

APFISN Workshop on Habitat and species specific protocols for management of forest invasive species in the Asia- Pacific region

23-27 October 2017, Colombo, Sri Lanka



APFISN workshop on 'habitat and species specific protocols for management of forest invasive species (FIS) in the Asia-Pacific region' was held at room Tulip of Bandaranaike Memorial International Conference Hall, Colombo, from 23rd to 27th of October 2017. The workshop focused on species-specific and habitat-specific protocols for the management of FIS, Dissemination of these protocols among researchers and forest managers, promote data exchange and collaboration between member countries and discuss new strategies of APFISN. Workshop was great with the august presence of Mr Kenichi Shono (FAO RAP, Thailand), Dr Shiroma Sathyapala (FAO RAP, Italy), Dr NDR Weerawardana (Forest Dept., Sri Lanka), Dr T V Sajeev (APFISN Coordinator), and representatives of different countries. 17 delegates from different nations in the Asia-Pacific region have shared their experience, views and suggestions on the topic. The entire workshop has of five scientific sections with the last session on special emphasized on protocols for managing FIS in Sri Lanka. The more details of APFISN workshop at Colombo, as follows -

Workshop Programme

Monday 23 October 2017		
0830 - 0845	Informal meet and greet	
0845 - 0920	Formal workshop opens	
0845-0855	Welcome address by Sri Lankan focal point	Weerawardana or Head of Forestry, Sri Lanka or any appropriate
0855-0905	Welcome address by FAO	Kenichi Shono
0905-0920	Overview of key work on forest invasive species in the region	Shiroma Sathyapala
0920 – 0950 Session 1. Protocols for managing Invaded forest landscapes		
0920 - 0930	Chairperson	AnzarKhuroo (India)
0930 - 0940	Speaker 1	Sujanapal P (India)
0940 - 0950	Speaker 2	Lee Su See (Malaysia)
0950 - 1000	Speaker 3	S H Bandumala (Sri Lanka)
1000 - 1015	Group Discussion	All participants
1015 – 1030	Coffee Break	
1030 - 1200 Session 2. Protocols for managing Invasive flora in the forests of Asia-Pacific		
1030 – 1040	Chairperson	T V Sajeev (India)
1040 – 1050	Speaker 1	A S Raghubanshi (India)
1050 – 1100	Speaker 2	TK Hrideek (India)
1100 - 1110	Speaker 3	Wai Wai Than (Myanmar)
1110 - 1120	Speaker 4	Al Amin (Bangladesh)
1120 - 1200	Group Discussion	All participants

1330 - 1410	Session 3. Protocols for managing Invasive insects and microbes	
1330 - 1340	Chair person	Lee Su See (Malaysia)
1340 - 1350	Speaker 1	Pham Quang Thu (Vietnam)
1350 - 1400	Speaker 2	Ali Amir (Maldives)
1400 - 1410	Speaker 3	Sri Rahayu (Indonesia)
1410 - 1500	Group Discussion	All participants
1500 - 1530	Coffee Break	
1530 - 1700	Session 4. Introduction to the forthcoming forest health Guide; Classical biological control of insect pests in forestry and Needs Assessment Shiroma Sathyapala / Carl Rankin	
1700	Wrap up of the workshop	
Wednesday 25 October		
15.30 – 16.30	Session 5. Protocols for managing IAS in Sri Lanka	
1630 - 1540	Chairperson	Buddhi Marambe (Sri Lanka)
1540 - 1550	Speaker 1	Siril Wijesundera (Sri Lanka)
1550 - 1600	Speaker 2	Pradeepa Silva (Sri Lanka)
1600 - 1610	Speaker 3	Devaka Weerakoon (Sri Lanka)
1610 - 1620	Speaker 4	Jagath Gunawardena (Sri Lanka)
1620 - 1630	Group Discussion	All participants
16.20-16.30	Session 6. Concluding Session	
Chair: Shiroma Sathyapala or TV Sajeev or Gary Man		
16.30-17.30	New Strategies for APFISN Work plan for 2018-2019	

1730	Wrap up of the workshop
Friday 27 October - Executive team meeting	

Session 1. Protocols for Managing Invaded Forest Landscapes

The initial session was chaired by Dr Anzar A Khuroo from India and Dr P Sujanalpal(India), Dr Lee Su See(Malaysia) and Dr S H Bandumala (Sri Lanka) have done a small presentation on this topic. The key points of their presentation as follows -

Dr Anzar A Khuroo(Chairperson)

In presentation entitled as “**Managing invaded forest landscapes: Problem, Progress and Prospects**”, Dr Anzar A Khuroo focused on the contributions of an anthropocentric society towards the process of biological invasion. Dr Khuroo’s presentation progressed through three distinct and related sub topics.

In the initial part, he explained the real problem of biological invasion with current and relevant examples. He pointed out that all things on earth are controlled by a single supreme power i.e. Humans, and the biological invasion rate increasing in an alarming pace. The common invaded species include Plants, Animals, Microbes, Fungi and Oomycetes and a large percentage of natural forests in the Asia-Pacific region are occupied by invasive species.

Then he smoothly entered into the next part of his presentation i.e. progress achieved in the field of biological invasion management. He explained various physical, chemical and biological control measures and main pathways of introduction of invasive species. He also suggested a ‘3P’ – Prediction, Prevention and Prescription-management protocol for the eradication of invasive species.

Towards the end of his presentation, he emphasized on the future prospects of biological invasion. He pointed out the importance of land scape approach of biological invasion management, regulation of introduction pathways, Alien biota-centric approach, Interdisciplinary collaboration, Global and regional information network and Public participation. He concluded his presentation with an opinion that humans are very critical in the management of Forest Invasive Species.

Dr P Sujanalpal (Speaker 1)

In presentation entitled as “**Management of Invasive alien plants in Moist Deciduous Forest of Western Ghats, India**”, Dr P Sujanalpal focused mainly on the Moist Deciduous Forest system related invasions. Introductory part was filled with immense knowledge regarding Western Ghats of India-

Phytogeography, Topography and Vegetation, Features of Moist Deciduous Forests (MDF)-general patterns, threats and nearby plantations and related problems.

Then Dr Sujanapal, discussed about major invasive plants of MDF, which are classified into high risk, medium risk and low risk plant category. 8 plants have been classified as high risk category - *Mikania micrantha* Kunth, *Chromolaena odorata* (L.) King & Robins, *Lantana camara* L., *Mimosa diplotricha* C. Wight ex Sanvalle, *Senna spectabilis* (DC.) H.S.Irwin & Barneby, *Pteridium aquilinum* (L.) Kuhn, *Pueraria phaseoloides* (Roxb.) Benth, *Mucuna bracteata* DC. ex Kurz and *Sphagneticola trilobata* (L.) Pruski. 12 plants have been classified as medium risk plants - *Ageratina adenophora*, *Hyptis capitata*, *Hyptis suaveolens*, *Leucaena leucocephala*, *Merremia vitifolia*, *Parthenium hysterophorus*, *Passiflora foetida*, *Pennisetum pedicellatum*, *Racosperma auriculiforme*, *Ricinus communis*, *Senna hirsute* and *Senna tora*. 14 plants have been classified as low risk plants - *Ageratum conyzoides*, *Alternanthera brasiliana*, *Amaranthus spinosus*, *Centrosema molle*, *Mimosa pudica*, *Senna occidentalis*, *Senna siamea*, *Sesbania grandiflora*, *Stylosanthes fruticosa*, *Alternanthera bettzickiana*, *Asclepias curassavica*, *Croton bonplandianus*, *Syndrella nodiflora* and *Tridax procumbens*. Dr Sujanapal also mentioned the pattern of invasion, its establishment and spread.

Towards the end of the presentation, Dr Sujanapal provided a detailed account on management of invasive plants reported from MDF of Western Ghats of India. Some of his suggestions include restrict the movement of infected soil and plant parts to uninfected areas, tourist destinations inside MDF should be under constant surveillance, plantations activities should be thoroughly monitored, adopt restoration policies by planting fast growing native species, effective measures against forest fire, implement control measures prior to flowering and fruiting, forest gaps should be under frequent surveillance, enrich the soil seed bank of native species in infested areas, implement site specific habitat management plan etc. Before concluding the presentation, Dr Sujanapal mentioned some experiments conducted in Teak plantations with in Moist Deciduous Forests.

Dr Lee Su See (Speaker 2)

In the presentation entitled as “**Invaded forest landscapes: *Ceratocystis* in Malaysian forest plantations**”, Dr Lee Su See focused on the impacts posed by an invasive fungus called *Ceratocystis* and its management in Malaysia. In the introductory section, Dr Su See made familiarized the audience with different invasive alien species of Malaysia such as *Acacia confuse*, *Cercropia peltata* (Trumpet tree/Snakewood), *Clidemia hirta* (Koster’s curse), *Chromolaena odorata* (Siam weed), *Candidatus liberobacter asiaticum* (citrus greening disease), *Erwinia papayae* (Papaya dieback), *Mimosa pigra*, *Spodoptera exigua* (Beet armyworm), *Rottboellia cochinchinensis* (Itch grass), Papaya Ringspot Virus, *Pomacea canaliculata* (Golden Apple Snail), *Pomacea insularum* (Black Apple Snail), *Striga asiatica*, *Ceratocystis spp.*, *Leptocybe invasa* (native to Queensland, Australia), *Ophelimus maskelli* (native to Australia), *Puccinia psidii* (native to Brazil)etc.

During the presentation, Dr Su See mentioned two species of *Ceratocystis* fungus – *C.fimbriata* and *C.manginecans* – which is a soil borne and widely distributed fungus, considered as Brazilian origin. It produces different types of spores like ascospores, conidia and thick-walled aleuroconidia and easily

dispersed by insects, wind etc. The major threatened plant host species are *Acacia mangium*, *Eucalyptus pellita*, *Hevea brasiliensis* and a hybrid variety of *Acacia*. The invasive fungi enter in to the host through the wounds or cuts on the stem, branch or roots of the plant.

Finally, Dr Su See explained the different levels of IAS management in Malaysia, rules implemented by the Government of Malaysia towards IAS Management, special management methods taken against the fungus *Ceratocystis* and the major hurdles faced by IAS management. Before concluding the presentation, Dr Su See raise a question against the practical logic of habitat specific protocols for the management of invasive pathogens and insect pests.

Dr S H Bandumala (Speaker 3)

In presentation entitled as “**Management of Forest invasive species in Sri Lanka**”, Dr S H Bandumala focused on four major forest invasive plants of Sri Lanka and its management practices. Presentation includes the type study of *Lantana camara*, *Miconia calvescens*, *Alstonia macrophylla* and *Oclandra stridula*.

L. camara has introduced in to Sri Lanka as an ornamental plant and presently invaded in almost all national parks of Sri Lanka. Spread of *Lantana* via seeds, suckers, stem cuttings etc. and generate impacts on biodiversity and wild life. *Lantana* control measures include ploughing, grubbing, brush cutting, hand pulling etc. *Miconia calvescens*, a woody shrub- has introduced as an ornamental plant, presently distributed in sub and lower montane zone forests. Spread of *Miconia* by seeds and root stocks and various biotic and abiotic agents’ help for the dispersal. It adversely affects the survival of native plants. Hand pulling, digging, debarking and cutting are the major control measures of *Miconia*. *Alstonia macrophylla* has introduced as a timber yielding plant and as a good choice for reforestation. It presently distributed in lowland and sub-montane areas of wet zone. Its light weighed and hairy seeds made its spread very fast. *Alstonia* invasion impact on biodiversity and survival of native species. Hand pulling, digging, de barking and basal cutting are the major management methods of *Alstonia*. *Oclandra stridula* is an aggressive reed bamboo species common in wet zone of Sri Lanka. *Oclandra* invasion resulted in ecological and economic impacts. Hand pulling, digging, trapping and basal cutting are the major control measures of *Oclandra* invasion.

After the treatment, the land show two type responses – regeneration of native flora and secondary invasion of *Dillenia suffruticosa* and *Alstonia macrophylla*. Before concluding the presentation, Dr Bandumala explained some restoration methods and significance of continuous monitoring.

Session 2. Protocols for Managing Invasive Flora in the Forests of Asia-Pacific

The second session was chaired by Dr T V Sajeev from India and Dr A S Raghubanshi (India), Dr T K Hrideek (India), Ms. Wai Wai Than (Myanmar) and Dr M Al Amin (Bangladesh) have done a small presentation on this topic. The key points of their presentation as follows -

Dr A S Raghubanshi (Speaker 1)

In the presentation entitled as “***Lantana camara Ecology and Management in Forested Landscapes***”, Dr A S Raghubanshi provided a detailed account on various aspects of *Lantana* invasion. The introductory part dealt with the distribution and invasive traits of *Lantana*, followed by the impacts of its invasion. *Lantana* widely distributed in Australia, India and South Africa and its invasive traits include sexual and asexual mode of reproduction, ability to out compete native plants, continuous production of viable seeds throughout the year etc. Loss of biodiversity, decreased rate of food availability, decreased survival rate of tree seedlings, altered soil qualities etc. are enlisted as the impacts of *Lantana* invasion.

Dr Raghubanshi continued his presentation with an elaborative note on the control measures of *Lantana*. He categorized the methods in following titles-Manual control methods (hand grubbing, hand pulling and hand cutting), Mechanical control methods (slashing, pushing or stick raking, mechanical grubbing, chain pulling and ploughing), use of fire, Chemical control methods (Foliar spray of Glyphosate, Fluroxypyr + Aminopyralid mixture, Fluroxypyr or Glyphosate + Metsulfuron methyl mixture and Low volume herbicide applications), Biological control methods (Use of biocontrol agents such as leaf mining beetles-*Uroplatagirardi* and *Octotoma scabripennis*, leaf sap sucking bug-*Teleonemia scrupulosa* and *Lantana* seed fly *Ophiomyia lantanae*) and a novel idea of control through Utilization (antimicrobial, insecticidal, insect repellent, herbicidal and antioxidant chemical, natural dye, herbal medicine, polymer composite board, fuel stock or charcoal, vermicompost or mulch, craft & furniture material, Thatching & fencing material etc.).

Towards the end of his presentation, Dr Raghubanshi narrated a success story of *Lantana camara* management reported from India through a method called CRS method i.e. Cut Root – Stock method. This method is based on the fact that cutting the root exactly below the transition zone eliminates the reproductive ability of the plant. The process involves making a small cut on main tap root 3-5 cm below the ground surface, lift the clump and place it upside down for drying and burn the dried clumps. Before concluding, Dr Raghubanshi suggested an integrated approach of *Lantana* management which is considered to be the most effective mode of control.

Dr T K Hrideek (Speaker 2)

In presentation entitled as “**Protocols for managing tree invasion: case studies in *Senna spectabilis*, *Maesopsis eminii* and *Acacia mearnsii***”, Dr T K Hrideek focused on the type study of three major invasive plants of Kerala. Dr Hrideek started his presentation with *Senna spectabilis* (DC) H.S.Irwin and Barney, an invasive tree. *Senna* introduced as an avenue tree, with yellow showy flowers. It has an allelopathic effect and good coppicing ability. Major invasion of *Senna* reported from Wayanad district if Kerala. *Senna* posing a threat to indigenous plants and wildlife, resulted in increased rate of man-animal conflict. Effective management protocols of *Senna* include cut stump treatment, removing or pull out by excavator and debarking.

Then Dr Hrideek entered into *Maesopsis eminii* Engl, an invasive tree species reported from Nilgiri biosphere reserve. *Maesopsis* introduced as a shade tree in plantations. It has very high seed

germination rate and this ability increases the invasiveness of this species. Effective management protocols of *Maesopsis* include cut stump treatment, debarking and hand pulling.

Towards the last phase of presentation, Dr Hrideek explained the case study of Acacia plant. *Acacia mearnsii* De Wild, an invasive tree species reported from the shola forests of Kerala. It has an allelopathic effect and high coppicing ability. The major management measures of Acacia include debarking, ring barking, cut up to 50 cm above the ground, drill fill and uprooting seedlings.

Ms. Wai WaiThan(Speaker 3)

In the presentation entitled as **“Mealy bug attack on introduced species Rain Tree (*Albizia saman* (Jacq.) F.Muell.) and control in Myanmar”**, Ms Wai WaiThan focused on the impacts caused by the Rain tree and its management. During the introductory part Ms Than explained about the native species *Albizia lebbek* (L.) Benth.and introduced rain tree species *A.saman* (Jacq.)F.Muell. *A.saman*, native of Central and South America, belongs to the family Mimosaceae and introduced into Hawaii and South East Asia as a shade providing avenue tree.

After the introductory part, Ms Than swiftly pierced into the details of pathogenic attack towards rain tree. The major pathogen of rain tree is an invasive insect called Mealy bug (*Paracoccus marginatus* Williams and Granara de Willink) belongs to the family Pseudococcidae and its infestation rate is very high during dry season. The insect accumulation is more on the leaves and leaf petiolar regions and they feed on plant sap. During the initial stages of infection, the affected regions are covered with whitish and pinkish waxy wool and later on the plant parts filled with a sooty mould. The plant responses start with yellowing of leaves, defoliation, drying of branches and finally dieback. The real cause of pathogen infestation pinpointed by Ms Than as follows – climate change, pollution, transportation and improper planting.

Towards the end of her presentation, Ms Than explained the two approaches applied against mealy bug in Myanmar. In first method, a mixture of 10 gallons of water and 100 cc of Neem oil are thoroughly mixed with a mixture of 6 gallons of water and 200 grams of detergent powder, and then it sprayed on the leaves using a pressure pump. During the second method, they made holes around the tree and filled with a mixture of diluted systemic insecticide (Fertera, Cyclone, Danadin or Chlorocyrifos) and diluted detergent. Major challenges they faced during insect management enlisted as large size of trees, extensive branching, thick canopy and public. Ms Than also advised to take attention regarding chances of air, soil and water pollution, meteorological conditions and impact on non-target organisms while handle with this approaches.

Dr M Al Amin (Speaker 4)

In presentation entitled as **“Educating professionals and sub professionals for managing invasive flora in Bangladesh”**, Dr M Al Amin focused on various aspects of biological invasion in Bangladesh context. Initially Dr Amin gave a brief introduction regarding socio-ecological status

of Bangladesh and its forest types. The remaining presentation was divided into four distinct phases.

In the initial phase, Dr Amin provided a detailed account on the invasive flora of Bangladesh. Major invasive plants reported from the country include *Ageratum conyzoides*, *Bidens pilosa*, *Caesalpinia decapetala*, *Chromolaena odorata*, *Cuscuta reflexa*, *Hedychium gardnerianum*, *Heitage benghalensis*, *Lantana camara*, *Ligustrum robustum*, *Mikania micrantha*, *Mimosa pudica*, *Parthenium hysterophorus*, *Prosopis juliflora*, *Saccharum spontaneum* etc. Dr Amin recommended for a reevaluation on invasive status of some plants such as *Casuarina equisetifolia*, *Dalbergia sissoo*, *Falcataria moluccana*, *Leucaena leucocephala*, *Melia azedarach* and *Spathodea campanulata*. Dr Amin also suggested some plants such as *Sphagneticola trilobata*, *Canna indica*, *Acacia auriculiformis*, *Ageratum conyzoides*, *Arundo domax* etc. to include in invasive plant list. In the next phase Dr Amin focused on the necessity of training forest officials about invasive organisms. Dr Amin also mentioned different methods and materials used for the training programs.

Third phase of Dr Amin's presentation dealt with the role of trans-boundary effects in invasion. At this point Dr Amin mentioned about the human invasion Bangladesh – Rohingya refugees – through Teknaf river port. Before concluding the presentation, Dr Amin explained various protocols IAS management such as afforestation and reforestation programs, alternate livelihoods to support forest communities and capacity development for forest resource planning and management.

Session 3. Protocols for Managing Invasive Insects and Microbes

The third session was chaired by Dr Lee Su See from Malaysia and Dr Pham Quang Thu (Vietnam), Mr Ali Amir (Maldives), and Dr Sri Rahayu (Indonesia) have done a small presentation on this topic. The key points of their presentation as follows -

Dr Lee Su See (Chairperson)

In the presentation entitled as “**Protocols for managing invasive insects and microbes**”, Dr Lee Su See focused on various aspects of insect and microbial invasion in the Asia Pacific region. As an introduction, Dr Su See presented a statistical analysis of damage caused by invasive species in the region. The major invasive pathogens and insects enlisted by Dr Su See as follows - *Liberibacter asiaticus* (Citrus greening) *Ralstonia solanacearum* (Southern bacterial wilt), *Puccinia psidii* (Guava rust), *Brontispa longissima* (Coconut hispine beetle), *Brontispa longissima* (Coconut hispine beetle), *Diaphorina citri* (Asian citrus psyllid), *Leptocybe invasa* (Blue gum chalcid), *Adoretus sinicus* (Chinese Rose Beetle), *Quadrastrictus*

erythrinae (Erythrina gall wasp), *Ophelimus maskelli* (Eucalypt gall wasp), *Heteropsylla cubana* (Leucaena psyllid), *Bactrocera cucurbitae* (Melon fruit fly), *Bactrocera tyroni* (Queensland fruit fly) etc.

Dr Su See also included some useful links which provide information on invasive insects and microbes, such as CABI Invasive species compendium <http://www.cabi.org/isc/>, INVASIVES Newsletter of APFISN <http://www.fao.org/asiapacific/resources/newsletter/invasives/en/>, Invasive species in Australia <http://www.environment.gov.au/biodiversity/invasive-species/publications/factsheet-invasive-species-australia>, US Forest Service Invasive Species Program <https://www.fs.fed.us/invasivespecies/> and USDA National Invasive Species Information Centre <https://www.invasivespeciesinfo.gov/index.shtml>. Dr Su See also mentioned the management of *Brontispa longissima* (Coconut hispine beetle) as a success story from the region.

As the chairperson of the session, Dr Su See pointed out some key issues for developing protocols and expected outcomes from this discussion.

Dr Pham Quang Thu (Speaker 1)

In the presentation entitled as “**Protocols for managing invasive plant pathogens to plantation forests in South East Asia**”, Dr Pham Quang Thu focused on the pathogens of *Acacia* and *Eucalyptus* plantations of South East Asia (SE Asia). The entire presentation is structured into five parts. Initial part pictured the present scenario of plantation forests in region. SE Asia’s forests constitute 29 percent of the total forests of Asia Pacific region. Among the 29 percent, 4.3 million ha occupied by *Eucalyptus* and 2.5 million occupied by *Acacia* plantations. Plantations are mostly monocultures, sometimes integrated with agriculture, productivity range is broad and managing short term rotation for pulp wood and long term rotation for furniture.

Major pathogen threat to *Acacia* plantations include Phyllode rust disease by *Atelocauda digitata*, Pink disease by *Corticium salmonicolor*, Ceratocystis wilt disease, Heart rot disease, Basidiomycete root rot disease, Phytophthora disease, Powdery mildew disease etc. Major plantation threat to *Eucalyptus* plantations include Guava rust caused by *Puccinia psidii*, leaf diseases caused by *Cylindrocladium* spp., *Teratosphaeria destructans*, and *Cryptosporiopsis eucalypti* and Bacterial wilt disease caused by *Ralstonia solanacearum*.

Towards the end of presentation, Dr Thu pointed out the protocols for the disease management, such as improved quarantine measures, continuous monitoring, identification of new diseases, comprehensive risk analysis etc. Before concluding the section, Dr Thu again listed out important points of the presentation.

Mr Ali Amir (Speaker 2)

In presentation entitled as “**Forest invasive species and its management in the Republic of Maldives**”, Mr Ali Amir focused on present scenario of Invasive Species in Maldives. Mr Ali started his presentation with an over view of invasive species reported from his place. Around 50 diseases are caused by invasive

microorganisms, 53 invasive insects are reported and more than 60 percent of existing flora comprises exotic and invasive plant species.

Mr Ali categorized existing IAS of Maldives into 3 – Pest, weeds and naturalized trees. Invasive pest species include Gypsy moth (*Euproctis fraterna*), Coconut hispid beetle, Rhinoceros beetle, Bacteria causing citrus canker, Stem borer of Mango & breadfruit, Banana weevil borer, psyllid insect of Water & rose apple and Spiraling whitefly of crop plants. Invasive weed species include Touch-me-not (*Mimosa pudica*), Lead tree (*Leucaena leucocephala*), *Wollastonia biflora* and *Cassytha filiformis*. Naturalized tree species are Red sandal wood (*Lingoum indicum*) and Golden shower (*Cassia fistula*).

Important pathways of IAS introduction to Maldives include import of agricultural commodities, timber, horticultural species, animals and animal products, organic manure and untreated packing materials. The major concern about IAS is because of its ability to lower agricultural productivity, impacts on economy, biodiversity and environment, human health hazards, increased degradation and fragmentation of natural habitats, highly threatened status of endemic species. Mr Ali concluded his presentation with some suggestions for IAS managements such as improved quarantine and inspection methods, continuous monitoring and surveillance methods, human resource development, training and awareness programs and a strategic action plan.

Dr Sri Rahayu (Speaker 3)

In presentation entitled as “**Protocols for managing invasive rust fungus as pathogen on Leguminosae in Indonesia**”, Dr Sri Rahayu concentrated to provide a detailed account on two species of gall forming fungus *Uromycladium*. Dr Rahayu started her presentation with gall formation by fungus. *U. tepperianum* follows demi cyclic life cycle and *U. falcatarium* follows micro cyclic life cycle. *Uromycladium* is considered as the most invasive fungi of Leguminosae members. Major members of Leguminosae threatened by this fungi include *Falcataria moluccana*, *Paraserianthes lapantha*, *Acacia decurrens*, *Caliandra calothyrsus* etc.

Fungi *Uromycladium* is widely distributed in South East Asia and reported as a biological control agent against *Acacia saligna*, a weed in South Africa. Pathogen enter into the host plant within 1 to 3 hours, gall formation takes place within 3 to 8 weeks and sporulation takes place after 3 to 7 days after gall formation. Meteorological factors related to gall rust disease include foggy condition, relative humidity and wind speed. Fog condition and relative humidity are directly proportional to disease incidence, at the same time wind speed lowers the rate of disease. Factors such as sunshine hours, rain fall, number of rain days and temperature have less significance on gall rust disease.

Towards the end of presentation, Dr Rahayu mentioned various methods of management such as prevention, control, sanitation and eradication in different levels. Prevention of disease in seed level include avoidance of infected and unhealthy seeds. Nursery level control methods include early detection, removal of infected seedlings, provide low humidity etc. Sanitation techniques include pruning, thinning, tar application, and regular and intense monitoring. Before concluding, Dr Rahayu pointed out some suggestions for a better management.

Session 4. Introduction to the forthcoming forest health Guide; Classical biological control of insect pests in forestry and needs assessment

Dr Shiroma Satyapala introduced the questionnaire to gather information on biological control operations in various member countries of the APFISN. The questionnaire was filled during the session and the discussion which ensued had narration of case studies from the participating countries.

Session 5. Protocols for Managing IAS in Sri Lanka

The fifth session was chaired by Dr Buddhi Marambe from Sri Lanka and Dr Siril Wijesundera (Sri Lanka), Dr Pradeepa Silva (Sri Lanka) and Dr Devaka Weerakoon (Sri Lanka) have done a small presentation on this topic. In absence of Adv. Jagath Gunawardena, Dr Buddhi presented a small presentation on legal aspects of biological invasion. The key points of their presentation as follows -

Dr Buddhi Marambe (Chairperson)

In presentation entitled as “**Strengthening the capacity to control invasive alien species – Sri Lankan experience**”, Dr Buddhi Marambe focused on the activities done by Sri Lankan officials. Introductory section dealt with the concept of biodiversity, biodiversity of Asia and biodiversity hotspots. Biodiversity is the variety or richness of life at all structural levels such as molecular/genetic, species and ecosystem. Asia comprises 8.6% of the world’s total land area, 61% of human population, 33% of threatened species, and 70% of world’s biodiversity. Out of 34 biodiversity hotspots, 11 are in Asia Pacific region. Then Dr Buddhi gave a brief description about Sri Lankan biodiversity.

In Asia, Sri Lanka has highest biodiversity per unit area and highest proportion of endemic species (98% of freshwater crabs, 85% of amphibians, 81% of land snails, 60% of reptiles, 55% of freshwater fish, 51% of Spiders, 28% of flowering plants and 17% of mammals). Tropical biodiversity of Sri Lanka is classified into native biodiversity and agro biodiversity. Dr Buddhi also mentioned the article 8 (h) of Convention on Biological Diversity (CBD; Rio 1992) regarding biological invasion. In his opinion, significance of IAS as a global problem is widely recognized and adverse effects are well described. The possible solutions against invasion is prevent the introduction of IAS In to new areas and prioritize management and control measures for already established areas. He also mentioned about some funded projects related to IAS done by Sri Lankan experts and its outcomes.

Towards the end of his presentation, Dr Buddhi has explained about IAS risk assessments in Sri Lanka. IAS risk assessment carried out in two levels – Pre and post entry risk assessments. Based on this assessments, IAS are categorized into Priority species, Potential species and Black listed species. Before concluding the presentation, Dr Buddhi described some management strategies of IAS such as pilot scale demonstration, Training and awareness programs etc. and future plans for the eradication of IAS.

Dr Siril Wijesundera (Speaker 1)

In presentation entitled as “**Habitat destruction by IAS flora**”, Dr Siril Wijesundera focused on Invasive Species Management. Dr Wijesundera started his presentation with the adverse effects of IAS such as ecological, economic, agricultural and social impacts. Later on he entered into a detailed account on various forest types such as riverine forest, dry evergreen forest, moist monsoon forest, lowland rain forest, lower montane forest, upper montane forest and mangroves, distributed in Sri Lanka.

Necessity of IAS management in forests is because biodiversity in forest should be conserved, some forest types are very unique and IAS cause serious habitat loss. IAS categorized on the basis of threat level, sensitiveness of the ecosystem and quantity of resources. 5 strategies of IAS management are prevent the introduction of new invasives, detect new invasives, eradicate new infestations, control and manage established invasions and restore degraded ecosystems.

Towards the end of presentation, Dr Wijesundera listed out the plants categorized under national priority list. This list was prepared on post entry risk assessment criteria, which is based on IAS distribution, impact and invasive attributes. Major plants included in this list are *Prosopis juliflora*, *Dillenia suffruticosa*, *Miconia calvescens*, *Clusiarosea*, *Cestrum aurantiacum*, *Mimosa pigra*, *Opuntia dillenii*, *Acacia nilotica* and *Ulex europaeus*. Before concluding the presentation Dr Wijesundera proposed some guidelines for the effective management of IAS. Guidelines include identify and list new IAS, continuous monitoring, information sharing, implementation of eradication programs in the early stages of invasion etc.

Dr Pradeepa Silva (Speaker 2)

In presentation entitled as “**Spread of IAS Fauna in Sri Lanka**”, Dr Pradeepa Silva focused on the faunal invasive species in Sri Lanka. Dr Silva started her presentation with a concept of Biodiversity as a wealth of Sri Lanka and its loss. Then she gave a brief idea regarding alien invasive fauna. A priority and potential lists of Sri Lankan invasive fauna has been made by using post entry risk assessment methods.

According to the priority list made during 2015-16, 5 fish species, 1 reptile species and 2 snail species are considered as more dangerous invasive animals reported from the country. They are *Oncorhynchus mykiss* (Rainbow trout), *Pterygoplichthys disjunctivus* (Vermiculated sailfin catfish), *Pterygoplichthys pardalis* (Amazon sailfin catfish), *Chitala ornate* (Clown knife fish), *Clarias batrachus* (Marble catfish), *Trachemys scripta* (Red ear slider), *Pomacea spp* (Apple snail) and *Lissachatina fulica* (Giant African land snail). Potential list include 6 fish species and 3 feral mammals. They are *Oreochromis mosambicus* (Mozambique Tilapia), *Oreochromis niloticus* (Nile Tilapia), *Labeo rohita* (Rohu), *Poecilia reticulata* (Guppy), *Trichopodus pectoralis* (Snake skin gourami), *Osphronemous goramy* (Giant gourami), *Felis catus* (Feral cat), *Canis familiaris* (Feral dog) and *Bubalus bubalis* (Feral buffalo).

Towards the end of presentation Dr Silva well explained many of these organisms with their mode of entry, distribution sites and impacts. As usual these species are introduced into the country intentionally (for commercial fishery, sports fishery or ornamental fishery, for mosquito control and agriculture) or accidentally (by various human activities). Before concluding, Dr Silva also mentioned the time scale of invasion, major ports in Sri Lanka and its significance in an Island country.

Dr Devaka Weerakoon (Speaker 3)

In presentation entitled as “**Communication tools used for management of IAS – The Sri Lankan Experience**”, Dr Devaka Weerakoon focused on the importance of awareness in different public sectors regarding IAS and various tools used for this purpose. Dr Weerakoon started his presentation with the significance of IAS education and awareness, because humans play a central role in biological invasion and majority of public unaware about IAS and related problems.

Dr Weerakoon suggested that, education, training and capacity building programs should be more efficient because the existing methods are not adequate, some have obtained training indirectly and more focused on theory than actual management activities. Training should be provided in different target groups such as general public, students, teachers, agencies involved in control and regulation of IAS etc. Present scenario of communication programs are organizing Symposia, articles in newspapers, magazines and journals, use of electronic media, designing and distribution of posters, brochures and pamphlets, conducting workshops and public lectures, provide information as a part of formal education and non - formal education.

Towards the end of presentation, Dr Weerakoon listed some communication tools developed by Sri Lanka such as IAS Pictorial guide, IAS Descriptive guide, Training manuals for farmers, managers and teachers, posters, leaflets etc. Dr Weerakoon also pointed out the relevance of a well maintained IAS Websites, record of provincial IAS profiles and focused awareness programs.

Dr Buddhi Marambe(Speaker 4)

In presentation entitled as “**Policy and Legal instruments to manage IAS in Sri Lanka**”, Dr Buddhi Marambe focused on the initiatives taken against biological invasion by the Sri Lankan government and supporting legislation. Dr Buddhi started his presentation by quoting the **Constitution of the Democratic Socialist Republic of Sri Lanka – “The state shall protect, preserve and improve the environment for the benefit of the community”**.

Dr Buddhi also mentioned some government policies for the protection of biodiversity, agriculture and environment. The policies include National Environmental Policy (2003), National Agriculture Policy (2007), National Wildlife Policy (2000), National Climate Change Policy (2012), National IAS Policy (2012), National Livestock Development Policy (2007), National Forest Policy (1995), National Fisheries and Aquatic Resources Policy (2006), National Wetland Policy (2004) and National Biosafety Policy (2005).

Towards the end of presentation, Dr Buddhi explained some ordinances or laws implemented against invasive species, which are Water Hyacinth Ordinance (No. 4 of 1909), Fauna and Flora Protection Ordinance (No. 2 of 1937; as amended), The Imports and Exports control act (No. 1 of 1969), Animal Disease act (No. 59 of 1992), Forest ordinance (No. 13 of 1995), Fisheries and Aquatic Resources act (No. 2 of 1996), Plant Protection act (No. 35 of 1999) and Invasive Species Control Act.