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Proceedings of the Regional Seminar-Workshop on Harmonizing Methods in Risk Assessment and Management of Forest Invasive Alien Plant Species in Southeast Asia

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Photo Caption : *Bartlettina sordida (Eupatorium sordidum)* and *Piper aduncum L.*
Source : SEAMEO BIOTROP Herbarium

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LIST OF ABBREVIATIONS

ACB	ASEAN Centre for Biodiversity
ASEAN	Association of Southeast Asian Nations
CABI	Commonwealth Agricultural Bureaux International
CBD	Convention on Biological Diversity
CCRRD	Center for Conservation and Rehabilitation Research and Development
CSIRO	Commonwealth Scientific and Industrial Research Organization
GBO	Global Biodiversity Outlook
GEF	Global Environmental Fund
FAO	Food and Agriculture Organization of the United Nations
FIAPS	Forest Invasive Alien Plant Species
FORDA	Forest Research and Development Agency
IAS	Invasive Alien Species
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
NBSAP	National Biodiversity Strategies and Action Plan
NISSAP	National Invasive Species Strategies and Action Plan
PRA	Pest Risk Analysis
SEAMEO BIOTROP	SEAMEO Regional Centre for Tropical Biology
UNEP	United Nations Environmental Program
WRA	Weed Risk Assessment
WRM	Weed Risk Management
WTO	World Trade Organization

PREFACE

Invasion of alien species is not new in Southeast Asia and elsewhere in the world considering that it occurs across national borders and regions brought about by trade and travel activities. The concern for invasive alien species (IAS) in the recent years, however, has become more imminent due to the greater volume and the faster rate at which they are spreading, and the alarming impacts they have created to natural ecosystems, economy, and human health. In fact in 2011, the Convention on Biological Diversity (CBD) included reduction of threats from IAS as among the Aichi Biodiversity Targets. The CBD hopes that by 2020, IAS and their pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment. Such target presents a big challenge to Southeast Asia as the region expects to achieve economic integration under the ASEAN Economic Community starting in 2015 which will allow for an open market system resulting in more frequent export and transportation of biological products. Effective implementation of pre- and post-border control measures in line with international standards is thus crucial in this situation to reduce the introduction of potential IAS. This also calls for increased collaborative efforts among countries in the region.

With this background, the SEAMEO Regional Centre for Tropical Biology (BIOTROP) and the United Nations Food and Agriculture Organization (FAO) co-organized a Regional Seminar-Workshop on Harmonizing Approaches to Risk Assessment and Management of Forest Invasive Alien Plant Species in Southeast Asia in Bogor, Indonesia on 2-5 December 2014. The seminar-workshop was attended by 28 participants from Bhutan, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Thailand, and Viet Nam, and eight resource persons and facilitators from international, regional, and national institutions based in Canada, Italy, Australia, Japan, and Indonesia to discuss and come up with recommendations on the subject matter. The seminar-workshop focused on forest invasive plant species considering that Southeast Asia's forests are becoming very susceptible to plant invasions due to various human disturbances. The event could be considered as a timely effort to articulate the need for countries in the region to work harmoniously, in support of the ASEAN Economic Community, to effectively assess and manage the risks of forest invasive alien plant species.

This publication contains the summary of presentations on current global protocols, guidelines, and specific country experiences in risk assessment and management of invasive alien species, and a comparative analysis of the available information gathered from the country reports of the participants. Although the country reports may not be comprehensive enough, they have nevertheless provided an overview of the successes gained and challenges besetting the participating countries as regards controlling and managing invasive alien plant species. Highlights of group workshop discussions on the current general and specific gaps in the risk analysis process including proposed solutions to address these gaps are also presented in this book. More importantly, it also provides the general recommendations agreed upon by the participants and resource persons on the seminar-workshop topic. Full papers of some of the resource persons' presentations and participants' country reports are also included as Appendices.

It is hoped that this publication contributes to ongoing and future efforts towards developing appropriate research and capacity building activities as well as advocacies to create more awareness among governments, scientific communities, and the general public on the importance of controlling and managing forest invasive alien plant species within and among countries in Southeast Asia.

SEAMEO BIOTROP and FAO would like to acknowledge the support extended by the Convention on Biological Diversity (CBD) Secretariat, the Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, CABI, the National Institute for Agro-Environmental Sciences of Japan, and the Ministry of Forestry of Indonesia in the conduct of the seminar-workshop in terms of providing resource persons and subsidies for attendance of participants. Likewise, the organizers wish to thank all the participants and resource persons for their valuable contributions that made it possible to produce this publication.

Dr. Hiroyuki Konuma
Assistant Director-General and Regional Representative
Food and Agriculture Organization of the United Nations

Dr. Irdika Mansur
Director
SEAMEO Regional Centre for Tropical Biology

SEMINAR-WORKSHOP RECOMMENDATIONS

Based on the resource persons' presentations, participants' country reports, small group workshop outputs, and plenary discussions, the seminar-workshop generated the following recommendations to further the implementation of a more harmonized and effective risk analysis of forest invasive alien plant species in Southeast Asia:

1. In collaboration with UN agencies and other relevant international and regional organizations, develop a region-wide long-term (i.e. graduate study and fellowship programs) and short-term (i.e. training, seminar workshops, policy dialogues, etc.) capacity building programs to improve individual and institutional capabilities to address gaps in implementing risk analysis for forest invasive alien plant species.
2. Enhance the awareness and implementation of National Invasive Species Strategies and Action Plan (NISSAP) as part of National Biodiversity Strategies and Action Plan (NBSAP) among relevant stakeholders.
3. Enhance the awareness and implementation of existing international standards (i.e. International Standards for PhytosanitaryMeasures-ISPMs, FAO procedures for post-border weed risk assessment, etc.) in collaboration with relevant parties.
4. Develop program/project research proposals in collaboration with other relevant institutions at both national and regional levels towards addressing gaps in risk analysis of forest invasive alien plant species (i.e. from goal setting and hazard identification, risk assessment, risk management, and risk communication) which are aligned with NISSAPs and NBSAPs.
5. Develop communication materials and policy instruments to improve public and decision makers' awareness and action on helping to understand the importance of preventing the spread and establishment of forest invasive alien plant species and their economic, social and environmental impacts.
6. Mainstream invasive alien species as a subject matter in all education levels where appropriate.
7. Review existing invasive alien species (IAS) networks and databases both regionally and globally on sharing and utilizing forest invasive alien plant species (FIAPS) information and affiliate where necessary in order to enhance knowledge sharing and understanding of international and regional trends for application at national level.

1. Background

1.1 Seminar-Workshop Rationale

The rapidly accelerating trade and travel through various forms of modern transportation have allowed both intentional and unintentional movements of plant and animal species between different parts of the globe, often resulting to unexpected and sometimes disastrous consequences. Invasive alien species (IAS) are regarded as one of the leading threats to natural ecosystems and biodiversity considering their numerous effects that are usually irreversible. They also impose great impacts on agriculture, forestry, and fisheries, as well as human health.

A recent study estimated that Southeast Asia incurs a conservative total annual loss of US$33.5 billion caused by IAS to agriculture, forestry, human health and the environment (Nghiem LTP, Soliman T, Yeo DCJ, Tan HTW, Evans TA, *et al.* 2013). Of this amount, about ninety percent was attributed as losses and costs to the agricultural and forest sectors while the rest were associated with human health and the environment. By 2015, the region is expected to achieve the ASEAN Economic Community which allows for an open market system and thus more frequent export and transportation of biological products. Such system is expected to increase problems associated with IAS unless effective methods for risk analysis, which scrutinizes the potential characteristics of a species to be invasive and identifies the feasibilities for managing them, are in place.

Management of IAS is the ninth Aichi Biodiversity Target of the Convention on Biological Diversity (CBD). By 2020, the CBD hopes that IAS and their pathways are identified and prioritized, priority species are controlled or eradicated, and measures are in place to manage pathways to prevent their introduction and establishment. Risk analysis plays a significant role in realizing this Target as well as in reducing the potential damages of IAS to global economy, health, and the environment.

To ensure international action towards protection of plants including forest tree species from IAS under the International Plant Protection Convention (IPPC), three international standards on pest risk analysis (PRA) have been developed and adopted by 176 member countries. These standards describe the integrated processes to be used for risk assessment as well as the selection of risk management options. Adoption of these standards in ASEAN countries has been slow and inconsistent due to poor co-operation between agencies and countries. It is therefore important to ensure that reliable methods and approaches in pre- and post-border risk analysis of IAS align with international standards exist in a harmonious way among countries in the region.

1.2 Seminar-Workshop Design

Objectives

The seminar-workshop was generally aimed to bring about consensus among participants in adopting a more harmonized approach to risk analysis of forest invasive alien plant species (FIAPS) in Southeast Asia.

The seminar-workshop's specific objectives were to:

1. Update the list of FIAPS that are found in the region
2. Identify and level off the gaps in regional capacities for risk analysis and management of FIAPS
3. Compile good practices in risk analysis and management of FIAPS which are aligned with International standards
4. Come up with a priority list of areas of concern on risk analysis of FIAPS needing further research and capacity building that could be undertaken collaboratively between and among countries in the region
5. Develop a mechanism for effective networking and regular sharing of information and expertise on risk analysis and management of IAPS in the region

Expected Outputs

The seminar-workshop was expected to produce the following outputs:

1. Updated list of FIAPS by country
2. Compilation of good practices and gaps in risk analysis of FIAPS
3. Recommendations for a more harmonized approaches to risk analysis of FIAPS
4. List of research and capacity building needs on risk analysis of FIAPS
5. Draft mechanism for networking and information exchange on risk analysis of FIAPS
6. Seminar-workshop Proceedings

Structure and Approach

The seminar-workshop was held on 2-5 December 2014 at SEAMEO BIOTROP headquarter in Bogor, Indonesia. The program of activities consisted of plenary lecture-discussions with invited resource persons, country report presentations by participants, and small group and plenary workshops.

A day before the start of the seminar-workshop, a meeting was held among the resource persons to ensure a smooth flow of the activities and avoid overlaps on the scope of topics that they will present. Appendix A contains the details of the revised program of the seminar-workshop.

Participants and Resource Persons

Twenty-eight researchers, mid-level officers, university lecturers, and post-graduate student comprised the seminar-workshop participants representing Bhutan (1), Indonesia (19), Lao PDR (1), Malaysia (1), Myanmar (1), Philippines (2), Thailand (1), and Viet Nam (2). Timor Leste and Cambodia were invited to participate in the seminar-workshop but the former did not nominate a representative while the latter's nominee eventually backed out due to important office concerns. Appendix B contains the names and organizational affiliations of the participants.

Resource persons and facilitators were drawn from international, regional, national institutions engaged in biodiversity conservation and risk analysis of invasive alien species. Appendix C lists the names and organizational affiliations of the resource persons.

2. Presentations and Discussions

2.1 Opening Speeches

Welcome Remarks
from Prof. Dr. Bambang Purwantara
SEAMEO BIOTROP Director

Assalamu'alaikum Wr. Wb. Good morning, Ladies and Gentlemen.

First of all, on behalf of our Centre, I would like to extend my cordial welcome to all of you in this important seminar-workshop on Harmonizing Approaches in Risk Assessment and Management of Forest Invasive Plant Species in Southeast Asia which we are hosting in our campus here in Bogor. Allow me also to publicly acknowledge and thank the UN Food and Agriculture Organization for co-organizing this regional seminar workshop together with the support from the Convention on Biological Diversity (CBD), Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia, CABI, and the Ministry of Forestry of Indonesia.

You may already know that BIOTROP is one of the 21 centres of excellence of the Southeast Asian Ministers of Education Organization or SEAMEO which is based in Bangkok, Thailand. We are now operating under our 9th Five-Year Development Plan (2012-2017) with a vision of becoming "A Leading Centre in Promoting and Enhancing the Real Values of Tropical Biology in Southeast Asia." This regional seminar-workshop falls under our Centre's two program thrusts on tropical biology for community welfare and environmental integrity considering the impacts of invasive alien species on biodiversity, human health, and the overall socio-economic development of countries in our region. In support of and in anticipation of the demands towards achieving the ASEAN Economic Community, we thought that this seminar workshop is very timely and relevant so that our respective countries can optimize efforts and resources together to overcome invasive species problems for our mutual benefits.

This regional seminar-workshop will focus on forest invasive plant species because we reckon that forests in our region have been experiencing a considerable disturbance and becoming very susceptible to plant invasions. We either have similar or different invasive plant species in our forests which could be attributable to past conditions and the pathways through which they have entered our forests. We could also say that the impacts created by these invasive plant species to the ecosystem, economy, and human health in our respective countries may vary from each other. For example in Indonesia, we are facing big problems now with the invasion of *Chimonobambusa quadrangularis* and *Cestrum aurantiacum* in our submontane and montane forests. You may not be experiencing the same in your respective countries now but there is a big possibility that you will once these species are introduced because you also have submontane or montane forests. Thus, there is an urgent need to anticipate such possible invasion by cooperating together to harmonize our risk analysis method to ensure that any invasive plant species existing in one country will not be transported to another country.

Risk analysis methods are plenty, from the most simple to the more sophisticated ones. We are lucky in this seminar workshop to have experts and practitioners on risk analysis of invasive plant species from Australia, New Zealand, Japan, FAO, and CBD. I sincerely hope that we will get sufficient guidance from them to enable us to develop a more harmonized method in risk analysis in Southeast Asia to benefit our region and other countries that we transact business with.

I encourage all country participants to also share their experiences, especially their challenges, on the subject matter to enable us to generate appropriate recommendations for future research and capacity building activities as outputs of this seminar-workshop.

I wish you a productive seminar-workshop. Thank you. Wassalamu'alaikum wr.wb.

Message
from Dr Shiroma Sathyapala,
Forestry Department
on behalf of the Food and Agriculture Organization of the United Nations (FAO)

Distinguished delegates, Officials and staff of SEAMEO BIOTROP, Ladies and Gentlemen,

It is my great honor to address you on behalf of FAO at this significant Seminar-Workshop on "Harmonizing Methods in Risk Assessment and Management of Forest Invasive Plant Species in South East Asia" here at SEAMEO BIOTROP.

First, I would like to take this opportunity to thank the SEAMEO BIOTROP for agreeing to host this event in this beautiful region rich in biodiversity. My thanks go also to members of Asia Pacific Forest Invasive Species Network for their cooperation with SEAMEO BIOTROP.

Before outlining the topics and challenges we will discuss during the next two days, I would like to say a few words about FAO's work in invasive alien species.

The Asian region is one of the world's biodiversity hotspots. Its mosaic of forest landscapes contributes greatly to the outstanding biological richness and multiple values contribute to poverty alleviation, socio-economic development of rural areas, food security of local people and the preservation of the multiple environmental services considered of major importance to the international community.

FAO's work is focused on five strategic objectives and on maintaining the high standards of our normative work. As a centre of excellence, FAO is committed to make available knowledge and best practices to promote the sustainable management of natural resources.

It is significant to protect the biodiversity of forests from pests and ensure that forests can "adapt to changing environmental conditions, including those stemming from climate change."

Timely responses to combat issues in invasive species in forestry in this region are required to ensure sustainable management of forest ecosystems in the coming decade. Only a collective mobilization and cooperation of all stakeholders involved in the management of forest ecosystems will overcome these challenges. The Asia Pacific Forest Invasive Species Network supported by FAO has been working at regional level and is one important tool and cooperation mechanism that is indispensable to overcome the challenges faced by Southeast Asian forest ecosystems today. FAO has several initiatives in managing invasive species in the region.

I think it is necessary to put more efforts to raise awareness of the importance of biodiversity and to control invasive species, as well as the development of national and regional programs such as this seminar-workshop to ensure the availability of expertise in the region.

I believe that this seminar-workshop will help to improve the application of best practices in managing forest invasive plant species in Southeast Asia and globally. I wish you a successful seminar-workshop.

Message
from Mr. Braulio Ferreira de Souza Dias
Executive Secretary of the Convention on Biological Diversity
(as delivered by Dr. Junko Shimura)

Distinguished delegates, Fellow scientists at the SEAMEO BIOTROP, Ladies and Gentlemen,

It gives me great pleasure to address you on the occasion of this important seminar-workshop on "Harmonizing Methods in Risk Assessment and Management of Forest Invasive Alien Plant Species in Southeast Asia" at the SEAMEO BIOTROP.

In October 2014 at its twelfth meeting in Pyeongchang, Republic of Korea, the Conference of the Parties to the Convention on Biological Diversity reviewed the progress on the implementation of the Strategic Plan for Biodiversity 2011-2020. This mid-term assessment of progress was underpinned by the fourth edition of Global Biodiversity Outlook (GBO4) in brief. I would like to express my sincere gratitude to all scientists and practitioners, including many of you here, who provided up-to-date information and thereby contributed to GBO4 and its underlying technical reports.

GBO4 informs us that reversing the threat from invasive alien species is often feasible and effective as evidenced by a growing number of eradications, particularly from islands. However, the overall rate of invasions, with great economic and ecological costs, shows no sign of slowing. Increased efforts to identify and control the main pathways responsible for species invasions are therefore crucial. Among these are the development of effective border control or quarantine measures to reduce the likelihood of potentially invasive alien species being introduced, and making full use of risk analysis and risk management approaches in line with international standards and tested national approaches.

Ladies and Gentlemen,

I am pleased to note that Southeast Asia has already gathered experiences in reducing ecological impacts of invasive alien species. You may recall that *Acacia nilotica*, the gum Arabic tree, was planted in Bogor Botanical Garden in the 1800s from where it escaped. It was intentionally planted as fire breaks in some national parks which provide the habitat of an ironic native species, *Bos javanicus*, commonly called Banteng. The tree spread within a few decades to dominate some 10,000 ha of Baluran National Park of Indonesia and thereby destroyed more than a half of the native savanna upon which the threatened Banteng population depends.

The GEF funded project, "Removing the barrier to invasive alien species management in production and protection forest in Southeast Asia" controlled the spread of *Acacia nilotica* by using integrated measures with mechanical, chemical and with biocontrol agent that was proven to be safe for the native plant community. Thanks to the governments in the region, The United Nations Environmental Programme, CABI and other partners, we have learned from the successful international efforts that risk assessment prior to introduction of biocontrol agents played a critical role in the Baluran National Park management success. With such good practices and experiences in the region I hope that this meeting will lead to concrete outcomes on applying comprehensive risk assessment methodologies and management options that support decision making on national legislation, border controls and the best applicable risk manner it would be most effective to systematically apply already existing approaches, including the international standard, "Pest risk analysis for quarantine pest including environmental risks and living modified organism" established under the International Plant Protection Convention, especially where plant protection is concerned.

With regard to the conservation and sustainable use of biodiversity and ecosystem services, the recent publication on Plant Invasions in Protected Areas-Patterns, Problems, and Challenges showed climate change, habitat fragmentation, and landscape change influence the probability of establishment and spread of alien species. Thanks to the authors and the publisher, an electronic version of the book has been made available to the public for a limited time and is still available for download from the CBD invasive alien species web site.

Needless to say that scientific collaboration between the sectors for plant pest management and the environment is needed more than ever. The more invasion biology experts actively contribute to these developments the greater

the chance we have that effective risk assessment and risk management methodologies are available and applied where they are needed.

I am fully convinced that your seminar-workshop will help to mobilize information on best practices in Southeast Asia and elsewhere and that such information will be fed into the global process of developing new and essential tools to deal with biological invasions. Your expertise is vital in conserving biodiversity in places of cultural or historical importance, such as Baluran National Park.

I wish you a successful seminar-workshop and I look forward to receiving outputs of this timely and important gathering as it supports parties in the ASEAN region and beyond to achieve Aichi Biodiversity Target 9 on invasive alien species, while contributing to other related targets of the Strategic Plan for Biodiversity and of the Global Strategy for Plant Conservation.

Thank you.

Opening Remarks
from Dr. Ir. San Afri Awang, MSc.
Director General of the Forest Research and Development Agency
Ministry of Forestry, Indonesia
(as delivered by Ir. Adi Susmianto, M.Sc)

Assalamu'alaikum Warahmatullahi Wabarakatuh,

Director of BIOTROP, distinguished guests, participants, resource persons, ladies and gentlemen,

First of all, I would like to welcome you all to Bogor City. I hope you are all in good condition and already enjoying your stay here for this important seminar-workshop jointly organized by SEAMEO BIOTROP, the UN FAO and the Forest Research and Development Agency (FORDA) of the Ministry of Forestry of Indonesia.

The presence of invasive alien species (IAS) in various ecosystems, including forest ecosystems, has caused detrimental effects to the environment, economy, and human beings in most countries in Southeast Asia. In Indonesia alone, almost 50% of the country's National Parks have been suffering from IAS. However, our respective governments, especially Indonesia, seem to be putting little attention to control and eradicate IAS compared to climate change issues. There are also limited public policies, regulations, and protocols on controlling and managing IAS. When I attended the Asia-Pacific Rainforest Summit in Sydney on 11-12 November 2014, there was no single expert, international institution or participating country, except Indonesia, that brought up the IAS issues despite the fact that the theme of the summit was "how to slow the loss of rainforest in Asia-Pacific region".

We are also fully aware that IAS now is becoming the second biggest threat to biodiversity loss after anthropogenic habitat destruction. Therefore, the Conference of Parties (COP) 10 in Japan clearly included Aichi Target No. 9 which specifically mandates member countries to prevent the introduction of IAS from damaging our natural biodiversity. Since then, Indonesia's Ministry of Environment and Forestry paid serious attention on this especially in forest conservation areas.

Since 2012, Indonesia's Center for Conservation and Rehabilitation Research and Development (CCRRD-FORDA) in collaboration with the UN Environmental Program (UNEP) received the Global Environmental Fund (GEF) to execute a 4-year regional project to manage IAS together with Viet Nam, Cambodia and the Philippines. Capacity and awareness building, formulating regulations and code of practices in controlling invasive species through collaboration with relevant institutions and stakeholders, including the development of risk analysis procedures for forest IAS, are among of the programs and activities to be addressed during the course of the project.

We have observed through the years that trading and international traveling are generally the main sources or trigger of IAS introduction. However, information on pathways has not been accurately identified yet. A number of exotic species that has been introduced to Indonesia has not been showing invasiveness yet, which indicates that invasion rates vary. Among the characters of invasiveness are the presence of internal change of human attitude within the invaded area, and many others. Rate of species establishment indicates that unintentional introduction remains as an important factor in IAS development.

Almost all plant and animal species have been introduced intentionally for various purposes such as for ornamental, circus and zoo, pet, ornamental fish and fishing pond. Meanwhile, the introduction of most invertebrate species including marine organism and microbes - commonly done unintentionally - existed by means of sticking to other species which is intentionally introduced. In this case, weed often carried as dirt sticking on imported seed, while ornamental plants tht later becoming weed, was firstly introduced unintentionally for ornament. Soil stabilization, firewood, and others may be brought in unintentionally during human aid program or during trading business. For example, *Eichornia crassipes* or water hyacinth, which is regarded as a major invasive species and become problematic in many places in Indonesia, was firstly introduced as ornamental plants.

IAS causes environmental damages including habitat fragmentation and decreasing wildlife population. In forestry, some species for forest plantation were exotic or introduced from other places, such as *Acacia mangium*,

A. crassicarpa and *Eucalyptus* spp. Undeniably, this monoculture forest plantation often brings serious problems because plantation companies do not prepare protocol on how to control the IAS properly. The planted species often do not have natural enemies and once outbreaks of pests and diseases arise, introduction of biological enemies from its origin should be considered. In agriculture, this effort is regarded as relatively successful and able to reduce economic loss significantly. In forestry, we have not done this yet, although similar problems are happening.

One of the approaches to prevent rapid spread of IAS is the implementation of Risk Analysis procedures for pre-, at, and post-border. Such procedures have long been implemented by Quarantine Agencies of the Ministry of Agriculture and Ministry of Fishery and Marine Affair of Indonesia that mostly dealt with exotic species. To avoid the unforeseen event where IAS may cause to biological and environmental impacts, regulatory authorities have a statutory responsibility to ensure that all plant taxa proposed to be imported, which are not already prohibited and are not already established, be evaluated for their possible invasiveness. It is important, therefore, to be able to predict the invasiveness of thousands of new potential entries.

To ensure international action towards protection of plants including forest tree species from IAS under the International Plant Protection Convention (IPPC), three international standards on pest risk analysis (PRA) have been developed and adopted by 176 member countries. These standards describe the integrated processes to be used for risk assessment as well as the selection of risk management options. Adoption of these standards in ASEAN countries has been slow and inconsistent due to poor co-operation between agencies and countries. It is therefore important to have reliable methods and approaches in pre-and post-border risk analysis of IAS which are aligned with international standards in a harmonious way among countries in the region.

I am happy to note that this seminar-workshop is aimed to bring about consensus among participants in adopting a more harmonized approach to risk analysis of forest invasive alien plant species (FIAPS) in Southeast Asia. I hope that functional linkages and collaborations among the countries represented in this event could be established in terms of sharing information and expertise with regard to the adoption of risk analysis methods and possibility of developing robust standards to produce reliable tools for prevention of IAS spread.

Finally, may God Almighty bless us with a successful seminar-workshop to be held here in BIOTROP complex from today on the 2nd until the 5th of December 2014. Please take all opportunities to acquire valuable knowledge and information from the resource persons and with co-participants on the subject matter. With that, I declare the meeting is officially opened.

Wassalamualaikum wr.wb.

2.2 Highlights of Papers Presented

2.2.1 Current Global Protocols and Initiatives in Biodiversity Conservation with Special Focus on IAS Control and Management

by Dr. Junko Shimura
Program Officer for Invasive Alien Species and Global Taxonomy Initiative, CBD Secretariat

Dr. Junko shared the following information:

- Definition of terms: alien species, invasive species, invasive alien species
- Evolution of the global interest on IAS from pests in 1920s to trade agreement (i.e. sanitary and phytosanitary measures) in the 1990s
- CBD's guidelines on IAS specifically Article 8h which is legally binding among member parties of CBD thus needs to be translated at the national policy for implementation
- Article 6 of the CBD Guidelines on National Biodiversity Strategies and Action Plans and Article 14-1a on Impact Assessment and Minimizing Adverse Impacts
- WTO SPS regulations concerning IAS and Pest Analysis of International Standards for Phytosanitary Measures (ISPM), OIE's Guidelines for assessing the risk of non-native animals becoming invasive which is considered under the WTO as equal to OIE standards
- CBD's Aichi Biodiversity Target 9: identification of target species, their pathways and ways to control and eradicate them; managing pathways to prevent their introduction and establishment
- Actions needed to be taken: (1) identify and control the main pathways responsible for species invasions; (2) develop border control or quarantine measures to reduce the likelihood of potentially IAS being introduced, and making full use of risk analysis and international standards
- Importance of information sharing and partnership for risk assessment (i.e. Global IAS Information Partnership and GEF 6 Program 4 on prevention, control or eradication of IAS)
- Global Environment Fund (GEF) priority on islands, prevention, pathway risk management and integrated invasive alien species control including biocontrol and the existing of National Biodiversity Strategies and Action Plans

2.2.2 Implementation of International Standards for Phytosanitary Measures (ISPMs) on Pest Risk Analysis (PRA) on Forest Pests

by Dr. Shiroma Sathyapala
Forestry Officer (Forest Protection and Health), FAO

Healthy forests are essential for sustainable forest management, yet today forests are subject to a number of biotic and abiotic threats including invasive species that can cause tree mortality or reduce their ability to provide a full range of goods and services. Increasingly, an additional and more severe threat has been affecting the forest sector worldwide - invasive species. Invasive species are any species that are non-native to a particular ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health. FAO's forest protection and health program aims to safeguard the health and vitality of forests, forest ecosystems, and trees outside forests with special reference to insects, diseases and woody invasive species

Forest health Web site is available at: www.fao.org/forestry/pests

Invasive species Web site at: www.fao.org/forestry/aliens/en/

With increasing global trade, new challenges emerge due to the increased frequency of international pest movement. In the last decade, several pests have been introduced into other countries and continents through international trade, and these have contributed to the international recognition of the importance of implementation of phytosanitary measures.

The International Plant Protection Convention (IPPC) is an international treaty to secure action to prevent the spread and introduction of pests of plants and plant products, and to promote appropriate measures for their control. The IPPC is governed by the Commission on Phytosanitary Measures (CPM) which adopts International Standards for Phytosanitary Measures (ISPMs). These standards are developed and approved through an international consultative process, and are recognized under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures. ISPMs provide guidance that is broadly applicable for forest health, monitoring, the safe transfer of germplasm, pest risk assessments and trade in trees and forest products.

FAO, using an integrated approach to deal with forest health problems, has produced the Guide to implementation of phytosanitary standards in forestry that provides easy to understand information to help protect the forests from pests. The Guide interprets the standards relevant to international forestry pest risks into the language and framework of forest health, outlining how generic principles, such as pest risk analysis and surveillance, can be applied by forest health agencies and forest managers at all levels. It focuses on the practical application of the standards in the forest sector.

Website for the Guide to implementation of phytosanitary standards in forestry is http://www.fao.org/forestry/foresthealthguide/en/

The ISPMs related pest risk analyses are: (1) Framework for pest risk analysis (ISPM No. 02); (2) Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms (ISPM No. 03); (3) Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms (ISPM No. 11); and (4) Pest risk analysis for regulated non-quarantine pests (ISPM No. 21). The ISPMs website is https://www.ippc.int/en/

The risk terminology varies with sectors, however, risk analysis is commonly recognized as having three components: risk assessment, risk management, and risk communication. In the context of IPPC, Pest Risk Analysis (PRA) consists of three stages: initiating the process for analyzing risk, assessing pest risk, and managing pest risk. The risk communication is embedded in all three stages. The ISPM 5 defines pest risk analysis as "The process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it" [FAO 1995; revised IPPC 1997].

Risk analysis of invasive alien species is a challenge in many ASEAN countries as there is still a lack of qualified staff, services, facilities and funds earmarked for management of invasive species. In addition, incomplete knowledge of native flora and fauna and the availability of reliable information on identification, distribution, biology, ecology, and control of important forest pests is another major concern in the region. Information sharing and collaborative studies are necessary in the planning and implementation of strategies for management of invasive alien species.

2.2.3 IAS Science-Based Approaches in the International Policy Context

by Dr. Andy Sheppard
Research Director, Biosecurity Flagship, CSIRO Australia

Dr. Sheppard discussed the following:

- Review of global health, environmental, and economic impacts of IAS
- Massive increase in IAS Research and Development and policy development with little evidence of improved impact prevention or management
- Key pillars of a policy on IAS:
  - (a) Regulation of trade/import/possession/release;
  - (b) Prevention: pathway management, early warning, rapid response, eradication;
  - (c) Management: strategies to reduce impacts;

(d) Data Access: reporting system, follow up; and

(e) Communication: public awareness and involvement of key stakeholders

- Effectiveness of eradication policies and management high (86%) but mainly vertebrate eradications using baits on islands not weeds
- Country specific listing systems need to be considered and adopted where workable:
  (a) White list approach (i.e. species allowed to come into a country) and
  (b) Black list approach (species that are banned for entry in a country)
- Challenges in IAS science-based approaches in the international policy:
  (a) Misconceptions about differences between exotic species and truly invasive species;
  (b) Likely need for assisted migration for rate and threatened species under climate change;
  (c) We may need novel ecosystems for novel climates;
  (d) Societal general ambivalences towards exotic organism as IAS has not yet achieved normal socialization and thus having problems in its managements
  (e) Global community still only waking up to the impacts of invasive species
  (f) International policy options are developing - but still not a priority in global sustainability priorities
  (g) Need a science-basis to international policy for IAS
  (h) Need better science based evidence for direct & indirect impacts
  (i) Need science-based and cost-effective solutions to the reduction of threats and impacts

2.2.4 BIOTROP's Research Experiences in IAPS Risk Analysis in Mt Gede Pangrango National Park

by Dr. Sukisman Tjitrosoedirdjo
Affiliate Scientist, SEAMEO BIOTROP
(Full paper as Appendix D1)

Gunung Gede Pangrango National Park is a protected primary forest located at the center of twin volcanoes i.e. Mount Gede (2,958 m) and Mount Pangrango (3,019 m) in West Java, Indonesia. The park covers about 24,000 ha of forest hills to submontane, montane, and subalpine zones, forming a very important water catchment area that supplies freshwater to West Java and Jakarta Provinces. The park has been experiencing a considerable disturbance either by human or natural means such as typhoon. These disturbances exposed the park to biological invasions mainly that of invasive alien plant species. The invasions were reported to inflict an alarming ecological damage influencing the regeneration of important local species. A number of invasive alien plant species were reported beside an explosion of a local species exploiting the change of the environment such as *Musa acuminata* and *Amomum coccineum*. A risk assessment method of Virtue (2010) was adopted to assess the risk of those invasive species, and their feasibility of containment to recommend actions appropriate for each assessed invasive plant species. The risk assessment was based on plant invasiveness, impact and potential distribution in the park, and categorized them having negligible, low, medium, high and very high risk. The evaluation was made simple by answering questions with designed score. With our expert judgement, those questions were answered and scores were allocated. Feasibility of containment was assessed through their cost of control, the extent of distribution and their persistence of control and was categorized also into very highly, highly, moderately, low and negligibly feasible. By arranging the categories into a matrix, various recommendations were proposed. While the protocol was designed for Australian condition, it proved to be generally appicable to Indonesia and probably also for the region. However, using this method in the future for other parks in Southeast Asia may require answering any of the questions with valid data for a more reliable assessment. Thus, there is a need to develop a networking system within the region to standardize the way data are collected, so that risk management may be based on the same ground.

While most countries in Southeast Asia have not developed their own weed risk management protocol, our experiences with the Virtue method provided a promising result for adoption and may just need modification where necessary to better suit specific conditions in the future.

2.2.5 Management of Invasive Alien Species through Information Management in the ASEAN Region

by Ms. Erica Villavelez
Biodiversity Information Management Officer, ASEAN Centre for Biodiversity

In 2008, the ASEAN Centre for Biodiversity (ACB) created the ASEAN Clearinghouse Mechanism (CHM) website ((www.chm.aseanbiodiversity.org) to function as the gateway to all available biodiversity related information in Southeast Asia. It is aimed at providing a cohesive and integrated perspective of the region's biological resources. The ASEAN CHM provides a range of services such as providing biodiversity-related information, capacity building guides and tools to aid the ASEAN Member states in conservation planning, monitoring and decision making, one of which is the Regional Database on Invasive Alien Species.

As an early warning facility launched in 2012, the Regional Database on Invasive Alien Species provides the reference for necessary security action and raises the urgency of biodiversity conservation. Knowing the occurrence of invasive alien species (IAS) in a country is important in mitigating possible damage to human health and livelihood. ACB collects information on invasive species that have been recorded in the ASEAN member states including the pathways of their introduction. The list of IAS included in this database is bulk harvested from global sources such as the Global Invasive Species Database maintained by the Invasive Species Specialist Group (www.issg.org) and the CABI Invasive Species Compendium (www.cabi.org/isc/). Only the species with specified biostatus are included in the database. Thus, the database currently holds a total number of 603 unique IAS, of which, 307 are introduced from other countries to the ASEAN region; and 296 are native in the region.

To maximize these existing information resources and mechanisms for the region, the ACB has lined up the following next steps:

1. Encourage sharing and contribution of IAS by using tools such as the Offline and Online Species Encoder developed by ACB. This Encoder is a Graphical User Interface (GUI) that facilitates species encoding using the Darwin Core format. Darwin Core is a standard format for sharing species information based on taxa and geographic occurrence in nature as documented by observations, specimens and samples, and related information. It allows data owners to publish species information in a format that can be understood and used by everyone. The Online and Offline Species Encoder aims to aid the organization of available information to store data in forms that would allow electronic data exchange at a later date. Such exchanges will help organize a regional picture of trends in species occurrence, state and conservation as well as the state of habitats essential to their survival. The offline species encoder is in MS Excel template. The online encoding interface was developed to facilitate remote species data contribution.
2. Validation of existing IAS records in the ASEAN CHM by IAS experts in the region
3. Analyse available data and produce more knowledge products useful for monitoring and assessing biodiversity conservation status and increase awareness about IAS. ACB has developed knowledge products such as:
    - Map of number of recorded invasive alien species in the ASEAN region - This map demonstrates the number of recorded invasive alien species in the ASEAN Region where the darker areas reflect comparably higher numbers of invasive species. This data is supported by an IAS database for the ASEAN Region that is maintained by ACB and populated from secondary data. (Note: ACB does not collect primary data)
    - Infographs - Infographs present statistics in a form that they will easily be understood.

- Policy Brief - ACB produces Policy Brief Series on key thematic areas. The first PB for the IAS thematic area was released last June 2014.
- IAS Video which is an animated cartoon imparting general information, threats, impacts and policy implications in managing IAS in the region towards raising awareness to policy makers and the general public

4. Facilitate networking and exchange of information among IAS experts through a contacts database, such as ACB's Friends of Biodiversity (FOB) database which is envisioned to keep track of individuals and institutions sharing a common interest in biodiversity.

2.2.6 The Australian Pre-Border Weed Risk Assessment and Management System

by Dr. Andy Sheppard
Research Director, Biosecurity Flagship, CSIRO Australia

Dr. Sheppard provided a general review and challenges of weed risk assessment in Australia as follows:

- The Biosecurity Continuum needs points of intervention to assess risks of biological invasions and to most cost effectively act to reduce those risks
- WRA is a simple pre-border scoring system for screening deliberate plant (an adaptable to animal) introductions in situations where imports can be controlled to understand their potential impacts to agriculture and the environment
- Pre-border WRA appears to be quite accurate at predicting invaders (up to 95%), but is less good at deciding whether risks outstrip benefits for low risk plants
- Alien plant invasions are complex processes that WRA is poorly adapted to assess because WRA accuracy is correlated to the probability an introduction will lead to impact and such "base rates" are generally very low
- There are quantitative approaches to assess risks and benefits of deliberate alien plant introductions– but they are more costly & complex (for why WRA prediction is not as easy as it seems see Hulme 2012)
- Despite its weaknesses WRA has been widely adapted and adopted for pre-border screening which is fine as long as the weaknesses are understood and noted and avoided where possible.
- A more cost effective way of managing alien plant invasions is to focus on post-border Weed Risk Management where probability of transition from naturalisation to invasion are 100 times higher.

2.2.7 Adapting the Australian Pre-Border Weed Risk Assessment System for Use in Other Countries

by Dr. Tomoko Nishida
Researcher, Biodiversity Division
National Institute for Agro-Environmental Sciences, Japan
(Full paper as Appendix D2)

The Australian Weed Risk Assessment system (Pheloung *et. al.* 1999) is a predictive tool to assess the weed potential of new plants. It is a question-based scoring system and consists of 49 questions. The system has been formally adopted by the governments of Australia and New Zealand (Groves *et al.* 2001; Rahman *et al.* 2003). Plants assessed with the system are classified into three categories, namely 'accept (<0); 'further evaluation (0–6); and 'reject(>6). Daehler *et al.* (2004) developed a decision tree as a secondary screening method to reduce the number of plant taxa in the category of 'further evaluation'. The A-WRA with or without the second screening has been tested and proven to be effective in at least 14 countries or areas (e.g. Chong *et al.* 2011; Crosti *et al.* 2010; Dawson *et al.* 2009; Daehler *et al.* 2004; Gassó *et al.* 2010; Gordon *et al.* 2008b; Kato *et al.* 2006; Krivánek and Pyšek 2006; McClay *et al.* 2010; McGregor *et al.* 2012; Nishida *et al.* 2009; Pheloung *et al.* 1999; Speek *et al.* 2013). The criteria were determined with an Australian dataset,

but are applicable to other regions (e.g. Daehler *et al.* 2004; Gordon *et al.* 2008; Kato *et al.* 2006; Krivánek and Pyšek 2006). It is also possible to change the criteria depending on regional conditions, if necessary (e.g. Nishida *et al.* 2009; Speek *et al.* 2013). One of the methods is receiver operating characteristic (ROC) curve analysis (Metz 1978), which is widely used to assess the performance of a screening test (Bewick *et al.* 2004). In the case of Japan, Nishida *et al.* (2009) searched more appropriate criteria using ROC curve analysis and suggested that plants with A-WRA scores greater than 10 should be regarded as weeds in Japan.

The 49 questions in the A-WRA could be answered without detailed knowledge of new plants. A manual for the A-WRA (Walton *et al.* 1999) is available, and interpretation of the questions is described. However, slight differences in the interpretation of questions have been observed among assessors. Because differences in the interpretation of questions reduce the consistency of its application (Onderdonk *et al.* 2010), clarified guidelines were developed (Gordon *et al.* 2010). The guidelines also provide sources of information to facilitate implementation of the A-WRA in new localities.

Although the system requires a minimum number of questions to be answered, it is best to answer as many questions as possible to assess the likelihood of the invasion success of the non-indigenous plants to be introduced. This is considered feasible since the databases on flora and invasive plants have recently been drastically improved. Further, developing an information-sharing system based on the Australian Weed Risk Assessment system would enhance the efficiency in assessing the weed potential of new plants and contribute to reducing the adverse effects of invasive non-indigenous plants.

2.2.8 The Australian Post-Border Weed Risk Management System

by Dr. Stephen B. Johnson
Weed Ecologist, Department of Primary Industries, Australia
(Full paper as Appendix D3)

A simple and human-centered definition of a weed is 'a plant growing in the wrong place at the wrong time'. Many weeds have some negative impact on economic, environmental and/or social/societal/community/cultural assets or values. Weeds are often managed to prevent their negative impacts. These same weeds may also be used for food, raw materials or other purposes, and this use results in positive impacts. Such opposing values can produce conflict in weed management.

The negative impacts of weeds are varied and include damage to primary industries (agriculture, horticulture, forestry and fisheries), natural ecosystems and aquatic areas, our urban areas, damaging infrastructure, causing injury and allergies, and damaging cultural heritage. Weed control costs are also a negative impact.

Regulation is an important tool in managing weeds, particularly those spread by humans, since it is these pathways that can be more easily managed. Preventing the entry of a weed into a country, and to the South-East Asian region, is one of the most effective means to prevent negative impacts. A pre-border Weed Risk Assessment (WRA) system, such as that proposed by Pheloung *et al.* (1999), will help evaluate the risk that proposed plant imports pose. High risk plants can be prevented from entry where border controls can be managed and enforced.

Unfortunately many potential weeds have already been introduced into countries within the South-East Asian region. Post-border Weed Risk Management (WRM) systems, such as those proposed in HB 294:2006, are often used to prioritise weeds that have already established. One component of this post-border system is the assessment of risks posed by weeds, while a second is the assessment of the feasibility of a coordinated control program targeting these weeds.

Where the weed is only present in limited instances, border controls, quarantine and prevention activities can be used to isolate weed species to areas within a region. Eradication campaigns, while involving considerable up-front investment, aim to remove the weed problem from the area permanently. In contrast, containment of a weed will incur ongoing costs. If the area invaded becomes larger, efforts may be made to reduce the impact of the weed, reducing its rate of spread and impacts. This may involve

local eradication and containment activities within invaded areas allowing for the protection of assets, whether economic, environmental and/or social/societal/community/cultural. Management approaches gradually transition from weed-led to site-led responses once the protection of assets becomes the main aim.

Priority setting for weed management is crucial in any limited resource environment. The priorities outlined (pre-border and/or post-border) inform a coordinated weed management program and its resourcing. There is much to learn from the global experience in the development, modification and use of pre-border WRA and post-border WRM systems, as well as from new perspectives and developments in these areas. This includes continuing research into how best to implement risk assessment systems in areas where import borders are relatively porous and where multiple jurisdictions occur within a region.

2.2.9 Prioritization in Invasive Alien Plant Management: Improving the Link between Science and Policy?

by Dr. Andy Sheppard
Research Director, Biosecurity Flagship, CSIRO Australia

Dr. Sheppard described the imperatives that all governments and policy makers should have in prioritizing actions for the management of invasive plants:

- Prioritization is the ranking of threats to society by society for taking action. This need is particularly acute for countries that are signatories to the Convention on Biological Diversity 2020 strategic targets.
- Prioritization is a policy imperative defined by societal values not just scientific evidence
- Prioritization is undertaken by decision makers and risk assessments undertaken by scientists – risk assessments support prioritization but do not determine the outcomes
- Prioritization considers community/stakeholder values and capacity to act.
- There are now strong International needs for good generic prioritization processes around IAS and many are being developed in country
- There is currently poor adoption of current science-based processes for undertaking prioritization – most processes are still ad hoc
- Multidisciplinary science teams need to help develop such processes with decision/policy makers
- The basis for prioritization should be kept as simple to understand as possible!

2.2.10 The Australian Post-border Weed Risk Management System: Contexts and Situations that will Help Support IAPS Risk Analysis Systems

by Dr. Stephen B. Johnson
(Full paper as Appendix D4)

The saying that 'prevention is better than cure' is true with respect to weeds and their entry into a country or a region. A pre-border Weed Risk Assessment (WRA) system, such as that proposed by Pheloung *et al.* (1999), can help evaluate the risk that proposed plant imports pose.

Having said this, many weeds have already been introduced into countries within the Southeast Asian region. A post-border Weed Risk Management (WRM) system, such as that proposed in HB 294:2006, can be used to prioritize established weeds so that the best use of resources available for weed management can be made. This WRM system can be used to prioritize weeds within any natural ecosystem or man-made situation, and can be used at a variety of scales, from a village to a park, a water catchment, a province or state, at a national level, and across national borders such as in the Southeast Asian region.

There are six stages in the WRM process, namely: (1) establishing the WRM context; (2) identification of weed risk candidates; (3) analysis and evaluation of weed risks; (4) analysis and evaluation of feasibility of coordinated control; (5) a determination of weed management priorities; and (6) implementation of weed

management actions. Two further steps are crucial in the WRM process and should be performed at each stage, these being: communication and consultation; and monitoring and review.

Establishing the WRM context will involve an evaluation of the: goal/s; geographic and land use scope; stakeholders; policy and legislation; the resources available; the expected outputs and outcomes; potential risk and feasibility assessment methods; and project management. The second step of identifying weed risk candidates will involve: listing current weeds; detecting new weeds; reviewing likely incursions; and then selection of a subset of weed species for further analysis.

The third and fourth steps are central to the WRM system and involve an evaluation of certain criteria. An analysis and evaluation of weed risks will involve comparing the invasiveness, impacts and potential distribution of each weed. Similarly, an analysis and evaluation of feasibility of coordinated control will involve comparing the current distribution, control costs and duration/persistence of a weed. Both steps involve semi-quantitative scoring of questions relating to these criteria, and subsequent compilation of separate weed risk and feasibility of coordinated control scores. Priorities for weed management can be set by comparing these two scores across a prioritization matrix. Implementation of weed management actions against priority weeds then occurs. Each step involves communication and consultation, as well as monitoring and review.

The resources needed for prioritization using a WRM system should be far less than those used to manage problem weeds. While global expertise and resources are increasing available 'online', formal commitment to implementation of both WRA and WRM systems at a national and Southeast Asian regional level is also necessary.

2.3 Highlights of Country Reports

The country reports were expected to give a collective overview of the current status of risk assessment and management of forest invasive plant species in the region in terms of the following aspects: (1) list of existing forest Invasive plant species (non-native or native invasive plant species) that have been prioritized for management including the methods used and the agencies responsible for analyzing their risks; (2) pre- and post-border risk analysis protocols/practices that are currently in use; (3) presence of a National Invasive Species Strategy and Action Plan (NISSAP) derived from the National Biodiversity Strategy and Action Plan (NBSAP) and the extent of its implementation so far; (4) list of institutions and the division/coordination of responsibilities among them in assessing and managing invasive plant species including the function of doing research and capacity building, on the subject matter; (5) Relevant policies mandating concerned institutions to carry out prevention, early detection and rapid response, as well as eradication, control and rehabilitation of areas damaged by forest invasive plant species; (6) Current research and capacity building activities on risk analysis of forest Invasive plant species; and (7) Challenges and Future Research and Capacity Building Directions on risk analysis and management of invasive plant species. However, the reports presented were far from complete in terms of the above mentioned aspects. This could either indicate the lack of readily available information or the extent by which the country representatives were able to gather the required information to come up with the reports.

Here are the summary highlights of the common information found in the country reports:

2.3.1 List of existing forest invasive alien and native plant species

All participating countries have their respective lists of invasive alien and native plant species. None of the countries have conducted a thorough risk analysis of such species. However, despite of this, Malaysia and Indonesia have come up with their priority lists. In the case of Indonesia, priority listing was determined due to the scope of invasiveness of the species considering that already 30 percent of the country's national parks have been invaded.

The following forest invasive alien plant species were reported to be the most commonly found in at least two countries represented in the seminar-workshop:

Name of Species	Classification	Countries where found
Chromolaena odorata	Shrub	Indonesia, Malaysia, Thailand, Philippines, Viet Nam, Myanmar
Lantana camara	Shrub	Indonesia, Thailand, Philippines, Viet Nam, Myanmar
Imperata cylindrica	Grass	Thailand, Philippines, Myanmar
Leucaena leucocephala	Tree	Thailand, Philippines, Myanmar
Mikania micrantha	Vine	Indonesia, Philippines, Myanmar
Acacia auriculiformis	Tree	Philippines, Myanmar
Acacia mangium	Tree	Indonesia, Philippines
Eucalyptus spp.	Tree	Myanmar, Philippines
Echinochloa crusgalli	Grass	Malaysia, Myanmar
Mimosa diplotricha	Grass	Viet Nam, Myanmar
Prosopis julifora	Shrub/small tree	Philippines, Myanmar

On the other hand, forest invasive plant species, either alien or native, that were only reported in one country were as follows:

Name of Species	Classification	Country where found
Acacia nilotica	Tree	Indonesia
Merremia peltatata	Woody climber	Indonesia
Pennisetum polystachion	Grass	Myanmar
Acacia comosa Gagnep	Woody climber	Thailand
Acacia megaladena Desv. Var. *indo-chinensis* I.C. Nielsen	Woody climber	Thailand
Acacia megaladena Desv. Var. *megaladena*	Woody climber	Thailand
Achyranthus aspera L.	Herb	Thailand
Achyranthus bidentata Blume	Herb	Thailand
Broussonetia kurzii (Hook.f.) Corner	Woody climber	Thailand
Byttneria andamanensis Kurz	Woody climber	Thailand
Lasiobema scandens (L.) de Wit	Woody climber	Thailand
*Neyraudia reynaudiana (*Kunth) Keng ex Hitchc.	Grass	Thailand
Pterolobium integrum Craib	Woody climber	Thailand
Pterolobium macropterum Kurz	Woody climber	Thailand
Thunbergia grandiflora L.	Climbing herb	Thailand
Thithonia diversifolia	Shrub	Thailand
Broussonetia papyrifera	Shrub/Tree	Philippines
Mimosa invisa	Shrub	Philippines
Spathodea campanulata	Tree	Philippines
Piper aduncum	Woody climber	Philippines
Callisia fragrans	Shrub	Viet Nam
Mimosa pigra	Shrub	Viet Nam

2.3.2 Governance of Forest Invasive Alien Plant Species

The country reports revealed that there is no single or central national agency responsible in preventing and managing the spread of FIAPS. The table below summarizes the agencies and their main responsibilities as regards the governance of FIAPS per country:

Country	Agencies involved in Governance of FIAPS	Main Responsibility(ies)
Indonesia	Ministry of Environment and Forestry	No information given
Philippines	Department of Environment and Natural Resources:	
	a. Ecosystems Research and Development Bureau	Develops research output for policies, plans and programs in management of IAS
	b. Environmental Management Bureau	Implements the Environmental Impact Assessment Law which governs the introduction of fauna (exotic animals) in public and private forest as environmentally critical, thus, any such undertaking will require an Environmental Compliance Certificate (ECC)
	c. Biodiversity Management Bureau (BMB)	Regulates the import/export of wild plant species, their by-product and/or derivatives for whatever purpose
	Bureau of Plant Industry of the Department of Agriculture	Develops policies, plans and programs in the management and protection of agricultural crops from pests and diseases including the implementation of quarantine policies for the prevention, control and eradication of pests and diseases and injuries to plant and plant products
	National Museum of the Philippines	In-charge of collecting, safe keeping and documenting IAS species
Thailand	Ministry of Ministry of Natural Resources and Environment (MNRE) consisting of:	
	a Royal Forest Department (RFD) and Department of National Park, Wildlife and Plant Conservation (DNWP)	Regulation of plants, shrubs, trees, animals and wildlife, and endangered animals listed under CITES
	b Office of Natural Resources and Environmental Policy and Planning (ONEPP)	Provides guidelines to recognize the inadequacy of present legislation as it relates to protection of native plants; responsible in implementing the Thailand National Invasive Species Strategy and Action Plan (NISSAP 2013)
Viet Nam	Department of Forestry	No information given
	National Agro-Forestry-Fisheries Quality Assurance	No information given

2.3.3 Relevant Policies, Laws, and Regulations Concerning Prevention, Early Detection and Rapid Response, as well as Eradication, Control and Rehabilitation of Areas Damaged by Forest Invasive Plant Species

At the least, all countries reported having a law, act, or code on forestry and plant quarantine which in one way or the other contain stipulations pertaining to governance of native and non-native plant species.

Other related legal instruments are contained in the table below:

Country	Policies, Laws and Regulations
Indonesia	• Act No. 5: Prevention of Ecosystem changes in natural reserves and national parks and introduction of non-native species (1990) • National Biodiversity Strategy and Action Plan (2003-2020) • Ministry of Forestry Regulation No. 57: Examination and testing of all species entering Indonesia territories (2008) • Act No.32: Environmental Management and Protection (2009) • Government Regulation No. 28: Conservation and Protected Area Management (2011)
Malaysia	• Plant Quarantine Regulations (1981) • Wildlife Conservation Act (2010) • Malaysia Quarantine and Inspection Service Act (2011)
Myanmar	• Forest Law (1992) • Protection of Wildlife and Protected Areas Law (1994) • National Biodiversity Strategy and Action Plan (2011)
Philippines	• Presidential Decree No.1433: Plant Quarantine Law (1978) • Presidential Decree No. 705: Revised Forestry Code (1975) • Republic Act No. 9147: Wildlife Resources Conservation and Protection Act (1992) • Presidential Decree 705: Importation of Forest-based Materials (2001)
Thailand	• National Park Act (1961) • Plant Quarantine Act (1964) • Wildlife Conservation and Protection Act (1992) • Plant Varieties Protection Act (1969)
Viet Nam	• Biodiversity Law No. 20 (2008) • Environmental Protection Law (2005) • Forest Protection and Development Law (2004) • Plant Protection and Quarantine Ordinance (2001)

2.3.4 Implementation of National Invasive Species Strategy and Action Plan (NISSAP)

Only Indonesia, Malaysia and the Philippines have reported having formulated and currently implementing their respective National Invasive Species Strategy and Action Plan (NISSAP) since 2014. The implementation of these plans is being coordinated by the Ministry of Environment and Forestry for Indonesia, the Department of Environmental and Natural Resources-Biodiversity Management Bureau for the Philippines, and a National Committee on IAS chaired by the Department of Agriculture for Malaysia.

2.3.5 Current Practices in Control and Management of Forest Invasive Plant Species

In general, mechanical, chemical, biological means are commonly practiced to control and manage the spread of forest invasive plant species in all the countries represented in the seminar-workshop. Mechanical practices include pulling, mowing, cutting and burning such as for *Chromolaena, Lantana camara* and *Leucaena leucocephala* in the case of the Philippines. Chemical control consists of herbicide application such as using Glyphosate, Metsulfuron Methyl, Oxadiazon, and Alchlor in controlling *Mimosa pigra* in Viet Nam. Viet Nam also indicated to have used bioagents such as *Acanthoscelides quadridentatus*, *A. puniceus,* and *Carmenta mimosa* to control *Mimosa pigra*. However, the effectiveness of such measures was not clearly stated in the country reports.

2.3.6 Capacity Building Needs on Risk Analysis of Forest Invasive Alien Plant Species

The countries vary in their status of development as well as their current capacities to address IAS issues. Thus, this is evident in their capacity building needs to carry out risk analysis of forest invasive alien plant species as shown in the table below. In general, majority of the countries expressed need to build capacities on risk assessment and management methods/techniques and impact assessment. Interestingly, the Philippines and Vietnam reported their need to acquire more knowledge and skills on IAS research methodologies.

Country	Capacity Building Needs
Indonesia	• Communication Strategies in raising awareness on the impacts of IAS • Mainstreaming IAS risk assessment and management into protected area management planning
Myanmar	• Mapping/Inventory of IAS • Risk assessment techniques (early detection, rapid response) • Risk management (long-term monitoring)
Philippines	• IAS taxonomy, inventory and pathways • IAS risk assessment and management (mitigation and eradication) • Development and implementation of institutional and legal measures for IAS control and management • Enforcement of quarantine regulations • Integrated Ecosystems management • Traditional ecological knowledge management • IAS research methodologies
Thailand	• Understanding the roles and impacts of IAS • Awareness raising on the roles and impacts of IAS • Risk assessment and management techniques
Viet Nam	• Risk assessment and management methods • IAS impact assessment • IAS research methodologies (integrated approach)

2.3.7 Challenges in Risk Assessment and Management

Like their capacity building needs, the countries represented in the seminar-workshop also varied in the challenges they face on risk assessment and management of forest invasive alien plant species as shown in the table below. However, the most common challenge among these countries has something to do with harmonization and coordination for a more effective implementation of existing legal instruments, including methods, tools and procedures, governing the control and management of invasive alien plants species. Indonesia, Myanmar, and Viet Nam emphasized the need for capacity building on this matter.

Countries	Challenges
Indonesia	• Harmonizing risk analysis protocols with other countries in the region • Harmonizing enforcement of regulations among related agencies • Mainstreaming IAS in education system • Mainstreaming IAS into protected areas management planning • Raising public awareness through effective communication campaigns
Malaysia	• Coordination among concerned agencies on the implementation of existing legislations, ordinances, subsidiary laws, and guidelines
Myanmar	• Mapping of Invasive species • Having effective risk assessment, early detection, rapid response and long-term monitoring of IAS • Capacity building activities on risk analysis and management of invasive alien plant species
Philippines	• Conflicting perspective on economic importance of some exotic trees and their impact to forest biodiversity is holding back any interests to pursue management programs for IAS in the forestry sector • Passage of an Executive Order or a law adopting the NISSAP • Passage of Sustainable Forest Management Act where new initiatives to improve forest governance based on science like IAS Management, control and eradication is highlighted • Harmonization/Improvement of the Risk Assessment Procedures • Development of a compendium on IAS related researches
Thailand	• Raising awareness on the roles and impacts of IAS • Ensuring effective implementation of existing laws to control and manage IAS
Viet Nam	• Lack of an orientation policy framework for IAS management at different levels • Planning of prevention and control issues is not comprehensive and synchronized • Legislation system has many drawbacks and inconsistencies; legal documents are scattered • Management system are incomplete with overlapping and unclear functions and responsibilities and weak coordination • Management capacity in IAS is limited

Full country reports from Indonesia, Myanmar, the Philippines, Thailand, and Viet Nam are included here as Appendices E1, E2, E3, E4 and E5, respectively.

3. Summary of Workshop Outputs

Two workshops were conducted to address objectives 2 and 4 of the seminar-workshop. These were on (1) Identifying and Leveling Off Gaps in Risk Analysis of Forest IAS; and (2) Proposing Solutions on the Gaps in Risk Analysis of Forest IAS in Southeast Asia.

The following are the summary highlights of the workshop outputs:

3.1 Identifying and Leveling Off Gaps in Risk Analysis of Forest IAS in Southeast Asia

For this workshop, the participants were divided into four groups to discuss and agree on the following: (1) general gaps in terms of existing policies, coordination mechanism, methods, and understanding of terminologies and concepts of risk analysis of forest invasive alien plant species; and (2) gaps in the risk analysis process (i.e. hazard identification, risk assessment, risk management, and risk communication). A resource person was assigned to each group to assist in the discussion.

The following are the general sentiments expressed by at least two groups as regards the gaps:

1. General Gaps

   (a) IAS issues are not national government priority considering that the matter is not integrated yet in national planning processes. This could also be based on the fact that only Indonesia, Malaysia, and the Philippines have reported that they have already formulated and implementing their respective NISSAPs

   (b) Lack or poor coordination mechanism at the national level. This could be attributed to having many government agencies involved that have different perspectives on how to control and manage IAS as reported by some of the groups. One group expressed the need to have a national coordinating body for IAS management

   (c) Lack of adequate knowledge on the comprehensive as well as priority list of IAS in all the countries. This could be related to (b) as there is no single agency responsible in consolidating and updating such information as well as the lack of competent people in identifying and performing risk assessment of IAS as mentioned by one group

   (d) Lack of adequate knowledge on current practices, policies, legislations, practices on IAS in each country as well as agreements across countries. Such legal instruments may be in place but would need better advocacy, stricter implementation, and proper coordination among agencies involved. Interestingly, one group mentioned the lack of measures to convince stakeholders (government, general public, and private sector) to adopt certain policies to reduce impacts of IAS

   (e) Too much and/or unclear concepts, methods, and tools on risk assessment and management create confusion

2. Risk Analysis Gaps

2.1 Goal Setting and Hazard Identification

   (a) Lack of information materials and knowledge on sources of information (publications and databases), especially on taxonomy and distribution of IAS, including mechanism for sharing such information within and across countries

   (b) Inadequate capacity and coordination among concerned agencies to undertake goal setting and hazard identification of IAS

   (c) Need to have a regional action plan on goal setting and hazard identification of IAS

2.2 Risk Assessment

   (a) Lack of capacity to implement risk assessment and a need for more research on the potential impacts of IAS on ecosystem

   (b) Need for appropriate risk assessment methods and/or modification of existing ones (e.g. the Australian Method) for wider adoption in the region

2.3 Risk Management

   (a) Lack of suitable methods/technologies for risk management

   (b) Lack of coordination among concerned agencies: Who decides? Who prioritizes? Who does what?

(c) Differences in regulations among countries on risk management

(d) Lack of or inadequate funding to conduct risk management activities

2.4 Risk Communication

(a) Inadequate information materials and appropriate system to increase awareness of all stakeholders on impacts of IAS

(b) Need to link research results to policy development and advocacy

(c) How to engage stakeholders in IAS management

The comprehensive list of gaps identified by the groups during the workshop is contained in Appendix F1.

3.2 Proposing Solutions on the Gaps in Risk Analysis of Forest IAS in Southeast Asia

Following the same group assignments, this workshop requested the participants to select at least five gaps that they identified in Workshop 1 which they think needing immediate attention and thus propose solutions for them.

The workshop outputs revealed that majority of the gaps selected and given proposed solutions by the groups pertained to General and Goal Setting/Hazard Identification Gaps in risk analysis. These gaps can be lumped into the following categories: (1) policy implementation and coordination among concerned institutions; (2) methods, tools, and approaches in conducting risk analysis; (3) building individual and institutional capacities in risk analysis; and (4) creating awareness and information of dissemination on impacts of IAS.

The table below lists the proposed general solutions given by the groups on the gaps as categorized above:

Gap Categories	Proposed Solutions
1. Policy implementation and coordination among concerned institutions on IAS risk analysis	Group 1: • Strengthen coordination and good communication among concerned Government departments • Formulate and disseminate of specific regulations for IAS control and management • Publish research outputs and disseminate through workshops to help advocate the importance of giving priority to IAS at all levels of the government
	Group 2: • Make an inventory of existing policies and legislations in the region related to IAS; introduce an international agreement reflecting the current legislations of each country • Create a plant quarantine experts working group – intra-country and intra-region • Establish and strengthen linkages among country IAS task forces; disseminate country policies and regulations • Coordinate country action plans for regional action
	Group 3: • Form a National IAS Coordinating Body • Institutionalize NISSAP implementation with all concerned Agencies

	Group 4: • Review existing policies, laws, regulations, guidelines and other legal instruments • Harmonize legal instruments with present realities on IAS • Define the roles and responsibilities of each agency/stakeholders • Develop a new policy, if necessary, that is acceptable and workable • Conduct meetings/workshops among concerned agencies and stakeholders to have agreement
2. Methods, tools, and approaches in conducting risk analysis	Group 2: • Adopt standard methods for the region
	Group 3: • Develop IAS identification guides (with photos, descriptions of species, country of origin, etc.) • Develop a national database on IAS
3. Individual and institutional capacity building on IAS risk analysis	Group 1: • Conduct awareness campaigns and training activities at all school levels • Establish collaborative private-public sector pilot project in specific area – in natural production forests and define training models for managers
	Group 2: • Organize appropriate capacity building activities on a sustainable manner
	Group 3: • Conduct capacity building activities e.g. on general identification, taxonomy of plant systematic, control and management, etc.
4. Creating awareness and information dissemination on the impacts of IAS	Group 1: • Conduct awareness campaigns and training activities at all school levels • Compile information on IAS impacts into easily understood format and work with the media to sell the message. Identify a real bad pest to be iconic and tell the story
	Group 2: • Increase awareness on IAS in schools, and in mass and social media
	Group 3: • Conduct communication campaigns in collaboration with the Ministry/ Department of Education and media outfits

APPENDICES

Appendix A : Seminar-Workshop Program of Activities

Day 1/December 2
Moderator: Dr. Jess C. Fernandez

Day/Time	Activity	In-Charge
8.30 am 9.00	• Registration • Opening Program and Overview of Seminar-Workshop	Secretariat
9.30	Coffee/Tea Break	
10.00	• Current Global Protocols and Initiatives in Biodiversity Conservation with Special Focus on IAS Control and Management	Dr. Junko Shimura
11.00	• Implementation of International Standards for Phytosanitary Measures (ISPMs) on Pest Risk Analysis (PRA) on Forest Pests	Dr. Shiroma Sathyapala
12.00	Lunch Break	
1.30 pm	• IAS Science-Based Approaches in the International Policy Context	Dr. Andy Sheppard
3.00	Coffee/Tea Break	

3.30	• Country Reports on IAS Inventory and Regulations and Challenges in Risk Analysis and Management
	  • Malaysia
	  • Thailand
	  • Lao PDR
	  • Indonesia
		Country Representatives

4.30	• General Discussion	
6.45	• Welcome Dinner (Hosted by FORIS)	

Day 2: December 3
Moderator: Dr. Sri Sudarmiyati

Time	Activity	In-Charge

8.45 am	• Continuation of Country Reports
	  • Philippines
	  • Myanmar
	  • Viet Nam
		Country Representatives

10.00	Coffee/Tea Break	
10.30	• BIOTROP's Research and Capacity Building Experiences in IAPS Risk Analysis • Management of Invasive Alien Species Through Information Management in the ASEAN Region	Dr. Sukisman Tjitrosoedirdjo Ms. Erica Villavelez
12.00	Lunch Break	
1.30	• The Australian Pre-Border Weed Risk Assessment and Management System • Adapting the Australian Pre-Border Weed Risk Assessment System for Use in Other Countries	Dr. Andy Sheppard Dr .Tomoko Nishida
3.15	Coffee/Tea Break	
3.45	• The Australian Post-Border Weed Risk Assessment and Management System • General Discussions/Day's Wrap Up	Dr. Stephen B. Johnson
Evening	FREE	

Day 3: December 4
Moderators: Dr. Shiroma Sathyapala and Dr. Jess C. Fernandez

Day/Time	Activity	In-Charge
8.45 am	• Workshop on Identifying and Leveling Off Gaps in Risk Analysis of Forest IAS in Southeast Asia and Presentation of Outputs	Dr. Shiroma Sathyapala
10.15	Coffee/Tea Break	
10.45	• Workshop on Proposing Solutions on the Gaps in Risk Analysis of Forest IAS in Southeast Asia and Presentation of Outputs	Dr. Jess C. Fernandez
12.00	Lunch Break	
1.30 pm	• Collaborative Options for IAPS Risk Analysis Research in Southeast Asia	Dr. Andy Sheppard
3.00	Coffee/Tea Break	
3.30	General Discussions/Day's Wrap Up	

Day 4: December 5
Moderator: Dr. Stephen B. Johnson

Day/Time	Activity	In-Charge
8.45 am	• A Review of the Global Protocols and Agreements Related to IAS	Dr. Junko Shimura
9.30	• Contexts and Situations Needed to Support Forest IAPS Risk Analysis System	Dr. Stephen B. Johnson
10.15	Coffee/Tea Break	
10.45	• Presentation and Consensus Building on Seminar-Workshop Recommendations	Dr. Shiroma Sathyapala & Dr. Jess C. Fernandez
12.00	Lunch Break	
1.30	• Plenary Discussion on Ways to Move Forward in Implementing Identified Research and Capacity Building Activities	Dr. Jess C. Fernandez
2.30	• Seminar-Workshop Evaluation	Dr. Jess C. Fernandez
3.00	Coffee/Tea Break	
3.30	• Closing Program	

Appendix B : List of Seminar Workshop Participants

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Appendix C : List of Seminar-Workshop Resource Persons and Facilitators

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Appendix D1 : Full Paper of Dr. Sukisman, *et al*.

RISK ANALYSIS OF ALIEN PLANT SPECIES INVADING GUNUNG GEDE PANGRANGO NATIONAL PARK AND RECOMMENDATION OF CONTAINMENT

S.Tjitrosoedirdjo[1], Setiabudi[1], I. Mawardi[1]
S. Bachri[1], Indah Wahyuni[1] and Sri S. Tjitrosoedirdjo[2]

ABSTRACT

Gunung Gede Pangrango National Park is a protected primary forest located in between two volcanoes i.e. Mount Gede (2,958 m) and Mount Pangrango (3,019 m) in West Java. The park covers an area of about 24,000 ha from forest hill to submontane, montane, and subalpine zones, forming a very important water catchment area supplying freshwater to West Java and Jakarta Provinces. The park has been experiencing a considerable disturbance either by human or natural means such as typhoon. These disturbances exposed the park to biological invasions mainly that of invasive alien plant species. The invasions were reported to inflict an alarming ecological damage influencing the regeneration of important local species. A number of invasive alien plant species were reported beside an explosion of a local species exploiting the change of the environment such as *Musa acuminata* and *Amomum coccineum*. A risk assessment method of Virtue (2010) was adopted to assess the risk of those invasive species, and their feasibility of containment to provide recommendation of actions appropriate for each assessed invasive plant species. The risk assessment was based on plant invasiveness, impact and potential distribution in the park, and categorized them having negligible, low, medium, high and very high risk. While their feasibility was assessed through their cost of control, the extent of distribution and their persistence of control and similarly their feasibility of containment were categorized also into very highly, highly, moderately, low and negligibly feasible. By arranging the categories into a matrix various recommendation of actions were proposed.

INTRODUCTION

Gunung Gede Pangrango National Park (GGPNP) is a protected valuable primary forest left in West Java. The park is centered on two twin volcanoes Mount Gede (2,958 m) and Mount Pangrango (3,019 m) forming a very important water catchment area supplying freshwater to West Java and Jakarta Provinces. In 1997 it was declared as part of the World Network of Biosphere Reserves by UNESCO. The GGPNP covers hill forest (Lamonier 1992) in the western part extending from the elevation of 500 – 1000 m asl; in the southern and eastern sites of the park the activities on agricultural, plantations, and forest plantations have been so high that the hill forest has gone and converted to other land use systems; submontane forest extending from 1000 – 1500 m asl. ; montane forest extending from 1500 – 2400 m asl, and subalpine > 2400 m asl.

In lowland and submontane forest a considerable area have been invaded by invasive plant species. These invasive plant species occupied degraded portion of the forest, and continue to expand their invasion threatening to alter the vegetation cover. Zuhri and Mutaqien (2011) for example conducted vegetation analysis in 2009 and compared the results with that reported by Meijer in 1959. The composition of vegetation changed considerably with more plant species recorded in 1959 than that in 2009 (Table 1).

Further tree inventory revealed that there were 63 tree species having Θ > 10 cm, with 47 tree species were still found in both 1959 and 2009 observations, and 16 tree species was recorded only in 2009 and 18 tree species were recorded only in 1959, it means that 18 tree species have gone from the plot, replaced by those 16 new tree species.

1 BIOTROP Staff
2 BIOTROP Affiliate Scientists

Table 1. Different vegetation composition recorded in 1959 and 2009 (modified from Zuhri and Mutaqien 2011)

No	Parameter	Observation Periods	
		1959 (Meijjer 1959)	2009 (Zuhri and Mutaqien 2011)
1.	Vegetation types: Trees	78	71
2	Small trees	40	38
3	Herbs	73	42
4	Liana (woody climber)	20	9
5	Vine (non woody climber)	10	2
6	Strangler	1	1
7	Creeper	10	3
8	Hemi parasite	1	0
9	Total	233	166
10	Diversity index	3.39	3.29
11	Index of evenness	1.91	1.83
12	Index of similarity	0.49	

Trees which were still numerous in both and especially in 2009 observation were *Vellebrunea rubescence, Ostodes paniculata*, and *Macropanax dispermum*, a type of pioneer trees indicating that the community was still in the early stage of succession. Another small tree which was very dominant was *Cestrum aurantiacum*, an invasive alien plants from Guatemala. The domination of this invasive species can be displayed in one of location in a the Wornojiwo forest (Table 2).

Table 2. The abudancy of alien species in Wornojiwo forest in Cibodas Botanical Garden (next to GGNP) based on growth category (adopted from Mutaqien *et al.* 2012)

Category	No	Species	Family	RD	RFre	RCov	Im.V
Tree	9/25	*Cestrum aurantiacum* Lindl	Solanaceae	3.45	4.41	6.22	8.08
Pole	1/61	*Cestrum aurantiacum* Lindl	Solanaceae	9.68	5.95	52.95	68.59
Sappling	1/23	*Cestrum aurantiacum* Lindl	Solanaceae	18.75	18.75	43.55	81.05
Shrubs	1/23	*Strobilanthes hamiltoniana* (Steud)	Acanthaceae	76.45	25.00	70.36	171.3
Herbs	3/34	*Calathea lietzei* E. Morren	Maranthaceae	12.14	4.76	11.03	27.93

C. aurantiacum trees dominated small tree stand (Θ < 50 cm). Gaps were dominated by alien plant species *S. hamiltonian* which has long been naturalized in Java (Bennet & Schotland 2003). While *C. litzei* successfuly dominated the undergrowth and the third among 34 local species. It is obvious that *C. aurantiacum* is a potential plant invasive in GGPNP ecosystem. Mutaqien *et al.* (2012) tested the distribution pattern of those alien plant species studies in that Wornojiwo forest and noticed that most of them carried a Morisita index of less than 1 (one) indicating that they spreaded uniformly, except *S. hamiltoniana* that occupied mainly in opened gap. That of *C. quadrangularis* had a negative Morisita index also, probably the area considered was only in Wornojiwo forest, where all the area had been invaded by *C. quadrangularis*, when a wider area in the GGPNP are considered where the distribution is highly clumped the index may not be less than one.

Based upon a survey carried out in 2006, the park management entity identified 35 specis of alien plants, 7 of which was considered invasive while the other 28 species were considered as non exotic, they were distributed in submontane, montane and subalpine forests, extending from 1200 m asl – 2700 m asl. The park management accordingly planned strategic actions 2011- 2021 (Renstra IAS 2011). The strategic plans underlined the actions, from establishment, early detection systems and rapid response, risk analysis of invasive species, control and eradication in the framework of management, up to restoration of degraded ecosystems.

BIOTROP and National Park of Gunung Gede and Pangrango in 2012 signed an agreement to manage invading plant species in the park, and develop education initiative or core or education centre related to the management of invasive plant species; to prevent the introduction, to eradicate, and to control plant invasion. Based upon the agreement for the last two years BIOTROP has been conducting vegetation mappings to study the vegetation coverage in various locations inside GGPNP with the associated invasive plants species . In this contact BIOTROP is complementing and filling the gap in the strategic action plan developed previously.

In 2013 the first year we discovered that *C. aurantiacum* was able to grow and establish well under closed canopy forest in the submontane region of GGPNP, indicating a high potency of becoming an invasive plant species. It supported the previous notion by Muttaqin *et al.* (2012) that this species must be given a sufficient attention to prevent its expansion. Further analyses indicated more invasive species were found growing under open canopy forest. It is important then to develop vegetation maps, how the park is differentiated into various different coverage, to estimate the threatened areas that may be invaded by the existing plant species, that is closely related to risk analysis of invasive plant species.

Risk Analysis of Invasive Plant Species

Risk analysis consists of 3 stages, initiation, evaluation and management (ISPM-2). Initiation is triggered by the invasion of alien plant species into GGPNP. Risk is defined as likelihood of undesired event occurring as a result of behaviour or action (including no action). Risk assessment is the means by which the frequencies and consequences of such events are determined, and should be accompanied by an expression of any uncertainty in the assessment process. The consequences of undesired events in question are usually adverse and are expressed in term of the assessment endpoint. Assessment end points are simply an expression of values that one is trying to protect by undertaking the risk assessment procedure, and thus distinguish the environmental risk assessment (ecological risk) from human health risk assessment (human fatality or human injury endpoint).

The risk associated with invasion of alien plant species can be defined as the likelihood of undesired events occurring as a result of invasion. It is important to recognize the interpretation of this definition that it is entirely dependent upon the endpoint of the assessment. If the endpoint is establishment of an invasive alien plant species in a new locality, then the risk is expressed in term of likelihood of establishment. If the endpoint is environmental damage, then the risk must be defined as the likelihood of environmental damage arising as a result the introduction and establishment of an alien plant species. If risk is expressed in term of an establishment of an alien plant species– there is thus an implicit assumption that the establishment of an invasive alien plant species in a new localities is an undesired event. This is equivalent to an expression environmental value that wishes to preserve "natural" or existing species assemblages. By contrast, if risk is defined in term of the environmental damage, the establishment of a new invasive alien plant species "per se" does not constitute the undesired event to be avoided it is merely concerned with the subsequent environmental damage that could arise as a result of this. Thus if an assessor could guarantee that a particular invasive alien species would have no adverse effect on the environment, then under this definition, there would be no risk.

Initiation, as outlined above there have been reports of invasion by alien plants in GGPNP. The plants are mostly escapees from the Cibodas Botanical Garden (CBG) previously imported and planted as plant collection. The reasons for plant collections whether as exchange materials, for studies, or for commercial purposes are not clear. Looking at the price of Cestrum as ornamenal plants advertised in internet, the Indonesia people start to question why not commercialize the plant. The list of invasive species was listed under the Strategic Plan of GGPNP (2012) also by Muttaqin *et al.* (2013).

Assessment, There are many methods developed for risk evaluation such Pheloung *et al.* (1999), Parker (2002), Virtue (2008). They scrutinized biological characters that supported the plant invasiveness. Parker (2002) among many other biological characters, brought out the growing behaviour of vines and the expansion of using rhizome as prominant biological characters that facilitated invasiveness. The first character is manifested by *Merremia peltata* in Bukit Barisan National Park, Sumatera, *Passiflora ligularis* in GGPNP, while the later is manifested by *Chimonanbambusa quadrangluaris* in GGPNP.

Risk Assessment has been quantitatively defined or assessed as a mathematical combination of the **magnitude of the consequence** of an event and **the likelihood** of that event occurring. The magnitude of consequence is further determined by the **impact** and the **potential** distribution of the **invasion**. The likelihood or probability of invasion occurring is usually termed as **invasiveness** evaluated from the biological characters of the plants. Baker (1974) run down basic characters of weeds that may be utilized to predict invasiveness. Rejmanek (1995) proposed among others fitness homoeostasis of population, small genome size that is associated with short minimum generation time, small seed size, high leaf area ratio, and high relative growth rate that may be an ultimate determinant of plant invasiveness in disturbed landscapes. Parker (2002) further pointed out the important of vegetative growth using rhizome zomes or stolons (but not if merely having short woody rhizome, or corms, bulbs, etc.), in this paper this charater is represented by *C. quadrangularis*, which sends very long rhizome (frequently > 5 m), with growings point in each nodes, crawling underground, but frequently emerged above the ground, become green, and continued underground to find a better light condition before emerging into erect new shoot. The green emerging portion of rhizome bearing a number of

nodes may send erect branches bearing leaves to become an individual entity. However it is more common to find a series of new shoots in a line emerging from a single long rhizome.

The assessment technique of Virtue (2010) was applied and presented in the Appendix.

MATERIALS AND METHODS

List of invasive species as mentioned above was listed under the Strategic Plant of GGPNP and by Muttaqin *et al.* (2014), 14 species were selected for demonstrating the technique. There were several pathways leading to the introduction of those species to GGPNP. The most conspicuous was the escapees from CBG, and the alien plants planted under the system of timber production by PERHUTANI that were delivered to GGPNP after the Minister of Forestry's decree. Some alien plants were also suspected of being thrown away by careless visitors.

The field information related to the distribution and the estimated area of various invasive plant species tested were derived from a vegetation map developed during the field works. The vegetative map developed through Quickbird satelit imagery under 2.4 x 2.4 m resolution with corrected geometrical systems at GWS 84, UTM 48S. The detailed interpretation was carried out manually (digit on screen). The vegetation identification and classification were subsequently carried out followed by estimation of their areas following technique developed previously (Setiabudi *et al.* 2014) and presented in Figure.1.

RESULTS AND DISCUSSION

The park is uneven, in that western side an extensive hill forest extending from 500 m up and followed by extensive submontane , montane forest, up to subapline still exists in the eastern and southern sides the agricultural and plantation activities were so intensive leaving this production systems directly face to face with submontane or montane zone. It is in this side that Cibodas Botanical Garden is located. It is easy to see that the pretest pathway leading to plant invasion is escapees from CBG. The disturbance inside the park no doubt also contributed to the susceptibility of the forest to plant invasion. Not only illegal logging but also natural disaster, such as that big thypoon in 1982 which uprooted about 3000 big trees, thereby inviting the domination of invasive plant species such as *Cestrum aurantiacum* and *Austroeupatorium inufolium*.

However when considered as a whole the park is still reasonably in a good state, the primary forest at a greater portion is still good. It should however not put aside the threat from the invasive plant species, although currently is still limited around the CBD, except that *Passiflora ligularis* which is already spreading far to other side. The invasive plant species in the park has been reported by Zuhri and Mutaqien (2011, 2013) and also record in the strategic plan of the Balai Besar Taman Nasional Gunung Gede Pangrango. It was interesting to see that there was still a remnant of the past acclimatisation of European vegetation in the area such the apel tree. The following is a list of invasive plants we selected to run with risk analysis.

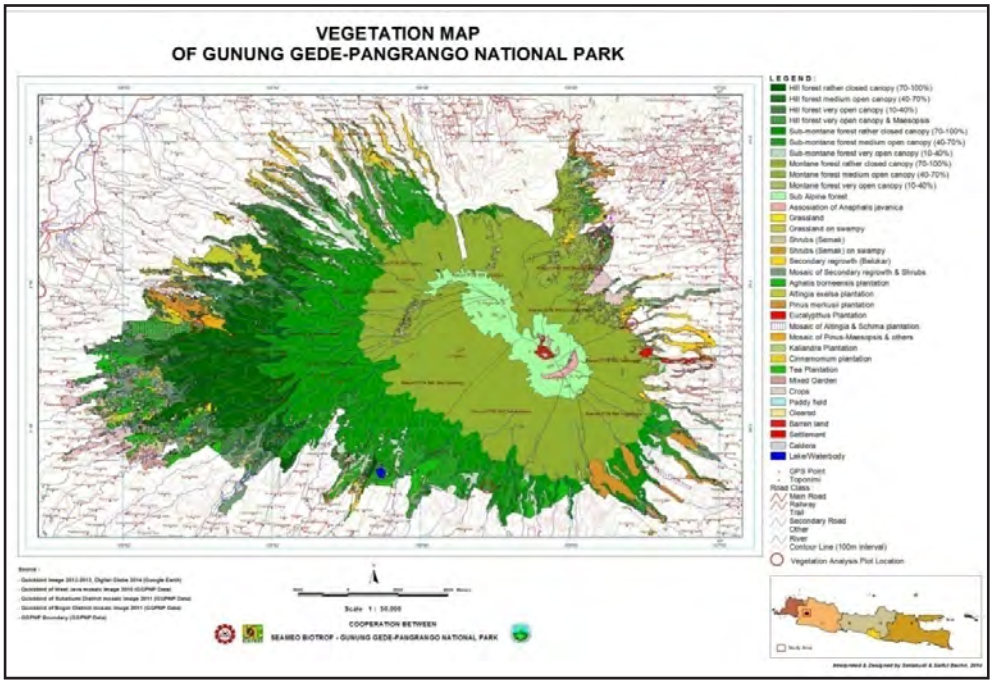

Figure 1. Vegetation map of Gunung Gede Pangrango National Park covering about 24,300 ha including natural primary forests, plantations and unvegetated areas including settlement areas.

Table 3. Various vegetation cover estimated from the developed vegetation map

No.	Vegetation Cover 2013	Area	Area
A.	**Spontaneous Vegetation Type**	**(ha)**	**(%)**
1	Hill forest rather closed canopy (70-100%)	2089.62	8.60
2	Hill forest medium open canopy (40-70%)	702.31	2.89
3	Hill forest very open canopy (10-40%)	960.85	3.95
4	Hill forest very open canopy & *Maesopsis*	158.51	0.65
5	Submontane forest rather closed canopy (70-100%)	4141.35	17.04
6	Submontane forest medium open canopy (40-70%)	1413.56	5.82
7	Submontane forest very open canopy (10-40%)	696.85	2.87
8	Montane forest rather closed canopy (70-100%)	7026.28	28.91
9	Montane forest medium open canopy (40-70%)	497.14	2.05
10	Montane forest very open canopy (10-40%)	277.41	1.14
11	Subalpine forest	1143.86	4.71
12	Assosiation of *Anaphalis javanica*	59.3	0.24
13	Shrubs (Semak)	378.65	1.56
14	Shrubs (Semak) on swampy	2.05	0.01
15	Secondary regrowth (Belukar)	484.68	1.99
16	Mosaic of Secondary regrowth & Shrubs	1307.03	5.38
17	Grassland	8.21	0.03
18	Grassland on swampy	1.08	0.00
19	Mosaic of *Maesopsis* & Belukar	70.05	0.29
B.	**Plantation**		
20	*Altingia excelsa* plantation	308.4	1.27
21	*Agathis borneensis* plantation	707.1	2.91
22	*Pinus merkusii* plantation	488.54	2.01
23	*Eucalyptus* Plantation	34.07	0.14
24	Mosaic of *Altingia* & *Schima* plantation	77.69	0.32
25	Mosaic of *Eucalyptus* plantation & Reforestation	40.05	0.16
26	Mosaic of *Pinus-Maesopsis* & others	53.96	0.22
27	Mosaic of *Eucalyptus* plantation & Crops	73.15	0.30
28	*Eucalyptus* plantation & crops	2.73	0.01
29	Kaliandra Plantation	130.74	0.54
30	Cinnamomum plantation	167.54	0.69
31	Tea Plantation	8.43	0.03
32	Mixed Garden	111.26	0.46
33	Paddy field	78.76	0.32
34	Crops	551.5	2.27
C.	**Non Vegetated**		
35	Cleared	4.24	0.02
36	Settlement	1.38	0.01
37	Barren land	26	0.11
38	Caldera	5.13	0.02
39	Lake/Waterbody	11.49	0.05
	Total	24300.95	100.00

Table 4. List of invasive plant species run through risk analysis method

No	Species	Family
1	*Ageratina riparia*	Asteraceae
2	*Ageratum houstonianum*	Asteraceae
3	*Ammomum concinianum*	Zingiberaceae
4	*Austroeupatorium inulaefolium*	Asteraceae
5	*Bartlettina sordida*	Asteraceae
6	*Brugmansia suaveolens*	Solanaceae
7	*Calliandra calothyrsus*	Fagaceae
8	*Cecropia peltata*	Urticaceae
9	*Cestrum aurantiacum*	Solanaceae
10	*Chimonobambusa quadrangularis*	Poaceae
11	*Cinchona lancifolia*	Rutaceae
12	*Clibadium surinamense*	Asteraceae
13	*Clidemia hirta*	Melastomataceae
14	*Cucurbita* sp. (liana)	Cucurbitacese
15	*Diodea sermentosa*	Asteraceae
16	*Lantana camara*	Verbenaceae
17	*Melastoma affine*	Melastomataceae
18	*Mikania micrantha*	Asteraceae
19	*Montanoa quadrangularis*	Asteraceae
20	*Musa acuminata*	Musaceae
21	*Passiflora ligularis*	Passifloraceae
22	*Piper aduncum* L	Piperaceae
23	*Solanum verbascifolium* L.	Solanaceae
24	*Solanum chriysothricum*	Solanaceae

The following is only an example how to utilize the protocol of Virtue (2010) to evaluate *C. quadrangularis*

INVASIVENESS

1. What is the weed's ability to establish among existing plants ?		Score
□ very high	"Seedlings" readily establish within dense vegetation of among thick infestations of other weeds	3
□ high	"Seedlings" ready establish within more open vegetation, or among average infestations of other weeds	2
□ medium	"Seedlings" mainly establish when there have been moderate disturbance to existing vegetation, which substantially reduces competition. This could include intensive grazing, moving, raking, clearing of trees, temporary flood or summer drought.	1
□ low	"Seedlings" mainly need bare ground to establish, including removal of stubble/ leaf litter. This would occur after major disturbancees such as cultivation, overgrazing, hot fires, grading, long-term flood or long droughts	0
□ don't know		?

This bamboo is particularly invasive, it is able to grow even under the shade therefore it earns the highest scoe of 3. Its invasiveness is also supported by the behaviour of its rhizome, where it is able to grow into every long rhizome, able to emerge above the ground but it was found to submerged again, leaving the portion above the ground coloured green. In some cases that green part supported a branch of mature bamboo stem with green leaves.

2. What is the weed's tolerance to average weed management practices in the land use?		Score
□ very high	Over 90% of weeds survive commonly used weed management practices	3
□ high	More than 50% of weeds survive	2
□ medium	Less than 50% of weeds survive	1
□ ow	Lees than 5% weed survive	0
□ don't know		?

In this National Park, this plant has not been controlled seriously, there was a trial to see if seedling of local species can compete against this bamboo, and no natural sapling can compete against this bamboo. In this national park any herbicide are not allowed to be utilized here, so practically no control technique has been practised upon this bamboo. This question is applicable if the bamboo is controlled manually by chopping it with parang and 100% still survive.

3. What is the reproductive ability of weed in the land use?				Total a+b+c	Score
a. Time to seeding	b. Seed set	c. Vegetative Reproduction			
□ 1 year 2	□ High 2	□ Fast 2	High	5 -6	3
□2-3 year 1	□ Low 1	□ Slow 1	Medium high	3-4	2
□>3 year 0	□ None 0	□ None 0	Medium low	1-2	1
□ Don't know ?	□ Don't know ?	□ Don't know ?	Low	0	0
			Don't know		?

The score allocated to this bamboo by the question is only1. It does not take into account its aggressiveness in sending very long rhizome with smart sense, i.e. it will not emerge into a new shoot when the light intensity is not enough.

4. How likely is long distance dispersal (> 100 m) by natural mean		Total a +b+c+d	Score
a. Flying birds	**b. Other wild animals**	6,7,8	3
Common 2	Common 2	3,4,5	2
Occasional 1	Occasional 1	1,2	1
Unlikely 0	Unlikely 0	0	0
Don't know ?	Don't know ?	Don't know	?
c. Water	**d. Wind**		
Common 2	Common 2		
Occasional 1	Occasional 1		
Unlikely 0	Unlikely 0		
Don't know ?	Don't know ?		

Dispersal is only by rhizome but it is extremely long rhizome.

5. How likely is long-distance dispersal (> 100 m) by human		Total a+b+c+d	Score
a. **Deliberate spread by people**	b. **b. Accidently by people and vehicles**	6,7,8	3
□ Common 2	□ Common 2	3,4,5	2
□ Occasionally 1	□ Occasinally 1	1.2	1
□ Unlikely 0	□ Unlikely 0	0	0
□ Don't know ?	□ Don't know ?	Don't know	?
c. **Contaminated produce**	**d. Doanimalsmestic/farm**		
□ Common 2	□ Common 2		
□ Occasionally 1	□ Occasionally 1		
□ Unlikely 0	□ Unlikely 0		
□ Don't know ?	□ Don't know ?		

Mountain climber sometime chop the stem of this bamboo as a stick to support this climber.

IMPACT

1. **Does the weed reduce the establishment of desired plants?**		Score
□>50% reduction	The weed stops the establishment of more than 50% of desired plants (e.g. regenerating pasture, sown crops, planted trees, regenerating native vegetation) by preventing germination and/or killing seedlings	3
□10 – 50% reduction	The weed stops the establishment of between 10% and 50% of desired plants	2
□ <10% Reduction	The weed stops the establishmnet of less than 10% of desired plants	1
□None	The weed does not affect the germination and seedlingsurvival of desired plants	0
□Don't know		?

We do not have documented data yet that this bamboo reduced the establishment of local species, but from visual observation that underneath this canopy is almost dark, that not many seedling can survive, but *Cestrum aurantiacum*, so certainly it reduces the establishment of desired plants more than 50%.

2. **Does the weed reduce the yield or amount of desired vegetation ?**		**Score**
□>50% reduction	The weed reduces crops, pasture or forestry yield, or the amount of mature of native vegetation more than 50%	4
□25 – 50% reduction	The weed reduces yield or amount of desired vegetation by between 25% and 50%	3
□10 – 25% reduction	The weed reduces yield or amount of desired vegetation by between 10 – 25%	2
□< 10% reduction	The weed reduces yield or amount of desired vegetation by up to 10%	1
□None	The weed has no effect on the growth of desired vegetation. Or the weed may become desirable vegetation at a certain time of the year (e.g. providing useful summer feed) which balances out the reduction in the growth of other desired plants	0
□Don't know		?

Does it reduce the amount of mature native vegetation? Again we do not have documented data yet to support any claims, but if the paper of Muttaqin can be referred to and the fact that the canopy is so thick, it will affect sapplings shorter than 2 m.

3. **Does the weed reduce the quality of produce or services obtained from the land use?**		Score
□ High	The weed severely reduces product quality such that it cannot be sold. This may be due to severe contamination, toxicity, tainting and/or abnormalities (chemical or physical). **For native vegetation**, the weed severely reduces biodiversity (plants and animals) such that it is not suitable for nature conservationand/or nature based tourism. **For urban areas**, the weed causes severe structural damage to physical infrastructure such as buildings, roads and footpaths.	3
□ Medium	The weed substantially reduces product quality such that it is sold at a much lower price for a lowgrade use. **For native vegetation**, the weed substantially reduces biodiversity such that it is given lower priority for nature conservation and/or nature based tourism. **For urban areas**, the weed causes some structural damage to physical infrastructure such as buildings, roads and footpaths.	2
□ Low	The weed slightly reduces product quality, lowering its price but still passing as first grade product. **For native vegetation**, the weed has only marginal effects on biodiversity but is visualy and degrades the natural appearance of the landscape. **For urban areas**, the weed causes negligible structural damage, but reduces the aesthetic of an area through untidy visual appearance and/or unpleasant odour	1
□ None	The weed does not affect the quality of product or services	0
□ Don't know		?

Does it reduce the quality or biodiversity? We believe it does reduce the number of plants growing underneath the canopy.

4. **Does the weed restrict the physical movement of people, animals, vehicles, machinery and/or water?**		Score
High	Weed infestation are impenetrable throughout the year, preventing the physical movement of people, animals, vehicles, machinery, and/or water	3
Medium	Weed infestations are rarely impenetrable, but do significantly slow the physical movement of people, animals, vehicles, machinery and/or water throughout the year.	2
Low	Weed infestation are never impenetrable, but do significantly slow the physical movement of people, animals, vehicles, machinery and/or water at certain time of the year or provide a minor obstruction throughout the year.	1
None	The weed has no effect on physical movement.	0
Don't know		?

Yes, it certainly effects the movement of human.

If we follow the questions of Virtue (2010) on invasive plant species growing in the park we will be able to estimate the risk index as shown below. The index of the risk is calculated as follows : sum all the score from each question for

1. Invasiveness (I) the total score is divided by 15 and multiplied by 10 and rounded off to one decimal place
2. Impact (Ip) of the invasive species the total score is divided by 19 and multiplied by 10 and rounded off to one decimal place
3. While the potential distribution is left as it is (PD).

The risk index = I x Ip x PD. The risk index is categorised into the following:

Risk Score	Category
>192	Very high
<192	High
<101	Medium
<39	Low
<13	Negligible

Table.5. Risk Category of some invasive species reported invading GGPNP

No	Species	Source of Risk			Risk Index	Risk Category
		Invasiveness	Impact	Pot Dist		
1	*Ageratina riparia*	5.333	1.579	4.000	33.684	Low
2	*Ageratum houstonianum*	5.333	1.053	0.500	1.754	Negligible
3	*Ammomum concinianum*	4.000	3.684	4.000	58.984	Medium
4	*Austroeupatorium inulaefolium*	6.667	3.684	6.000	147.368	High
5	*Bartlettina sordida*	6.667	2.105	0.500	7.018	Negligible
6	*Brugmansia suaveolens*	6.000	2.105	4.000	50.526	Medium
7	*Calliandra calothyrsus*	7.333	2.632	4.000	77.193	Medium
8	*Cecropia peltata*	5.333	3.158	4.000	67.368	Medium
9	*Cestrum aurantiacum*	8.000	4.211	6.000	202.105	Very high
10	*Chimonobambusa quadrangularis*	5.333	5.265	8.000	224.561	Very high
11	*Cinchona lancifolia*	6.000	4.737	6.000	170.526	High
12	*Clibadium surinamense*	4.000	1.053	1.000	4.211	Negligible
13	*Clidemia hirta*	4.667	1.053	0.500	2.456	Negligiblwe
14	*Cucurbita sp.* (liana)	4.000	4.737	6.000	113.684	High
15	*Diodea sermentosa*	2.667	0.526	0.500	0.702	Negligible
16	*Lantana camara*	4.667	3.158	1.000	14,737	Low
17	*Melastoma affine*	6.000	1.053	1.000	6.316	Negligible
18	*Mikania micrantha*	4.667	4.737	4.000	88.421	Medium
19	*Montanoa quadrangularis*	4.000	4.211	4.000	67.38	Medium

20	*Musa acuminata*	6.000	3.684	4.000	88.421	Medium
21	*Passiflora ligularis*	6.667	3,684	8.000	196.491	Very high
22	*Piper aduncum* L	6.000	3.158	4.000	75.789	Medium
23	*Solanum verbascifolium* L	6.667	2.105	4.000	56.140	Medium
24	*Solanum chriysothricum*	6.667	1.579	4.000	42.105	Medium

It is obvious that the risk of each species differs one from the other, running from negligible up to very high risk according to Virtue (2010). *C. quadrangularis* gave a very high risk so is *C. aurantiacum*, but *A. inulaefolium* only in the category of high, although immediatelly after the thypoon in 1982 it was very dominant. It seems they competed one against each other. *M. acuminata* and *A. coccinianum* are actually local species, but after that big thypoon become so dominant up to the time when this list was prepared. It is intended that in the process of restoration, the population these local species will also be reduced to give way to selected planted seedling. The risk category together with feasibility category will determine the recommendation of actions upon the respective invasive plant species.

After completing the calculation of risk index, we have to estimate the index of feasibility, consisting of cost of control, distribution of invasive species (area) and persistency of control. Virtue (2010) provided questions with answers each carrying a score; each score indicates the feasibility of containing or controlling or managing those invasive plant species.

The calculation of feasibility index also similar to that of risk index, except that when it has higher value, it indicates low feasibility; when it costs higher dollars to control a plant invasive species, it means that its feasibility is low. When you have wide area to spray you will need more herbicides, more workers, more money to spend, it will bear low fesibility. However in allocating the score to any answer just follow as indicated in the table provided. The index of feasibility = Cost of control x distribution x persistency. The total score of answers to questions on cost of control is divided by 15 and mutiplied by 10; while that of distribution is divided by 12 and mutiplies by 10, that of persistency is divided by 12 and multiplied by 10. The resulting values are converted to feasibility category as the following:

Score of feasibility	Category
>113	Negligible
<113	Low
<56	Medium
<31	High
<14	Very high

Table 6. Feasibility category of invasive plant species in Gunung Gede Pangrango National Park

No	Species	Source of Feasibility			Feasiblity Index	Feasibility Category
		Cost of control	Distribution	Persistency		
1	*Ageratina riparia.*	3.333	1.667	5,456	30.303	High
2	*Ageratum houstonianum*	4.000	0.833	5.455	18.182	High
3	*Ammomum concinianum*	4.667	1.667	3.636	28.283	High
4	*Austroeupatorium inulaefolium*	2.667	2.500	3.636	24.242	High
5	*Bartlettina sordida*	2.000	0.417	4.565	3.788	Very high
6	*Brugmansia suaveolens*	2.667	1.250	4.545	15.152	High
7	*Calliandra calothyrsus*	3.333	1.667	3.636	20.202	High
8	*Cecropia peltata*	3.333	0.083	3.636	1.010	Very high
9	*Cestrum aurantiacum*	4.000	0.083	6.364	21.212	High
10	*Chimonobambusa quadrangularis*	4.667	0.083	4.545	1.768	Very high
11	*Cinchona lancifolia*	4.000	0.883	4.545	15.152	High
12	*Clibadium surinamense*	1.333	0.417	3.636	2.02	Very high
13	*Clidemia hirta*	0.667	2.500	3.636	6.061	Very high
14	*Cucurbita sp.* (liana)	2.667	0.417	2.727	3.030	Very high
15	*Diodea sermentosa*	2.667	0.083	5.455	1.212	Very high
16	*Lantana camara*	2.000	1.500	3.636	10.909	Very high

17	*Melastoma affine*	0.667	2.500	5.545	7.576	Very high
18	*Mikania micrantha*	2.000	0.917	5.545	10.000	Very high
19	*Montanoa quadrangularis*	2.667	0.417	3.636	4.040	Very high
20	*Musa acuminata*	4.667	1.667	3.636	28.283	High
21	*Passiflora ligularis*	2.667	1.250	4.545	15.152	High
21	*Piper aduncum* L	4.000	0.417	3.636	6.01	Very high
23	*Solanum verbascifolium* L	3.333	0.833	4.545	12.626	Very high
24	*Solanum chriysothricum*	4.000	0.083	4.545	1.515	Very high

After completing the calculation of relative risk and feasibility we can further see what is the best actions to take against those invasive plant species by setting those risk relative and feasibility relative values into a matrix

The actions recommended by dr. John Virtue was as follows (see the Matrix):

1. Limited Actions
2. Monitor
3. Manage sites
4. Manage Invasive Species
5. Protect sites
6. Protect sites and manage invasive species
7. Contain spread
8. Destroy infestation
9. Eradication

Matrix of recommendation developed from categorization of risk and feasibility

WEED RISK	FEASIBILITY OF CONTAINMENT				
	Negligible >113	*Low >56*	*Medium >31*	*High >14*	*Very High <14*
Negligible <13	LIMITED ACTION	LIMITED ACTION	LIMITED ACTION	LIMITED ACTION	MONITOR
Low <39	LIMITED ACTION	LIMITED ACTION	LIMITED ACTION	MONITOR	MONITOR
Medium <101	MANAGE SITES	MANAGE SITES	MANAGE SITES	PROTECT SITES	CONTAIN SPREAD
High <192	MANAGE WEED	MANAGE WEED	PROTECT SITES	CONTAIN SPREAD	DESTROY INFESTATIONS
Very High >192	MANAGE WEED	PROTECT SITES & MANAGE WEED	CONTAIN SPREAD	DESTROY INFESTATIONS	ERADICATE

ALERT

Table 7. Recommendation of actions

No	Species	Risk Category	Feasibility	Recommendation
1	*Ageratina riparia*	Low	High	Monitor
2	*Ageratum houstonianum*	Negligible	High	Limited action
3	*Ammomum concinianum*	Medium	High	Reduced the population
4	*Austroeupatorium inulaefolium*	High	High	Contain spread
5	*Bartlettina sordida*	Negligible	Very high	Monitor
6	*Brugmansia suaveolens*	Medium	High	Protect sites
7	*Calliandra calothyrsus*	Medium	High	Protect sites
8	*Cecropia peltata*	Medium	Very high	Contain spread
9	*Cestrum aurantiacum*	Very high	High	Destroy infestation
10	*Chimonobambusa quadrangularis*	Very high	Very high	Eradicate
11	*Cinchona lancifolia*	High	High	Contain spread

12	*Clibadium surinamense*	Negligible	Very high	Monitor
13	*Clidemia hirta*	Negligiblwe	Very high	Monitor
14	*Cucurbita* sp. *(*liana*)*	High	Very high	Destroy infestation
15	*Diodea sermentosa*	Negligible	Very high	Limited action
16	*Lantana camara*	Low	Very high	Monitor
17	*Melastoma affine*	Negligible	Very high	Monitor
18	*Mikania micrantha*	Medium	Very high	Contain spread
19	*Montanoa quadrangularis* .	Medium	Very high	Contain spread
20	*Musa acuminata*	Medium	High	Contain spread
21	*Passiflora ligularis*	Very high	High	Destry infestation
22	*Piper aduncum* L	Medium	Very high	Contain spread
23	*Solanum verbascifolium* L.	Medium	Very high	Contain spread
24	*Solanum chriysothricum*	Medium	Very high	Contain spread

If we look at the table of recommendation, *C. quadrangularis* is recommended to be eradicated. The eradication bears a heavy requirement such as that eradication is only achieved when the last individual has been removed and eradication involves high initial costs, but negligible subsequent costs.

If we look at the result of risk and feasibility assessment, the existing invaded area is still relatively small, in the first 3 invaded area in submontain forest is the target area spread along the fench of CBG, approximately 12 ha, while the second largest invaded area is already above 1500 m asl, approaching the inner zone of the park, therefore it is recommended to be eradicated. The third area is in the submontane forest only less than 100 m^2 . However, the decission to actually eradicate the invasion of *C. quadrangularis* is still subjected to the availability of fun to execute the recommendation. Beside the availability of friendly technology accepted by the park manager.

Three conditions that MUST be met if an eradication programme is to succeed:

(a) Every individual of the target IAS must be killed.

(b) IAS must be removed faster than they breed

(c) Re-invasion risks must be effectively zero

By definition, eradication involves removing all individuals of a targeted population. This means the techniques employed must put all individuals in that population at risk. Where established populations are involved this will take careful planning and execution.

To be certain that all individuals are put at risk it is often necessary to use several techniques at once – or sequentially. Accidentally eradicating native species or endangering human life or health during the course of IAS eradication is considered unacceptable.

Eradication operations are very intensive and can be relatively expensive. To be justified there must be a reasonable prospect that the site will remain free of the eradicated IAS – at least for the foreseeable future. While there is always some risk of re-invasion, this must be kept as low as possible. The appropriate way to manage re-invasion risks is to recognise them at the outset, develop an understanding of the dispersal abilities of the IAS – and its pathways, and to put in place appropriate preventative quarantine and contingency measures. For long lasting eradication of the IAS, its re-invasion must be reduced to zero.

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Appendix D2 : Full Paper of Dr. Tomoko Nishida

ADAPTING THE AUSTRALIAN WEED RISK ASSESSMENT SYSTEM FOR USE IN OTHER COUNTRIES

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ABSTRACT

The Australian Weed Risk Assessment system is a predictive tool to assess the weed potential of new plants. It is a question-based scoring system and consists of 49 questions. The system has been formally adopted by the governments of Australia and New Zealand. In addition, it has been tested around the world and proven to be effective. Plants assessed with the system are classified into three categories, namely 'accept,' 'further evaluation', and 'reject.' The criteria were determined with an Australian dataset, but are applicable to other regions. It is also possible to change the criteria depending on regional conditions, if necessary.Although the system requires a minimum number of questions to be answered, it is best to answer as many questions as possible to assess the likelihood of the invasion success of the non-indigenous plants to be introduced. This is considered feasible since the databases on flora and invasive plants have recently been drastically improved. Further, developing an information-sharing system based on the Australian Weed Risk Assessment system would enhance the efficiency in assessing the weed potential of new plants and contribute to reducing the adverse effects of invasive non-indigenous plants.

Key words: Australian Weed Risk Assessment system, Key variable, Non-indigenous plant, Pre-entry screening, ROC curve analysis

INTRODUCTION

Preventing harmful plants from introduction is the most effective and efficient way to avoid adverse effects caused by non-indigenous plants (Williams 1997). Therefore, it is essential to develop a method to predict the weed potential of new plants. Since potentially harmful plants determined by the method should not be introduced, the assessment procedure should be in accordance with international trade agreements such as the WTO Sanitary and Phytosanitary Agreement. That is, the procedure should be fully transparent and based on scientific evidence. In addition, the assessment procedure should be feasible. Therefore, a resource-intensive process is not appropriate. Various types of methods to assess the weed potential of new plants have been developed (e.g. Parker *et al.* 2007; Pheloung *et al.* 1999; Reichard and Hamilton 1997; Tucker and Richardson 1995; Weber and Gut 2004). Among these pre-entry weed risk assessment systems, the Australian Weed Risk Assessment system (A-WRA) (Pheloung *et al.* 1999) is one of the most decisive and easy-to-use systems, and has been formally adopted by the governments of Australia and New Zealand (Groves *et al.* 2001; Rahman *et al.* 2003). In addition, the system has been tested in at least other 12 countries or areas in Europe, Africa, Asia, the Pacific islands, and North America, and has proven to be effective (e.g. Chong *et al.* 2011; Crosti *et al.* 2010; Dawson *et al.* 2009; Gassó *et al.* 2010; Gordon *et al.* 2008a). Especially, Chong *et al.* (2011) concluded that the A-WRA scores estimated at a particular locality could be appliedto regions with a similar climate and propounded a global database of A-WRA scores.

In this session, I will explain how to use the A-WRA, including a demonstration, and how to modify the criteria depending on the regional conditions. In addition, I will explain why it is important to answer as many questions as possible irrespective of the minimum number specified by the system guidelines.

THE AUSTRALIAN WEED RISK ASSESSMENT SYSTEM

The A-WRA was developed by Pheloung *et al.* (1999) for pre-entry weed risk assessment. It consists of 49 questions on the plant's climatic preferences, biological attributes, and reproductive and dispersal methods (Figure 1a). The responses to the questions are mostly 'yes', 'no', or 'unknown,' and are used to generate a numerical score. Typically, one point is added for a weedy attribute and one point is deducted for a non-weedy attribute (Figure1b). Plants are classified into three categories, namely 'accept (<0); 'further evaluation (0–6); and 'reject (>6). The criteria were determined with an Australian dataset consisting of 370 non-indigenous plant taxa in the country (Pheloung *et al.* 1999). The plants were classified into three weed statuses, namely 'non-weed,' 'minor weed', and 'serious weed,' according to experts' decisions. The relationship between weed status and the A-WRA score was examined and criteria were set so that none of the serious weeds are accepted and that less than 10 % of non-weeds will be rejected (Figure 2). Approximately 30 % of

plant taxa assessed would be categorized as 'further evaluation' using the criteria (Daehler and Carino 2000; Daehler *et al.* 2004; Pheloung *et al.* 1999). Daehler *et al.* (2004) developed a decision tree as a secondary screening method to reduce the number of plant taxa in the category (Figure 3). The A-WRA with or without the second screening has been tested and proven to be effective in at least 14 countries or areas (e.g. Crosti *et al.* 2010; Dawson *et al.* 2009; Daehler *et al.* 2004; Gassó *et al.* 2010; Gordon *et al.* 2008b; Kato *et al.* 2006; Křivánek and Pyšek 2006; McClay *et al.* 2010; McGregor *et al.* 2012; Nishida *et al.* 2009; Pheloung *et al.* 1999; Speek *et al.* 2013).

Although the A-WRA can be implemented manually, the system is designed to run on Microsoft Excel. The Excel spreadsheet is available from the Plant Division, Biosecurity Australia. A ready-made electronic version of the secondary screening is not yet available.

HOW TO MODIFY THE A-WRA FOR USE IN OTHER COUNTRIES

When the A-WRA is applied to other countries, four question in the system, namely 2.01, 2.04, 4.10, and 8.05, which are related to geography and climate, are usually changed to fit the focal area. For countries in the tropics, the four questions would be modified as following Daehler *et al.* (2004):

2.01 Species suited to tropical or subtropical climate(s)? 2.04 Native or naturalized in regions with tropical or subtropical climates? 4.10 Tolerates a wide range of soil conditions? 8.05 Effective natural enemies present locally?

	Botanical name:	*Chromolaena odorata*	**Outcome:**	
	Common name:	**Siam weed**	**Accept <0 Evaluate 0-6 Reject >6**	**Reject**
	Family name:	**Asteraceae**	**Score:**	**23**
			Your name:	**CW**
		History / Biogeography		
A	1 Domestication/ cultivation	1.01 Is the species highly domesticates? If answer is 'no' go to question 2.01	N	A
C		1.02 Has the species become naturalized where grown?		
C		1.03 Does the species have weedy races?		
	2 Climate and Distribution	2.01 Species suites to Australian climate (0-low; 1-intermediate; 2-high)	2	
		2.02 Quality of climate match data (0-low; 1-intermediate; 2-high)	2	
C		2.03 Broad climate suitability (environmental versatility)	N	
C		2.04 Native or naturalized in regions with extended dry periods	Y	
		2.05 Does the species have a history of repeated introduction outside its natural range?	Y	
C	3 Weed elsewhere	3.01 Naturalized beyond native range	Y	
E		3.02 Garden/amenity/disturbance weed		
A		3.03 Weed of agriculture/horticulture/forestry	Y	
E		3.04 Environmental weed	Y	
		3.05 Congeneric weed	Y	
		Biology/Ecology		
A	4 Undesirable traits	4.01 Produces spines, thorns or burs	N	B
C		4.02 Allelopathic	N	
C		4.03 Parasitic		
A		4.04 Unpalatable to grazing animals	N	
C		4.05 Toxic to animals	Y	
C		4.06 Host for recognized pests and pathogens		
C		4.07 Causes allergies or is otherwise toxic tohumans		
E		4.08 Creates a fire hazard in natural ecosystems	Y	
E		4.09 Is a shade tolerant plant at some stage of its life cycle	N	
E		4.10 Grows on infertile soil	N	
E		4.11 Climbing or smothering growth habit	Y	
E		4.12 Forms dense thickets	N	
E	5 Plant type	5.01 Aquatic	N	C
C		5.02 Grass	N	
E		5.03 Nitrogen fixing woody plant		
C		5.04 Geophyte		
C	6 Reproduction	6.01 Evidence of substantial reproductive failure in native habitat	N	
C		6.02 Produces viable seed	Y	
C		6.03 Hybridizes naturally		
C		6.04 Self-fertilization		
C		6.05 Requires specialist pollinators	N	
C		6.06 Reproduction by vegetative propagation	Y	
C		6.07 Minimum generative time (years)	1	
A	7 Dispersal mechanisms	7.01 Propagules likely to be dispersed unintentionally	Y	
C		7.02 Propagules dispersed intentionally by people		
A		7.03 Propagules likely to disperse as a produce contaminant	Y	
C		7.04 Propagules adapted to wind dispersal	Y	
E		7.05 Propagules buoyant	Y	
E		7.06 Propagules bird dispersed		
C		7.07 Propagules dispersed by other animals (externally)	Y	
C		7.08 Propagules dispersed by other animals (internally)		
C	8 Persistence attributes	8.01 Prolific seed production	Y	
A		8.02 Evidence that a persistent propagule bank is formed (> 1 yr)		
A		8.03 Well controlles by herbicides	Y	
C		8.04 Tolerates or benefits from mutilation, cultivation or fire		
E		8.05 Effective natural enemies present in Australia		

Figure 1a) Question sheet for Siam weed (*Chromolaena odorata*) using the Australian Weed Risk Assessment system (Pheloung 2001).
A = agricultural, E = environmental, C = combined

A minimum number of questions must be answered from each of the three main sections, i.e. A: Biogeography, B: Undesirable attribute and C: Biology/ecology. The minimum number of questions for each section is: 2 for Sections A and B, and 6 for Section C.

	a	b	c	d	e
Section	Question	Response[1]	Score	*N* score	*Y* score
A C	1.01			0	-3
C	1.02			-1	1
C	1.03			-1	1
	2.01		The response for these questions is 2 unless a climate analysis is done		
	2.02				
C	2.03			0	1
C	2.04			0	1
	2.05				
C	3.01			Refer to lookup table	
E	3.02				
A	3.03				
E	3.04				
C	3.05				
B C	4.01			0	1
C	4.02			0	1
C	4.03			0	1
A	4.04			-1	1
C	4.05			0	1
C	4.06			0	1
C	4.07			0	1
E	4.08			0	1
E	4.09			0	1
E	4.10			0	1
E	4.11			0	1
C	4.12			0	1
C E	5.01			0	5
C	5.02			0	1
E	5.03			0	1
C	5.04			0	1
C	6.01			0	1
C	6.02			-1	1
A	6.03			-1	1
C	6.04			-1	1
C	6.05			0	-1
A	6.06			-1	1
C	6.07				
A	7.01			-1	1
C	7.02			-1	1
A	7.03			-1	1
C	7.04			-1	1
E	7.05			-1	1
E	7.06			-1	1
C	7.07			-1	1
C	7.08			-1	1
C	8.01			-1	1
C	8.02			-1	1
A	8.03			1	-1
A	8.04			-1	1
C	8.05			1	-1
	Total score [3]				
	Outcome [4]				
	Agricultural score[6]				
	Environmental[6]				

Only score 1.02 and 1.03 if you answered yes to 1.01

Lookup table for section 3.										
Locate value of inputs and lookup output for each										
		Yes to questions 3.01 - 3.05								default
Inputs	2.01	0	0	0	1	1	1	2	2	2
	2.02	0	1	2	0	1	2	0	1	2
Results	3.01	2	1	1	2	2	1	2	2	2
	3.02	2	1	1	2	2	1	2	2	2
	3.03	3	2	1	4	3	2	4	4	4
	3.04	3	2	1	4	3	2	4	4	4
	3.05	2	1	1	2	2	1	2	2	2
		No to questions 3.01 - 3.05								
Input	2.05	?	N	Y						
Results	3.01	-1	0	-2						
	3.02-3.05	0	0	0						

Procedure for scoring assessment

1. Record appropriate responses in column b.
2. Look up score in columns d & e and record result in column c.
3. Calculate total score.
4. Lookup and record recommendation.
5. Verify that minimum number of questions from each section are answered.
6. Compute Agricultural (A&C) and Environmental (E&C) scores: if either score is less than 1, the outcome pertains to the other sector.

Lookup table for 6.07			
years	1	2	4
score	1	0	-1

Score	Outcome
< 1	Accept
1-6	Evaluate
> 6	Reject
Section	**Minimum # questions[5]**
A	2
B	2
C	6
Total	10

Figure 1b) The Australian Weed Risk Assessment system scoring sheet (Walton *et al.* 1999)

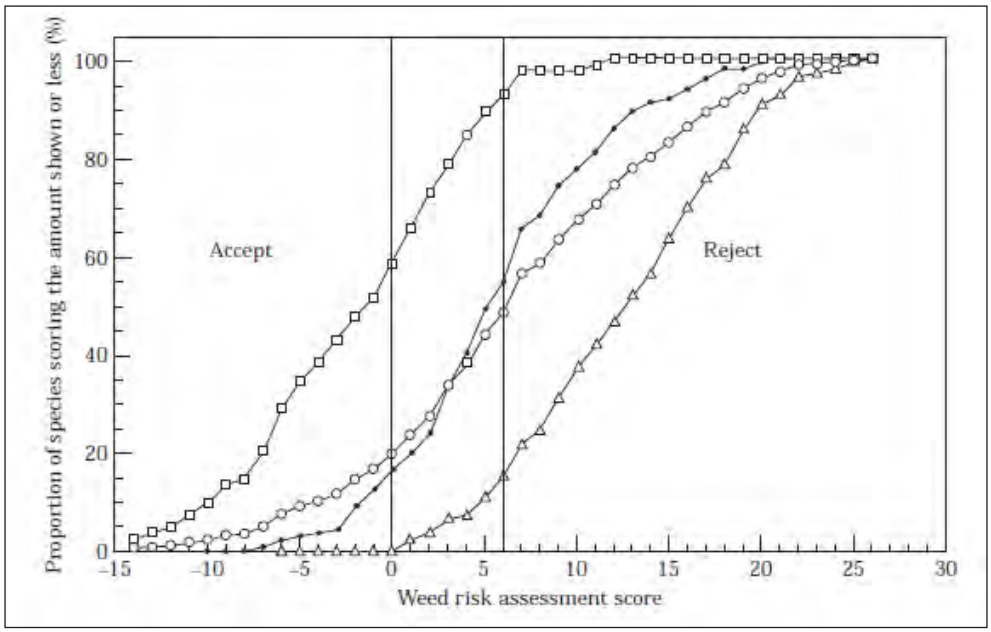

Figure 2. Cumulative frequency of taxa receiving a particularA-WRA score or lower, for each survey classification. Survey categories: (–Δ–), serious weeds (139); (–●–), minor weeds (147); (–□–),non-weed (84); (–○–), all plants (370) (Pheloung *et al.* 1999)

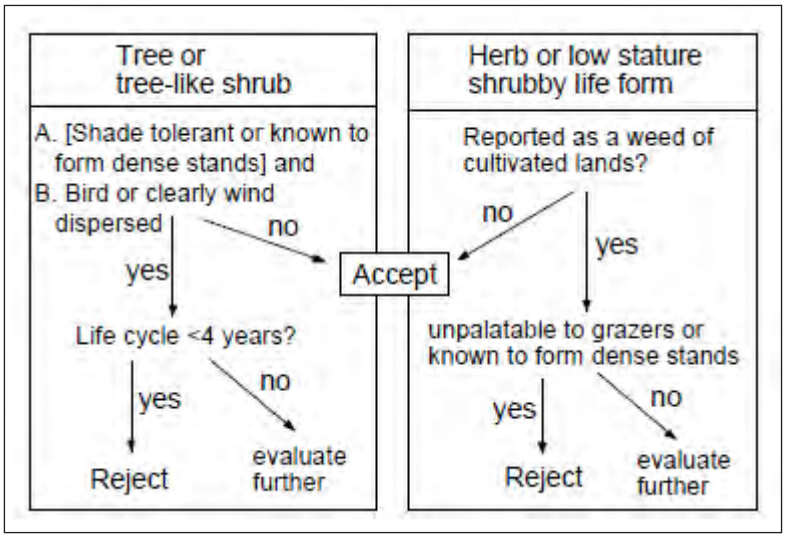

Figure 3. Secondary screening for plant taxa evaluated as 'further evaluation' based on the Australian Weed Risk Assessment system (Daehler *et al.* 2004)

The criteria were originally set for Australia, but are applicable to other regions (e.g. Daehler *et al.* 2004; Gordon *et al.* 2008b; Kato *et al.* 2006; Křivánek and Pyšek 2006). However, predictionsmade using the A-WRA were more accuratewith modified criteria in some countries (e.g. Nishida *et al.* 2009; Speek *et al.* 2013). Because the sensitivity (i.e. the proportion of plants for which the outcome is 'weed' that are correctly identified by the system) is negatively related to specificity (i.e. the proportion of plants for which the outcome is 'non-weed' that are correctly identified by the system), appropriate criteria might vary depending on the situation.Receiver operating characteristic (ROC)curve analysis (Metz 1978), is widely used to assess the performance of a screening test (Bewick *et al.* 2004), and is useful to set the criteria in these cases. Because the method is applicable to datasets with only two categories, 'minor weeds' should be included in 'non-weed' or 'serious weed' categories.

An ROC curve is formed by plotting test sensitivity against the complement of specificity, i.e. 1 – specificity, over the range of potential cut-off levels. The performance of a screening test is quantified by calculating the area under the ROC curve (AUC). A perfect test would have an AUC of 1. When the AUC is greater than 0.5, the test is considered to have some ability for classification. The cut-off level should be set to maximize the benefits from the use of the test. This is dependent on the baserate (the actual proportion of weeds in the set of introduced plants in this case) and the benefit and loss from introducing plants. When these variables are known, the optimum cut-off level can be obtained

(Nishida *et al.* 2009). However, they are not usually readily available. Thus, the cut-off level would be set at the point on the ROC curve that maximizes the classification ability of the test. This point is estimated as follows:

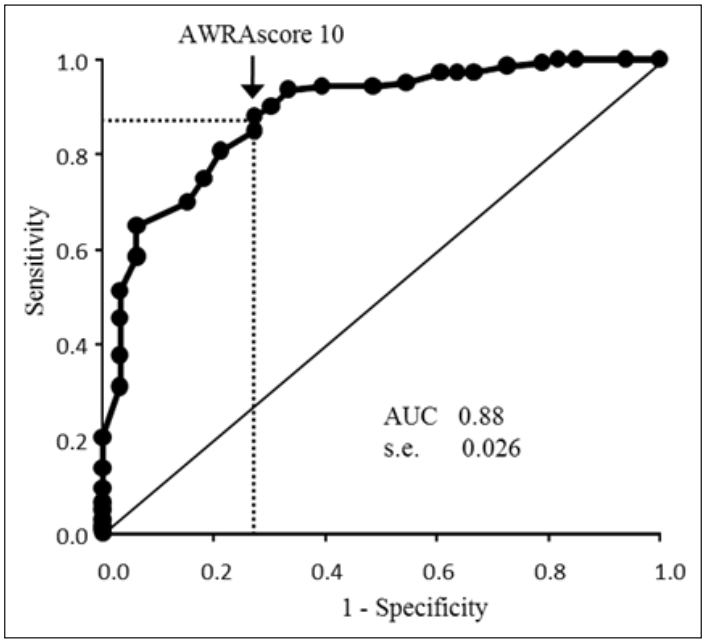

Figure 4. ROC curve for a Japanese dataset using a modified A-WRA questionnaire. The first point at the lower left-hand end of the curve corresponds to an A-WRA score of 30, whereas the point on the upper right corresponds to an A-WRA score of -5. The arrow shows the point where the Youden index is maximal

J = Sensitivity – (1 – Specificity) whereJ refers to theYouden index (Bewick *et al.* 2004).

An ROC curve for a Japanese dataset (Nishida *et al.* 2009) is shown in Figure. 4. The dataset consisted of 259 plant taxa classified as 'non-weed,' 'minor weed', or 'serious weed' based on 20 experts' decisions. Four A-WRA questions were modified to fit the Japanese conditions. Two to four scientists assessed each plant taxon in the dataset using the modified version of the A-WRA. The scores for each taxon were averaged. The ROC curve was created using two-thirds of the dataset. The cut-off level was 10, i.e. taxa with A-WRA scores greater than 10 were regarded as weeds. The sensitivity and specificity were 0.88 and 0.78, respectively. The cut-off level was validated with the remainingone-third of the dataset not used for the calibration. The sensitivity and specificity were 0.87 and 0.94, respectively.

GUIDELINES FOR ANSWERING QUESTIONS IN THE AUSTRALIAN WEED RISK ASSESSMENT SYSTEM

The 49 questions in the A-WRA could be answered without detailed knowledge of new plants. A manual for the A-WRA (Walton *et al.* 1999) is available, and interpretation of the questions is described. However, as the number of studies applying the A-WRA to other countrieshas increased, slight differences in the interpretation of questions have been observed, although the accuracies in these studies reported to be similar (Gordon *et al.* 2008a). Because differences in the interpretation of questions reduces the consistency of its application (Onderdonk *et al.* 2010), clarified guidelines were developed during the second International WRA workshop and ninth annual conference on the Ecology and Management of Alien Plant Invasions, both held in Perth, Australia in 2007 (Gordon *et al.* 2010). The updated guidelines are largely consistent with the interpretation used by the Australian Government, but are more specific. The guidelines also provide sources of information to facilitate implementation of the A-WRA in new localities. Table 1 shows the first part of the interpretation and information sources in the guidelines. Please refer to Gordon *et al.* (2010) for the complete guidelines.

HOW MANY QUESTIONS SHOULD BE ANSWERED?

An assessment of a new plant using the A-WRA takes 5 h (Kato *et al.* 2006) to 24 h (Pheloung *et al.* 1999). Although this requirement appears reasonable, answering all 49 questions in the system can be labor intensive. Several authors have tried to determine the key variables in the system and thereby reduce the number of questions. Although smaller sets of variables that maintain similar accuracy with the original 49 variables have been found, the set varies between datasets. Therefore, it may be best to answer as many questions as possible to assess the likelihood of invasion success of a variety of non-indigenous plants to be introduced (Nishida *et al.* unpublished). This is considered feasible since the databases on flora and invasive plants have recently been drastically improved. Further, as Chong *et al.* (2011)

advocated, developing an information-sharing system based on the A-WRA would enhance the efficiency in assessing the weed potential of new plants and contribute to reducing the adverse effects caused by invasive non-indigenous plants.

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I thank the Plant Division, Biosecurity Australia for providing a copy of the Australian Weed Risk Assessment Excel spreadsheet.

WRA Question	Australian WRA System Guidance used by the Australian Government Department of Agriculture, Fisheries and Forestry	International Working Group Guidance	Suggested Examples and Data Sources
1.01 Is the species highly domesticated? If answer is 'no' go to Question 2.01	The taxon must have been cultivated and subjected to substantial human selection for at least 20 generations. Domestication generally reduces the weediness of a species by breeding out noxious characteristics.	This question will rarely receive a positive answer. Answer 'yes' if the taxon has been intentionally selected over several to many generations for a particular trait or suite of traits that likely reduces weediness. The 'yes' answer should be accompanied by evidence that one or more traits have been substantially modified by people through domestication efforts. Evidence to the contrary (no domestication, or selection that increases invasive traits) or no information results in a 'no' response.	• Examples of 'yes' data: *Mangifera indica* (mango) – see www.botany.hawaii.edu/faculty/daehler/wra/full/Mangifera%20indica.xls; *Litchi chinensis* (lychee) – see www.botany.hawaii.edu/faculty/daehler/wra/full/Litchi%20chinensis%20SA.xls. • Domestication of *Ardisia crenata* has resulted in increased seed production (Kitajima *et al.* 2006), which likely confers greater, rather than reduced weediness. In this case, the answer would be 'no'.
1.02 Has the species become naturalized where grown?	Is a domesticated plant, which has been introduced from another region, and is growing, reproducing and maintaining itself in the introduced range. A 'yes' answer to question 1.01 will be modified by the response to this question.	Skip this question if the answer to 1.01 is 'no'. Answer 'yes' if the taxon has been documented to be regularly producing new generations of reproductive individuals in the environment without human assistance. A 'yes' answer to question 1.01 will be modified by the response to this question. Answer 'unknown' if the taxon is reported to 'sparingly naturalize' or 'occasionally escape from cultivation'. A lack of positive evidence for this question results in a 'no' or 'unknown' answer depending on the amount of information available on the taxon (see General Guidelines section). 'No' responses should be supported by data demonstrating that the taxon is not self-perpetuating.	• Search on taxon name + 'weed' 'naturalized,' 'naturalized' or 'invasive'. • Look into floras of the region to which the taxon is not native. Some useful floras are (1) New Zealand: Webb *et al.* (1988); (2) Florida: Wunderlin and Hansen (2003); (3) Jamaica: Adams (1972); (4) Puerto Rico and Virgin Islands: Little and Wadsworth (1964); (5) British Isles: Stace (1991); (6) South Africa: Glen (2002); (7) Europe: Walters *et al.* (1984–2000) and Tutin *et al.* 1964–1993). • Some online floras are: (1) multiple – www.efloras.org/; (2) Taiwan – http://tai2.ntu.edu.tw/fotdv/fotmain. htm; (3) Hawaii – www2.bishopmuseum.org/HBS/checklist/query.asp?grp=Plant; (4) South Africa – posa.sanbi.org, www.plantzafrica.com and www.agis.agric.za; (5) New Zealand – http://floraseries.landcareresearch.co.nz/pages/Index.aspx; (6) Australia – www.anbg. gov.au/abrs/online-resources/flora/main-query-styles.html; (7) US – http://plants.usda.gov/. • Print or on-line weed lists: e.g., (1) Global Compendium of Weeds – www.hear.org/gcw/; (2) Europe – www.europe-aliens.org; (3) (5) Japan – www.rib.okayama-.ac.jp/wild/okayama_kika_v2/Seed-image-database.html (Note that not all of the plants listed are 'invasive' according to the definition by Pyšek *et al.* [2004]).

Table 1The first part of Table 1 in Gordon *et al.* (2010), which provides the interpretation and information sources for the WRA

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Appendix D3 : Full Paper of Dr. Stephen B. Johnson

THE AUSTRALIAN POST-BORDER WEED RISK MANAGEMENT SYSTEM

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SUMMARY

A simple and human-centred definition of a weed is 'a plant growing in the wrong place at the wrong time'. Many weeds have some negative impact on economic, environmental and/or social/societal/community/cultural assets or values. Weeds are often managed to prevent their negative impacts. These same weeds may also be used for food, raw materials or other purposes, and this use results in positive impacts. Such opposing values can produce conflict in weed management.

The negative impacts of weeds are varied and include damage to primary industries (agriculture, horticulture, forestry and fisheries), natural ecosystems and aquatic areas, our urban areas, damaging infrastructure, causing injury and allergies, and damaging cultural heritage. Weed control costs are also a negative impact.

Regulation is an important tool in managing weeds, particularly those spread by humans, since it is these pathways that can be more easily managed. Preventing the entry of a weed into a country, and to the South-East Asian region, is one of the most effective means to prevent negative impacts. A pre-border Weed Risk Assessment (WRA) system, such as that proposed by Pheloung *et al.* (1999), will help evaluate the risk that proposed plant imports pose. High risk plants can be prevented from entry where border controls can be managed and enforced.

Unfortunately many potential weeds have already been introduced into countries within the South-East Asian region. Post-border Weed Risk Management (WRM) systems, such as those proposed in HB 294:2006, are often used to prioritise weeds that have already established. One component of this post-border system is the assessment of risks posed by weeds, while a second is the assessment of the feasibility of a coordinated control program targeting these weeds.

Where the weed is only present in limited instances, border controls, quarantine and prevention activities can be used to isolate weed species to areas within a region. Eradication campaigns, while involving considerable up-front investment, aim to remove the weed problem from the area permanently. In contrast, containment of a weed will incur ongoing costs. If the area invaded becomes larger, efforts may be made to reduce the impact of the weed, reducing its rate of spread and impacts. This may involve local eradication and containment activities within invaded areas allowing for the protection of assets, whether economic, environmental and/or social/societal/community/cultural. Management approaches gradually transition from weed-led to site-led responses once the protection of assets becomes the main aim.

Priority setting for weed management is crucial in any limited resource environment. The priorities outlined (pre-border and/or post-border) inform a coordinated weed management program and its resourcing. There is much to learn from the global experience in the development, modification and use of pre-border WRA and post-border WRM systems, as well as from new perspectives and developments in these areas. This includes continuing research into how best to implement risk assessment systems in areas where import borders are relatively porous and where multiple jurisdictions occur within a region.

INTRODUCTION

This paper provides a general introduction to Weed Risk Assessment (WRA) and Weed Risk Management (WRM) systems. Firstly, it examines some introductory concepts around plants that are weeds, briefly looking at their impacts and where they come from, with particular reference to Australian examples.

History to this point illustrates that resources made available are never enough to ensure sound management action on all weed species. Thus, there is a need to prioritise in these limited resource environments. Weed Risk Assessment systems are used to do so and evaluate the risks posed by plants entering an area (pre-border or pre-entry). Alternately, WRM systems are used to prioritise weeds that have already established in an area (post-border or post-entry). One component of WRM systems is the assessment of risks posed by weeds.
The principles surrounding WRM systems derive from broader risk management practices, for example in HB 89:2012, and are encompassed in the Australian and New Zealand Standard Risk Management-Principles and Guidelines (AS/NZS ISO 13000:2009). Much of the material presented here comes from the Standards Australia handbook National

Post-Border Weed Risk Management Protocol (HB 294:2006), its revised edition (see Auld *et al.* 2012) which is still under development, also in summary at FAO UN (2011). An overview of WRM systems is outlined in this paper and examined in more detail in the companion paper (Johnson 2015). Finally, a brief history of WRA and WRM systems is given as are examples of systems currently in use.

WHAT ARE WEEDS?

A simple and yet anthropocentric (human-centred) definition of a weed is 'a plant growing in the wrong place at the wrong time'. Often these plants are more abundant than what we expect them to be. As such, weedy plants have some negative effect or impact. In more specific terms, a weed is a plant (which may be native species) that grows in a place where it is not wanted and has negative impacts on economic, environmental and/or social/societal/community/cultural assets or values. Because of their negative impacts, these plants usually need to be controlled or managed. This document uses the definitions above, as modified from Richardson *et al.* 2000).

Beyond the impact costs, costs of control are also incurred, for example: economically for herbicides and application equipment; environmentally in lost biodiversity and off-target damage; and socially such as in the time spent on these control activities. Weeds not only affect primary production, for example agriculture, horticulture, fisheries and forestry, but they affect natural ecosystems and aquatic areas, our urban areas, damaging infrastructure, causing injury and allergies and damaging cultural heritage.

Regulation is an important tool in managing weeds, particularly those spread by humans, since spread pathways can more easily be controlled (Carter 2000). The invasion process of a weed can typically be thought of as in Figure 1 (Auld and Johnson 2014). There is a point when the weed is not present and quarantine and prevention activities are most effective at this point. Both Australia and New Zealand, among others, have a strong pre-border Weed Risk Assessment system (Pheloung *et al.* 1999) to assess and prevent potential weed species from entering both countries (see also Downey *et al.* 2010 and Auld 2012). Preventing the entry of a weed into a country or region, is one of the most effective means to prevent the negative impact of weeds. Borders may be breached, and once detected, a weed may be subject to an eradication campaign, often as a result of a post-border Weed Risk Management assessment (assessing the risk a weed poses and the feasibility of controlling it). Eradication campaigns, while involving considerable up-front investment (Auld and Johnson 2014), aim to remove the weed problem from the area permanently. Containment is often attempted if eradication attempts have been unsuccessful, or if eradication is no longer economically feasible (Auld and Johnson 2014). Having said this, it should be remembered that containment incurs ongoing costs to society (Grice *et al.* 2013). As the area invaded becomes larger, efforts may be made to reduce the impact of the weed, reducing its rate of spread and impacts (Auld and Johnson 2014). This may involve local eradication and containment activities within areas allowing for the protection and/or recovery of certain assets, for example Downey (2010) and Hamilton and Turner (2013). Management approaches gradually transition from weed-led to site-led as invasion continues such that, increasingly, the most important assets need to be identified and protected. An example of environmental asset protection can be found in Downey (2010).

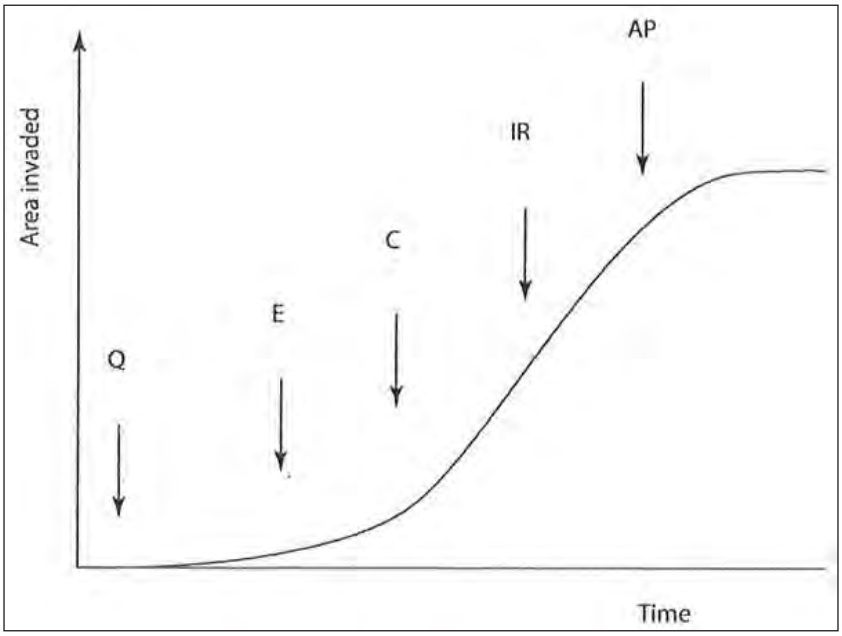

Figure 1. Notional weed management strategies/activities at various stages of weed invasion with the following stages highlighted: Q, Quarantine/Prevention; E, Eradication; C, Containment; IR, Impact Reduction; and AP, Asset Protection (from Auld and Johnson 2014, based on Chippendale 1991).

AN AUSTRALIAN PERSPECTIVE

There are many factors that influence weeds and weed invasion, for example the biological characteristics of the weed, the ecological interactions of the weed with the invaded community, and, as discussed, the impacts caused. As whole-continuum biosecurity approaches become more common, the pathways of entry or means of introduction have received focus, particularly as a means of preventing entry to specific areas. An analysis performed by Virtue *et al.* (2004) indicated that nearly 70% of all plants that were weeds in Australia were introduced for ornamental/garden purposes and that the second highest sector responsible for introductions was the pasture industry, responsible for another 14% of introductions. Although some later studies have sought to highlight that pasture introductions may have been indeed been higher, and that accidental introductions (the 7% in Virtue *et al.* 2004) were probably lower, for example Cook and Dias (2006), the fact that people were responsible for the overwhelming number of intentional introductions of plant species that are now weeds in Australia remains.

A plant species that is valuable in one situation, for example as a food or garden plant can escape cultivation and become a problem weed in another situation, often in an environmental area. These species are commonly called conflict (contentious or commercial) species (Johnson 2012). There are many examples of pasture grasses invading natural ecosystems; two of the more common in northern Australia are gamba (Ferdinands *et al.* 2010) and buffel (Grice *et al.* 2012) grass. Research continues into policy and management solutions to resolve this difficult problem, for example, and aside from above, Bennett and Virtue (2004), Johnson (2007, 2010), Stone *et al.* (2008), Clarkson *et al.* (2010), Friedel *et al.* 2010, Grice *et al.* (2010, 2013), Ferdinands *et al.* (2011) and Kumschick *et al.* (2012).

More than 26 000 plant species have been introduced into Australia (Randall 2007), roughly 40% more than the number of native Australian species (Randall 2006). Of these plants, at least 2,739 have naturalised (just over 10%) while a further 5,907, while not yet naturalised in Australia, have naturalised elsewhere in the world (Johnson n.d.). Further, of the 11,119 Australian native species in cultivation in Australia, at least 606 (just over 5%) have naturalised outside of their native range (Randall 2007). More than 10% of these are recognised as significant weeds, for example see Virtue *et al.* (2004). It is likely that with such a large number of species in Australia that have not yet become naturalised, with increased global trade and continued strong interest in gardening, even with a pre-border WRA system, the number of plants discovered to be naturalising and causing impacts will increase for some time yet. Strategic future weed management will mean a focus on these species now and in the future.

THE NEED TO PRIORITISE WEEDS FOR MANAGEMENT IN A LIMITED RESOURCE ENVIRONMENT

The experience of history shows us that the resources made available have, very often, not been enough to ensure sound management action on all potential, or even current, weed species. Thus, there is a need to prioritise in these limited resource environments. One way to do so is to evaluate which weeds present the greatest threats or risks and/or which ones that we can feasibly manage. Other priorities are likely to be important, for example, which weeds are priorities for:

- research into better control techniques?;
- education and awareness programs?;
- legislative management e.g. noxious weed declaration and enforcement?;
- eradication?;
- containment? and/or
- managing the spread of invasive crops (conflict species)?

Necessarily, these priorities may be influenced by what invasion stage certain weeds are at (Figure 1), and almost certainly by political considerations.

POST-BORDER WEED RISK MANAGEMENT

Weed Risk Management systems are used to prioritise weeds that have already established in an area (post-border or entry). The principles surrounding WRM systems derive from broader risk management practices and are encompassed in the Australian and New Zealand Standard Risk Management-Principles and Guidelines (AS/NZS ISO 13000:2009) and the Handbook Managing environment-related risk (HB 203:2012). Much of the material presented in this paper (and its companion paper Johnson 2015) comes from the Standards Australia handbook National Post-Border Weed Risk Management Protocol (HB 294:2006), its revised edition (Auld *et al.* 2012) which is still under development, also in summary at FAO UN (2011).

The Australian and New Zealand Standard (AS/NZS ISO 13000:2009) defines risk as:

"The chance of something happening that will have an impact (positive or negative) upon objectives. Risk is measured in terms of a combination of the consequences of an event and their likelihood."

In terms of weed risk management we could consider:

- an event to be a new weed (or an existing weed);
- the likelihood as the invasiveness of the weed; and
- the consequences as the total effects of a weed, that is the impacts of that weed over the potential distribution of the species.
- Risk is measured in terms of a combination of the consequences of an event and their likelihood.

The Australian and New Zealand Standard (AS/NZS ISO 13000:2009) defines risk management as:
"The culture, processes and structures that are directed towards realising potential opportunities whilst managing adverse effects".

Applying this to weed risk management, we use a standardised procedure to identify, prioritise, communicate and review the coordinated control of various weed threats within a defined region.

THE (WEED) RISK MANAGEMENT PROCESS – AN OVERVIEW

An overview of a risk management process is illustrated (Figure 2). Two significant changes are applied when this process is applied to weed risk management (Figure 3). The first is the identification of weed risk candidates (weeds) of Step 2 before analysis and evaluation of weed risks at Step 3 (the shaded areas of Figure 3). The second is an additional step where an analysis and evaluation of the feasibility of coordinated control at Step 4 is made. Both of the steps will be examined in more detail in the companion paper (Johnson 2015) after being examined briefly below.

Note: In a weed risk management system, weed risk assessment is just one step in the process.

As mentioned in the introduction, Weed Risk Assessment systems are used to evaluate the risks posed by plants entering an area (pre-border or pre-entry). The outcome of such quarantine systems are generally an entry decision of "yes" or "no". The situation is more complicated when it comes to evaluating weeds in post-border situations: weed control decisions need to be made about whether a weed is high enough priority to be subject to a coordinated control program (a combination of weed risk and feasibility of coordinated control).

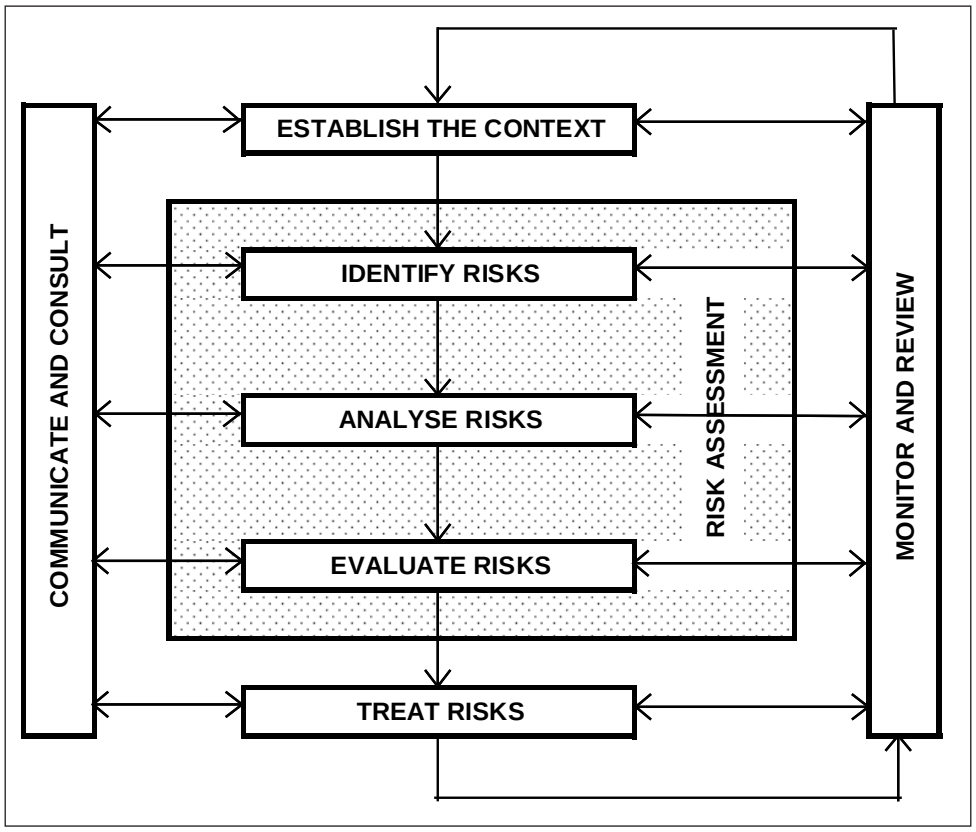

Figure 2. An overview of a typical risk management process (from HB 294:2006).

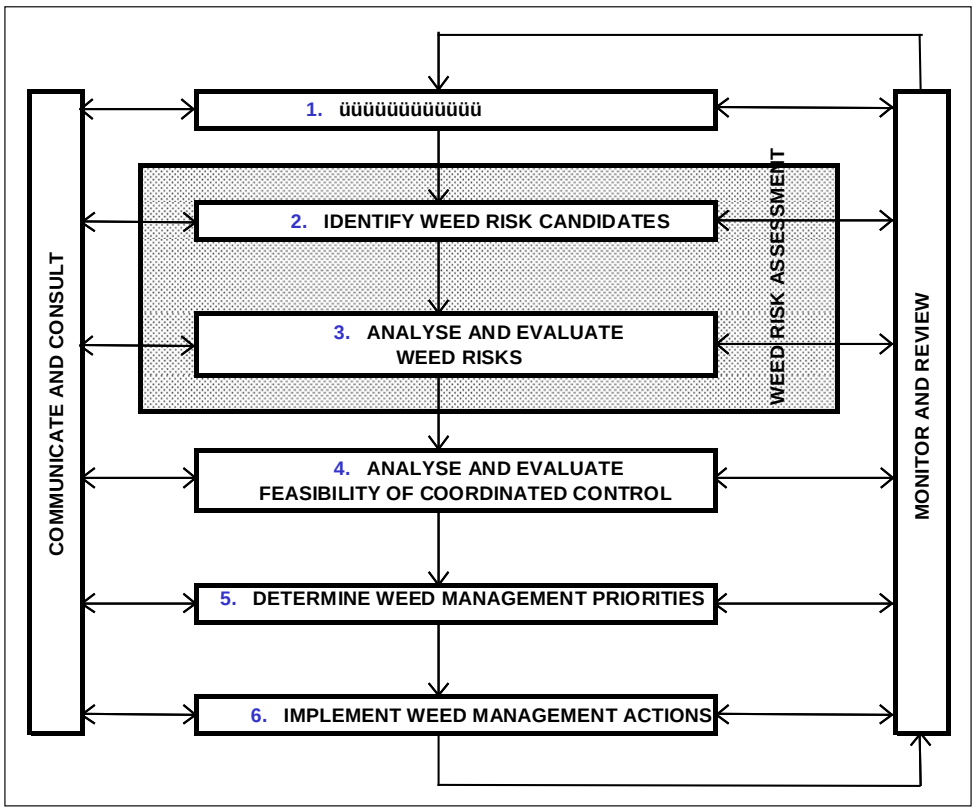

Figure 3. An overview of the weed risk management process (from HB 294:2006).

Weed control can be defined as the application of any of a number of methods, for example mechanical, chemical or biological, that are designed to reduce the density and reproductive output of weed infestations, so that impacts are reduced or mitigated. In contrast, weed management is a strategic, planned, long-term combination of a range of preventative hygiene procedures and active weed control tactics to minimise the spread and impacts of one or a range of weed species. This leads to a coordinated program which is a strategic, usually government-led, weed management program that takes into consideration all occurrences of a weed and involves the application of weed control procedures towards a specific end, for example, eradication or containment. As one moves through weed control to weed management to a coordinated weed control program, one moves from more individual-led to more government-led responses (and from more short-term to long-term responses).

A SHORT HISTORY OF WEED RISK ASSESSMENT

Much of the following discussion is Australian-centric since many early developments in weed risk assessment systems occurred in Australia (Groves *et al.* 2001, Pheloung 2001).

The 'Australian' weed risk assessment system currently used (Pheloung *et al.* 1999) was based around principles drawn from two earlier systems, that is from Hazard (1988) and Panetta (1993). While the Australian Quarantine and Inspection Service (AQIS) used the 12 question decision-making system of Hazard (1988) until 1997, a report earlier commissioned by the Australian Weeds Committee (Panetta *et al.* 1994), as part of the Australian Weeds Strategy, gave guidelines for an improved three-tier process. The 'Australian' or 'Pheloung' system was developed as tier 2 of this pre-border process (Pheloung *et al.* 1999). Tier 1 of the system involves the identification of species with reference to current lists of prohibited and permitted species, and determination of its Australian distribution, if applicable (Walton 2001). The outcomes of the tier 2 (weed risk assessment) system are that the species be accepted for entry, rejected from entering, or further evaluated. In the case of the third tier, that is "further evaluate" research may need to be conducted where insufficient information is available to determine the weed risk and/or to complete the weed risk assessment system (Walton 2001).

This 'Australian' weed risk assessment system (tier 2) involves the application of a numerical-based scoring system of 49 questions which are of a historical, biogeographical, biological and ecological nature. The scoring is generally done by the addition of a point for a 'yes' response, the subtraction of a point for a 'no' response and a zero scored for a 'do not know' response.

Note: the scores from the system can not be used to compare across species or to prioritise a group of species.

Further information on the system, including the question and scoring sheet can be found at Australian Government (2015), with guidance on answering the questions outlined separately (Gordon*et al.* 2010). More detail on the 'Australian' weed risk assessment system and its application can be found in Nishida (2015).

The Australian Weeds of National Significance. The 'Australia' weed risk assessment system was used to develop a system to help determine Australia's inaugural 20 Weeds of National Significance in 1999, for example Thorp and Lynch (2000), Virtue *et al.* (2001) and Weeds Australia (2015). After modifications based on the Post-Border Weed Risk Management system (HB 294:2006), a revised system (Lizzio *et al.* 2010) was used to determine a further 12 Weeds of National Significance, added in 2012 (Weeds Australia 2015).

Use of the 'Australian' Weed Risk Assessment system The use of various pre-border weed risk assessments has been extensively reviewed elsewhere, for example in Downey *et al.* (2010a) and Auld (2012). Having said this, the most common of these applications is the 'Australian' weed risk assessment system tested or adopted: throughout nations around the Pacific Ocean (Daehler *et al.* 2004; Nishida *et al.* 2009; PIER 2013); parts of the United States of America, for example Hawaii (Daehler *et al.* 2004) and Florida (Gordon *et al.* 2008a); throughout continental United States of America for aquatic plants (Gordon *et al.* 2012); in other parts of North and South America (McClay *et al.* (2010) and Fuentes *et al.* (2010), respectively); parts of Africa (Dawson *et al.* 2009); and in parts of Europe such as the Czech republic (Krivánek and Pysek 2006), Italy (Crosti *et al.* 2010) and Spain (Gasso *et al.* 2010).

Global interest in the use of weed risk assessment systems resulted in the 1st international workshop in 1999 involving 45 participants from more than eight nations (see Groves *et al.* 2001). Continued interest and use of the system, including by the Food and Agriculture Organisation of the United Nations (FAO UN 2005), resulted in a 2nd international workshop in 2007 with 70 participants from more than 13 nations (HEAR 2007 and Daehler *et al.* 2010). Following earlier work (Gordon *et al.* 2008b), a review by Onderdonk *et al.* (2010) considered that the Australian weed risk assessment system was robust across various geographies and should be used as uniformly and transparently as possible (Auld 2012).

Some history and use of Weed Risk Management systems In comparison to pre-border weed risk assessment, post-border weed risk management systems are relatively less developed (Auld 2012).

One of the earliest post-border weed risk management systems was developed for South Australia in 1998-2000 (Virtue 2010), itself based on the development of a ranking system for the Australian Weeds of National Significance program (see above). Two main post-border systems are in use in Australia reflecting a diversity of situations, for example those based around: Virtue (2010), that is Setterfield *et al.* (2006) and Johnson (2009a, b) for use in South Australia, the Northern Territory and New South Wales, respectively; and the approach used by Weiss *et al.* (2004) for Victoria. These systems are consistent with the Standards Australia/Standards New Zealand approach (HB 294:2006) which is currently being revised (Auld *et al.* 2012). This system can evaluate weed risk and feasibility of control across a range of scales from local to regional, state/province to national levels.

Significant global interest and training in the use of the post-border weed risk management system (HB 294:2006) has occurred through the Food and Agriculture Organisation of the United Nations (see for example FAO UN 2011) with training in Central and South America, Northern Africa and throughout South-East Asia (including in this volume). This coincides with a broader interest in the assessment of post-border risk, for example by Randall *et al.* (2008) in the United States of America, in parts of the same, for example USGS (2006), Cal-IPC (2015)and USDA FS (2012), as well as in Australia, for example for botanic gardens (Virtue *et al.* 2008), for the Australian Nursery and Garden Industry (NGIA (2013) for genetically modified crops (for example OGTR (2013) and Keese *et al.* (2013)), both of which are based on Virtue 2010), and regional species-led prioritisations affecting environmental values (Downey *et al.* 2010b, c). Published works on the translation of weed risk management outcomes to policy and management responses is more recent and includes both Australian (Clarkson *et al.* 2010, Downey 2010, Downey *et al.* 2010c, NSW DPI and OEH 2011), North American (for example Fox *et al.* 2008, Gordon *et al.* 2008a, WS NWCB 2010 and USGS 2015) and United Kingdom instances (for example DEFRA 2015). Most recently, Blackburn *et al.* (2014) proposed a system for assessing the environmental impacts of a range of alien species including weeds.

Further information and new applications of post border weed risk management systems can be found in the reviews of Downey *et al.* (2010a), Auld (2012) and Steel and Johnson (2015). Having said this, there is a need to both rationalise and reduce the number of scoring/ranking systems to enable better sharing of assessment data and improve the consistency of results between different WRM systems.

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Appendix D4 : Full Paper of Dr. Stephen B. Johnson

SUMMARY OF AND RESOURCES NEEDED TO IMPLEMENT POST-BORDER WEED RISK MANAGEMENT SYSTEM

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SUMMARY

There is a saying that 'prevention is better than cure'. This is true with respect to weeds and their entry into a country or a region. A pre-border Weed Risk Assessment (WRA) system, such as that proposed by Pheloung *et al.* (1999), can help evaluate the risk that proposed plant imports pose.

Having said this, many weeds have already been introduced into countries within the South-East Asian region. A post-border Weed Risk Management (WRM) system, such as that proposed in HB 294:2006, can be used to prioritise established weeds so that the best use of resources available for weed management can be made. This WRM system can be used to prioritise weeds within any natural ecosystem or man-made situation, and can be used at a variety of scales, from a village to a park, a water catchment, a province or state, at a national level, and across national borders such as in the South-East Asian region.

The six stages in the WRM process are examined in this paper. These are: establishing the WRM context; identification of weed risk candidates; analysis and evaluation of weed risks; analysis and evaluation of feasibility of coordinated control; a determination of weed management priorities; and implementation of weed management actions. Two further steps are crucial in the WRM process and should be performed at each stage, these being: communication and consultation; and monitoring and review.

Establishing the WRM context will involve an evaluation of the: goal/s; geographic and land use scope; stakeholders; policy and legislation; the resources available; the expected outputs and outcomes; potential risk and feasibility assessment methods; and project management. The second step of identifying weed risk candidates will involve: listing current weeds; detecting new weeds; reviewing likely incursions; and then selection of a subset of weed species for further analysis.

The third and fourth steps are central to the WRM system and involve an evaluation of certain criteria. An analysis and evaluation of weed risks will involve comparing the invasiveness, impacts and potential distribution of each weed. Similarly, an analysis and evaluation of feasibility of coordinated control will involve comparing the current distribution, control costs and duration/persistence of a weed. Both steps involve semi-quantitative scoring of questions relating to these criteria, and subsequent compilation of separate weed risk and feasibility of coordinated control scores. Priorities for weed management can be set by comparing these two scores across a prioritisation matrix. Implementation of weed management actions against priority weeds then occurs. Each step involves communication and consultation, as well as monitoring and review.

The resources needed for prioritisation using a WRM system should be far less than those used to manage problem weeds. While global expertise and resources are increasing available 'online', formal commitment to implementation of both WRA and WRM systems at a national and South-East Asian regional level is also necessary.

INTRODUCTION

This paper presents a summary of the Weed Risk Management (WRM) system as found in the Standards Australia handbook National Post-Border Weed Risk Management Protocol (HB 294:2006). That document is currently undergoing revision, for example, see Auld *et al.* (2012). It is also summarised in FAO UN (2011). The principles surrounding WRM systems derive from broader risk management practices and are encompassed in the Australian and New Zealand Standard Risk Management-Principles and Guidelines (AS/NZS ISO 13000:2009).

Each of the six stages in the WRM process is examined in this paper. These are: establishing the WRM context; identification of weed risk candidates; analysis and evaluation of weed risks; analysis and evaluation of feasibility of coordinated control; a determination of weed management priorities; and implementation of weed management actions. Two further steps are crucial in the WRM process and should be performed at each stage, these being: communication and consultation; and monitoring and review. Finally, the paper examines the resources needed to implement a weed risk management system.

This paper is a companion to another paper introducing both weed risk assessment and weed risk management (Johnson 2015).

THE SIX STAGE WEED RISK MANAGEMENT PROCESS

An overview of the weed risk management process is examined in this paper (Figure 1). Each of the six stages in the Weed Risk Management process will be examined in more detail in this paper, that is the paper discusses:

- establishing the WRM context;
- identification of weed risk candidates;
- analysis and evaluation of weed risks;
- analysis and evaluation of feasibility of coordinated control;
- determining of weed management priorities; and
- implementing of weed management actions.

There are two additional steps that are usefully carried out at each stage, that is:

- communication and consultation; and
- monitoring and review.

Stage 1 Establish the weed risk management context

Establishing the weed risk management context is an essential step in the WRM process (Figure 1). Many later problems that are encountered arise from inadequate consideration of one or more of the steps below, these being consideration of: goal/s; geographic and land use scope; stakeholders; policy and legislation; the resources available; the expected outputs and outcomes; risk and feasibility assessment methods; and project management. For this reason, each of these factors will be briefly examined and examples given below.

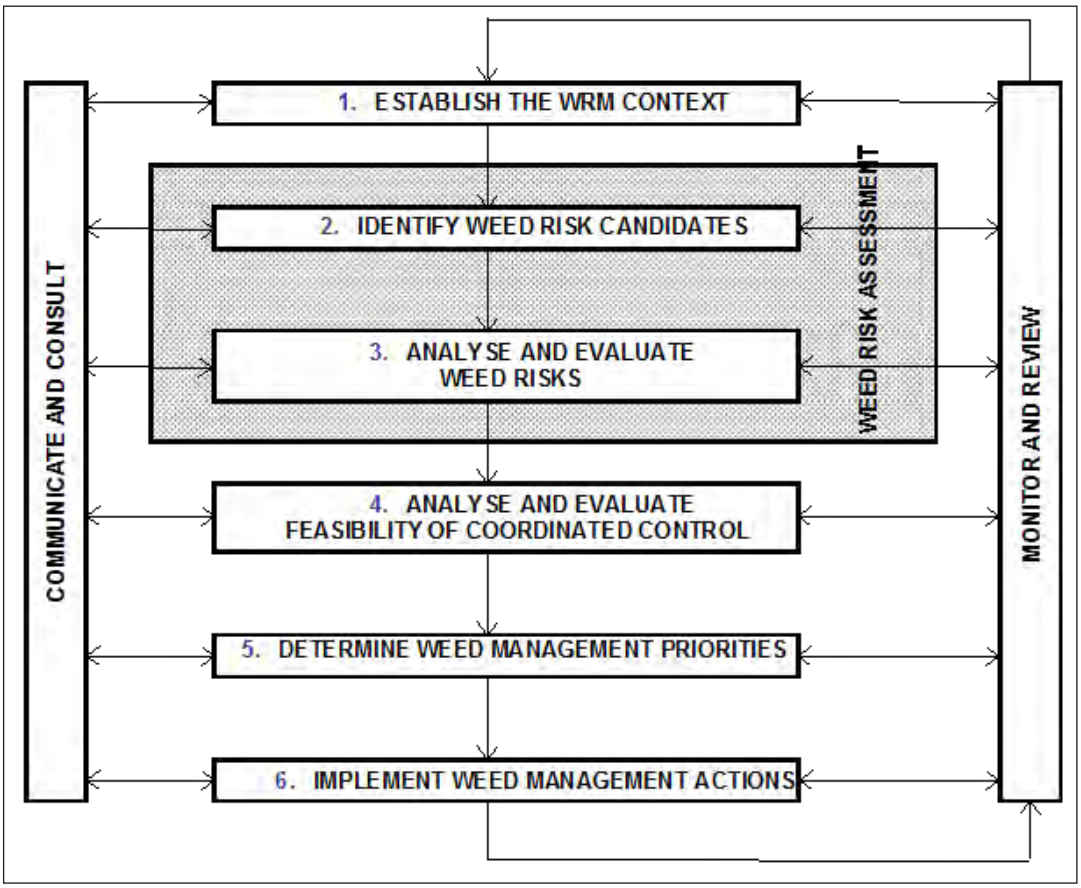

Figure 1. An overview of the weed risk management process (from HB 294:2006).

Goals. It is important to consider what the organisation you are working for/with wishes to achieve from the WRM process. Examples may include:

- determining a country or a region's 10 worst weeds;
- identification of all significant weeds (far more than 10?) and categorisation of these weeds into best management actions for them;
- identification of new weed threats which can and should be eradicated or contained in the immediate future; and/or
- deciding which existing weeds should be a priority for research into better control techniques.

There are, of course, many other equally valid goals. Choice of a goal/s is critically important in influencing the entire WRM process.

Geographic and land use scope. Many different people will be influenced by, and may wish to have influence on, the WRM process. Who these people are will be determined by the geographic area being considered and the land use within that area. Most importantly those affected by weed management decisions need be considered, for example those:

- who will be advantaged by better weed management; and
- who will face costs of control in order to protect themselves and others.

Examples of those affected, positively or negatively includes government, farmers, indigenous people, the garden industry, scientists, environmentalists, people involved in transport, those who own land, and many others. Such a diverse group of people **need to have adequate stakeholder representation throughout the WRM process.**

Stakeholders. The identity of stakeholders is determined in relation to the geographic area and land use scope above. This will necessarily be influenced by the weed management area within the geographic area. This may involve recording details of which properties, water catchment, region, state or province, or even country, depending on the size of the program. It may also involve recording the land uses in each of these areas, for example forestry, agriculture, natural ecosystems, freshwater areas and/or urban/village areas. This process will help focus the overall goals if necessary, examples including: weeds affecting forestry in the region (across national boundaries); weeds affecting cattle production in the country; weeds affecting horticulture in the province; and/or weeds threatening conservation and tourism in the national parks.

Policy and legislation. Policy and legislation are important to help with enforcement of control, and management, where necessary. Laws and official procedures may already exist at a national level, for example noxious or proclaimed plant laws and/or agricultural industry hygiene policies and procedures. Typically, noxious weed laws have powers to:

- to prevent the sale of weeds, for example as garden plants;
- to prevent the movement of weeds in contaminated produce, for example weed seed in grain or attached to livestock, or via other means, for example on vehicles; and/or
- require landholders to control the weed.

Resources available. Resources are needed to both undertake the WRM process and also to act upon the results, that is, to manage the weeds. Resources needed include time, people, money and information. If there are limited resources it may be easier to aim to do a simpler WRM process which identifies a short list of priority weeds for management. The resources needed to implement a weed risk management system are outlined in the final part of this paper.

Expected outputs and outcomes. Outputs and outcomes differ, with outputs generally involving some sort of activity, and with a whole range of outputs contributing to an outcome or general change.

Examples of outputs at the end of the WRM process could be:

- a published report;
- a revised list of noxious weeds (under legislation); and/or
- management plans for priority weeds.

These outputs contribute to an overall outcome which could be:

- coordinated control programs initiated to substantially reduce the impacts of 5 priority weeds; and/or
- new research into control of a number of priority weeds.

Risk and feasibility assessment methods. How one is going to assess weed risk and feasibility of coordinated control needs to be decided before analysis of candidate weeds. This will avoid the potential for bias and allows stakeholder concerns to be taken account of before the assessment process formally commences.

Project management. Project management is needed to ensure the WRM process is completed. It is best to have a WRM steering committee which adequately represents stakeholders and has good weed expertise. A project manager will also be needed to run the WRM process.

Stage 2 Identify weed risk candidates

Context setting needs to occur before any weed candidates are identified (Figure 1). Identification of the risks (weeds) is the first step in the weed risk assessment process (Figure 1). In general there are four steps often used in identifying weed risk candidates, that is to:

- list current weeds;
- detect new weeds;
- review likely incursions; and
- select species for further analysis.

There may be a very large plant flora within the geographic area in which you are working and/or a large number of weeds. Which weeds should be considered will depend on the WRM goal (from Stage 1), for example:

- to prioritise existing weeds; and/or
- to prevent new weeds.

It is often necessary to develop a list of weed species, then to screen this list to a manageable number for formal assessment. Correct taxonomic identification is vital at this stage and it may be necessary to refer to the internationally-accepted scientific name so that global literature can be found to risk assess the species. A useful resource for internationally accepted scientific plant names is the Germplasm Resources Information Network (GRIN; USDA, ARS (2013)).

List current weeds. A useful first step in listing current weeds will be consolidation of any published lists of problem weeds in the agreed geographic area. This may also involve surveying stakeholders about their weeds of concern and examining key regional publications. Key regional publications may include weed books, regional or country floras, checklists and other published material.

Detect new weeds. Early detection is vital if the goal of the program is to eradicate new weed threats. In general, eradication is more feasible when a species is only recently naturalised since this avoids future impacts and control costs. To do this properly, there is a need to invest resources in surveillance networks which may contain botanists, foresters, agronomists and others to ensure new weeds are found as quickly as possible; and also taxonomists, to ensure that proper weed species identification occurs.

Review likely incursions. Early detection activities can be enhanced if likely new incursions are analysed and surveillance for these performed. This may involve considering which weeds occur in adjacent countries/regions and are likely to be transported to your area, and which exotic plants have been introduced to the country, for example for agriculture including pastures, for gardening, for forestry, and others but that which are not yet naturalised. Known weeds in other parts of the world, particularly in similar climatic areas, are of particular concern even if they have not begun to naturalise yet in their new environment. All pathways of entry should be considered and this may include plant trade both informally between people, but also more formally via the internet. New incursions in neighbouring areas, particularly if covered in electronic floras or new incursion lists may also be valuable.

Selection of species for further analysis. Subsequent to the three steps above, a large list of potential weeds may be obtained. There will rarely be enough resources to formally analyse every weed species, nor may this be necessary. Selection of species for further analysis depends on the goals of the WRM process.

The list of candidate species can be reduced by removing those species which clearly do not fit the goal of the process, for example, if the goal is:

- a list of priority weeds for eradication, then exclusion of weeds which are already widespread would occur; or
- to prioritise all existing agricultural weeds, then exclusion of those that farmers have never specifically targeted may occur.

Stage 3 Analyse and evaluate weed risks

The weed risk assessment, or analysis and evaluation of the risks posed by weeds is at the core of the WRM process (Figure 1). The information below has been significantly summarised, but further detail can be found in the Standards Australia handbook National Post-Border Weed Risk Management Protocol (HB 294:2006). Application of this information into an overall assessment system can be found in various sources, for example Johnson (2009a, b).

As outlined in the companion paper (Johnson 2015), the Australian and New Zealand Standard (AS/NZS ISO 13000:2009) defines risk as:

"The chance of something happening that will have an impact (positive or negative) upon objectives. Risk is measured in terms of a combination of the consequences of an event and their likelihood."

In terms of the WRM process, we could consider:

- an event to be a new weed (or an existing weed);
- the likelihood as the **invasiveness** of the weed; and
- the consequences as the total effects of this weed, that is the **impacts** of that weed over the **potential distribution** of the species.

Risk is measured in terms of a combination of the consequences of an event and their likelihood.

Definition of existing weed controls. An important first step in Stage 3 is in defining existing weed controls. In analysing weed risk, we consider the potential threat that a weed poses if it is not controlled. In doing so, it is important to consider and agree about what current routine weed management practices occur, for example, in many environmental areas this may only be fire, whereas in agricultural areas weed management may involve removal by hand, herbicide application and/or cultivation. We then consider the risk that particular weeds pose under these

existing practices. The implication is that weeds that are controlled by routine management practices will never pose as significant a risk as those not controlled.

Invasiveness. A measure of the invasiveness of a weed gives a likely rate of spread of the plant. A worst case scenario is assumed so as to compare 'like with like'. There are three factors, and their magnitude, to consider when assessing invasiveness, these being:

- **Ability to establish**, for example, the weed may establish in dense vegetation in forests or crops, or alternately it may mainly establish following significant disturbance which bares the soil;
- **Ability to reproduce**, for example, the time period from germination to seed set, the quantity of seed and ability/quantity of vegetative reproduction should be considered. Often plant species with rapid sexual and vegetative reproduction are invasive; and
- **Ability to spread or disperse**. Spread generally depends on the number of dispersal modes for a weed, the frequency with which dispersal occurs and the distance both sexual and vegetative propagules are moved. Both natural and human-influenced modes need to be considered such as: wind; water; flying and ground animals; deliberate and accidental human spread. Vehicles and contaminated produce are particularly important accidental human modes of dispersal.

Impacts. A measure of the impacts that a weed causes will help reveal the problems caused by/effects of the weed. The levels of impact are often related to weed density (how frequent a weed is within an area), so it is important to record this density as an assumption so that impact can be assessed on a common basis (see Johnson 2009a, pg. 24 for example). Once density is determined, a worst case scenario for impacts is then assumed so as to compare 'like with like'. There are six factors, and their magnitude, to consider when assessing impacts, these being:

- **competitive exclusion of other plants**, for example, to what extent will the weed kill or exclude seedlings of the desired plant, whether in a crop, pasture or forestry situation, or in a natural environment;
- **reduction in yield/biomass (quantity) of other plants**, for example, to what extent the weed will reduce the yield of crops, growth of pastures, time to maturity of forest trees or the cover of native plants;

The establishment of animals and other organisms is often directly related to plant establishment and biomass production. It is useful to assume that reductions in plant establishment and biomass will result similar reductions in animal biomass and yield.

- **reduction in quality of products/services** as opposed to yield or biomass (quantity), this factor examines the quality of products or services. Examples may include contamination or tainting of milk, grain, meat or drinking water. Broader societal impacts such as damage to roads, buildings and infrastructure may occur. Reductions in threatened and non-threatened biodiversity are common environmental impacts of weeds but so too are a reduction in the tourism values once biodiversity declines beyond a certain point.
- **restriction of physical movement**, for example, the extent to which the weed restricts or stops the physical movement of people, animals, vehicles, machinery and/or water. Tall, thorny, dense and/or tangled weeds commonly restrict access on land, while thick infestations of water weeds can impede the movement of people and flow of water;
- **on human and/or animal health**, whether this be native or domesticated animals. Weeds may cause physical injuries, for example via thorns, or may result in a range of physiological reactions and symptoms from death or severe illness, to poisoning and hayfever, to minor rashes; and
- **altered ecosystem processes**, that is major changes to a number of ecosystem processes can occur. From an anthropocentric (human) point of view, these may be viewed as positive or negative effects, for example major changes in water and nutrient availability, changes to fire regimes, soil stability and soil salinity. Weeds may provide food/shelter/an alternate host to animals, invertebrates and pathogens. Other direct impacts include altering soil acidity and carbon levels, reducing water oxygen and acidity levels, altering flooding regimes, or, perhaps, a range of changes resulting in whole ecosystem transformation from dense weed monocultures. Indirect impacts should also be considered, if known.

Potential distribution. The impacts caused by a weed species are experienced across the total potential area that it can invade. A worst case scenario is assumed so as to compare 'like with like'. The potential area of invasion will depend on a combination of suitable climate, soil tolerances and susceptible land uses. For aquatic weeds, water temperature and other water properties such as salinity, depth, clarity and flow are more important (for example see Champion and Clayton 2001).

Although there are a number of factors that influence the invasion of weeds on land, temperature and rainfall are common climate parameters used, and soil pH texture and drainage influence soil tolerances. Not all weeds appear to be capable of invading all land use systems, whether used for primary production, environmental or community purposes. Potential distribution will be affected by future climate change (Kriticos *et al.* 2006; Kriticos *et al.* 2010). At

a minimum, potential establishment areas should be estimated by matching known distribution data to similar climatic zones, for example Köppen's climate classification (Köppen 1936), which is available from CliMond (e.g. CliMond 2015.

Further information about estimating the Potential Distribution of a weed can be found in the revised version of in the Standards Australia handbook National Post-Border Weed Risk Management Protocol (HB 294:2006).

Analysis of (Determining) weed risk. Weed risk analysis (often also called Weed Risk Assessment) is the use of standard, technical criteria to determine the relative weed threats posed by different plant species. In a WRM process, a ranking system is used which combines the scores for Invasiveness, Impacts and Potential Distribution, that is:

risk = likelihood consequences

with **likelihood = Invasiveness** and

consequences = Impacts and Potential Distribution

or **expressed another way**:

weed risk =	**impacts**	**x**	**potential distribution**	**x**	**invasivenes**
	$/hectares/year		**hectares**		**hectares (current year)/hectares (previous year)**

Any scoring and ranking system used should be logical, tested for accuracy before formal use and be easy to use. One example can be found in Johnson (2009a, b).

Evaluation of weed risk, Risk evaluation is the interpretation of the weed risk score into a level of risk, for example high, medium or low. One example can be found in Johnson (2009a, b).

Stage 4 Analyse and evaluate feasibility of coordinated control

The analysis and evaluation of the feasibility of coordinated control is an extra step inserted in the WRM process (Figure 1), and not present in more generic risk assessment processes. This stage aims to determine which weed is easier to control since coordinated control programs often aim to achieve eradication or containment of a weed within the geographic area through locating and treating all occurrences and restricting all movement/dispersal of seeds or vegetative material. Again, the information below has been significantly summarised, but further detail can be found in the Standards Australia handbook National Post-Border Weed Risk Management Protocol (HB 294:2006). Application of this information into an overall assessment system can be found in various sources, for example Johnson (2009a, b).

Determining feasibility of coordinated control also involves three steps, these being estimating:

the **current distribution** of the weed x **the control costs** x t**he duration/persistence (or how long control is needed for)**.

Definition of targeted weed controls. An important first step in the feasibility of coordinated control part of the WRM process is in defining targeted weed controls. When analysing weed risk, we examined the potential threat a weed posed under the current, routine weed management practices. When analysing feasibility of coordinated control it is important to consider how a weed responds under targeted weed control practices. These control practices need to be defined and recorded. The implication now is that a weed that is easily controlled by targeted management practices will be more feasible to control.

Current distribution. The cost and duration of weed management will be directly influenced by where the weed is found. Considering the post-border context, the weed may not yet be present in the landuse under consideration (but could be found in the geographic area under consideration), it may have recently naturalised, it may be found in restricted areas right through to being widespread. A best case scenario for current distribution is assumed so as to compare 'like with like'. There are three factors, and their magnitude helps determine current distribution, these being the:

- **total area infested** which could be thought of as the area bounded by all known plants and summed for all known infestations (and areas where it is grown if necessary). Eradication of a species is generally difficult to achieve for infestation areas greater than 100-1000 ha (Groves and Panetta 2002, Panetta and Timmins 2004);
- **number of infestations** which is the number of distinct infestation sites that need to be independently searched and treated; and
- **accessibility of infestations** which includes the travelling times to, and movement within the infestations, that is for searching and for treatment. This will be influenced by the maximum distance between each infestation and the ease of movement within infestations.

Control costs. These are influenced by the costs of finding and treating infestations. Although exact costs are often difficult to determine, they can be estimated by scoring the factors below. To do so, one considers that the control costs per hectare that will be incurred in the first year of targeted control for an infestation that has reached its maximum

density in the landuse at risk. This allows a comparison of 'like with like'. There are three main factors, and their magnitude, to consider when assessing control costs, these being:

- **detectability** is important not only so as to find all new plants, but also to manage these prior to reproduction. Detection will depend on the height of the plant, if it can be readily differentiated against surrounding vegetation and its lifecycle which influences the length of time plants are growing and visible (for example, some plants are readily frosted off);
- **treatment of infestations and the expense incurred**. Control costs can be broken down into chemical costs, labour costs (including of volunteers) for all control activities and equipment costs (including fuel and operating costs). High equipment costs are incurred when using earthmoving equipment and helicopters, and low costs when using standard spray equipment or physical means of control such as a machete or an axe. Calculation of costs should not include the capital costs of buying equipment, nor the costs travelling to an infestation or obtaining water access for mixing herbicides. Assume these are already available; and
- **land manager involvement** and the effort required to achieve long-term landholder cooperation. Necessarily, this will include education, awareness raising and enforcement costs, but also project administration and management costs. It is also dependent on the financial, operational and technical capacity of the land managers/stakeholders. It is useful to assume that there is no conflicts of interest here that is landholders wishing to make economic use of the plant (for example from wild harvest or from plantings).

Duration/Persistence. The duration or persistence of control needed to achieve either eradication or some other level of desirable level of control necessarily dictates the feasibility of control. A best case scenario for current distribution is assumed so as to compare 'like with like'. There are four factors, and their magnitude helps determine the duration or persistence of control, these being:

- **efficacy of targeted control**, that is what level or percentage of weeds are killed after treatment. Efficacy of control may be reduced by tolerance of the weed to treatment, weed resistance, incomplete treatment application, or early or late germination events. Without a highly effective control technique, it is unlikely that eradication will be achieved;
- **reproduction under targeted control**. Even if all plants are controlled after treatment, new plants may regrow, often from seed. Unaffected seeds or vegetative material also give rise to new plants. The minimum time this takes needs to inform the retreatment period so that new plants from seeds or vegetative propagules do not replace those controlled;
- **propagule longevity** is one of the key determinants of whether weed eradication will be achieved. It is necessary to continue to treat all establishment events from seed or dormant vegetative organs such as rhizomes. The longer lived the seed or 'vegetative 'bud' bank, the longer control will be needed; and
- **ongoing dispersal**. It is important to consider if seeds or vegetative propagules continue to arrive at control sites and start new infestations during control efforts. These may arrive by natural or human means. It is particularly difficult to manage a weed if it is also grown in the geographic area for agricultural, forestry, horticultural or gardening purposes (a conflict species), and it can redisperse into the control areas.

Analysis of (Determining) feasibility of coordinated control, The three criteria outlined above are used to determine the relative feasibility of coordinated control posed by different plant species. In the WRM process, a ranking system is used which combines the scores for current distribution, control costs and duration/persistence as follows:

Feasibility of coordinated control =	**control costs**	**x**	**current distribution**	**x**	**duration/persistence**
	$/hectares/year		**hectares**		**years**

Any scoring and ranking system used should be logical, tested for accuracy before formal use and be easy to use. One example can be found in Johnson (2009a, b).

Evaluation of feasibility of coordinated control, Evaluation of the feasibility of coordinated control is the interpretation of the feasibility score into a level of feasibility, for example high, medium or low. One example can be found in Johnson (2009a, b).

Stage 5 Determining weed management priorities

Once the weed risk posed by, and feasibility of coordinated control of, a plant is determined, these are compared so that a priority list of weed species can be determined (Figure 1). At this stage it is important to recall the original goal/s of the WRM process.

Weed management priorities can be determined by plotting weed species on a prioritisation matrix, for example, the generalised example in (Figure 2). Each of the strategic weed management principles in Figure 2 is supported by a description. An expanded example of these can be found in Johnson (2009a, pg. 79-84).

Stage 6 Implement weed management actions

Once a priority list of weeds species is determined, preparation and implementation of weed management plans is needed. This is the stage at which strategic planning transitions to operational planning.

Depending on WRM context, for example the goal, resources, scope, … , as determined in Stage 1 of the WRM process, this may entail coordinated control programs with elements of:

- quarrantine – preventing entry;
- surveillance – looking for weed incursions;
- enforced control – eradication and containment;
- research – new control techniques; and/or
- extension – education and awareness activities.

WEED RISK	FEASIBILITY OF COORDINATED CONTROL		
	Low	***Medium***	***High***
Low	**No action**	**No action**	**Monitor**
Medium	**Improve general weed management**	**Improve general weed management & Local containment**	**Prevent entry & Regional containment**
High	**Targeted management incl. Biocontrol & Local containment**	**Targeted management & Regional containment & Local eradication**	**Prevent entry & Regional eradication**

Figure 2. A generalised weed management priorities matrix upon which relative scores of plant species weed risk and feasibility of coordinated control can be plotted.

For each weed species, there is a need to prepare a weed treatment plan, which addresses:

- proposed actions;
- resource requirements and budgets;
- responsibilities;
- work schedules;
- performance measures, for example monitoring progress against milestones;
- reporting requirements; and
- communication of procedures and outcomes.

Communicate and consult

Effective communication and consultation throughout the WRM process is vital (HB 294:2006). Stakeholders identified at Stage 1 are ideally engaged on the WRM steering committee. Effective communication and consultation will foster participation, understanding, trust and ownership of the process and the resulting priorities. The WRM steering committee can also bring together a diverse range of expertise, values and perspectives. A communication and consultation plan should be developed and implemented as past of the overall project management of the WRM project (HB 294:2006).

Monitor and review

Ongoing monitoring is needed to record changes in the status of weeds and to evaluate the effectiveness of control of the priority weeds (HB 294:2006). Recording each stage of the WRM process can demonstrate how decisions have been made (as well as literature and data used, assumptions, results and reasons for decisions). This allows for audit and review activities so that changes in coordinated programs occur.

Ongoing surveillance is needed to detect new weeds or to reconsider weeds that have not yet been evaluated. Changes in land use, resources or information available, technology, and even climate can be managed through regular review of both the species assessments and the WRM process.

Examples of completed Weed Risk Management system assessments

Limited examples of weed risk management assessments using the precursor South Australian WRM system, for example Virtue (2010), and the New South Wales WRM system derived from it (Johnson 2009a, b) can be found at:

- http://www.pir.sa.gov.au/biosecuritysa/nrm_biosecurity/weeds/sa_weed_risk_mgt_system (Government of South Australia, Biosecurity South Australia 2013); and
- http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/wrm-system (NSW Government 2015); respectively.

Resources needed to implement a weed risk management system

The resources needed for the weed risk management process should be far less than the resources then used to combat the identified prioritised weeds. The WRM system aims to help make decisions quickly in a consistent and transparent manner because we are all limited by a range of factors including time and resources, by our ability to measure and quantify the biological attributes of many plants, and because any process, including WRM, will always have uncertainties. These can all be reduced by careful process design and being able to access and use appropriate resources (including literature and people).

WRM questions/ranking

The WRM process uses existing knowledge and understanding to answer questions, where possible. Other WRM process design factors include using:

- fairly easy/quick to measure questions, with high/medium/low ratings that are clearly defined;
- as few questions as possible, whilst still retaining accuracy; and
- a ranking system that is logical, based on ecological and economic principles and has been previously validated with a set of test weeds.

WRM people

At the basis of the WRM process are people. Experience suggests that the following people greatly contribute to the success of the WRM process:

- a WRM expert (perhaps a national champion?) to drive the process who needs to:
    - understand the range of weeds of concern, their taxonomy, distribution, biology and impacts, and how to apply these to the principles of WRM; and
    - have or develop a WRM ranking system, prior to undertaking formal analysis of weeds.
- a stakeholder committee to steer the process, that is to set milestones and deadlines, and communicate the WRM process and its results;
- often there is a need for the support of research scientists within the country and/or internationally; and many of these linkages can initially be made through
- joining a weed society and subscribing to its journal.

WRM information

The other basis for a sound WRM process and outcomes is access to information. This will include:

- access to literature on weed species:
- both from within the country/region and internationally;
- often from government and university libraries, and/or herbaria;
- noting that many websites have species information (see below); and also that
- email list-servers exist through which information can be sought informally and networks of people can be built.
- access to colleagues and other experts working on weeds, for example; botanists (often in herbaria), agronomists, ecologists, and other experts such as quarantine staff who have seed collections; and
- the need to travel to see weed species, in particular for taking field observations about their biology and impacts.

Professional journals, There are a wide range of professional (and peer reviewed) journals that publish information about weeds. These include the titles:

- Weed Science, Weed Technology and Invasive Plant Science and Management (WSSA 2015);
- Weed Research (EWRS 2015);
- Weed Biology and Management (published by Wiley Online and Weed Science Society of Japan, WOL 2015); and more importantly from SEAMEO BIOTROP
- BIOTROPIA (the Southeast Asian Journal of Tropical Biology) (SEAMEO BIOTROP 2015b); and
- Plant Protection Quarterly (Weed information (2010).

Conference and meeting proceedings, International and National weed conference proceedings include (but are not limited to) the following, the

- International Weed Science Congress (IWSS 2015);
- Asian-Pacific Weed Science Society Conferences (APWSS 2015);
- Ecology and Management of Alien Plant Invasions Conferences, for example see EMAPI (2015);
- Australasian Weeds Conferences (CAWS 2015); and
- Regional plant protection organisation publications and symposiums of weeds, including from SEAMEO BIOTROP (SEAMEO BIOTROP 2015a).

Internet sites, A selection of internet sites from which useful sources of weed information can be found include:

- A Global Compendium of Weeds, 2nd edition (Randall 2012);
- Pacific Island Ecosystems at Risk (PIER 2013);
- Germplasm Resources Information Network, GRIN, (USDA ARS 2013);
- SEAMEO BIOTROP (SEAMEO BIOTROP 2015a);
- FAO weeds website (FAO UN 2015);
- Global Invasive Species Database (GISD 2015);
- Tropicos (MIB 2015); and for lesser known species, a
- Google search with weed species name (Google 2015) or using another search engine.

Australian internet sites, As a subset of global internet sites, many Australian sites have WRM information on species, for example South Australia (Government of SA, Biosecurity SA 2013), Victoria (State Government Victoria, DEPI 2014) and New South Wales (NSW Government 2015).

The Australian government is also developing a more general weeds portal which will either be found AWC (2015) or Australian Government (2013).

Australian herbarium data, including distribution records is available from the Atlas of Living Australia (ALA 2015) which uses Australia's Virtual Herbarium (AVH 2015) data as one of its sources, supported by a range of Australian State and Territory data sources, such as from New South Wales, that is RBG&DT (2015). Publications and information can often be found at Australian State and Territory government agency internet sites, for example from the websites for the New South Wales Department of Primary Industries Biosecurity (NSW DPI Biosecurity 2015) and for the New South Wales Office of Environment and Heritage (NSW OEH 2012)

WRM technology

A certain level of technology is greatly helpful to support the WRM process. For example a computer is almost essential: for the analysis and storage of information; for access to the internet; to run and develop models; to share information with colleagues; to record and map weed distributions; and to prepare reports for publishing.

Official support

Considering all this, and to act on the results of the WRM process, it is very useful to have a formal government weed control program that:

- provides access to facilities and equipment to support much of the activities described above;
- has noxious weed laws/legislation; and undertakes
- research;
- education;
- enforcement;
- quarantine and inspection; and
- surveillance.

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Appendix E1 : Indonesia Country Report

STATUS, REGULATIONS AND CHALLENGES IN RISK ASSESSMENT AND MANAGEMENT OF INVASIVE ALIEN SPECIES IN INDONESIA

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INTRODUCTION

Since ages, the presence of invasive (alien) species in various landscapes, forest ecosystems and waters can cause detrimental effects to the environments and human beings. In this regard, most ASEAN member countries are facing serious problems on the spread of several invasive species, especially in forestry, agriculture and fishery sectors. However, central governments of respective ASEAN member countries, especially Indonesia, have been paying little or less attention to control and eradicate the invasive species so far. The countries also provide limited public policies, regulations and protocols concerning controlling Invasive Alien Species (IAS).

IAS has now becoming the second biggest threat to biodiversity loss after anthropogenic habitat destruction and after COP 10 CBD in Japan where AICHI Target no 9 specifically has mandated country member to prevent introduction of IAS to prevent damage to natural biodiversity. Since then, Ministry of Environment and Forestry paid serious attention on how to control the spread of invasive alien species in forest areas, especially in conservation areas. In 2012, CCRRD in collaboration with UNEP received GEF funding to execute 4 years regional project to manage IAS together with Vietnam, Cambodia and the Philippines. Capacity building, increase awareness and IAS management control, formulating regulations and code of practices in controlling invasive species through collaboration with related institutions and stakeholders, including the development of Risk Analysis procedures for forest IAS were among of the program to be addressed during the course of the project.

Almost all plant and animal species are introduced intentionally for various purposes such as for ornamental, circus and zoo, pet, ornamental fish and fishing pond. In the meanwhile, the introduction of most invertebrate species including marine organism and microbe - commonly done unintentionally – existed by means of sticking to other species which is intentionally introduced. In this case, weed often carried as dirts sticking on imported seed, while ornamental plants that later becoming weed, was firstly introduced unintentionally for ornament. Soil stabilization, firewood, and others may be brought in unintentionally during human aid program or during trading business. For example, *Eichornia crassipes* or water hyacinth, which is regarded as a major invasive species and become problematic in many places in Indonesia, was firstly introduced for ornamental plants.

IAS can lead to severe environmental damages including habitat fragmentation and global climate change. Not all non-native species is considered to be dangerous. In many places, agriculture crops and cattle were intentionally introduced from other country. In forestry, most species for plantation forest was exotic or introduced from other place, such as *Acacia mangium, A. crassicarpa,* and *Eucalyptus* spp. Undeniable, this monoculture plantation in forestry often brings serious problems by the fact that the planted species do not have natural enemies and once outbreaks of pest and disease arouse, introduction of biological enemies from its origin would be of better alternatives. In agriculture case, this effort is regarded relatively successful and able to reduce pesticide uses and significantly reduce economic loss. In forestry, we have not done this yet although similar problems are happening.

One of the most powerful tools to prevent rapid spread of IAS is the adoption of Risk Analysis procedures for pre, at and post border. This procedure has long been adopted by Quarantine Agency under Ministry of Agriculture and Ministry of Fishery and Marine Affair who mostly dealt with exotic species. To avoid the unforseen event where IAS may casue to damaging biological and environmental impact, regulatory authorities have a statutory responsibility to ensure that all plant taxa proposed to be imported, which are not already prohibited and are not already established, be evaluated for their possible invasiveness. It is important, therefore, to be able to predict the invasive potential of thousands of new potential entry.

To ensure international action towards protection of plants including forest tree species from IAS under the International Plant Protection Convention (IPPC), three international standards on pest risk analysis (PRA) have been developed and adopted by 176 member countries. These standards describe the integrated processes to be used for risk assessment as well as the selection of risk management options. Adoption of these standards in ASEAN countries has been slow and inconsistent due to poor co-operation between agencies and countries. It is therefore important to ensure that reliable methods and approaches in pre-and post-border risk analysis of IAS align with international

standards exist in a harmonious way among countries in the region. As this seminar and workshop is aimed to bring about consensus among participants in adopting a more harmonized approach to risk analysis of forest invasive alien plant species (FIAPS) in Southeast Asia, we further hope constructive collaboration among ASEAN country member by sharing information with regard to the adoption of RA and possibility of developing robust standard to produce reliable tools for prevention of IAS spread.

INVASIVE ALIEN SPECIES IN INDONESIA

Some exotic species that have become invasive are found in Java island and it is also expected that these species such as *Chromolaena odorata, Mikania micrantha, Lantana camara, Piper aduncum, Melastoma affine, Mimosa pigra, Mimosa diplotricha, Widelia trilobata, Ruvina humilis, Acacia mangium*, and *Spatodea campanulata* can also be found in other islands within Indonesian region (Setyawati, 2013). At present, there are plenty of ornamental plants either shrubs or trees that were introduced from overseas but have not shown their invasiveness or known as sleeper weeds but have already spread all over Indonesia. Historically, most of current terrestrial plants are introduced since the colonial period. The Dutch brought agriculture products from Europe to be planted in Java islands for various purposes. Most of these plants and animals survived and easily adapted to their new environment and became naturalized such as teak (*Tectona grandis*), mahagony (*Swietenia mahagony*) and many others. However, some have become dominant and suppressed the growth of other plants species such as the well-known prickly acacia (*Acacia nilotica*) from Africa that was introduced in 1969 to Indonesia for gum/latex but later on became invasive in Baluran National park and invaded the savanna ecosystem there and taken over the growth of local grasses.

Not only terrestrial but also some aquatic organisms such as local fish have already taken over by exotic fish species such as those happening in some fresh water ponds in Indonesia. Wetland, lakes, ponds, rivers and fresh water ecosystem in many regións in Indonesia are believed to be invaded by various exotic species. However, information formally recorded and issued by government institutions, universities, and other research agency remains lacking. Example cases as are follows: (1) red devil fish in Kedung Ombo Reservoir in Central Java, Cirata Reservoir in West Java, and Sermo Reservoirs in Yogyakarta; (2) fresh water lobster (*Cherax quadricarinatus*) in Maninjau Lake in West Sumatra;(3) Perch Nile (*Oreochromis niloticus*) in Laut Tawar Lake; (4) carp fish (*Cyprinus carpio*) in Ayamaru Lake in Papua; and (5) Mozambique perch (*Oreochromis mossambicus*) in Lake Lindu and Poso.

Another example of an invasive faunal species is Golden Snail (*Pomacea canaliculata*) that was first introduced in 1980s from South America and is now becoming pest in almost all tropical and sub - tropical. This species, originally brought as pets or ornamental animals to the aquarium and for food consumption because of rich in protein and is believed to bring luck. However, when they release into the wild, they became invasive due to its ability to quickly adapt to the new environment and outcompeted with local predator. They are able to spawn at the age of 2 years with a single colony composed of over 400 eggs and egg's hatching survival of 90 %. Other animals that become invasive are Timor Deer/Rusa Timor (*Cervus timorensis laronesiotes*) that was introduced from Java Island to Wasur National Park in Papua. This species has been reported to suppress the growth of kangoroo (*Dendrolagus inustus*), an endemic species to Papua region.

Based on the data recorded by the Ministry of Fishery and Marine Affair and also reported in the article of Environment and Health (Kompas, Tuesday, September 10, 2013), some carnivorous fish species from South America that are reported invasive elsewhere, was introduced to the Indonesian fresh water ecosystem, and among of those were small alligator fish (*Lepisosteus oculatus*), alligators gar (*Atractosteus spatula*) and piranha (*Serrasalmus serrulatus*). Alligator species, both large and small, were reportedly found in Jatiluhur reservoir, while piranha reportedly found in Cirata reservoir. These species are initially imported into Indonesian territory as ornamental fish for hobby.

LIST OF PRIORITY FOREST IAS

Under current GEF project, where Center for Conservation and Rehabilitation Research and Development was assigned as the executing agency and UNEP as the Implementing Agency, only IAS of plants were covered. Based on the criteria developed, four plant species was selected as the priority to be control and managed. This does not mean that other invasive alien plant species will not be targeted, but more comprehensive management will firstly be focused on these four plant species. One of the reason was they have already become problems since ages and there was no significant progress and the damage it caused was considered severe.

The following is the list of existing forest Invasive plant species (non-native or native invasive plant species) that have been prioritized for future management in Indonesia:

1. *Acacia nilotica* : non-native species, origin from India, invaded Baluran NP since 1986, control: manual, mechanic and chemicals (problems with policy in conservation areas), impact: take over native grasses, reduce banteng (*Bos javanicus*) population, - need to carry out Cost Benefit Analysis (CBA) to determine economic impact
2. *Mikania micrantha* : non-native species, origin from South America, invaded all forest and agriculture area, control: manual, and biological control (lack of post release evaluation), impact: take over native plants, disturbed forest regeneration - need CBA to determine economic impact

3. *Chromolaena odorata*: non-native species, origin from South America, invaded all forest and agriculture area, control: manual, and biological control (lack of post release evaluation), impact: take over native plants, disturbed forest regeneration-need CBA to determine economic impact
4. *Merremia peltata*: native species (remain unclear due to limited information on natural distribution), invaded all open areas, ex-forest and agriculture area. Control: manual and chemicals, impact: take over native plants, disturbed forest regeneration - need CBA to determine economic impact.

Despite the fact that some invasive alien species either plan and animal have been reportedly causing serious damage to some natural ecosystem such as those happening in other sector than forestry, but data and information with regard to the economic losses is very limited. In the absence of specific regulation to manage invasive alien species in Indonesia, until recently there was no list of priority IAS species under such regulation that need to be control or managed. Those listed is proposed under the FORIS project and this certainly need to get formal recognition from relevant institution in order to take action on the ground.

Before country declared list of IAS priority to be managed or controlled, there should be adequate information available concerning their presence and distribution including for risk analysis purposes. IAS pose significant environmental, biological and social impacts worldwide and the number of invasive species posing such impacts is increasing annually. Thus, the magnitude of the problem requires prioritization across IAS policy, management and legislation. Such prioritization needs to be developed through mechanisms/processes that can assess and account for the risks associated with IAS introductions.

RISK ASSESSMENT AND MANAGEMENT OF IAS

Until presently, there is no Invasive Alien Species Risk Assessment/Analysis method available except those developed by quarantine agency under the Ministry of Agriculture and Ministry of Fishery and Marine Affair, where quarantine agency are hosted. Both ministries have developed Pre-border Risk Analysis (PRA) adopted from Weed Risk Assessment (WRA) from Australia. And the existing policy only covers weed and other organisms disturbing plants/animals. In contrast to pre-border WRA systems which aim to prevent the risk of new weed incursions, post-border Weed Risk Management systems aim to prioritize the management of invasive alien plants species which are present in a country or region, based on the level of risk they pose (Tjitrosoedirdjo 2013).

The term risk management (i.e. whether to avoid, mitigate, or tolerate the risk) has been adopted to be aligned with that used in generic standard for risk management. This standard, which has now been accepted as an International Organization for Standardization (ISO) standard, considers risk management as the overall process of identifying, assessing and treating risks. Note, however, that it is different from the International Plant Protection Convention (IPPC) international standards on phytosanitary measures, which considers risk analysis as the overall process and equates risk management to risk treatment.

Hiebert and Stubbendieck (1993) developed a ranking system for resource managers to sort exotic plants within a park according to the species level of impact and its innate ability to become a pest. This information was then weighed against the perceived feasibility or ease of control. This Exotic Species Ranking System was designed to first separate the innocuous species from the disruptive species. The separation allowed park managers to then concentrate further efforts on species in the disruptive category. The system was also designed to identify those species that were not presently a serious threat but have the potential to become a threat and, thus, should be monitored closely. Finally, the system asked the park manager and the ecologist to consider the cost of delaying any action.

The Exotic Species Ranking System uses numerical ratings, is written in outline format, and is divided into two main sections, namely: Significance of Impact and Feasibility of Control or Management. Each section is based on a scale of 100 points. Significance of Impact is further divided into (a) Current Level of Impact and (b) Innate Ability of Species to Become a Pest. Stubbendieck *et al.* (1992) considered a species with a combined score of over 50 points for significance of impact to be seriously disruptive and needing appropriate attention. Species receiving high scores for feasibility of control will be easier to control than those receiving lower scores (Tjitrosoedirdjo 2013)

Kindly specify the (a) methods used for risk analysis, (b) the criteria for prioritizing them, and (c) the agency responsible in doing the risk analysis. This information will become the baseline for developing harmonzed approaches to IAS risk analysis in the region.
Risk analysis (pre- and post-border conditions) protocols that are currently operational or any protocols that may be in the process of government adoption.

- RA developed by Quarantine Agency under Ministry of Agriculture and Ministry of Fishery and Marine Affair. And this is only for pre and at-border measures
- RA only done for species potentially carrying pathogen or disease (not for IAS)
- RA and IAS management is relatively new for forestry sector
- Under FORIS project, activities are proposed to develop Risk Analysis for forest IAS (submitted to Quarantine Agency)

POLICIES AND REGULATIONS ON IAS

A. International Regulation and Policies

Conventions associated with invasive alien species of animals and plants which have been ratified by Indonesia include:

1. CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora).

   CITES is a treaty in force since 1975 and is the only global treaty or treaties (treaties) with a focus on the protection of wild flora and fauna which are affected by international trade, which may endanger the sustainability of their exixtence. The Government of Indonesia has ratified the convention with the Presidential Decree No. 43 in 1978. CITES has shown to be effective in contributing to the conservation of wild flora and fauna through a strict system of permits and issuance of certificates. It is also effective in terms of the ability to control the commercial trade if it proves detrimental to populations of species, and therefore supports the conservation of the national convention and the rule of law in member states.

   CITES Resolution No. Conf. 13:10 on Trade in alien invasive species have come to realize that alien species can cause a serious threat to biodiversity because of the species of flora and fauna that are traded internationally has been introduced into a new habitat. Therefore CITES through this resolution recommending to all CITES member countries to: a) consider the problem of alien invasive species in developing national regulations related to trade living plants or animal , b) consult the CITES Management Authority of importing country if possible, at the time will provide or issue export license for wild flora and fauna species that are potentially invasive to determine whether there iare domestic measures regulating the import and c) consider the synergies between CITES and the CBD and looking into the possibility of cooperation between the two conventions regarding the issues on the introduction of the flora and fauna species that have the potential to become invasive. Besides that, this resolution also instructs the CITES Secretariat with the Animals and Plants Committee to work with the CBD Secretariat and IUCN/SSC Invasive Species Specialist Group.

2 CBD (Convention on Biodiversity)

   The Government of Indonesia has ratified the Convention on Biological Diversity through Act No. 5 of 1994. These followings are the mandates that are given in several meetings of the parties of CBD related to invasive alien plant species:

   a. COP V Article 8 - In situ conservation: CBD at its meeting in 2000 (COP V) has called on its member states to prevent the importation of alien species of invasive plants that harm ecosystems, habitats and native species (COP V article 8h).
   b. COP Decision VI/23 VI - Alien sp that threaten ecosystem, habitats or species: In a meeting in 2002, the member states have adopted the 15 terms of reference and guidance for the prevention, introduction and mitigation of impacts of invasive alien types and a number of other decisions to implement Article 8 (h) and a maximum effective CBD.
   c. IX COP Decision IX/4 - In-depth review of ongoing work on alien sp that threaten ecosystems, habitats or jspecies: Generate recommendations regarding the evaluation gap held between developed and developing countries in the early identification technology, the science of taxonomy of the kinds of plants and control of invasive alien technology (Sastroutomo 2010).
   d. COP Decision X/38 X - Invasive Alien Species: Generate a frame of reference about handling techniques of invasive alien plant species as pets, aquarium and terrarium species and producing food and feed ingredients.

   Futher in Article 8/h of the CBD stipulates:

   "Each contracting Party shall, as far as possible and as appropriate: Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species."

   To implement this obligation, a Contracting Party shall set up a national strategy on IAS, develop legislation as to prevent the introduction of new IAS and the spread of the already present IAS, carry out risk analysis, to make use of information and communication technology for carrying out risk communication, and provide infrastructure. While currently, some factors have already been in place, namely commitment of certain government institutions in the importance of addressing the issues of IAS although mostly do not know precisely who is doing what, the ratification of CBD without supporting it with sufficient implementing regulations and administrative procedures, risk analysis on certain IAS of plants and animals included in the pest list under the guidance of IPPC, and leave the others unregulated, development of database of IAS already present in certain areas of the country, a little activities in information exchange without implementing standardized methods, and the provision of limited infrastructure.

3. Ramsar (Convention on Wetlands): Indonesia has ratified the Ramsar Convention through Presidential Decree No. 48/1991. In Ramsar Strategic Action Plan 2003-2008 states that the Ramsar Secretariat has a mandate to develop guidelines and protocols and promote measures to prevent, control and eradicate IAS in wetland systems. International Provisions should be translated and packaged into national policies and regulations that conform to national conditions.

B. National Regulations and Policies

To date in Indonesia does not have regulations that specifically regulate the invasive alien plant species, although many agencies including the Ministry of Environment, Ministry of Agriculture, Ministry of Maritime Affairs and Fisheries, the Ministry of Forestry, LIPI, Universities, Research Institutes etc. are involved in this issue. National laws and policies that have been developed and that are associated with invasive alien plant species, include:

1. Law no. 5/1990 on the Conservation of Biological Natural Resources and Ecosystems: in Chapter IV Article 19, paragraph 3 describes that the things that can alter the integrity of one's nature reserves is to add (introduce) plant and animal species that are not native. Chapter VII, Article 33 Paragraph 2 explains that adding plants and animals that are not native to the park is one of the causes of changes in the integrity of the core zone of the national park.
2. Law no. 12/1992 on Plant Cultivation System: This rule emphasizes the protection of plants to prevent losses due to the impact of weeds or other plants that interfere and eradication measures to eradicate these weeds that can spread in a specific location and suppress the growth of other plant species (Chapter I Article 1, paragraph 7,8,9) while in Chapter III of article 10 and 21 describe the mechanism of entry of foreign types as well as monitoring and management of weeds and alien types.
3. Law No. 16/1992 concerning Animal, Fish and Plant Quarantine: Sets the duties and functions of animal and plant quarantine applied in airports, ports, border posts and inter-islands ports . Quarantine actions performed on food commodities, horticulture, plantation and forestry. This action using SPS (agreement on the application of sanitary and phytosanitary measures), which aims to protect the life and health of animals and plants.
4. Government Regulation No. 27/1999 on Environmental Impact Assessment: Emphasis on the implementation of the EIA for any activity that has a significant impact on the environment including the introduction of plant, animal and genetic. This regulation requires technical guidance reviewers risks and risk management associated with the introduction of. All activities related to the introduction of assessment should be completed by the EIA, but guidelines for the management, assessment and evaluation of risk does not exist.
5. Ministerial Decree No. 447/2003 on Administrative Decision or Capture and Distribution of Plants and Wildlife: Aims to control specimens of wild plants and animals that will enter into the territory of the Republic of Indonesia (imports).
6. Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2003-2020. Currently, Indonesia has the Biodiversity Management Strategy is to be implemented effectively to minimize the biodiversity crisis. National management strategy has a vision to conserve and utilize biodiversity in an optimal, equitable and sustainable world through responsible management to improve the welfare of the community. This document states that the actions to be taken in order to improve the management of biodiversity policy instruments, including programs to implement control and prevention of the spread of invasive alien plant species and the type of farming (Bappenas 2003).
7. Ministry of Forestry Regulation No.57/2008 concerning NATIONAL STRATEGY ON SPECIES CONSERVATION 2008-2013. Under Objective 5: Biosecurity, the stratregy outlined the following direction:
    - alien/exotic species can be imported to Indonesia under certain consideration for special purposes (pet, attraction, cultural and natural/biological agent).
    - alien/exotic species is only allowed under controlled ecosystem and restricted from natural release to anticipate invasiveness potency
    - Role of quarantine (plant, animal and fish) to select and issue permit for alien/exotic species importation.
    - Role of veterinary in biosafety and biosecurity, especially to prevent spread of disease between animal and human (zoonosis).
    - Other issues related to biosecurity may refer to CBD guide
    - All species entering Indonesian territory ate subject to be examined and tested using Risk Analysis. And this has not adequately addressed so far

In 2012, GEF Trust Fund 0515 granted funding through UNEO/CABI to implement program Removing Barriers to Invasive Species Management in Production and Protection Forest of South East Asia (FORIS) for 4 years duration covering 4 countries, Vietnam, Philippine, Cambodia and Indonesia. In collaboration with Center for Conservation and Rehabilitation Research and Development (Forest Research and Development Agency), Ministry of Environment and Forestry, FORIS has facilitated the development of National Invasive Species Strategy and Action Plan (NISSAP). This draft document shall be treated as part of the National Biodiversity Strategy and Action Plan (NBSAP). This draft document is about to be endorsed by the Ministry of Environment and Forestry during February 2015. The document cover strategy for the following action:

1. Prevention
2. ED and RR
3. Control and Mitigate Impact

4. Rehabilitation and Restoration
5. Capacity Building
6. Information Management
7. Instutional Collaboration (National and International level)

C. Institutional Network/Collaboration

Division of responsibility among concerned institutions for managing Invasive Species from prevention, early detection and rapid response systems, eradication, control, and management strategies, capacity building, coordination and financing.

- MoE and F: develop national strategy and coordinate national mechanism, control introduction and spread of IAS in forestry, including conservation areas
- MoA: control introduction and spread of IAS in agricultulre, including estate and cattle farm
- MoFFA: control introduction and spread of IAS in marine and coastal ecosystem
- MoHealth: control introduction and spread of IAS in settlemen areas.
- LIPI & Universities: research on IAS

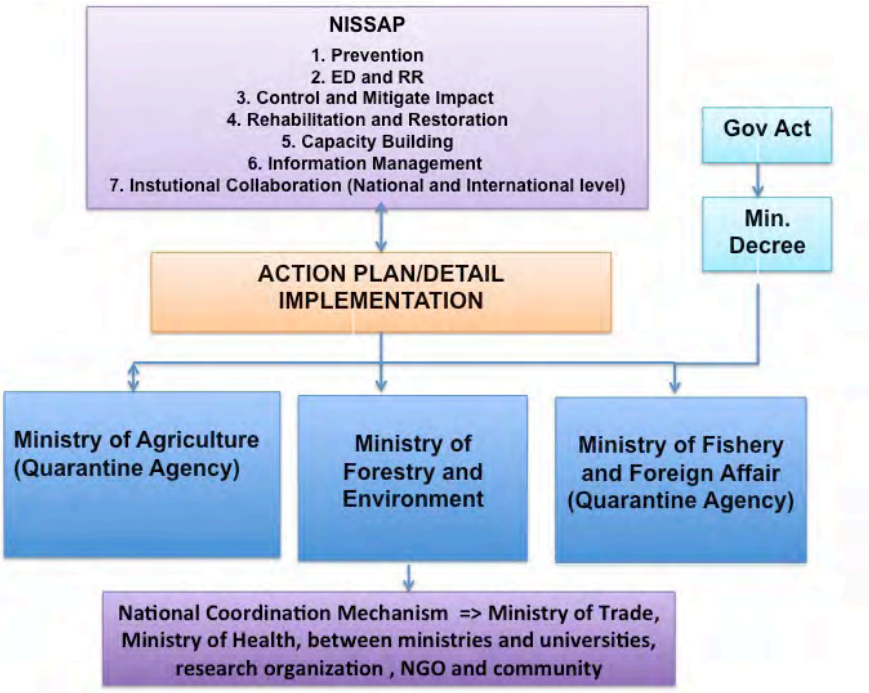

Figure 1. Proposed coordination mechanism for IAS management

Types and scope of collaborations with international bodies engaged in prevention and control of forest invasive plant species

- BIOTROP – capacity building (training and education) – staff of MoF/MoA/MoFF also received numbers of regional and overseas training/course
- ACB (ASEAN Center for Biodiversity) – in collaboration with PHKA
- UNEP/CABI – project on prevention and control of IAS including capacity building
- WCS – patrol and IAS control
- Rhino Foundation (YABI)
- APFISN – network for IAS information and dissemination

D. Research and Capacity Building

FORIS Indonesia facilitates the development of NISSAP through close collaboration with Ministry of Agriculture, Ministry of Fishery and Marine Affair, BIOTROP and other relevant agencies. The development of the document also includes public consultation process. The project deliverable outputs among of those are the development of RA procedures for forest IAS, Cost Recovery Analysis and Mechanism, and Early Detection System and Rapid Respond mechanism to anticipate the potential threats of IAS, Research on IAS control and management (*Acacia nilotica* and *Merremia peltata*), social impact study, study of IAS awareness, environmental impact assessment on IAS, and provide research grant to undergraduate and post graduate students, and provide training on Classical Biological Control, Cost Benefit Analysis, CLIMEX, and forest restoration.

Considering that training and education on IAS management are remain lacking, there are a number of challenged that need to be addressed. Challenges and future research and capacity building directions on risk analysis and management of invasive plant species are as the following:

1) develop adequate tools and improve human resource capacity under relevant institution to identify IAS and potential IAS,
2) conduct risk analysis (pre, at and post-border) and take measures to manage and minimize risk,
3) control and eradication of priority IAS, and
4) produce and issue regulation enacted by 2020 to prevent species entering Indonesian territory that potentially becoming invasive.

CONCLUSION

As a country that has high commitment to save its natural biodiversity as mandated under Convention on Biodiversity, there should be a way forward to meet challenges and create future research than can fill the existing gaps. A number of challenges that need to be addressed among of those are: i) Rapid spread of IAS while policy and regulation to prevent and control remains lacking, ii) Limited data and information of forest IAS, iii) Limited knowledge on biological invasion, including negative impact that IAS has on environment and community, iv) Weak of community awareness on negative impact of IAS, v) Limited study on "ecological impact" and "economic loss" due to IAS invasion (cost benefit analysis study), vi) Up-date data on all forest IAS (plant, animal, microorganism, pathogen, insect, etc.), vii) Biological agent (natural enemy) application, viii) Establish coordination mechanism among relevant agencies, ix) Lack of information on IAS pathways, and x) Increase level of awareness, either public/community or government officer.

Beside, government support in term of sustainable financial scheme shall be in place especially to embrace more global support to prevent massive spreading of IAS across country. In this case, we need to develop collaborative research across national and international agencies in the field of these following: i) Social, ecological and biological impact, ii) Cost benefit analysis (CBA), iii) Ecosystem restoration, iv) Determine pathways, v) Biological control application (host testing, and others) and IAS ecology. Not to mention the need to increase capacity in more effective prevention through strong quarantine syste, and develop robust monitoring and evaluation system for IAS spread and distribution.

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Appendix E2 : Myanmar Country Report

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INTRODUCTION

Invasive alien species negatively impact the forest sector in economic, ecological and environmental, and social and health terms, though these impacts are almost never mutually exclusive. The ecological and environmental impacts of alien invasive species can be felt by all levels of organization including the gene, species, habitat and ecosystem level. Alien invasive species can influence species diversity, richness, composition and abundance (IUCN 2005). The respective ASEAN member countries, especially Myanmar, have been paying little or less attention to control and eradicate the invasive species so far. The countries also provide limited public policies, regulations and protocols concerning controlling Invasive Alien Species (IAS).

Almost all plant and animal species are introduced intentionally for various purposes such as for ornamental, circus and zoo, animal's food and fishing pond, etc. In this case, weed often carried as dirt sticking on imported seed, while ornamental plants that later becoming weed, and was firstly introduced unintentionally for ornament. Introduction of invasive species, both deliberate and accidental, has occurred at a number of locations in Myanmar, although, to date, there has been little research into the impacts of invasive species in the country. Invasive species are potentially a significant threat to some aquatic ecosystems. For example, two large introduced species, Grass Carp (*Ctenopharyngodon idellus*) and Rohu (*Labeorohita*), are found in Inlay Lake, of which the former is considered to definitely pose a threat to the lake's ecosystem (Kullander *et al.* 2004). Invasive plant species are a major conservation issue in the Central Dry Zone, where introduced species such as *Prosopis juliflora* and *Euphorbia* spp. dominate the vegetation in some areas. In general, however, it has yet to be determined whether the impacts of invasive species are relatively localized or less severe than those of many other threats to biodiversity in the country. Due to lack of adequate field assessments, the problem is underrated.

One of the most powerful tools to prevent rapid spread of IAS is the adoption of risk analysis procedures for pre, at and post border. This procedure has long been adopted by Quarantine Agency under Ministry of Agriculture and Ministry of Fishery and Marine Affair who mostly dealt with exotic species. To avoid the unforeseen event where IAS may cause to damaging biological and environmental impact, regulatory authorities have a statutory responsibility to ensure that all plant taxa proposed to be imported, which are not already prohibited and are not already established, be evaluated for their possible invasiveness.

To ensure international action towards protection of plants including forest tree species from IAS under the International Plant Protection Convention (IPPC), three international standards on Pest Risk Analysis (PRA) have been developed and adopted by 176 member countries. These standards described the integrated processes to be used for risk assessment and the selection of risk management options. However, adoption of these standards in ASEAN countries has been slow and inconsistent due to poor cooperation between agencies and countries. It is therefore important to ensure that reliable methods and approaches in pre-and post-border risk analysis of IAS align with international standards exist in a harmonious way among countries in the region.

INVASIVE ALIEN SPECIES IN MYANMAR

Invasive alien species negatively impact the forest sector in economic, ecological and environmental, and social and health terms, though these impacts are almost never mutually exclusive. The ecological and environmental impacts of alien invasive species can be felt by all levels of organization including the gene, species, habitat and ecosystem level. Alien invasive species can influence species diversity, richness, composition and abundance (IUCN 2005).

According to the Forest Research Institute of Myanmar, IAS such as *Prosopis* spp., *Acacia auriculiformis, Ageratum conyzoides, Leucaena leucocephala, Eucalyptus* spp., *Casurina equisetifolia, Chromolaena odorata, Hyptis suaveolens, Lantana camara, Mimosa diplotricha, Mikania micrantha, Sorghum halepense, Paspalum conjugatum, Imperata cylindrica, Echinochloa crus-galli, Eleusine indica, Pennisetum polystachion* and many others are commonly found in forest plantations, agriculture land, urban areas, wetlands and natural lands. Their presence in these places is associated with the risk of native species losses and as such IAS threaten biological diversity, agricultural and forest ecosystems. Water Hyacinth *(Eichhornia crassipes)* was put into lakes and ponds for aesthetic purposes but it has been widely spread into natural water bodies. Ponds, lakes and streams are clogged with these plants and consequently, it is threatening the biodiversity of native aquatic species.

Another example of an IAS is *Achatina fulicaor* the Giant African Snail, which was introduced into Myanmar through trade. It has moved into croplands and is a vector for parasites, which attack native snail species but its population is now decreasing gradually in Myanmar. Importation of the honeybee (*Apis mellifera ligustica*) from Israel in 1979 by the Bee Keeping Department of Myanmar resulted in the introduction of the parasitic mite (*Varroa jacobsoni*). This parasite attacks the imported and indigenous bee species including the Giant Honey Bee, Hollow Hived Honey Bee and Bush Honey Bee. Moreover, according to the World Conservation Union (IUCN), the Invasive Species Specialist Group (ISSG), and Food and Agriculture Organization (FAO) databases concerning invasive weed species are (60) species (FAO 2005). However, according to the "Invasion Alien Plants in the Forest of Asia and the Pacific (2013)", which has been described (31) species Invasion Alien Plants species in Myanmar. An attempt is made in compiling a list of the major IAS in Myanmar together with their scientific names, invasive pathways, distribution in Myanmar, and observed damage or negative impact by these species (Annex. 1).Among them, ecology and impact of some IAPS are summarized in as follow.

Some trees such as *Prosopis* sp., *Acacia* spp*, Leucaena leucocephala*, and *Eucalyptus* spp. etc. are brought into Myanmar through seed exchange programs and some are introduced into Myanmar for testing, for greening and for economic purposes (W. J Kress *et al.* 2003).

Prosopis juliflora (Sw.) DC is a multipurpose tree used for fuel wood, charcoal. The habitats include abandoned agricultural lands, wastelands, degraded lands, deserts and grasslands. The tree grows gregariously in its preferred habitats, impenetrable thickets. Its poisonous thorns can injure livestock and people.

Ageratum conyzoides is a weed in crop fields and hosts many diseases. It is allopathic and can displace native vegetation such as grasses and medicinal herbs and create homogenous monospecific stands. The weed is allergic to humans and is a health hazard. It is also a threat to forest communities and dynamics of natural ecosystem processes.

Chromolaena odorata is fast growing invasive shrub. It is commonly occurrence around of natural forests and wastelands. It is a major threat to forest and agricultural lands. *Chromolaena* prevents plantation establishment of native species due to competition.

Elaeagnus umbellate: The plant invades natural forests and adjacent to planting sites. It grows well on a variety of soils and tolerate drought. The invasion can be rapid because of fast and vigorous growth, prolific fruit and seed production and high germination of seeds. Seeds are widely disseminated by birds and the seedlings can adapt too many sites.

Lantana camara is a major invader in natural forests, and forests. As the density of native species in a forest increases, species richness decreases. Forest fire can stimulate growth of lantana. Bushes of the plant provide shelter to several insects.

Imperata cylindrica (cogon grass) is an erect, perennial rhizomatous grass native to Southeast Asia. It occurs throughout the warmer and tropical regions of the globe occupying nearly 200 million hectares of land. Cogon grass is considered a pernicious pest plant due to its ability to successfully disperse, colonize, spread and subsequently compete with and displace desirable vegetation and disrupt ecosystems over a wide range of environmental conditions. It has been ranked as one of the top ten worst weeds of the world, reported in 73 countries and on all six continents (Newsletter of the APFISN, APFISN, and Volume 6 December 2006).

Leucaena leucocephala was introduced to Myanmar around 1978. It was tested for multipurpose and fuel wood. It grows very well and flowers almost 8 months of a year and natural regeneration is very good which makes the plant a nuisance and competition with other plant species very strong (S.M. Wint 2005)

Ligustrum robustum, which is heavy infestation by the weed alters the structure and composition of forests by affecting nutrient cycling and water availability. It can displace native species by competing with them for nutrients and water.

Mikania micrantha Kun, this a perennial vine with climbing, creeping and twining habit. It can penetrate crowns, choke and pull down plants. The damage to crops is extensive in young plantations. It also competes with native plants for water and nutrients. Infestation by the weed hampers collection of non-wood forest products and harvesting of crops such as ginger.

Mimosa diplotricha is thorny nitrogen-fixing weed that threatens native flora and fauna in many countries. It can form dense thickets in a short span of time in all invaded ecosystems. It is a major threat to forest ecosystems, agricultural land and pastures. The main economic impacts of mimosa are reducible land value and soil degradation. Uprooting and burning, grubbing and slashing are effective physical control methods.

Pennisetum polystachion was introduced from Australia in 1976. It invades in deforested and reforested land, railway line, roadsides glove influence other species.

Saccharum spontaneum L. is a species of grass that grows in areas with moderate but prolonged dry period. The extensive network of rhizomes and allopathic effects of the plant impede growth of other plants. It is a serious weed of cultivated land and heavy infestation necessitates abandoning the area.

Weed control by mechanical, chemical and biological methods were used by MAS. However, in forestry sector, mechanical weeding are being carried out during the first to the third years of the plantation establishment. In the forest nurseries, weeding by hand, hoeing and sometimes chemical spraying are practiced (MAS 2002).

LIST OF PRIORITY IAS

Considering the negative impacts of IAS, comprehensive research needs to be undertaken by a multi-disciplinary team composed of scholars and researchers from various concerned government departments and universities in order to fill the knowledge gap about the presence of IAS and its associated impacts on environment and local livelihoods. If a national research project is not possible, the following sites should be given priority at least for conducting a systematic study in order to respond to the problems caused by IAS in these areas. (1) Inlay Lake, situated in Southern Shan State of Myanmar, is a unique place from a historical and geographical perspectives with distinctive features attracting both local and foreign visitors. The lake is also a major source of water for hydro-electricity generation. There is also a wildlife sanctuary in the lake in order to protect endangered bird species. Local people, known as Inthars, live near the lake and their livelihoods are dependent on tourism, agriculture, fishing, handicraft making and silver smithing. However, Inlay Lake is facing rapid environmental degradation and its biodiversity are threatened by increasing competition among stakeholders for the use of natural resources and land. One of the environmental threats is the increased population of Golden Apple Snail (*Pomacea canaliculata*) in recent years. It is believed that a business company introduced this snail in order to control the growth of water hyacinth (*Eichhornia crassipes*). However, the population of snail rapidly increased in the water bodies and it is now becoming an extremely serious pest that is affecting vegetables grown in floating garden by the Inthars. It is also a health concern when people touch the snail.

Dry Zone, located in the central part of Myanmar, also needs urgent action to strengthen the management of IAS that is widespread in the region. With the aggressive regeneration capacity and rapid growth, IAS such as *Prosopis juliflora* easily colonizes the remaining dry forests, grazing land and farmland. This imposes not only a serious threat to biodiversity and land use in the dry zone but the thorns can injure people and livestock. Without proper control and management, this semi-arid ecosystem is likely to be strongly affected by invasive species.

DIVISION OF RESPONSIBILITY AMONG CONCERNED INSTITUTIONS FOR MANAGING INVASIVE SPECIES IN MYANMAR

The Director General of the Forest Department is the management authority with the Director of Nature and Wildlife Conservation Division as the scientific authority for Convention on International Trade in Endangered Species of Wild Fauna and Flora. There are, at national level, governmental institutions which can be identified as authorities concerning various aspects of invasive species.

1. Ministry of Agriculture and Irrigation (MoAI)
2. Ministry of Environmental Conservation and Forestry (MoECaF)
3. Ministry of Livestock and Fisheries (MoL&F)
4. Ministry of Science and Technology (MoSc&T)
5. Ministry of Education (MoE)
6. Ministry of Health (MoH)

LEGISLATIONS MANDATING CONCERNED INSTITUTIONS PERFORMANCE OF BIOSAFETY MEASURES IN MYANMAR

Myanmar neither has a stand-alone national policy on biosafety nor biotechnology yet. Traditionally, sect oral policies and laws cover some aspects and Government department pursue their respected duties and responsibilities related to biosafety in the country. For instance, the MoAI is responsible for implementing four sector laws, (1) The Pesticide Law (1990), (2) The Plant Pest Quarantine Law (1993, revised in 2011), (3) The Fertilizer Law (2002) and (4) The Seed Law (2011).

The MoLF is responsible for implementing (1) The Animal Health and Development Law (1993), (2) The Law Relating to Fishing Rights of Foreign Fishing Vessels, (3) the Myanmar Marine Fisheries Law (1990), (4) The Freshwater Fisheries Law (1992) and (5) The Territorial Sea and Maritime Zone Law (1997).

Ministry of Forestry has promulgated the Forest Law (1992) in which the basic principles encompassed to implement the forest policy and the environmental conservation policy, to prevent the dangers of destruction of forest and diversity. And also has proclaimed the Protection of Wildlife and Protected Areas Law (1994).

TYPES AND SCOPE OF COLLABORATIONS WITH INTERNATIONAL BODIES ENGAGED IN PREVENTION AND CONTROL OF INVASIVE PLANT SPECIES

Myanmar is a member country of the APFISN-FAO and involve in the activities of the network. Forest Protection Section, FRI has conducted the research on Invasive Alien Species. Although, to implement any necessary research program concerning invasive forest species, joint effort of international agencies or institutions or governmental institutions with Myanmar is still needed.

POLICIES AND REGULATIONS ON INVASIVE PLANT SPECIES

A. International Regulation and Policies

1. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
   CITES has been in operation since 1975 and 175 countries have signed the Convention as of 2010. It was established to ensure that trade in wildlife and wildlife products is managed sustainably. It aims to regulate international trade in wildlife products through international cooperation while recognizing national sovereignty over wildlife resources. CITES poses three appendices of species for regulating trade. Two main appendices are Appendix I, which lists species that cannot be traded commercially and Appendix II, which lists species that can only enter international trade under specific controlled circumstances. Myanmar's accession to CITES on 13th June 1997 was highly significant, in light of the significance of the wildlife trade as a driving force for over-exploitation of wildlife populations in the country.
2. Convention on Biological Diversity (CBD)

   The CBD has been effective since 1993 and as of December 2010, 193 nations have signed this convention. Its objectives are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. It seeks to promote conservation of biological diversity in the wild, through requesting contracting parties to identify regions of biodiversity importance, establish a system of protected areas, restore degraded ecosystems, maintain viable populations of species in their natural surroundings, and develop or maintain necessary legislation and/or other regulatory provisions for the protection of threatened species and populations. Myanmar ratified the CBD on 25th November 1994 and this NBSAP is prepared as a commitment to Article 6 of the Convention. Myanmar is also preparing a clearinghouse mechanism (CHM) as a commitment to Article 18.3 of the Convention.
3. World Heritage Convention (WHC)

   The WHC has been effective since 1975 and as of December 2010, had 192 contracting parties. The WHC's aim is to identify and conserve cultural and natural monuments and sites of outstanding universal value. The convention is implemented through the nomination of World Heritage Sites by national governments. Myanmar acceded to the WHC on 29 April 1994. To date, no sites in Myanmar have been inscribed on the list of World Heritage Sites despite the fact that a number of sites clearly meet the criteria for nomination.
4. Ramsar Convention

   Effective since 1975, the Ramsar Convention, officially known as the Convention on Wetlands of International Importance especially as Waterfowl Habitat, currently has 144 contracting parties. It provides a framework for international cooperation for the conservation and wise use of wetlands. As of December 2004, the contracting parties had nominated 1,401 Ramsar sites globally, covering a total area of 123 million ha. Myanmar acceded to the Ramsar Convention on 17 March 2005, nominating Moeyungyi Wetland Bird Sanctuary as the country's first Ramsar site. In addition to Moeyungyi, Myanmar supports a large number of other wetlands that could also be listed as Ramsar sites.

CHALLENGES ON RISK ANALYSIS AND MANAGEMENT OF IAS

Species that have become established in areas outside their natural range are known as "alien species". Generally, alien species do not pose a significant risk and many are even beneficial. However, when alien species are capable of causing significant harm to our environment, the economy or to society, they are referred to as "invasive alien species". Little is known about the status of IAPS in Myanmar. We, therefore, highlighted the major problem of IAS facing damage of forest ecosystem today.

- Introduction of invasive alien species that will cause negative impacts on native biodiversity
- Require to strengthen national level units for IAS control plan and management
- To check the loss of biodiversity and impact in IAS affected areas
- Urgent need development of indication for IAS

- Lack of human resources and capacity building
- Incorporate IAS considerations, including monitoring and reporting and notification of new threats, into regional agreements and other instruments, and information on IAS status and trends available through other relevant regional information system

RESEARCH AND CAPACITY BUILDING

The Ministry of Environmental Conservation and Forestry (MoECaF) of Myanmar facilitates the development of NISSAP through close collaboration with Ministry of Agriculture, Ministry of Fishery and Marine Affair and other relevant agencies. The development of the document also includes public consultation process. Considering the training and education on IAS management remain lacking, there are a number of challenges that need to be addressed. Challenges and future research and capacity building directions on risk analysis and management of invasive plant species are as the following:

1. develop adequate tools and improve human resource capacity under relevant institution to identify IAS and potential IAS,
2. conduct risk analysis (pre, at and post-border) and take measures to manage and minimize risk,
3. Control and eradication of priority IAS.

CONCLUSION

With the existing policies and regulations and collaboration with regional and international organizations, Myanmar strives to move forward to meet the challenges and conduct research and capacity building activities to fill the existing gaps in assessing and managing invasive alien species especially on the lack of information on IAS pathways to the country.

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.Annex .1. List of Major IAPS in Myanmar

No	Species name	Common name	Type	Introduction	Habitat	Impact
1.	*Ageratum conyzoides*	Ageratum, goatweed	Shrub	Native	Grow in a variety of soil type	Can displace native vegetation threat to forest communities and dynamics of natural ecosystem processes
2.	*Acacia auriculiformis*	Acacia, Aurisha	Tree	Intentional for agroforestry	Road side, plantation	Cause irritation and asthma from pollen
3.	*Adenanthera parvonina*	Coral bean tree, Yawe tree	Tree	Native	Natural forests and lowland tropics in coastland	-
4.	*Leucaena leucocephala* (Lam.) De Wit	Leucaena	Tree	Intentional for agroforestry	Road side, plantation	Displacing native Species

5.	*Prosopis juliflora* DC.	Mesquite	Shrub/ tree	Intentional for shade, fodder and dry zone greening	Wastelands, degraded lands, deserts and grasslands	Very aggressive in displacing native vegetation. Its poisonous thorns can injure livestock and people
6.	*Chromolaena odorata* (L) R.M King & H Robinson	Bitter bush	Shrub	Ornamental	Ornamental Fallow and, road sides, pasture	Skin irritation, asthma, and toxic to animals. Displaces native vegetation and species
7.	*Hyptis suaveolens* (L.) Poit	Bush tea	Shrub	-	Plantation, road sides, pastures, dry lands	Causes asthma, and damage to arable lands
8.	*Lantana camara*	Lantana	Shrub	Intentional for ornament	Plantation, pasture, urban	Poisonous to cattle, understory competitor, and displaces native species
9.	*Echinochloa crus- galli* (L.) P.Beauv.	Barnyard grass	Grass	Unintentional	Rice fields	Yield reduction, and toxic to animals
10	*Elaeagnus umbellate* Thumb	Autumn-olive	Large shrub	-	Common in natural forest	Invades grasslands and disturbed areas adjacent to planting
11	*Imperata cylindrica* (L.) P. Beauv.	Congo grass	Grass	Cosmopolitan distribution	Plantation, pasture, dry lands	Inhibits natural regeneration of forests and highly flammable
12	*Pennisetum* spp.	Mission grass	Grass	Intentional for pasture	Forest and plantations	Aggressive, competitive and inhibits growth of plantation trees.
13	*Mikania micrantha* H.B.K	Minute weed	Climber	Ornamental	Forest and plantations	Plants, and competes for water and Nutrients
14	*Mimosa diplotricha*	Sensitive	Plant	Small shrub	Ornamental	Thorny, spreads rapidly, smothers vegetative
15	*Saccharum spontaneum*	Weed	Grass	Intentional for pasture	Fallow fields, Wasteland, riverbanks and roadsides	Serious weed of cultivated land and heavy infestation necessitates abandoning area

Appendix E3 : Philippine Country Report

RISK ANALYSIS AND MANAGEMENT OF FOREST INVASIVE ALIEN PLANT SPECIES (IAS) IN THE PHILIPPINES

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INTRODUCTION

The Philippine archipelago of more than 7,100 islands is one of the 17 mega-diverse countries in the world. It is home to at least 38,000 animal species, of which at least 35,000 are invertebrates and 3,000 are vertebrates (NRMC-UP 1986; DENR/UNEP 1997; PBCPP 2002). The estimated number of Philippine plant species ranges from about 14,000 to more than 15,000 species, representing about 5% of all species globally described so far. The rich Philippine biodiversity is attributed to its high endemicity. Represented by 16 biogeographic zones, the Philippines is host to many endemic flora and fauna with limited distributional ranges which are prone to extinction from predatory and competitive advantage of invasive species. The archipelagic nature of the Philippines suggests that IAS interventions should recognize the uniqueness of each biogeographic zones across the archipelago such that movement of native species outside their natural range is adequately manage.

The forest interior, which harbors high level of biodiversity and endemism, becomes vulnerable to species invasion via the entry points along forest fringes and forest gaps (Brothers & Spingarn 1990). The introduction of alien or exotic species in the Philippines was both intentional and accidental. Many plant species were introduced to the Philippines during prehistoric times mainly from the Malayan region. During the Spanish and American colonization eras, more species were introduced mainly for food production, reforestation or rehabilitation of denuded areas, aesthetic and recreational purposes. Exotic or introduced plant species are found in all types of forest habitats even in protected areas. A preliminary resource assessment of twelve national parks in the Philippines conducted in 1985 indicated that nearly 50% of the inventoried 'wild-food' plant species were alien, most of which were found at forest fringes and abandoned kaingin farms or "slash and burn " farm (Catibog-Sinha 1994).

LIST OF EXISTING INVASIVE ALIEN PLANT SPECIES AND THEIR IMPACTS ON ECOLOGY, ECONOMY, PRODUCTION SYSTEMS AND HEALTH

Invasive alien plant species in the country were deliberately introduced mainly for food production, reforestation of denuded areas, and aesthetic and recreational purposes until they were observed and reported to have become invasive and have caused economic losses and environmental damage. Biosafety measures and environmental impacts were not considered before their introduction in those early years.

Currently, the country through the Philippine Plant Conservation Committee is in the process of coming up with the list of Invasive Alien Plant Species or the plant species introduced deliberately or unintentionally into the country where they become established and cause negative environmental and economic impact. The classification system for determining levels of invasiveness/impacts of these species for management is also being formulated.

Among the invasive alien plant species introduced into the country are the following:

1. *Leucaena leucocephala* –Ipi-ipil
2. *Acacia auriculiformis*-auri
3. *Broussonetia papyrifera*-paper mulberry
4. *Piper aduncum* –Spiked pepper
5. *Spathodea campanulata*- African tulip
6. *Thunbergia grandeflora*- Blue tumphet vine
7. *Acacia mangium*- mangium
8. *Prosopis julifora* – Aroma; Aroma
9. *Lantana camara*- Coronitas
10. *Chromolaena odorata*- Siam weed
11. *Mikania micrantha*- Mile-a –minute
12. *Mimosa invisa*- Giant sensitive plant

The following are some of the reported impacts of Plant IAS on Philippine biota and agriculture:

Species	Basic information and Impacts
Piper aduncum	Deliberately introduced in some denuded areas in the country for reforestation and immediate forest cover; Invades disturbed areas where it is able to form thickets; competes for light, nutrients and space needed by indigenous species; dominated open areas of lower and middle elevation of mountain ranges, pasturelands and cultivated lands in Mindanao and in several islands in the Visayas.
Acacia mangium	Introduced in 1960 from Sabah; used for forestry and ecological restoration; displaces indigenous forest tree species due to competition for light, nutrients and space; It also harbors wood decaying microorganisms that affect other indigenous timber species.
Broussonetia papyrifera	Introduced in 1935 to augment the bast fibre-producing tree crops on Makiling Forestry School campus; It expands rapidly by vegetative reproduction and by stolon and byits shade, eliminate other light demanding indigenous plants. It is a pioneer species and thus inhibits succession by native plants (Florece *et al.* 2006).
Chromolaena odorata	Introduced into the tropical regions of Asia, Africa and the Pacific, where it is an invasive weed; poisonous to grazing livestock; displaces indigenous forage /grass species for livestock; harbors agricultural pests; may occupy forest gaps and retards natural regeneration by competing with space and nutrients; and, an agent of forest fire.
Mikania micrantha	It smothers the ground and annual and perennial crops including agroforest plantations; competes for light, water, nutrients and space with crops; harbors pests; it smothers trees and affects natural regeneration of native vegetation.
Lantana camara	Introduced as landscape plant; can become the dominant understory species in disturbed forest; disrupts succession and decrease biodiversity; reduces productivity of pasture lands and toxic to animals; competes for light, water, nutrients and space with indigenous species; they compete for nutrients and space thus affects natural regeneration of forest vegetation.
Mimosa invisa	Pest in forest plantations, cropland, orchards and pasture. Increase cost of farm management.
Leucaena leucocephala	It is a host to Psyllids that affected the indigenous forest tree species; competes with indigenous species for nutrient, light and space,thus displacing the indigenous species and eventually eliminating them in their habitat.
Acacia auriculiformis	Prevents the growth and reproductions of indigenous species due to its fast growth and high dispersal coverage; competes for nutrients, space and light needed by indigenous species.

MANAGEMENT OF SOME INVASIVE PLANT ALIEN SPECIES

Conflicting perspective on economic importance of some exotic trees and their impact to forest biodiversity is holding back any interests to pursue management programs for IAS in the forestry sector. Currently, forest IAS interventions are mostly done in the context of farm management to the extent that they also affect land cultivation. For instance, the *Piper aduncum* which also affects farms is controlled by manual cutting of the trunk and the stump is uprooted manually by plowing. Some farmers burn the invaded area to kill the plants. *Leucaena* also grows in lands planted with perennial or annual crops and are controlled by manual removal and burning of the stumps. Both plants are also utilized as wood and in the case of leucaena, its leaves as fodder, and therefore both are controlled to some extent by harvesting.

Most of the noxious weeds are managed or controlled by brushing or manual cutting, burning or use of herbicides.

NATIONAL GOVERNMENT BODIES CONCERNED ON PLANT IAS

Name of Organization	Key Responsibilities
1. **Department of Environment and Natural Resources (DENR)**	The primary government body responsible for the conservation, management, development, and sustainable use of the country's environment and natural resources, including protected areas, forest land, watersheds, public land and ancestral land It is comprised of four (4) of its relevant Bureaus

a. Biodiversity Management Bureau (BMB)	Develops policies, plans and programs in the conservation of biodiversity through integrated protected area management, conservation and sustainable use of wildlife and protection of their habitats, sustainable tourism, nature conservation, and information and public education
b. Forest Management Bureau (FMB)	Develops policies, plans and programs in the protection, development, and management of mangroves, upland forest lands, grazing lands and watersheds, and the reforestation/rehabilitation of degraded areas
c. Environmental Management Bureau (EMB)	Develops policies, plans and programs in management of environmental quality through clean air and water management, solid waste management, and the implementation of the Environmental Impact Assessment system
d. Ecosystems Research and Development Bureau (ERDB)	Develops research output for policies, plans and programs in management of IAS
2. Department of Agriculture (DA)	The primary government body responsible for the promotion of agricultural and fisheries development and economic growth by providing support services necessary to make agriculture, fisheries, and agri-based enterprises accessible and profitable to rural communities
a. Bureau of Plant Industry (BPI)	Develops policies, plans and programs in the management and protection of agricultural crops from pests and diseases including the implementation of quarantine policies for the prevention, control and eradication of pests and diseases and injuries to plant and plant products
3. Palawan Council for Sustainable Development (PCSD)	In Charge with the governance, implementation and policy direction of the strategic Environmental Plan for the Province of Palawan (SEP) RA 7611
4. Academe (State Colleges and Universities) Department of Education and Sports and Commission of Higher Education	In charge of ensuring that IAS knowledge will be incorporated to the curricula of education
5. National Museum of the Philippines	In-charge of collecting, safe keeping and documenting IAS species

RELEVANT LAWS AND POLICIES FOR PLANT IAS

The concern on IAS and the need to manage them are embedded in existing laws and policies that address the conservation and protection of biodiversity . These are as follows:

1. **Presidential Decree No. 1433 (Plant Quarantine Law, 1978)**. This law regulates the entry of plant, plant products, and animals that may harbor pests or cause harm to agricultural products. Pest Risk Analysis is a fundamental element of quarantine law that adheres to the International Standards for Phytosanitary Measures of the Sanitary and Phytosanitary Agreement-WTO. The quarantine law is being implemented by the Department of Agriculture-Bureau of Plant Industry.

   This Law does not consider the regulations of plants and animals themselves as to their invasiveness. Integration however of IAS concerns in the Pest Risk Analysis is being addressed under the FORIS-Philippines project.

2. **Wildlife Resources Conservation and Protection Act (R.A. 9147)**. It provides that no exotic species shall be introduced into the country, unless a clearance from the Secretary of the DENR (for terrestrial species), DA (for aquatic), Chairman of the Palawan Council for Sustainable Development (PCSD) for flora and fauna in the Palawan Island. It also requires an environmental impact study and management plan prior to the introduction of non-native species.

   Within the DENR, applications for the introduction of terrestrial non-native species are reviewed by the National Wildlife Management Committee (NWMC) of the Biodiversity Management Bureau. Parallel committees also exist with the DA and PCSD. The NWMC reviews proposals for intentional introduction of exotic terrestrial species for whatever purpose such as in biological control, research, farming, and agroforestry, etc. Risk assessment procedures follows the "Guidelines on Planned Release of PHES" developed by the NCPB.

3. **Presidential Decree No. 705, as amended (Revised Forestry Code of the Philippines)**. This law is the basic policy for forestry in the country it regulates the entry of imported forest based materials for the forest industry as well as the establishment of forest plantations, restoration and rehabilitation of forestlands.
4. **R.A. 7586, National Integrated Protected Areas (NIPAS) Act**, prohibits the introduction of exotic species within protected areas. Such policy intends to prevent new introductions in already IAS infested forest edges and gaps. More aggressive guidelines to eradicate or control IAS in PA is among the objectives of the draft NISSAP of the country; and
5. **Presidential Proclamation No. 2146 1981** (Environmental Impact Assessment law. This proclaims certain areas and types of projects as environmentally critical and within the scope of the environmental impact statement system established under Presidential Decree No. 1586. It considered the introduction of fauna (exotic animals) in public and private forest an environmentally critical project, thus, any undertaking which included such activities, will require an Environmental Compliance Certificate (ECC).

The coverage of the above policies however is limited on the aspect of preventing entry and new introductions of potential IAS. The policies does not adequately provide direction to manage already introduced exotic species which have potential to become IAS and those which are recognized as IAS causing havoc to the Philippine environment.

NATIONAL STRATEGY FOR MANAGING IAS

The country had already developed (final draft) the National Invasive Species Strategy and Action Plan (NISSAP). By developing and implementing the NISSAP, the Philippine Government hopes not only to prevent the introduction of invasive species but also to effectively manage the spread of invasive species and minimize their threats.

The NISSAP provides a framework for coordinated and multi-sectoral management of IAS. It aims to foster cooperation among relevant government and non-government organizations, industries, local communities, civil society, and other stakeholders for a collective and coordinated action to reduce the rate of biodiversity loss through the prevention of new introductions and spread of IAS, and minimize their impacts. The NISSAP, which is consistent with and complementary to the goals of Philippine Biodiversity Strategy and Action (PBSAP), covers implementing goals and guidelines including strategic objectives and planned actions for implementation during the period 2014-2020.

RISK ANALYSIS PROCEDURES AND THE PREVENTION OF ENTRY OF EXOTIC SPECIES IN THE PHILIPPINES

Prevention of entry of exotic species in the country is being undertaken by the Department of Agriculture (DA) and the Department of Environment and Natural Resources (DENR).

Department of Agriculture

The Bureau of Plant Industry (BPI) of the Department of Agriculture (DA), the country's National Plant Protection Organization (NPPO), is the lead agency tasked in conducting Pest Risk Analysis (PRA). The BPI-Plant Quarantine Section (BPI-PQS) Pest Risk Analysis is a process responsive to importing countries' requests for market access of their agricultural products.

Before a commodity (plant/plant product) can be imported from a certain country it should first undergo Pest Risk Analysis (PRA)-ISPM 11. It is an international standard Plant Quarantine procedure conducted by the importing country in assessing the risk of entry of any plant/plant product capable of harboring insect pests, plant diseases, and other plant-associated organisms. The result of the PRA will be the basis whether the importation of the commodity will be allowed or not (Source BPI-PQS website).

Department of Environment and Natural Resources

The Forestry Sector led by the Forest Management Bureau (FMB), issues permit for the importation of forest-based materials. The BPI-PQ officer and Customs officer may not allow entry of forest products unless registered or with permit from FMB or the concerned DENR Regional Office.

Wild plants and animals, by-products and their derivatives are within the purview of DENR-Biodiversity Management Bureau (BMB). Applications for the entry and/or introduction of terrestrial non-native species, review and evaluations are made by the BMB-Wildlife Resources Division through the National Wildlife Management Committee. In cases where introduction is allowed, it shall require the prior clearance of the Secretary or the National Wildlife Management Council, provided that no introductions shall be made into protected areas & critical habitats.

The clearance shall be issued after compliance with the following requirements:

- Environmental Impact study focusing on the bioecology, socio-economic aspects of the area where the species will be introduced and status and suitability of the proposed area where the species will be introduced;
- Scientific study & background research (taxonomic status & other relevant data) and risk assessment of the exotic species to be introduced
- Management Plan which includes preparatory activities such as conditioning of the species
- Prior Informed Consent (PIC) secured from local stakeholders. Proofs of consultation such as notices & minutes of meetings, resolutions, endorsements shall be submitted in support thereof
- Affidavit of Undertaking stating that the Proponent shall establish a Monitoring & Research Fund - the monitoring & research fund shall be utilized for monitoring, study or research purposes of the introduced exotic species & in the case of unforeseen harmful effects to the environment or endemic species, control/ eradicate the introduced species in the area at his expense. For this purpose, the proponent shall post a bond. The amount shall be determined by the Secretary or the Council

IAS-RELEVANT INTERNATIONAL TREATIES AND AGREEMENTS SIGNED/RATIFIED BY THE PHILIPPINES

Below are IAS-relevant international treaties and agreements signed/ratified by the Philippines. The Philippine compliance with these commitments will enable the country to contribute to the global effort to halt biodiversity resulting from the invasion of alien species.

Convention	**Date**	**IAS Focus***		
		Species	Pathway	Ecosystem
Convention on Biological Diversity (CBD)	Ratified: October 10 1993	X	x	x
International Plant Protection Convention (IPPC)	Ratified: December 3 1953	X	x	
World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures	Signed: January 1 1995		x	
International Maritime Organization: Ballast Water Convention (BWC)	Member: 1964		x	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Ratified: August 18 1981	X	x	
Ramsar Convention on Wetlands (Ramsar)	Ratified: November 8 1994			x
The World Organization for Animal Health (OIE)	Entry to force: January 25 1924	X		
Convention on the Conservation of Migratory Species of Wild Animals	Entry to force: January 2, 1994	X		
United Nations Framework Convention on Climate Change (UNFCCC)	Ratified: August 2 1994			x
Cartagena Protocol on Biosafety to the Convention on Biological Diversity (Cartagena Protocol on Biosafety	Ratified: October 5 2006		x	
United Nations Convention to Combat Desertification (UNCCD)	Ratified: February 10 2000			x
United Nations Convention on the Law of the Sea (UNCLOS)	Ratified: May 8 1984			x
The World Organization for Animal Health (OIE)	Enter into force: January 25 1924	X		

* Reference: CBD 2011

CHALLENGES AND FUTURE RESEARCH AND CAPACITY BUILDING DIRECTIONS ON RISK ASSESSMENT AND MANAGEMENT OF INVASIVE PLANT SPECIES IN THE PHILIPPINES

Challenges:

1. Passage of an Executive Order or a law adopting the draft National Invasive Species Strategy and Action Plan to effectively manage the impact of IAS to Environment and Biodiversity and to direct relevant government entities to implement the goals of the Plan within the targeted period and to allocate regular, adequate, and timely budget for its efficient and timely implementation.
2. Passage of Sustainable Forest Management Act wherein new initiatives to improve forest governance based on science like IAS management, control and eradication are highlighted; and
3. Harmonization and Improvement of the Risk Analysis Procedures.

Research Needs:

There is limited in-depth and science-based information about the IAS in the Philippines, basic research about the biology and ecology of invasive alien species remains crucial in reducing the environmental and economic impacts of IAS in the country.

Capacity Building/ Training Needs:

As an output of the FORIS Project, Training Needs Assessment (TNA) & Training Strategy for Invasive Species Management & Prevention in the Philippines were developed. Implementation of such will strengthen the technical and management capacities of relevant government units, at the national and local levels, as well as concerned stakeholders for risk analysis and management of IAS specially in implementing the NISSAP.

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Draft National Invasive Species Strategy and Action Plan (NISSAP) -Philippines

Training needs assessment & training strategy for invasive species management and prevention in the Philippines

Draft "Review of the Current Risk Analysis Procedures in Relation to the Prevention of Entry of Invasive Alien Species in the Philippines and Recommendations for Improved Risk Analysis Procedures for Quarantine Authorities

Report on the Management of Invasive Alien Species in the Philippines

Appendix E4 : Thailand Country Report

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The regional seminar workshop on harmonizing approaches to forest invasive alien plant species risk analysis and management held at SEAMEO BIOTROP, Bogor, Indonesia during 2-5 December 2014. Thailand had listed 46 IAPS in forest areas both protected and productive areas, when considered using the criteria and suggested keywords following; 1) naturalized (outside its natural distribution range), 2) noxious & harmful weed (disturbance weed, weed of agriculture, forestry, fishery, environmental weed, allelopathic weed, host for recognized pests or pathogens, created a fire hazard), 3) broad climate suitability or diverse plant community types and 4) fast growing, quickly to produce propagules and easily dispersed. The impacts of IAPS have been strongly operative to economic, environmental and social impacts. There is no centralized national authority responsible neither on biosafety measure, as for the prevention and management of IAPS in Thailand that consisted of 4 ministries; the Ministry of Agriculture and Cooperatives, the Ministry of Ministry of Natural Resources and Environment, Ministry of Public Health and Ministry of Commerce. The FIAPS responsibility organizations are RFD, DNWP and DMCR. The national legislation mandating concerned institutions performance of biosafety measures in Thailand by National Park Act (1961), responsibility by RFD & DNWP and) Plant Quarantine Act (1964) responsibility by DOA. Thailand NISSAP (2013) provides a framework for coordinated and multi-sectoral management of IAPS, consistent with and complementary to the goals of Thailand 3rd NBSAP, covers implementing goals and guidelines including strategic objectives and planned actions for implementation during the period 2008-2012.

INTRODUCTION

The article 8(h) of the Convention on Biological Diversity (CBD) calls on parties to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species", as far as is possible and appropriate. Decisions V/8 and VI/23 of the Conference of the Parties to the CBD expand on how Article 8(h) should be addressed at a national and international level, including the development and implementation of invasive alien species (IAS) strategies and action plans. Decision VI/23 reaffirmed the importance of both national and regional strategies and plans for addressing IAS, and for collaboration between neighboring countries and trading partners, both regionally and internationally. The importance of raising awareness of threats posed by IAS and of the means to address the threats has also been emphasized in the decisions (GISP Secretariat 2004).

Now, Invasive Alien Plant Species (IAPS) are 1 in 5 of the threat continuously and more and more in the future for biodiversity loss. Biodiversity conservation in Thailand has face to this problem continuance from IAPS. Consequently, the cooperation among government agencies, official authorities and private sector has prevention, controlling and elimination IAPS in Thailand, but the key issue that they did not identify IAPS, as a result they misunderstand to identify as native species, because it was introduced so long time to Thailand. They did not know how to prevent, control and eliminate IAPS by suitable methods, sometime after they treated IAPS with in contrast to the results, some of them had been knighted to cultivate IAPS for ornamental plants, that they affected wide spread and more severe. Many native invasive plant species also have reported serious threatened to biodiversity loss in forest protected areas.
IAPS are harmful by introduction or spread threatened the environment, the economy, and society, including human health. They can be introduced into Thailand from other countries. The current threats posed by IAPS are real and growing, besides it also is harmful to forest ecosystems from native invasive plants in Thailand from native invasive woody climber species in some protected areas. The economic cost of invasive alien plants to Thailand is enormous. Weeds in crops alone cost an estimated 123 billion US$ annually (ONEP 2006a), while herbicide imports increased from 291.83 million US$ (MUSD) and 53,615.20 tons in 2009, to 352.93 MUSD and 60,231.52 tons in 2012 (Suvittawat 2014). IAPS also damaged the environment by changing the diversity, structure, and function of an ecosystem. Their negative impact extends to our society, causing health problems for humans and reducing our enjoyment of natural areas.

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SECTION 1 : SPECIES DIVERSITY OF IAPS, THEIR BENEFICIAL AND IMPACTS IN THAILAND

1.1 Species diversity of IAPS.

The plant species was considered to be IAPS using the criteria and suggested keywords following; 1) naturalized (outside its natural distribution range), 2) noxious & harmful weed (disturbance weed, weed of agriculture, forestry, fishery, environmental weed, allelopathic weed, host for recognized pests or pathogens, created a fire hazard), 3) broad climate suitability or diverse plant community types and 4) fast growing, quickly to produce propagules and easily dispersed.

The species diversity of IAPS when considered from their origins, can classified in to 2 groups; native group and exotic groups. Their negative impact extends to our society, causing health problems for humans and harmful to forest ecosystems.

1.1.1. Alien plant species.

It is consisting of all exotic plant species which have originated from natural habitats outside Kingdom of Thailand, which were recorded 29 species in Thailand (Table 1).

1.1.2. Native plant species.

It is consisting of all species which they have limited their distribution range within Kingdom of Thailand, which were recorded 17species in Thailand (Table 2).

Table 1 List of IAPS in Thailand.

Botanical name	Family name	Habit	Local uses	Prevention, Controlling and Eradication
Ageratina adenophora (Spreng.) R.M. King & H. Rob.	ASTERACEAE	Herb	Insect repellent	Physical: cutting Biocontrol: using Trypetid gallfly (*Procecidochares utilis*) Chemical: using glyphosate, 2,4-D amine, dicamba and MCPA or triclopyr
Alternanthera philoxeroides (Mart.) Griseb.	AMARANTHACEAE	Herb	Ornamental (aquarium), food (young leaf for tempura)	Physical: clear removal from reservoir, promote to eat vegetable Chemical: Dicamba, triclopyr and bentazone
Amaranthus spinosus L.	AMARANTHACEAE	Herb	Food (young leaf)	Physical: cutting, promote to eat vegetable Chemical: Dicamba, triclopyr and bentazone Biocontrol: by insect; *Hypolixus trunculatus*
Bidens pilosa L.	ASTERACEAE	Herb	Ornamental	Physical: cutting Chemical: using diuron, bromacil, atrazine, simazine,ropazine, hexazinone, oryzalin or ametryn, 2,4-D, glyphosate, amitrole, metribuzin and dicamba
Cabomba caroliniana A. Gray	CABOMBACEAE	Herb	Compost, ornamental (aquarium),	Physical: clear removal from reservoir Chemical: Endothall
Chromolaena odorata (L.) R.M. King & H. Rob.	ASTERACEAE	Herb	Ethnomedicine (leaf sap from fresh for stanch, root decoction for pain and fatigue)	Physical: cutting Biocontrol: using the stem gall fly (*Cecidochares connexa*) Chemical: using triclopyr and Tordon
Dactyloctenium aegyptium (L.) P. Beauv.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder Chemical: imazapyr, glyphosate, and 2,2-DPA
Eichhornia crassipes (Mart.) Solms	PONTEDERIACEAE	Herb	Compost, raw materials for crafts, fodder, food (young inflorescence), wastewater treatment	Physical: clear removal from reservoir, promote to use for crafts, food
Hydrilla verticillata (L. f.) Royle.	HYDROCHARITACEAE	Herb	Ornamental (aquarium)	Physical: clear removal from reservoir Chemical: Fluridone and endothall (dipotassium) Biocontrol: tuber-feeding weevils, fodder for *Ctenopharyngodon idella*
Hyptis suaveolens (L.) Poit.	LAMIACEAE	Herb	Ethnomedicine , insect repellent	Physical: cutting Chemical: amines and ester group of herbicides ; dicamba, clopyralid and picloram Biocontrol: tuber-feeding weevils, fodder for *Ctenopharyngodon idella*
Imperata cylindrica (L.) P. Beauv.	POACEAE	Grass	Fodder , raw material for roofing, ritual ceremony	Physical: cutting, promote to use for roofing Chemical: imazapyr and glyphosate

Lantana camara L.	VERBENACEAE	Shrub	Ornamental, Ethnomedicine (dry leaf decoction for rheumatism)	Physical: cutting Biocontrol: by insects; *Teleonemia scrupulosa* St l (Hemiptera), *Octotoma scabripennis* (Coleoptera), *Uroplata girardi* Pic (Coleoptera) and *Ophiomyia lantanae* (Froggatt) (Diptera), by fungi; *Prospodium tuberculatum*, *Puccinia lantanae, Ceratobasidium lantanae-camarae*
Leucaena leucocephala (Lam.) de Wit	FABACEAE	Tree	Fodder, firewood, N_2 fixing	Physical: cutting, promote to use for fodder, firewood Biocontrol: by insects; *Acanthoscelides macrophthalmus* (seed destroy beetle), psyllid insect (*Heteropsylla cubana*)
Mikania micrantha Kunth	ASTERACEAE	Herb	-	Physical: cutting Chemical: using glyphosate and 2,4-D
Mimosa diplotricha C. Wright ex Sauvalle	FABACEAE	Herb	Fodder , N_2 fixing	Physical: cutting, promote to use for fodder Chemical: using sodium arsenite, 2,4-D plus atrazine, fluroxypyr and glyphosate Biocontrol: by insects; *Heteropsylla spinulosa*
Mimosa pigra L.	FABACEAE	Shrub	Fodder, firewood, N_2 fixing	Physical: cutting, promote to use for fodder Chemical: using sodium arsenite, 2,4-D plus atrazine, fluroxypyr and glyphosate Biocontrol: by insects; *Heteropsylla spinulosa*
Panicum maximum Jacq.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder Chemical: imazapyr and glyphosate
Pennisetum pedicellatum Trin.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder
Pennisetum polystachion (L.)Schult.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder
Pennisetum purpureum Schumach.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder Chemical: imazapyr, glyphosate, and 2,2-DPA
Pennisetum setosum (Sw.) Rich.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder
Rhynchelytrum repens (Willd.) C.E. Hubb.	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder Chemical: imazapyr, glyphosate, and 2,2-DPA
Rottboellia cochinchinensis (Lour.) Clayton	POACEAE	Grass	Fodder	Physical: cutting, promote to use for fodder
Salvinia molesta D. S. Mitch.	SALVINIACEAE	Fern	Compost	Physical: clear removal from reservoir Chemical: Diquat
Salvinia cucullata Roxb.ex Bory	SALVINIACEAE	Fern	Compost	Physical: clear removal from reservoir Chemical: Diquat
Sphagneticola trilobata (L.) Pruski	ASTERACEAE	Herb	Ornamental	Physical: cutting Chemical: Roundup 2-5%
Spirodela polyshiza (L.) Scheiden	LEMNACEAE	Herb	Fodder (fish)	Physical: clear removal from reservoir Chemical: Diquat

Tithonia diversifolia (Hemsl.) A. Gray	ASTERACEAE	Herb	Ornamental, scenic point for tourism	Physical: cutting Chemical: using glyphosate
Typha angustifolia L.	TYPHACEAE	Herb	Ornamental, wastewater treatment	Physical: clear removal from reservoir, promote to use for decoration and eat shoots for food. Chemical: Round up 50%

Sources: modified from ONEP, 2013

Table2 List of common native invasive plants in Thailand.

Botanical name	Family name	Habit	Local uses	Prevention, Controlling and Eradication	Impacts to Forest types
Acacia comosa Gagnep.	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Acacia megaladena Desv. var. *indo-chinensis* I.C. Nielsen	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Acacia megaladena Desv. var. *megaladena*	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Acanthus ebracteatus Vahl	ACANTHACEAE	Shrub	Ethnomedicine	Physical: cutting	Mangrove forest
Acanthus ilicifolius L.	ACANTHACEAE	Shrub	Ethnomedicine	Physical: cutting	Mangrove forest
Achyranthus aspera L.	AMARANTHACEAE	Herb	No data	Physical: cutting	Both deciduous and evergreen forests
Achyranthus bidentata Blume	AMARANTHACEAE	Herb	No data	Physical: cutting	Both deciduous and evergreen forests
Acrostichum aureum L.	PTERIDACEAE	Woody climber	No data	Physical: cutting	Mangrove forest
Acrostichum speciosum Willd.	PTERIDACEAE	Woody climber	No data	Physical: cutting	Mangrove forest
Aerva sanguinolenta (L.) Blume	AMARANTHACEAE	Herb	No data	Physical: cutting	Both deciduous and evergreen forests
Broussonetia kurzii (Hook.f.) Corner	MORACEAE	Woody climber	Young inflorescences eaten for Local vegetable	Physical: cutting	Mixed deciduous forest & Dry evergreen forest

Byttneria andamanensis Kurz	MALVACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Lasiobema scandens (L.) de Wit	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Neyraudia reynaudiana (Kunth) Keng ex Hitchc.	POACEAE	Grass	Dry inflorescens to use for broom making	Physical: cutting	Both deciduous and evergreen forests
Pterolobium integrum Craib	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Pterolobium macropterum Kurz	FABACEAE	Woody climber	No data	Physical: cutting	Mixed deciduous forest & Dry evergreen forest
Thunbergia grandiflora L.	ACANTHACEAE	Climbing herb	Ornamental, and ethnomedicine	PPhysical: cutting Chemical: using glyphosate	Evergreen forests

1.2. BENEFICIAL USES OF IAPS

Many IAPS have used in many aspects in Thai styles both direct and indirect, directly usages for food (Figure1), fodder, medicinal plant, ornamental plant, wood, firewood, insect repellent, raw materials for crafts (Figure 2 & 3), roofing (Figure 4), etc., and indirectly usages for wastewater treatment, cover crops, soil erosion protection, compost, green belt for forest fire protection, scenic point for tourism (Figure 5), carbon sequestration and other ecosystem services .

Figure 1 Some local vegetables from IAPS; A) *Eryngium foetidum*, B) *Hydrocotyle umbellata,* C) *Marsilea crenata* and D) *Schinus terebinthifolius.*

Figure 2 Handicrafts for water hyacinth *(Eichhornia crassipes)* petioles.

Figure 3 Handicraft form leaves of *Agave americana*.

Figure 4 The roofing was made from alang alang *(Imperata cylindrica)* leaves.

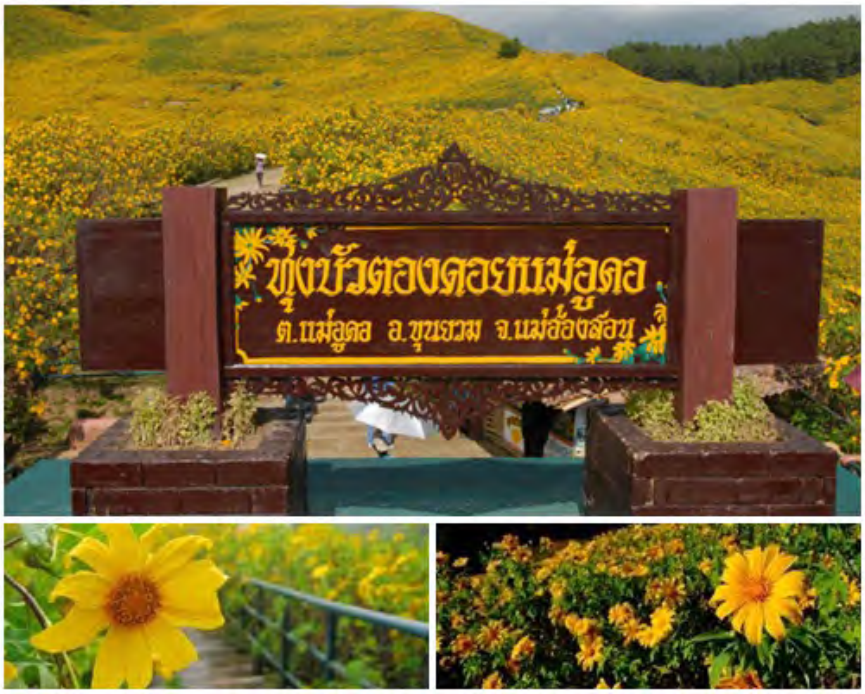

Figure 5 Scenic point for tourism of *Tithonia diversifolia* field at Mae Hong Son province, northern of Thailand.

1.3. IMPACTS OF IAPS

The impacts of IAPS have been strongly operative to economic, environmental and social impacts.

Table 3 Cost and quantity of herbicide substances import to Thailand during 2005-2013.

Years		Value of import herbicide substances (Baht)	Quantity of herbicide substances (kg)	Note
AD	BE			
2005	2548	5,485,729,778.23	47,507,410.16	
2006	2549	6,820,815,586.46	62,129,173.45	
2007	2550	8,914,131,188.14	79,239,127.14	
2008	2551	11,487,037,763.36	68,824,594.71	
2009	2552	9,338,498,815.25	97,956,856.41	
2010	2553	8,845,038,256.90	80,278,187.82	
2011	2554	11,479,521,716.89	112,176,809.59	
2012	2555	11,293,852,477.74	106,860,024.20	
2013[1)]	2556	8,188,099,080.61	77,122,826.97	6 m (Jan-Jun)
Mean		9,208,078,198[2)]	81,871,522.94[2)]	

Sources: DOA, 2014 Remark: [1)] data from 6 moths recorded, [2)] mean from 8 years excluded 2013.

1.3.1 Economic impacts

IAPS can cause enormous economic damage over a broad range of economic sectors. The most obvious economic impacts are direct, quantifiable costs such as losses in potential agricultural output or costs of herbicides. Additional costs related to indirect effects or less tangible values, such as ecosystem services (e.g. water purification, soil stability, and carbon sequestration), are more difficult to quantify. Few studies have attempted to quantify the economic impacts of invasive plant species in Thailand.

The sectors most directly affected by IAPS, which impacts are best known on crop and animal production. In many areas the range and abundance of cropland weeds is known from surveys, while impacts have been estimated through

experimental studies on weed-crop competition. Besides, causing yield loss and boosting herbicide costs, IAPS can also endanger the health of livestock, reduce animals' weight gain, and diminish the growth of edible vegetation. Nationwide, annual costs of invasive plants for import herbicide substances are estimated at 9.2 billion baht (Table 3).

1.3.2 Environmental impacts

The greatest impacts of IAPS entail modifying entire ecosystems, because modifications are likely to affect most of the originally resident species. This may include change in the structure of physical habitat, by overgrowing and shading out native species, change in fire regime, and modifying water or nutrient regimes; N_2 fixing exotics can favor other exotics over natives that have evolved to tolerate such soil. For example; water hyacinth can smother submerge vegetation, reduce dissolve oxygen and can also be affected other organisms (both plants and animals) in its habitat.

IAPS impact many aspects of ecosystem diversity, structure, and function. They can compete with and, in some cases, displace native plant species, potentially changing the plant composition of an ecosystem and endangering species of concern.

In terms of structure, thick stands of IAPS can add or subtract one or more canopy layers of a natural ecosystem and change the dynamic in which plants, animals, and micro-organisms use those layers, ultimately changing habitat for wildlife. *Typha angustifolia* and *T. latifolia* for instance, can growth rapidly form dense, in open areas of mash habitats that create a continuous clump of *Typha angustifolia* and *T. latifolia*, will be firing to destroy wildlife habitat when in dry season and to obstruct for tree regeneration.

IAPS can also have adverse effects on the natural functioning of ecosystems, such as the productivity of plants, animals, and micro-organisms; water levels and characteristics; soil erosion; and natural fire cycles. *Typha angustifolia* and *T. latifolia* are an invasive plant species that can alter ecosystem functioning. These species have been suspected of reducing the carbon-sequestering capacity of wetland plant communities, implying a possible role for these species in global climate change and reduced species diversity of estuarine vegetation.

The complexity and variety of environmental impacts caused by IAPS make their evaluation more difficult than the direct economic impacts on traditionally marketed commodities such as agricultural crops and forest products. However, the natural environment is clearly important to Thais, who spend on annual nature-related activities. Invasive plants have the potential to endanger the value of Thailand's protected areas by compromising their natural integrity and diminishing their quality. Some native invasive plant species have covered spread and occupied after logging, especially native woody and herbaceous climber species such as *Acacia comosa, Acacia megaladena* var. *megaladena*, *Acacia megaladena* var. *indochinensis*, *Pterolobium integrum*, *P. macropterum*, *Lasiobema scandens*, that the invaded areas had covered estimate about 48,000 ha in 2009 in Kaeng Krachan national park, western part of Thailand, it's called forest avalanche.

1.3.3 Social Impacts

Social impacts of invasive plants include a diverse group of effects such as human health problems (allergies, dermatitis, etc.), interference with traditional lifestyles, and reduction or loss of tourism, employment, aesthetic values, property values, and enjoyment of natural areas in general.

Many invasive plants (*Pistia stratiotes*, *Salvinia cucullata* , *S. modesta*) can provide breeding habitat for mosquitoes, which carry many diseases, that are malaria, dengue, and Chikungunya, etc. *Typha angustifolia* also is originated in tropical America that was introduced to Thailand. It also has impact on social consequences. It has become a serious nuisance weed in urban areas in central Thailand and many marsh areas. This species has shaggy seeds and flying to human habitation that cause asthma when sniffed. Few studies from Thailand have focused on the social and environmental impacts, they are often difficult to quantify.

SECTION 2: DIVISION OF RESPONSIBILITY AMONG CONCERNED INSTITUTIONS TO MANAGE IAPS

There is no centralized national authority responsible neither on biosafety nor for biotechnology, as for the prevention and management of IAS in Thailand that were scattered responsibility among different organizations such as:

- the Ministry of Agriculture and Cooperatives (MOAC), having division of responsibility among concerned institutions that are the Department of Agriculture (DOA) for cultivated, ornamental and other plants, plant pathogens, and biological control agents, Department of Fisheries (DOF) for fish, aquatic animals and aquatic plants (freshwater, brackish and marine), and the Department of Livestock Development (DLD) for, the domestic animal quarantine,
- the Ministry of Ministry of Natural Resources and Environment (MNRE) consisting of Royal Forest Department (RFD) and Department of National park, Wildlife and Plant Conservation (DNWP) for other plants, shrubs,

trees, animals and wildlife, and endangered animals listed under CITES, Office of Natural Resources and Environmental Policy and Planning (ONEPP)for Policy and Planning, Department of Marine and Coastal Resources (DMCR) for marine and Coastal Resources,

- Ministry of Public Health (MOPH) in the Department of Medical Science (DOMS) and the Department of Disease Control (DODC) for microorganisms, animal and insect vectors of human diseases, and causal agents of epidemiological importance,
- Ministry of Commerce (MOC) for the import and export of certain kinds of fauna and flora.

While the plant quarantine office is under DOA, the animal quarantine office is under the DLD. Both departments supervised quarantine services in all important international land, sea, and airports and border posts as well as domestic animal quarantine stations located at key geographical locations. The FIAPS responsibility organizations are RFD, DNWP and DMCR. The Working Group on IAPS created under the National Environmental Board Subcommittee on the Convention on Biological Diversity, is not an authorized legal body.

SECTION 3: EXISTING LAWS, REGULATIONS AND PROTOCOLS

Thailand has signed a number of environmental agreements such as the CBD (Thailand acceptance in 2006), as a party to the convention and protocol. Thailand has committed itself to reducing the rate of biodiversity loss. Examining existing laws, regulations and protocols will help to realize the Thailand' goal. Such examination provides valuable information to determine whether existing laws are sufficient, need strengthening or enacting additional laws is necessary.

3.1 National legislation mandating concerned institutions performance of biosafety measures in Thailand.

The relevant policies for IAPS in Thailand have developed many acts viz.,

a. Plant Quarantine Act (1964) responsibility by DOA
b. Export & Import Act of Goods (1979), responsibility by MOC
c. The National Park Act (1961), responsibility by RFD & DNWP
d. Wildlife Reservation and Protection Act (1992), responsibility by RFD & DNWP
e. Fisheries Act (1947), responsibility by DOF
f. Plant Varieties Protection Act (1999), responsibility by DOA
g. Protection and Promotion of Traditional Thai Medicine Wisdom Act (1999), responsibility by MOPH
h. The Enhancement and Conservation of National Environmental Quality Act (1992), responsibility by MNRE

3.2 Regulations and Protocols

In the absence of legislation, several regulations and protocols have been initiated by the Office of Environmental Policy and Planning (ONEP). A part of the duties of the ONEP is to provide guideline to recognize the inadequacy of present legislation as it relates to protection of native plants. Therefore, it has proposed national strategies.

3.2.1 The National Invasive Species Strategy and Action Plan (NISSAP; 2013)

Thailand NISSAP strategy is a broad overview of the national focus on IAPS. It suggested that prevention, early detection and response, eradication and control were most important in managing alien species. The strategy had done on IAPS of plant information by list manual for Prevention, Controlling and Eradication in Thailand and recommended training of customs officers, agricultural officers, forestry officers, fisheries officers and enforcement officers as essential to the success of the strategy.

Areas proposed for regular monitoring were public places and protected areas. The committee working on the invasive species document advised that an inventory of all alien species be performed. In addition, it categorized species and recommended them for eradication and others for control. The Thai government policy for managing invasive species includes the commitment to enact legislation, prepare and implement management plans for the control of invasive species, and the re-establishment of native species. The government also promised to encourage research into best management practices and foster regional and international cooperation to assist in the control and eradication of alien species. Voluntary codes of conduct for government and non-government agencies were also included in this document. It was suggested that the implementation of improved stakeholder participation, innovative projects to restore degraded land, funding, collaborative research, coordinated activities and added participation from a more informed public could assist in the process of reducing land degradation. This plan also opined that these steps could indirectly contribute to controlling and eradicating IAPS of plant.

3.2.2 The Thailand National Biodiversity Strategy and Action Plan (3rd NBSAP; 2008-2012)

The national biodiversity strategy and action plan focused on the generalities of biodiversity in the Thailand. However, it recognized that alien species are a serious threat to biodiversity loss, therefore the need to control or eradicate these species are critical to ecosystems health. The plan further suggested that risk assessment be done on each alien species, implementation of a public education program and inter-regional corporation be utilized to reduce biodiversity loss. This dual strategy and action plan also recommended an integrated ecosystems approach to biodiversity conservation because of the fact of interdependence of these systems. An action for the protection or rehabilitation of threatened or degraded ecosystems and of threatened species was central to the management process. The 3rd Thailand National Biodiversity Strategy and Action Plan (2008-2012) approved by Thai cabinet on 15 January 2008, it consisted of 5 strategies, main article content related to enhancing fertility of biodiversity and stability utilization for Thai society, coupled with research on biological diversity values for sustainable economic uses including a mechanism to access and sharing of benefits from country biodiversity development at fair and equitable (http://chm-thai.onep.go.th/2014).

3.2.3 International Agreements and Protocols

Among the international agreements with Thailand were the UN Convention on Biodiversity, the UN Convention on Cartagena Protocol on Biosafety to the CBD (Thailand accessed on 10 Nov 2005, https://treaties.un.org, 2014) and the Convention on International Trade on Endangered Species and wild Flora and Fauna (CITES; Thailand ratificated on 21 January 1983; CITES 2014). These conventions provide the framework for individual member states to develop plans to address the concerns outlined in the documents. In most instances, Thailand has complied with the various agreements and has produced its national action plans to address issues in the UN documents on biodiversity and invasive species.

SECTION 4: PLANNING FOR IAPS MANAGEMENT

- Compile information on the list and status of IAPS in Thailand
- Compile information and conduct investigation on the biology, ecology, and impacts of IAPS in Thailand,
- Prepare guidelines and measures for the control and eradication of those IAPS affecting and causing economic damage,
- Prepare guidelines to regulate the introduction of IAPS including genetically modified organisms (GMOs),
- conflicting perspective on economic importance of IAPS and their impact to forest biodiversity is holding back any interests to pursue management programs for IAPS in the forestry sector
- Currently, forest IAPS interventions are mostly done in the context of farm management to the extent that they also affect land cultivation.

In addition, organizations responding to IAPS in Thailand included provincial, and municipal governments, universities, colleges, botanical gardens, herbaria (collections of dried plants), non-government environmental organizations, youth groups, businesses. Responses to IAPS have included surveys, mapping, management programs, monitoring, and regulations. Preventive programs are widely recognized as the most effective and cost-efficient means of control for IAPS.

SECTION 5: CURRENT RESEARCH AND CAPACITY BUILDING ACTIVITIES ON RISK ANALYSIS AND MANAGEMENT OF IAPS

It is vital that we underpin policy decisions with strong scientific evidence. Research outcomes are often a key component helping to inform risk assessment; surveillance; detection; monitoring; control; and eradication strategies. Applied research is particularly important to help inform and refine control methods as well as assessing the feasibility of proposed action. Feasibility studies, often involving modeling, are a key tool for assessing the likely costs and probability of success for larger-scale control or eradication efforts. Research could provide technological or biological control solutions to help address problems that have previously seemed intractable (Department of Environment of North Ireland 2013). Developments in research nationally and internationally are monitored to identify technological or biological advances and to ensure any research undertaken is cutting edge and avoids any duplication.

In the past, research outcomes in Thailand of some IAPS of plants were reported to be obstructed some impacts to forest trees regeneration for seedling establishment in the *Leucaena leucocephala* plantation by its invasive growing habit which reduces light transmittance to the forest floor (Marod *et. al.* 2012). Pramual *et. al.* (2011) reported on levels of genetic variation within populations of *Mimosa pigra* were revealed high that suggested patterns of genetic variation and genetic structure are likely due to multiple introductions of *M. pigra* into Thailand. While Zungsontiporn (2014) mentioned on status of *Hydrocotyle umbrellata* and Chomchalow (2011) reported on status of *Salvinia molesta*, both species

were introduced to Thailand as ornamental plant, which are fast growing species and adaptation to be IAPS plants in Thailand. Chemical control is a method to use paraquat herbicide for eradicating, but not officially recommended, except for use directly on the plant. As for research outcomes related native invasive woody climbers, Sakchuwong (2011) and Viriyabuncha *et. al.* (2011) reported 8 serious species (*Acacia comosa*, *Acacia megaladena, Pterolobium integrum*, *Pterolobium macropterum*, *Lasiobema scandens Congea tomentosa*, *Ventilago denticulata* and *Combretum procursum*) that have been harmful to forest ecosystem in Kaeng Krachachan national park, western Thailand (Figure 10).

Figure 10 Native invasive woody climbers have been threatened to forest ecosystem in Kaeng Krachachan national park, western Thailand (Viriyabuncha *et. al.* 2011).

SECTION 6: COLLABORATIONS WITH INTERNATIONAL BODIES ENGAGED IN PREVENTION AND CONTROL OF IAPS

6.1 The CBD Parties

The CBD identified IAPS as a major factor in the loss of biodiversity based on their capacity to out-compete or prey on native species and subsequently cause a degradation of the biodiversity in the area of their introduction. The risks and damages caused by IAPS can be massive and threatened to native plant species. Besides, the obvious environmental impacts, IAPS of plants may cause economic damages through yield losses or control costs and may adversely affect animal and/or human health. The Global Invasive Species Program (GISP) with a mission to conserve biodiversity and sustain human livelihoods by minimizing the spread and impact of IAPS. GISP's partner organizations included Centre for Agricultural Bioscience International (CABI), IUCN, The Nature Conservancy (TNC) and the Secretariat of the CBD. Since its creation, the focus of GISP was on policy development, awareness raising and information exchange (WTO Secretariat 2013).

6.2 Training workshop, and electronic reporting service

The Conference of the Parties (COP) to the CBD adopted the Strategic Plan for Biodiversity 2011-2020 of 10th meeting with its 20 Aichi Biodiversity Targets, the COP requested the Executive Secretary of the CBD, with the assistance of the Coordination Mechanism for the Global Taxonomy Initiative (GTI) and in collaboration with relevant international organizations, to hold capacity-building workshops in all sub-regions and regions as needed. During 30 July-01 August 2012, The Secretariat of the CBD jointly organized the workshop with the ASEAN Centre for Biodiversity (ACB), in collaboration with the Government of Thailand; the ONEP and MONRE, held the workshop with entitled "GTI Sub regional Capacity-building Workshop to Address Invasive Alien Species and to Achieve Aichi Biodiversity Targets in East and Southeast Asia", in Bangkok. Overall, 41 participants attended the workshop, including 11 countries (8 ASEAN member states including Japan, Mongolia and Korea) (ACB 2012).

The outputs of the training workshop were the following (ACB 2012);

1. Skills of the participants in terrestrial plants taxonomy especially on recognizing, identifying and general taxonomy of IAPS were upgraded,
2. Knowledge of participants in managing/controlling IAPS was increased,
3. Framework in risk assessment and impacts of IAPS was introduced,
4. Skills in proposal development, especially with respect to IAPS, were upgraded, and
5. Updates from the ASEAN Member States on the integration of IAPS and GTI in their national biodiversity strategies and action plans (NBSAPs) and also in addressing relevant Aichi Biodiversity Targets were presented.
6. The outcomes of the project included;
    a. Enhanced capacity of CBD National Focal Points to apply the activities of the GTI and tools provided by the Secretariat of the CBD and resource persons to address IAPS and other targeted areas at the national and sub-regional levels,
    b. Suggestions to the CBD National Focal Points and other relevant officials in the region to ensure that

Taxonomic capacity gaps are addressed towards IAPS and to achieve Aichi Biodiversity Targets.

SECTION 7: CHALLENGES AND FUTURE RESEARCH AND CAPACITY BUILDING DIRECTIONS ON RISK ANALYSIS AND MANAGEMENT OF IAPS

There is a growing amount of research on IAPS of plants underway in universities, institutes, government related on IAPS activities and by other stakeholders. The research topics covered range from highly applied through to fundamental research on invasion biology. A key challenge is ensuring that this research informs management and that scientific research is accessible to all stakeholders. Monitoring of IAPS of plants currently takes place in an ad-hoc way. There is no dedicated monitoring program as IAPS of plants have not yet been fully integrated into current monitoring program. An effective program development of monitoring, recording and reporting is challenging as it requires the participation of a wide range of stakeholders and information to be submitted and verified in a timely way.

There is a limited understanding of the threats posed by IAPS of plants. Improved awareness and understanding of the issues surrounding IAPS of plants is vital to gain support for the relevant policies and programs and to engage the public in decision-making. As well as raising general awareness, there is a need for initiatives targeted at key groups whose activities can contribute to the problem or be part of mini-missing the risk from IAPS of plants. An effective stakeholder engagement program which identifies these groups and the most effective means of engaging with them is vital for success. The goals of communications, awareness raising and capacity building activities programs are more than providing information. Awareness about the importance of addressing IAPS of plants should be present at multiple levels, from the senior political level to the general public. Raising such awareness should be a high priority for any IAPS action plan. It encourages behavior change, capacity building and provides practical skills. Given the limited resources available for tackling IAPS of plants it is vital to build capacity of a wide range of individuals and organizations to lead, contribute to and support any national program.

- Passage of an executive order or a law adopting the NISSAP
- Passage of sustainable forest management act where new initiatives to improve forest governance based on science like IAPS management, control and eradication is highlighted
- Harmonization/improvement of the risk assessment procedures
- Compendium on IAS related to researches

SECTION 8: RECOMMENDATIONS FOR FUTURE STEPS

1. Prioritize list of IAPS related to forest areas
2. To develop program/project research proposals in collaboration with other relevant institution both national and regional levels towards addressing gaps in risk analysis of IAPS (i.e., from goal setting and hazard identification, risk assessment, risk management, and risk communication) which are aligned with National Invasive Species Strategies and Action Plans (NISSAP) as part of the National Biodiversity Strategies and Action Plans (NBSAP)
3. To enhance the awareness and implementation of NISSAP as part of NBSAP among relevant stakeholders and existing international standards (i.e., ISPMs, FAO procedure, etc.) in collaboration with relevant parties
4. Review existing IAS networks and databases both regionally and globally on sharing and utilizing IAPS information and affiliate where necessary in order to enhance knowledge sharing and understanding of international and regional trends for application at national level

5. In collaboration with UN agencies and other relevant international and regional organizations, develop a region-wide long- (i.e. graduate study and fellowship programs) and short-term (i.e. training, seminar workshops, policy dialogues, etc.) plans to improve individual and institutional capacities to address gaps in implementation of Risk analysis methodologies for IAPS
6. To develop communication materials and policy instruments to improve public and decision makers' awareness and action on helping to understand the importance of preventing the spread and establishment of forest invasive alien plant species and their economic, social and environmental impacts
7. Mainstream invasive alien species as a subject matter in all education levels where appropriate

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Appendix E5 : Viet Nam Country Report

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INTRODUCTION

In Vietnam, invasive alien species (IAS) can be found popular in aquaculture, agriculture, forestry and horticulture. Besides their usage, some species cause significant threats to the environment, biodiversity, and economy. There had been very little attention paid to invasive alien species in Vietnam in the early 1990s, before the golden apple snail plague broke out and the species spread from Mekong River Delta to Red River Delta. After the event, invasive alien species has been gradually seen as a hot issue in Vietnam. However, research on invasive alien species has still been inadequate. The most noticeable researches were on Mimosa pigra and some other invasive plants in Mekong River Delta, the golden apple snail (*Pomacea canaliculata*), the coconut-leave eating insect (*Brontispa longissima*), *Lepidoptera* harmful to pines (*Dendrolimus punctatus* Walker), the pine-leaf eating bee (*Diprion* sp) and some studies about imported aquatic animals, mostly fishes.

1. Key IAS by Sector

Table 1: List of top IAS (both plants and invertebrates) by sector

Sectors	Key IAS
Forestry	*Mimosa diplotricha* *Mimosa pigra* *Lantana camara* *Chromolaena odorata* *Callisia fragrans* *Parthenum hysterophor*us
Agriculture	*Brontispa longissima* *Pomacea canaliculata* *Pomacea bridgesii* *Achatina fulica* *Cherax quadricarinatus*
Aquatic	*Gambusia affinis* *Pygocentrus nattereri* *Hypostomus punctatus* *Pterygoplichthys pardalis* *Micropterus dolomieu* *Micropterus salmoides*

2. Relevant Policies Related to IAS

Vietnam has a relatively adequate and strong legal regulation system from central to local level about biological import and export by overland, water-way, oversea and air transits. The main legal system relating to control and management of invasive alien species includes:

- Biodiversity law No.20/2008/QH12 (section 3 – article 50 to 54: Control of invasive alien species)
- Environmental Protection Law (2005); Law on Fisheries (2003); Customs Law (2005); Law on Forest Protection and Development (2004);
- Ordinance on Plant seeds (2004);
- Ordinance on Livestock Breeds (2004);
- Ordinance on Plant Protection and Quarantine (2001);
- Ordinance on Veterinary (2004);

- Decree No. 27/2005/ND-CP of March 08, 2005 by the Government on providing detail regulations and guidance for implementation of some articles of Law on Fisheries;
- Decree no. 02/2007/ND-CP of 5 january 2007 on Plant quarantine;
- Decree NO. 33/2005/ND-CP of 15 March, 2005 of the Government on providing detail regulations on implementation of some articles of Ordinance on Veterinary.
- Decree No. 31/2010/ND-CP of 29 March, 2010 of the Government on Penalties in the Fisheries sector

The issues of IAS, in fact, have not been mentioned thoroughly and systematically in legal documents yet. They have just been mentioned sparsely in some legal papers related to biodiversity conservation and plant protection. Some regulations on Invasive alien species appear in the following documents:

- Decree No. 31/2010/ND-CP of 29 March 2010 on Penalties in the Fisheries Sector prescribing "a financial penalty of 10,000,000 to 20,000,000 VND is applied to releasing invasive exotic aquatic species into natural water bodies, of 20,000,000 to 30,000,000 VND is applied to releasing invasive exotic aquatic species into water bodies in protected areas, both in-land and oceanic."
- Circular No. 53/2009/TT-BNNPTNT of 21 August 2009 of the Ministry of Agricultural and Rural Development on Managing Aquatic Exotic Species in Vietnam
- BIODIVERSITY LAW NO.20/2008/QH12 (SECTION 3 – ARTICLE 50 TO 54: CONTROL OF INVASIVE ALIEN SPECIES):

Article 50. Survey and listing of invasive alien species

1. Invasive alien species include known invasive alien species and potential invasive alien species.
2. Provincial-level People's Committees shall organize surveys for drawing up lists of invasive alien species in their localities and report them to the Ministry of Natural Resources and Environment and the Ministry of Agriculture and Rural Development.
3. The Ministry of Natural Resources and Environment shall assume the prime responsibility for, and coordinate with the Ministry of Agriculture and Rural Development, other ministries and ministerial-level agencies and provincial-level People's Committees in, conducting surveys and identifying invasive alien species, examining and promulgating a list of invasive alien species.

Article 51. Control of import of invasive alien species and invasion of alien species

1. Customs offices shall assume the prime responsibility for, and coordinate with competent authorities at border gates in, inspecting, detecting and handling violations in importing species on the list of invasive alien species.
2. Provincial-level People's Committees shall coordinate with competent agencies in organizing the inspection and assessment of the potential invasion of alien species before devising measures to prevent and control invasive alien species.

Article 52. Control of the rearing or planting of potential invasive alien species

1. The rearing or planting of potential invasive alien species may be conducted only when tests of these alien species show that they are not harmful to biodiversity and it is permitted by provincial-level People's Committees.
2. The rearing or planting and development of alien species in conservation areas may be conducted only when tests of these alien species show that they are not harmful to biodiversity of the biodiversity areas and it is permitted by provincial-level People's Committees.
3. The Ministry of Natural Resources and Environment shall assume the prime responsibility for, and coordinate with the Ministry of Agriculture and Rural Development, other concerned ministries and ministerial-level agencies in, issuing regulations on tests of alien species and the grant of permits for rearing or planting and development of alien species.

Article 53. Control of the spread and development invasive alien species

1. The State invests and encourages organizations and individuals to invest in implementing programs to isolate and eradicate invasive alien species.
2. Provincial-level People's Committees shall organize surveys to identify areas of distribution of species on the lists of invasive alien species in their localities, and work out plans to isolate and eradicate these species.

3. Organizations and individuals that discover invasive alien species shall immediately inform the nearest commune-level People's Committee thereof. After receiving such information, the commune-level People's Committee shall promptly report it to immediate superior authorities or the specialized agency of the provincial-level People's Committee for application of control measures.

Article 54. Publication of information on invasive alien species

1. The Ministry of Natural Resources and Environment, the Ministry of Agriculture and Rural Development and provincial-level People's Committees shall post the list of invasive alien species and information on their areas of distribution and levels of invasion on their websites.
2. Border-gate customs offices and competent authorities shall post up the list of invasive alien species at their border gates.
3. Mass media agencies shall disseminate information on invasive alien species and measures to control, isolate and eradiate these species.

- Decree NO. 02/2007/ND-CP of 5 January 2007 on Plant Quarantine/Article 9 prescribing "Prohibition of bringing any living regulated pests under the lists into non-infested areas; bringing plants with soil into Viet Nam in any form."
- Decree no. 109/2003/ND-CP of September 23, 2003 on the conservation and sustainable development of submerged areas/Article 7/item 5 PRESCRIBES "Prohibition of introducing alien animals and plants into the submerged areas habitat causing ecological unbalance or genes modification of native animals and plants".
- Law on Fishery (2003)/Chapter 1- General provisions/Article 6/item 12 PRESCRIBES "prohibition of culturing new aquatic strains without the permission of the Ministry of Fisheries and aquatic species on the list of those banned from culture" (notice: the list of species list of those banned from culture have not been made).
- Ordinance on Plant Seeds No. 03/2004/L/CTN of April 05, 2004 by the President Tran Duc Luong/ Chapter 1-General provisions/Article 9/item 6 prescribes "prohibition of import of gene sources and forbid of production and trade of plant seeds which are harmful to production and human health, environment and eco system".
- Ordinance on Livestock Breeds No. 04/2004/L/CTN of April 05, 2004, by the President Tran Duc Luong/ Chapter 1 general provisions/Article 9/item 6 prescribes "prohibition of producing or trade animal breeds which could be harmful to human, animal gene sources, environment and ecosystem".
- Ordinance on Veterinary No. 18/2004/PL-UBTVQH11 of April 29, 2004 prescribes the animals required to quarantine are "animals causing adverse impacts on human, animals, environment and ecosystem".
- Law on Forest Protection and Development (2004)/Chapter 1-General provisions/Article 6/item 12, prescribe "prohibition of breeding, cultivating, grazing that animals and plants that is not native species of Vietnam without permission of relevant authorities".
- Ordinance on Plant Protection and Quarantine of July 25, 2001 by The National Assembly prescribes "prohibition of introducing exotic alien species into Vietnam or spreading them between areas within the country".
- Resolution No. 41/NQ-TW of November 15, by Political Bureau on environment protection in the period of accelerated industrialization and modernization/ Mission 1- general tasks/ item c prescribes "To conduct surveys to identify natural resources and developing plans for protection, rational exploitation of resources and biodiversity protection; to protect wild animals, potentially extinction species; to prevent invasion form alien species, genetically modified organisms that pose adverse impacts on human - being and environment; to protect valuable and rare native genes and prevent the loss of their genetic sources".
- Follow-up the above-mentioned laws, ordinances and decisions, the Government, ministries and branches have issued a variety of other legal papers such as circular letter, guidance and resolutions dealing with control and management of imported biological objects in Viet Nam at individual disciplinary and inter-disciplinary levels which are concerned with invasive alien species in some extents. However, most of the papers only deal with serious problems. Examples:
- Decision No. 3061/QD-BNN-KHCN by the Minister of the Ministry of Agricultural and Rural Development prescribes that the procedure to eliminate *Mimosa pigra* in Vietnam is a technical initiative and recommend this procedure to be widely applied.
- Directive No. 151/TTg of September 20, 1995 by the Prime Minister on prohibiting breeding and ordering to eradicate of Apple nails (*Pomacea canaliculata*).
- Directive No. 151/TTg of March 11, 1995 by the Prime Minister on mobilization of sources for eradicating apple nails (*Pomacea canaliculata*).

- Joint Circular No. 4/LB/TT of March 22, 1995 on guiding to implement the Directive No. 151/TTg of March 11, 1995, which regulates the mobilization of sources for eradicating apple nails (*Pomacea canaliculata*).
- Announcement No. 914/TB-KNKL of August 09, 2002 on informing the conclusions of on importation of the Agriculture and Forestry Promotion Department on *Myocastor coypus* (chuot Hai Ly) by Thien Tan Nam Company.
- Decision No. 488/QĐ-TY of August 14, 2002 by Department of Animal Health of Vietnam on prevention of illegal import of *Myocastor coypus* (chuot Hai Ly) and establishment of the working group for resolving related problems.
- Directive No. 07/NN-BVTV/CT of September 3, 1996 by Minister of Ministry of Agriculture and Rural Development on prohibiting the import, transport and use of alien insect species as food for ornamental birds in Vietnam.

3. Specific Impacts of IAS

Among alien species found in Vietnam, following species are considered as dangerous species:

- *Mimosa pigra*: The species originated in the American Tropics and was first recorded in the Mekong Delta of Vietnam in 1979, but is now present almost throughout in the country. The species is becoming a serious problem for wetland areas such as in Tram Chim, Cat Tien, and Yok Don National Parks, Bien Lac Lake, and Tri An and Dong Mo-Ngai Son Reservoirs. The Government and locals had paid millions of VND for its prevention, control and elimination but no effective solutions.
- Golden apple snail (*Pomacea canaliculata*): originates from Southern America and were imported into Viet Nam before 1975 at first just as some couples to put in concrete tanks. Then it has been imported through different ways as a kind of food for people and livestock. Golden apple snail (GAS) have introduced Vietnamese agricultural fields and have been being supported by suitable ecological conditions, they have rapidly developed and become a plague causing harmful impacts to many plants, especially rice and spinach. According to the report from Department of Plant Protection (December 26 2006), 242.663 hectares is infected with GAS, in which 242.663 ha hectares is infected with high density. This is dangerous specie to agricultural plants and their productivity and consuming a large expenditure for elimination.
- Snails (*Achatina fulica*): Its origin was from Africa and exotic inland snail intruded Vietnam since 1960s. Nowadays, they already become harmful species to inland plants (vegetables, bean, and banana) from delta to mountainous areas.
- Water Hyacinth (*Eichhornia crassipes*): *E. crassipes* was introduced from Japan in 1902 for ornamental reasons. It has now spread to most freshwater systems in Vietnam. It covers water surfaces and lowers dissolved oxygen levels as it decays, consequently killing many fish, blocking river traffic, slowing water currents in reservoirs and thus reducing power generation ability and irrigation potential, and increasing maintenance costs.
- Lantana (*Lantana camara*): *L. camara* was introduced to Vietnam at the beginning of the 19th Century for ornamental reasons, and is now planted throughout Vietnam. IUCN (2003) warned that this plant was a potentially serious invasive.
- Nutria (*Myocastor coypus*): was imported widely to Vietnam at the end of the 19th Century as an alternative livestock species, raising income for farmers. This is a rodent animal which destroy agricultural plant. Therefore, they were timely confiscated and destroyed, but this species is now eradicated.
- White butterfish (*Piaractus mesopotamicus*): it was imported from Southern America in 1997. Researches show that white butterfish is capable to biologically improve environment, especially in wastewater area and ponds in VAC system because white butterfish is multi-food eater and they consume well the waste of husbandry and food's leftovers. White butterfish has very sharp teeth and when starves, it even chews fin of other fish species such as tilapia
- White-leg prawn (*Litopenaeus vannamei*): The species is a newly imported species into Vietnam from the United States since 2000. White-legged prawn is a plague transmitter with a high possibility, especially white-dot disease found in larva.
- Ty ba fish (*Hypostomus punctatus*): has been imported in Viet Nam for ornament purpose since 1970 and they presently have been found natural water areas. Ty Ba fish is a multi-food eater which competes with native species to habitat and food.
- Red-eared turtle (*Trachemys scripta*): has been introduced in Viet Nam for ornament purpose and escaped to natural water area, they have made rapid development, drastically competed against native turtle species, and caused harmful impacts to water ecosystems, especially to bio diversity.
- Coconut-leaf eating insect (*Brontispa longissima*): has been found in Ben Tre province, Me Kong River Delta in 1999. They caused serious losses of coconut productivity and output; and reduced economic values of other plants which belong to areca-coconut family and cycad family. The government had paid millions of VND for raising a public awareness and eliminating in the localities.

- Pine caterpillar (*Dendromilus punstatus* walker): intruded Viet Nam since 1950s and created significant plagues to pine forests in Quang Ninh and Ha Bac provinces. Nowadays, they have spread to Northern provinces of the Central Region causing a significant loss for pine forests and are showing threats to other provinces. Prevention and elimination of pine caterpillar are facing difficulties in Vietnam.

4. Management of IAS

In Vietnam, *Mimosa pigra* causes serious problems in many National Parks and Protected Areas. Therefore, eradication methods have been applied to control *Mimosa pigra*. The fisrt method ever applied is chopping down the tree. However, the effectiveness of this method doesn't last long due to the ability of *Mimosa pigra* to regenerate from stumps and to germinate from the seed. The other physical method for eradicating the *Mimosa pigra* is burning the tree with little effect. Other recommendation is to put up the saplings (Nguyen Hong Son *et al.* 2007).

In national parks and protected areas, it recommends to plan native weed to cover the land and compete with *Mimosa pigra* (Nguyen Hong Son *et al.* 2007).

The chemical method such as Glyphosate, Metsulfuron Methyl, Oxadiazon and Alachlor also is applied to eradicate the *Mimosa pigra*.

Biological control is also applied for eradication of *Mimosa pigra* from 1995-1997. The bioagents include *Acanthoscelides quadridentatus, A. puniceus, Carmenta mimosa* and *Phlocospora mimosae-pigrae*. However, after completion of the project, there is no monitor the effect of *Carmenta mimosa* on *Mimosa pigra*.

5. Concluding remarks.

- Scientific studies on IAS in Vietnam are insufficient, especially in-depth studies. Most research are conducted singly, focus on a few specific species. Therefore, comprehensive and baseline studies on IAS in Vietnam are still lacking, making analysis and prediction unreliable. In addition, studies on eradication programs are mostly in small scale or experimental conditions but not in actual and natural conditions, rendering application of such methods at the national scale impractical.
- The capacity of the authorities is still limited in many aspects, including knowledge and skills. The number of authorities responsible for conduction research is low and is mostly responsive to the problem of IAS, i.e. lacking in-depth training on IAS.
- Risk Analysis and mangagement of IAS in Vietnam hasn't been studied yet.

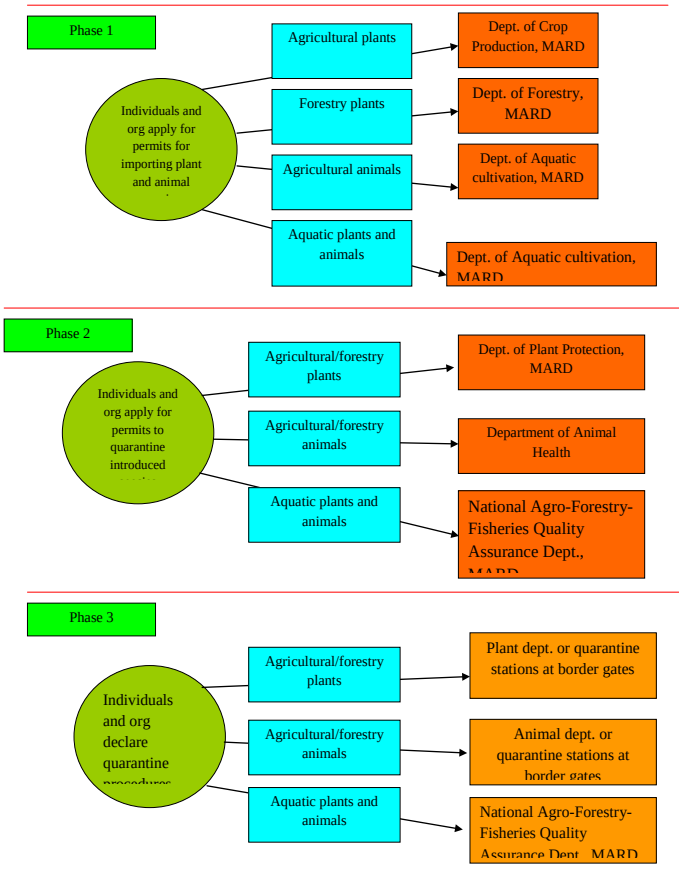

Figure 1. Procedure to quarantine and issue permits for importing new plant and animal species to Vietnam

Appendix F1 : Workshop 1 Summary of General and Risk Analysis Process Gaps

A. General

Group 1	Group 2	Group 3	Group 4
• Landuse planning does not clearly define where different activities can take place i.e. commercial forestry vs conservation areas especially outside national parks • Different perspectives of different government departments on IAS as a priority and how to manage them • Can we have an ASEAN declaration on IAS and how to manage them at the regional level? • How do we manage differences within and between country borders for different biogeographic regions. • Borders between commercial forests, conservation forests and botanical garden: how to physically separate them • Inadequate capacity building for applied research to tackle IAS management in forest • Resources needed to fund projects for risk assessment and IAS management in forests and environmental • Resources not available to support IAS because high level priorities are different from local priorities	• Lack of list of common and priority IAPS species for all countries • Lack of adequate knowledge on current practices, policies, legislations, practices on IAS in each country • Lack of collaboration with each country on implementation of plant quarantine regulations	• No National IAS Coordinating Body that will lead in the management of IAS • IAS issues are not integrated yet into the legislative, plannning and management processes in all relevant government sectors • Lack of cooperation of other concerned Agencies on law enforcement on IAS • Lack of cordination mechanism at the national level • Invasiveness of exotic species is not being addressed in existing pra • Policies are in place but implementation need to be strengthened • Not strict on the implementation on transfering species from one area to another within and across countries • Lack of national list of IAS • Inadequate competency of quarantine personnel at every entry points/ borders in identifying species • Lack of expert on the field of IAS • Lack of IAS identification tools • Different methods on identification between neighboring countries • Lack of information materials on IAS for public education • IAS is not included in school/University curricula • Confusion on terminologies between Risk asseesment and Risk Management	• IAS not Government priority • No unified guidelines on how to identify invasive species • Lack of regulation in IAS risk assessment • IAS Policy not comprehensive (ex. *Acacia mangium*) • Too many policies and some are overlapping • No post border management (mitigating measures in case the spp become invasive • Inconsistency in functional responsibility • Too many agencies involved in risk assessment • Vested interest of the sectors concerned • Not clear what methods/ processes to follow, e.g FAO- PRA, WRA. IRA • Impact not clearly to assess • Government dictates what policy to follow • Lack of measures that can convince stakeholders (government and private sector) to adopt certain policy to reduce IAS impacts • Too many concepts • Concepts not clear

B. Risk Analysis Process Gaps

a. Goal Setting/Hazard Identification

Group 1	Group 2	Group 3	Group 4
• Need better data bases at the national and regional level – how to manage the information around political sensitivities around national conformation to international agreements • Need more regional plan for managing IAS as very few exist (only on NP in Indonesia) • Border management of IAS transport in land locked countries • Capacity and knowledge to understand what is invasive and what is not • Conflict species – how to categorise impacts in different contexts • National level strategy for managing invasive species needed and should be widely publicised • Regional, national and local mapping of the distributions of IAS.	• Lack of coordination among countries for early detection • Making sure all countries have common standards particularly on plant quarantine • Understanding of existing methods within and among countries in the region • How countries adopt current methods that are available • Understanding of Australian RA and RM methods if it is possible for all countries to adopt or modify • Sharing of data and information for the IAPS • Inadequate capacity building - personal development of staff • Establishing networks, within country, within region, global • Lack of published information and databases for scientists and general public, including accessibility • Coordination of country action plans for regional action	• Lack of Taxonomic Information on IAS • Lack of information materials on IAS for public education	• Who should lead this activity? • Conflict of interest? • Inadequate Capacity • Lack of proper coordination • Recognition of indigenous knowledge and value

b. Risk Assessment

Group 1	Group 2	Group 3	Group 4
• Lack of capacity to test outcomes of the risk assessment whether species are invasive or not • Need more post- border risk assessment to decide which species are invasive and which are not.	• Lack of List of common and priority FIAPS for all countries • Pathways of introduction • Understanding more of the Australian RA method if it is possible and can be modified for all countries	• Lack of researches on IAS specially on their potential impact on ecosystem	• No risk assessment method for IAS for developing countries • Lack of technical capacity to implement IAS risk assessment in the field/local government (at all levels) • Capacity to assess risk for bio-control • Lack of warning system or rapid response and early detection system

c. Risk Management

Group 1	Group 2	Group 3	Group 4
• Regulations for IAS differ between forests and native woodlands and this management hard – Native forests IAS not allowed and will be penalised – Commercial has no regulations just voluntary codes. Acacia forests and oil Palm. Green wood standard is to not plant but planting of IAS still happens • Problem with planting naturalised and deliberately introduced alien tree plantations for commercial wood – teak • Department of agriculture only regulates against pests and diseases not IAS so public does not know what not to use/plant • Nursery industry still not regulated on what plants they can sell or people can grow so IAS are still being encouraged • Not enough disincentives to plant IAS where profits from growing them are still significant • Enforcement of regulations when not always a priority area for management	• Identification of suitable method for prevention, control and eradication of IAFPS for each country • Determine who does what and the funding sources • Integrated culture of biosecurity in IAFPS management	• No enough technology • Not enough budget	• Lack of financial resources • No clear cut policy on roles/responsibilities of stakeholders (who should control/ eradication once identified) • Lack of decision making process • Lack of coordination among stakeholders: who decide, source of resources, who prioritize, who implement, international cooperation (countries not willing to share information) • Lack of measures/ methods on how to manage/control IAS • Lack of rapid response system

d. Risk Communication

Group 1	Group 2	Group 3	Group 4

• Knowledge sharing from international expertise on how to manage IAS in different ASEAN countries to improve general national capacity in each country.
• Poor understanding of IAS
• Better links between research knowledge and policy makers for better policy development
• How to engage different public stakeholders to integrate knowledge for managing IAS in forests
• Public awareness to understand the impacts of IAS
• Basic knowledge on IAS for local people and commercial growers – which species is good and which is bad
	• Inform ministers of ASEAN committee i.e. AWGNCB ASEAN Working Group for Nature Conservation and Biodiversity
	• More Communication and education with:
	  • the general public
	  • scientific communities
	  • Stakeholders e.g. NGOs, diff government departments, private sectors (companies involve in trade of exotic plants)
	  • International organizations (e.g., IUCN, UN, ACB, etc)
		• lack of awareness on IAS by all stakeholders
		• Lack of information materials on IAS for public education
			• Inadequate system to create awareness or to disseminate information of IAS
			• Lacks of IEC materials (school, universities, communities and in tri media)
			• Lack of involvement of local communities and other stakeholders in IAS management
			• Need to conduct appropriate research on IAS (follow up and further investigation) for advocacy

Appendix F2 : Summary of Workshop 2 Outputs on Proposed Solutions to Gaps in Risk Analysis

Gaps	Proposed Solutions	Agency(ies) Responsible	Resources Needed
Group 2			
Lack of a common and priority IAPS species list (GG)	Form an IAS task force or coordinating body that would Identify and disseminate common and priority IAPS species list	Relevant government agencies e.g. Biodiversity Conservation Agency (Viet Nam); Royal Forestry Department (Thailand); Min of Forestry and Environment (Indonesia); research institutions; academic institutions; IAS experts	IAS Data and information; subject matter experts; funding support
Lack of/ Fragmented policies and legislations (GG)	Make an inventory of existing policies and legislations in the region related to IAS; introduce an international agreement reflecting the current legislations of each country	Relevant government agencies; national IAS Task Force	Subject matter experts; Funding support
Lack of collaboration with each country on implementation of plant quarantine regulations (GG)	Create a plant quarantine experts working group – intra-country and intra-region	Relevant government agencies ; Plant quarantine experts working groups	Subject matter experts; Funding support
Lack of: • Coordination among countries for early detection • common standards particularly on plant quarantine; • Sharing of data and information for the IAPS	• Establish and strengthen linkages among country IAS task forces; disseminate country policies and regulations • Conduct dialogues/ meetings to review and agree to develop standardized methods for RA; • Coordinate country action plans for regional action	Relevant government agencies e.g. Biodiversity Conservation Agency (Viet Nam); RFD (Thailand) Min of Forestry and Environment (IND); Country IAS Task Forces , relevant International organizations	Subject matter experts; copies of policies and regulations; Funding support
Inconsistent and inadequate capacity building	Organize appropriate Capacity building activities on a sustainable manner	Management agencies e.g. Biodiversity Conservation Agency (Viet Nam); RFD (Thailand) Min of Forestry and Environment (IND); Working Groups; Regional and international organizations	Subject matter experts; Funding support
Inconsistent/different risk assessment methods in each country (RAG/ Understanding of existing methods within and across countries in the region;	Adopt standard methods for the region	Management agencies e.g. Biodiversity Conservation Agency (Viet Nam); RFD (Thailand) Min of Forestry and Environment (IND); Working Groups; Regional and international organizations	Subject matter experts; Funding support
Lack of awareness and appreciation of invasive alien species (RAG/GS)	Increase awareness in schools and mass and social media	Government agencies; NGOs; Private Organizations	Funding and Communication experts

Gaps	Proposed Solutions	Agency(ies) Responsible	Resources Needed
Group 3			
1. No National IAS Coordinating Body that will lead in the management of IAS (GG)	Form a National IAS Coordinating Body	Relevant government and research Institutions	Subject matter specialists from various relevant disciplines Funding/Budget
2. Lack of coordination mechanism at the national level (GG)	Institutionalize NISSAP implementation with all concerned Agencies	All concerned institutions in the country	Funding
3. Lack of National List of IAS (GG)	Develop a national database on IAS	Ministry/Department of Agriculture and/or Environment Academic institutions Museum of Natural History	Database on IAS (CABI, GISP, EPPO) Publications
4. Inadequate competency of quarantine personnel at every entry point/ border in identifying species (GG)	Conduct capacity building activities e.g., on general identification; taxonomy of plant systematic; control and management, etc.	ACB Training Center SEAMEO Biotrop	Great taxonomists, funding; IAS Risk assessment experts
5. Lack of IAS identification tools (GG)	Develop IAS identification guides (with photos, descriptions of species, country of origin, etc.)	Ministry/Department of Agriculture, Environment, Forestry, Quarantine	Funding Quality Photos and information
6. Lack of information materials on IAS for public education (GG, GS, RC) IAS is not included in school/university curricula (GG)	Conduct communication campaigns in collaboration with the Ministry/ Department of Education and media outfits	Ministry/Department of Agriculture, Environment and Education, Media, universities, NGOs	Proposal Consultant/Expertise Funding

Gaps	Proposed Solutions	Agency(ies) Responsible	Resources Needed
Group 4			
1. IAS is not a Government priority	- Convince Government with Policy Brief, concrete research, impact scenario if action not taken	- Focal agency for CBD,	Expert on impact assessment and modeling, policy development
2. No unified guidelines on how to identify invasive species (GG) 3. Lack of regulation in risk assessment (GG) 4. Policy not comprehensive (ex. Acacia mangium) (GG) 5. Too many policies and some are overlapping (GG) 6. Inconsistency in functional responsibilities of government agencies (GG) 7. Too many agencies involved in risk assessment (GG) 8. Government dictates what policy to follow (GG) 9. Lack of measures that can convince stakeholders (government and private sector to adopt certain policy to reduce IAS impacts	Review existing policies, laws, regulations, guidelines and other legal instruments Harmonize legal instruments with present realities on IAS Define the roles and responsibilities of each agency/stakeholders Develop a new policy, if necessary, that is acceptable and workable	- Focal agency for CBD as a lead agency with the concerned stakeholders	Financial and technical with different expertise on coordination, socio-economic, botanist, ecologist, geologist, forestry, etc
10. Lack of coordination among stakeholders: who decide? Source of resources? Who prioritize? Who implement? (RAG/RM)	Conduct meeting/workshop among concerned agencies and stakeholders to have agreement		
11. Not clear what method/ processes to follow, e.g., FAO- PRA, WRA. IRA (GG) 12. Inadequate capacity building on risk assessment and management (RAG/GS)			

Appendix G : Members of Organizing Team

A. From BIOTROP

1. Dr. Jess C. Fernandez
2. Dr. Sri Sudarmiyati
3. Dr. Sukisman Tjitrosoedirdjo
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6. Mr. Harry Imantho and Knowledge Management Department staff
7. Mr. Tajudin and Finance Department staff
8. Mr. Asep Syaefudin and Facilities Management Department staff
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B. From FAO

10. Mr. Kenichi Shono
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