have identified 24 serious insect pests of agricultural importance as IAS. In addition, four vertebrate species have been introduced for biological control of water weeds, 12 insects for the biological control of terrestrial and aquatic weeds, two predatory snails for the control of the giant African snail *Achatina fulica*, and a total of 42 beneficial alien species for biological control of insect pests and weeds of agricultural importance as well as insect vectors of medical and public health importance. Thailand has also recorded two alien species for biological control of weeds from South America which have found their way through unknown means to Thailand and neighboring countries;

- The Department of Fisheries (DOF) has estimated that there are at least 32 species of introduced aquatic animals, including snails, in Thailand;

- Another authority has estimated that Thailand hosts 94 species of mammals, 168-228 species of birds, 63-93 reptile species, 23 species of amphibians, 218 fish species, four non-insect invertebrates, and 37 species of insects which were alien.

- The Royal Forestry Department (RFD) has reported 190 alien plant species, while the National Science and Technology Museum inventory documented 921 alien plant species, and the Office of Cane and Sugar Board under the Ministry of Industry estimates that there are 59 major alien weed species present in the sugarcane growing areas of the country. The Institute of Horticultural Research (DOA) maintains an inventory of horticultural crops imported into the country annually.

- The RFD documented that 116 bird species and 15 mammal species were brought into the country in 1995 under the Convention on the International Trade of Endangered Fauna and Flora (CITES). The Zoological Parks Organization of Thailand has identified 371 alien zoo animals in governmental as well as privately owned zoos.

Status of invasive alien species problems

Of the species included on the IUCN-Invasive Species Specialist Group's (ISSG[31]) list of 100 IAS, Thailand hosts at least one micro-organism, one aquatic plant, 13 land plants, nine land invertebrates (three snails, six insects), five fish, one bird and eight mammals. Several of these species were introduced to Thailand for specific purposes. Examples include: the rosy wolf snail *Euglandina rosea*,

[31] www.issg.org

which is native to Florida (USA) and was introduced for biological control of the giant African snail *Achatina fulica*; fish species introduced as sources of protein, such as carp *Cyprinus carpio*, tilapia *Oreochromis mossambicus* and Nile perch *Latus niloticus*, and walking catfish *Clarius batrachus* and mosquito fish *Gambusia affinis* which were introduced for biological control of mosquito larvae.

Examples of invasive alien species

Invasive plants already identified in Thailand include: water hyacinth (*Eichhornia crassipes*), giant water fern (*Salvinia molesta*), giant sensitive plant (*Mimosa pigra*), Siam weed (*Chromolaena odorata*), mile-a-minute (*Mikania micrantha*), and croftonweed (*Ageratina adenophora*) among others. The latter two are invading the northern highland areas of Thailand, Myanmar, and Laos and appear to have come from India and China. Many of the problematic IAS in Thailand also cause high economic impacts in other neighboring Southeast Asian and South Asian countries as well.

Plants and other animals native to Thailand and other countries in Southeast Asia can become IAS elsewhere. For example, weeds of endemic origin in Southeast Asia, such as itch grass (*Rottboelia cochinchinensis*) and giant bramble (*Rubus alceifolius*), have also became IAS of economic importance outside of this region in South America, Reunion, and Mauritius, respectively. A semi-cultivated ivy gourd (*Coccinia grandis*) has traveled along with Southeast Asian refugees to Hawaii and became one of its worst weeds during the mid-1980s. Recently, an invasion of cycad scale (*Aulacaspis yasumatsui*) from Thailand was discovered in cycads shipped to Miami Botanic Gardens (Florida, USA) from Pattaya. The same scale insect was also discovered in California and Hawaii (USA) in early 2002. Immediate release of an insect parasite and a predatory nitudulid from Thailand into Miami has helped to lessen the problem.

List of existing programmes and other government agencies involved in IAS issues

The list of Thailand's existing programmes for IAS management, awareness raising, and national-level campaigns is very short. The only bold and clear-cut programme dealing with management of IAS was that of the National Biological Control Research Centre (NBCRC; established 1978) at Kasetsart University in collaboration with the National Research Council of Thailand (NRCT) and 17 collaborating universities and agencies under the MOAC, MOPH, and some other government enterprises. However, NBCRC deals only with biological control programmes aimed at IAS and within integrated pest management (IPM) systems operating through collaborations with other national, regional and international organization and institutions.

Other programmes relevant to IAS are expected to be identified and prioritised in accordance with Thailand's National Biodiversity Strategies and Action Plan (NBSAPs; 2002-2006) by the CBD subcommittee and the OEPP. When priorities for future work are identified, and policy recommendations, as well as necessary strategies management, are undertaken by the WG on Alien Species, the roles of other government agencies involved in biological control of IAS as well as in other IAS issues can be clarified. A bibliographic list of publications, references, journals, and other resources pertinent to biological invasions in Thailand is being compiled at present. The list of experts in the field of biological invasions and their corresponding contact information will be gathered in the near future.

Invasive alien species in Singapore: a review

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Introduction

Singapore has a long history of introduction of foreign plants and animals. The island's location at the centre of major air and shipping routes has inevitably resulted in the accidental or deliberate introduction of numerous plant and animal species, not to mention micro-organisms and fungi (Ng et al. 1993). As Singapore strives to become a world class cosmopolitan city and centre of tourism in Southeast Asia, it is expected that the deliberate introduction of organisms will continue if only to enrich the quality of life and the living environment. This is especially true in the case of alien species with ornamental or food potential. In the 1970s and 1980s, the water hyacinth *Eichhornia crassipes* and the water fern *Salvinia molesta* were introduced as ornamental plants. They have since escaped from cultivation and caused environmental problems in several reservoirs and river systems in Singapore (Wee and Corlett 1986). In the same way, the rock or feral pigeon *Columba livia*, the Javan myna *Acridotheres javanicus* and the house crow *Corvus splendens* were all probably introduced over the last two hundred years as a result of the pet trade. These birds have become well adapted to the urban environment and have at one time or another caused health concerns due to their large populations located in the vicinity of human populations.

Terrestrial flora

The status of alien plant species has been discussed by Corlett (1988) and Turner & Tan (1992), while introduced animal species in Singapore has been reviewed by Chou & Lam (1989) and Ng et al. (1993). For plants, more than half of the introduced species are originally from the tropical New World, followed by Asia, and lastly, Australia and Africa (see Table 1). However, among plant groups, the attention has been solely on the seed plants. It is only now that we have information about alien pteridophytes and exotic mosses that have become established in Singapore (Wee 1997, Tan & Tan, 2000, Tan & Buck, 2002).

Terrestrial and freshwater fauna

Among animals there is good taxonomic knowledge about alien mammals, birds, reptiles, amphibians, freshwater fishes, and decapod crustaceans. Apart from rats, few non-native mammals have established in Singapore. In contrast, a total of 72 species of alien birds are now known to reside in Singapore (Lim and Gardner 1997; see Table 1). The effect of these species on what little is left of the original flora and fauna of Singapore, however, has not been studied. The majority of naturalized birds in Singapore originate from the Asian subcontinent, with only few species known from Australia and Africa (see Table 1). Many are cage escapees that have become adapted to the now largely urban environment of Singapore.

Naturalized reptiles typically entered the country via pet trade and later escaped or were released. These species include: the red-eared terrapin *Trachemys scripta* from North America (Anonymous, 2002), striped keelback *Xenochrophis vittatus* from Indonesia, and changeable lizard *Calotes versicolor* from Indochina (K.K.P. Lim, pers. comm.). The painted bullfrog *Kaloula pulchra* from Indochina and the American bullfrog *Rana catesbeiana* from the United States are now common in residential areas and reservoirs, respectively. A smaller number of reptile species have been introduced in connection with religious and cultural practices, such as the Malayan box turtle *Cuora amboinensis* and black marsh turtle *Siebenrockiella crassicollis*. These species are commonly purchased in Singapore and released by local Buddhist followers on Vesak Day.

The majority of alien freshwater fishes resident in Singapore entered the country through the ornamental fish trade. Of a total of 58 alien teleost fish species recorded from Singapore so far (K.K.P. Lim, pers. comm.), about half of these species are from Asia, while species from Central and South America comprise a further 33% of the total number of alien species. The remaining species consist mainly of African cichlids.

Two species of freshwater prawns (*Macrobrachium lanchesteri* from Thailand and *M. nipponense* from East Asia) are now established in freshwater streams in Singapore their impact on native inhabitants has not been elucidated. The giant African snail *Achatina fulica* and the African tilapia *Oreochromis mossambicus*, both now with well-established populations throughout Singapore, were deliberately introduced during World War II as a potential source of protein. Other invertebrate groups, such as protozoa, platyhelminthes, nematodes and insects, remain poorly documented and their presence (or absence) is not immediately known.

Marine fauna

In the estuarine environment, two alien bivalve species have established themselves in Singapore in recent years. The Caribbean bivalve known as the Santo Domingo falsemussel *Mytilopsis sallei* is found in large numbers, mostly along the walls and floor of tidal monsoon canals, forming mats of several kilometers long in some cases (Tan & Morton, unpublished). This bivalve is closely related to the notorious Asian zebra mussel *Dreissena polymorpha* which has invaded and caused havoc in waterways on the North American continent. Not surprisingly, *Mytilopsis* has already established in various Asian ports including Japan, Taiwan, Hong Kong, Thailand, Fiji, Darwin, and India. In Singapore, *Mytilopsis* occurs together with native byssate bivalves *Isognomon ephippium* and *Musculista senhausia*, which are common in mangroves but have found the monsoon canals to be suitable habitats as well. It is interesting to note, however, that *Mytilopsis* is rare in the mangroves, and it remains to be seen if this bivalve can be classified as "invasive" as defined in this review. The other exotic bivalve is the Indian mussel *Brachidontes striatulus*, which, although not as widespread as *Mytilopsis*, is also found in monsoon canals (Morton & Tan, unpublished). It is quite likely that the two bivalves have traveled to Singapore either as adults attached to ships' hulls, or as larvae in ballast water.

Discussion

Thus far most of the introduced species in Singapore are from freshwater and terrestrial habitats (Ng et al., 1993, Corlett, 1988), and by comparison, little is known about the alien species in the marine environment. Similarly, the taxonomy of many groups of native organisms, particularly the marine algae, plankton, and invertebrates, remain problematic and poorly documented. It is evident that this incomplete knowledge of native flora and fauna has impeded the positive identification of alien species. This is a major hurdle for Southeast Asian countries in general, where inherent biological diversity is extremely high but taxonomic expertise is either highly inadequate or lacking. Furthermore, the available literature pertains only to the history and listing of alien species of plants and animals, but does not address the ecological impacts of these aggressive invaders on native species.

Not all alien species that have become adapted to or naturalized in Singapore are invasive in character, threatening the survival of local counterparts. Cursory observations suggest that a great majority cannot even survive without human intervention. Of the more than 2,000 introduced plant species grown in Singapore, about 136 species have become naturalized on their own capability (Corlett, 1988). Only a small fraction of these, such as California maidenhair *Adiatum latifolium*, Koster's curse *Clidemia hirta*, Africa tulip tree *Spathodea campanulata*, heathgrass *Dioscorea sansibarensis*, and blue trumpet vine *Thunbergia grandiflora*, have been reported to actually invade the primary and old secondary forests, and/or inhibit the regeneration of secondary forest (Turner & Tan, 1992). The explanation has been attributed to the fact that many of the introduced species are sun-loving plants and require a nutrient rich soil for their establishment and expansion. Apparently, in Singapore many local forest plant species have evolved over the millennia to become well adapted to the closed tropical forest condition and, therefore, are resistant to foreign aggression as long as the remaining forest or original vegetation is not disturbed further by human activities (Teo et al., 2003). In other words, it would appear that the continuous human disturbance facilitates the local spread of invasive alien plant species.

Interestingly, Ng et al. (1993) came to the same conclusion in their assessment of the invasiveness of introduced freshwater fishes and prawns that have entered the country through the aquarium trade in recent years. According to them, these introduced species have not significantly affected the fauna in pristine forested streams. Of a total of 58 alien fish species known to occur in Singapore, about 22 of these have established populations in Singapore. The likely reason for the limited impact of these alien species lies in the fact that more than 80% of the native species are forest species. The native species are adapted to living in acid water that is characteristic of the streams found inside the remaining forests, whereas the introduced species are believed to prefer more neutral and harder waters. In fact, their study showed that more than 50% of the native fauna have become extinct today due to forest clearance.

The poor performance of invasive plant and animal species at present in Singapore does not mean that serious cases of invasive weeds and pests will not occur in the future. Perpetual alertness and constant monitoring are needed to prevent the problem from becoming an environmental crisis. This is particularly relevant in the case of micro organisms, which has direct relevance for ballast water management.

Fortunately or unfortunately because of the non-existence of serious invasion of alien species on the island, the government of Singapore has taken a light attitude in managing this potential ecological problem. As a signatory of the Convention on International Trade in Endangered Speceis of Fauna and Flora (CITES), the government has concentrated its effort on the implementation of the treaty by controlling the illegal trading of plant and animal species listed as endangered and prohibited under the CITES regulatory programme. Likewise, with the decrease of agricultural activities in the country, the

government has relaxed its monitoring of the introduction of the many officially listed crop plant diseases and soil nematodes.

Government agencies

Currently, there are four government agencies tasked with the function of monitoring the movement of alien species, namely, the Agri-food and Veterinary Authority of Singapore (AVA), the National Parks Board (NParks), the Maritime and Port Authority of Singapore (MPA), and the recently formed National Environment Agency (NEA). As the names of these offices imply, each is given the responsibility to monitor the alien species in a defined and separated area, such as the agriculture and food sector, forest and park administration, and other types of environment management. There is a lack of comprehensive legislature governing the introduction of "friendly" alien species and the prevention of "harmful" species. Likewise, there is no single umbrella office to oversee and coordinate the various offices should there be a need at the national level to confront a developing environmental crisis due to the outbreak aggression of an invasive plant or animal species.

Acknowledgements

We are grateful to many colleagues in the National University of Singapore who have kindly provided valuable information regarding the situation of IAS in Singapore. In particular, we thank Drs. P. Ng, H.T.W. Tan, N. Sodhi, and Mr. K.K.P. Lim for providing pertinent information with regards to alien species. We also wish to express our sincere appreciation to Drs. L. Chan, I. M. Turner, Ms. P.T. Chew and R. Chou for their valuable input towards the preparation of this paper. We thank the Office of Environmental Policy and Planning, Ministry of Science, Technology and Environment of the government of Thailand, Thailand Biodiversity Centre, the Global Invasive Programme, and the U.S. government for providing the financial support to enable us to attend the workshop in Bangkok.

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Appendix 1. List of established alien species in Singapore*

Scientific name	Common name	Family	Origin
I. PLANTS			
Ferns			
Adiatum latifolium		Adiantaceae	tropical America
Pityrogramma calomelanos	silver fern	Pteridaceae	America
Salvinia molesta	water spangle	Salviniaceae	tropical America
Angiosperms			
Acacia auriculiformis		Leguminosae	Australia/ PNG
Albizia falcataria		Leguminosae	Moluccas
Mimosa pigra		Leguminosae	South America
Eichhornia crassipes	water hyacinth	Pontederiaceae	tropical America
Lantana camara	lantana	Verbenaceae	tropical America
Manihot glaziovii	tapioca	Euphorbiacease	tropical America
Mikania micrantha		Asteraceae	tropical America
Peperomia pellucida		Piperaceae	tropical America
Pilea microphylla		Urticaceae	tropical America
Dioscorea sansibarensis		Dioscoreaceae	Africa
Spathodea campanulata		Bignoniaceae	Africa
Thunbergia grandiflora		Acanthaceae	SE Asia
Wikstroemia ridleyi		Thymeliaceae	Asia
Clidemia hirta		Melastomaceae	tropical America
II. ANIMALS			
Mollusca: Gastropoda			
Pomacea canaliculata	apple snail	Ampullariidae	South America
Taia polyzonata		Viviparidae	Thailand?
Achatina fulica	giant African snail	Achatinidae	Africa
Mollusca: Bivalvia			
Pseudodon vondembuschianus		Unionidae	Indonesia
Brachidontes striatulus		Mytilidae	Bay of Bengal
Mytilopsis sallei		Dreissenidae	Central America, Caribbean
Arthropoda: Crustacea			
Macrobrachium lanchesteri	riceland prawn	Palaemonidae	Thailand
Macrobrachium nipponense	Japanese freshwater prawn	Palaemonidae	East Asia
Cherax quadricarinatus	red-clawed crayfish	Parastacidae	Australia
Teleostei			
Rasbora borapetensis	red-tailed rasbora	Cyprinidae	Thailand
Esomus metallicus	Siamese flying barb	Cyprinidae	Thailand
Puntius binotatus	two-spotted barb	Cyprinidae	Southeast Asia
Puntius partipentazona	Malayan tiger barb	Cyprinidae	Thailand, West Malaysia
Puntius tetrazona	Sumatran tiger barb	Cyprinidae	Sumatra
Puntius semifasciolatus	green barb	Cyprinidae	China
Liposarcus pardalis	armoured sucking catfish	Loricariidae	South America
Poecilia reticulata	guppy	Poeciliidae	South America
Poecilia sphenops	green molly	Poeciliidae	Central America
Gambusia affinis	mosquito fish	Poeciliidae	Eastern USA
Oxyeleotris marmorata	marbled goby, soon hock	Eleotridae	Southeast Asia

Rhinogobius giurinus	pond goby	Gobiidae	China
Channa micropeltes	toman, giant snakehead	Channidae	Southeast Asia
Parambassis siamensis	glass perch	Chandidae	Thailand and West Malaysia
Oreochromis mossambicus	tilapia	Cichlidae	East Africa
Tilapia buttikoferi	hornet tilapia	Cichlidae	Africa
Cichla ocellaris	peacock bass	Cichlidae	South America
Cichlasoma urophthalmus	cichlid	Cichlidae	Central America
Nandopsis managuense	jaguar cichlid	Cichlidae	Central America
Nandopsis festae	red devil	Cichlidae	Central America
Veija synspillum	cichlid	Cichlidae	Central America
Etroplus suratensis	green chromide	Cichlidae	India, Sri Lanka
Amphibia			
Kaloula pulchra	painted bullfrog	Microhylidae	Indochina,Thailand
Reptilia			
Trachemys scripta elegans	red-eared slider, terrapin	Emydidae	USA
Xenochrophis vittatus	striped keelback	Colubridae	Sumatra and Java
Calotes versicolor	changeable lizard	Agamidae	India, Indochina
Aves			
Dendrocygna arcuata	wandering whistling-duck	Dendrocygnidae	Philippines to east
Eos bornea	red lory	Psittacidae	South Maluku
Cacatua sulphurea	yellow-crested cockatoo	Psittacidae	Eastern Indonesia
Cacatua goffini	Tanimbar cockatoo	Psittacidae	Tanimbar Id, Indonesia
Psittacula krameri	rose-ringed parakeet	Psittacidae	Africa to Myanmar
Psittacula alexandri	red-breasted parakeet	Psittacidae	India, Myanmar, Indochina
Columba livia Gmelin	rock pigeon	Columbidae	Eurasia?
Streptopelia tranquebarica	red-collared dove	Columbidae	South Asia
Threskiornis melanocephalus	black-headed ibis	Threskiornithidae	Pakistan to Thailand
Corvus splendens	house crow	Corvidae	Iran to Thailand
Sturnus melanopterus	black-winged starling	Sturnidae	Java to Lombok
Acridotheres javanicus	Javan myna	Sturnidae	Java to Sulawesi
Acridotheres cristatellus	crested myna	Sturnidae	S China to Myanmar
Pycnonotus jocosus	red-whiskered bulbul	Pycnonotidae	S China, India to SE Asia
Zosterops palpebrosus	oriental white-eye	Zosteropidae	W to SE Asia
Garrulax leucolophus	white-crested laughing thrush	Sylviidae	N India to SW China
Garrulax canorus	hwa-mei	Sylviidae	S China to Indochina
Passer domesticus	house sparrow	Passeridae	Europe to Asia
Lonchura leucogastroides	Javan munia	Passeridae	Sumatra to Lombok
Padda oryzivora	Java sparrow	Passeridae	Java, Bali

*principally compiled from Corlett (1988) (plants), Ng et al. (1993) (freshwater animals), Lever (1996) (fishes) and Lim & Gardner (1997) (birds). The geographic distribution of bird species follows Sibley & Monroe (1990).

2.2.3 Panel presentations: regional and international organisations

The role of the International Plant Protection Convention in the prevention and management of invasive alien species

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Introduction

The International Plant Protection Convention (IPPC) is a multilateral treaty deposited with the Director-General of the Food and Agriculture Organization (FAO) administered through the IPPC Secretariat, located in FAO's Plant Protection Service. One hundred and seventeen (117) governments are currently contracting parties to the IPPC, including all countries in South and South-East Asia.

The purpose of the IPPC is to secure common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote measures for their control. The Convention provides a framework and forum for international cooperation, harmonization and technical exchange in collaboration with regional and national plant protection organisations (RPPOs and NPPOs). The IPPC is the organization recognised by the World Trade Organization (WTO) in the Agreement on the Application of Sanitary and Phytosanitary Measures (the WTO-SPS Agreement) as the international standard setting body for International Standards for Phytosanitary Measures (ISPMs).

International Plant Protection Convention and IAS

Amendments to the Convention were unanimously adopted by the FAO Conference in November 1997. Forty-four contracting parties have accepted or adhered to the New Revised Text of the IPPC. This revision updates the Convention and reflects the role of the IPPC in relation to the WTO-SPS Agreement- primarily the institutional arrangements for international phytosanitary standard setting.

The New Revised Text of the IPPC provides, among others, for the establishment of a Commission on Phytosanitary Measures that will serve as the global agreement's new governing body. The members of the Commission are the contracting parties to the Convention and are the governing body as established in the New Revised Text of the IPPC. An Interim Commission on Phytosanitary Measures (ICPM) has been established by the Conference as an interim measure until the New Revised Text comes into force.

At its Third Session in April 2001, the ICPM clarified the role of the IPPC regarding its relationship to the Convention on Biological Diversity (CBD), including the relationship between IAS and quarantine pests and the role of the IPPC regarding IAS. It was noted that the IPPC provides for rights and obligations, and has established standards and procedures that are designed to prevent the introduction and spread of pests of plants and plant products, which include IAS.

The ICPM confirmed that the implementation of the IPPC (both the Convention and standards) is directly relevant to the implementation of Article 8(h) and other relevant articles and activities of the CBD, and noted many areas of overlap with the CBD's Guiding Principles on IAS. The need for

harmonization and collaboration was emphasized by the ICPM, noting in particular problems with terminology and operational issues associated with implementation. In addition, a number of areas for possible joint activities were identified with a view to providing relevant inputs into standard setting.

Challenges

Some key challenges for prevention and management of IAS in the Asian region include:

- The region is mostly tropical and sub-tropical, with expansive, diverse and delicate ecosystems;
- South and Southeast Asia has many land borders which are difficult to control;
- Tourism and trade are intense and extremely important for the economies of the region;
- The region is composed of many developing countries with severely limited resources;
- IAS issues are not fully integrated or well coordinated by government authorities; and
- There is strong industry competition for land use.

Opportunities

Some key advantages in the area of plant health are:

- Phytosanitary authorities are generally well-developed and competent;
- Existence of active regional plant protection organization (APPPC);
- Some legislation and regulations are already in place;
- Strong support for harmonization; and
- History of successful regional cooperation.

Phytosanitary officials representing their governments in the ICPM recognised that concepts and initiatives associated with the CBD generally fell within the range of responsibilities of ministries of the environment or similar agencies. They also noted that collaboration on biodiversity issues under the CBD was generally weak or lacking because national plant protection organisations are usually the responsibility of ministries of agriculture. On the other hand, it is increasingly clear that phytosanitary officials will play a key role in implementation of the CBD, in particular regarding the exclusion of IAS. This recognises the need for increased collaboration and harmonization between agriculture and biodiversity concerns at the national, regional, and international levels.

At national level, the greatest need is for establishing and/or strengthening communications between relevant authorities to ensure consistent national understanding and action. In many countries the approach has involved the formation of a council, committee, or board composed of high-level officials from relevant government ministries. The main purpose of these bodies is to review and decide on overlapping issues as well as to clarify responsibilities and manage resources.

At regional level, there is tremendous potential for the sharing of resources, information, and approaches for the prevention and management of IAS. Throughout its 50-year history, the IPPC has benefited greatly from the support of regional plant protection organisations. In the case of IAS, and in particular where developing countries are concerned, there are many potential benefits to regional approaches. An important factor to consider is that IAS are a threat to species, habitats and ecosystems that are quite often regional rather than national. Regional agreement and cooperation between countries on the approach and activities for managing IAS threats is therefore both logical and practical to the extent that differences in political agendas, authority, and the availability of resources can be overcome.

The way forward

Overall, the region is in a good position to demonstrate the potential benefits of holistic IPPC-CBD approaches to IAS issues at the national and regional level. However, political commitment will be an essential element for success. At the international level, the lack of communication and understanding between authorities noted at national level is multiplied. Secretariats may agree to communicate and collaborate, but have only limited effectiveness without the understanding and support of member governments. It is essential that countries have a clear understanding and consistent positions that represent their entire government – not only their sector, discipline, or ministry. This is especially important with operational and regulatory issues that may have significant impacts in areas beyond the protection of biodiversity (e.g. trade, social welfare).

Another important aspect of international harmonisation involves the exchange of information, especially official information from governments. The subject of IAS is surrounded by a great diversity of information found in various forms, formats and locations. Likewise, there are also large information gaps. There is a general tendency is to promote the creation and maintenance of databases and other information repositories on the Internet. Such initiatives can require significant effort and resources to be effective. Unfortunately, many information exchange mechanisms fall short of desired objectives, mainly because they become unsustainable. The main cause of this is the 'piecemeal' nature of the information sources and the lack of harmonization in approaches and mechanisms. Internationally harmonized initiatives are desperately needed to create frameworks for information exchange based on a common understanding of the needs and approach. As initiatives on IAS move from conceptual and scientific discussions and towards implementation, there is also an increasing need to complement the biological information with official information from governments who are setting policies and formulating regulations that may affect their neighbors and trading partners.

Conclusions

In summary, it is clear that there is an important role for the IPPC where IAS involve threats to plant health and life. Although the implementation of the IPPC has historically focused on the protection of agriculture, the scope of the Convention is not limited in this respect. Governments are becomingly increasingly aware of the relationship of the IPPC to IAS and the opportunities to leverage the IPPC on IAS issues. The IPPC has 50 years experience with the implementation and harmonization of initiatives for the prevention and management of plant pests, including IAS species, which can be highly beneficial to dealing with these species. It is important to take advantage of this experience and existing national, regional and international structures for harmonization and implementation and IPPC's position as an international standard setting organization recognised by the WTO. The region of South and Southeast Asia enjoys many advantages, but is also faced with many challenges in the prevention and management of IAS. The national, regional, and international resources associated with the IPPC provide significant opportunities for realizing synergies and promoting effective prevention and management as regards the protection of plant health.

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Ms Pipthvanichtham presented a paper, but this was not provided in written form to the editors.

South Asia Cooperative Environment Programme and approaches to dealing with invasive alien species

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Introduction

The South Asia Cooperative Environment Programme (SACEP), established in 1982, is an inter-governmental programme of eight governments of South Asia (Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka – see Figure below). Its mandate is to promote and support protection, management and enhancement of the environment in the South Asian region. Since its inception, SACEP has promoted sustainable development in the region by implementing a number of projects and programmes in the fields of environmental education, environmental legislation, biodiversity, air pollution, and the protection and management of the coastal environment with the assistance of various bilateral and multilateral funding agencies such as United Nations Environmental Programme (UNEP) and International Maritime Organisation (IMO).

The designation of SACEP as the Secretariat for implementating the South Asian Seas Programme in 1983, by its five Maritime Member States, further enhanced the role of SACEP as the Central Agency for Environmental Management Activities in the South Asian Region. Under this programme, an Action Plan for the Protection and Management of the Marine Environment and the related Coastal Ecosystems of the South Asian Seas Region was adopted in 1995. Another highlight in SACEPs existence is the adoption of the Malé Declaration by its member states and Iran in 1998, which encourages intergovernmental cooperation to address the increasing threat of transboundary air pollution and its impacts.

Priority issues in spread of IAS in South Asia

The major reason for the spread of IAS within South Asia is the deliberate introduction of species to meet the ever-increasing demand from the growing human population, especially regarding:

- Food security
- Fuel needs
- Nutritional needs
- Reversing severe deforestation
- Need to develop aquaculture and cash crops.

Trees such as *Acacia* and *Eucalyptus* have been introduced to alleviate shortages of timber and fuelwood, while food fish species such as *Tilapia* have been introduced to supply the much needed animal protein component of the human diet. Lack of understanding of the functioning of ecosystems, a lack of information on life histories of the species introduced, and inadequate dissemination of the lessons learned from introductions of IAS in other parts of the world has led to the introduction of these species without consideration of the associated risks. By all accounts, the frequency of harmful introductions of alien species appears to be increasing and impacting more of South Asia. However,

threats posed by IAS are often go 'unseen,' as governments of the region have other serious problems that require more immediate solutions.

The main obstacles faced by the South Asian countries in management of IAS include:

- Lack of political commitment and inter-agency co-ordination;
- Weak institutions, national laws and their enforcement;
- Lack of financial resources;
- Inadequate capacity for risk assessment, environmental impact assessments;
- Weak monitoring and mitigatory mechanisms.

The role of the South Asia Co-operative Environment Programme

The presentations by speakers from the member countries of SACEP at this regional workshop will undoubtedly highlight the importance of IAS in agriculture, environment, veterinary, and human health. The programme of work carried out thus far has dealt with cross-cuttting issues of environmental degradation, especially of marine ecosystems, which are so vital to the economies of many of the members of SACEP. As pointed out in the overviews to global and regional scenarios on IAS at this meeting, there is a need for action at a regional level, and SACEP can play an important role.

The following ongoing programmes of SACEP can be used to promote awareness, research, monitoring, and reporting of IAS within South Asia:

- Environmental Education programme– awareness building;
- South Asian Seas Action Plan– ballast water programme;
- Environmental Legislation Programme– identification of gaps and introduction of new legislation;
- Assessment of Faunal & Floral Biodiversity– identification of alien species and their impacts;
- State of the Environment Reporting for South Asia– annual reporting of the state of the environment of the member countries, which is a key document to be used in policy formulation and programme development.

The development of a clearing-house mechanism to share information and to develop networks is a high priority for consideration as a future activity of SACEP. This could facilitate development of a database on IAS within the region and thus raise awareness of the magnitude of the IAS problem.

SACEP, being an intergovernmental organization, can play a pivotal role in bringing together policy and other decision makers from the sectoral agencies of its member countries. It can also assist in leveraging donor support for regional programmes on IAS, while at the same time informing global platforms of the region's status, trends, and measures to address IAS.

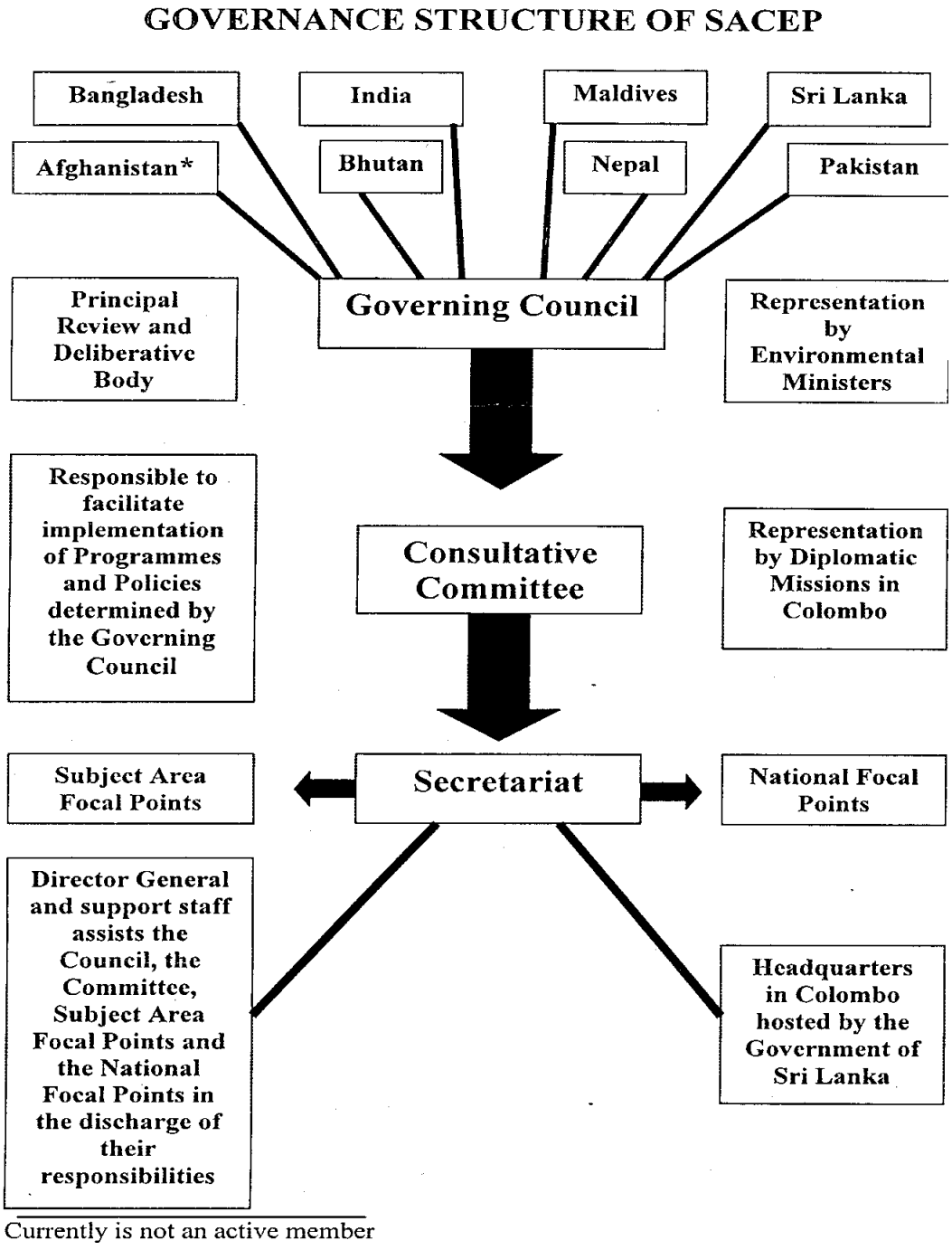

Figure 1. The governance of SACEP.

CAB International: its activities related to invasive alien species in South and Southeast Asia

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Introduction

CAB International (CABI) is an intergovernmental, not-for-profit organisation established by a treaty-level agreement among its 41 member countries. It seeks to help improve human welfare worldwide through the dissemination, application, and generation of knowledge, with emphasis on agriculture, forestry, human health, and the management of natural resources, and with particular attention to the needs of developing countries. It has its headquarters in Wallingford, United Kingdom, and an international network of centres.

CABI's publishing programme[32] is broad-based in terms of product type, and has a focus on the applied life sciences. Product areas include:

- Bibliographic databases delivered on the Internet, CD-ROM, and in print
- Primary journals delivered on the Internet and in print
- Books and related products, including the Topics in International Health CD-ROM series developed with the Wellcome Trust
- Compendia developed in collaboration with partners in government, industry and development
- Internet Knowledge Communities

CABI Bioscience[33] operates from CABI Centres in the UK, Switzerland, Malaysia, Pakistan, Kenya, and Trinidad and Tobago. CABI Bioscience's unique multidisciplinary scientific capability, and its links with CABI Publishing, position it ideally for tackling some of the world's most challenging problems in agricultural sustainability and biological diversity. CABI Bioscience has mutually productive partnerships with many global organisations, agencies, foundations and corporations. By working together the complementary capabilities are combined to create a potent scientific force in support of sustainable development.

The CABI Information for Development Programme is an interdivisional programme providing information in applied life sciences. It supports programmes to design, build and sustain information and knowledge management systems in developing countries, as well as participates in access to research information initiatives.

[32] www.cabi-publishing.org
[33] www.cabi-bioscience.org

CABI activities relevant to invasive alien species in South and Southeast Asia

Many of the projects of CABI have been on biological control of introduced pests. A list of invasive plants that have associated biological control programmes includes:

- Water fern (*Salvinia molesta*) in Malaysia (funded by Australian Centre for International Agricultural Research, ACIAR);
- Bittervine (*Mikania micrantha*) in Malaysia (funded by Malaysian Oil Palm Growers' Council; MOPGC) and in Indonesia through the Partnership Facility funding;
- Siam weed (*Chromolaena odorata*) in Malaysia;
- False ragweed (*Parthenium hysterosporus*) in India; and
- Itch grass (*Rottboellia cochinchinensis*) in Thailand.

Ongoing activities in South and Southeast Asia on invasive plants are:

- Giant senstive plant (*Mimosa pigra*) in Malaysia (monitoring on biocontrol agents);
- Water hyacinth (*Eichhornia crassipes*) in Malasia (monitoring biocontrol agents);
- Itch grass (*Rottboellia cochinchinensis*) in Malaysia (with Universiti Putra Malaysia); and
- Bittervine (*Mikania micrantha*) in India (UK Department for International Development).

CABI is at present formulating regional projects in management of these and other invasive plants in South and Southeast Asia. They are: concept notes developed for projects to control *Mikania micrantha* in Indonesia, Malaysia, China, India, Philippines, and Papua New Guinea; exchange of ideas on control of *R. cochinchinensis* in Indonesia, Malaysia, Philippines, and Thailand; and Siam weed (*Chromolaena odorata*) and *Austropatorium inulaefoium* in Indonesia and Malaysia.

Work is also underway to manage invasive insects, mostly using parasitoids (biocontrol agents). Completed projects include:

- Control of leaf miners in Indonesia, Malaysia, and Vietnam
- Diamond back moth control (*Plutella xylostella*) in the Philippines, Bangladesh, Laos, Indonesia, and Vietnam (Asian Development Bank, UN FAO, and others).

Ongoing insect projects include:

- Diamond back month control in Democratic Peoples Republic of Korea (funding from Swiss Development Corporation) and Vietnam (FAO)
- Beet armyworm (*Spodoptera exigua*) in Malaysia (funding from Ministry of Science, Technology and the Environment)

CABI's future programme of work includes a regional project on management of newly-introduced invasive insects (mites, whiteflies, leaf miners) in Southeast Asia, which is still at a concept stage.

In 2001, CABI Bioscience organised India's first national conference on the management of IAS, which brought together a wide range of technical experts from forestry, agriculture, and freshwater systems as well as experts from Indian agencies responsible for prevention and management of IAS. This important event helped to identify priorities for action. CABI will provide assistance in some of them. India is at present taking steps to increase its responses to IAS such as formulating a national action plan for prevention and management of IAS.

Southeast Asia has been plagued by severe infestations of whiteflies, as well the appearance of new alien species. A CABI Bioscience regional training course on whitefly identification and biology and ecology of whitefly pests of agricultural importance brought together participants from Southeast Asian countries to build in-country capacity on whitefly taxonomy.

CABI-GISP synergy

CABI Bioscience is a partner of the Global Invasive Speceis Programme (GISP), and in a collaborative effort, CABI Bioscience produced the *Toolkit for Prevention and Management of Invasive Alien Species* (Wittenberg & Cock, 2001). CABI also carried out a review of the efficiency and efficacy of existing measures for prevention, early detection, eradication, and control of IAS and their impacts for the SBSTTA 6 meeting of the Convention on Biological Diversity (CBD) in 2002, and has worked with other partners to develop GISP's second phase of work.

CABI's wider contribution to invasive alien species issues

CABI contributes to the resolution of IAS problems and pest management in general in three ways:

- Provision and management of information related to IAS (research, surveys of IAS and their impacts, needs assessments, risk analysis, databases, compendia, journals, internet knowledge community such as ICMFocus.com);

- Capacity building (taxonomic services, training, formulation of management tactics, supporting policy and institutional frameworks, supporting national and regional programmes and actions;

- Specific services such as third-country quarantine for biological control agents of IAS (UK-Bioscience Centre, CABI-Southeast Asian Regional Centre in collaboration with Malaysian post entry quarantine facilities).

CABI is carrying out research and development on a number of fronts in environmentally friendly agricultural production, including integrated pest management, rational pesticide use, and biopesticides. It supports the larger cause of biodiversity conservation through award winning research into cryo-preservation protocols for micro-organisms, conservation of endangered insects in the United Kingdom, and investigating impacts of climate change on ecosystems.

Reference

Wittenberg, R. & M.J.W. Cock (eds). 2001. Invasive alien species: a toolkit of best prevention and management practices. CAB International, Wallingford, Oxon, UK.

2.3 Summary of working group discussions

The second day of the workshop commenced with an introduction by the chair of the session to the composition and functions of working groups on regional cooperation. Participants were then divided into two groups according to island (insular) or continental South and Southeast Asia setting, each addressing the same set of questions developed by the workshop Steering Committee (listed below). Each working group had a chairperson for the session (selected by the members), a rapporteur, a note-taker, and supporting technical experts. The set of questions discussed in the first morning session were:

- *What do we want the region to achieve collectively?*
- *What are the challenges to achieving regional cooperation?*
- *What are the necessary elements for a strategy to facilitate regional cooperation?*

In the afternoon session, participants addressed the following questions:

- *How can we promote collaboration/cooperation within existing frameworks?*
- *What are the existing resources that can be utilized to achieve regional cooperation?*
- *What additional resources are needed?*
- *Who needs to be involved, when, and where?*

The account provided below is a synthesis of the discussions from both working groups (see Appendix 3.4 for working group membership), listed by questions and the responses. Significant differences of opinions on the topics under discussion between the two working groups are indicated.

Morning session

A. What do we want the region to achieve collectively?

The common goal of collective action by the region was to better prevent and manage IAS. There was consensus that IAS are a problem: the scale of the problem varies between countries, but even relatively unaffected countries recognised the potential threats posed by IAS, especially to countries dependent on agricultural crops and/or livestock, whether native or alien. All countries participating in the workshop appeared to face the same set of problems in combating IAS, albeit at different levels. Participants identified several key areas which would benefit from greater regional cooperation leading towards achieving the regional goals. Working group 1 voiced significant concern about the introduction of alien biological control agents and the safety of these control methods, as well as the methods used for monitoring of them. Members of working group 2 engaged in considerable discussion on whether or not to keep the South and Southeast regions together to formulate a single regional forum, strategy, and its attendant mechanisms. Agreement was not reached on this matter, and it was decided that this decision should be left to a later forum which could devote greater attention to this topic.

Seven key regional objectives were identified:

⇒ ***Set up a regional forum for the development of a regional strategy that emphasizes prevention and management of IAS***

Regional action needs a dual focus: a) limit the entry of IAS to the region and b) for IAS already present, limit their spread and share information on how to deal with the problem. See objectives below for related proposed actions that have relevance to the above.

⇒ ***Greater integration of national and regional approaches***

- The region needs to formulate national, sub-regional and regional strategies and action plans that are co-ordinated and mutually supportive of one another, as well as to recognise the different values and perspectives of each country. Biological invasions are very complex issues where some invaders may be viewed as beneficial by some stakeholders. Such conflicting views need to be resolved as much as possible through consultation to ensure greater co-operation within and between countries.

- National strategies and action plans should take into account the insidious and pervasive threat posed by IAS, and the importance of biogeographical rather than political boundaries in the spread of IAS.

⇒ ***Agreement on common terminology and lists of major IAS, and an understanding of IAS issues to provide a common basis for discussion and actions***

- The region needs to clarify and agree on common definitions of terms (specifically terms such as agricultural pests). There was agreement that terms should (as appropriate) cover both economic and environmental aspects. A glossary of key terms could be developed cooperatively. See also answers to question two below.

- Adopt a system of classification of alien biocontrol agents.

⇒ ***Harmonisation of legal instruments at national, sub-regional and regional levels***

- National legal frameworks should undergo sectoral review for harmonisation and for filling gaps to cover the full range of IAS as pests with environmental impacts, such as threatening native biodiversity, and not only as agricultural, medical or veterinary pests.

- Take steps to harmonise national frameworks with regional concerns, such as through development of a master list (a "negative"/"black" list) of IAS at the regional or sub-regional level for national guidance (see also below objective on capacity building).

- Harmonisation of plant quarantine protocols within the region.

⇒ ***Effective sharing of information at national and regional levels***

- National clearing house mechanisms (CHMs) can play a key role in bringing together organisations that have different types of data collection systems and different kinds of data. They can also acquire more information on IAS with environmental impacts which are urgently needed for use at a regional level.

- A regional IAS information exchange mechanism to enable national information to be shared regionally and promote development of appropriate approaches for common problems. More efficient use could be made of neighbouring country's databases and regional/international technical expertise. Most countries suffer from IAS due to lack of information, but in some cases, it may not be the best use of resources and time to concentrate on primary research or build new national databases.

- An operational regional database that addresses environmental, agricultural and social aspects of IAS to be perhaps maintained by a global programme such as GISP.

- Strengthen or establish Asia wide networks that provide technical support from IAS management specialists and authorities in public health, quarantine, and other agencies; maximize the lessons learned and exchange experiences from national to regional levels and *vice versa.*

⇒ ***Capacity building and greater use of available expertise***

Asian countries are at very different stages of development and some will require more resources and capacity building than others:

- The taxonomic impediment is a serious issue that needs to be addressed on a priority basis. Regional networks of taxonomic specialists, such as ASEANET (as part of Bionet International), and programmes of Convention on Biological Diversity enhancing taxonomic capability could be enlisted in this issue.

- Awareness raising is critical to combat successfully the problem of IAS. The profile of IAS needs to be raised across stakeholders spanning different societies and across the region. Special attention should be paid to local communities that depend on subsistence agriculture.

- Enhanced ability to implement risk analysis procedures, early warning tools, and guidelines for the prevention and management of IAS.

Absence of clearing house mechanisms, technical specialists, weak or absent relevant data, and development of legislative frameworks, are addressed in actions set out under previous objectives.

⇒ ***Greater cooperation, especially for problems with a trans-boundary/regional dimension***

- Strengthen and establish structures and mechanisms for regional cooperation (see also regional objective below).

- At present there are virtually no opportunities for trans-boundary assessment and management of IAS. Three major areas were identified as suitable for regional/trans-boundary cooperation.

    - Measuring impacts - several countries noted that particularly for species with serious environmental impacts, there is often no available assessment/information on the possible (future) impacts. Assessment of the economic costs of at least major IAS should be undertaken on a region wide basis;

    - Engaging regional support for research to search for solutions and to obtain greater understanding of the vulnerability of ecosystems to invasions (why and how questions);

    - Implementing IAS management programmes.

    The appointment of national IAS Focal Points could facilitate ongoing regional cooperation after this workshop (see elements of a regional strategy section on Regional Statement and recommendations and in afternoon deliberations given below).

⇒ ***Cooperation to reduce movements of IAS between countries of the region***

This is linked to the above objective, but was considered separately as it merited special mention:

- Need for a common "protocol" or agreed approach to reduce trans-boundary movements of IAS. This should engage the key exporting partners. Such cooperation is particularly important for countries, such as the Maldives, which has growing sectors of tourism, shipping and fishing – all very important pathways of migration for IAS. Island states and states with islands need to address cooperatively the problem of controlling the inter-island movements and marine pathways of IAS.

- Common tools (e.g. harmonised plant quarantine procedures) are essential to reduce the spread of IAS among countries and between regions of the same country.

- Asian countries that are currently less affected by IAS problems need to support such approaches as part of a larger regional responsibility.

B. What are the challenges to achieving regional cooperation?

The challenges identified by the participants can be grouped into three major categories and are generally the same issues for which potential solutions have been suggested from national to regional levels in Question 1 above.

⇒ ***Lack of human resources and legal capacity, including:***

- Weak infrastructure and inadequate staff for adequate regional information exchange.

- Lack of expertise (especially in taxonomy) in technical aspects of IAS.

- Lack of data on the status, trends, and impact assessments of IAS, as well as the pathways of unintentional IAS introductions.

- Absence of national clearing house mechanisms.

- Inadequate laws and regulations and poor implementation of existing legal instruments and systems.

- Numerous gaps and inconsistencies *between sectors* (e.g. inconsistent approaches between trade-related and quarantine instruments) and *between national and sub-national laws and policies.* The latter is particularly problematic for States with islands, or peninsular territory, or with federal/decentralised governance systems.

⇒ ***Lack of financial resources to address problems adequately***

⇒ ***Challenge of maintaining longer-term interest on the topic***

The following political, institutional, economic, social and cultural factors influence the willingness of governments and others to address the IAS problems over the long run:

- Lack of awareness and information among the general public and policy makers, especially on the environmental and economic impacts of IAS.

- Lack of common definition and understanding of key terms that raises difficulties inter agency co-ordination and co-operation.

- Areas of difficulty of common definition include:

    - alien/native; there is a lack of baseline data about what is native, especially in the marine environment.

    - invasive ("harm" is often unquantified and subject to a range of interpretations).

    - use of "pest" terminology at the national level often takes little account of biodiversity, or fails to reflect the CBD's broader coverage of impacts on wild species, ecosystems, and genetic diversity.

- Lack of leadership and coordination between sectoral institutions. This challenge is often exacerbated by the territoriality of institutions that formulate and implement policy. It is both a problem within and between countries. It is particularly acute at the national level, but also important at the regional level. Key stakeholder groups need to be brought together to support and share the priorities of taking steps against IAS. Such groups should include industry and producer/importer/trade groups that depend on a particular crop, and often those who bring in IAS for economic benefit while others pay the price.

- Lack of commitment of policy makers. Nowhere are IAS adequately covered by national policies and too few governments have given them a high priority. There is poor connectivity between policy and implementation. This is partly due to lack of awareness. If the true costs of IAS in a given country were better known, this would greatly increase the level of priority accorded to it. More economic data is needed to generate this engagement and increase the high-level commitment as policy makers are generally unaccustomed to science-based policymaking.

- Different countries give the same issue different levels of priority. The importance of regional responsibility and collective action has to be reiterated frequently.

Note: the consequence of free trade policies was raised and recognised as being important, but there was no time to develop the discussion on this topic.

C. What are the necessary elements for a strategy to facilitate regional cooperation?

Seven core elements were identified.

⇒ ***Coordination enhancement: effective coordination at regional, sub-regional and national levels***

- Provide greater co-ordination between national institutions to permit consensus building on approaches to address the problems of IAS.

- Establish or strengthen IAS focal points at the national, sub-regional and regional levels.

- Define the roles of existing national and regional institutions and make effective use of existing institutional resources. This may require revisions of the roles of some institutions to accommodate IAS issues.

- Prioritise programme actions and identify lead agencies/actors at both national and regional levels.

- Establish regional coordination mechanisms that will obtain greater support from international institutions in responses to IAS.

⇒ ***Awareness education: increase of awareness and 'raising the profile' of IAS and its threat in the region***

Lack of awareness of IAS issues pervades through all sectors of society in Asia, except the small groups of technical specialists on IAS. Therefore, government, private sector, managers of natural resources, law enforcement officials, media, scientists, forestry, fisheries, agriculture, trade, tourism and environment sectors, NGOs, and local communities should all become the targets of awareness and education programmes. In this regard,

- National workshops, extension services, publicity campaigns, printed and electronic media should be used; marketing of problems and management of IAS are needed.

- Some countries in the region have had impressive gains in increasing computer literacy especially among its youth. Use of information technology and rIASing the levels of literacy should be made to maximize the awareness in any campaigns.

- The formal education sector (school curricula) and its tertiary counterparts are key partners in the production of future policy and decision makers. They should be encouraged to give greater importance to the topic of IAS at schools.

⇒ ***Support: formulation and implementation of a regional strategy on IAS***

- Obtain financial and technical support: funding sources including from the private sector and industries more likely to introduce IAS; support from international institutions including technical cooperation and extension work of government organisations.

- Establish regional experts groups to develop common definitions of IAS and address other technical aspects.

- Facilitate the development of tools for management of IAS, including common quarantine protocols applicable at national and regional levels.

- Facilitate the development of appropriate policies and legislation.

- Develop regional regulatory framework and harmonisation of legal instruments. In the context of definitions, there is a need to clarify "species" and address the issue of genetic variation at the infra-specific level. For example, a spider species in Japan has regional populations having different genetic characteristics. There is a risk of hybridisation if one population is introduced to other region with a different subspecies.

⇒ ***Information exchange through clearing house mechanisms: national and regional levels***

- Establish clearing house mechanisms at regional, sub-regional levels *as per* the model of the Convention on Biological Diversity alongside with the national focal points for greater effectiveness and speedier action.
- Establish networks for information exchange.
- Create regional database for pest risk analysis and assessment, as well as other national databases (see responses for Question A also).

⇒ ***Research: providing a sound scientific basis for national and regional actions***

- Conduct a regional assessment of status, trends and major threats, ecosystem impacts, economic impacts, etc.
- Apply latest research knowledge to understand the susceptibility of Asian ecosystems to invasions of IAS.

⇒ ***Building and strengthening the capacity for action***

- Develop human resources;
- Fulfill training needs at national and regional scales.
- Enhance intellectual capacity through education systems.
- Enable community participation.

⇒ ***Political commitment: appropriate policies, budgets, legislation and enforcement and longer term focus on IAS***

- Organise national workshops on IAS that brings together many stakeholders, including those from the local community level, as a way of obtaining joint political commitment.

See also responses to Questions A and B above.

Afternoon session

D. How can we promote collaboration/cooperation within existing frameworks?

National level

The organisations most commonly involved in the development of national strategies and action plans at the national level are include CBD focal points; Ministries of Environment, Agriculture, Forestry, Fisheries, Education, Trade, Tourism, and others; ministries/departments involved with customs, border control, and quarantine; and universities, research institutes, NGOs, and professional organisations.

⇒ ***Each country should hold national workshop or symposia to design the most appropriate mechanism for national needs and circumstances***

There was agreement on the need to avoid a prescriptive approach in the development of national frameworks. Some countries had experience in using national committees chaired by CBD focal points, while others had worked under the subject of environment facilitated by regional organisations. National mechanisms should be broad-based and inter-departmental to include all concerned regulatory bodies.

⇒ ***Establishment of a national technical and policy expert group to support the work of national coordinating committees and provide independent expertise***

Regional level

⇒ ***Sub-regional approach to be adopted in developing further cooperation/ collaborative work***

⇒ ***Inter-regional and sub-regional cooperation was also emphasised***

Working group 1 discussed in detail whether IAS cooperation should be developed primarily at the regional level or at the sub-regional level (South/Southeast Asia). There was broad support for a sub-regional approach, for several reasons:

- *Practicality*: environment/biodiversity institutions for the two sub-regions, South and Southeast Asia, are already in place - but there may be a need to create an equivalent of ASEAN's ARCBC for the SAARC subregion.

- *Biogeography*: the sub-region has evolved itself through geologic time into sharing a similar flora and fauna.

- *Trade relationships*: the sub-regions have rather different trade partnerships and transport pathways. ASEAN is closer to the South Pacific. In addition, there are much greater trade volumes within ASEAN+ China, Japan and Korea than between South Asia and ASEAN countries. South Asia has closer links to Central Asia and possibly to parts of Africa, including the South Asian Developing Country bloc.

In contrast, Working Group 2 considered a list of major organisations ranging from national, sub-regional to regional which can be meaningfully involved in supporting IAS issues within their existing programmes of work (see Appendix 3.1).

E. What existing resources can be utilized to achieve regional cooperation?

Participants identified a series of institutions, programmes, and mechanisms that can contribute to regional cooperation. As some IAS issues are pandemic, they noted that it is important to engage other potentially-affected regions in information sharing. A list of relevant organizations can be found in Appendix 1. The following points were made:

- At the national level each country can provide its own human resources, its already available information, its experiences of managing the IAS, and in addition, its NGO network and resources, etc.

- Regional and sub-regional organisations can provide technical support, access to data bases, and political support for the formulation of policy, including legal and institutional arrangements.

- Multi-lateral and bi-lateral funding organisations active in the region can support regional and sub-regional cooperation.

- Donors need to be kept informed of the conclusions of meetings such as this and of the importance of IAS at national level.

- Mechanisms for region-to-region links need to be explored.

- Global organisations and conventions can contribute to regional activities and provide links to other regions and activities at the global level, including through thematic work programmes.

- Multi-lateral environmental treaties can help by bringing about consistency and harmonisation of approaches to address IAS.

- Consideration should be given to incorporating IAS elements into:

    - Existing conventions (decisions, recommendations, and programmes of work at national, regional levels, etc.).

    - International mechanisms and processes (e.g. standard-setting).

    - International certification schemes (e.g. possible incorporation of IAS elements into forest certification schemes, links to International Tropical Timber Organisation).

- Non-institutional resources such as those listed below can be utilized:

    - Compile resource directory of IAS experts, available guidance, manuals and training programmes of IAS in the region.

    - Identify and make better use of existing regional expert groups that deal with specific aspects of IAS. Better known groups seem to be limited to plant health (within APPPC) and animal health (linked to OIE).

    - Actively engage existing industry/trade/producer groups that are commercially involved in IAS (agricultural commodities, ornamental fish, tourism, transport etc) and make sure that they may be able to contribute their practical expertise and financial resources.

F. What additional resources are needed?

Four key needs were identified:

- Human resource development (HRD), especially in taxonomy.
- HRD in information technology.
- Specific IAS-related programmes to be developed within existing regional institutions (specifically ASEAN and SAARC).
- As a priority, these should provide for regional and sub-regional assessments of IAS problems, their pathways of introduction and monitoring.
- A regional steering committee/mechanism to co-ordinate and integrate the elements of a regional strategy on IAS and all the participating countries.

The FAO was mentioned as a possible nodal agency for regional coordination (see below for more detail on this topic). The FAO fits the requirement of a regionally active and a United Nations Organization whose mandate (agriculture, forests and fisheries, but not all aspects of the environment) covers nearly 50% of IAS information at present.

G. Who needs to be involved, when and where?

- Establish a Steering committee made up of all national government ministries (eight SAARC countries and 10 ASEAN countries). The steering committee could also be at the sub-regional level as suggested by working group 1 and make use of existing structure such as the ASEAN and SAARC. ASEAN has a high-level body called ASEAN Senior Officials on the Environment (ASOEN) that could be invited to address IAS issues as they affect the sub-region.
- Create a technical committee consisting of specialists/experts in IAS to inform the Steering Committee. Three types of composition of the technical committees were considered: government experts, specialists from international organisations (e.g. GISP, CABI, SCOPE, IUCN, etc.), and both.
- Engage public participation and community involvement in any IAS programmes. Local communities can play an important role in the identification of problems on the ground, especially environmental pests
- Create a regional node for IAS acitivities. Participants suggested that FAO, IUCN, or a regional GISP office fulfull this role.

3. Appendices

Appendix 3.1. Relevant organizations

Organization	Website	Resources
ASEAN Regional Conservation Biodiversity Centre (ARCBC)	http://www.arbc.org.ph	Technical guidance, project development and implementation, policy guidance, inancial support for research and data management
Association of Southeast Asian Nations (ASEAN) Secretariat	http://www.aseansec.org	Assisting countries with IAS policy development and implementation
ASEANET		Regional loop for BioNET International, info. exchange, taxonomic capacity building
Asia Development Bank (ADB)	http://www.adb.org	Financing
Asian Institute of Technology (AIT)	http://www.ait.ac.th	Technological assistance
Asia Pacific Plant Protection Commission (APPPC)	http://www.eppo.org/WORLDWIDE/PPROS/apppc.html	Framework for policy development, networking, technical guidance
AusAID	http://www.ausaid.gov.au	Financing, development of best practices for international assistance and IAS
CAB International (CABI)	http://www.cabi.org	Partner in GISP, information exchange, technical support for agricultural IAS issues (e.g., biocontrol)
Centre for Research on Introduced Marine Pests (CRIMP)	http://www.marine.csiro.au/CRIMP/	Technical support and research on marine IAS
Consultative Group on International Agricultural Research (CGIAR)	http://www.cgiar.org	Information sharing, technical assistance
Convention on the International Trade of Engangered Species of Wild Fauna and Flora (CITES)	http://www.cites.org	Legal framework
Conservation International (CI)	http://www.conservation.org	Technical assistance, project development, funding
Convention on Biological Diversity (CBD)	http://www.biodiv.org	Legal and policy framework for IAS of environmental concern, guiding principles for prevention and management
European Union (EU)	http://www.euruion.org	Financing, development of best practices for international assistance and IAS
Food and Agricultural Organization (FAO)	http://www.fao.org	Technical support, training, and funding for IAS problems in agriculture and marine sectors
Global Environment Facility (GEF)	http://www.gefweb.org	Financing
GloBallast Programme	http://www.globallast.imo.org	Technical support and training related to IAS and ballast water as a pathway for invasion
Global Invasive Species Programme (GISP)	http://www.gisp.org	Coordination, strategy development, technical information and training
International Epizootics Organisation (IOE)	http://www.oie.int	Framework for policies and standard setting on IAS pathogens relevant to animal health, particularly livestock and poultry
International Maritime Organization (IMO)	http://www.imo.or	Ballast water management standards, technical assistance, funding
International Plant Protection Convention (IPPC)	http://www.ippc.org	International cooperation, standard setting

Invasive Species Specialist Group (ISSG)	http://www.issg.org	Associated with IUCN, technical and scientific information, networking
Japan International Cooperation Agency (JICA)	http://www.jica.go.jp	Financing, development of best practices for international assistance and IAS
International Civil Aviation Organization (ICAO)	http://www.icao.int	Framework for policy setting and standards relevant to transport of IAS via aircraft
International Centre for Integrated Mountain Development (ICIMOD)	http://icimod.org	Information relevant to mountain ecosystems
International Crop Research Institute for Semi-Arid Tropics (ICRISAT)	http://icrisat.org	Technical assistance, see also CGIAR
International Tropical Timber Organization (ITTO) and International Tropical Timber Authority (ITTA)	http://www.itto.org	Policy development and implement for IAS and forest ecosystems
Mekong River Commission (MRC)	http://www.mrcmekong.org	Information sharing, regional policy development, project development and implementation, funding
Ramsar Convention	http://www.ramsar.org	Legal and policy framework for IAS in wetland ecosystems
Scientific Committee on Problems of the Environment (SCOPE)	http://www.icsu-scope.org	Partner in GISP, scientici information, networking
South Asian Association for Regional Cooperation (SAARC)	http://www.saarc-sec.org	Regional policy development and implementation
South Asia Cooperative Environment Programme (SACEP)	http://www.sacep.org	Framework for policy development and implementation in South Asia
The Nature Conservancy (TNC)	http://www.tnc.org	Technical assistance, project development, funding
United Nations Development Programme (UNDP)	http://www.undp.org	Technical assistance and training
United Nations Environment Programme (UNEP)	http://www.unep.org	Financing and technical assistance
U.S. Agency for International Development (USAID)	http://www.usaid.gov	Financing and network building, development of best practices for international assistance and IAS
World Bank	http://www.worldbank.org	Financing, development of best practices for international assistance and IAS
World Conservation Union (IUCN)	http://www.iucn.org	Partner in GISP, technical informationi, networking
World Fish Center (ICLARM)	http://iclarm.org	Policy development, development of best practices for international assistance and IAS, project development and implementations, funding
World Health Organization (HWO)	http://www.who.org	Monitoring, policy development, and standard setting in epideimiology
World Wildlife Fund (WWF)	http://www.worldwildlife.org	Tech. assistance, proj. development, funding
World Tourism Organization (ITO)	http://www.world-tourism.org	Framework for policy development and standards on spread of IAS through tourism
World Trade Organization (WTO)	http://www.wto.org	Framework for trade policy and standard setting institutions

Appendix 3.2. Workshop agenda

The Prevention and Management of Invasive Alien Species: Forging Cooperation throughout South and Southeast Asia, Bangkok, Thailand, 14-16 August 2002

Day 1: Morning session (14 August) Plenary – Defining the issue on the global and regional scale. Moving from global perspective to regional perspective

Time	**Objective**	**Speaker (s)**
08:30	Welcome and opening ceremony	*Mr. Sunthad Somchevita*, Permanent Secretary, Ministry of Science, Technology, and Environment, Thailand *Mr. Darryl N. Johnson*, Ambassador, U.S. Embassy
09:00	Welcome and overview of the workshop objectives	*Dr. Jeffrey Waage, Chair Global IAS Programme (GISP)*- Head, Department of Agricultural Sciences, Imperial College, UK
09:10	Overview of the IAS issue globally – problem definition, causes, and consequences	*Dr. Jamie K. Reaser,* Vice Chair, GISP/Assistant Director, U.S. National IAS Council
09:35	Overview of international instruments addressing IAS issues	*Ms. Clare Shine, Legal Specialist* IUCN – The World Conservation Union
10:00	Overview of the Global IAS Programme's (GISP) Partnership Network and "best practices" for preventing and managing IAS	*Dr. Jeffrey K. Waage*
10:30	Break	
10:50	The Global IAS Information Network	*Dr. Vishwas Chavan* Co-Chair GISP Global Information Working Group National Chemical Laboratory, India
11:15	IAS: opportunities for international research collaboration	*Dr. Nirmalie Pallewatta*, Senior Lecturer, Department of Zoology, University of Colombo, Sri Lanka
11:40	Environmental threats to South-Southeast Asia: the role of IAS	*Dr. John MacKinnon,* ASEAN Regional Centre for Biodiversity Conservation Headquarters, Phillippines
12:00	Lunch	

Time	Objective	Speaker(s)
13:30	**Subregional overviews (15 min ea) and National Reports (10 min ea)** Questions to be addressed: • What is the status of the IAS problem? • What are the most significant challenges to addressing the problem? • What are the needs and opportunities for cooperation throughout South-Southeast Asia?	**South Asia (Continental)**: *Mr. M C Diwakar,* Directorate of Plant Protection, Quarantine, and Storage, India **South Asia (Insular)**: *Dr. Buddhi Marambe,* Unviersity of Peradeniya Sri Lanka **Southeast Asia (Contintental)**: *Dr. Banpot Napompeth,* National Biological Control Research Centre (NBCRC), Thailand **Southeast Asia (Insular)**: *Ms. Faustina Hardjanti,* Directorate Biodiversity Conservation, Indonesia **National Reports**: *Dr. Benito C. Tan,* National University of Singapore
15:00	Question and answer session	Facilitated by co-chair
15:30	Break	
15:50	Panel presentations – Opportunities for addressing IAS in South and Southeast Asia through existing regional instruments and programmes (10 min ea.) Questions to be addressed: • What programmes already exist for addressing IAS issues within the region? • What are the needs for programme linkages, expanded programmes, +/or new programmes?	*Mr. Bob Griffin,* International Plant Protection Con. *Ms. Piyathip Pipthvanichtham,* IUCN Asia Reg. Office *Mr. Mahboob Elai,* South Asia Cooperative Environment Programme *Dr. Soetikno Sastroutomo,* CAB International
16:50	Question and answer session	Facilitated by co-chair
17:10	Summary of conclusions and recommendations	Co-chair
17:30	Announcements and adjourn	Co-chair

Evening- Special reception for workshop participants

Day 2: Morning session (15 August)

Working groups – begin exploring regional approach to achieving success throughout the region

Time	**Objective**	**Speaker (s)**
08:00	Overview of directives for Day 2	Co-chair
08:10	Participant introductions	Facilitated by co-chair
09:00	**Working groups on regional cooperation** Separate into two working groups to address the following questions: • What do we want the regional to achieve collectively? • What are the challenges to achieving regional cooperation? • What are the necessary elements for a strategy to facilitate regional cooperation?	Each group individually facilitated with rapporteur and note taker
10:45	Break	
11:00	Plenary – presentation of group summaries	Chair from each working group
11:30	Group discussion	Facilitator
12:00	Lunch	

Day 2: Afternoon session

Time	**Objective**	**Speaker (s)**
13:30	Directive for afternoon sessions	Session chair
13:40	**Working groups on regional cooperation** Separate into two working groups to address the following questions: • How can we promote collaboration/ cooperation within existing frameworks? • What are the existing resources that can be utilized to achieve regional cooperation? • What additional resources are needed? • Who needs to be involved, when, and where?	Each group individually facilitated with rapporteur and note taker
15:30	Break	
15:50	Plenary – presentation of group summaries	Chair from each working group
16:20	Group discussion	Facilitator
16:40	Expected meeting outcomes – regional recommendations	Co-chair
17:30	Announcements. Overview of Day 2 programme and objectives, adjourn.	Co-chair

Thursday, 15 August – Evening

Three teams convene for evening work, with reports distributed to all participants the following morning::

Team 1: Writes summary of working group A's findings

Team 2: Writes summary of working group B's findings

Team 3: Writes first draft of regional statement

Day 3: Morning session (16 August)

Time	Objective	Speaker (s)
08:00	Overview of Day 2 conclusions/ recommendations and brief outline of the process for Day 3	Co-chair
08:20	Presentation of draft regional recommendations	Team leader
08:35	Group discussion	Facilitator
09:15	**Working groups on regional cooperation** Separate into two working groups to address the following questions: • What are the steps to establish regional collaboration and promoting action? • What are the steps that can be taken immediately and who should take them? • What is at least one action that each participant will pledge to take soon after the meeting?	Each group individually facilitated with rapporteur and note taker
11:00	Break	
11:20	Plenary – presentation of group summaries	Chair from each working group
11:40	Finalization of regional recommendations	Team leader
12:15	Closing Remarks	Co-chairs
12:30	Adjourn/Field Trip	

Optional field trip 12:45 – 17:00: Royal Chitralada Projects

The Chitralada Palace is unlike any other royal palace. Dotted with diverse agricultural projects - fish ponds, laboratories, a dairy farm - it looks more like an experimental agricultural village than a king's residence. For more than four decades, King Bhumibol has focused on agricultural research and sustainable development. Since 1992, Crown Princess Sirindhorn has conducted a Plant Genetics Conservation Project. By participating in the field trip to the Royal Projects you will come to understand the royal family's emphasis on biodiversity protection and on the development and conservation of Thailand's natural resources.

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Mr. Gamini Gamage (Chair, 15/8 afternoon session)
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Appendix 3.5. Poster abstracts

Biological invasions nagtively impact ecology and genetic diversity of native species; the case of introduction of alien insect species in Japan

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Many alien species have been introduced to Japan as biological materials and as pets and some of them have invaded Japan's native biodiversity. This is illustrated by two examples in the posters displayed at the workshop: bumble bees introduced as pollinators and stag beetles as pets. There tends to be a misconception among the general public that increase of alien species in Japan will produce rather good results because it will increase biodiversity. The answer to this should be a clear NO, as can be illustrated from the studies carried out by Dr. Koichi Goka and others. The European bumble bee, *Bombus terrestris,* has been introduced into Japan from Europe for pollination of tomato plants since 1991 and since become naturalized. Laboratory experiments showed that *B. terrestris* and a Japanese native species, *B. hypocrita sapporoensis,* could copulate and produce hybrids which are indistinguishable by their appearance. Many stag beetle species both native and exotic are now in circulation throughout Japan as commercial pets. This has led to genetic introgression of exotic species genes into Japanese beetle populations as some individuals that have originated from exotic species *Dorcus titanus* were detected from the field. In addition, both bumble bee and stag beetles from other parts of the world harbour parasitic mites that cause diseases and even death of Japanese species in some cases.

The concept of biodiversity does not means only the number of species but the variation in each level of it: landscape, ecosystem, community, species, population and genes. The local genetic composition and the species created through evolutionary processes all ultimately support global biodiversity. However, artificial transportation of many species between widely diferent biogeographical regions within a very short time will cause homogeneity of genes and fauna, which if not reversed will cause breakdown of local, regional and finally global biodiversity.

Increasing damage caused by golden apple snail (Pomacea* sp.*) in lowland rice in the Lao PDR

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The posters illustrated the case of the voracious pest of rice paddies and an alien species- the golden apple snail (GAS) (*Pomacea* sp.) in Laos PDR. This species was introduced into the Lao PDR (to Vientiane Municipality) in 1991 almost simultaneously from Thailand and from Vietnam mainly as a source of food. In 1992, however, the first signs of damage to lowland rice fields were reported. Since then, GAS has spread to nine of 17 provinces of the Lao PDR mainly through connecting waterways such as irrigation canals and rivers as well as being transported by people. Many people in the Lao PDR are still unaware of the threat and are attracted by the snails' colourful egg masses, and take it along with them as a delicacy, thereby helping to spread it even more.

GAS does most damage while rice seedlings are young (seedbed up to 20 days after transplanting) and fields infested with GAS have to be re-planted several times to replace the missing hills. Collecting GAS in the field has become inefficient in severely infested areas and farmers turn to various chemicals for help. The Lao government strongly discourages the use of chemical pesticides in order to protect the environment as well as the consumers from harmful effects to health caused by their misuse. To find alternatives, the National Agricultural Research Centre has initiated research to test the efficiency of several biological control agents.