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A strategy for addressing issues of aquatic invasive alien species in the Lower Mekong Basin

Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme & Regional Species Conservation Programme

MEKONG WETLANDS BIODIVERSITY
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Cover Photo: Water Hyacinth *(Eichhornia crassipes*) in Vientiane city © Tran Triet

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Summary

The Millennium Ecosystem Assessment, conducted between 2001 and 2005, identified Invasive Alien Species (IAS) as one of five major drivers of biodiversity loss in inland waters. IAS compete vigorously, homogenise ecosystems and have caused hundreds of extinctions. They are as damaging economically, and directly and indirectly affect human livelihoods. While all ecosystems have the potential to be invaded by IAS, inland water systems are particularly vulnerable.

The Mekong River flows through six countries and drains an area of some 795, 000 km^2. The Lower Mekong Basin (LMB) supports a wide variety of ecosystems including a vast wetland system, extending over some 5 million ha. During monsoons there is extensive flooding, and a natural storage system is formed which is of great importance to livelihoods in the region.

The LMB is of exceptional significance to biodiversity conservation as it supports a great diversity of species, including many highly endangered species. There are also about 60 million people living in the LMB, three quarters of whom rely on resource-based livelihoods such as agriculture and fisheries.

Like most natural ecosystems across Asia, the wetlands in the LMB are under threat from various human activities and from invasive alien species. Currently, major pathways for introduction of IAS in the region include aquaculture, horticultural and ornamental fish trades. Dams, urbanisation, expansion of agriculture, trans-boundary road development and other rapid development activities are exacerbating the spread of IAS.

Mauritius Grass (*Brachiaria mutica)*, Water Hyacinth (*Eichhornia crassipes*), Water Lettuce (*Pistia stratiotes*) and Giant Mimosa (*Mimosa pigra*) have been listed as invasive alien flora on wetlands. Also of concern are the Siam Weed (*Chromolaena odorata*), Torpedo Grass (*Panicum repens*), Mission Grass (*Pennisetum polystachyon*), Horse Tamarind (*Leucaena leucocephala*), Giant False Sensitive Plant (*Mimosa diplotricha*), and *Lantana camara*. Among faunal species, Tilapia (*Oreochromis spp.*), Common Carp (*Cyprinus carpio*), Pacu (*Colossoma macropomum*) and the Sucker mouth catfish (*Hypostomus spp.*) are spreading in parts of the LMB. Also of serious concern is the Golden Apple Snail (*Pomacea canaliculata).*

Many global agreements acknowledge the ecological and economical importance of IAS, including the Convention on Biodiversity and the Ramsar Convention. The Global Invasive Species Programme (GISP) has contributed extensively to creating awareness and increasing knowledge about IAS, and as part of their programme, has developed 'A toolkit of best prevention and management' to assist managers to deal with IAS problems and developed a Global Strategy for IAS.

While the LMB nations have made some progress in addressing IAS, much remains to be done. This report recommends the following strategic responses to address issues related to aquatic IAS in the LMB: (1) Controlling existing IAS known to have spread widely; (2) Raising public awareness and increase support; (3) Increasing scientific research; (4) Building capacity; (5) Strengthening national and regional policies and laws; (6) Identifying alternate uses for IAS and promoting business opportunities; (7) Developing economic valuation of IAS; (8) Ensuring that funding is available for IAS related programmes; (9) Preventing further entry of IAS; (10) Developing an early warning and rapid response system; (11) Monitoring routinely; and (12) Developing an institutional mechanism to address IAS issues.

It also recommends maximum participation at national, regional and international levels is essential and suggests possible participants at the three levels. It also identifies the Global Invasive Species Database(GISD) (http://www.issg.org/database/) as the single most important resource for use with respect to IAS.

Facing page: *Pistia stratoides* infestation in Vietnam © Alvin Lopez

Introduction

Invasive Alien Species:

The Millennium Ecosystem Assessment, conducted between 2001 and 2005, identified Invasive Alien Species (IAS) as one of five major drivers of biodiversity loss in inland waters (MEA, 2005). Increased trade, travel and transport of goods in the accelerated process of globalisation have facilitated the intentional and unintentional spread of IAS. IAS grow rapidly, competing vigorously in the absence of their natural predators, out-competing native species, homogenising ecosystems and generally causing ecological mayhem. They have spread and affected native species in almost every ecosystem on Earth and have caused hundreds of extinctions (McNeely et al., 2001).

Mimosa pigra **in** Tonle Sap Lake Cambodia © Tran Triet

They are also as damaging economically, and directly and indirectly affect human livelihoods. In the United States alone, the total cost of dealing with invasive weeds was between 4.5 – 6.3 billion USD (McNeely, 2001). The damage from Zebra mussels to the US and European industries cost 750 million to 1 billion USD from 1988-2000 (Khalanski, 1997 and Bright, 1999 in McNeely, 2001). Controlling rabbits introduced from Europe into Australia costs the Australian government about 373 million USD per annum (White & Newton-Cross, 2000 in McNeely, 2001). Water Hyacinth, introduced from South America, is clogging and choking waterways in Africa costing seven African countries 20-50 million USD per annum to eradicate (Kasulo, 2000 in McNeely, 2001).

In addition to affecting economies at a national level, IAS seriously impact local economies such as fisheries, tourism and local agriculture. Developing countries are especially vulnerable to the impacts of IAS, because they rely heavily on resource-based livelihoods such as agriculture, aquaculture, fisheries and forestry (Matthews & Brandt, 2004).

While all ecosystems have the potential to be invaded by IAS, certain areas of the planet are more vulnerable than others: islands, as well as other geographically isolated ecosystems such as lakes and mountains; agro-ecosystems, degraded and stressed ecosystems, enclosed marine systems, such as bays and estuaries, as well as arid low-diversity ecosystems are known to be especially vulnerable (McNeely, 2001). Particularly vulnerable are inland water systems (Ciruna et al., 2004).

Pistia stratiotes in LSWR Vietnam © Alvin

[1] Invasive Alien Species are alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm. These are addressed under Article 8(h) of the CBD and other instruments (McNeeley et al., 2001)

The Lower Mekong Basin (LMB):

The Mekong River, ranked as the 12th longest of the world's rivers, originates in the Tibetan Plateau and empties some 475, 000 million m^3 of water into the South China Sea some 4,800 km later. Flowing through six countries - China, Myanmar, Thailand, Lao PDR, Cambodia and Vietnam - it drains an area of some 795, 000 km^2. The Lower Mekong Basin supports a wide variety of ecosystems including a vast wetland system, extending over some 5 million ha. Interspersed are open Dipterocarp and riverine forests and seasonally inundated grasslands. The area experiences two monsoonal periods – from May to October and November to March – when extensive flooding occurs. When this happens, water is forced back into the Tonle Sap River in Cambodia to the Great Lake, which expands from 0.3 million ha to 1.3 million ha. When the water levels drop, the flow reverses. This natural storage system is of great importance to livelihoods in the region (IUCN, 2003).

The LMB is of exceptional significance to biodiversity conservation as it supports a vast array of species, with a diversity of river fauna only less than the Amazon and the Congo rivers. With some 1500 recorded species of fish, it is one of the nine richest watersheds for fish biodiversity in the world, and is home to the endemic Giant Catfish (*Pangasianodon gigas*) and the Giant Mekong Barb (*Catlocarpio siamensis*). It is considered a biodiversity hot-spot for molluscs, with160 species, of which 72% are endemic to the Mekong. The region also supports the entire world population of the Giant Ibis (*Pseudibis gigantea*) and ten species of threatened wetland birds as breeding residents and several threatened forest birds (Birdlife International, 2004). It is in the path of a critical migratory flyway for many migratory birds. The area also harbours populations of the highly endangered Siamese crocodile (*Crocodylus siamensis*) and Irrawaddy Dolphin (*Orcaella brevirostris*) (MWBP, 2006).

Equally importantly, there are about 60 million people living in the LMB who are amongst the poorest in the world. About three quarters of this riparian population rely on resource-based livelihoods such as agriculture and fisheries. The total value from fisheries (there are some 120 commercially important species) and rice production in the lower Mekong River basin is estimated at 1,350 and 6,400 million USD, respectively, per annum. More than 50% of the protein needs of communities living are met by fish caught from the Mekong river (IUCN, 2003).

Mekong River Lao PDR © Channa Bambaradeniya

Like most natural ecosystems across Asia, the wetlands in the LMB are under threat from human activities such as habitat loss and degradation, overexploitation, infrastructure development and lack of capacity in regulating protected area systems.

The LMB is also under serious threat from invasive alien species. Alien species have been introduced both deliberately and accidentally, and some of these have become invasive. IAS are considered to be a leading cause of threat in freshwater systems (Sala et al., 2000). Currently, major pathways for introduction of IAS in the region include aquaculture and the horticultural and ornamental fish trades (McNeely et al, 2001). Dams, urbanisation, expansion of agriculture, trans-boundary road development and other rapid development activities are exacerbating the spread of IAS (McNeely et al, 2001).

Triet (2000) records 68 alien plants in the Mekong Delta and lists 12 as major weeds and four species - Mauritius Grass (*Brachiaria mutica*), Water Hyacinth (*Eichhornia crassipes*), Water Lettuce (*Pistia stratiotes*) and Giant Mimosa (*Mimosa pigra*) - as invasive alien flora on wetlands. Also listed are the Siam Weed (*Chromolaena odorata*) and Torpedo Grass (*Panicum repens)* (IUCN, 2006).

Mauritius Grass forms dense monotypic stands and is known to overgrow native species. Rafts of grass can break off and float out onto rivers, interfering with stream flow and water traffic (www.anbg.gov.au/weeds/index.html).

Water Hyacinth (included in the list of 100 of the World's Worst Invasive Alien Species) is widespread in the LMB, especially in standing water. This species forms a dense mat on the surface of water, blocks underwater channels, clogs waterways, impedes water traffic and prevents fishing. The mat blocks sunlight and oxygen from reaching below, drastically reducing aquatic biodiversity (Matthews and Brandt, 2004).

Eichhonia crassipes © Fen Beed

Water Lettuce, like Water Hyacinth, is a floating aquatic plant that has similar impacts.

These three species could cause serious problems to the flow and natural storage of water in the LMB.

The Giant Mimosa – also on the list of 100 of the World's Worst Invasive Alien Species – is widespread in the LMB, found in most sections of the main river and along its tributaries from northern Laos to the Mekong delta in Vietnam, the border between Laos and Thailand, and in Cambodia in the seasonally inundated areas of the Tonle Sap river and the Great Lake (Triet, 2005). Giant Mimosa has replaced natural wetland species and is also spreading to small wetland areas under Dipterocarp forests. It has colonised the Mekong river channel mud/sediment flats and sand bars in the Laos region, resulting in the loss of feeding and breeding habitats of wading birds (Lazarus et al., 2006). In a case study of Tram Chim National Park in Vietnam, Triet (2004) shows that the Giant Mimosa doubled its area between 2000 and 2002. Triet also reports that with the replacement of vegetation and loss of feeding grounds is one of the main reasons for the sharp decrease in the Eastern Sarus Cranes (*Grus antigone*) from 600-800 in the 1990s to 100 in 2003. Dense, prickly thickets impede the movements of animals, including livestock. In addition, this species increases siltation and impedes movement in waterways.

Chromolaena odorata © Colin Wilson

The Siam weed is known to form dense stands, aggressively competing with native species and preventing their growth. When dry, this weed becomes a fuel which is known to promote wild bushfires in other countries (Orapa, 2004). In addition, the leaves contain high levels of nitrates and are toxic and can, if consumed, cause fatalities among grazing animals, (Orapa, 2004).

Torpedo Grass is an aggressive competitor, forming dense monotypic stands and results in the reduction in native biodiversity (Dian et al., 2004).

Other invasive plants of concern include Mission Grass (*Pennisetum polystachyon*), Horse Tamarind (*Leucaena leucocephala*), Giant False Sensitive Plant (*Mimosa diplotricha*), and *Lantana camara* (Tran Triet pers. comm.).

Among faunal species, some deliberate introductions for aquaculture and other purposes have proven to be detrimental. There are reports of Tilapia (*Oreochromis spp.*), Common Carp (*Cyprinus carpio*) and Pacu (*Colossoma macropomum*) spreading in parts of the LMB (Mattson, 2006). Recently, the Sucker mouth catfish (*Hypostomus spp*.) has become widespread in natural wetlands of the Mekong Delta (Tran Triet pers. comm.).

Oreochromis mossambica © Ruchira Samaraweera

Another faunal species that is known to have spread is the Golden Apple Snail (*Pomacea canaliculata*). Introduced from the new world to Taiwan and the Philippines as a means of supplementing protein needs for the rural poor, these snails soon escaped into waterways, quickly spreading through waterways and irrigation canals. They rapidly developed into a serious pest in many areas of cultivated rice land in Asia (Over half of rice fields in the Philippines are infested with the Golden Apple Snail. In 1990, associated costs of damage to rice due to Golden Apple snail infestation were estimated as 28-45 million USD.) The Golden Apple Snail is a voracious feeder and three snails in a square metre of rice can cause considerable damage (Joshi, 2005). Like the Giant Mimosa and Water Hyacinth, this species is also on the list of 100 of the World's Worst Invasive Alien Species. Introduced in 1988 to Vietnam, this snail had become an endemic pest four years later, with rice fields in 57 out of 62 provinces infested (Joshi, 2005). In Thailand, 43 provinces are affected; in Vientane, Lao PDR, nine out of ten villages have been impacted (Joshi, 2005).

An attendant problem is the issue of ecosystem pollution which is a consequence of heavy use of chemicals to control the Golden Apple Snail. This pollution is now posing problems to aquatic biodiversity and to human health (Pallewatta et al., 2003).

These snails also are vectors for the nematode *Angyostrongylus cantonensis* that causes eosonophilic meningoencephalitis in humans (Mochida, 1991, in Joshi 2005) .

Except for detailed data about the extent and spread of the Giant Mimosa, currently there is a paucity of information about the impacts of IAS within the LMB, in particular, ecological and economic effects. Details about how these impacts affects communities, key sector groups and governments are also lacking. Most often, the problem is not recognised until the invasion becomes noticeable or has ecological, economic or social consequences. Based on published sources, a list of aquatic IAS in the LMB is presented in Annex 1.

Initiatives for management of IAS in the LMB

Pomacea canaliculata eggs on *Mimosa pigra*, Laos © Tran Triet

The capacity of dealing with IAS varies among countries within the LMB, but there are a few ongoing management programmes.

In Cambodia, Siam weed is managed currently by manual slashing and chemical control using herbicides. The biological control agent caterpillar of the moth *Pareuchaetes pseudoinsulata* was introduced to Cambodia for control of the Siam Weed, but has not established itself. In Thailand, Siam weed is harvested for use for herbal purposes. The Chalcid (*Branchymeria euploeae*) and tephritid gall fly (*Cecidocharef connexa*) are used for biological control of the species in Thailand.

In Laos, the Golden Apple Snail is managed through an integrated approach using a combination of different, simultaneous techniques. Similarly, in Thailand management involves chemical and biological control methods, as well as hand-picking. Biological control have focused on using predators such as ducks or fish to minimise the snail population. In Vietnam the most common method of control is by handpicking and by rice-fish farming where fish are raised in the paddy-fields to control snails (FAO, 1998).

In Vietnam, the Ministry of Agriculture and Rural Development has initiated a programme to manage Giant Mimosa and Nutria rat (IUCN, 2006).

All LMB nations use pesticides that not only impact non-target organisms but also endanger the health of people working in the rice fields.

While the LMB nations have made some progress in addressing IAS, much remains to be done.

The purpose of this report is to recommend avenues and strategies involving a comprehensive approach to deal with aquatic IAS in the lower Mekong Basin.

The global context for the management of IAS

Many global agreements acknowledge the ecological and economical importance of IAS. The Convention on Biological Diversity (CBD) ratified by 188 countries, through Article 8(h), requires its Parties, to 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species' (http;/www.biodiv.org). The guiding principles for the implementation of Article 8h, including the definition of IAS were developed at the sixth conference of parties of the CBD in decision VI/23. The seventh conference of parties recognised the need to strengthen further institutional coordination among international organisations and urged further collaboration between the CBD, and other conventions such as the United Nations Framework Convention on Climate Change (UNFCCC) and the United Nations Convention to Combat Desertification (UNCCD), the Collaborative Partnership on Forests and organisations such as the Food and Agricultural Organization of the United Nations (FAO), the World Health Organization (WHO) the Convention on International Trade in Endangered Species (CITES) and the International Plant Protection Convention (IPCC) (decision VII/13) (http;/www.biodiv.org).

Since 1952, the International Plant Protection Convention (IPCC) ratified by 111 countries, is designed to prevent the spread of plant pests and its standards are recognised by the World Trade Organisation (WTO) (McNeely et al., 2001).

The International Maritime Organisation (IMO) has been working since the mid 1970s to prevent the spread of marine alien species in ballast water. In 1997, the general assembly adopted a series of guidelines and a legal framework is now being developed.

The Convention of Wetlands of International Importance especially as Waterfowl Habitat (more commonly referred to as the Ramsar Convention) in its seventh conference of parties adopted a resolution (VII/14) in which the contracting parties urged that steps be taken to identify, eradicate and control invasive species within their authority. Subsequent decisions urged parties to prepare guidelines, establish priorities for action, and manage IAS which could threaten to wetlands and wetland species (http://www.ramsar.org).

A comprehensive list of 'international and regional instruments and institutions pertaining to alien invasive species' is presented in McNeely et al., 2001.

Under the aegis of the Species Survival Commission, the Invasive Species Specialist Group (ISSG) beings together a group of 146 experts on IAS from 41 countries all over the world. This specialist group provides advice on IAS to, among others, managers and policy-makers. The Global Invasive Species Programme (GISP) is coordinated by the Scientific Committee on Problems of the Environment (SCOPE), in collaboration with the World Conservation Union (IUCN), and CAB International (CABI). GISP has received initial financial support from the United Nations Environment Programme (UNEP) - Global Environment Facility (GEF), United Nations Education, Scientific and Cultural Organization (UNESCO), the Norwegian Government, the National Aeronautics and Space Administration (NASA), the International Council for Scientific Unions (ICSU), La Fondation TOTAL, the United States Department of State, Bureau of Oceans and International Environmental Affairs Initiative (OESI), the David and Lucile Packard Foundation, and the John D. and Catharine T. MacArthur Foundation. Participating groups and individuals have made substantial in-kind contributions. GISP is a component of DIVERSITAS, an international programme on biodiversity science.

GISP has contributed extensively to creating awareness and increasing knowledge about IAS, and as part of their programme, has developed 'A toolkit of best prevention and management' to assist managers to deal with IAS problems. The GISP toolkit recommends four major options for dealing with IAS: 1) prevention, 2) early detection, 3) eradication, and 4) control (Figure 1). It notes that prevention is the most cost-effective option and that exclusion methods based on pathways rather than species are the most effective. When prevention fails, early detection and early eradication is preferred; and successful eradication often includes multiple methods. When both the above have not been successful, then control is the option left. However, integrated pest management is often the most successful method of control (Wittenberg and Cock, 2001).

It has also developed, with other partners (including the ISSG), a Global Strategy for Invasive Alien Species.

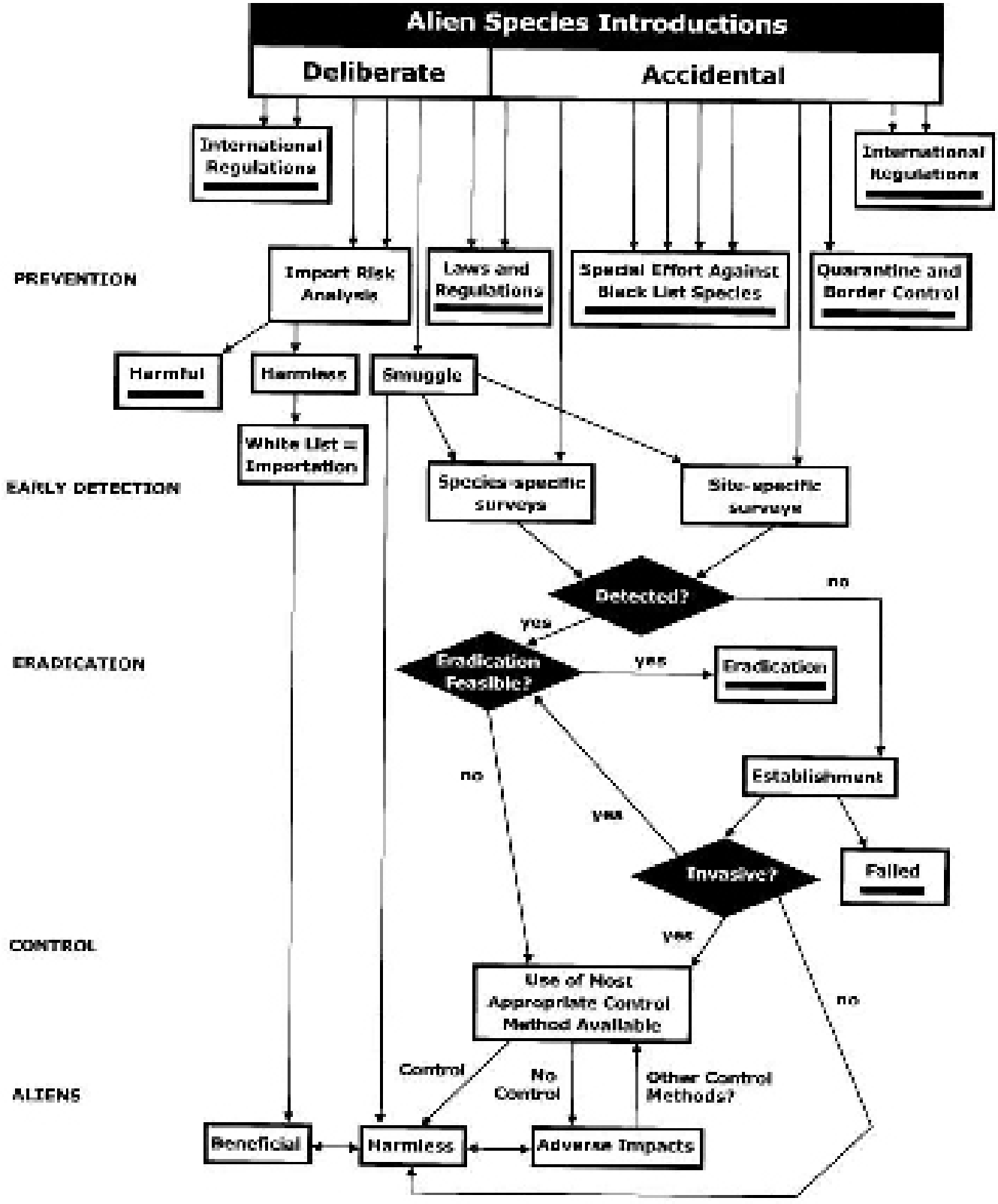

Figure 1 - Summary of options to consider when addressing alien species. Black bars mark the potential final stages of introduced alien species. Diamonds symbolise important bifurcations and decision points.

Source: Wittenberg & Cock, 2001

Scope of this strategy

This strategy only addresses issues related to aquatic invasive alien species found in the LMB. Hence, it refers only to aquatic species (not terrestrial) and to the Mekong areas under the jurisdiction of Cambodia, Lao PDR, Thailand and Vietnam (not China and Myanmar).

It does not address pathogens as IAS nor does it apply to genetically modified organisms.

The strategic responses proposed here for the LMB region can be modified and adopted to address IAS issues at a national and/or local scale as well.

The purpose of this report is to recommend avenues and strategies involving a comprehensive approach to deal with aquatic IAS in the lower Mekong Basin.

Strategic responses to address issues related to aquatic IAS in the LMB

1. Control the spread of existing IAS known to have spread widely

   Detailed research carried out by Triet et al. (2000, 2004) has identified four species of plants as invasive in the LMB and two others have been highlighted in a recent review of IAS in the LMB (IUCN, 2006). These are the Giant Mimosa, Mauritius Grass, Siam Weed, Torpedo Grass, Water Hyacinth and Water Lettuce. Also listed in the IUCN report is the Golden Apple Snail. Much has been written about these IAS and plenty of information is available on management practices that can be used for control and eradication. Although piecemeal management is ongoing, a cooperative and concerted effort is necessary to control these species. Achieving this will require:

   - Developing and implementing action plans for the control and management of each of these species, for the LMB region as a whole, incorporating existing management practices and introducing new ones where necessary. Such plans could be implemented on a pilot scale in selected localities, with continuous monitoring, leaving provision for adaptive management.
   - Prioritising IAS control at biodiversity hotspots such as protected areas, national parks.
   - Preventing further infestation by developing toolkits for action. Each toolkit should contain guidelines and checklists for manager for each phase of prevention for specific species.
   - Forging cross-country cooperation, especially in the control of regionally-invading species such as Giant Mimosa.

2. Raise public awareness and increase support

   Although IAS can wreak ecological and economical havoc, very few people know what an invasive alien species is and much less of the damage they can cause to human well-being. This lack of knowledge can make it difficult to mobilise key stakeholders, with the result that issues related to IAS are not mainstreamed into conservation agendas. It is essential that a ‘culture of awareness [is created] among stakeholders so that prevention, monitoring, control and eradication are made much more successful’ (Stokes et al., 2006). Achieving this will require:

   - Developing awareness and education programmes in local languages, for the general public, (especially communities dependent on the Mekong River for their livelihoods), government officials, local authorities, NGOs and schools.
   - Developing targeted awareness programmes for key managers such as customs officials and protected area managers.
   - Developing specific education programmes among sectors that facilitate the spread of IAS such as shipping, tourism/travel, aquaculturists, horticulturists and aquarium traders.

Mimosa pigra in Vietnam © Tran Triet

3. Increase scientific research

While research has been carried out by Triet et al. (2004, 2005) identifying aquatic plant species that are invasive in the LMB, little research has been carried out on aquatic fauna IAS in the area. Also lacking is a comprehensive list of all aquatic IAS – i.e., a 'black list' - for each of the countries in the LMB. Once these lists are obtained, basic data on biology, ecology and epidemiology of listed species, risk assessments, impacts on livelihoods and economy should all be obtained. This information will be worthless unless shared among LMB countries, regionally and globally. Achieving this will require:

- Developing comprehensive black lists of aquatic invasive species for the four LMB countries. If red listing is proposed, then black listing should be incorporated into this process (IUCN, 2005).
- Increasing basic research on known aquatic invasive species in the LMB - including, *inter alia*, species taxonomy and biology, if possible date and place of introduction, extent and timing of range and spread and its patterns (using GIS technology), population size and trends, invaded habitats, ecological, sociological and economical impacts observed. Existing sources of information such as the Global Invasive Alien Species database, maintained by the Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission, should be used to gather such information.
- Increasing basic research on vectors and pathways of introduction; examining national and international trade, tourism, shipping, fisheries, agriculture, construction projects, ground transport, forestry, horticulture, landscaping, pet trade and aquaculture as applicable.
- Conducting research to understand the human dimensions governing the introduction and spread of IAS in the LMB region.
- Encouraging basic research on all introduced species in order to evaluate their potential for becoming invasive.
- Ensuring that this information is available for all stakeholders in the LMB through a system of linked national databases on IAS available in multiple languages to increase effectiveness.
- Ensuring that this information is shared not only among the countries of the LMB, but also regionally and globally by feeding into the Global Invasive Alien Species database. To this end, lead organisations that will be responsible for this should be identified for each country.

4. Build capacity

There is still little awareness of codes of practice and guidelines on introductions of new species among senior policy makers and line officers in the Mekong region, (GBF, 1999). Even with adequate knowledge about the biology, ecology and impacts of IAS and enhanced public, if there is little capacity within government and other sectors relevant to IAS, initiated programmes will fail. To ensure the prevention of introducing IAS, an informed and skilled group of workers in relevant sectors is a prerequisite for successful management. Achieving this will require:

- Strengthening basic control and quarantine capacity within each country and ensuring that all sectors involved – agricultural and livestock quarantine, customs, and food inspection – are given focussed and adequate training on international agreements such as the Convention on Biodiversity and its relevant protocols, as well as on local and regional legislation.
- Strengthening knowledge in the above sectors – specifically in identification of species.
- Developing task forces that bring together IAS specialists with all sectors listed above to ensure that IAS issues are mainstreamed into conservation management programmes.
- Establishing an IAS National Focal Point in each LMB country for coordination of activities and information sharing.
- Identifying key organisations responsible for management of IAS in each country.
- Strengthening knowledge (identification of IAS) and skills (prevention, control and management of IAS) among protected area managers.
- Developing trans-boundary cooperation in all of the above.

The Global Invasive Species Program has the necessary expertise to provide training for all of the above.

5. Strengthen national and regional policies and laws

While Lao, Thailand and Vietnam have laws and policies such as a Water Hyacinth Eradication Act, Quarantine Legislation Act and the Biodiversity Action Plan, Cambodia has none. Even when there are laws and policies, often there is conflict between relevant sectors and therefore lack of clarity about who is responsible and for what activity. Thus, there is not only disparity in the regulatory measure available in the LMB but also lack of clarity where laws do exist. Therefore, a comprehensive suite of national policies and laws as well as agreements and treaties within the LMB region, that specifically incorporate IAS issues, is necessary to ensure the prevention, management, eradication and control of IAS. Achieving this will require:

- Reviewing comprehensively all relevant policies, legislation and institutions to identify gaps, inconsistencies and conflicts and developing a comprehensive framework of national legislation and regional cooperation to prevent, regulate, control and eradicate aquatic invasive alien species in the LMB.
- Ensuring the participation of all stakeholders – including local communities and sectors such as fisheries (including aquaculture and the aquarium trade), agriculture, forestry, horticulture and tourism) – in the development and implementation of laws and policies.
- Ensuring that all possible vectors, pathways and sectors are addressed in this legislation.
- Providing measures for controlling and minimising the introduction of IAS both at the point of export and import.
- Making it a requirement for environmental impact assessments to include examination and evaluation of IAS as part of their terms of reference.
- Incorporating incentives, disincentives and compensation into this legislation.
- Ensuring that free market policies and trade liberalisation that facilitate the entry of IAS are revised to address the issue.
- Providing for the application of the precautionary principle to decision making related to IAS, within a risk analysis framework that accounts for native species and ecosystems.
- Ensuring provision for making people responsible for entry of IAS liable for costs incurred (user pays principle).

6. Identify alternate uses for IAS and promote business opportunities

Some Asian countries have reported success stories relating to known IAS by using them as resources for small-scale industries. For example, Bangladesh has found several useful applications for Water Hyacinth including making paper (with 120 paper producers), fibre board and yarn (www.itdg.org/docs). In Vietnam, long petioles of Water Hyacinth are used for making handicrafts and furniture. In fact, a top-end furniture company in Vietnam imports from Thailand furniture and crafts made from Water Hyacinth and sells these globally (http://www.vvg-vietnam.com/furniture_rattan.htm). Other countries such Philippines, Indonesia and India are also using this species to make paper; in India and the Philippines, this species is also being used to make baskets; in China and Malaysia it is an ingredient of animal feed; and technologies are also available to generate biogas and to purify water.

Among faunal IAS in the LMB, the Golden Apple snail has a high protein content and large body size, and has the potential to be useful as livestock or fish feed (Kaensombath, 2005).

Already, in Thailand, Siam weed is harvested for use for herbal purposes and thereby controlled.

Thus, there are already identified alternate uses for some of the more serious IAS in the LMB, and these uses should be examined for suitability and formalised as methods of controlling certain species. Achieving this will require:

- Seeking support from the private sector to establish small community projects with at least one pilot project in each country for Water Hyacinth and the Golden Apple snail. In the current climate in the private sector of increasing portfolios on corporate social responsibility, such community-based projects will undoubtedly gain support.
- Ensuring that deliberate introductions for commercial purposes are prevented.

7. Develop an understanding of the economic implications of IAS

Invasions have serious local, national and even global economic impacts. IAS are known to have affected many industries such as agriculture, fisheries and tourism as well as on local economies. About half of the extent of land under rice cultivation in the Philippines is infested with the Golden Apple snail and in 1990, it cost the government an estimated as 28-45 million USD in the loss of rice. Detailed economic evaluations for IAS are lacking in the LMB and are needed urgently. Achieving this will require:

- Carrying out economic studies of the market impacts of IAS, i.e., costs of loss of production. This will include decreases in fish catch and aquaculture production as a result of IAS, decline of water availability for industries, decreases in ability to navigate in waterways and decrease in property values.
- Carrying out economic studies of the non-market impacts of IAS in the LMB i.e., costs associated with changes in ecosystems services such as water availability and energy flow.
- Carrying out economic studies of the costs of controlling or eradicating IAS.
- Carrying out economic studies to ascertain the extent to which lower income communities are affected by IAS in the LMB. It is known that subsistence farmers, for example, have fewer options to manage IAS that farmers with higher incomes (Shogren, 2000).
- Assessing both short and long term costs to all communities, as IAS may extract much greater costs from future generations.

8. Ensure that funding is available for IAS related programmes

Funding for IAS related programmes remains a major challenge in all parts of the world (IUCN, 2005). Poverty-related matters and other human dimensions are relegating IAS to be a low priority issue among governments in the region (Bambaradeniya, 2005). There is a paucity of funding designated for developing and implementing IAS related research or management programme in the LMB region as well. In order to change the patterns of financial contributions to the IAS sector, some creative and lateral thinking is needed, which will use non-traditional methods to create and identify new concepts and ideas. Achieving this will require:

- Examining the private sector as a possible source for funding.
- Identifying corporations and companies, both at the national and multinational level who can be targeted for funding IAS related programmes.
- Focussing on companies/corporations - such as, *inter alia*, travel, trade, aquaculture and horticulture - that are intentionally or unintentionally causing the spread of IAS in the LMB. This will accrue the double benefits of not only harnessing funding but also forcing these organisations into implementing environmentally sound management practices.
- Ensuring the provision, in national budgets, of financial allocations for dealing with IAS.

Pomacea canaliculata in Vietnam © Alvin Lopez

For the long term well-being of both communities and ecosystems of the LMB, it is essential that this strategy addresses not only IAS already present in the LMB, but also the prevention of further infestation and rapid intervention should an infestation occur. Therefore, these two responses are critically important for the management of IAS in the LBM region.

9. Prevent further entry of IAS

Preventing the introduction of an IAS is the simplest, cheapest and most effective method of dealing with IAS (IUCN, 2000). For aquatic systems such as the LMB, prevention is essential, because early detection is not easy and by the time IAS are detected, much damage has already been done. Achieving this will require:

- Encouraging research on potential aquatic invasive alien species and identifying possible pathways and vectors into the LMB. The list of 100 of the World's Worst Invasive Alien Species found in the Global Invasive Species Database will serve as a source of information.
- Developing an evaluation process including a rigorous risk assessment before new introductions are authorised.
- Developing and implementing best practice guidelines, standards and codes of conduct to minimise risks during the introduction of species for aquaculture and horticulture.
- Ensuring that border control and quarantine measures are developed as per Strategy 5 and implemented.

10. Develop an early warning and a rapid response system.

When prevention fails, early warning and a rapid response before IAS spread and significant populations develop is essential. Between entry of an IAS and establishment in a new habitat, there is a short period during which total eradication is still a viable and inexpensive option. Therefore, an early warning system, reporting of potential danger and a quick and concerted response is needed. Achieving this will require:

- Setting up an early warning system that surveys high risk areas such as, inter alia, entry points for travel, trade, disturbed areas and areas identified for development activities such as dams.
- Formulating contingency plants for quick eradication. This plan should have roles and responsibilities clearly allocated, with a streamlined process of authorisation and should be buttressed by legislation. Funds for such activities should be allocated.

11. Monitor routinely

Even if complete eradication of certain IAS species is possible, efforts would be worthless if there is re-infestation. To this end, continuing vigilance with respect to known and potential IAS is essential. Achieving this will require:

- Encouraging monitoring, recording and reporting so that any lessons learned from practical experiences in management of alien invasive species can contribute to the knowledge base.

12. Establish an institutional mechanism at national level to address IAS issues in the LMB countries

At present, institutional mechanisms to address IAS issues in each of the LMB countries is weak, resulting in inadequate coordination and lack of consolidated efforts to manage IAS. Achieving this will require:

- Establishing a steering committee, consisting of key partners (see below) at the national level, to coordinate IAS management activities.

Salvinia sp. © Alvin Lopez

Key partners for dealing with issues related to aquatic IAS in the LMB

A holistic approach in all aspects of dealing with IAS in the LMB is a prerequisite to successful management. To achieve this end, maximum participation at national, regional and international levels is essential. A three tiered approach in recommended: at national, at regional (LMB) and global levels.

Participation at the national level

Participation should include as many stakeholders and relevant sectors as possible. A list of institutions responsible for or peripherally involved in IAS issues in Cambodia, Lao PDR, Thailand and Vietnam is detailed in the IUCN report on the current state of play of IAS in the LMB (IUCN, 2006). Listed below are key players at a national level:

- Local communities
- Ministry of Fisheries
- Ministry of Agriculture
- Ministry of Forestry
- Ministry of Science and Technology
- Ministry of Environment
- Ministry of Trade
- Ministry of Tourism
- Ministry of Shipping
- Departments of Customs and Quarantine
- Departments of Plant protection and Animal Health
- Biology, GIS, environmental economics, sociology and legal specialists from recognised universities. (Some of these are listed in the IUCN report.)
- Companies and corporations in relevant sectors such as, inter alia, those engaged in trade, travel, aquaculture, fisheries, aquarium trade, agriculture, horticulture.

Participation at the Regional Level

- National Focal points identified in Strategy 4.
- The Mekong River Commission.
- Key regional players in Biodiversity Conservation such as the Asian Regional Species Conservation Programme of the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF), Conservation International (CI) and The United Nations Environmental Program (UNEP).
- The Global Invasive Species Programme (GISP).

Participation at the Global Level

- National Focal points identified in Strategy 4.
- Key Global players in Biodiversity Conservation such as the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF), Conservation International (CI) and The United Nations Environmental Program (UNEP).
- The Global Invasive Species Programme (GISP).
- The Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission.

Key resources for dealing with issues related to aquatic IAS in the LMB

The singlemost important resource for dealing with IAS in the LMB will be the Global Invasive Species Database(GISD) (http://www.issg.org/database/). This database 'aims to increase awareness about invasive alien species and to facilitate effective prevention and management activities' (http://www.issg.org/database/). This database focuses on invasive alien species that threaten native biodiversity and covers all taxonomic groups from micro-organisms to animals and plants in all ecosystems and contains information about the ecology, distribution, impacts, management information, references and contact for each species listed. It also contains a list of 100 of the World's Worst Invasive Alien Species (http://www.issg.org/database/).

Pistia stratiotes © Alvin Lopez

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Literature Cited/References

Bambaradeniya, C. N. B. (2005) Management of invasive alien species: an Asian perspective on the way forward. In subtheme Coping with Aliens. In *Proceedings of a Global Synthesis Workshop on Biodiversity Loss and Species extinctions: managing risk in a changing world* convened at the IUCN World Conservation Forum 18-20 November 2004. Bangkok:Thailand

Ciruna, K. A., Meyerson, L. A., Gutierrez , A. (2004) The ecological and socio-economic impacts of invasive alien species in inland water ecosystems. *Report to the Conservation of Biological Diversity on behalf of the Global Invasive Species Program*, Washington Dc. Pp 34

Dian, S. A., Michael, M. R. and C. G. Hanlon (Abstract) (2004). Influence of water level on torpedo grass establishment in Lake Okeechobee, Florida. Lake and Reservoir Management 20(1):1-13.

FAO Integrated Golden Apple Snail Management in Rice project, 1998 http://www.fao.org/News/1998/980410-e.htm

Genovesi, P. and Shine, C. (2003). *European Strategy on Invasive Alien Species.* Report to the Standing Committee, Convention on the Conservation of European Wildlife and Natural Habitats.

IUCN (2006). *Invasive Alien Species in the Lower Mekong Basin:Current State of Play.* Colombo, Sri Lanka: Asia Regional Species Conservation Programme.

IUCN (2005). Biodiversity loss and species extinctions: managing risk in a changing world: synthesis and decision makers' summary. In *Proceedings of a Global Synthesis Workshop on Biodiversity Loss and Species extinctions: managing risk in a changing world* convened at the IUCN World Conservation Forum 18-20 November 2004. Bangkok:Thailand

IUCN (2003) *The Lower Mekong River: International Collaboration for Sustainable Development. IUCN Water and Nature Initiative*.http://www.iucn.org/themes/wani/flow/cases/Mekong.pdf

IUCN (2000) *IUCN guidelines for the prevention of biodiversity loss caused by alien invasive species* http://www.iucn.org/themes/ssc/publications/policy/invasivesEng.htm

Joshi, R. (2005). Managing invasive alien mollusc species in rice. *International Rice Research Notes* 30.2 5-13.

Kaensombath, L. 2005. *Evaluation of the nutritive value of ensiled and fresh Golden Apple snails (Pomacea spp) for growing pigs www.mekarn.org/m*sc2003-05/theses05/content/lamplr.pdf

Lazarus, K., P. Dubeau, C. Bambaradeniya, R. Friend and L. Sylavong. 2006. *An Uncertain Future: Biodiversity and Livelihoods along the Mekong River in Northern Lao PDR*. IUCN, Bangkok, Thailand and Gland, Switzerland, 49pp.

Lower Mekong Basin, 2004. Birdlife International.
http://www.birdlife.org/action/science/species/asia_strategy/pdf_downloads/wetlandsW18.pdf

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-Being: Global Assessment Reports Current State & Trends pp 553-586, Washington DC: Island Press.

McNeely, J. A., Mooney, H. A., Neville, L .E., Scheir, P., and Waage , J. K. (eds) (2001). A Global Strategy on Invasive Alien Species. Gland, Switzerland and Cambridge, UK: IUCN +50 pp.

Matthews, S. (2004). Tropical Asia invaded. The Global Invasive Species Programme

Matthews, S., and Brandt, K (2004). Africa Invaded: The growing danger of invasive alien species Global Invasive Species Programme

Mattson, N. S. (2006) Conservation and enhancement of fisheries – the case of the Lower Mekong Basin. International Journal of Ecology and Environmental Sciences 32(1) 109-117.

Mekong Wetland Biodiversity Programme, 2006. http://www.mekongwetlands.org/Common/download/MWBP-Programme.pdf

Orapa, W. 2004. Chromolaena (Siam) weed.Pest Advisory Leaflet no. 43 .Secretariat of the Pacific Community. ISSN 1017-6276

Pallewatta, N., J.K. Reaser, and A.T. Gutierrez. (eds.). 2003. Invasive Alien Species in South- Southeast Asia: National Reports & Directory of Resources. Global Invasive Species Programme, Cape Town, South Africa.

Sala, O. E. and eighteen others (2000) Global biodiversity scenarios for the year 2100. Science 287: 1770-1774.

Stokes, K .E. , O'Neill, K. P., Momtgomery, W. I., Dick, J. T. A., Maggs, C. A., and MacDonald, R. A. (2006). The importance of stakeholder engagement in invasive species management: a cross-jurisdictional perspective in Ireland. Biodiversity Conservation 15: 2829-2852.

Triet, T (2005). Impacts of Mimosa pigra on wetlands of the lower Mekong Basin. In subtheme Coping with Aliens. In Proceedings of a Global Synthesis Workshop on Biodiversity Loss and Species extinctions: managing risk in a changing world convened at the IUCN World Conservation Forum 18-20 November 2004. Bangkok:Thailand.

Triet, T., Le Cong Kiet, Nguyen Thi Lan Thi, Pham Quoc Dan (2004). The invasion of Mimosa pigra in wetlands of the Mekong Delta, Vietnam. Pp 45-51 in M. Julien, G. Flangan, T. Heard, B. Hennecke, Q. Paynter and C. Wilson (eds) Research and management of Mimosa pigra, Canberra: CSIRO, Entomology.

Triet, T (2000) Alien invasive plants of the Mekong Delta: an overview. Pp 96-104 in P. Balakrishna (ed) Report on the workshop on alien invasive species. Global Biodiversity Forum, South and Southasia session. Colombo, Sri Lanka: Regional Biodiversity Programme, IUCN.

www.itdg.org/docs/technical_information_service/water_hyacinth_control.pdf -

P.canaliculata eggs and *Pistia stratiotes* in Vietnam © Alvin Lopez

Annex 1. List of IAS in the LMB. (Source IUCN, 2006.) (with additional information from Tran Triet)

Common name	Species name	Country
Flora		
Alligatorweed	*Alternanthera philoxeroides*	Thailand
Barnyard Grass	*Echinochloa crusgalli*	Cambodia, Lao PDR, Thailand, Vietnam
Croftonweed	*Ageratina adenophora*	Lao PDR, Thailand
Giant Mimosa	*Mimosa pigra*	Vietnam, Cambodia, Lao PDR, Thailand
Giant Water Fern	*Salvinia molesta*	Thailand, Vietnam
Mauritius Grass	*Brachiaria mutica*	Thailand, Cambodia, Lao PDR, Vietnam
Mile-a-minute	*Mikania micrantha*	Lao PDR, Thailand, Vietnam
Siam Weed	*Chromolaena odorata*	Vietnam, Cambodia, Lao PDR, Thailand
Swamp Grass	*Echinochloa colonum*	Lao PDR, Thailand, Cambodia, Vietnam
Torpedo Grass, Victoria Grass	*Panicum repens*	Vietnam, Cambodia, Thailand, Lao PDR
Velvetleaf, Yellow Bur-head	*Limnocharis flava*	Thailand, Lao PDR, Cambodia, Vietnam
Water Hyacinth	*Eichhornia crassipes*	Vietnam, Cambodia, Lao PDR, Thailand
Water Lettuce	*Pistia stratiotes*	Vietnam, Cambodia, Lao PDR, Thailand
Mission Grass	*Pennisetum polytachyon*	Vietnam, Cambodia, Lao PDR, Thailand
Fauna		
Bighead Carp	*Aristichthys nobilis*	Vietnam, Cambodia, Lao PDR, Thailand
Common Carp	*Cyprinus carpio*	Vietnam, Cambodia, Lao PDR, Thailand
Giant African Snail	*Achatina fulica*	Thailand
Golden Apple Snail	*Pomacea canaliculata*	Vietnam, Cambodia, Lao PDR, Thailand
Goldfish	*Carassius auratus*	Vietnam, Thailand
Mosquito Fish	*Gambusia affinis*	Thailand, Vietnam, Cambodia, Lao PDR
Nile Perch	*Latus niloticus*	Thailand
Nutria	*Myocastor coypus*	Vietnam, Thailand
Rainbow Trout	*Oncorhynchus mykiss*	Thailand
Red-eared Slider Terrapin	*Trachemys scripta elegans*	Vietnam, Thailand
Rosy Wolf Snail	*Euglandina rosea*	Thailand
Silver Carp	*Hypophthalmichthys molitrix*	Vietnam, Lao PDR, Thailand
Sucker mouth Catfish	*Hypotenuse spp.*	Vietnam
Tilapia	*Oreochromis spp.*	Vietnam, Cambodia
Walking Catfish	*Clarius batrachus*	Thailand

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The Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme (MWBP) is a joint programme of the four riparian governments of the lower Mekong basin – Cambodia, Lao PDR, Thailand and Vietnam – managed by the United Nations Development Programme (UNDP), the World Conservation Union (IUCN), and the Mekong River Commission (MRC), in collaboration with other key stakeholders. With funding from the Global Environmental Facility (GEF), UNDP, the Royal Netherlands Government, MRC, the Water and Nature Initiative (WANI) and other donors, the programme tries to address the most critical issues for the conservation and sustainable resources in the Mekong wetlands.

The programme aims to strengthen the capacity of organisations and people to develop sustainable livelihoods and manage wetland resources wisely.

The World Conservation Union in Asia

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The IUCN Asia region covers 23 countries, stretching from Pakistan in the West to Japan in the East, Indonesia in the South to Mongolia in the North. The World Conservation Union maintains offices in Bangladesh, Cambodia, China, Lao PDR, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam. The Asia Regional Office is in Bangkok, Thailand.

IUCN's seven thematic programmes, collectively known as the Ecosystems and Livelihoods Group (ELG) are based in two clusters: one in Colombo, Sri Lanka (environmental economics, marine and coastal, species) and one in Bangkok, Thailand (environmental law, forests, protected areas, wetlands and water resources).

Photography of the cover:
Water hyacinth in Vientiane city

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