Regional Workshop on

UNDERUTILIZED FISH AND MARINE GENETIC RESOURCES AND THEIR AMELIORATION

Colombo, Sri Lanka
July 10-12, 2019

PROCEEDINGS AND RECOMMENDATIONS

Asia-Pacific Association of Agricultural Research Institutions

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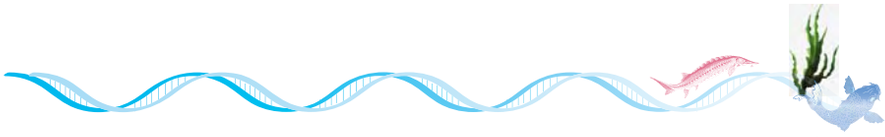


Foreword

The fish and marine genetic resources (FMGR) for food and agriculture have some distinct features that differ significantly from genetic resources for terrestrial agriculture and that will impact the priorities for their conservation, sustainable use and development. There are drivers for consolidation of production around a few major species of FMGR but there are also drivers for diversification into underutilized and new species. Wild relatives in nature and farmed species in aquaculture may respond differently to present and emergent drivers such as human population growth and increased wealth, climate change and environmental degradation. Besides, use of underutilized FMGR for food and non-food purposes remains under-reported or under-recorded. It was thus considered important to assess the current status of underutilized FMGR at regional level and to assess R&D status of priority species those are needed to be promoted for the use in food and agriculture; to discuss the knowledge gaps and way forward in defining regional priorities concerning underutilized FMGR and create awareness on its role and value that have potential for diversification of food basket and improve the livelihoods of rural and coastal population, and to formulate strategies for strengthening the institutional framework for FMGR management, and legal and policy framework to promote conservation and sustainable use of underutilized FMGR at regional level.

In the above backdrop, APAARI under its programme on Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) organized the Regional Workshop on Underutilized Fish and Marine Resources and their Amelioration from July 10-12, 2019 at National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka with active support of Sri Lanka Council for Agricultural Research Policy (SLCARP) and NARA.

More than 100 delegates from Asia-Pacific region attended the Workshop representing participants from 12 countries (Bhutan, Fiji, India, Iran, Lao PDR, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan and Thailand) in Asia-Pacific region including a large number from Sri Lanka. The importance of the Workshop can be gauged by the presence of two Ministers of Sri Lanka *viz.*, Cabinet Minister for Agriculture, Livestock Development, Irrigation and Fisheries & Aquatic Resources Development, and State Minister for Fisheries & Aquatic Resources Development, Government of Sri Lanka. Very useful deliberations were made in different sessions on Conservation, Improvement and Use of FMGR Resources with good inputs by panelists that were made on Value Addition, Marketing and Export, Biotechnology for Enhancing Utilization, Partnership and Capacity Building and on need for Regional Information Sharing System and Focal Point. It is hoped that the recommendations made for different stakeholders would serve as a guiding force for intensifying our efforts on underutilized FMGR and their amelioration. I profusely thank SLCARP and NARA for their active support and to my colleague Dr Rishi Tyagi (APCoAB Coordinator) for bringing out the proceedings and recommendations so succinctly.

Ravi Khetarpal
Executive Secretary, APAARI

Acknowledgements

On behalf of Asia-Pacific Association of Agricultural Research Institutions (APAARI) and its programme Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB), and my own behalf, I would first like to thank Mr P. Harison, Hon'ble Minister of Agriculture, Rural Economic Affairs, Irrigation and Fisheries and Aquatic Resources Development, Government of Sri Lanka for gracing the occasion and delivering a very inspiring speech during Opening Session. I am equally thankful to Mr Dilip Wedaarachchi, Hon'ble State Minister of Fisheries and Aquatic Resources Development, Government of Sri Lanka also for his benign presence and addressing the participants.

I thank immensely to the Co-Organizers, Sri Lanka Council of Agricultural Research and Policy (SLCARP), Council of Agriculture (COA), Taiwan, and National Aquatic Resources Research and Development Agency (NARA), for their whole-hearted support in the organization of the Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration, which was held on July 10-12, 2019 at NARA in Colombo, Sri Lanka.

Whilst organizational support was important, strategic and technical input of individuals were also very critical. We place on record, our immense gratitude to Dr D.T. Kingsley Bernard, Chairman, SLCARP, for agreeing and encouraging the organization of this workshop and unstinted support. I thank profusely Eng. E.A.S.K. Edirisinghe, Chairman, NARA, Sri Lanka, for providing the venue for the Workshop and immense organizational support from staff of NARA. We are equally thankful to Dr Chung-Hsiu Hung, Director General, COA, Taiwan, for supporting APCoAB programme under which this Workshop was organized. Dr Frank Niranjan, Deputy Director (Research), SLCARP, deserves very special thanks for his efficient coordination and logistic arrangements for organization of the Workshop. Administrative support and guidance provided by Dr Ravi Khetarpal, Executive Secretary, APAARI, Bangkok, is thankfully acknowledged. Technical help provided by Mr C.C. Lin, APAARI, is gratefully acknowledged. My sincere thanks are also extended to all the co-chairs, rapporteurs, speakers, panellists and participants.

Successful and professional organization of the Workshop is a very hard work of the members of various committees. Sincere appreciation is extended to all committee members of SLCARP, NARA and APAARI Secretariat, for their concerted and untiring efforts and invaluable contributions in the preparatory phase as well as during the event. They have worked constantly behind the scene to manage with all technical, financial, logistic and administrative aspects of organization of the Workshop.

Sincere thanks are accorded to all the co-editors, especially Prof. D.H.N. Munasinghe and Dr K.H.M. Ashoka Deepananda, University of Ruhuna, Sri Lanka, for their intensive involvement in collation, compilation and critical editing and giving shape to the proceedings in the present form and Dr Ashoka Deepananda for his valuable contribution in developing the Concept Note also.

I hope that the recommendations presented in this document will draw attention of the policy makers, administrators, researchers, farmers and other stakeholders towards efficient conservation and sustainable use of underutilized fish and marine genetic resources in the Asia-Pacific region.

Rishi Tyagi
Coordinator, APCoAB

Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

https://www.apaari.org/

The APAARI is a voluntary, membership-based, apolitical and multi-stakeholder regional organization. It is bridging national, regional and global stakeholders to bring about collective change in agri-food systems of Asia and the Pacific. APAARI's wide network of members and partners comprises of National Agricultural Research Institutes (NARIs) and National Agricultural Research Organizations (NAROs), CG centres, Association of International Research and Development Centers for Agriculture (AIRCA), universities, extension service providers, civil society organizations, (farmers' organizations – FOs and non-governmental organizations – NGOs), international development organizations and the private sector. The close links and collaboration with these stakeholders are instrumental in strengthening agri-food research and innovation systems towards more sustainable development in Asia and the Pacific region.

Sri Lanka Council for Agricultural Research Policy (SLCARP)

https://www.slcarp.lk/

The SLCARP serves as an organization in an advisory capacity for co-coordinating and consolidating efforts within Sri Lanka NARS, funding research projects/programmes and promoting scientific research linkages in prioritized areas both nationally and internationally. SLCARP has been instrumental in promoting and facilitating research, by improving and enhancing agricultural research through documentation and communicating latest advances in research to the NARS scientists. SLCARP has identified its own perspective, plans and programs for the future in keeping with the aspirations and goals of the Ministry of Agriculture Development and Agrarian Services to meet the future challenges in enhancing domestic food production and exports focused on poverty reduction.

Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB)

http://www.apcoab.org

The APCoAB was established as a programme under the umbrella of APAARI in 2003 with the mission to harness the benefits of agricultural biotechnology and bioresources for human and animal welfare through the application of latest scientific technologies while safeguarding the environment for the advancement of society in the Asia-Pacific region. The goal of APCoAB is to enhance the benefits of biotechnologies for the sustainable agricultural development in the Asia-Pacific region, through greater stakeholder partnerships, improved dialogues with policy makers, capacity building and greater public awareness.

Council of Agriculture (COA)

http://www.tari.gov.tw/english

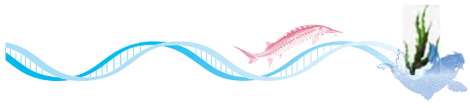
The COA is the competent authority on agriculture, forestry, fishery, animal husbandry and food affairs in Taiwan. Its responsibilities include guiding and supervising provincial and municipal offices in these areas. Under the council, there are Department of Planning, Department of Animal Industry, Department of Farmers' Services, Department of International Affairs, Department of Science and Technology, Department of Irrigation and Engineering, Secretariat, Personnel Office, Accounting Office, Civil Service Ethics Office, Legal Affairs Committee, Petitions and Appeals Committee and Information Management Center respectively in-charge of related affairs.

National Aquatic Resources Research and Development Agency (NARA)

http://www.nara.ac.lk/

The NARA is the apex national institute vested with the responsibility of carrying out and coordinating research, development and management activities on the subject of aquatic resources in Sri Lanka. The NARA is a statutary body duly established by NARA Act of No. 54 of 1981, during the past 34 years. NARA conducted numerous scientific studies in the field of fisheries and aquatic sciences. NARA also provides services for development and sustainable utilization of living and non-living aquatic resources.

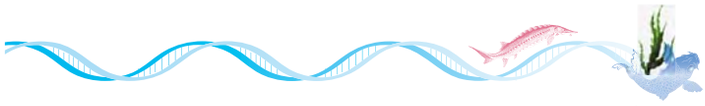
Abbreviations and Acronyms



ABS	Access and Benefit-Sharing
AIRCA	Association of International Research and Development Centers for Agriculture
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APCoAB	Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
AREEO	Agricultural Research Education and Extension Organization
CBD	Convention on Biological Diversity
COA	Council of Agriculture
DOF	Department of Fisheries
EAF	Ecosystem Approach to Fisheries
EEZ	Exclusive Economic Zone
FAO	Food and Agriculture Organization
FMGR	Fish and Marine Genetic Resources
FMP	Fishery Management Plan
FO	Farmers' Organizations
GDP	Gross Domestic Product
ha	hectare
HPLC	High Performance Liquid Chromatography
ICAR	Indian Council of Agricultural Research
ICT	Information and Communication Technology
IPRs	Intellectual Property Rights
IUU	Illegal, Unreported and Unregulated
kg	kilogram
km	kilometer
m	meter
MAS	Marker Assisted Selection
MAT	Mutually Agreed Terms
MCS	Monitoring, Control and Surveillance
MMDE	Ministry of Mahaweli Development and Environment
MOAF	Ministry of Agriculture and Forestry
MOF	Ministry of Fisheries
MSY	Maximum Sustainable Yield
MT	Metric Tons
MUZE	Multi-stream Zero Effluent

NACA	Network of Aquaculture Centres in Asia-Pacific
NARA	National Aquatic Resources Research and Development Agency
NARI	National Agricultural Research Institutes
NARO	National Agricultural Research Organization
NARS	National Agricultural Research Systems
NAQDA	National Aquaculture Development Authority
NGO	Non-Governmental Organizations
NMR	Nuclear Magnetic Resonance
NPCI	National Plan of Control and Inspection
PCB	Partnership and Capacity Building
PDR	Peoples' Democratic Republic
PIC	Prior Informed Consent
QTL	Quantitative Trait Loci
R&D	Research and Development
RAP	Regional Office for Asia Pacific
RU	Rajarata University
SDG	Sustainable Development Goals
SLCARP	Sri Lanka Council for Agricultural Research Policy
SLR	Sri Lankan Rupee
SSF	Small Scale Fisheries
SU	Sabaragamuwa University
SWOT	Strengths, Weaknesses, Opportunities and Threats
TAC	Total allowable catch
UN	United Nations
UNCLOS	United Nations Convention on the Law of the Sea
UPD	University of the Philippines Diliman
UPV	University of the Philippines Visayas
USD	US Dollars
USJP	University of Sri Jayawardhana Pura
UoR	University of Ruhuna

Executive Summary



The Regional Workshop on Underutilized Fish and Marine Genetic Resources (FMGR) and their Amelioration was held on July 10-12, 2019 at National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka. The workshop was organized by Asia-Pacific Association of Agricultural Research Institutions (APAARI) under its programme on Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB), Sri Lanka Council for Agricultural Research Policy (SLCARP) and National Aquatic Resources Research and Development Agency (NARA). The objectives of the workshop were to (i) assess the current status of underutilized FMGR at regional level and to assess R&D status of priority species those are needed to be promoted for the use in food and agriculture, (ii) discuss the knowledge gaps and way forward in defining regional priorities concerning underutilized FMGR and create awareness on the role and value of underutilized FMGR that have potential for diversification of food basket and improve the livelihoods of rural and coastal population, and (iii) formulate strategies for strengthening the institutional framework for FMGR management, and legal and policy framework to promote conservation and sustainable use of underutilized FMGR at regional level.

A total of 106 participants attended the inaugural session including participants from 12 countries in Asia-Pacific region (Bhutan, Fiji, India, Iran, Lao PDR, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Taiwan and Thailand) including 51 Sri Lankan scientists participated in the 3-day workshop. Participants represented national organizations such as universities, research institutes, research councils that are dealing with management and conservation of marine resources. Technical papers were presented by expert scientists, country status reports by country representatives, and all the participants contributed in World Café discussion followed by a Plenary Session.

Inaugural address was delivered by the Chief Guest Hon. P. Harison, Cabinet Minister for Agriculture, Livestock Development, Irrigation and Fisheries & Aquatic Resources Development, Government of Sri Lanka followed by the speech of Guest of Honour Hon. Dilip Wedaarachchi, State Minister for Fisheries & Aquatic Resources Development, Government of Sri Lanka. The inaugural session was also addressed by representatives of SLCARP, APAARI, COA and NARA.

The workshop was organized under three sessions followed by a World Café discussion and a panel discussion. Technical Session I was focused on **Thematic Presentations on Underutilized Fish and Marine Genetic Resources** and four presentations were delivered in this session. There were six presentations for Technical Session II which were based on **Strategies for Conservation and Utilization of Underutilized Fish and Marine Genetic Resources.** Technical Session III was **World Café Discussion – Regional Priorities for Underutilized FMGR** in which round table discussions were conducted under five key areas: (1) Conservation, improvement and use, (2) Value addition marketing and export, (3) Biotechnology for enhancing utilization,

(4) Partnership and capacity development, (5) Regional information sharing system and focal points. Technical Session IV was a **Panel Discussion on Legal and Policy Framework Support to Promote the Sustainable Use of Underutilized Fish and Marine Genetic Resources** and eight presentations were made in this session.

Major recommendations emanated from the workshop are mentioned below:

1. Conservation, Improvement and Use

- Develop strategic plans for conservation and sustainable utilization by establishing a task force including all stakeholders at national level to check the loss of genetic resources due to over-utilization of FMGR and conservation and sustainable use of FMGR.
- Identify underutilized species to utilize as substitutes of vulnerable, and threatened and over-exploited species. Also, degraded fishing grounds should be identified and strategies for their restoration by establishing marine parks with demarcating specific zones to be developed at national levels.
- Employ various strategies such as hybridization techniques, production of mono sex cultures and analyses of inbreeding levels to enhance the quality of the products. National conservation programmes should be in 'Mission Mode' not in 'Project Mode' to ensure the availability of resources.
- Develop captive breeding techniques to establish selective breeding programmes for commercially important traits.
- Identify, prioritize and develop new marine resources that have not yet been investigated and establish genome resource banks for both conservation and breeding purposes.
- Economic and policy analysis tools to be developed to facilitate the policy makers to take decisions for conservation and sustainable utilization.

2. Value Addition, Marketing and Export

- Introduce simple and cost-effective methods/technology at household levels through awareness programmes and improve infrastructure facilities to produce alternative value added food sources.
- Improve and promote culture-based method in association with genetic tools to reduce the pressure on natural fishery resources and establish alternative livelihoods.
- Along with the priority as food source, investigations should be initiated towards other uses of marine resources e.g. seaweeds, sponges can be used for production of new enzymes (biocatalysts), secondary metabolites, pharmaceutical products, etc. While developing new byproducts, it requires a comprehensive analysis of species characteristics such as texture forming properties, flavor, colour, frozen stability from safe use point of view.
- Develop and maintain regionally accepted common standards for branding the products and trade negotiation among regional countries to expand international markets.

3. Biotechnology for Enhancing Utilization

- Apply biotechnological tools, wherever possible, for *in situ* and *ex situ* conservation of genetic resources to protect the endemic and endangered species.
- Comprehensive studies should be carried out using molecular markers for species identification and phylogeographic, phylogenetic and stock assessment of populations.
- Molecular markers need to be applied for selection and characterization to identify the economically important traits to develop quality breeds and better marketable products.
- Identify and establish suitable micro-propagation methods of selected seaweed types to enhance the seaweed farming.
- Establish policies and regulations, exchange knowledge, techniques and resources among countries to enhance the utilization and development of marine resources in the region.

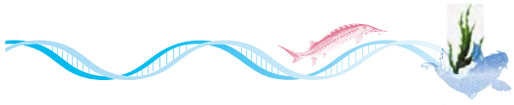
4. Partnership and Capacity Building

- Explore the possibility to establish an inter-governmental/regional cooperation body to assess the capacity building needs and gaps at the regional level, strength and weakness of the nations, possible modalities of capacity and partnership building.
- Develop collaborative programmes at regional or sub-regional level with sufficient funding to identify research capacities of national partners and sharing or exchange of technology, knowledge, infrastructures and expertise, standardize material transferring protocols (genetic or live samples), share repositories to facilitate safe custody of germplasm accessions and exchange for research.
- Capacity development related to underutilized FMGR in Asia-Pacific region are needed in areas such as genetic improvements by selective breeding and genetic modifications, application of molecular marker technology, aquatic genetic resources cataloguing and management, stock assessment of exploited species, taxonomy and genetic identification, landscape approach for *in situ* conservation, disease diagnostics, surveillance and management and food safety.
- PCB is needed between countries for sharing water and genetic resources to harmonize policies on introduction of aliens/exchange of germplasm in region and outside region, transboundary movement of aquatic organisms, quarantine and disease management and access benefit sharing of programmes.

5. Regional Information Sharing System and Focal Point

- Existing commodity-wise national databases to be enriched with other relevant metadata of the species including the conservation status that is maintained in a standard format which may eventually be developed/linked to the regional database at later stage.
- Mechanism to be developed for sharing the information in accordance to national laws keeping in view the IPRs.
- A duplicate set of database should be maintained preferably in more than one country as safety back-up.
- Addition of any information should be allowed with the approval of an authorized system administrator and expert committee of the Focal Point which may be identified in each country and the region.

Background and Objectives



In the 2030 United Nations (UN) Agenda for achieving Sustainable Development Goals (SDGs 2030), food and agriculture are given prominence. Many SDGs are directly or indirectly related to fisheries and aquaculture, particularly SDG #14, which includes enhancement of the conservation and sustainable use of oceans and their resources.

There is no argument that fishery is the main source of the animal protein in Asia-Pacific countries, which provides about 60% of the animal protein requirement of the Sri Lankan people. Situation in the other countries in South Asia is also similar. According to Food and Agriculture Organization (FAO) reports, there is a gradual depletion of fish resources in the global scenario as well as country specific situation due to over exploitation and adverse climate impacts. FAO and other global and regional corporations are now promoting their member states to uphold culture-based fisheries and other alternatives.

In view of the above, the most of the countries in Asia-Pacific region are now paying the greatest concern on aquaculture and utilizing underutilized fish and marine genetic resources. Though, most of the other Asian countries are now equipped with sound knowledge and skills in the areas of utilizing underutilized fish and marine genetic resources (FMGR), however, some countries inculding Sri Lanka have not adequately gained such knowledge and information. Considering the importance of grasping the same, Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand, in collaboration with National Committee on Aquatic Resources of the Sri Lanka Council of Agriculture Research Policy (SLCARP), Sri Lanka and National Aquatic Resources Research and Development Agency (NARA), Sri Lanka jointly organized a Regional Workshop on Underutilized Fish and Marine Genetic Resources to facilitate a forum for discussion on this subject involving other countries of the region.

The key objectives of the Workshop were to:

- assess the current status of underutilized FMGR at regional level and to assess R&D status of priority species those are needed to be promoted for the use in food and agriculture.
- discuss the knowledge gaps and way forward in defining regional priorities concerning underutilized FMGR and create awareness on the role and value of underutilized FMGR that have potential for diversification of food basket and improve the livelihoods of rural and coastal population.
- formulate strategies for strengthening the institutional framework for FMGR management, and legal and policy framework to promote conservation and sustainable use of under-utilized FMGR at regional level.

Opening Session

Dr D.T. Kingsley Bernard, *Chairman,* SLCARP

It is a great honour for me to welcome you all, coming from the countries of Asia-Pacific region to Sri Lanka, and being present at the Regional Workshop on Underutilized FMGR and their Amelioration. I welcome you warmly and appreciate your participation at this workshop. I hope that you will enjoy your stay in Sri Lanka and take away as good memories with you. Let me bring the compliments and best wishes from Dr Ravi Khetarpal, Executive Secretary of APAARI, who is unable to attend this workshop due to prior commitments. Let me also divert a bit of the welcome speech to recognize the assistance provided by NARA, Sri Lanka, by sharing part funding and offering their facilities to conduct the workshop. Ladies and gentlemen, finally, let me welcome all of you, representing the fisheries and aquatic resources sectors, and our friends from media. I wish the fruitful workshop, and the findings of the workshop will hopefully be useful to the Asia-Pacific region and other parts of the world as well. I wish you all very fruitful and happy workshop.

Dr Rishi Tyagi, APAARI, Thailand

It is my great pleasure to welcome Mr P. Harison, Hon'ble Minister, Mr Dilip Wedaarachchi, State Minister and Mr K.D.S. Ruwanchandra, Secretary, Ministry of Agriculture, Rural Economic Affairs, Irrigation and Fisheries & Aquatic Resources Development, Government of Sri Lanka; Dr D.T. Kingsley Bernard, Chairman, SLCARP; Eng. E.A.S.K. Edirisinghe, Chairman, NARA; Senior Officials from SLCARP, NARA and other organizations; and all the participants of the workshop from all the countries as well as from Sri Lanka. I feel proud and honour to be part of this workshop in Sri Lanka, because Sri Lanka has a lot of fisheries and expertise. Therefore, we chose Sri Lanka to organize this workshop.

The APAARI is apolitical member-based, multi-stakeholder organization, based in the Bangkok, Thailand. One of the programme on APCoAB is being conducted under umbrella of APAARI

under which this workshop is organized. In the series of underutilized bioresources, one on underutilized plant genetic resources, another on underutilized animal genetic resources have been organized, and this workshop meant for the underutilized fish and marine genetic resources. All you know that fish and fisheries products are very valuable component of the food and nutritional security which has been underlined the importance in SDGs, chartered by United Nations (UN) in 2015 to achieve in 2030.

Considering the importance of fish and fisheries, this workshop has been organized. Main objectives of this workshop are to assess the current status of underutilized fish and marine genetic resources to find out the knowledge gap and defining the priorities; create awareness about the diversifying food passage in the region; and form legal policy framework which pave the path for the effective conservation and sustainable utilization of fish and marine genetic resources.The expected outcome of this workshop stand that it may be providing the active platform to interact and share their experience from the participants from different countries. Representatives from about 12 countries in the Asia-Pacific region are attending this workshop. Availability of expertise from Sri Lanka is a huge strength which will be deliberating in coming two and half days to have an assessment of most potential underutilized fish and marine genetic resources in the region. We would like to develop a road map to see the effectiveness of conservation of underutilized fish and marine genetic resources in the region, exploring the possibility for developing regional network for regional collaboration among countries. Technical programme of the workshop has been articulated to have presentations in technical sessions from some experts from the region, in addition to the country status reports which will give the idea about the level or status of underutilized fish and marine genetic resources in each country.

I need to underline here that many workshops have been done in many countries in the region at national and international level on fish and marine genetic resources, but this workshop is focussed on underutilized fish and marine genetic resources, because underutilized resources play very significant role in addressing the livelihood security of the small entrepreneurs. I like to thank immensely Hon'ble Minister, State Minister, Chairman, SLCARP and Chairman, NARA, for making it convenient to organize this workshop. I am indebted to the government of Sri Lanka for permission to organize this workshop for the Asia-Pacific region in Colombo. Finally, I wish you a very fruitful deliberation for next two and half days, and enjoy stay in a very beautiful country – Sri Lanka. Thank you!

Dr Hsin-ming Yeh, COA, Taiwan

Good morning! It is my pleasure to receive you here today to opening ceremony of the Regional Workshop on Underutilized FMGR and their Amelioration. On behalf of the COA, Taiwan, I would like to thank APAARI and NARA for co-hosting this event. As you are aware, today for about 3.2 billion people with almost 20% of their average per capita animal protein intake is provided by fish. Aquaculture and capture fishery directly employ over 59 million people and each

sector provide about 50% of the world average food supply. The research of marine genetic resources is a very new, but growing regularly. Biological compounds taking from marine resources include those with potential medical benefits like anticancer agents, and those with industrial value like antitoxin proteins. These biologically derived compounds can be patented by those who isolate and test them to be used for profit. Taiwan is small Island but have higher proportion of species number, when compare to world average. This makes preserving genetic resources of Taiwan's native species is more important. Better management and conservation of important aquatic genetic resources toward the sustainable aquaculture has been focussed in Taiwan in recent years. The fisheries research institute had concerns for aquaculture and established National Aquatic Genetic Resources Centre in 2001. It has alredy been undertaken on genetic mapping quantitative trace loci analysis and gene expression in aquaculture species. It is my honour that I have the chance to elaborate more on the Taiwan status on underutilized FMGR and their amelioration in one of the technical sessions of this workshop. I am confident that this workshop will provide great opportunity for all the participants to review the current situation and challenges that we are facing. I believe that with your contribution and inputs, this workshop will yield fruitful outcome and valuable suggestions for stakeholders. Finally, I would like to express my great gratitude to NARA and APAARI for their meticulous organization of this event. My sincere thanks also go to all participants here for their gracious presence. I wish the workshop a great success!

Eng. E.A.S.K. Edirisinghe, *Chairman*, NARA, Sri Lanka

Being the Chainman of NARA, I am proud to have this regional workshop entitled 'Underutilized Fish and Marine Genetic Resources and their Amelioration' under the Ministry of Agriculture, Rural Economic Affairs, Irrigation and Fisheries & Aquatic Resources Development, Sri Lanka. As the Chairman of NARA, I am really impressed to have this workshop in our premises, because it is very relevant to our activities at NARA as well as to Sri Lanka as an Island nation. I should extend my sincere gratitude to SLCARP for the help they have rendered for NARA for capacity building of our staff. Up to now, NARA has obtained nearly 12 PhD opportunities from SLCARP, as well as they have donated nearly SLR 112 million for construction of building of NARA. Hope in future also, SLCARP will continuously support NARA for capacity building and other facility enhancement. I am not going to explain much about NARA as previous speaker has explained all about NARA and SLCARP. Thus, I wish to invite our State Minister of Fisheries & Aquatic Resources Development, Government of Sri Lanka, to say few words on this occasion.

Mr Dilip Wedaarachchi, *Hon'ble State Minister*, Fisheries & Aquatic Resources Development, Government of Sri Lanka

"*Ayubowan*" to all! I understood that achievement of the ultimate goals of this workshop will secure the future of this world. Main concern of the UN for year 2030 is the food and agriculture sector, in which fishery industry play a significant role. Marine resource management is vital in achieving these UN goals. Only few countries of the world manage marine resources effectively. Fish resources are important because the protein requirement of 60% of the Sri Lankans is fulfilled from fish resources. Thus, major threat to Sri Lankans is the gradual decline of the fish resources, which are affected by several factors. Fisheries in Sri Lanka extends over 2000 years back, and fishing is a traditional occupation even before British colonization. Fisheries industry is expanding after independence in 1948, and freshwater fisheries sector cannot be considered simple. Sri Lanka is an island, having 517500 km^2 of Exclusive Economic Zone (EEZ), 21000 km^2 of territorial sea, 1580 km^2 of estuaries & lagoons, and over 5000 reservoirs constructed by ancient kings. Capture fishery production in Sri Lanka is not adequate for current requirements of the country and the aquaculture sector, which is developing since 75 years. Therefore, fisheries ministry has a plan to develop aquaculture sector, through National Aquaculture Development Authority (NAQDA) with the support of Ministry of Agriculture. In this context, NARA and fisheries expertise of the country are providing the technology through research. Prawn and crab culture and pond culture of fish have been already initiated and fish resources in reservoirs should be further enhanced, and this workshop will support to uplift the fishery industry. Further, Ministry of Fisheries has taken necessary step to secure the protein supply from fish. In this regard, support from the experts in Sri Lanka has been taken to increase the production. Ministry of fisheries have identified that inland aquaculture is vital for providing protein for people in Sri Lanka in future. Thus, we have merged the Fisheries and Agriculture Ministries in order to use the aquatic resources more effectively. I hope that we can produce and achieve the required aquaculture production in near future. Also, I believe that representatives from Asia-Pacific region will jointly work with our expertise and will support to increase the fisheries production in Sri Lanka. I thank you all for coming here to share your knowledge and technology with the nations of the Asia-Pacific region.

Mr P. Harison, *Hon'ble Minister*, Agriculture, Rural Economic Affairs, Irrigation and Fisheries & Aquatic Resources Development, Government of Sri Lanka

"*Ayubowan*" to all! It is indeed a great pleasure for me to address you all participating from different countries of Asia-Pacific, including Sri Lanka during this Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration, being held at Colombo, Sri Lanka.

Food and Agriculture Organization of the United Nations (FAO) have been given the emphasis to achieve sustainable development goals of the UN by 2030. Most of the SDGs are directly and indirectly liaise with fisheries and aquaculture. Conservation of ocean and its resources and increased sustainable utilization are specially highlighted in SDG #14. The animal protein requirement of Sri Lankans is mainly fulfilled by fish resources and over 60% of people in Asia and Sri Lanka are benefitted by this. According to the FAO, when consider the global trend, different conditions affect each country like over-exploitation of fish resources, unfavourable climatic conditions are some of the factors that decrease the fish resources. Presently, FAO and other Global Associations work to gether to establish cultural integration of the fishing industry in each country and also direct and instruct their members to follow alternative methods.

Sri Lankan fisheries industry has a long history over 2000 years, and it was a primary economic activity of the coastal populations. After the independence from the British in 1948, ocean fisheries have become from primary livelihood activity to billion-dollar industry. Freshwater fisheries and aquaculture are a recent development from 75 years back. Coastal aquaculture was developed in early 1980s with the initiation of shrimp farming in North Western Province, Sri Lanka. After that in 2010, ocean aquaculture was initiated.

Fisheries production in Sri Lanka is basically harvest from 517500 km^2 of EEZ, 21500 km^2 of territorial water, 1580 km^2 of estuaries and lagoons, and 5200 km^2 of manmade reservoirs/ water bodies. Lands associated with lagoons, estuaries, reservoirs and coastal areas provide the basic resources for aquaculture development. Fisheries and aquaculture sector of Sri Lanka contributes approximately 1.4% to the Gross Domestic Production (GDP), and provide direct and indirect employment for 57,5000 persons which was a 3.7% of labour force of the country. Of the 53,0000 tons annual fish production in 2017, valued USD 1300 million, 5% of that includes the production of tuna, prawns, lobsters, crabs, sea cucumbers and ornamental fishes have been exported, earning 250 USD million export revenue. About 65% of the fish consumed by Sri Lankans are from local fish production and the rest are being imported to the country.

Presently, most of the Asian countries have paid the attention towards the underutilized fish and marine resources. In this context, other countries have acquired the knowledge to use these important resources, but Sri Lanka has yet to acquire the knowledge in this context. Considering this dearth of knowledge, SLCARP has organized this workshop on Underutilized FMGR and their Amelioration in order to discuss the important matters and fill the knowledge gap. The APAARI, which is based in Bangkok, Thailand, has extended support on this through the workshop in order to uplift the conditions. Finally, I wish that, through the development of genetic resources, the condition of protein deficiency and poverty could be eliminated from Sri Lanka.

Dr Frank Niranjan, SLCARP, Sri Lanka

Planning and implementing a workshop of this nature and magnitude by any means is not an easy task. I am extremely happy to propose the vote of thanks at the end of a very successful opening session. On behalf of the SLCARP and NARA, I am privileged to express our gratitude to the following individuals who made this regional workshop a success. First and foremost, I thank Hon'ble P. Harison, Cabinet Minister and Hon'ble Dilip Wedaarachchi, State Minister of Agriculture, Rural Economic Affairs, Irrigation and Fisheries & Aquatic Resources Development, Government of Sri Lanka, for gracing the occasion and I really appreciate you to be with us today as our chief guests. I would like to thank Dr Ravi Khetarpal, Executive Secretary of APAARI and Dr Rishi Tyagi, Coordinator, APCoAB, APAARI, for initiating this workshop and providing part funding. Meticulous planning and professional approach of Dr Rishi Tyagi was significantly instrumental to the success of the workshop. My sincere thanks goes to all foreign delegates for accepting APAARI's invitation and to all Sri Lankan Scientists for accepting SLCARP's invitation to make technical presentations, rapporteuring and chairing of sessions at the workshop. My special thanks are due to foreign delegates for visiting Sri Lanka and I hope they will carry pleasant memories. I extend my sincere thanks to Secretary of the Ministry, Mr K.D.S. Ruwanchandra, State Secretaries, Advisor to the Hon'ble Minister, Additional Secretaries, all other Heads of Institutions and eminent scientists for taking their time off from their busy schedules to participate this workshop. All sponsors – APAARI; Council of Agriculture, Taiwan; NARA were acknowledged for generous contributions. Also, I would like to thank Chairmen of NARA and SLCARP, Director General and Deputy Director General of NARA, Secretary SLCARP, Chairman and Members of the National Committee on Aquatic Resources, officers of NARA and SLCARP for assisting in various ways to make this event a success. I thank all the media personnel for providing publicity and officers at Modara Police, Sri Lanka, for providing security for the participants.

TECHNICAL SESSION I

Thematic Presentations on Underutilized Fish and Marine Genetic Resources

Co-Chair: J.K. Jena, ICAR, India
Rapporteur: Suseema Ariyarathna, NARA, Sri Lanka

The following sections will deal about the salient points of presentations made by the experts in different technical sessions.

Mainstreaming the biodiversity in fisheries and aquaculture with special reference to underutilized resources, Thailand

Praulai Nootmorn, DOF, Thailand

A Kingdom in South-East Asia, is divided into 77 provinces, covers an area of 513,120 km^2. It is bordered by Myanmar on the North and West, Laos on the North-East, Cambodia and the Gulf of Thailand on the South-East. From the South it was bordered by Malaysia and on the South-West by the Andaman Sea and Myanmar. Thailand has a monsoon climate with a wet season (90% of the annual rainfall) from April to September during the South-West monsoon and a dry season from October to May with dry continental northerly winds (North-East monsoon).

When we look at the fish production and consumption, a total number of 40,688 fishing vessels caught 1.34 million tons of fish. It produces a generally affordable source of protein, contributing significantly to dietary health and food security, particularly for the more than 2,500 villages of artisanal fishing communities along the coasts. The consumption rate per capita is 42 kg/year. From 1996 to 2006 total production was increased up to 4000 tons and it was gradually decreased up to 2500 tons by 2016. Marine capture fishery covers more than 3/4 of the total production.

Approximately 63 species have been recorded in marine capture fishery production including demersal and pelagic finfish species, prawn and crab species and mollusks such as squid, cuttlefish, octopus as well as cockles, mussels, oysters, and clams. Jelly fishes were also abundant in the production. The composition of artisanal catch was recorded as anchovies (2%), demersal fishes (14%), pelagic fishes (17%), shrimps (3%), squids (3%), others (59%) and trash fishes (2%). There were slight changes of composition in commercial catch and it was reported as anchovies (11%), demersal fishes (20%), pelagic fishes (37%), shrimps (2%), squids (9%), others (4%) and trash fishes (17%).

Marine fisheries management plan of Thailand is controlled under four sections; rules and regulations (Ministerial Regulations, Ministerial Notification and Registration and Licensing System), legislations (Fisheries act 2015, Royal Ordinance and B.E 2558 & 2560), policies (National Marine Fisheries Policy, Implementation Plan and Management Measures) and plans (Operation Manuals - NPOA – IUU, NPCI, Traceability) which are interconnected with each other for practice. Marine fishery management strategies are applied on several categories; open access fishery, overfishing, Royal Ordinance on Fisheries B.E. 2558 (2015), limited access fishery, biological reference point, Maximum sustainable yield (MSY), Total allowable catch (TAC), Catch allocation and Fishing license issuance. Over fishing has been controlled at both Gulf of Thailand, and Andaman Sea for Demersal fish. Productions were controlled at MSY for pelagic fish and below MSY for anchovy at both sites. When compare the status, anchovy production was higher under MSY than other two demersal or pelagic fish at both sites.

Analysis of progress against the detailed management measures specified in the 2015-2019 FMP was focused under several objectives; reduce fishing capacity and fishing effort, reduce the catch of juveniles of the larger commercial species, minimize IUU fishing through effective MCS, resolve conflicts between small-scale and large-scale fishers, restore and maintain critical habitats, improve fisheries data and information and strengthen fisheries management capacity. The marine fisheries industry of Thailand has showed a success at the international level and achieved IUU Fishing Index score as 2.33. The deep areas in the Andaman Sea were surveyed cooperation with EAF-Nansen Programme (GCP/GLO/690/NOR) in 2018, which recorded a total of 133 families belonging to 7 taxonomic entities.

Conservation and sustainable use of fisheries and aquaculture in Asia and the Pacific[1]

Simon Nicol, FAO-RAP, Thailand

Global total production of capture fishery industry in 2016 was estimated as 170.9 million tones which 79.3 million tones come from marine fishery industry while 11.6 million tons were added by the inland fishery industry. The contribution of aquaculture for the total production was valued as 80 million tones. The fraction of contribution for the global total production from Asia-Pacific region was more than half and valued as 130.2 million tons. The production of capture fishery in Asia-Pacific region was estimated as 49.1 million tons which the contribution of marine and inland fishery sectors were estimated as 41.7 and 7.4 million tons, respectively.

Over the last decade Asia-Pacific region remains the world's largest producer of fisheries products. In 2007 growth in production in China (including its territories) and Southeast Asia was 35% each from the total. Productions of East Asia and the south Asia were 16% and 11% respectively and the lowest was from Oceania (3%). By 2016, the productions of China and territories raised up to 38% and the South Asia up to 12% while no growth in

[1] Delivered the presentation over the Skype

the South-East Asia and Oceania. The growth in production has been decreased in East Asia and recorded as 11%. Most reported growth is associated with aquaculture and the trend of production in aquaculture sector in Asia-Pacific region was increased from 49% to 55%. As the world largest fish producer, Chinese fisheries industry makes a significant contribution to the global market. From 1999 to 2016, slight fluctuations around 7500,000 tones were recorded for low and higher valued fish production in marine capture fishery industry. In contrast to that total aquaculture production in China was raised from 25,000,000 tons to 37,500,000 tons during this period.

Key trade partners who influence the region's fisheries and the trade of its commodities include: import of product from United States, Norway, and Chile, export of product to USA, Japan and European Union and Vietnam's and India's increasing role as export nations. Inter-regional trade flows also significantly drive regional trends and more than half of China's total exporting value in 2016 was to Asia-Pacific partners.

The highest proportions of biologically sustainable stocks are available in Eastern Central Pacific region which was approximately 88% (overfished 12%) and it was gradually decreased in regions as North-East Pacific> Western Central Pacific > North-West Pacific > Eastern Indian Ocean and the lowest level was recorded from Western Indian ocean which was around 68% (overfished 32%). In 2018, the world overall IUU fishing index score was 2.29 while it was 2.69 and 2.16 for overall Asia and Oceania regions, respectively. The highest score was recorded from mainland china (3.93) and the lowest from Tonga (1.82).

When look at the global food lost and waste for all food sectors, the highest value was reported from North America and Oceania region and it was estimated as 1520 Kcal/capita/day. The lowest value, 414 Kcal/capita/day was reported from the South and South-East Asia. For industrialized Asia, it was estimated as 746 Kcal/capita/day. There are five main stages considered during the fish and seafood loss/waste throughout the food supply chain; production, post-harvest, processing, distribution and consumption. In North America and Oceania region the highest percentage loss was occurred at the consumption stage (22%) and the lowest at the post-harvest stage (2%). In industrialized Asia the highest and the lowest percentage losses recorded at the production stage (16%) and the consumption stage (2%), respectively. As compared to that in South and South-East Asia the loss of distribution stage (10%) is slightly higher than the production stage (9%).

Opportunities to increase the production in capture fisheries are limited due to several reasons such as availability of under-utilized stocks and low value fish, removing IUU fish from supply chains and lack of methods for minimizing waste. Aquaculture production continues to grow in the region due to rapid growth of feed supply and the production of anti-microbial resistant varieties. However, sustainability remains as a key issue for both capture fisheries and aquaculture industry.

Dr Fridtjof Nansen survey around Sri Lanka – recent studies

Prabath Jayasinghe, NARA, Sri Lanka

The EAF-Nansen Programme is a multi-lateral research and development programme funded by the FAO of the United Nations which provides Research Vessel Dr Fridtjof Nansen to the developing nations to assess the status of marine environment and fish stocks. Upon a request made by the Government of Sri Lanka in 2017, the Research Vessel Dr Fridtjof Nansen arrived in Sri Lanka to conduct an "Ecosystem Survey" in the coastal waters from 24 June to 16 July 2018 (21 days). Local and Norwegian (Institute of Marine Research) scientists were onboard to conduct research. Similarly last comprehensive studies have been carried out in Sri Lanka during 1978-1980 using another Dr Fridtjof Nansen Research Vessel and data derived from those surveys are still used as the reference points. The main objectives of the survey were to obtain updated scientific information on Sri Lankan coastal waters with special reference to oceanography and hydrography, marine fauna and microplastics, contaminants and marine debris.The focused area was divided in to six regions to collect information. Coastal waters <20 m depth, coral reefs and other vulnerable habitats were avoided. Bottom and pelagic trawling were used for fish sampling at >100 m depth.

Following are the outcomes and conclusions were made from the survey: During Dr Fridtjof Nansen Survey, Marine Biology, Oceanography, Hydrography, Water quality and Pollution aspects were well studied; high species composition was recorded around the coast. Approximately, 593 different species recorded and more samples yet to be identified. The largest taxonomic group was bony fish: >400 different species belonging to >100 different families, followed by; 21 ray and 13 shark species. Some species have been recorded for the first time in Sri Lankan waters and morphological and molecular methods have been used to identify them. Several underutilized/unutilized marine resources have been discovered (phytoplankton, zooplankton, sponges, jellyfishes and mesopelagic species) during the survey. There is a potential to harvest these resources; the recorded demersal fish biomass was lowering the recent survey (53,000 MT) compared to the previous surveys during 1978-1980 (250,000 - 350,000 MT), higher number of species recorded closer to the coast; low oxygen in deeper water but also low effort >100 m, both pelagic and demersal fish stocks are possibly overfished and management measures need to be taken care off. There was a clear trend that large long lived species were replaced by smaller and shorter lived species. These species have often less commercial values, therefore, alternative sources have to be introduced to minimize the fishing pressure for key commercial species. Conducting studies on stock assessments and trophic structure/relationships/dynamics of these species are highly recommended.

Possible alternative uses of underutilized fish and marine genetic resources (FMGR)

Chamari Dissanayake, USJP, Sri Lanka

According to recent statistics, the global fish production from both aquaculture and capture fisheries is around 171 million tons. However, capture fisheries have plateaued at about 91 million tons of which 87% contribution is from the marine fisheries sector. The declining trend of marine capture fishery production has been evident and it is expected to continue this trend as 93% of global marine fish stocks are fully or overexploited. Therefore, the use of underutilized marine fishery resources is considered as one of the most prominent strategies to strengthen the global fishing industry.

The preliminary results of the Dr Fridtjof Nansen survey carried out in 2018, revealed the availability of unutilized and underutilized fish resources around Sri Lanka. A high potential of mesopelagic fish resources, including fish belonging to families Trachichthyidae, Myctophidae, Congridae, Gempylidae, and several unidentified species was reported in this study. Therefore, there is a high potential to utilize currently unexploited mesopelagic resources around the country to provide cheap animal proteins for ever increasing local population, fulfill the increasing demand for fish meal in the aquaculture industry and produce some nutraceuticals.

High abundance of underutilized demersal fish resources, including puffer fish, conger eels and spiny dogfish sharks was also evident. Assess the possible uses of puffer fish for direct human consumption as practiced in the South-East Asian countries and extraction of marine drugs are some future potentials. As a high abundance of demersal sharks, especially dogfish sharks was evident around Sri Lanka, expansion of shark oil industry, which is currently practiced in domestic level can be considered in the future. Other possible uses include utilization of the fins and tail of dogfish sharks to make fish needles in shark fin soup, jaws and teeth as ornaments and flesh for direct human consumption. The high abundance of some sea cucumber species such as *Holothuria edulis* (140±346 ind. ha^{-1}) has been reported, especially in the North-West and East coasts of Sri Lanka. As this species is not exploited at a commercial level, sustainable utilization of this species can be considered in the future aiming to develop value-added sea cucumber products as well as some pharmaceuticals.

Around 28 sea urchin species have been recorded in the coastal waters of Sri Lanka, including some edible species such as *Stomopneustes variolaris*. High potential exists to exploit edible sea urchins to obtain roe for export market, shells as ornaments and extract some medicinal drugs. Jellyfish is considered as another underutilized marine resource around Sri Lanka and high abundance of jellyfish was evident in both coastal and offshore waters. The taxonomic status of around 25 jellyfish species was recently revealed in Sri Lanka and seasonal exploitation of jellyfish was also reported. High potential exists to harvest jellyfish for direct human consumption, to prepare fertilizers and insecticides in agriculture, cosmetics and pharmaceuticals production and extract collagen. Cephalopod resources are also considered as an underutilized marine resource and potential exists in the pharmaceutical industry as they are reported to have anti-bacterial, anti-septic effects. Therefore, it is time to utilize these underutilized marine fishery resources in a sustainable manner to strength the fishing industry in Sri Lanka.

Key Discussion Points – Technical Session I

- Each country should identify their available underutilized marine resources and its potential for usage
- Technology should be acquired through knowledge sharing basis among the countries of the region
- Strategies should be implemented to popularize the value-added products
- National systems should encourage the research and development activities related to the underutilized marine resources e.g. identification and characterization of bioactive compounds

TECHNICAL SESSION II

Strategies for Conversation and Utilization of Underutilized Fish and Marine Genetic Resources

Co-Chairs: Monty Ranathunga, Fisheries Sector of the Ministry, Sri Lanka and Praulai Nootmorn, DOF, Thailand
Rapporteur: Suseema Ariyarathna, NARA, Sri Lanka

Applications of biotechnologies in *ex situ* conservation, characterization and utilization of fish genetic resources

J.K. Jena and K.K. Lal, ICAR, India

Aquaculture become a dependable way for future food production. Out of 151.2 million MT fish consumed, 80 million MT comes from aquaculture (about 50% of the demand). The industry showed consistent growth from 7-9% in the last two decades and are expected to see the global fish production to reach 201 million MT by 2030, from which 109 million MT (≈60%) will be expected from the aquaculture industry.

Sustainable intensification targets have been identified as increase in productivity, sustained genetic diversity during domestication, safeguard biological diversity and compliance to international policy frameworks and conventions. Although the blue revolution accelerated with the rapid growth of global aquaculture sector in the 21st century, some major impediments that are common to all countries have been identified. Lack of information on fish genetic resources and threats to their survival became one of the major drawbacks. Inadequate national programmes and information systems as well as lack of a global policy and management approach to aquatic genetic resources are the issues that need to be addressed.

Characterization of fish genetic resources, for their genetic make up, production traits, both at farm and wild relatives is becoming an important area of research. This will help in knowing the resources and their diversity at inter- and intra-specific levels. This becomes a critical input for planning genetic improvement and conservation programmes. *Ex situ* conservation of germplasm need new protocols for long-term storage of genetic material. Molecular and biotechnological advancements are becoming useful means to develop new tools and knowledge, which can be useful for conversation efforts. Genetic erosion is a major threat during the domestication. Therefore, standardized markers with gene indices need to be identified to characterize and monitor genetic alterations happening in farm and domestication process. Selective breeding is the key to improve the production efficiency which overcome the limits of resources in

aquaculture intensification. However, preventive measures should be applied for protection of farmed stocks from genetic erosion. Such measures have been recognized under different aspects such as characterization of farmed populations, quantitative assessment of hatchery populations, establish sperm banks to assist exchange of germplasm, production of seed with authenticated origin and quality standards for aquaculture and development of brood stock banks. There is a trend to apply novel techniques such as transcriptome associated markers to study population variation and Quantitative Trait Loci (QTL) association linkage mapping for marker assisted selection (MAS) in genetic improvement programmes. Number of projects have been started in the region to analyze genome/transcriptome of marine species.

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Access and benefit sharing of fish and marine genetic resources – legal considerations

Padma Abeykoon, MMDE, Sri Lanka

Sri Lanka together with Western Ghats of India considers as one of the 36 hotspots of biodiversity in the world and shows high level of endemism in the region. There is high amount of indigenous species and valuable traditional knowledge associated with the biodiversity. According to National Biodiversity Profile (2018), total of 1,514 fish species (freshwater -130 and marine and brackish water – 1384) have been recorded. There are 62 endemic species restricted to freshwater bodies and among them 46% are confined to wet zone of the country. The main threat on biodiversity in Sri Lanka is habitat loss due to anthropogenic activities. According to statistics, 38% of freshwater species are under threat and among them 73% are endemic species.

The Convention on Biological Diversity (CBD) is an international legally-binding treaty which was signed June, 1992 and ratified in March, 1994. There are three goals; conservation of biodiversity; sustainable use of biodiversity; fair and equitable sharing of the benefits arising from the use of genetic resources. There are significant potential benefits to be gained by accessing genetic resources and making use of them. It can be used to develop a wide range of products and services for human benefit.

Access and benefit-sharing (ABS) is based on two concepts (i) Prior Informed Consent (PIC) is the permission given by the competent national authority of a provider country to a user prior to accessing genetic resources, in line with an appropriate national legal and institutional framework and (ii) Mutually Agreed Terms (MAT) is an agreement reached between the providers of genetic resources and users on the conditions of access and use of the resources, and the benefits to be shared between both parties.

Providers and users of genetic resources are the two parties involving in the ABS process. Providers have sovereign rights over natural resources under their jurisdiction. Users are responsible for sharing the benefits derived from genetic resources with the providers. Benefit sharing mechanism should be identified as case by case; it could be bilateral negotiations of benefit-sharing, monetary and non-monetary benefits sharing; benefit-sharing through

partnerships or multilateral benefit-sharing. Under this process material transfer agreement has to be signed on either commercial or non-commercial basis.

The main National Legislations in Sri Lanka that relate to access and benefit sharing include the Forest Ordinance (1907), Fauna and Flora Protection Ordinance (1937), (Under the section 40 for fish export) Fisheries and Aquatic Resources Act (1996).

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Inclusive development including gender equality of small-scale fisheries: a feminist perspective

Achini M. De Silva, SU, Sri Lanka

Does the term small scale fisheries (SSF) really describe its size and scope? Social, economic, and ecological cotribution of small scale fisheries is not small as defined in its name. Its enormus contribution on employment generation, food fish supply, human nutrition, alleviation of poverty and food fish markets appear to have invisibly large. SSF takes the lion's loin of socio-economic indicators of fisheries industry; interms of number of fishermen (direct employment), fishing fleets, gear types, diversified catch, indirect employment, etc. Diverse SSF workforce composed of both men and women playing an important roles where female comtribtuion is multi-faced. Further, SSF value chains are short, few nodes but large number of actors concentrated in each node. Value chains were fragmented and scattered geographically, species-wise, level of technology, market intelligence and customer segment. In general, SSF value chain architecture consists with masculine upstream and femine downstream.

Paper eying to explore the present status of gender in SSF value chains, formulated SWOT matrix to analyse the strategic capacities and creating gender inclusive value chains. Rapid market chain analysis employed to investigate the gendered SSF value chains. Masculine upstream of the SSF value chain mainly focused on prodcution role where male actors perform for paid services or share of catch. While female actors were playing invisible but key role in their households. Unpaid and unrecognized female roles include give birth to their sucessors, child and elderly care, educate their children, search for food and prepare food, financial handling, community work, and post-harvest handling of catch. Resource access and control profiles of upstream members were more with male actors. Climate vulnerabilities, drug abuse, alcoholism and anti-social behaviours make female actors more vulnerable. Moreover, female actors were now harnessing new tools for creating space, networking, search for knowledge through ICT. Female roles were concentrated in downstream of the SSF value chains where earned and paid services performed by them. Fish retailing is one of the traditonal and most common occupation among female actors while considerable numbers were engaged in handling, grading and traditional processing. In contrast, most common female appearance in value chains were noticed in traditional as well as export processing nodes where female labour plays an important role. SSF value chains rarely supply raw materils to the traditional and export processing nodes and similar feature is common in many developing nations.

Exsisting mechanism hinder the gender inclusion in SSF value chains. Key barriers for females were information assymetry, rules and cultural norms, allocate narrow spaces for females to manage the resources and essential need to clear the complex relationships with families, comunities and local market access opprtunities. While common contstrains for both were prodcution discretion, control and access barries of resources, time allocation, poor technical and ICT literacy and weak networks. Female exclusion from value chain made them more vulnerable, lack of capsity or access to social opprtunities, distribution of wealth, cretion of decent work and managing the risks.

Key features were to empower the female actors with knowledge and literacy of ICT enabled mechnization, markets and safety and quality managament. Development of area-based supporting function and appropriate methods were prime requirements for inclusion. Skill development, hands on practical training, coaching and mentoring were absent in many gender incusion programmes but crying needs of the vaue chain actors. Governance mechnisms need to focused on four key areas; laws and regualtions, safety and quality standards, socio-cultural norms, and informal rules. Gender inclusion, especially a space for female actors in SSF value chains having limited focus. Hybrid value chain a new operating framework that transform markets by leveraging the strength of business and social action.

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Information systems on fish and marine genetic resources

Simon Wilkinson, NACA, Thailand

From an aquaculture perspective the term 'underutilized' can be viewed in different contexts. In the perspective of biodiversity, it may be a new species with high potential to be farmed, an alternative species useful in some circumstances or supplementary species that can fill vacant niches in existing farming systems. Improved varieties are another context which contains the best performing genetic resources and those could be used to develop high-performance (genetically improved) lines for improved growth, disease resistance, etc.

The information system available are can be categorize as general taxonomy, biodiversity and biology database, geographic distribution and occurrence reports, environmental monitoring and management systems, and molecular genetic databases. There are many more databases available relevant to each category or combination of them. Information systems about genetic resources have been developed for many other reasons but not focussing on underutilized genetic resources.

There are issues in gathering common information; firstly, it is very little known about most non-commercial species; about their biology, species-specific details and existance of technical barriers. Secondly, most of the available information is not available in public databases but in publications. Most publications are not free and need access to university-level library systems. It is a big issue in developing countries that most of the scientists work without accessing into publications. On the other hand, older non-journal publications may not be available in electronic format (recent ones usually are) but in printed documents.

Systems on molecular genetics are potentially extremely useful in breeding programmes for improved productivity or conservation purposes. But pubicaton of data with commercial value is questionable. Systems with general information of resources are useful as general references and starting points for investigation. However, even for mainstream species, profiles are a small subset/summary of available data. Therefore, manual literature review is required.

Information systems will probably never replace experts. If look at recent aquaculture developments, it is often a subtle biological characteristic makes one species more suitable than another. It is likely that identification of new or alternative species will be made by farmers' direct observations and experience, or by scientists that have sufficient personal familiarity with a species to recognize an opportunity. There are many context matters relevant to technical barriers in hatchery production, as well as socio economic issues that must be address and analyzed before farming.

One of the gaps identified in information system is the opportunity of developing and making better use of selectively bred lines of fish in aquaculture for improve their productivity. Inbreeding is a problem, and genetic management must be implemented improved varieties are to be maintained. An online, decentralized network of brood stock holding registries would enable small holdings to be combined into a larger, virtual population. This would facilitate exchange of genetic resources, mitigate inbreeding, and help maintain a high level of adaptive capacity.

Although free tools avaiable nowadays, databases are not emerged due to constraints such as getting, validating, entering and curating data is time consuming and expensive. For data acquisition, different models have been established for collating and curating databases. More recent method based on internet is 'Crowd-sourced' database which has potential to access huge data set and "grey" or unpublished data. It needs higher initial investment to allow for public participation and lower control over quality (mitigate with public moderation) thus, security issues much more difficult. On the other way can have mixed approach such as blended data base which core team efforts supplemented by voluntary contributions.

Technical issues arise when linking and federating information systems. It is easier if collaborating systems expose their records *via* an agreed protocol and data format. IP issues come when there are collaborations which are massively enhanced by publishing data under an open access license. Open access licenses are available with a range of restrictions to suit different purposes."Copyleft" licenses generally involve in which the author asserting copyright over a work, granting the public permission to use, redistribute or adapt the work in various ways, so long as derivatives are distributed under the same license and restrictions can include non-commercial use without modification.

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Asia-Pacific seaweed: farming and its sustainability

Anicia Q. Hurtado, UPV, Philippines

The seaweed industry has undergone a dramatic global expansion, particularly over the past 50 years and currently represents about 25% of global aquaculture production with a collective value of 6 billion USD annually (FAO, 2018). The Asia-Pacific region, notably the temperate coastlines of China, Japan and Korea are the leading producers of farmed *Monostroma, Pyropia, Saccharina* and *Undaria*, whilst tropical regions such as Indonesia, Malaysia and the Philippines predominantly produce farmed *Eucheuma, Gracilaria* and *Kappaphycus*.

The phyconomic lessons learned from the successful, extensive, mass cultivation of red seaweeds in the Asia-Pacific region, the Philippines, Indonesia and Malaysia, in particular are guidelines which can be applied for the necessary technology transfer and capacity building required by a number of other forms of marine, macro-algal agronomy.

A number of important phyconomic issues were highlighted in this paper including: a) Lessons learned from the use of repeated, vegetative propagation of *Kappaphycus alvarezii* and its long-term production as a monocrop using extensive, surface cultivation methods; b) Lack of development in commercial utilization of local biodiversity led to seemingly unnecessary introductions of non-indigenous eucheumatoids for unfettered expansion into new farming areas; c) Failures to innovate new techniques of eucheumatoid farming and utilization of raw materials in the original cultivation sites, merely fueled expansion of operations by unregulated transfers of seedlings to new farming areas to meet global demands; d) Even after expansion of operations, much of the current tropical carrageenophyte farming efforts are still dependent on rudimentary, labor-intensive technologies; e) Use of plastic attachments for hanging seedlings on cultivation lines continues to contribute to plastic pollution in the oceans and there is a cost to its removal at the point of raw materials processing; f) There is considerable promise in the recently introduced tubular-net bags for farming in Brazil, Indonesia and India; g) There is seemingly stagnation in innovation and the research and development required for biomass production by the carrageenan industry, which still largely focuses on gels for processed food applications; h) It is encouraging that Multi-stream Zero Effluent (MUZE) processing is gaining ground in India and Indonesia.

A shift in innovation from simple cultivation to technical seaweed agronomy for eucheumatoids is imperative in order to sustain positive outcomes, such as: enhancement of human resource capacity, diversified livelihoods, adoption of sound, ecosystem-based management principles, sustainability of operations through resiliency to climate change and secured environmental and crop sustainability and food security. Sustainability of commercial farming of seaweed is imperative to meet the increasing demand in the global market as: 1) direct sources of human food; 2) indirect sources of human food; 3) as a feed/supplement component to poultry, hogs, fish, and companions animals; 4) as source of gelling hydrocolloids (i.e. agar, alginate and carrageenan; 5) sources of bio-stimulant for agricultural crops and horticulture, as well as red seaweed cultivation and mitigation of their pests and disease; and 6) as components for personal care products.

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Sponges and their potential uses

Ranjith Edirisinghe, RU, Sri Lanka

Marine Sponges show greater diversity especially on the temperate reefs and estimated number are as 5000-9000 species in the world. Sponges belong to Kingdom Animalia, Phylum Porifera which can be classified into 3 main classes – Calcarea, Hexactinellida and Demospongiae. They are multicellular organisms and possess a simple body arrangement without organized tissues or organs.

Marine reefs are highly crowded and extremely competitive ecosystems due to limited space and nutrients. They are expected to depend heavily on secondary metabolites that are toxic or

objectionable to their competitors. Predictably they are a rich sources of natural products with diverse and potent biological activities such as in terpenoids, steroids, alkaloids, peptides, poly-ketides, etc.

The sponges use secondary metabolites available in their body as defensive chemical weapons for their protection which are rich in terpenoids, steroids, alkaloids, peptides, poly-ketides, etc. Those Natural products (secondary metabolites) are a critical resource in the search for new pharmaceuticals, agrochemicals and other useful chemicals. For example, a majority of the pharmaceuticals currently in clinical use are natural products or are derived from them. At present, almost all commercially important natural products have been derived from terrestrial sources (mainly plants and soil microorganisms) and now there is a trend to investigate marine sponges for their natural chemical products.

Sponges are important as they provide multitude of functions on reefs such as food for other organisms, forms numerous symbiotic associations and maintains reef health. Many species are highly colourful and attractive which enhances the beauty of reefs and several species utilized in the ornamental fish industry. Some examples for pharmacologically important metabolites of sponges arealyculins from *Discodermiacalyx* (a novel antitumor metabolite), Discodermolide from *Discodermiadissolute* (inhibit *in vitro* proliferation of P388 murine leukemia cells Inhibit the growth of *Candidaalbicans,* Latrunculins from *Latrunculia magnifica* (disrupt microfilament organization in cultured cells) Spongistatins from *Spongia* sp. and *Spirastrella* sp. (act as antineoplastic agents).

Limited studies have been conducted on sponges in Sri Lanka. Biodiversity of these reefs is largely unrecorded and represent mostly unexplored and untapped resource for the discovery of biomolecules with potential applications. The challenges are such as sampling which need Scuba diving skills, lack of knowledge on sponges and other marine resources, lack of facilities for taxonomic identification of sponges and for advanced analysis (such as HPLC, NMR), structural determination, drug design etc. have to be overcome. At the moment there are number of joined projects that are established between Sri Lankan Universities/Institutes and foreign collaborators to work on marine sponges in Sri Lanka especially on species *Haliclona (Soestella)* sp. and *Neopetrosiasp* with the focusing on their taxonomic identification, study of immune-pharmacological, anticancer and toxicological characters and isolation these compounds for use in pharmaceutical industry.

Key discussion points – Technical Session II

- Identification of populations of target species using common genetic markers and get expertise knowledge for intensifying conservation programmes in the region.
- Proper studies should be conducted on threatened status of the species; their populations and biology, adaptability to *ex situ* conditions and value addition ability.
- Need to share good practices such as access and control rights – equal rights; socio-economic barriers, regional centers should be established for shared services.
- Gender segregated data of the people should be collected and their critical issues have to be addressed such as health, education, etc.
- Databases should be developed for non-commercial species including information in publications and issues on IP rights should be addressed; development of a decentralized breeders' registry for brood stock holdings.
- Strategies need to be implemented for conservation and sustainable utilization of marine genetic resources such as hands-on training experience for farmers; get support from experts and policy makers; identification of marine resources and their potential usage should be investigated; monitor species resilient to climate change and their adaptations.

TECHNICAL SESSION III

World Café Discussion – Regional Priorities for Underutilized Fish and Marine Genetic Resources (FMGR)

Co-Chairs: D.H.N. Munasinghe, UoR, Sri Lanka and Kuldeep K. Lal, ICAR, India
Rapporteurs: Sujeewa Ariyawansa, NARA, Sri Lanka and Ashoka Deepananda, UoR, Sri Lanka

Conservation, Improvement and Use

Application of strategic plans for conservation and sustainable utilization has been recognized in order to prevent losses in the fisheries industry. Therefore, finding ways for better utilization of marine resources and conservation of over-utilized resources are key points that need to be addressed. The initial point of conservation of marine genetic resources is the identification of over-utilized and underutilized FMGR in each country. To prevent over-utilization of marine resources, policies and regulations should be implemented on catch size, prohibited seasons, fishing gear, etc. Those regulations have been documented in many Asia-Pacific countries although magnitude of its applications is varying within the region.

Biotechnological tools could be applied in *ex situ* and *in situ* conservation methods which support to protect endemic and endangered species. Special attention need be paid when introduce exotic species and their threat on native species should be evaluated. Comprehensive studies should be carried out using molecular markers on species identification and phylogeographic, phylogenetic and stock assessment of populations to identify Management Units and Evoutionary Significant Units for sustainable utilization and conservation purposes. Underutilized resources should be identified for utilize as substitutions for vulnerable or threaten species due to over-exploitations. Knowledge and skill transfer among countries to upgrade the biotechnological applications will be an advantage to improve the conservation and development of the marine resources of the region.

Value Addition, Marketing and Export

Value addition is one the major point focus particularly in fish processing industry, mainly because of the increased opportunities, the activity presents for earning foreign exchange. A large number of value added and diversified marine fish products both for export and internal market based on shrimp, lobster, squid, cuttle-fish, bivalves, farmed fish and minced meat from low priced fish have been identified. Instead of priority as a food source, investigations should be initiated to other uses of marine resources such as new enzymes (bio catalysts), secondary metabolites, etc. When develop new byproducts from different sources, it requires a comprehensive analysis of species characteristics such as texture forming properties, flavor and colour characteristics, frozen stability, etc. The main constrains for value addition in many developing countries are lack of technology, knowledge and the infrastructure facilities.

Besides value addition, identification of potential markets at national and international level is another possible approach to raise the profitability of fisheries industry. Modern techniques need to be introduced to minimize the accumulation of trash fish accumulate due to by catch of commercial species and the waste originate during processing fish for export markets or when prepare value added products. Consumption of value-added products could be promoted through media and awareness programmes with the target of establishing local and international markets. Disruption of continuous supply due to lack of products and data have been identified as the main limitations for maintaining the export market.

Biotechnology for Enhancing Utilization

Biotechnological methods could be applied to upgrade the fishery industry from its initial step until it proceeds to the marketed product. Establish germplasm and genomic repositories could be used to enhance the breeding techniques and thus, produce more improved varieties. Various strategies such as hybridization techniques, production of mono sex cultures and analyses of inbreeding levels are applied to enhance the quality of the product. Molecular techniques such as marker-assisted selection and characterization support to produce economically important traits and marketable products.

However, when consider Asia-Pacific region, some countries such as India, Thailand and Taiwan use more advanced biotechnological methods to enhance the product of fisheries industry. Application of micro-propagation techniques for seaweed farming is already being practiced in Philippines**.** Due to lack of knowledge and facilities in some countries such as Sri Lanka, Nepal and Bhutan, genetic potential of commercially important fish species have not been identified and suitable breeding programmes to enhance economically valuable traits have not been developed. Molecular characterization of economically important and endemic fish species has not been reported from many developing countries. Another major issue is to find out year-round brooders due to sexual dimorphisms of species that show potential for culture (e.g. Grouper). Although seaweed is commonly available in many Asia-Pacific countries, only few countries have taken the advantage to take up the seaweed farming industry up to a commercial level.

Partnership and Capacity Building

Partnerships provide incentive for all the stakeholders such as fishermen, scientists and managers to make decisions that will be in their interest as well as contribute to development of sustainable fisheries industry. Partnerships between community and industry are important to protect indigenous knowledge related to marine resources and their utilization in different fields. There is a trend that governments of many countries establish public-private partnerships to mobilize finance, skills and experience to support development of the industry. Especially, partnerships between publicly funded national research institutes and the private sector are key drivers of technological progress in the process of exploring un-utilized marine genetic resources. Partnerships extended by other government institutes facilitate to implement policies and regulations in order to development and conservation of marine resources.

Capacity development involves various initiatives to support the achievement of research and development outcomes, with a strong emphasis on partnerships. In many developing countries lack of human capacity and financial resources is a major obstacle to developing the necessary

institutions, planning and implementing a strategic approach to use, develop and conserve marine genetic resources. Capacity development activities such as common regional database building with the help of expertise in regional countries, establish a region wide common process for certifications, standards and food safety, co-management of aquatic genetic resources and utilization could be implemented through well-established partnership programmes. Areas that have been identified for capacity development related to underutilized marine genetic resources in Asia-Pacific region are: genetic improvements by selective breeding and genetic modifications, application of molecular marker technology, aquatic genetic resources cataloging and management, stock assessment of exploited species, taxonomy and genetic identification, landscape approach for *in situ* conservation, diseases diagnostics, surveillance and management.

Regional Information Sharing System and Focal Point

Development of information sharing systems at different levels from national system to regional and then to international system are effective tools to secure genetic information of fish and marine genetic resources. Networking among such databases is important in linking stakeholders, and in supporting institutional development and capacity building. It has been identified the need of information sharing system which is governed under a recognized focal point in order to enhance utilization and conservation of genetic resources within the region. Well-established information sharing system support to promote information exchange within and between the organizations and countries, utilization and sharing of genetic resources among participants, avoid duplications of efforts in the field and enhance the coordination of research and training among stakeholders is also equally important.

TECHNICAL SESSION IV

Panel Discussion on Legal and Policy Framework Support to Promote the Sustainable Use of Underutilized Fish and Marine Genetic Resources – Perception of Panelists

Co-Chairs: J.K. Jena (ICAR, India) and S. Thayaparan (King Aqua Services Pvt. Ltd, Sri Lanka)
Rapporteur: Shyamalee Weerasekara (NARA, Sri Lanka)

Simon Wilkinson *(NACA, Thailand)*

Access and benefit sharing are highlighted as the prime task of the presentation. In the beginning, access to genetic resources was opened and often regulated. Convention for Biological Diversity (CBD) that carry sovereign right to declare the genetic resources was introduced in 1992. CBD protects the genetic resources, and permission or informed consent has to be taken to use the resources. Also, it has the requirements that one needs to share the benefits accrued due to use of the resources. The provision in CBD are for the conservation purposes. But, unintended consequences of CBD are the real problems. Main issue for scientists is that conventional biological diversity also bound with genetic resources that we used for food and agriculture. During the human civiliztion sharing germplasm was fundamental, that needs to develop new varieties of plants and new breeds. Presently, scientists cannot proceed any more due to legal bindings. With respect to the fish, getting permit for sharing germplasam is pre-requisite. Fish in reservoirs of a country need new varieties develop in captivity to perform well in reservoirs. But permit from the environmental agency has to be taken to develop/make a new fish variety. Genuine research for conservation purposes as well as for management purposes are blocked by present restrictions. Sampling that scientists need for research to protect the resources has been restricted. Such restrictions have negative impacts. For instance, study on population genetics reveals the stock structure, which is important for management of the resource. Cryptic species have been recognized by questioning in same way.

Furthermore, solution for restricting research by CBD was elaborated. Issues in plant sector (agriculture) and aquaculture and fisheries sectors have been recognized very early. In 2004, FAO negotiated the treaty of plant genetic resources in agriculture, and necessity for taking permit by the researchers for the list of common food producing crops has been exempted.

Consequently, new more productive genetic resources could be developed in agriculture. Thus, it was stressed that similar instrument is a must to support the productivity of fisheries and aquaculture. Such a development is vital for aquaculture and aquatic resources and for animals in general, emphasizing the priority issues that countries need to be addressed particularly relevant to Asia-Pacific region. In this context, long-term projects that countries can work together and genuine scientific research for better management purposes were proposed.

Achini M. De Silva *(SU, Sri Lanka)*

It needs to understand the matters discussed during first two days of the workshop on legal and policy framework support for sustainable use of underutilized FMGR. What resources we really need at present and how much we depend on species, while improving existing species to use in sustainable way were highlighted as missing points in sessions and discussions. Food and nutritional needs, especially Zn and Fe deficiency in South-East Asia is critical. Through diversification of meals, use of underutilized fish and marine genetic resources for protein, micronutrient antioxidants are discussed by the panelists. However, underutilized fish and marine genetic resources should also be considered in filling the gap for micronutrient or protein supplement. Food protein security is one factor that need to be addressed. Resource availability in any country, mitigation measures to climate change issues, and resilient and vulnerability of existing commercial species are important points to be discussed. Thus, it is essential to get strong information on new varieties, existing species and nutritional profile of species to promote the indigenous aquatic environment. Use of fish and marine genetic resources in a commercially useful way is important point to be discussed further. Scientists should have avenues to access the resources for research. In this context, government and all universities should be linked to get the information. Storing and sharing acquired information and knowledge with other countries of the region are essential, and mechanism should be implemented for this purpose. This information can be on genetic resources, commercial use or post-harvest and processing methods. This kind of umbrella strategy is the way to share the knowledge gained by researchers. Improving genetic resources of existing commercial varieties, legal and policy issues in sharing genetic resources, use of traditional knowledge, and formation of new employments can be done through improving knowledge base. Therefore, identifying what kind of policy and legal support we needed has a paramount importance. There should be a policy intervention for sustainable use of fish and marine genetic resources. Conservation of biodiversity is well documented and, therefore, problems arise when accessing the resource base. Thus, legal framework should be implemented, defining access rights especially for rural community. Furthermore, there is a high potential and opportunities in marine and freshwater ornamental fish industry. But policy should be implemented specifying how wild relatives can be exploited to develop new varieties. In addition, new hybrid varieties to substitute current food fishes should be developed. There should be a legal and policy support for this process.

Anicia Hurtado *(UPV, Philippines)*

Fisheries aspects particularly with respect to the seaweeds are lined up to four eye cap areas for policy making or frame working. First, conservation of seaweed resources is important in Asia-Pacific. Nowadays, concerning conservation of seaweeds, there are lot of policies, specifying what kind of species to be gathered. Seaweeds are excellent source for marine drugs, especially in health research. Exploration of seaweeds in countries like Sri Lanka need to go beyond from taxonomic research to bioactive compounds. Countries like Sri Lanka are recommended to culture the species like *Kappophycus, Eucheuma* and *Gracilaria*, that have high demand globally. In this regard, countries need to have some rules for biosecurity, and there are existing rules made by the FAO. Second, good aquaculture practices should be followed by the countries over the globe. Also, seaweed aquaculture should be carried out scientifically to have sustainable industry in future. It is essential to pay special attention in cultivating seaweed for export market. For instance, moisture content of *Kappophycus* species and carrageenan contents are major concern by byers. In this regard, there is a standard for the carrageenan contents in seaweed. Export will be accepted by the buyers only if the carrageenan contents is over 35%. Furthermore, quality of the carrageenan is important, and viscosity will be assessed in this regard.

Hsin-ming Yeh *(COA, Taiwan)*

Database for fish and marine genetic resources will have a research and financial value. In this regard, establishment of database, having easy access is important for sustainable resource use and management of fish and marine genetic resources in future. This is important in several ways. First, genetic resources contribute directly to the efforts of scientists who are working on global warming. Second, the magnitude and speed of climate change need to be identified. Third, sustainable fishery is a key to reserve the fish and marine genetic resources. Overfishing or any environmental damage affect the genetic resource, damaging ecosystem, and resulting overall deterioration of natural resources.

Pathma Abeykoon *(MMDE, Sri Lanka)*

(Mr Monty Ranathunga of Fisheries Sector of the Ministry, Sri Lanka presented the recommendations on behalf of the panellist).

Sri Lanka have prepared the Fisheries and Aquatic Resources Policy that has already been approved by the Cabinet of Ministers as well as the Parliament of Sri Lanka. This document is a policy framework and limited to Sri Lanka. Thus, regional cooperation for the fisheries and aquatic resources is still a doubt. However, results of the Dr Fridtjof Nansen research vessel survey which has exposed many underutilized fish species has shown that regional cooperation is possible on underutilized FMGR to use the resources in sustainable manner. In addition, Norway has already agreed with the government of Sri Lanka to carry out a survey on marine fishery resources, and there is a high possibility to cooperate with several other countries in the region, if they are willing to request to Norway through the FAO. This regional cooperation would be possible from the beginning of the next year.

Ali Salarpouri *(AREEO, Iran)*

Current legal and policy framework should be further improved in order to direct sustainable utilization of underutilized FMGR. In this regard, conservation of ecosystems through ecosystem-based management of FMGR and for improving the quality of life and the livelihood of consumers through sustainable exploitation of marine fishery resources were highlighted. Further, it is essential for sharing the information by the beneficiary on biotechnology and enhancement methods of underutilized fish resources. Conservation of marine resources and management is important, and these aspects should be considered for utilizing underutilized FMGR. In this regard, legal and policy frameworks formed by international associations like UNCLOS and IUCN are important and needs to be followed.

Tevita Vodivodi *(MOF, Fiji)*

Three points were highlighted in the presentation. First, legal and policy frameworks should be science-based, and they should be in the format that any layman can understand. It is necessary to keep the information in the format that decision makers can understand legal and policy framework. This is important for their perception and effective decision making. Second, everyone in this forum have responsibility to drive this information on underutilized FMGR fish and marine genetic resources, and need to advice the decision makers in different countries of the region. Third, agree with the the points highlighted by Simon Wilkinson about CBD.

Rachel June Ravago-Gotanco *(UPD, Philippines)*

Legal and policy framework which was mentioned by Simon Wilkinson (NACA, Thailand) is important matter to be highlighted. Data are very important in this regard, and there should be regional database on FMGR. Therefore, it is necessary to have a fruitful discussion on how species should be prioritized for getting funds. Species prioritization can be done at the country level, as different countries in the region have their own problems or issues in the process of decision making to prioritize the species. In the decision-making process, it is necessary to communicate systematically with all stakeholders and governments on legal and policy framework from top down to bottom up level and bottom up to regulatory authorities. Thus, each country should identify important stakeholders to facilitate the process. The decision should be made available for others. Therefore, all countries of the region should contribute to form regional database.

Key Discussion Points – Technical Session IV

(Discussants: J.K. Jena, Tevita Vodivodi, Monty Ranathunga, Rishi Tyagi, Prabath Jayasinghe, Anyanee Yamruingrueng, Hsin-ming Yeh, Chaminda Walpita)

1. Standardized definition for the underutilized FMGR should be developed. This is important, as there are enormous number of underutilized FMGR, and measures should be taken to conserve and effective management of the resources.
2. Comprehensive specific policy for the underutilized FMGR should be developed according to the purpose of use and its requirements. For instance, use for ornamental, biotechnological or pharmaceutical purposes in which simple and specific policy may be implemented at regional level through science-based research. While developing the policy for underutilized FMGR, environmental concerns such as introduction of new species to environment and environmental pollutions should be considered.
3. In the process of implementation, policies, acts that based on policies and finally, regulations that specify how acts are implemented could be prepared. Therefore, it was suggested that APAARI may consider to organize the next workshop focusing on policy making for underutilized FMGR for those who are involved in policy development and decision-making process.
4. The economic and policy analysis tools are needed to facilitate decision makers to take decision for effective management of underutilized FMGR. It is essential to develop scientific tools to convince policy makers the impact of underutilized FMGR for food security and to strengthen the economy through improving the livelihoods of fisherman community.
5. Assessing economic potential of the underutilized FMGR should be considered as an important point. Policy decisions should be based on those aspects, as marketing is very important. The workshop also will help small entrepreneurs to develop and utilize marine genetic resources. Thus, marketing and inventory of marketing system were discussed. Consequently, with the involvement of private sector, knowledge gap can be filled, local market system can be strengthened, and potential for spots can be assessed. This would help to develop knowledge base at national level, assess the existing marketing system, and improve fish and marine genetic resources.
6. Workshop anticipates that it is necessary to develop the network among the experts working on FMGR. It is suggested to identify a focal point in each country to develop the network and partnership

among countries in the region. It is essential to convince donors that experts are available in all participted countries to collaborate the projects on underutilized FMGR. Discussants proposed that at least few collaborative projects can be initiated as a fruitful outcome of the workshop. Management and effective utilization of resources was discussed as very important. It was suggested to identify few important species (5-6) available in several partner countries to initiate collaborative projects.

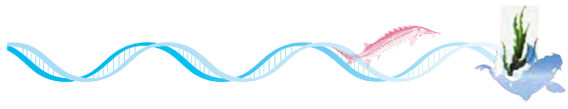
7. The way forward of outcome of the workshop at the regional level were discussed. In this regard, capacity building or knowledge sharing seminars/workshops were suggested to be organized. In addition, market linkages should be exposed to all stakeholders and further discussion were proposed. Resource sharing especially with respect to the sharing of species should be carefully handled, as each country has their own rules and regulations on import/export of the species.
8. The type of underutilized FMGR that are harvested and potentials of their usage in future were highlighted as a one of the important points for further discussion. The effects of using underutilized fish and marine genetic resources to the ecosystem was also discussed and considered.
9. Importance of the outcome of Dr Fridtjof Nansen research vessel survey for the countries of the Bay of Bengal was thoroughly discussed and discussants highlighted the relevance of its results on FMGR which should be made available to all countries of the region.
10. Marine ornamental fish industry and possible transportation of pathogens with the fishes were discussed, and discussants highlighted that issues of the industry should be considered in holistic way and further discussions is needed for developing a policy for the private sector.
11. Establishing a task force, including all stakeholders was discussed for conservation and management of underutilized FMGR. In this context, every country should have a task force to conserve and manage the FMGR at national level.

Closing Remarks

Dr J.K. Jena, Deputy Director General (Fisheries), ICAR, India, and Chair of the Plenary Session, mentioned that the workshop has been very useful to discuss and deliberate about the important issues of underutilized marine resources which were essentially needed the due attention at this hour. He expressed his happiness that every participant contributed significantly to the discussion during the workshop and the recommendations emanated from the discussion will be useful in long way through implementation by the concerned countries in Asia-Pacific region. He mentioned that India has developed the expertise in *ex situ* conservation methods and application of biotechnology tools for characterization and conservation of fish genetic resources and assured to extend the collaboration with the other countries in these areas to develop the capacities in the region. Dr Jena thanked APAARI, SLCARP and NARA for successful organization of the regional workshop.

Dr Rishi Tyagi, Coordinator, APCoAB, APAARI, expressed his satisfaction about the organization of the workshop which has been very successful as it covered most of the relevant aspects of underutilized FMGR. The discussion and deliberations during the workshop led to very important recommendations for management and sustainable use of marine genetic resources. He assured that proceedings will be brought out by APAARI and shared with all the participants and stakeholders in the region for sustainable utilization of FMGR. He mentioned that SLCARP is very valuable partner of APAARI and now NARA is also explored to have more future collaboration in the areas related to fisheries. Finally, he proposed vote of thanks to authorities of SLCARP and NARA, experts, participants, co-organizers and staff of APAARI. He also thanked the Committee Members of SLCARP and NARA for their valuable contribution in efficient organization of the workshop.

Major Recommendations



Major recommendations emanated during the deliberations and discussions in the workshop are mentioned below:

Conservation, Improvement and Use

1. Develop strategic plans for conservation and sustainable utilization at by establishing a task force including all stakeholders at national level to check the loss of genetic resources due to over-utilization of FMGR and conservation and sustainable use of FMGR.
2. Identify underutilized species to utilize as substitutes of vulnerable, and threatened and over-exploited species. Also, degraded fishing grounds should be identified and strategies for their restoration by establishing marine parks with demarcating specific zones to be developed at national levels.
3. Employ various strategies such as hybridization techniques, production of mono sex cultures and analyses of inbreeding levels to enhance the quality of the products. National conservation programmes should be in 'Mission Mode' not in 'Project Mode' to ensure the availability of resources.
4. Develop captive breeding techniques to establish selective breeding programmes for commercially important traits.
5. Identify, prioritize and develop new marine resources that have not yet been investigated and establish genome resource banks for both conservation and breeding purposes.
6. Economic and policy analysis tools to be developed to facilitate the policy makers to take decisions for conservation and sustanaible utilization.

Value Addition, Marketing and Export

1. Introduce simple and cost-effective methods/technology at household levels through awareness programmes and improve infrastructure facilities to produce alternative value-added food sources.
2. Improve and promote culture-based method in association with genetic tools to reduce the pressure on natural fishery resources and establish alternative livelihoods.
3. Along with the priority as food source, investigations should be initiated other uses of marine resources e.g. seaweeds, sponges can be used for production of new enzymes (biocatalysts), secondary metabolites, pharmaceutical products, etc. While developing new byproducts, it requires a comprehensive analysis of species characteristics such as texture forming properties, flavor, colour, frozen stability from safe use point of view.
4. Develop and maintain regionally accepted common standards for branding the products and trade negotiation among regional countries to expand international markets.

Biotechnology for Enhancing Utilization

1. Apply biotechnological tools, wherever possible, for *in situ* and *ex situ* conservation of genetic resources to protect the endemic and endangered species.
2. Comprehensive studies should be carried out using molecular markers for species identification and phylogeographic, phylogenetic and stock assessment of populations.
3. Molecular markers need to be applied for selection and characterization to identify the economically important traits to develop quality breeds and better marketable products.
4. Identify and establish suitable micro-propagation methods of selected seaweed types to enhance the seaweed farming.
5. Establish policies and regulations, exchange knowledge, techniques and resources among countries to enhance the utilization and development of marine resources in the region.

Partnership and Capacity Building

1. Explore the possibility to establish an inter-governmental/regional cooperation body to assess the capacity building needs and gaps at the regional level, strength and weakness of the nations, possible modalities of capacity and partnership building.
2. Develop collaborative programmes at regional or sub-regional level with sufficient funding to identify research capacities of national partners and sharing or exchange the technology, knowledge, infrastructures and expertise, standardize material transferring protocols (genetic or live samples), share repositories to facilitate safe custody of germplasm accessions and exchange for research.
3. Capacity development related to underutilized FMGR in Asia-Pacific region are needed in areas such as genetic improvements by selective breeding and genetic modifications, application of molecular marker technology, aquatic genetic resources cataloging and management, stock assessment of exploited species, taxonomy and genetic identification, landscape approach for *in situ* conservation, diseases diagnostics, surveillance and management, and food safety.
4. PCB is needed between countries for sharing water and genetic resources to harmonize policies on introduction of aliens/exchange of germplasm in region and outside region, transboundary movement of aquatic organisms, quarantine and disease management and access benefit sharing of programmes.

Regional Information Sharing System and Focal Point

1. Existing commodity-wise national databases to be enriched with other relevant metadata of the species including the conservation status that is maintained in a standard format which may eventually be developed/linked to the regional database at later stage.
2. Mechanism to be developed for sharing the information in accordance to National laws keeping in view the IPRs.
3. A duplicate set of databases should be maintained preferably in more than one country as safety back-up.

4. Addition of any information should be allowed with the approval of an authorized system administrator and expert committee of the Focal Point which may be identified in each country and the region.

Action Points for APAARI

Subjected to availability of resources, APAARI, under its programme APCoAB, needs to take up following action points:

1. In collaboration with other organization, focused capacity building programmes may be organized for the researchers of APAARI member countries for conservation and utilization of FMGR.
2. Facilitate in organization of regional expert consultation/workshop for developing the enabling policies for conservation and sustainable utilization of underutilized FMGR.
3. Facilitate for developing partnerships and the technical and professional assistance to APAARI member countries based on their requests.

Appendix 1: List of Participants

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Appendix 2: Technical Programme

Regional Workshop on Underutilized Fish and Marine Genetic Resources of Asia-Pacific and their Amelioration

TECHNICAL PROGRAMME

Date: **July 10-12, 2019**
Venue: **National Aquatic Resources Research and Development Agency (NARA), Colombo, Sri Lanka**

DAY 1: MONDAY; JULY 10, 2019

08:00 – 09:00	Registration	
09:00 – 10:30	Opening Session	
	Welcome Address	D.T. Kingsley Bernard, Chairman, SLCARP, Sri Lanka
	Remarks	Rishi Tyagi, APAARI, Thailand
	Remarks	Hsin-ming Yeh, COA, Taiwan
	Remarks	E.A.S.K. Edirisinghe, Chairman, NARA, Sri Lanka
	Address by Guest of Honour	Hon'ble Dilip Wedaarachchi, State Minister of Agriculture, Livestock Development, Irrigation and Fisheries and Aquatic Resources Development, Sri Lanka
	Inaugural Address by Chief Guest	Hon'ble P. Harison, Minister of Agriculture, Livestock Development, Irrigation and Fisheries and Aquatic Resources Development, Sri Lanka
	Vote of Thanks	Frank Niranjan, SLCARP, Sri Lanka
	Group photo and Tea/Coffee Break	

TECHNICAL SESSION I

Thematic Presentations on Underutilized Fish and Marine Genetic Resources

Co-Chair: J.K. Jena, ICAR, India
Rapporteur: Suseema Ariyaratna, NARA, Sri Lanka

10:30 – 10:50	Mainstreaming the biodiversity in fisheries and aquaculture with special reference to underutilized resources, Thailand	Praulai Nootmorn, DOF, Thailand
11:50 – 11:10	Conservation and sustainable use of fisheries and aquaculture in the Pacific	Simon Nicol, FAO – RAP,Thailand (Via Skype)
11:10 – 11:30	Fridtjof Nansen survey around Sri Lanka – Recent studies	Prabath Jayasinghe, NARA, Sri Lanka
11:30 – 11:50	Possible alternative uses including non-food uses of underutilized FMGR	Chamari Dissanayake, USJ, Sri Lanka
11:50 – 12:20	***Discussion***	***All Participants***
12:20 – 13:30	*Lunch*	

TECHNICAL SESSION II
Strategies for Conservation and Utilization of Underutilized Fish and Marine Genetic Resources

Co-Chairs: Monty Ranathunga, Fisheries Sector of the Ministry, Sri Lanka and Praulai Nootmorn, DOF, Thailand
Rapporteur: Deishini Herath, NARA, Sri Lanka

13:30 – 13:50	Applications of biotechnologies in *ex situ* conservation, characterization and utilization	J.K. Jena, ICAR, India
13:50 – 14:10	Access and benefit sharing of fish and marine genetic resources – Legal considerations	Pathma Abeykoon, MDE, Sri Lanka
14:10 – 14:30	Inclusive development including gender equality of small-scale fisheries and aquaculture	Achini De Silva, SU, Sri Lanka
14:30 – 15:00	***Discussion***	***All Participants***
15:00 – 15:30	*Tea/Coffee Break*	
15:30 – 16:10	Information System of fish and marine genetic resources	Simon Wilkinson, NACA, Thailand
16:10 – 16:30	Sea weeds: farming and its sustainable use	Nicholas Paul, USC, Australia
	Sponges and their Potential uses	Ranjith Edirisinghe, RU, Sri Lanka
16:25 – 17:00	***Discussion***	***All Participants***
18:00 – 20:00	*Reception Dinner Hosted by APAARI in Pegasus Reef Hotel*	

DAY 2: TUESDAY; JULY 11, 2019

TECHNICAL SESSION III
Country status Reports on Underutilized Fish and Marine Genetic Resources

Co-Chairs: Hsin-ming Yeh, COA, Taiwan and Palitha Kithsiri, NARA, Sri Lanka
Rapporteurs: Sujeewa Ariyawansa, NARA, Sri Lanka and Ashoka Deepananda, UoR, Sri Lanka

South and West Asia		
09:00 – 09:20	Bhutan	Gopal Prasad Khanal, DOA, Bhutan
09:20 – 09:40	India	Kuldeep K Lal, ICAR, India
09:40 – 10:00	Iran	Ali Salarpouri, AREEO, Iran
10:00 – 10:20	Sri Lanka	Varuni Gunathilake, USJ, Sri Lanka
10:10 – 10:40	Nepal	Neeta Pradhan, NARC, Nepal
10:40 – 11:10	*Tea/Coffee Break*	
11:10 – 11:30	Pakistan	Rehana Kauser, NARC, Pakistan
11:30 – 12:00	***Discussion***	***All Participants***
12:00 – 13:00	*Lunch*	

TECHNICAL SESSION III

Country Status Reports on Underutilized Fish and Marine Genetic Resources (Contd.)

Co-Chair: Varuni Gunathilake, University of Sri Jayawardenapura, Sri Lanka
Rapporteurs: Sujeewa Ariyawansa, NARA, Sri Lanka, Ashoka Deepananda, UoR, Sri Lanka

South-East and East Asia		
13:00 – 13:20	Lao PDR	Latsamy Phounvisouk, NAFRI, Lao PDR
13:20 – 13:40	Malaysia	Masazurah A. Rahim, DOF, Malaysia
13:40 – 14:00	Philippines	Rachel June Ravago-Gotanco, UPD, Philippines
14:20 – 14:40	Taiwan	Hsin-ming Yeh, COA, Taiwan
14:40 – 15:10	*Tea/Coffee Break*	
15:10 – 15:40	Thailand	Anyanee Yamrungrueng, DOF, Thailand
15:40 – 16:00	Fiji	Tevita Vodivodi, MOF, Fiji
16:00 – 16:30	***Discussion***	***All Participants***

TECHNICAL SESSION IV

World Café Discussion – Regional Priorities for Underutilized FMGR

Co-Chairs: D.H.N. Munasinghe, UoR, Sri Lanka and Kuldeep K. Lal, ICAR, India
Rapporteurs: Sujeewa Ariyawansa, NARA, Sri Lanka, Ashoka Deepananda, UoR, Sri Lanka

16:30 – 18:10 (About 20 min. for a group of about 10 participants on each table)	**Moderator:** Rishi Tyagi **Table 1**. Conservation, improvement and use (**Host/Facilitator**: R.M.G.N. Thilakaratne, Sri Lanka) **Table 2.** Value addition, marketing and export use (**Host/Facilitator**: M.M.A.S. Maheepala, Sri Lanka) **Table 3.** Biotechnology for enhancing utilization (**Host/Facilitator**: S.S. Herath, Sri Lanka) **Table 4**. Partnership and capacity development utilization (**Host/Facilitator**: V. Pahalawattaarachchi, Sri Lanka) **Table 5.** Regional information sharing system and focal points (**Host/Facilitator**: S. Hettiarachchi, Sri Lanka)
17:10 – 17:45	Compilation of Recommendations: By all Hosts/Facilitators of each table
	Farewell Dinner Hosted by SLCARP

DAY 3: WEDNESDAY; JULY 12, 2019

TECHNICAL SESSION V

Panel Discussion on Legal and Policy Framework Support to Promote the Sustainable Use of Underutilized Fish and Marine Genetic Resources

Co-Chairs: J.K. Jena, ICAR, India and S. Thayaparan, King Aqua Services Pvt. Ltd., Sri Lanka
Rapporteur: Shyamalee Weerasekara, NARA, Sri Lanka

09:30 – 10:45	Perception of 7-8 Panellists (8 min each)
	Simon Wilkinson, NACA, Thailand
	Achini De Silva, SU, Sri Lanka
	Anicia Hurtado, UPV, Philippines
	Hsin-ming Yeh, COA, Taiwan
	Padma Abeykoon, MMDE, Sri Lanka
	Ali Salarpouri, AREEO, Iran
	Tevita Vodivodi, MOF, Fiji
	Rachel June Ravago-Gotanco, UPD, Philippines
10:45 – 11:10	***Open Discussion***
11:10 – 11:30	*Tea/Coffee Break*

PLENARY SESSION

Co-Chairs: J.K. Jena, ICAR, India and Monty Ranathunga, Fisheries Sector of the Ministry, Sri Lanka
Rapporteur: Prajanee Heenatigala, NARA, Sri Lanka

11:30 – 12:30	Presentation of recommendations of Technical Sessions/World Café Discussion	Rapporteurs of each Session/ Discussion
12:30 – 12:40	Brief remarks by the Co-Organizers 2-3 min. each)	Representatives of SLCARP, ACIAR, COA, APAARI
12:40 – 12:50	Remarks by the Co-Chairs (5 min. each)	
12:50 – 12:55	***Vote of Thanks***	Rishi Tyagi, APAARI, Thailand
13:00 – 14:00	*Lunch*	
Departure		

Appendix 3: Organizing Committees

International Organizing Committee

Co-Chair	Ravi K. Khetarpal, APAARI, Thailand
Co-Chair	Rishi K. Tyagi, APAARI, Thailand
Member	V.K. Sah, APAARI, Thailand
Member	Thansita Thanaphatrujira, APAARI, Thailand

National Organizing Committee

Chair	N.B.M. Ranathunga, Ministry of Agriculture, Rural Economic Affairs, Livestock Development, Irrigation and Fisheries & Aquatic Resources Development - Fisheries Sector, Sri Lanka
Coordinator	Frank Niranjan, SLCARP, Sri Lanka
Member	V. Pahalawattaarachchi, NARA, Sri Lanka
Member	J.M. Ashoka, NADA, Sri Lanka
Member	K.R. Gamage, University of Ruhuna, Sri Lanka
Member	S. Thayaparan, King Aqua Services Pvt. Ltd., Sri Lanka
Member	S.S.S. de S. Jagoda, University of Peradeniya, Sri Lanka
Member	H.D.N.K. Hettiarachchi, Department of National Planning, Sri Lanka
Member	S.J. Kahawatta, Department of Fisheries & Aquatic Resources, Sri Lanka

Registration Committee

Chair	N.B.S. Darshanie, SLCARP, Sri Lanka
Member	S.R.M.P. Himansha, SLCARP, Sri Lanka
Member	P.G.C.L. Sumanasinghe, SLCARP, Sri Lanka
Member	A. Nisansala Perera, NARA, Sri Lanka
Member	L. Dilukshani, NARA, Sri Lanka
Member	S. Sudarshani, NARA, Sri Lanka
Member	M.P.M.T. Karunaratne, NARA, Sri Lanka
Member	R. Manori, NARA, Sri Lanka
Member	T.G.S.M. Madhusahnaka, NARA, Sri Lanka

Venue, Auditorium, Food and Transport Arrangement Committee

Chair	S.M.P. Chandra Padmini, Senior Scientist, SLCARP, Sri Lanka
Member	L.G. Hettiarachchi, SLCARP, Sri Lanka
Member	D.S.S. Dissanayake, SLCARP, Sri Lanka
Member	B.M.U.S. Basnayake, SLCARP, Sri Lanka

Member	D.M.D.D.N. Abeyrathne, SLCARP, Sri Lanka
Member	Tharanga Buddhika, NARA, Sri Lanka
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Member	W.G. Rukman, NARA, Sri Lanka
Member	S. Thiruchenduran, NARA, Sri Lanka
Member	H.B.U.G.M. Wimalasiri, NARA, Sri Lanka
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Member	Anuruddha, NARA, Sri Lanka
Member	P.J.M. Jayamaha, Sri Lanka

Administration and Finanace Committee

Chair	R.Y.M.P. Ranathunga, SLCARP, Sri Lanka
Member	P.P.M. Kumari, Accountant, SLCARP, Sri Lanka
Member	R.P.N.B. Premathilaka, SLCARP, Sri Lanka

Appendix 4: Photo Gallery

Reception and Registration of Participants


SLCARP Officials Recieveing Guests and Participants


Registration of Participants

Participants of the Workshop along with Mr P. Harison, Hon'ble Minister of Agriculture, Livestock Development, Irrigation and Fisheries and Aquatic Resources Development and Mr Dilip Wedaarachchi, Hon'ble State Minister of Fisheries & Aquatic Resources Development, Government of Sri Lanka

Opening Session

Dignitaries on Dias (left) and Lighting the Lamps (right)

Dr K.T. Kingsley Bernard, Chairman, SLCARP

Dr Rishi Tyagi, Coordinator, APCoAB, APAARI

Mr P. Harison, Hon'ble Minister of Agriculture, Livestock Development, Irrigation and Fisheries and Aquatic Resources Development, Sri Lanka

Dr Frank Niranjan, Deputy Director (Research), SLCARP

Participants Corner






World Café Discussion






Plenary Session

Dr Suseema Ariyarathna, NARA, Sri Lanka (Left) & Ms Deshinee Herath, NARA, Sri Lanka (Right)

Dr Ashoka Deepananda, Univ. of Ruhuna, Sri Lanka (Left) & Dr Sujeewa Ariyawansa, NARA, Sri Lanka (Right)

Mr Simon Wilkinson, NACA, Thailand (Left) & Dr Kuldeep K. Lal, ICAR, India (Right)

View of NARA Museum

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