Regional Workshop on

UNDERUTILIZED FISH AND MARINE GENETIC RESOURCES AND THEIR AMELIORATION

COUNTRY STATUS REPORTS

Asia-Pacific Association of Agricultural Research Institutions

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Ocean bed with soft corals (*Comaster, Alcyonacea, Gorgonians* species), Fisher-Scalefin anthias (*Pseudanthias squamipinnis*) Brown crab (*Cancer pagurus*), Giant tiger prawn (*Penaeus monodon*) and some under utilised species (Photo courtesy: K.H.M. Ashoka Deepananda).

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Contents

Foreword

The importance of fish and marine genetic resources (FMGR) for food and agriculture is well known to all. However, use of underutilized FMGR for food and non-food purposes remains under-reported or under-recorded. Keeping this in mind, the Asia-Pacific Association of Agricultural Research Institutions (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). More than 100 delegates from Asia-Pacific region attended the Workshop representing participants from 12 countries in Asia-Pacific region (Bhutan, Fiji, India, Iran, Lao PDR, Malaysia, Nepal, Pakistan, Philippines, Sri Lanka, Thailand and Taiwan) including a large number from Sri Lanka. Very useful deliberations were made in different sessions on Conservation, Improvement and Use of FMGR 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 Points.

The Proceedings and Recommendations of the Workshop was duly published by APAARI recently. The present document specifically focuses on Country Status Reports belonging to 12 countries of Asia-Pacific region. It may be noted that while compiling the chapters the authors have also extracted some raw data from various reports and literature.

It is hoped that the Country Status Reports will help to assess the current status of underutilized FMGR at regional level and 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. This document will also help to create awareness on the role and value of underutilized FMGR that have potential for diversification of food basket and improving the livelihoods of rural and coastal population. Strategies for strengthening the institutional framework for FMGR management, and legal and policy framework may be formulated to promote conservation and sustainable use of underutilized FMGR at regional level.

My sincere thanks to SLCARP and NARA for being the host of the event and to the Council of Agriculture (COA), Taiwan, who generously support our APCoAB programme. I take this opportunity to profusely thank the authors of all the chapters for their excellent compilation of country status reports in a very crisp manner. Thanks to all the editors of this compilation viz., D.H.N. Munasinghe, Rishi K. Tyagi, K.H.M. Ashoka Deepananda and Frank Niranjan for their meticulous support and contributions in compilation of the report. Special thanx to my colleague Dr Rishi Tyagi (APCoAB Coordinator) for coordinating the task effectively.

Ravi K. Khetarpal
Executive Secretary, APAARI

Acknowledgements

On behalf of Asia-Pacific Association of Agricultural Research Institutions (APAARI) and its programmes 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 the 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 for Agricultural Research and Policy (SLCARP), Council of Agriculture (COA), Taiwan, and National Aquatic Resources Research and Development Agency (NARA) Sri Lanka, 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 his unstinted support. I thank profusely Eng. E.A.S.K. Edirisinghe, Chairman, NARA, 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 extended by Mr C.C. Lin, APAARI, is thankfully acknowledged. My sincere thanks are also extended to all the co-chairs, rapporteurs, speakers, panelists 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 in giving shape to this document in the present form. I am also thankful to Dr Ashoka Deepananda for his valuable contribution to develop the Concept Note.

This document contains Country Status Reports belonging to 12 countries of Asia-Pacific region with some raw data extracted from various reports and literature by the authors, which were presented during the Workshop. I hope that the information and data presented in this document will be useful for researchers to assess the status of underutilized FMGR and also draw attention of the policy makers, administrators, and other stakeholders towards the urgency of 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 programmes 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

AAH	Aquatic Animal Health
ACIAR	Australian Center for International Agriculture Research
ADB	Asian Development Bank
AGDP	Annual Gross Domestic Product
AIRCA	Association of International Research and Development Centers for Agriculture
AIT	Asian Institute of Technology
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APCoAB	Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
APEC	Asia-Pacific Economic Cooperation
AqGRISI	Aquatic Genetic Resource Information System of India
ASEAN	Association of Southeast Nations
AQIP	Aquaculture Improvement and Extension Project
BFAR	Bureau of Fisheries and Aquatic Resources
BFDA	Brackish Water Fish Farm Development Agency
BNu	Bhutan Ngultrum
BOLD	Barcode of Life Database
BTFEC	Bhutan Trust Fund for Environmental Conservation
BUA	Biodiversity Utilized for Aquaculture
CBD	Convention on Biological Diversity
CBFM	Community-Based Fisheries Management
CBFMG	Capture-Based Fisheries Management Group
CBFMP	Community-Based Fisheries Management Programmes
CBFP	Community-Based Fisheries Projects
CBOL	Consortium for Barcode of Life
CBS	Central Bureau of Statistics
CFPCC	Central Fisheries Promotion and Conservation Center
CGIAR	Consultative Group of International Agricultural Research
CHED	Commission on Higher Education
CIFT	Central Institute of Fisheries Technology
COA	Council of Agriculture
COI	Cytochrome C Oxidase subunit I gene
CPUE	Catch per Unit Effort
DBT	Department of Biotechnology
DA-BFAR	Department of Agriculture – Bureau of Fisheries and Aquatic Resources
DLF	Department of Livestock and Fisheries
DNA	Deoxyribo Nucleic Acid
DOF	Department of Fisheries
DoFPS	Department of Forests and Parks Services
DoL	Department of Livestock
DPPH	2,2-diphenyl-1-picrylhydrazyl
EAF	Ecosystem Approach to Fisheries
EEZ	Exclusive Economic Zone

EIA	Environment Impact Assessment
EMBRC	Eastern Marine Biology Research Center
EPU	Economic Planning Unit
EU	Europe
F$	Fiji Dollar
FA	Fisheries Agency
FAO	Food and Agriculture Organization
FARC	Freshwater Aquaculture Research Center
FFDAs	Fish Farmers Development Agencies
FGR	Farmed Genetic Resources
FIP	Fisheries Improvement Project
FJD	Fijian Dollars
FLMMA	Fiji Locally Managed Marine Areas
FMGR	Fish and Marine Genetic Resources
FMP	Fisheries Management Plan
FMSY	Fraction Maximum Sustainable Yield
FRD	Fisheries Research Division
FRI	Fisheries Research Institute
FRS	Fisheries Research Station
FWAEs	Fresh Whole Animal Equivalent Weights
GBS	Global Bio-identification System
GDP	Gross Domestic Product
GIA	Guaranteed Investment Account
GIFT	Genetically Improved Farmed Tilapia
GOI	Government of India
GR	Genetic Resources
GT	Gross Tons
ha	Hectare
HAB	Harmful Algal Blooms
HACCP	Hazard Analysis and Critical Control Points
HH	Households
HIV	Human Immunodeficiency Virus
HMG	His Majesty's Government
HP	Horse Power
HS	Harmonized System
iBOL	International Barcode of Life
ICAR	Indian Council of Agricultural Research
ICLARM	International Center for Living Aquatic Resource Management
IDRC	International Development Research Centre
IFO	Iran Fisheries Organization
IMC	Indian Major Carps
IMR	Individual and Moving Range
INR	Indian Rupees
IPRs	Intellectual Property Rights
IUCN	International Union for Conservation of Nature
KPK	Kyber Pakhtunkhwa
KGFH	Kali Gandaki Fish Hatchery
KIOST	Korea Institute of Ocean Science & Technology

LARReC	Living Aquatic Resources Research Center
LFS-DAF	Livestock and Fisheries Section, Department of Agriculture and Forestry
LPS	Lipopolysaccharides
MFD	Marine Fisheries Department
MFOR	Ministry of Fisheries and Ocean Resources
MFRDD	Marine Fisheries Research and Development Division
MFRDMD	Marine Fisheries Research, Development and Manangement Division
MGC	Mannoside Glycolipid Conjugates
MGR	Marine Genetic Resources
MITI	Ministry of International Trade and Industry
MoAF	Ministry of Agriculture and Forests
m MT	Million Metric Tonne
MPAs	Marine Protected Areas
MPEDA	Marine Products Exports Development Authority
MPUAT	Maharana Pratap University of Agricultural and Technology
MRC	Management of Reservoir Fisheries Component
MRFDMD	Marine Fisheries Research Development and Management Department
MSY	Maximum Sustainable Yield
MT	Metric Ton
N	North
NF-kB	Nuclear Factor Kappa B
N.S.	Not Specified
NACA	Network of Aquaculture Centers of Asia
NAFP	National Agro Food Policy
NAFRI	National Agriculture and Forestry Research Institute
NARA	National Aquatic Resources Research and Development Agency
NARC	National Agricultural Research Center
NAROs	National Agricultural Research Organizations
NAQDA	National Aquaculture Development Authority
NBC	National Biodiversity Centre
NBFGR	National Bureau of Fish Genetic Resources
NGDP	Nominal Gross Domestic Product
NRCR & LF	National Research Centre for Riverine and Lake Fisheries
NRDCA	National Research and Development Centre for Aquaculture
NRDCR & LF	National Research and Development Centre for Riverine and Lake Fisheries
OAAs	Other Aquatic Animals
PARC	Pakistan Agricultural Reseach Council
PCARRD	The Philippine Council for Agriculture, Aquatic, and Natural Resources Research and Development
PCR	Polymerase Chain Reaction
PDR	Peoples' Democratic Republic
PGOSERI	Persian Gulf and Oman Sea Ecological research Institute
PHA	Polyhydroxyalkanoate
PhP	Philippine Peso
PIC	Pacific Island Countries
PL	Post Larva
PMBRC	Penghu Marine Biology Research Center
PCB	Public Awareness and Capacity Building

QTL	Quantitative Trait Loci
R&D	Research and Development
RA	Republic Act
RARS	Regional Agricultural Research Station
RCA	Regional Centre for Aquaculture
RECOFI	Regional Commission for Fisheries
RM	Malaysian Ringgit
RNA	Ribo Nucleic Acid
ROC	Republic of China
SCP	Single-Cell protein
SEAFDEC	South-East Asian Fisheries Development Center
SIA	Social Impact Assessment
SLCARP	Sri Lanka Council for Agricultural Research Policy
SNP	Single Nucleotide Polymorphism
SPC	Secretariate of Pacific Community
SWIM	Small-scale Wetland Indigenous Fisheries Management
TAC	Total Allowable Catch
UAE	United Arab Emirates
UFGR	Underutilized Fish Genetic Resources
UK	United Kingdom
UKM	Universiti Kebangsaan Malaysia
UM	Universiti Malaya
UMS	Universiti Malaysia Sabah
UMT	Universiti Malaysia Terengganu
UNIMAS	University of Malaysia Sarawak
UPM	Universiti Putra Malaysia
US	United States
US$ or USD	United States Dollars
USA	United States of America
USM	Universiti Sains Malaysia
USP	University of South Pacific
UTM	Universiti Teknologi Malaysia
WWF	World Wildlife Fund

Executive Summary and Recommendations

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.

In addition to the Country Status Reports contained in this document, 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, diseases 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.

COUNTRY STATUS REPORTS

SOUTH AND WEST ASIA

Country Status Report: BHUTAN

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Mr Gopal Prasad Khanal works as Senior Livestock Production Officer with National Research and Development Centre for Riverine and Lake Fisheries (NRDCR & LF), Department of Livestock, Ministry of Agriculture and Forests, Bhutan. Currently, he is looking after Fisheries Ecology and Environment Unit and is mostly engaged in providing technical support to hydropower sectors in fisheries assessment, management and conservation. In addition, he also engaged in conducting researches like fisheries way assessment and exotic fishes. Prior to the current appointment at NRDCR&LF, he was working with NRDCA for promotion of fish farming in Bhutan.

Introduction

Bhutan is small, landlocked and mountainous country, in the Eastern Himalayas with an area of 38,394 km^2. It lies between India and China, within 88° E and 93° E longitude and 26° N and 29° N latitude; stretching maximum of 325 km along East-West and 170 km along North-West axis. Within this limited area, great altitudinal variations exist, ranging from 97 m in the South to 7570 m in the high mountains. Besides, Bhutan constitute 7.6% of Eastern Himalaya region (Sharma *et al.*, 2009), an area of Himalayan Hotspot bordering Indo-Burma and Mountains of South-West China Hotspots. Concurrently, our freshwater ecosystem is home to diverse flora and fauna; including several endemic fish species (Thoni *et al.*, 2016; Thoni & Gurung, 2018). Though, studies on diversity of fishes in Bhutan have been initiated by several institutions, complete inventory is yet not available. In Bhutan 109 species of fish are recorded by Gurung and Thoni (2015) whereas 104 species of fishes are reported from three major rivers of western Bhutan, namely the Amochhu, Wangchhu and Punatshangchhu (NRCR&LF, 2017). However, review of most recently available literatures indicates presence of 130 species of fishes in Bhutan (Thoni & Gurung, 2018; NBC, 2019). Of these, 8 are endemic and 12 are exotic species.

Fish farming is only aquaculture activity undertaken in Bhutan. It is represented by seven species introduced to enhance food fish production. During the 1980s, seven species of carp (catla, rohu, mrigal, silver carp, bighead, grass carp and common carp) were introduced to promote carp-based polyculture along the warmer belt of southern Bhutan. Similarly, to promote coldwater fish farming along the potential northern belts, rainbow trout was introduced in 2008.

Fish farming is still at evolving stage in Bhutan. Warmwater-based carp farming with over 600 household (Dorji, 2016) is more popular than rainbow trout farming. The rainbow trout farming is mainly restricted to government farms (Trout Breeding Centre under the National Research and Development Centre for Riverine and Lake Fisheries, Haa) and two private ventures.

In Bhutan, fishing is regulated by Department of Forests and Parks Services (DoFPS) in accordance to Forest and Nature Conservation Rules and Regulation of Bhutan, 2017. Though fishing for consumption and commercial purpose is illegal, communities having customary rights to utilize fish from designated water bodies and are allowed to fish with proper management plans. Thus, Community-Based Fisheries Management Programmes (CBFMP) are legalized in Bhutan for sustainable utilization of natural fisheries resources. First CBFMP was legalized in 2010 by Department of Livestock (DoL) in collaboration with DoFPS at Harachhu River in Wangdue. The domestic fish production in Bhutan is about 223 MT and is dominated by aquaculture (DoL, 2017; MoAF, 2018).

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

The changes in production, consumption and import of fish and fishery products (live weight equivalent) in Bhutan for past five years (2014-2015) was analyzed from data maintained by Department of Livestock (Livestock Statistics) and Department of Revenue and Customs (Bhutan Trae Statistics). According to available data, the annual fish production in Bhutan is increasing over the years. The domestic fish production increased from 119.08 MT in 2014 to 228.40 MT by 2018 (Figure 1). Thus, in past five years, fish production in Bhutan increased by about 92%. The self-sufficiency of fish and fishery products in 2014 was 1.83% (119.08 MT) as compared to 10.98% (228.4 MT) in 2018. However, per capita per year fish consumption exhibited a reverse trend. The average per capita per year fish consumption in 2014 was 8.76 kg as compared to 2.86 kg in 2018. During the same period (2014-2018), the average per capita per year fish consumption was about 5.29 kg (Figure 2).

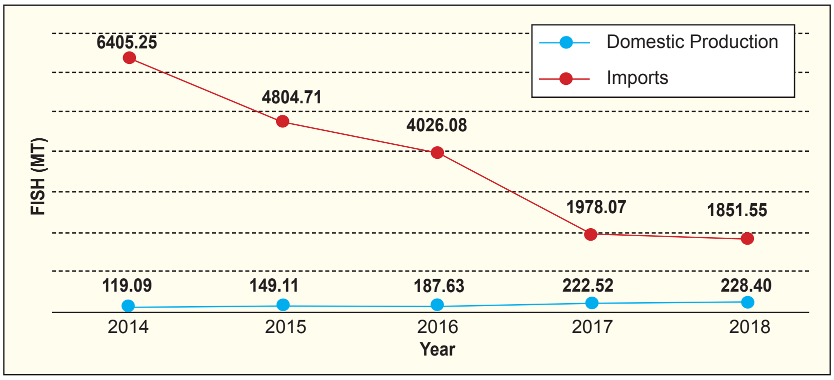

Figure 1. *Import and domestic production of fish (Live weight equivalent)*

This is mainly because of significant reduction in import of fish and fishery products. According to household consumption survey, the per capita per year consumption of fish and fishery product in Bhutan (2009) was 5.58 kg and fish accounted 3.18% of all protein consumed (Needham & Funge-Smith, 2014).

b) Imports and Exports

Mainly, the demand of fish and fishery products in Bhutan are meet through import. In 2014, about 6524.33 MT of fish and fishery products (live weight equivalent) were consumed of which import constituted 6405.25 MT (98.17%) worth Nu. 402.74 million. In 2018, the consumption of fishery products was 2079.95 MT of 1851.55 MT (89.01%) valued Nu. 179.31 million was imported.

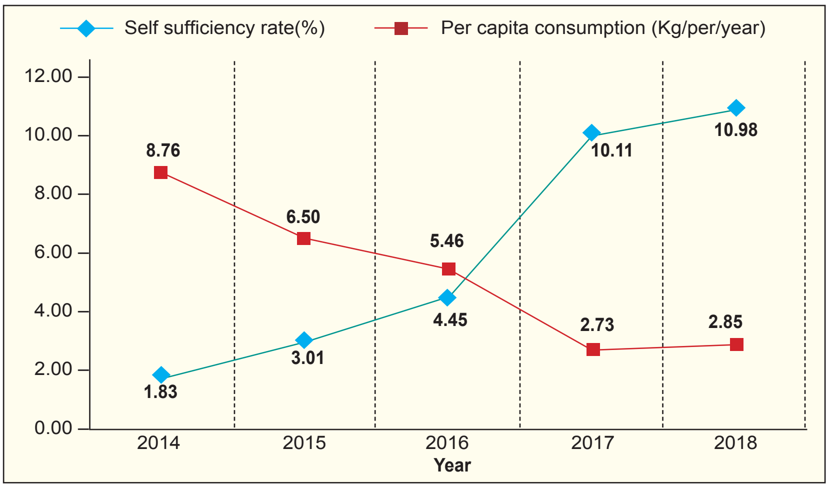

Figure 2. *Self sufficiency rate and per capita fish consumption from 2014-2018 (live weight equivalent)*

The average fish requirement in Bhutan (2014-2018) is 3994.48 MT, with import accounting 3813.13 MT (95.46%). The average value of import is about Nu. 281.41 million. At present, Bhutan do not export any fish and fishery products.

Status of Fish and Marine Genetic Resources

a) Unique Underutilized Fish and Marine Genetic Resources

In Bhutan, fishes utilized for food purposes are mostly represented by introduced species. At present, no attempt has been made to use indigenous fishes for aquaculture. In addition, current researches are mainly focused on taxonomy in nature and the potential of fisheries resources for food purpose is yet to be evaluated. However, most abundant fishes such as chocolate mahseer (*Neolissochilus hexagonolepis*), common snowtrout (*Schizothorax richardsonii*) and stone rollers (*Garra gotyla*) are legalized for sustainable harvest under CBFMP in certain catchment area of rivers. The CBFMP is facilitated by The National Research and Development Centre for Riverine and Lake Fisheries (NRDCR&LF) in collaboration with DoFPS and other stakeholders. These species contributed 5.46% (6.5 MT) of domestic fish production in 2014 (Dorji, 2016) and 9.42% (21 MT) in 2017 (MoAF, 2018). In addition, many other potential species are likely to be underutilized for fisheries and this requires proper study. Among the indigenous fishes, chocolate mahseer and common snow trout have high aquaculture potential.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Development

In the field of fisheries, proper collection, characterization, evaluation, conservation and development of germplasm is yet to be initiated in Bhutan. However, *ex situ* conservation of prioritized species such Golden Mahseer (*Tor putitora*), Chocolate Mahseer and Common Snow trout has already been initiated. Further, Golden Mahseer has been breed successfully under captivity at National Research and Development Centre for Aquaculture (NRDCA) in 2013. This rudimentary captive reproduction and breeding technology is further being researched for improvement. However, most of the activities related to conservation are focused on collection of important fish species for *ex situ* research with aim to develop breeding and husbandry techniques.

Lately, fish specimens in form of fin clips are being tissue-banked for genomic studies. The NRCR&LF and University of Arkansas, US are collaborating for development of first ever fisheries genetic database of Bhutan. Similarly, collection of germplasm such as sperm, ova and embryos for preservation of genetic resources to secure biological diversity for population reconstitution needs attention and is realizable only with similar support from international organizations. Access to Bhutan's genetic resources and associated traditional knowledge for fair and equitable sharing of benefits arising from their research and commercial utilization is guided by Access and Benefit Sharing Policy of Bhutan, 2014 and is coordinated by National Biodiversity Centre (NBC), Ministry of Agriculture and Forests.

c) Processing, Value Addition and Development

In Bhutan, domestically produced fishes are mostly sold as fresh. There are no major interventions with regard to processing, value addition and product development. This is mainly because of small scale of production which are just sufficient enough to meet demand within their locality. However, in some cases, fishes are processed and sold. The processed fishes mainly include the smoked and salted fishes. "*Nya Doesem*" is most popular traditionally smoked fish produced by communities of Harrachhu CBFMP. It is prepared from wild snow trout which is bent curved using bamboo slits.

They are then placed on bamboo mats, compressed by river stones and smoked to give unique flavor (NCWFC, 2010). Most of snow trout from Harachhu CBFMG is processed into *Nya Doesem*. Lately, production of hot smoked fish has been demonstrated by NRDCR&LF.

Challenges and Opportunities

As most of the essential food commodities including meat products are imported, ensuring food and nutrition security and food self-sufficiency has always been major goal of Bhutan. The self-sufficiency of meat (chicken, pork, fish and chevon) is only 37.9%, of which merely 3.05% is contributed by fish (MoAF, 2018). With regard to fresh fish, self-sufficiency is only about 14.5% (223 MT) of which 13.13% is represented by cultured fishes and about 1.36% by capture fisheries. Thus, fish production in Bhutan should be rigorously pursued to meet the domestic demand.

Aquaculture sector needs further strengthening, especially in terms of species diversification and development of climate resilient fish farming techniques. The fisheries resources are yet to be well studied which are threatened by hydropower development, road construction and mining, sand and boulder extraction and illegal fishing. In addition, exotics and alien species of fish is potential threat to our fisheries resources. The impact of climate change on fisheries and aquaculture resources has never been considered in Bhutan. The introduction of exotics to enhance domestic food fish production and ornamental purpose neglected same potential from our own indigenous species. Thus, there are huge opportunities here to explore potential of indigenous species for fish farming and fisheries development.

Marketing, Commercialization and Trade

In Bhutan, fish farming is still at its infancy and needs further promotion whereas CBFMP is a recent concept. In addition, the scale of production is very small as most products are consumed within the production locality. Because of this, commercialization and trade are yet to be developed. In major fish aquaculture production areas, government facilitates marketing of fish in refrigerated vans. However, fishes from CBFMG, especially from Harachhu region are processed (*Nya Dosem*) and marketed to urban areas where demands are very high. In addition, CBFMG are provided with cool box to facilitate transport of freshly harvested fish within their locality. Fabricated smoking chambers are also provided in case to meet the small-scale consumer specific demands.

Strategies Adopted to Harness Potential of Underutilized FMGR

The NRDCR&LF and NRDCA under Department of Livestock (DoL), Ministry of Agriculture and Forests (MoAF) are two nodal agencies engaged with fisheries and aquaculture development in Bhutan. In addition, Regional Centre for Aquaculture (RCA) caters the need of aquaculture development in eastern Bhutan. The NRDCR&LF aims to be competent authority for the provision of technical advice for sustainable utilization, conservation and management of fisheries resources in Bhutan. In order to realize this goal, the center is engaged in assessment of fisheries resources of Bhutan, through Bhutan Trust Fund for Environmental Conservation (BTFEC) funded project.

The first phase focused on major rivers of western Bhutan documented a total of 104 species of fish. The final phase focuses on rivers of eastern Bhutan and results will be forthcoming. In addition, the center is closely associated with hydropower sector in accessing their impacts on aquatic systems for development of proper mitigation strategies. As mitigatory measures, fish conservation centers and other conservation measures are proposed to minimize the impact on potential and vulnerable fishes. These fisheries conservation centers will provide us an opportunity to study biology and ecology of impacted species. In addition, both the aquaculture and fisheries centers are engaged in *ex situ* rearing of important fishes. Although fishing is highly regulated, communities traditionally associated with utilization of fisheries resources are relaxed by Forest and Nature Conservation Rules and Regulation of Bhutan, 2017 through CBFMP. The locals associated with fishing have good knowledge about fishery resources within their locality and their knowledge plays important role in validating the potential of fishery resources for CBFMP.

Major Focus Areas for Underutilized FMGR

At present, apart from assessment of fishery resources NRDCR&LF is engaged promotion of CBFMP. The main aim of the programmes is utilizing fisheries resources with sustainable management practices and develops sense of ownership to the resources among community, thereby reducing incidences of illegal, indiscriminate and destructive fishing practices. Besides, the programmes is expected to benefit the community in terms of socio-economic enhancement. The CBFMP is further regulated by provisions under management plans such as permissible fishing grounds, species, gears, size, fishing season, quota and effort (Changlu, 2016). Seven such programmes are currently functional (MoAF, 2018) and additional 8 are expected to realize by June 2023. These programmes are closely monitored in order to ensure sustainability.

In addition, fishes of conservation, socio-cultural and economic importance are considered for research in Bhutan. They are held in *ex situ* facilities with long-term objective to understand their biological and ecological needs for development of breeding technologies. With technologies in place, their potentials in aquaculture and fisheries can be evaluated under our conditions.

Infrastructure, Capacity Building and Financial Investment

The fishery resources of Bhutan received attention only in recent years. As production is low, post-production and marketing infrastructures are not well developed. The capacity of stakeholders needs prior attention, exposure and upgradation. Intervention and support in latest innovations in area such as genetics, germplasm collection, characterization, evaluation, conservation and development are pre-requisites. In addition, existing institution requires strengthening in area of sustainable utilization and conservation of fisheries resources. The allocated resources for fisheries development are insignificant, need prioritization and are fragmented within different stakeholders.

Future Thrusts

Indigenous fishes form an important component of culture and tradition in certain communities. In addition, they represent important component of an aquatic ecosystem. Though, sustainable utilization of resources through CBFMP is based around realizing socio-economic and ecological objectives, it needs proper synchronization with ecosystem approach to fisheries (EAF) management practices. In addition, existing research in areas of fisheries should be further strengthened. Therefore, the following are some of the areas which need attention for proper management of FMGR in Bhutan.

- Application of molecular genomics in fish identification, development of gene banks and genetic database of fish.
- Map and document fisheries resources having potential for enhancing food, nutrition and economic security.
- Collect and maintain germplasm like sperm, ova and embryos for preservation of genetic resources for population reconstitution.
- Initiate more scientific fish conservation and management plans.

- Initiate advanced fish breeding and rearing researches for important indigenous fish species. The technology can be used to promote fish farming based on indigenous species. In addition, it can be used as conservation measures to replenish depleted population when all the available alternatives and mitigative measures fails.
- Promote CBFMP in closed lakes with indigenous fish species through responsible management practices.
- Investigate socio-economic impacts of CBFM on fisher communities.
- Document the types, method of application, merits and demerits of indigenous fishing gears.
- Integrate adaptive management practices within CBFMP through constant monitoring and enforce catch limits based on changes in growth, recruitment, survival and reproductive success. In addition, timing or location of CBFMP should be changed, as the species arrive earlier or later or may shift to new areas (Celton, 2014).
- Introduce new fishing gears and promote CBFP for other underexploited species. As climate change and other factors is likely to change species composition, new fishing gears must be introduced and more exploited fishes should be exited from CBFM so to continue sustaining on fishing (IFAD, 2014).
- Study the impact of developmental activities (hydropower, roads, sand and boulder extraction, etc.) and exotic species on indigenous fish populations.
- Study fish migration and interactions among biotic communities and abiotic components of an ecosystem.

However, to achieve the above expectations, the following interventions are pre-requisites:

- Invest in capacity development of the stakeholders.
- Collaborate within regional and international organizations.
- Develop infrastructure and facilities for advanced studies and enhance research programmes.
- Seek funding support from national, regional and international organizations.

Conclusions

The aquatic ecosystem of Bhutan is home to diverse fishery resources of which several are endemic ones. These resources have important role to play within their ecosystem. Some of riverside communities are traditionally associated with utilization of these resources from their locality. Although, FMGR of Bhutan is yet to be fully documented, most abundant fish species are legalized for sustainable utilization under CBFMP. In addition, the candidate species under fish farming are represented by exotics and utilization of indigenous species are yet to be considered.

In addition, there is huge gap between domestic production and requirement. Further, the contribution of fisheries to fish self-sufficiency is merely a small fraction. Although, some fishes in Bhutan have high potential for fisheries in enhancing food and nutrition security proper documentation and evaluation is required. In addition, legalization of additional species for CBFMP requires proper study. In such scenario, it is high time to collaborate with national agencies, international organizations and experts to further research on the available FMGR to promote sustainable management of resources for enhancing food and nutrition security, including their conservation.

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Country Status Report: INDIA

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Introduction

More than 70% population of India depend upon agriculture and allied sector for livelihood which makes the sector as the most important one for development of the country. India with its vast aquatic resources spread across various ecosystems, exhibit high diversity and endemicity in fish genetic resources. The diverse resources ranging from deep seas to lakes in the mountains make nearly 9.5% of the global biodiversity in terms of fish and shellfish species. The diversity is also seen in the consumption pattern, fish as part of nutrition, culinary preparations and tastes, and hence this also affects trade and priority on fish production. At present, the quantity-wise production is largely contributed by aquaculture of three carp species, rohu, mrigal and catla and value-wise it is dominated by white-leg shrimp. The aquatic genetic resources other than finfish and shrimps such as mollusks, coelenterates and seaweeds are not very popular and consumed in a few regions. Over the course, people are becoming aware of fish as health food, with ingredients for growth of brain and safeguarding from lifestyle diseases. However, still raising consumption of fish in India is a challenge, which needs strategies to overcome. The country has largest vegetarian population in the world. Out of 53% non-vegetarian population, fish consumption as preferred food is mostly restricted to coastal states and parts of eastern and North-eastern India. The projections indicate that India is likely to achieve one of the highest growth in fish production. Aquaculture growth will make a critical impact on fish availability from India, for domestic as well as global consumption.

Government of India has launched an umbrella mission 'Blue Revolution' to improve fish production at various levels starting from seed production to processing and necessary infrastructure required. The horizontal expansion of cultivable area as well as productivity enhancement, both will be effectively required for the success of blue revolution. This cannot be achieved without aquaculture diversification and inclusive involvement of populations, both in production and consumption system. Given the available diversity and considering regional preferences, there can be ample opportunities of aquaculture growth, more than achieved till now through harnessing several unutilized aquatic genetic resources and at the same time enhancing the consumption and improve protein availability for the masses.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

The phenomenal growth in fisheries production was from 0.75 m MT in 1950-51 to 12.60 m MT during 2017-18. A total of 65% of fish production is from inland sector and about half is realized from aquaculture. India contributes about 6.3% of the global fish production. Fisheries sector support 14 million people for food/livelihood and contributes 0.9% to total India's GDP (5.23% to Agriculture GDP). Paradigm shifts in terms of increasing contributions from inland sector and aquaculture have been significant over the years. With high growth rates, the different facets, *viz*., marine fisheries, coastal aquaculture, inland fisheries, freshwater aquaculture, and coldwater fisheries are contributing for the supplying food, health, economy, exports, employment opportunities and tourism industry of the country.

The need of including potential species into the freshwater aquaculture have been realized in India since long time ago. Prioritization of native minor carp species with culture potential and regional importance and high consumer preference is need of the hour to meet out the demand. Being termed as local fish by the consumers, these minor carps also command 20-30% higher market price than the Indian major carps depending on the regional demand. Apart from IMCs, vast majority of medium and minor carps distributed in different climatic and ecological zones of India also has the potential to increase the existing fish production. The diversification of fish species using prioritized region-specific fishes in aquaculture will help to cater local preferences. Besides, this will contribute to the conservation of species diversity in long run.

Vast majority of medium and minor carps distributed in different climatic and ecological zones of India, also has the potential to increase the existing fish production. Captive breeding and larval rearing of non-conventional food fish species *viz*., *Chitala chitala, Ompok pabo, O. pabda, Labeo dussumieri, Semiplotus semiplotus, Clarias dussumieri, Channa diplogramme, Anabas testudineus, Cirrhinus reba, Barbodes carnaticus, Puntius sarana, Horabagrus brachysoma* and indigenous ornamental species that have export potential such as *Pristolepis marginata, Horabagrus nigricollaris* etc. could be used to increase the food basket of the country. Captive breeding of ornamental fish species like *Chela fasciata, Danio malabaricus, Puntius filamentosus, P. denisonii, P. fasciatus, Mesonemachilus triangularis* can be upscaled with an aim to develop alternate rural livelihood options.

Diversification is a tool of risk management in aquaculture practices. Viability of fish culture will be more with diversification, mitigating the risks associated with the dependence on a few high value species. In addition to the above fishes, country possesses other cultivable medium and minor carp species which are of high regional demand, includes *L. calbasu, L. fimbriatus, L. gonius, L. bata, L. ariza, Puntius sarana, Hypselobarbus pulchellus, H. kolus* and *Amblypharyngodon mola* and several others, commercial farming of these species has been almost non-existent or picking-up slowly. These medium-sized carps have initial higher growth rate and market value. Acceptability at 300-400 g makes them ideal species for intercropping in the major carp farming system. These species can be considered as more suitable for the utilization of seasonal ponds, which have 5-6 months of water retention. Over the years, levels of the various species of minor carps and barbs in the IMC based grow-out culture system worked. The diversification is also seen as risk management strategy in rural small-scale livelihood scenario and implemented using integrated farming systems.

a) Production and Consumption

The diversity in consumption pattern, fish as part of nutrition, culinary preparations and tastes, and hence this also affect trade and priority on fish production. The aquatic genetic resources other than finfish and shrimps such as mollusks and seaweeds are not very popular and consumed in a few regions. People are becoming aware of fish as healthy food, however, still raising consumption of fish in India is a challenge, which needs strategies to overcome. Average per capita consumption is around 9 kg (in some regions North-East, Goa and Lakshadweep >30 kg). The country has largest vegetarian population in the world. Out of 53% non-vegetarian population, fish consumption as preferred food is mostly restricted to coastal states and parts of eastern and North-eastern India.

b) Imports and Exports

Fish products have presently emerged as the largest group in agricultural exports from India, with 1.4 million tones in terms of quantity and INR 45,106 crores (USD 7000 million) in value (10% of total export and 20% of Agriculture export). The import of fish and other aquatic products (MPEDA, 2019) is 45264 MMT of value INR 16,395 crores (USD 2,545.33 million). This accounts for around 10% of the total exports and nearly 20% of the agricultural exports, and contribute to about 0.91% of the GDP and 5.23% to the agriculture GDP of the country. The large share, over 90% of total import, is worked pearls for jewelry. The import has grown 7 folds in 2017-2018 from 2016-17 (INR 263 crores). Other import for food items includes fillets pangasius, silurus, salmon, shrimps, sauces and other products from small restricted consumers (INR 200 crores or USD 31 million).

Status of Fish and Marine Genetic Resources

a) Unique Underutilized FMGR

Fish genetic resources in India are unique as these are distributed across wide variety of agro-climatic conditions ranging from tropical to temperate to palaeo-arctic kind. These resources are inhabitant of ecosystems freshwater, brackishwater and marine ecosystems. The uniqueness of these resources is important from the point of view of various adaptive traits, they possess. The geological history and tectonic movement which impacted the gene flow and migration and consequently speciation has resulted in species evolving while passing through the changing climates such as alternating desiccation and glaciations periods, especially since 65 million years ago when the Indian plate collided with Eurasia. There are two important aspects of underutilized resources: (1) Exploited fishery and aquaculture is limited to only three species, and (2) Available intra-specific genetic diversity (diversity below the species level) still inadequately used for improvement. One of the important concerns is lack of adequate mechanism of evaluation of variety of fish genetic resources leading to their utilization strategies. The native ornamental fish species is another area which raises concern, as the utilization is through unorganized wild harvests rather than thrust on its breeding and sustainable utilization in trade. From capture fishery, the deep-sea resources and the diversity beyond national jurisdiction are hardly used.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Documentation

In terms of biodiversity, a total of 3137 native fishes, 1039 are freshwater, 116 are brackish water and 1982 are marine species and at least 258 species are of commercially important (NBFGR, 2017). AqGRISI (Aquatic Genetic Resource Information System of India) is a platform implemented by NBFGR for hosting information available on Indian finfish species, including biology, taxonomy, type specimens, genomic and patent information. The system is compatible to link to other data coming in future. The databases also make a link to the accessions in the repository.

Indian aquaculture utilizes primarily the three species of Indian major carps, *viz.*, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* supplemented by exotic carps *viz.*, *Hypophthalmichthys molitrix*, *Ctenophayrngodon idella* and *Cyprinus carpio*. Pangas catfish, *Pangsianodon hypophthalmus* and freshwater prawn, *Macrobrachium rosenbergii* from freshwater aquaculture and shrimps from coastal shrimp farming. In recent years, the exotic shrimp, *Litopenaeus vannamei* is contributing more than 95% of the total shrimp production. Culture of marine fish species has been initiated in the country and presently carried out for seaweeds and fish species such as seabass, cobia, pompano and green mussel have been taken up on commercial scale. Though, India is rich and diverse in aquatic genetic resources, the index of biodiversity utilized for aquaculture (BUA) is of the order of 0.13 (~85% from Indian major carps; ~ 5% air breathing fishes; ~10% rest all species together), so it is the fact that domestication of resources that can provide sustainable utilization is not proportionate with the level of biodiversity and agro-climatic environment possessed. Therefore, there is a need to promote the diversification of aquaculture to enhance the production and exploring the various aquatic resources and agro climatic environments. During recent years, diversification efforts have been taken up. The captive breeding of 60 species, by different organizations, has been successful and further upscaling programmes are also in line.

Evaluation of germplasm is an important aspect. Recently, ICAR-NBFGR has propagated the concept of live fish germplasm resource centers, which aims to promote establishing breeding population, so that captive seed produced aid in conservation as well as aquaculture and livelihood. Such centers in the native distribution of the species also help domestication, performance evaluation of the new species or geographically isolated genetic stock of the species. Under these programmes, some of the endemic and rare species have been established such as *Clarias dussumieri*, *Horabagrus brachysoma*, critically endangered *Hemibagrus punctatus,* etc. This programmes are also helping establishing wild collected populations of Indian major carps and Indian catfishes. The newly discovered *Pangasius silasi* (Dwivedi *et al*., 2017) have been found to have good aquaculture potential and becomes candidate for domestication.

NBFGR implemented a programme on characterization of fish genetic stocks using molecular and biological markers in combination. The information on 32 fish species, their wild relatives have been studied across their native distribution range. Sperm cryopreservation protocol is developed for 18 fish species with production of viable hatchlings. Most of such work is done at the level of wild population, mostly from conservation perspective. The future direction is also needed to document genetic diversity in farmed stocks so that the intra-specific genetic diversity available can be used to alleviate the genetic erosion for healthy seed production.

c) Processing, Value Addition and Product Development

More than 50 different types of fish and shellfish products are being exported to 75 countries around the world. The frozen shrimp make most of the export from the country. Ready to eat fish products, including traditional dishes are gaining popularity at regional level. The technology is based on ICAR-CIFT research and is taken up by some private industry. However, such items fulfill the niche demands.

Challenges and Opportunities

The lack of adequate knowledge on characteristics and their adaptive traits of most of the FGR becomes a limitation in strategic planning for enhancing their utilization. Further, the uniform evaluation and characterization procedures for FGR is also area of work that need attention. Genetic Resource Management Guidelines of India (NBFGR, 2016; 2019) has been a step in this direction. However, with opportunities available in terms of highly diverse germplasm, there is a need for more multi-disciplinary programmes.

Marketing, Commercialization and Trade

Presently, freshwater fisheries are growing faster as compared to marine fisheries. About 3.58 MT (33% of total) is from marine fisheries and rest (67%) from freshwater. India stands around 136th rank in per capita fish consumption with 9 kg. In the primary fish consuming states, marketing is not a problem. In addition to local production, such areas also receive iced fish material from different parts of the countries or non-consuming states. There is urgent need for increasing domestic consumption, especially shrimp. This will help resilience against fluctuating prices. With the organized retail and infrastructure growing and rising incomes, there are strong domestic opportunities are available which need to be harnessed.

Strategies Adopted to Harness Potential of Underutilized FMGR

Knowledge generation and evaluation is one of the starting points. The prioritized species and with the advent of new species to the science, there is need for evaluation for possible preferable traits for using in aquaculture. However, necessary research trials to be carried out to authenticate the superiority of the species in terms of growth rate, nutritional profile compared with their counter parts. Further, many prioritized fish species for aquaculture also falls under the various conservation categories such as, *Chitala chitala* (endangered), *Puntius denisoni* (endangered), *Hemibagrus punctatus* (critically endangered), *Clarias dussumieri* (near threatened) and *Horabagrus brachysoma* (Vulnerable). Captive propagation of these fish species not only will help in widening the food basket of the country but also conserving in the wild by stock specific ranching programmes (NBFGR, 2012).

Further, the importance and beneficial effects of fish in human diet is well established in terms of food security and in combating under nutrition and micronutrient deficiencies in developing countries. Knowledge base on the nutritional composition of the edible fishes would be helpful in using them in public health nutrition programmes for nutritional security. The studies on the proximate composition of the fishes revealed the protein and fat content, essential fatty and amino acids content along with vitamins and minerals are more or less similar for the minor carps and other fishes as compared with IMCs (Mohanty *et al.,* 2017). Therefore, it is essential to include the potential minor carps and other fishes in the aquaculture systems to meet the need of nutritional security of the country.

The developing package of practices for the suitable species, which could be used at different levels of strata high trade value to backyard culture is important. The local level aquaculture with underutilized and low-priced species can have beneficial effect in improving family level nutrition.

Major Focus Areas for Underutilized FMGR

- Prioritization of species for conservation and aquaculture and utilization.
- Knowledge on genetic characteristics and production traits.
- On-farm evaluation and breeding technologies.
- Upscaling for developing culture practices and economic viability.

Infrastructure, Capacity Building and Financial Investment

With the growing demand for Indian seafood products across the world, the dynamics of the seafood business in India is changing rapidly. There is a tremendous growth in the resources and infrastructure of the Indian seafood industry today. India has 37 live fish and shell fish handling units and 42 fresh and chilled fish processing units (Table 1) with a capacity of 2,142 and 1488 MT per day. India has an installed processing capacity of 27,850 MT with 529 state-of-the-art processing plants apart from other supporting system (Table 2). Almost every unit has an HACCP system and other quality control systems on par with the world to ensure highest quality output.

With over 2.4 lakh of fishing crafts operating along the coast, 7 major fishing harbours, 75 minor fishing harbours and 1,537 landing centers are functioning to cater to the needs of over 4.0 million fisher folks. For promoting aquaculture, 429 Fish Farmers Development Agencies (FFDAs) and 39 Brackish water Fish Farms Development Agencies (BFDAs) were established in the country. The annual carp seed production is to the tune of 40 billion fry and that of shrimp is about 54 billion PLs, with increasing species diversification in the recent past. Besides large-scale freshwater food fish culture, ornamental fish culture and high value marine fish farming are gaining importance in the recent past (Mohan and Ravishankar, Pers. Comm.).

Table 1. Indian seafood handling facilities

Facilities	Numbers	Quantity (MT d^{-1})
Fresh/chilled	42	1488
Live fish & shellfish	37	2,142
Dried & salted	69	845

Table 2. Indian seafood processing facilities

Facilities	Numbers	Quantity (MT)
Pre-processing/peeling shed	620	11,657
Processing units	529	27,850
Chilled store	29	11,376
Cold store	479	193,464
Dry fish products store	57	11,506
Ice plants (per day)	78	2,211
Others	32	7,701

Case Studies/Success Stories for Improvement of Health and Livelihoods

Some of the cases, which have been initiated from the perspective of enhancing use of FGR, done experimentally or pursued for upscaling are as below:

- Attempts are made to diversify the major carp based composite culture systems by changing the composition by incorporating minor carps. Minor carps such as *Labeo calbasu*, *Labeo fimbriatus*, *Labeo gonius*, *Labeo bata*, *Cirrhinus reba, Puntius sarana* exhibited promising results in terms of compatibility with major carps and possibility of increasing the biomass yield (Jena *et al.*, 2007)
- *Labeo rajasthanicus*: western Rajasthan, restricted population, risk of unrecognised extinction. Established breeding population in MPUAT, Udaipur. Seed production and stocking in sanctuaries for conservation to be carried out.
- *Pangasius silasi* endemic to river Krishna. On-farm evaluation reveals potential for domesticating this indigenous species.
- Rare species endemic to Kerala, *Clarias dussumieri* captive population bred and reached F_2 generation.
- Captive breeding of *Labeo dussumieri* and *Horabagrus brachysoma* and stock specific ranching enhanced the capture fishery of the species in their native range.
- Murrels, high valued species are promoted for upscaling at farmers' level.

- Indigenous marine ornamental species breeding facility to harmonize conservation and improving community livelihood are (i) Airoli (ICAR-NBFGR & Mangrove Board, Government of Maharashtra), and (ii) Lakshadweep islands (ICAR-NBFGR & DBT, GOI & Lakshadweep administration).

Future Thrusts

Focus on four main areas are: (1) Exploration of FGR in underexplored areas for their status, abundance and biological knowledge; (2) Evaluation and categorization of FGR with respect to potential and on-farm evaluation of FGR and genetic stocks of aquaculture species; (3) Establish live germplasm resource centers, with multi-species broodstock as platform to aquaculture diversification and establishing knowledge which can be used for upscaling aquaculture and utilization; and (4) Prepare *ex situ* conservation protocols for the important species.

Conclusions

To meet the need for cheap nutrition fish as component of diet will play a critical role. However, this will need to enhance the availability and also the affordability of the consumers. Utilization through aquaculture is a potential path, however, sustainability of aquaculture is important. The utilization of underutilized resources will be useful to provide diversified produce which can have wide range of benefits ranging from family nutrition, local livelihood and generation of income and employment through development of trade and exports. In India, establishing regional level aquaculture practices will have special role in meeting the nutritional needs of the growing population.

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Country Status Report: NEPAL

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Dr Neeta Pradhan is the Chief of the Fisheries Research Division, Godavari, Nepal under Nepal Agricultural Research Council. She has twenty-four years experience on fish biodiversity, fish nutrition, post-harvest and genetics. Dr Pradhan is responsible for improving research, development of projects and coordination of national research on fisheries station under NARC in the context of achieving national plan of 2021. Her future plans are to continue stock enhancement programmes of potential indigenous fish species by phenotyping and molecular characterization to improve the productivity of aquaculture species.

Introduction

Underutilized fish genetic resources (UFGR) are those fish species which have not been adequately focused for mainstreaming to scientific investigation for mass scale production due to insufficient scientists, physical facilities, and funding resources. However, it is realized that UFGR should be given adequately prioritized for their potential contribution as such species has life history traits ensuring food and nutritional security of global communities in changing scenario of increasing human population, climate change, environmental degradation etc. The UFGR, in general, are wild or partially domesticated inland waters fish species adapted to particular water bodies of specific location such as warmer or colder regions.

Many species representing UFGR are known to be declining sharply in their abundance due to constrains arising such as use of agriculture pesticides, construction of hydro dam without considering the movement of fish across the up and down stream of the rivers and devastating ecological conditions. These UFG offers tremendous opportunities and tools to fight against hunger, malnutrition by ameliorating to use as food, recreation, decoration, and high value products. Understanding UFGR for their amelioration can help make agricultural production systems more resilient to climate change, price hike and food crisis issues. Acknowledgment of the value of UFGR in traditional foods and cultures can empower indigenous communities (women in particular) and reaffirm their identity. Similar to neglected and underutilized food crops and livestock farming, the UFGR has also important role to play in advancing agricultural development beyond the Green Revolution model.

Nepal is deprived of any oceanic resources and overwhelmed by mountains, which comprise about 83% of the total area of 147,181 km^2. Nepal is a country with unique and varied ecological features. The country is situated between the longitudes 80°00' to 88°15' E and the latitudes 26°30' to 30°15' N. Nepal is divided into three physiographic regions from South to North: the Terai Plain, the Mid-hills and the Himalayas. The climate varies little from East to West. Nepal's rich biodiversity is a reflection of this unique geographic position as well as its altitudinal and climatic variations.

Although, only 0.09% of global land area is in Nepal, it possesses a large diversity of flora and fauna at genetic, species and ecosystems level. Approximately, 5% of the total area of the country is occupied by different freshwater aquatic habitats (Bhandari, 1992). In general, the aquatic habitats and fish species can be viewed as prospects for fisheries and aquaculture development in the country. This also implies that aquatic resources located at different altitude and climatic zones can offer potential for different fisheries and aquaculture activities in Nepal. The economic development of the country depends on careful utilization of natural resources and water resources of the country. Altogether 6000 rivers with approximately 45,000 km length, including rivulets and tributaries passing through the country comprised of Koshi, Gandaki and Karnali river systems receive water from snow, glaciers and monsoon which harbouring 236 fish species. The various forms of inland water resources in the country have been shown in Table 1.

Table 1. Estimated water surface area in Nepal (Source: CFPCC, 2018)

Resource details	Estimated area (ha)
Natural water	
Rivers	395,000
Lakes	5,000
Reservoirs	1,500
Village ponds	9,934
Seasonal water	
Marginal swamps	9,000
Irrigated rice fields	398,000
Total	**818,434**

a) Production and Consumption

The total national fish production is 86,544 MT and capture fisheries from natural waters shares about 25% of the national production (Figure 1). Since the capture fisheries practiced in natural water, the fish production solely comprised of indigenous fish. Fisheries sector contributed little over 1.13% in NGDP and 4.18% in AGDP (Figure 2). The *per capita* consumption of fish is only 3.01 kg, which is very low and fish contributed only about 19.3% of animal protein consumption (CFPCC, 2018; Figure 3). Substantially large quantities of fresh fishes are imported especially from India and other countries to fulfill the local demand in the capital and many others urban destinations (Gurung, 2012). The trend of per capita fish availability is presented in Figure 3 (CFPCC, 2018).

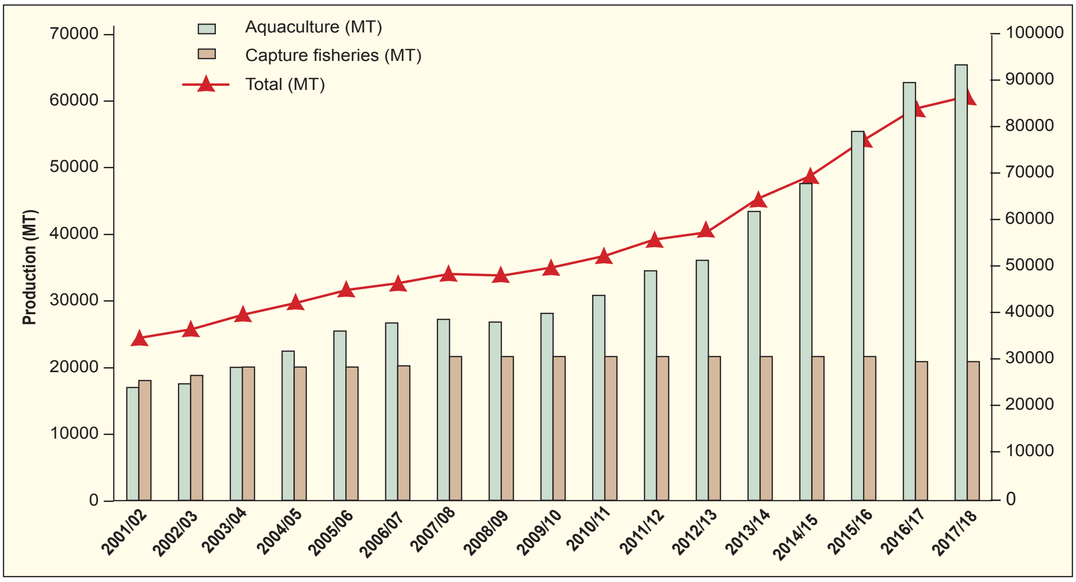

Figure 1. *Total fish production (year-wise)*

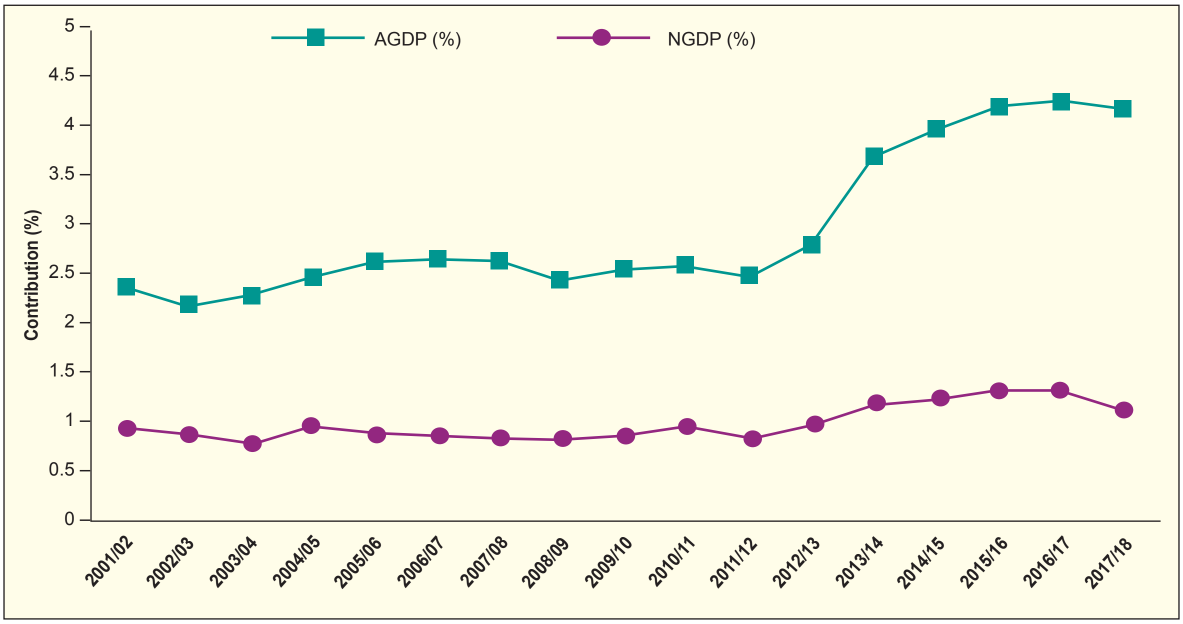

Figure 2. *Contribution of fish to AGDP and NGDP (year-wise)*

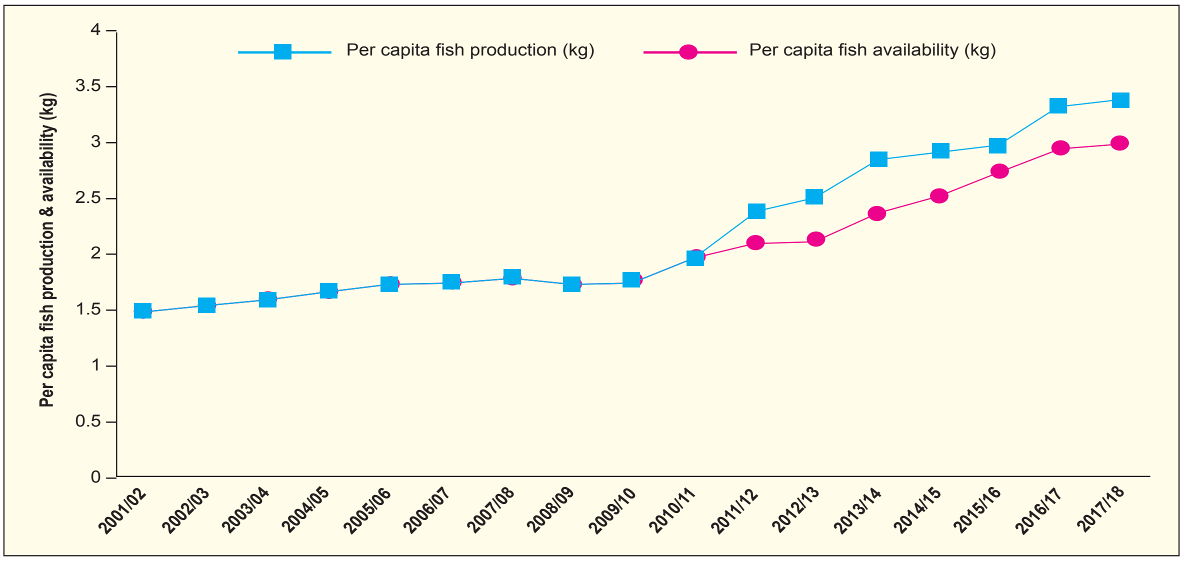

Figure 3. *Trend of per capita fish production and per capita fish availability (year-wise)*

b) Status of Fish Genetic Resources (FGR)

Indigenous fish species represented by 120 genera, 40 families and 15 orders have been reported in Nepal (Shrestha, 2019). The indigenous fish species are distributed in the different water bodies of Nepal from 60-3323 m altitude. A large number of fish species remain confined to a limited range of the water body. A number of other species distinctly exhibit migratory habitat either with the change of ecological conditions, for feeding, breeding or for all purposes. Cold water fishes, *Tor* sp., *Acrossocheilus hexagonolepis, Anguilla bengalensis* are good example of migratory fish. In light of the trend toward increasing habitat destruction, destructive fishing, barrier in waterway and fishing pressure, the catch of large migratory fish species, which typically reproduce more slowly, could decline while the catch of small and fast reproducing species would appear as high as ever. Decline in fish fauna and catch have been reported from lower basin of Narayani River (Dhital & Jha, 2002), and sharp depletion of fish stock in many water bodies around densely populated areas (Rajbanshi, 1996). Some of the high value and migratory native fish species of the country are listed as vulnerable and endangered (Swar, 2002).

According to the IUCN (2004) red list common/occasional, insufficiently known, vulnerable, endangered and rare fish were 71, 59, 11, 2 and 23, respectively.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

Many rural households living around wetlands subsist on a combination of fishing and agricultural activities, being agriculture as their primary employment and fisheries as secondary occupation in general. According to CFPCC (2018) capture fisheries in natural waters involves an employment opportunities for about 448,700 families. Swar (2002) estimated only 5% fishing households (HH) are full time fisher (>9 months) while 60% and 35% HHs ranked as part time (3 months) and occasional fisher (1 month), respectively. The total monetary value of total fish produced from aquaculture and capture fisheries was estimated to about 33,835 million Nepalese Rupees (CFPCC, 2018).

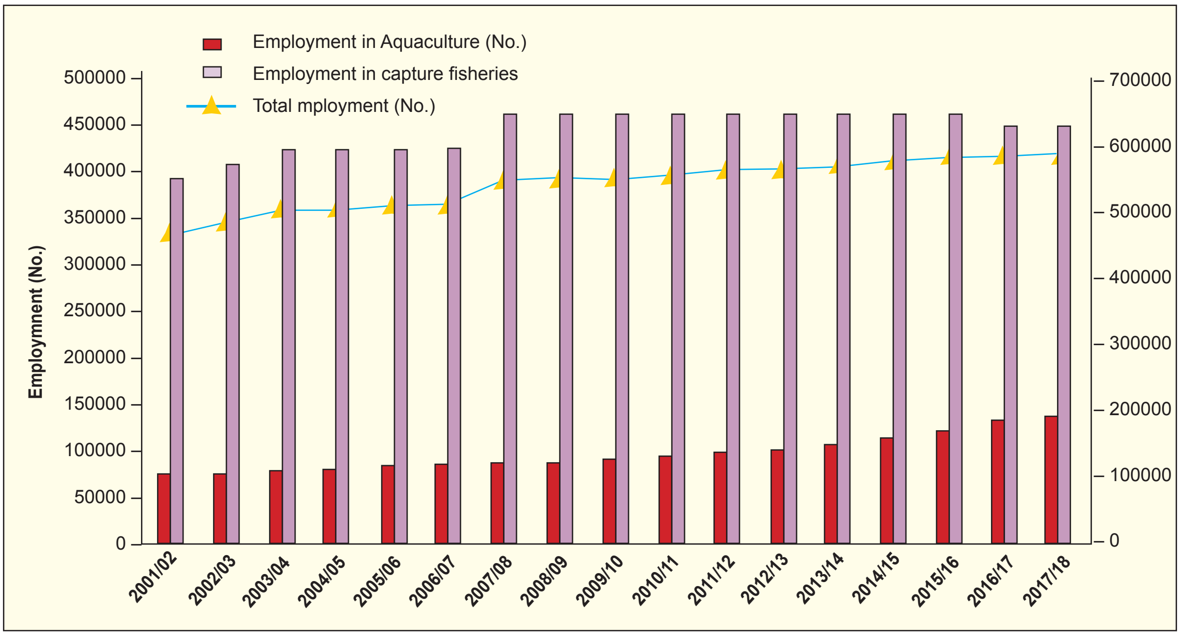

Figure 4. *Trend of employment in aquaculture and capture fisheries (year-wise)*

By tradition, Nepalese society has distinctly identified ethnic communities for fishing, which entirely depend upon fishing and water related occupations such as boating and fishing net mending as a family profession. Nepal has some 103 ethnic and caste group (CBS, 2006). Twenty of these groups are largely living on the bank of water resources and heavily dependent on the wetland products or services (IUCN, 2004).

Status of Fish and Marine Genetic Resources

a) Unique Underutilized FMGR

Local fishes with food value

Generally, all fishes are consumable in Nepal. Regardless of the taste, size and appearance, fish serves the purpose of food. There are only three warm water fish species (*Labeo rohita, Cirrhinus mrigala* and *Catla catla*) involved in commercial aquaculture production. Asala (*Shizothorax progastomus* and *Shizothorax richardsonii*), Sahar (*Tor putitora* and *Tor tor*) and Katle (*Acrosshochielus hexagonolepis*) have been identified as high value fish and common in the high hill water bodies with partial success in their propagation and domestication mostly within the premises of government owned farms. There is huge potential to increase production from fisheries or aquaculture based on the utilization of these species. There are more indigenous fishes having aquaculture potential, such as murrel (*Channa marulius*), catfish (*Wallago attu*), tengra catfish (*Aorichthys seenghala*), mud eel (*Monopterus cuchia*), *Mystus oar,* Jalkapoor (*Clupisoma garua, Pseudeutropius antherinoids, Silonia silondia, Ompak bimaculatus* and *Pangasius pangasius*). However, further detailed studies on their propagation, nursing, feed and husbandry practices would be desirable.

Local fishes with sport value

The cold water fishes e.g. *Tor tor, T. putitora* and *Acrosshochielus* spp., *Schizothorax* spp., *Schizothoraicthys* spp. and *Barilius* spp. are well known for their high sport value and recreation since time immemorial. These fishes migrate downward in winter and upstream in summer invading the turbulent water of the river. They are very strong and grow to big size.

Local fishes with decorative and academic values

A total of 42 native fishes have ornament value (Shrestha, 2019). Those species are: *Moringua raitaborua, Barilius moseestus, Brilius radiolatus, Bengala elanga, Devario aequipinnatus, Devario aequipinnatus, Raiamas bola, Schizothorax labiatus, Psilorhynchus balitora, Psilorhynchus homaloptera, Psilorhynchus nepalensis, Balitora eddsi, Homaloptera bilineata, Schistura beavani, Paracanthocobitis botia, Physoschinstura prashadi, Nemacheilus corica, Schistura fasciata, Schistura himachalensis, Schistura horai, Schistura multifaciatus, Schistura rupecula, Schistura zonata, Turcinoemacheius himalaya, Neoeucirrhichthys maydelli, Botial almorhae, Botial dario, Botial geto, Batasio batosio, Batasio macronotus, Erethistes pussilus, Pseudolaguvia kapuri, Pseudolaguvia assula, Pseudolaguvia nepalensis, Pseudolaguvia mubile, Pseudolaguvia ribeiroi, Pseudolaguvia eddsi, Pseudecheneis crassicauda, Pseudecheneis seracula, Macrognathus lineatomaculatus, Macrognathus zebrinus, Leioden cutcutia,* and *Neoanguilla nepalenis.*

b) Germplasm Collection, Characterization, Evaluation, Conservation and Documentation

The most recent work is a compilation of 236 fishes in Nepal (Shrestha, 2019). Collection and phenotypically identified 135 native fishes in the country are in the fish museum at Fisheries Research Division, Godawari of NARC. Genetic characterization of *Schizothorax richardsonii*, *Labeo rohita, Cirrhinus mrigala, Cyprinus carpio, Cirrhinus mrigala* and *Tor putitora* for stock improvement is initiated. The Kali Gandaki Fish Hatchery (KGFH), Beltari, Nepal produces about one million fingerlings of native fishes for restocking in regulated rivers every year (Gurung & Baidya, 2012).

c) Processing, Value Addition and Product Development

Regarding the status of production and marketing of value-added fishery products, most fish species were sold as fresh or traditionally dried, salted or smoked. Whole smoked local/indigenous fishes: asala (*Schizothorax* sp.), sahar (*Tor putitora*), mahseer (*Tor tor*), rohu (*Labeo rohita*), naini (*Cirrhinus mrigala*), kalanch (*Labeo dyocheilus*), gardi (*Labeo dero*), malki bam (*Mastacembalus armatus*), buduna (*Garra gotyla*), faketa (*Barilius* sp.) were found in the hotels and shops near the rivers and lake side (Pradhan *et al*., 2017). Usually the whole fish were smoked without any additives. *Schizothorax* sp. fetched high price due to high demand and good taste. While *Cirrhinus mrigala*, cultured species produced in mass scale comprised least price. In Nepal value addition was very much in its infant stage. With financial support the production and marketing of value-added fishery products can be enhanced.

Challenges and Opportunities

Out of the indigenous fishes, a number of fish species are of high economic, academic and decorative value. But with the modernization, the increased developmental works (e.g. construction of hydropower and irrigation projects), industrialization, urbanization, deforestation, landslides and siltation, increasing sewerage and excessive use of chemical with the modernization of agriculture the inland waters have been subjected to a range of stress and along with the non-conventional method of fishing e.g. poisoning, dynamiting and electro-fishing has further lead to threatening the indigenous fishes.

Water quality and quantity

Climate change, habitat loss, pollution, deforestation, siltation, intensive agriculture, littering, road construction, barrages, dam for irrigation, hydropower, sewage, removal of boulders and pebbles from river bed might cause water quality and quantity alterations. Thus, impacting fish habitat and fish decline in rivers, lakes and other water bodies (Gurung, 2007; Jha *et al.*, 2007).

Nuisance species

There are certain introduced fishes which have been blamed causing competition for space, food and other resources. There are studies advocating that fish introduction is beneficial as they provide means of livelihood (IDRC, 2007; Gozlan, 2008). Recently, a number of fish used in aquaculture have been reported contributing significantly to food production with significant social impacts but without hampering on native fish biodiversity loss. It was agreed to consider such species as 'naturalized species' (IDRC, 2007). These species could be taken positively contributing in national, regional and local economy (Gurung, 2005) but poses to be the potential nuisance fish in long run, if taken as 'trash' but not as food fish.

Dam for hydropower and irrigation

In near future, hydropower and irrigational dams with interference to conservation of fish and fisheries would be challenging. In Nepal, electrical power has high demand. Since Nepal is rich in river water resources, therefore, hydropower generation probably is the best option economically and socially. However, the damming operation would require harmonious technologies to sustain fish diversity (Jha *et al.*, 2007). Therefore, development of appropriate technologies would be challenging for native fish conservation.

Climate change

Climate change is a great threat to aquatic environment (Wagle *et al.*, 2011). Nepal has been rated as 4th most vulnerable countries of the world despite of the fact that contribution of Nepal for climate change is only 0.025% (Gurung *et al.*, 2011a). Fish habitat shift due to climate change in upper high hills has been expected (Wagle *et al.*, 2011). The climate change has threatened to artisanal fishing communities representing 'the poorest of the poor of the world' in Nepal. Among fishing depended fishers, majority are women (IUCN, 2004; Thapa & Dahal, 2009). Therefore, fish conservation has been also challenging for livelihood of ethnic women.

Marketing, Commercialization and Trade

All fish produced are sold as fresh fish in market or kept by preservation techniques smoking and sun-drying due to lack of fish processing factory. The internal fish production in Nepal is not sufficient covering the demand for consumption and many other purposes (Shrestha, 1999), this to fulfill the market demand of food fish, major parts of its is fulfilled from India (Shrestha, 1999). The trend of fish import is given in Figure 5. Price of exotic and important commercial species, rainbow trout is comparatively higher than local species. Only some fraction of food fishes is exported from Nepal. Fish marketing infrastructures are available in Kathmandu and only some cities. Certification procedure for fresh fishes and labeling systems are not developed but monitoring is done by Municipality consumer's forum and Department of Food Technology and Quality control on random basis (FAO, 2012).

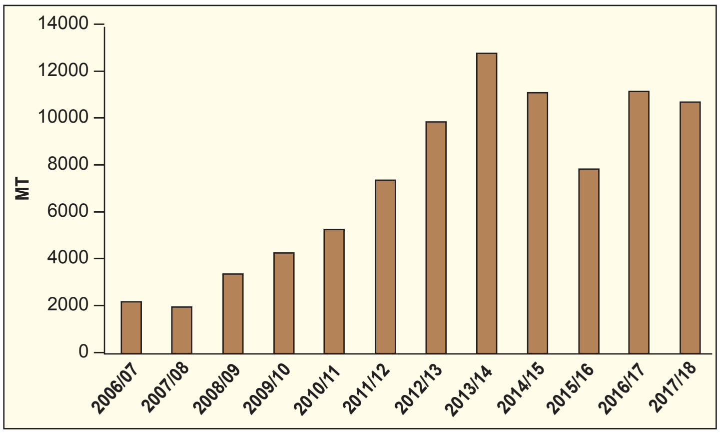

Figure 5. *Fish import trend in Nepal (year-wise)*

Strategies Adopted to Harness Potential of Underutilized FMGR

For conservation of fisheries resources, His Majesty's Government (HMG) has formulated legal device "Aquatic Life Protection Act 2017". Breeding of native fish species in hatchery condition continued. Social mobilization and fishery enhancement techniques (stocking, translocation) were increasingly used as conservation strategy. Live fish gene bank under the aegis of Nepal Agricultural Research Council has been established in Banke district of Terai in 2015 with a view to promote the IUCN Red List Buhari fish (*Wallago attu*). Similarly, the live fish gene bank has initiated establishing five other such banks in the mid-hills region of Nepal to promote artificial breeding of economically important native fish species.

Infrastructure, Capacity Building and Financial Investment

There are eight fisheries research stations under NARC: FRD, Godawari, FRS, Pokhara, FRS, Tishuli, RARS, Tarahara, RARS, Parwanipur, RARS, Nepalganj, KGFH, Beltari and RTFRS, Dhunche. There is lack of skilled manpower (scientists, support staff, lab technicians) on taxonomy. There is lack of field staff on technology, data management, permitting and legislation. Low budget allocation for fisheries sector is one of the major constraints (Figure 6).

Future Thrusts

- Enforcement of legal instrument: Aquatic Animal Protection Act 2017.
- Surveying and inventorying of FGR.
- *In situ* conservation should include declaration of fish sanctuary/park in parts of river and lakes.
- To control the discharge of harmful municipal and industrial wastes.
- To prohibits the use of explosive/poisonous substances.
- Rehabilitation of depleted fishes.
- *Ex situ* conservation of FGR should be promoted by domestication and their inclusion in aquaculture setting.
- Awareness campaign on legal aspect of aquatic biodiversity conservation should be incorporated in fisheries programmes.

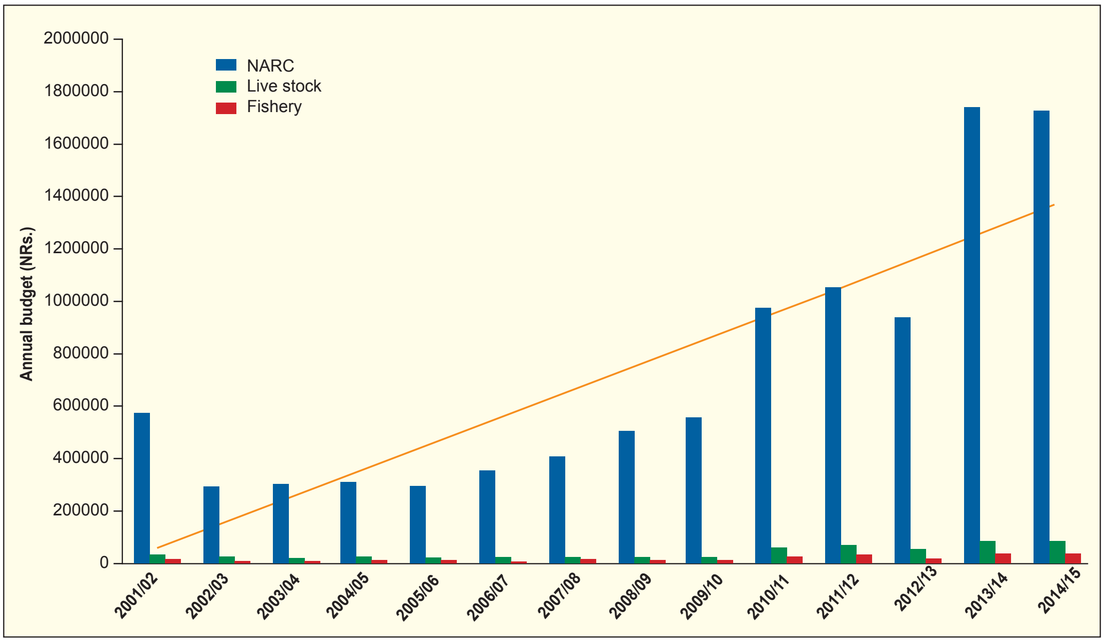

Figure 6. *Budget (year-wise) allocation for fisheries sector under NARC in Nepal*

Conclusions

Most of the FMGR are still remained underutilized and the country needs to pay attention to develop them into marketable products. Many of the UFG might disappear before realization of their importance and economic importance due to environmental degradation, climate change impact, damming and diversion of the streams and several other factors. It is recommended that such UFGR should be conserved, studied, and ameliorated focusing on business model approaches specially to fight against poverty, hunger and malnutrition considering the advantage of life history traits of such fishes which might overcome problems associated with harsh environment and climate change.

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Country Status Report: PAKISTAN

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Introduction

Pakistan is one of the countries in the world where agriculture is practiced on a large scale. It also has great hydraulic potential for aquatic exploitation. A wide coastline about 1120 km long and an exclusive economic zone of 290,000 km^2, gives access to the sea, and internal waters allow aquatic production of various aquatic animals (Siddiqi, 1992). Thus, aquatic products are very important for humans in terms of nutrition (one of the main sources of animal protein for human consumption) and economic (Welcomme *et al.,* 2010). In addition to these benefits, the exploration of new fish species as well as other aquatic animal organisms are increasing for other reasons. In fact, the diversity of aquatic animal species makes the exploitation of this resource inequitable. Some species are less exploited, perhaps through limited knowledge of their way of life or at the genetic level, hence there is a need to evaluate some underutilized marine genetic and fishery resources and to consider some possibilities for improvement of their production.

According to the Convention on Biological Diversity (CBD), genetic resources are genetic material of actual or potential value; and genetic material is any material of plant, animal, microbial or other origin containing functional units of heredity. In this sense, FMGR comprise all finfish and aquatic invertebrate genetic material that has actual or potential value for capture fisheries and aquaculture (Bartley *et al.,* 2006). Although, the study of marine genetic resources is new, this field is developing rapidly.

The biological molecules extracted from these aquatic products may contain many interesting properties such as anti-carcinogenic agents, proteins for industrial use. In Pakistan, There are three categories of fishing being done, including small pelagic fisheries (these include fishes that are found in water column in the coastal waters, including sardines), large pelagic (large fishes found in the offshore waters, including tuna and marlins) and demersal fisheries (bottom dwelling fishes such as shrimp, snappers and pomfrets) (Jarwar, 2008).

However, a large proportion of these capture fish remains underutilized due in most cases to their organoleptic characteristics such as unattractive color, flavor, small size, texture, and high saturated fat content. Most of these underutilized fish belong to the abundantly available pelagic species, which are landed as by-catch. Sometimes, to reduce post-harvest losses, some species of these fish are used in industries for the manufacture of flour and fish oil. However, these underutilized products can also be used in the human diet, through several stages of processing and prior treatment. These treatments can be done by adding value to the initial product.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

Fish and other aquatic products are important food sources for humans and other animals. Indeed, in humans, aquatic products provide food for billions and livelihood for millions of people worldwide (FAO, 2014). In addition, fisheries contribute significantly to food security on three essential points. Firstly, food availability for which the increase in fish production allows for the availability of sufficient and low-cost food in local markets. Secondly, access to food through the fact that fish and all related economic activities in the "fish-chain" represent an important means to generate jobs, income and wealth, with positive effects from household level to broader economic scales. Thirdly, the quality of utilization of fish to good nutrition, by providing primary sources of animal protein, essential nutrients such as vitamin A, calcium, iron, zinc and income (Welcomme *et al.*, 2010).

a) Production and Consumption

In Pakistan, FMGR contribute modestly to economic growth and social development. In fact, fisheries account for less than 0.4% of GDP. FMGR generate many jobs for people. Fisheries employ a reported 390,000 people directly, and when secondary jobs such as processing, transporting, and retailing are considered, the number rises to between 900,000 and 1,800,000 jobs in total (Ebrahim, 2014). However, production varies considerably depending on the year. In 2015, for example, marine capture fisheries produced almost 360,000 tons of fish, while inland capture fisheries and aquaculture operations produced a further 132,500 tons and 151,000 tons, respectively.

The Pakistan Economic Survey 2017-18 estimated that during the first eight months of fiscal year 2017-18, total marine and inland fish production was estimated as 482,000 MT, out of which 338.000 MT was from marine waters and the remaining catch came from inland waters (Syed *et al.*, 2018). About 50% of the total production is consumed by the local population, 22% of total fish production is exported, and 28% is converted to feed for breeding other animals (FAO, 2009). However, the per capita, fish consumption is about 1.5-2.0 kg per year, which is extremely low to world average of 18.4-20.0 kg per person (FAO, 2017). The demand for fish is seasonal but is on the rise due to high prices of alternative meat like beef, chicken and mutton.

b) Imports and Exports

The development and expansion of infrastructure in the country aims to increase the production of seafood. In this context, export and import data for aquatic products from previous years have shown that Pakistan exports almost half of its total fish production. However, Pakistani fish exporters receive relatively low prices because the majority of their products are unprocessed or targeted towards low-value market segments. During 2017-2018, a total of 108,262 MT of fish and fishery products were exported. Pakistan's major buyers are China, Thailand, Malaysia, Middle East, Sri Lanka and Japan (Syed *et al.*, 2018). On the other hand, imports are much lower compared as to exports, and this is due to the setting up of infrastructures and the increase of the internal production.

Status of Fish and Marine Genetic Resources

The current status of FMGR is not exactly known in Pakistan. However, data on the species produced and their use show that approximately 30% of total landed species can be considered as underutilized, by-catch, unconventional or unexploited.

a) Unique Underutilized FMGR

Overall, the FMGRs are small pelagic fish (minced fish, sardine, mackerel) and other species such as diadromous, Sea Spiders, Crabs, Lobsters, Spiny, Rock Lobsters, Shads, Flounders, Halibuts, Soles, Snoeks, Cutlass fishes, Squids, Cuttle fishes and Octopii. These species are sometimes used in other value-added food products.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Documentation

The biodiversity of fish and other underutilized aquatic animal species is complex. Several environmental factors such as over-exploitation, aquatic pollution, flow modification, destruction or degradation of the habitat, as well as the invasion of exotic species, can affect this biodiversity and lead to the disappearance of certain species. It was, therefore, imperative to develop strategies for preserving certain cells of threatened or underutilized species in order to ensure their continued survival.

Thus, since several years, research has focused on the germplasm collection of many aquatic animal species making it possible to preserve the survival of many species (Lakra & Goswami, 2011). In fact, germplasm are the genetic materials of germ cells, including gametes, embryos, or larvae for animals. Their collection consists of taking the tissues or gametes (spermatozoa or ovum) from the fish or shellfish to extract DNA or RNA suitable for genetic and genomic studies of biodiversity. The germplasm thus extracted is usually preserved by cryopreservation (at –20°C or – 40°C approximately) (Di Santo *et al*., 2012).

c) Processing, Value Addition and Product Development

The treatment depends on the raw material to be used as well as the finished product that is to be obtained. However, for all underutilized products, the first step for their use is a hygienic collection of mince by mechanical meat separating machines. Bone-separation processes can be applied to most fish species, crustaceans such as krill and molluscs as well as fish frames obtained from filleting operations. After this step, the fish muscle, fat and blood are squeezed through another machine having an orifice size of about 3-5 mm. The minced product obtained from this operation must be quickly stabilized, because the process of deboning causes a rupture of the membrane tissues, and consequently accelerates the oxidation processes.

Thus, depending on the species or type of fish used, the stability of the thin fish during storage (at –40°C) varies with time. However, many other compounds are used daily to improve either the taste, the flavor, the texture or even the stability of the product. This is an example of a complex mixture of muscle tissue with other soluble proteins, fat, spices, salt and water during the manufacture of sausage (Roy, 1992). The manufacture of other products includes the incorporation of compounds such as glutamic acid, polyphosphate, gelatin, and glycine. The products obtained can be patties, balls, wafers, loaves, burgers, fish fingers, fish fritters, and pickled products (Regier & Raizin, 1988).

Challenges and Opportunities

In Pakistan, several challenges restrain considerably the development of FMGR:

- Lack of coordination among institutions including Government, Non-governmental organizations, Research institutes and Universities
- Insufficient inputs infrastructure
- Poor post-harvest facilities and handling
- Shortage of national and international research projects as well as experts, especially in the areas of production system, fish nutrition, fish diseases and fish genetics
- Lack of technical services to fish farmers such as training packages and materials including with inadequate capacity
- Limited budget for basic research and development projects
- Insufficient scientific awareness to design aquaculture research and development projects
- Improper fishery policy and guidelines for the developing aquaculture
- Expensive commercially produced seed and lack of quality fish seed
- Highest per unit cost due to improper management of production units
- Limited aquatic animal health (AAH) surveillance and control

Regarding opportunities, Pakistan has great potential for the production of aquatic products and the practice of aquaculture, inoculant livelihood to local communities, contribution in food production, training and management staff, conservators, researchers, ecologist and business and other jobs, through offering different types of aquaculture system such as integrated aquaculture, cage culture, bait culture, ornamental fish culture, export and import of fisheries product, integrated aquaculture, intensive aquaculture and culture-based fisheries. In addition, with the presence of several species of aquatic animals that abound the Pakistani coastline, the underutilized fish species and other marine and genetic resources to be an asset for the manufacture of new products (Muhammad, 2018).

Marketing, Commercialization and Trade

Pakistani fish products are exported to over 50 countries, including Vietnam, UAE, Thailand, Sri Lanka, Japan, China, Malaysia, South Korea, Egypt, and Saudi Arabia. During the fiscal year 2015-16, Pakistan exported approximately 140,000 tons of fish products, worth more than US$350 million. The most important export product categories are frozen fish (excluding fish fillets), which account for 50% of export value. Shrimp make up a further 23%. Fresh fish, fish fillets, salted fish, and fishmeal account for most of the balance, each within the range of 3-5%. In addition, due to the establishment of a new land trading route from Gwadar to Guangdong, China for example, exportation may increase in the next few years.

Strategies Adopted to Harness Potential of Underutilized FMGR

Several strategies are currently being developed in the context of improving the production potential of underutilized FMGR:

- Made investments in education and training for fisheries
- Develop supporting diagnostic and research capability
- Improved management of marine resources

- Improving value-added production
- Reduce fishing effort to below scientifically-informed thresholds to maximize (or at least improve) yields
- Review of fisheries legislation to inform the legislative and regulatory changes necessary to ensure sustainability
- Knowledge of the status of the marine environment and the social and economic processes that affect it is indispensable for effective decision-making
- Regenerate mangroves, ensuring water flow for healthy rivers, reducing water pollution (Ministry of Climate Change, 2012)

Major Focus Areas for Underutilized FMGR

The FMGR have already been exploited and used in many ways of life.

Pharmaceuticals: Derivatives of genetic material (DNA and RNA) extracted from MGRs have already used several times as antioxidants, antiviral, anti-inflammatory, antibiotic, anti-HIV, anti-cancer, anti-tuberculosis and anti-malaria. Examples of molecules isolated from MGC are cyanovirin (isolated from cyanobacteria) who active in blocking cell entry of pathogenic viruses such as HIV and Hepatitis-C, and dolastatin, with great potential as anti-cancer agents.

Cosmetics: Other compounds have been isolated and used as a skin protection cream. This is the case Scytonemin, pigment derived from cyanobacteria, which protects the skin against ultraviolet irradiation.

Bioremediation: This involves using living organisms such as micro-organisms, in the treatment of hazardous waste (such as wastewater), and the control of pollution due to chemical compounds.

Nutraceuticals: From marine products, some compounds have already been synthesized and used as nutraceuticals for human health. For examples, with polysaccharides, polyphenols, bioactive peptides, polyunsaturated fatty acids and carotenoids, identified anti-cancer, anti-inflammatory, anti-oxidant and antimicrobial activities (Vidanarachchi *et al*., 2012). Other compounds like Fucoidan have been bought from seaweed, on the beneficial effects of the immune system and gastrointestinal health and neutralizing free radicals.

Infrastructure, Capacity Building and Financial Investment

Pakistan has several production facilities and research in improving the production of aquatic animals. Among these, we have the Marine Fisheries Department (MFD), National Agricultural Research Center (NARC) (Hayat, 2003). The country also has more operational harbours like Karachi Fish Harbour, Korangi Fish Harbour, Pasni Fish Harbour and Gwadar Fish Harbour and Miniport. Other facilities such as hatcheries units and nurseries units (about 8) are also available and operational. Currently, there are approximately 107 hatcheries in the private sector, and only 28 in the public sector in several provinces: Punjab, Sindh, KPK, Baluchistan, AJK and others.

Future Thrusts

For future improvement of FMGR, the following factors must be taken into consideration:

- Water area surveys
- Improvements in post-harvest technology and availability of soil/water analysis and disease control laboratories, processing and hygienic fish landing facilities

- Research laboratories and other infrastructure development as well as quality control measures
- Improvements in socio-economic conditions of fishers and incentives for them during fishing holidays
- Soft/easy small-medium loans with easy accessibility to aquaculturists and fishers
- Effective extension services and quality assurance
- Strict conservation measures and fishing moratoriums with regard to species and areas/zones and strict vigilance for fishing as per rules
- Incentives for fishers during fishing moratoriums
- Use of special nets for fishing to save juvenile and unwanted biota
- Zonation (species-wise) and designation of fish reserves and parks

Conclusions

Fish and marine genetic resources have been the subject of some studies for some decades. However, overexploitation of aquatic products, pollution, climate change, as well as the increase of the population, are leading researches to focus on techniques that will allow increasing production, to exploit the animal species wisely already known, and to develop methods for the identification and classification of underutilized species. In this sense, some marine animal species nowadays are studied for their genetic resources, the extraction of compounds or bioactive substances for their applications in several areas of human life such as pharmacology, nutraceuticals, bioremediation, and cosmetics. However, the purpose of studying underutilized marine genetic species and their potential to increase knowledge and production, perhaps for commercial purposes, is to inform and commercial interests, environmental concerns, ethics, and considerations to international law and policy. It would also be necessary to improve infrastructure that will help increase production, improve product quality and reduce post-harvest losses.

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Country Status Report: SRI LANKA

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Dr Varuni Gunathilake serves as a Senior Lecturer at the Department of Zoology, University of Sri Jayewardenepura. Her PhD was based on marine pharmacognosy and the title of the thesis was 'Taxonomic identification, immuno-pharmacological and toxicological study of *Haliclona* (*Soestella*) sp. a novel marine sponge species from Sri Lanka'. The research outcomes were published in many national and international scientific fora. Her research interests are extended to sponge identification based on DNA barcoding, molecular and chemical characterization of immunomodulatory bioactive pharmacophores from marine invertebrates.

Introduction

Sri Lanka is an island nation, situated South of the Indian sub-continent between 5°55′ and 9°51′ N latitude, and 79°41′ and 81°53′ E longitude North of the equator (National Report of Sri Lanka, 2002). The island has a total land area of 65,000 km^2 and a coastline of about 1585 km of which 300 km are beaches and sand dunes (GSL, 1985, Lowry and Wickremaratne, 1989). The maritime area of 230,000 km^2 belonging to Sri Lanka is about three times larger than the land area (Rajasuriya & White, 1995). The continental shelf of the country as an area of about 31,000 km^2 and the width ranges from 9 to 45 km with an average depth of 66 m (Cooray, 1967). The Territorial sea of Sri Lanka extends to a distance of 12 nautical miles, contiguous zone extends to a distance of 24 nautical miles and the Exclusive Economic Zone (EEZ) extends to a distance of 200 nautical miles from the baseline (National Report of Sri Lanka, 2002). The area enclosed by the exclusive economic zone (EEZ) is reported as 517,000 km^2. (MFOR, 2002), which is 7.8 times the total land area of the country (Figure 1). Being an island nation, despite its small size, Sri Lanka has a rich ecosystem diversity because of its topographic and climatic heterogeneity as well as its coastal influence (Table 1) (Gunatillake *et al.*, 2008). The country is globally recognized for the outstanding biological diversity.

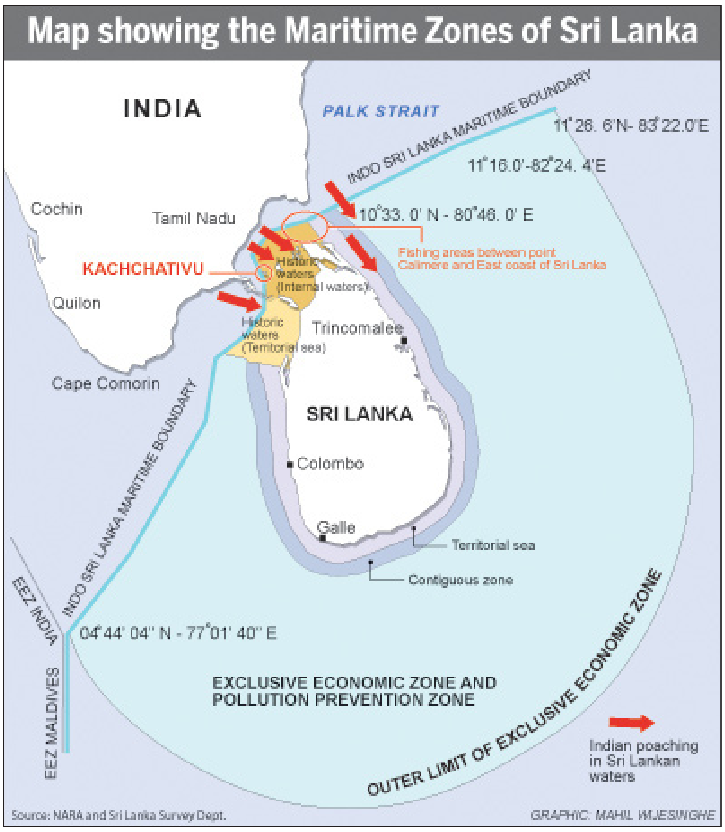

Figure 1. *Maritime zones of Sri Lanka (Source: National Aquatic Resources and Research Agency and Survey Department, Sri Lanka)*

The marine ecosystems of Sri Lanka are represented by coral reefs, sea grass beds and the marine habitats around the country (Gunatillake *et al.,* 2008).

Coral reefs, both near-shore reefs (mostly fringing, sandstone, rock and boulder) and well-developed off-shore reefs are found along 2-3% of the island's coastline, creating a rich diversity with about 183 species from 68 genera, principally *Acropora, Montipora, Porites, Favia, Favites, Pocillopora, Goniastrea, Platygyra* and *Leptoria.* Green, red, and brown algae, mollusks, sea cucumbers, sea anemones, lobsters and reef fish abound in these reefs (Gunatillake *et al.*, 2008; Rajasuriya, 1991). The coral reefs also provide habitat for about 1000 species of fish.

Sea-grass beds are found in calm shallow seas, estuaries and lagoons around the island where 12 species of angiosperms halophytes have been recorded including, *Enhalus acoroides, Thalassia hemprichii, Halophylla* and *Najas* (Gunatillake *et al*, 2008).The sea grass beds provide home to fish that directly feed on sea grass and peneid shrimp larvae feed on grass detritus. Sea-grass beds also provide habitats for sea turtles and dugong (Gunatilleke *et al,* 2008). The marine fishery of the country depends on the near-shore and off-shore waters of the Indian Ocean surrounding Sri Lanka. These waters are rich with predatory fish such as reef sharks, and a range of food and shell-fish, lobsters, marine mammals, cetaceans including the sperm whale, blue whale and dolphins.

The salt marshes of Sri Lanka are dominated by the halophytic or salt-loving plants *Halosarcia indicum, Salicornia brachiata, Sueda maritima,* and *S. monoica*, which are confined to this ecosystem. Mangroves provide nursery grounds for finfish, shellfish, clams, crabs, oysters and shrimp. The coastal area consists of a vegetation which is unique and rich in biodiversity. The dominant vegetation is *Ipomea pescaprae* in the wet zone of the country and the grass *Spinifex littoreus* in the drier parts. Species such as *Vernonia, Hedyotis, Phyllanthus* and *Crotalaria*, *Scaevola*, *Clerodendrum, Morinda* and *Calotropis*; *andanus* spp., *Barringtonia asiatica, Calophyllum inophyllum* and *Thespesia populnea* are also abundant (Table 1; Gunatilleke *et al.*, 2008).

Marine fishery is a well-established practice in Sri Lanka since past. In 2017, total catch of fish from coastal fishery exceeded 250,000 MT (Fishery Statistics, 2018, Department of Fisheries). Large pelagic fish: large tunas, pelagic sharks and billfishes currently contribute about 85,000-95,000 tonne to Sri Lanka's annual fish production. The fish catches are highly diverse but about 8 species groups

Table 1. Ecosystem diversity and their extents in Sri Lanka (Source: Gunatilleke *et al.,* 2008)

Aquatic ecosystem diversity		Present extent (ha)	Terrestrial ecosysytem diversity		Present extent (ha)
Coastal ecosystems			**Natural forest ecosystems**		
1	Coral reefs	not available	1	Tropical lowland wet evergreen forests/ lowland rain forests	141,506
2	Sea grass beds	23,819	2	Tropical submontane forests	68,616
3	Salt marshes	33,573	3	Tropical montane forests	243,886
4	Mangroves	12,189	4	Tropical moist evergreen forests	1,090,981
5	Sea shores/beaches	not available	5	Tropical dry mixed evergreen forests	464,076
6	Mud flats	not available	6	Thorn scrub forests	not available
7	Lagoons and esturies	158,017			
8	Sand dunes	7,606			
			Natural grassland ecosystems		
Inland aquatic systems			1	Wet patanas	not available
1	Fresh water marshes	10,000**	2	Dry patanas*	65,000
2	Rivers and streams/ Riverine forests	22,435	3	Savannas*	not available
3	Reservoirs*	179,000	4	Talawas*	not available
			5	Damanas*	10,000
			6	Villu	–

** Man-influenced ecosystems. ** Also includes the villus* (surgeon fishes, jacks and trevallies, grunts and sweetlips, pony fishes, emperors, snappers, groupers, and sharks and rays) are predominant, each making up more than 10% of the catch (Preston, 1998). There are about 30 species of shrimps but only a few (e.g. *Penaeus monodon, P. indicus, P. merguiensis, P. monodon, P. semisulcatus* and *Metapenaeus* spp.) are consumed.

Marine genetic resources (MGR) can be broadly defined as genetic material, i.e. DNA or RNA of actual or potential value (Marciniak, 2017). It includes every cell of a living organism and their genes, chromosomes, tissues, gametes embryos and other early life history stages, individuals, strains, stocks, and communities of organisms of actual or potential value for food and agriculture or any other human needs such as health. MGR encompass most natural products due to the evolution of genomic studies and biotechnology to extract and isolate compounds from harvested or cultured marine organisms.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

The importance of developing FMGR for food security is recognized as a global asset. Marine biotechnology, which involves marine bioresources, either as the source or the target of biotechnology applications (European Science Foundation, 2010), is identified as the main tool to achieve the task of developing MGR to valuable products. The global market for marine biotechnology products and processes is estimated at € 2.8 billion in 2010, with a cumulative annual growth rate of 4-5%, revealing the huge potential and high expectations for further development of the marine biotechnology sector at a global scale.

a) Production and Consumption

The majority of Sri Lankan fishery depends from the wild catch of fish, finfish and shellfish, which are bestowed by nature. The total fish catch reached to its highest peak in 2017, accounting 81,870 MT small pelagic fish such as sardines, herrings, anchovies and mackerels currently counts about 65,000-70,000 tonne per year (Fisheries Statistic Report, 2018). Contribution from medium pelagic fish such as small tunas, which tend to be exploited within the shelf area is estimated to be of the order of 6,500-10,000 tonne per year at present. Large pelagic fish such as large tunas, pelagic sharks and billfishes currently contribute about 85,000-95,000 tonne to Sri Lanka's annual fish production. The tunas, billfishes, and pelagic sharks are primarily oceanic species that predominate beyond the continental shelf (Preston, 1998). Demersal fish production is currently estimated to be about 25,000-30,000 tonne annually. Catches are highly diverse but about 8 groups (surgeon fishes, jacks and trevallies, grunts and sweetlips, pony fishes, emperors, snappers, groupers, and sharks & rays) are predominant, each making up more than 10% of the catch (Preston, 1998).

The underlying biodiversity in the Sri Lankan marine environment is extraordinary rich and complex, yet remained untapped, provides an open reservoir of genetic resources to explore and investigate unique and diverse novel natural compounds (bioprospecting). There is a huge potential to utilize these MGR to develop in to products which can be commercialized in a sustainable manner. Underutilized MGR including marine invertebrates, sea weeds and even microorganisms, dwelling in the Sri Lankan sea waters are considered as good donors of secondary metabolic compounds. Marine secondary metabolites are considered as a potential source of biologically active metabolites with great chemical diversity. These compounds are structurally complex, diverse and also proven as valuable therapeutic agents (Blunt *et al.*, 2018, Hu *et al.*, 2011).

The global concern on MGR has reached to its peak as new compounds are isolated and patented annually from various MGR including marine invertebrates, algae and microorganisms. A large number of pre-clinical and clinical research is ongoing on drug discovery and therapy, for the treatment of a variety of human diseases, including cancer, microbial infections, inflammatory and even HIV (Mayer *et al.*, 2007; Hu *et al.,* 2011). Therefore, Sri Lanka is armed with a huge genetic resource to contribute to the global challenge.

b) Imports and Exports

There is a considerable contribution from Sri Lankan marine fishery to Sri Lankan economy. In 2017, annual export earnings from fish cost USD 257 million. The highest contribution for this was from Tuna, which was 19,698 million SLR while majority was exported to EU countries (Fisheries Report, 2017). There are 33 fish processing plants and 16 packing centers which utilize the commercial fish catch. Collection of reef fish, invertebrates and live coral for the ornamental fish export industry is of considerable importance. In fisheries export products, ornamental fish exports are rated as the third highest in volume and value after prawns and lobsters (Baldwin, 1991).

Many coastal and inshore resources associated with the coastal habitats support a thriving export industry based on export of shrimp, lobster, chank, ornamental fish, etc. Wild-caught and cultured prawn species together account for over half the value of Sri Lanka's fishery exports. Potential yields of wild prawns are unknown, but the catch trends do not indicate the potential for a substantial increase in production (Preston, 1998). Six species of spiny lobsters are present around Sri Lanka and over 2000t per year production has been recorded in recent years. They are variously found in coral reefs, sandstone, rocks and mud banks up to a depth of 25 m, and comprise one of Sri Lanka's most valuable export fisheries.

Despite the marine resources around the country, Sri Lanka, still import some fishery products from international producers. Sri Lanka imports 3 to 4 billion worth of canned fish per annum (Gunawardene C, unpublished data). Mackerel canned fish are imported mainly from Chile. Sri Lanka import red algae derived agar-agar from Indonesia. This is widely available for local customers at local supermarkets.

Most of the Sri Lankan MGR are still remained underutilized and the country need to pay attention to develop them in to marketable products. Bioactive compounds can be used in the biotechnology, biopharmaceutical, and cosmetics industries. The potential of developing these underutilized MGRs will be discussed in following sections.

Status of Fish and Marine Genetic Resources

a) Unique underutilized FMGR

There is a rapid increase in the inventory of marine natural products and genes of commercial interest derived from bioprospecting efforts. The number of natural products described from marine species is growing at a rate of 4% per year, which is much faster than the rate of species discovery, because many species yield multiple natural products (Arrieta *et al.*, 2010).

Marine ecosystems are particularly suited for bioprospecting as marine species are about twice as likely to yield at least one gene in a patent than their terrestrial counterparts (Arrieta *et al.*, 2010), and the success rate in finding previously undescribed active chemicals in marine organisms is 500 times higher than that for terrestrial species (Venugopal, 2008). The applications of genes of marine organisms patented, with a prevalence of applications in the pharmacology and human health (55%), agriculture or aquaculture (26%), food (17%), cosmetics (7%) industry and an emerging and growing number of applications in the fields of ecotoxicology, bioremediation, and biofuel production (Arrieta *et al.*, 2010; Molinski *et al.*, 2009).

Although, the coastal and marine waters of Sri Lanka are endowed by numerous MGR, most of these are remained underutilized to date. A large untapped reservoir of MGR available, associated with the coral reefs, mangroves, sea grass beds, lagoons and estuaries, and shallow water. Rajasuriya and White (1995), reported 12 species and 3 genera of corals only, previously not recorded from Sri Lanka, increasing the total to 183 species of stony corals divided among 68 genera, which contributes to the massive coral diversity in Sri Lanka. These reefs provide breeding and nesting sites for reef fish, marine invertebrates such as sponges, coelenterates, bryozoans and echinodermates and marine algae. Such resources are remained untapped and some of these are not even identified through proper channels, thus available as gold mines to discover natural products through bioprospecting.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Documentation

In Sri Lanka, germplasm collection, cryopreservation for conservation and breeding purposes have already initiated for inland fish species such as *Catla catla* by Fish Genetic Unit and Aquaculture Development Center of National Aquaculture Development Authority (NAQDA). The *ex situ* conservation of few endemic fish species is also practiced at NAQDA, Sri Lanka. However, collection and preservation of marine fish germplasm is yet to be initiated in Sri Lanka.

Developing centers such as gene banks for biologically and economically important MGR has not been done so far for marine species. On the other hand, formulating a national policy for germplasm conservation, and strengthening the capacity and scope of the MGR have not received adequate consideration.

Sperm cryopreservation protocols are available now for over 200 species of finfish and shellfish (Divan *et al.*, 2010) which might be used as a guide to Sri Lankan MGR. Developing cell lines, embryonic stem cells and germ cells from Indian fishes has been established in India (Pandian, 2002). However, these technologies are yet to be practiced in Sri Lanka for marine fish species.

c) Processing, Value Addition and Product Development

Although most of the research are already initiated on bioprospecting, majority of MGR of Sri Lanka is underutilized for processing, value addition and product development. The screening of MGR for novel bioactive compounds is remained as an open area for research, followed by the screening and precise identification, necessary measures should be taken to isolate these compounds and develop them into value-added patented products.

The sponges of Sri Lanka are recorded as more than 77 species (Dendy, 1905) but the number may be much higher than this value due to evolution of novel species. This untapped resource of marine sponges is investigated by few Sri Lankan scientists (de Silva *et al.*, 1991; Gunathilake *et al.*, 2015; Rathnaweera *et al.*, 2016) for various bioactive compounds. However, the transformation of knowledge from research to industry has not adequately addressed. Similarly, soft corals, cnidarians, echinodermates and marine microbes can be investigated for their bioactive properties. Extractions of polyunsaturated fatty acids from marine fish can be facilitated. These are components of dietary supplements that deliver health benefits to humans and can alleviate a broad range of non-communicable diseases. Production of reporter to be used in biomedical research and cell and molecular biology is already established but can be performed from jelly fish available in the Sri Lankan coast. These metabolites will serve as potential source for value addition to Sri Lankan MGRs.

Sri Lankan fishery is well-established and practiced to provide food and nutrition to the people locally and internationally. There are large scale fish processing industries which aim at exporting fish to other countries. Most of the underutilized fish belong to the abundantly available pelagic species, which are landed as by-catch, and some are unconventional species such as krill (Venugopal, 2008). Post-harvest fishery losses are also reported high in Sri Lankan Fishery. Recovery of flesh by mechanical deboning and development of value-added products are probably the most promising approaches which are already practiced in some private firms in the country. Surimi and surimi-based products, sausages, fermented products, protein concentrates and hydrolysates, extruded products are some of the possibilities of which these underutilized fish can be utilized.

Although, most of the researches are already initiated on bioprospecting, majority of MGR of Sri Lanka is underutilized for processing, value addition and product development. The screening of MGR for novel bioactive compounds is remained as an open area for research, followed by the screening and precise identification, necessary measures should be taken to isolate these compounds and develop them in to value added patented products. The blooming of marine patents associated with MGRs is largely a result of recent technological advances in exploring the ocean and the genetic diversity. Levels of research activity and product development from MGR can be identified under few main categories, marine pharmacognosy, marine derived enzymes, cosmeceutical industry and bioremediation. Marine pharmacognosy or marine derived pharmaceuticals for drug discover for herpes, cancer and AIDS is valued \$100 million, \$1 billion and \$23 million, respectively (United Nations Informal Consultative Process on Oceans and the Law of the Sea, 2007). These drugs are derived mainly from marine sponges, tunicates and microorganisms, which are also available in the Sri Lankan coastal habitats.

Challenges and Opportunities

Bioprospecting of marine resources only requires the collection of a very limited amount of biomass for the initial gene or product discovery. Therefore, bioprospecting does not generally involve threats to biodiversity of Sri Lanka, comparable to the large biomass removals involved in harvesting of marine resources for food. A small amount of biomass can provide enough DNA for endless replication by PCR. However, in biopharmaceuticals, when a promising drug candidate is found, a second more substantial harvest may be needed to collect a considerable weight of the specimen, which may indirectly result the exploitation of the valuable GR. Therefore, adequate measures should be taken for sustainable use of these MGR. After the identification of the MGR, mariculture can be practiced to extract bioactive agents, but the activity of these agents may not be similar exactly potent as derived from the natural resource.

Despite the promise of the oceans, the technical challenges of accessing areas outside the shallow coastal zone, and the costs of deep-water exploration, mean much of the oceans' depths remain to be discovered. The new organisms should be discovered from benthic zones of Sri Lanka, to screen for novel compounds is an essential support for future innovation. New opportunities are available with new biotechnologies, such as gene editing and genomic selection for genetic gain but are either at the experimental stage or at the early phases of adoption at present. Practical application of genetic technologies appropriate to specific circumstances and consumer acceptance of new biotechnologies will need to be addressed before their application in MGR.

The lack of standardization of nomenclature and terminology is problematic in most of invertebrate marine genetic resources. This is due to lack of taxonomist locally to identify for most of the marine species such as microorganisms, aquatic plants and marine invertebrates like sponges. Complications associated with the correct authentication of species can be overcome by adapting molecular biological techniques such as DNA bar coding. DNA barcoding is a widely used molecular tool in identification of marine species throughout the world.

Major opportunities exist to extend the use of ocean bioresources in markets for industrial enzymes, pharmaceuticals, functional foods, cosmetics and agricultural products. The potential of using Sri Lankan marine invertebrates such as sponges, ascidians and Echinodermates to isolate bioactive compounds to treat type II diabetes and inflammation (Senthilkumar & Kim, 2013) is already proven by research. There is a good opportunity to study bioactive pharmacophores from these species, in order to look in to their potential as therapeutic agents. Marine sponges, algae, bacteria, and invertebrates are highly promising sources of NF-κB inhibitors with a wide range of molecular targets in the NF-κB pathway (Senthilkumar & Kim, 2013). Opportunities do available to Sri Lankan scientific community to identify, isolate and characterize these untapped genetic resources for such valuable bioactive properties.

Marine cyanobacteria are also prolific producers of novel biologically active compounds and have been recognized as a source of pharmaceutical lead compounds. Opportunities are available to isolate and characterize bioactive compounds from marine fungi as well. Marine-derived fungi isolated from marine macroorganisms or from sediment as well as endophytic fungi from mangrove plants continue to be a prolific source of a plethora of natural products with pharmacological activities (Dissanayake *et al.,* 2016). Isolation of compounds with cytotoxic activities is also well practiced in other parts of the world. Marine sponges, soft coral and even marine bacteria are good donors of such compounds. These compounds are successfully involved in suppressing tumors and cancer progression.

The microalgae represent a very large, untapped reservoir of novel compounds, many of which are likely to show biological activities such as antibacterial and antifungal activities. They are good biological sources of single cell protein (SCP). They are also considered as the best source of protein, approximately 50% of dry weight. In global context, microalgae are used to prepare fish feed due to its high content of proteins (Kiron *et al.,* 2012).

Macroalgal species i.e. green, red and brown algae are most abundantly found in the Sri Lankan coast yet remained as underutilized for their beneficial values. Red seaweeds *Gracilaria salicornia* and *Gracilaria edulis* which are abundantly distributed in Sri Lankan coast, can be used to extract agar (Vinobaba *et al.*, 2016). Red algae are considered as potential source to extract carrageenan, which is a stabilizing agent used in food industry. However, agar-agar is currently importing from Indonesia. Therefore, there is an opened field to develop local agar-agar market, based on underutilized red algae from Sri Lankan coast. Similarly, there are opportunities available to extract polysaccharides from brown alga as well. These were used in 1970s to tan cloths but now remained underutilized (Personal communication with Dr Isuru Wijesekara, Food Science and Technology, University of Sri Jayewardenepura, Sri Lanka).

Marketing, Commercialization and Trade

Marketing, commercialization and trade of MGR is not adequately addressed in Sri Lanka. However, few FGR-based products are produced. Fish oil is consumed as a source of nutraceutical to obtain Omega-3 fatty acids and vitamin A. A considerable amount of shark liver oil is extracted from spiny dogfish shark in Sri Lanka. Crude water extracts of marine sea cucumbers are consumed by local Sri Lankan community as a remedy for arthritic-related pains. The scientific validation of these treatments is underway.

Bivalves, gastropods, amphipods and decapods are considered as good source of proteins and carbohydrates (Kristensen, 1972) yet remained as underutilized sources in Sri Lanka. There is no survey about consumer preferences, risk, prices, marketing strategies, quality control and technical support for processing, packaging, labeling, certification, etc. Therefore, it is important to encourage to develop variety of products and test them in the market with the technical support from the government. The strategy for MGR utilization and development is directed toward fulfilment of domestic market and for export purposes. This strategy is actually parallel with the establishment of local and regional markets for the commercialization of Sri Lankan MGR.

Strategies Adopted to Harness Potential of Underutilized FMGR

Strategies can be developed to utilize by the successful use of marine bioprospecting. Implementation of genomic analysis of microorganisms, algae and invertebrates, mariculture of organisms, developing cell culture techniques of invertebrates with bioactive properties, bioengineering of marine organisms are some of the strategies which can be adapted to harness potential of underutilized MGR of Sri Lanka. Identify and prioritizing marine model organisms that are still not investigated in the tree of life can be identified and cultivated to perform genomic and chemical analysis.

Major Focus Areas for Underutilized FMGR

The rich and untapped resource of Sri Lankan MGR can be utilized under the following focused areas:

i) **Food**
Under this area, measures can be taken to develop innovative methods based on genomics, proteomics and metabolomics for selective breeding of marine organisms. Sustainable production of food products from these resources can be developed through strategic biotechnological approaches to increase productivity, alternative to preventive and therapeutic measures to enhance welfare zero-waste recirculation systems.

ii) **Energy**
Unused marine algae can be utilized by improving knowledge of basic biological functions, tools for steering the metabolism and cultivation methods of marine microalgae to improve the photosynthetic efficiency, enhance lipid productivity and obtain microalgae with optimum characteristics for mass cultivation. Development of efficient harvest of these, separation and purification processes will also be helpful.

iii) **Health**
As previously mentioned, secondary metabolites from marine invertebrates such as marine tunicates, sponges, cucumbers, cnidarians, algae and microorganisms can be developed to novel drugs, treatments and health. Comprehensive research on taxonomy, systematics, and chemical characterization from underutilized MGRs can be used to increase the hit rate of novel bioprospective agents. Bio-assay guided fractionation and structure elucidation of novel marine derived bioactive agents will be helpful to patent Sri Lankan underutilized MGRs.

iv) **Environment**
Biotechnological approaches, mechanisms and applications can be developed to find solutions for environmental issues we face today. Automated high-resolution bio-sensing technologies, which monitor coastal water quality, including prediction and detection of Harmful Algal Blooms (HAB) and marine toxins, can be developed. Development of cost-effective and non-toxic antifouling technologies is also possible to be practiced. Precise molecular level identification of

microbial strains which have bioremediation ability and their mass production and maintaining of cell cultures are also helpful.

v) **Industrial products and processes**

Marine-derived enzymes (from marine bacteria and fungi), biopolymers (from marine invertebrates such as crustaceans, marine algae and microbes), marine collagen (from fish waste) and biomaterials (from marine invertebrates) which can be used in industry are yet to be investigated from Sri Lankan MGRs. For example, red algae which is abundantly found in the northern coastal area of the country can be used to produce agars and carrageenans. Similarly, brown algae produce alginates, fucans and laminarins. These hydrocollids are well-known for their gelling properties and are used in a variety of laboratory and industrial applications. Bioplastics such as polyhydroxyalkanoate (PHA) are well popular biomaterial derived from marine bacteria, due to their high molecular weight, thermoplastic/elastomeric properties, biodegradability, biocompatibility, non-toxicity and potential for production from renewable carbon sources. Developing high throughput enzyme screening, studying the expression of marine proteins and enzymes are considered as important tasks.

vi) **Genomics and meta-genomics, molecular biology**

Implementation of genomic analyses of marine organisms which are not properly identified such as sponges, cnidarian species and marine microorganisms will be helpful for proper identification and taxonomic analysis.

vii) **Mariculture**

Technologies should be developed for culture and isolation of uncultivated microorganisms, to adapt innovative culture methods to vertebrate or invertebrate cell lines for production of active compounds.

viii) **Bioengineering of marine microorganisms**

Bioengineering of marine microorganisms to increase their photo reactions can be focused.

ix) **Marine model organisms**

Identify and prioritize new marine model organisms that are still not investigated in evolutionary process, are needed to fill knowledge gaps. Only a few model organisms such as sea urchin, sea squirt, lamprey, polychaete, platyneris that are currently investigated.

Infrastructure, Capacity Building and Financial Investment

To promote sustainable utilization of FMGR, innovation, training of the next generation of scientists is considered as critical. A link should be built between international research institutions to build capacity of Sri Lankan scientists and technicians. Further, priority should be given to explore the underutilized MGR from Sri Lankan waters, and funding should be allocated to research and bioprospecting approaches.

Increase the capital funds to develop research laboratories, training of scientists and technicians by proper international collaborations and introduction of bioprospecting and biotechnological products to the private industry are also essential and to be prioritized. Being an island nation, Sri Lanka has the access to sea from everywhere in the country. Therefore, only the initial financial investments on sample collection, storing and extraction facilities should be prioritized.

Case Studies/Success Stories for Improvement of Health and Livelihoods

Research work was already established since early 1983, to investigate the bioactive compounds from MGRs. Researchers have contributed significantly to identify, test and isolate such compounds and published their work in reputed scientific entities.

Research on marine algae belonging to Chlorophyceae, Phaeophyceae and Rhodophyceae (*Ulva reticulata, Ulva fasciata, Chaetomorphaaerea, limedamacroloba, Valoniopsis, pachynema, Padina pavonia, Sargassum cervicone, Gracilaria* sp. *Sarcodiaceylanica, Laurencia* sp. have resulted isolation of secondary metabolites with anti-biotic algae have shown DPPH, alkyl, and hydroxyl radical scavenging activities in the Chang liver cell line (Fermnando *et al*., 2017). *Chaetomorpha antennina*, *Gracilaria edulis* and the sea grass; *Halophila ovalis* have resulted anti-inflammatory properties using LPS stimulated RAW 264.7 macrophages and by *in vivo* zebra fish embryo model (Fernando *et al*., 2017). Three species of red algae (*Chondrophycus ceylanicus, Gelidiella acerosa, Gracilaria corticata*), two species of green algae (*Chaetomorpha crassa*, *Caulerpa racemosa*) and one species of brown algae (*Sargassum cassifolium*) were evaluated for anti-oxidant and anti-cancer properties, have proven their effectiveness (Lakmal *et al*., 2014 a, b). Further, isolation of agar from red seaweeds *Gracilaria salicornia* and *Gracilaria edulis*is also reported (Vinobaba *et al.,* 2016). Sri Lankan brown algae extracts have shown potent antioxidant activity (Samarakoon *et al*., 2013, 2014). Extensive research is underway on Sri Lankan marine algae in many Sri Lankan universities and research institutes. A Collaborative Research Project investigation of Sri Lankan Marine Algae is established between Korea Institute of Ocean Science & Technology (KIOST) and Industrial Technology Institute of Sri Lanka, which have shown a green light to marine bioprospecting-based research. Rathnaweera *et al. (2016),* reported the isolation of fungi *Aspergillus flavipes* along with structure elucidation and antimicrobial activities of the isolated compounds.

Research works from Sri Lankan scientists are extended to marine invertebrates such as sea slugs, soft corals, sponges and many more. Secondary metabolites such as diterpenoids, dendrillolide A, 12-desacetoxyshahamin C 13 (3), shahamin F 171 (5), aplyroseol are reported from Nudibranch *Chromodoriscavae* skin extract (de Silva *et al*., 1991). Lankalapuol A and B from marine mollusk *Aplysia dactylomela* was isolated (Baker *et al*., 1988).

Few Sri Lankan marine demosponge species collected from Batticaloa, Sri Lanka, were identified as potent sources for modulating mammalian immune system by *ex vivo* phagocytosis (Gunathilake *et al*., 2013 a, b). These sponge extracts had shown their potential to upregulate the immune cell profiles of Wistar rats. Further, extensive immunomodulatory study based on *Haliclona (Soestella*) sp. been conducted to evaluate immunomodulatory anti-inflammatory and anti-cancer activities of crude and fractions (Gunathilake, 2017; Gunathilake *et al*., 2013, 2014a, b; 2015a, b; 2017). Anti-inflammatory activity was detected in 4 Sri Lankan marine sponge species including *Phakelia* sp., *Axinella* sp. and *Stylissa carteri* (Silva & Gunathilake, 2018). Dissanayake *et al.* (2016) investigated a nutrition-rich soup powder from Sri Lankan sea cucumber extract and in 2019, a patent was approved for this production. This soup powder contained anti-oxidant activity and also rich in proteins and minerals.

Future Thrusts

Appropriate capacity building, knowledge and skills serve as key requirements to better characterize, sustainably use and develop the FMGR, and therefore, support livelihoods, health of people and national economies. Research should improve and increase bioprospecting approaches on FGMR in a range of disciplines, including molecular characterization, health, nutrition, industry environment and food science. Furthermore, education, training and capacity building are crosscutting themes for sustainable development in the aquaculture sector. Training and extension material, guidelines and participatory approaches to knowledge creation could be developed, promoted and applied around the world; ongoing research is relevant for all countries.

The future marine bioprospecting should focus to capitalize on the knowledge which is already available and use globally accepted technologies and tools to harness bioactive molecules for food and human health. Finally, if a national or regional strategy for bioprospecting related to economic development is to have a chance of succeed, it requires efficient access to financing sources for long term programmes as much as training and a legal framework. Updating or establishing data bases for Sri Lankan MGR and sharing information, deposition of valuable genes in genbanks are also remained as future targets.

Conclusions

Being a biological hot spot, Sri Lanka is a rich source of marine genetics resources. However, compared to the other countries of the region, marine bioprospecting is still remained at its infancy, resulting a large resource of MGR as underutilized. The biological potential of these underutilized MGR is already initiated by Sri Lankan scientists. Research has been carried out to identify underutilized marine genetic resources, screen their bioactivity, isolation of bioactive compounds and characterizations. However, with respect to its large untapped biodiversity, most of the marine resources are remained unexplored and underutilized.

Development of marine biotechnology through bioprospecting can be developed through proper strategic plans, infra-structure and capacity building, enhancing scientific knowledge by international collaborations, development of marine based products to improve heath, food security and economy of people. The legal aspects of sustainable utilization of marine resources and patenting the products or mechanisms associated with Sri Lankan MGRs should also be considered and prioritized. Through proper planning and sustainable use of the underutilized marine genetic resources will thus make the Sri Lanka economically strong and benefited.

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Country Status Report: IRAN

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Introduction

Geographically, Iran is located in West Asia and has the second largest population (after Egypt) of the Middle East with more than 80 million people. In the Iranian ecosystems approximately 8000 species of plants, 197 species of mammals, 535 species of birds, 227 species of reptiles, 21 species of amphibians, 160 species of freshwater fishes and more than 900 species of marine fishes have been recorded (DOE, 2015). Iran is one of the most important countries in the Middle East and Western Asia for the conservation of biological diversity. Habitat diversity in Iran allows for a wide range of animals to inhibit in Iran. With regards to ecosystem diversity of marine and coastal zones in the North and South of the country, it consists of 25 ecological types and units, in which the most important are coral reefs, bays and small islands (DOE, 2015). The total area of the country is 1.65 million km^2, which includes 1.64 million km^2 land area and 12000 km^2 of water surface. It has a coastline stretching for 2700 km, the Caspian Sea (890 km), Persian Gulf (1200 km, without Islands), and Gulf of Oman (637 km). The long Iranian coastline coupled with a diversified climate in the land area suitable for various type of aquaculture system makes Iran as one of the powerful fishing courtiers in the region. There are three different fishery activities in Iran: the southern fishery (the Persian Gulf and Oman Sea); the northern fishery (the Caspian Sea); inland fishery and aquaculture. In 2017, total fish production in Iran was 120,4000 MT, fishery and aquaculture were 724,000 MT and 480,000 MT, respectively (IFO, 2018).

The Caspian Sea, the largest lake in the world, is located in northern Iran. The Caspian Sea coast, with its thick forests and intensive rice cultivation, presents a striking contrast to the dry inner plateau of Iran. The most important commercial bony fish of the Caspian Sea are kutum (*Rutilus kutum*), golden grey mullet (*Liza aurata*), leaping grey mullet (*Liza saliens*), pikeperch (*Sander lucioperca*), European carp (*Cyprinus carpio*), roach (*Rutilus rutilus*), Caspian shads (species of genus *Aloza*), bream (*Abramis brama*), Caspian shamaya (*Chalchalburnus chalcoides*) and Caspian vimba (*Vimba vimba*). The Caspian Sea is an inhabitant of five species of Sturgeon fish: great sturgeon (*Huso huso*), Russian sturgeon (*Acipenser guldenstadedti*), Persian sturgeon (*Acipenser persicus*), stellate sturgeon (*Acipenser stellatus*) and spiny sturgeon (*Acipenser nudiventris*) (Karimpouri *et al*., 2013). The annual catch in the Caspian Sea reduced from 98,000 MT in 1997 (IFO, 1998) to 40,314 MT in 2017 (IFO, 2018). There was a reduction (83.8%) in the catch of Kilka fishes from 1997 to 2008 (Karimpouri *et al*., 2013).

The Persian Gulf and Oman Sea were located in the South of Iran. The most important commercial fishes are: skipjack tuna (*Kasuwonus pelamis*), long tail tuna (*Tunnus taggul*), yellow fin tuna (*Thunnus albacores*), kawakawa (*Euthynus affinis*), narrow-barred Spanish mackerel (*Scomberomorus commerson*), chub mackerel (*Scomber guttatus*), sharks (Cacharhinidae), scads (Carangidae), black marlin (*Makaira indica*), sailfish (*Istiophorus platypterus*), snappers (species of genus *Lutjanus*), southern meagre (*Argyrosomus hololepidotus*), orange-spotted grouper (*Epinephelus coioides*), deep-flounder (*Pseudorhombus elevates*), black-pomfret (*Parastromaleus niger*), barracudas (Sphyraenidae), black banded kingfish (*Seriolina nigrofasciata*, Carangidae), common dolphinfish (*Coryphaena hippurus*), and species of genus *Sardinella* (Karimpouri *et al*., 2013). The annual catch in the Persian Gulf and Oman sea raised from 260,500 MT in 1997 (IFO, 1998) to 691,174 MT in 2017(IFO, 2018).

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

According to IFO (2018), Iran's total production of fishery and aquaculture commodities counted 120,2086 MT in 2017. More than half (60%) of the total production in Iran was derived from marine waters, the remaining from inland waters (FAO, 2016). Capture fisheries are responsible for most of the seafood production (724,817 MT), but the contribution of aquaculture has sharply grown from 4935 MT in 1978 (less than 1% of the total seafood production) to 477,269 MT in 2017 (40% of the total seafood production). Nevertheless, the role of the seafood sector as a contributor to the Iranian economy is limited and its share of the agricultural sector remains low. About 80% of the total aquaculture production is utilized for domestic markets, the main commodities are being fish, shrimp, and caviar. As fish was not a popular part of the Iranian diet in the 1980s, per capita consumption increased from 1 kg/year to 11.2 kg/year in 2017 (IFO, 2018). However, it’s less than world per capita consumption (19.8) and more than South American (10.2 kg/year) and African (10.1 kg/year) countries (FAO, 2016). The total number of people employed in fisheries has risen from 101,931 in 1997 to 141,917 by 2017. The number of employed in the aquaculture sector and in the inland fishery has risen from 10,250 in 1997 to 87,502 by 2017 (IFO, 1998; 2018).

b) Imports and Exports

The most important export fishery products are caviar, shrimp, fish species and other aquatic animals. The range of total value of export fishery products was between 49.7 million $ (in 1997) and 507.2 million $ (in 2017). The range of exported caviar value from Iran was 33.7 million $ in 1997 and reduced to 2.8 million $, in 2017, after 2010 all exported caviar comes from aquaculture. There has been a sharp reduction in the export amount of caviar in recent years. The amount of caviar exported in 1997 was 106 MT (IFO, 1998), and reduced at a minimum level of 1 MT in 2017 (IFO, 2018). Shrimp was the second important fisheries product for export, it reached the maximum level in 2017 with 116.3 million $. The value of fish and other aquatic animals (lobster, squid, crayfish, etc.) exported in 1997 was 6.7 million $ and exceeded to 388.1 million $ in 2017. The total amount of fishery product export was 7,104 MT in 1997; it reached to 137,581 MT (19.3 times more) in 2017. After 1997, the shrimp export was 2,489 MT, it exceeded to 24,780 MT in 2017 (10 times more) (IFO, 1998; 2018).

Status of Fish and Marine Genetic Resources

a) Unique Underutilized FMGR

Fish marine resources in Iranian territory include the Caspian Sea, the Southern Seas (the Persian Gulf and Oman Sea), inland water fisheries and aquaculture. Two water bodies of the Persian Gulf and Oman Sea located in the South of Iran and different vertebrate aquatics inhabiting there consist of fishes (Osteichthyes & Chondrichthyes), marine mammals, sea snakes, and reptiles. A total of 900 fish species belongs to 31 orders and 142 families have been identified and reported (Valinassab & Sedghi Marouf, 2013; Owfi, 2015; Carpenter, 1997; Randall, 1995). Amongst them, some important species have been studied from point of molecular genetics and population genetics such as croaker, silver pomfret, cobia, sardines, and Sturgeons. On the other hand, from marine mammals, a total of 10 species of dolphins, 14 species of whales and one species of dugong have been identified. Also, 9 species of sea snakes have been reported from the Persian Gulf and Oman Sea belongs to 6 genus and 2 subfamilies of family Hydrophidae. It should be mentioned that no genetic studies have been done on marine mammals and sea snakes till now. In addition, a total of 5 species of sea turtles have been reported from the Persian Gulf and Oman Sea (Valinsassab *et al*., 2018).

Total fish landings in southern Iran have been almost rising since 1989, with a recorded 691,174 MT in 2017, comprising demersal species (241,136 MT), big pelagic fishes (326784 MT), small pelagic fishes (94,650 MT), Shrimps (11,194 MT) and Myctophids (17,181 MT). Total landings along the Iranian portion of southern Caspian coast reached 33,643 MT, including sturgeon (29 MT), Kilka (22,602 MT) and bony fishes (11,012 MT) in 2017. The bony fishes include Kutum (*Rutilus frisii*), mullets, carp, pikeperch, breams, herrings, mullet and a few others (IFO, 2018). Base on the analysis of data statistics, it seems most of fish marine resources in Iranian waters are fully exploited, except lanternfishes, squids, and jellyfishes.

Lanternfish schools are found in offshore waters, on the edge of the continental shelf wherever sea depth is more than 100 m. During the day the fish occur in two vertical layers, with the densest schools in the shallower layer (80–130 m), whereas at night *Benthosema pterotum* occur in a single dispersed layer closer to the surface (mainly at 30-70 m). Biomass estimates range from 1 to 4 million MT, with an average of 2.3 million MT, the MSY is estimated 400,000 MT. Densities vary seasonally, with the highest densities recorded in spring (May-June) and lowest in autumn (October-November). The highest densities were seen in the western Oman Sea (Valinassab *et al*., 2007). In 2008, exploitation of lanternfishes stock was started by Iranian fisheries organization with 10 midwater trawlers, a total of 18,000 MT of lanternfishes were caught by 92 midwater trawler vessels in 2017 (IFO, 2018).

Iranian waters of Oman Sea and the Persian Gulf contain large resources of Oegospid and Myospid squids. Ommastrephidae and Loliginidae families consist of commercial squid species. Because of high depths (up to 3000 m and more) of Oman Sea, Ommastrphids are mainly found in this area. However, Loliginids stocks are distributed all over the continental shelf in the northern part of Oman Sea (Rajabipour *et al*., 2001). Among all cephalopods, *Sthenoteuthis oualaniensis*is absolutely dominated numbers and biomass in the epipelagial of the Arabian Sea. Juveniles (3-10 cm ML) and middle-sized specimens (10-30 cm) were observed at night, hunting on lanternfishes and flying fishes around the drifting vessel. The giant females (30-62 cm) were caught mainly close to the thermocline. The total stock of *S. oualaniensis* over the entire investigated grid (equal to 159,560 km^2) was estimated as 750,000 MT. Moreover, approximately 200,000 MT of squid was concentrated on one-tenth of the grid in aggregations with biomass more than 10 tons/km^2 (Chesalin *et al*., 2002).

Jellyfishes were reported as a new potential of marine species for exploitation (Valinassab *et al*., 2016). The annual bloom of jellyfishes in the Persian Gulf and Oman Sea occurs in early summer to autumn.

Dominate species of jellyfishes were reported by some authors, Michel *et al*. (1981) 29 species, Michel *et al*. (1986) 26 species, Dehghan Mediseh *et al*. (2017) 17 species. A high density of *Crambionella orsini* was observed in the eastern part of the Oman Sea, the biomass of this jellyfish was estimated about 52,035 tons, the bloom extended up to 16 months in this region (Daryanabard & Dawson, 2008). The total catch of Jellyfishes was reported 2,045 MT in 2017 (IFO, 2018), but jellyfish landing exceeded to 7,918 MT because of foreign customers.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Documentation

Genetic resources provide basic material for selection and improvement through breeding to ensure food security needs of the world's rapidly rising population. Iranian National Center for Genetic and Biological Diseases of Iran with the aim at collecting, identifying, controlling the quality, classification, registration, maintenance, reproduction and distribution of a variety of cultivated and renewable microorganisms and cells, including bacteria, fungi, viruses, seeds, plant and animal cells, and genomic DNA and nucleotide products were established in March 2007 by the University Jihad. Outlooks of this center is achieving a central national and international leader in collecting, organizing, standardizing, preserving and exploiting the country's genetic and biological resources for the development of knowledge, technology and improving the quality of life and health and preserving the biodiversity of the country and supplying the international community. Fishes germplasm collection in Iran was not developed as well as other organisms (animals, plants, and microorganisms). There is currently no codified plan for the collection of fish germplasm in Iran. Of course, some attempts have been carried out by Shiraz University, IFSRI, and so on. There were good background on genetic studies for main species in the Persian Gulf and Caspian Sea on Kobia (Aliabadi *et al*., 2009), on Kutum (Rezvani, 1997; Rezvani*et al*., 2012), on Hilsha Shad (Jorfi *et al*., 2009), on Sturgeons (Pourkazemi *et al*., 1999; Nourouzi *et al*., 2009), Narrow-Barred Spanish Mackerel (Mansourkiaei *et al*., 2016; Abedi *et al*., 2012), silver pomfret (Archangi *et al*., 2013; Golestani *et al*., 2010), sardine (Rahimi *et al*., 2016) and shrimps (Shahrawy *et al*., 2016; Niamaimandi *et al*., 2010). Recently in 2018, Iranian Fisheries Science Research Institute in response to the preservation of Iranian fish genetic resources announced a national programmes for construction of Iranian fish resources genetic bank (http://www.ifsri.ir).

Challenges and Opportunities

A review of fishery statistics shows a trend of increasing fishing effort in the Persian Gulf and Oman Sea during the last decade. Thus, the number of fishermen increased from 70,729 in 1993 to 131,330 in 2017 (IFO, 2018). Although total landings have increased, catches of certain preferred species, such as Sturgeon and Kilka in the Caspian Sea, and shrimp, Silver pomfret and demersal species in the Persian Gulf have declined dramatically in the last decade. Fisheries legislation is in place, but compliance has been limited. Despite huge investments by the government in conservation and surveillance activities, illegal fishing methods are still common. Like many other nations, Iran has over-capacity in its fleet and fishing capacity, resulting in too many fishers chasing limited wild fish resources, while simultaneous political, social and economic pressures exist for further expansion of fishing effort. Catch from wild natural resources is very limited due to overfishing, pollution, and illegal fishing. Attempts are in progress to improve matters through a fish stock enhancement programmes, conservation, fishery management and a buy-back scheme for reducing the number of existing fishing licenses. In contrast, aquaculture is very promising due to the vast areas suitable and diverse climate conditions. It is extremely difficult to make management decisions and proper action on resource allocation between competing user groups. In addition, environmental challenges continue, with water with extremely high temperatures in summer, and environmental degradation from dredging, land reclamation and dam construction on the southern coast of the Caspian Sea. Each coastal state in the Persian Gulf has their own legislation for fisheries management in place, but the Regional Commission for Fisheries (RECOFI) – the only regional body for fisheries management in the Persian Gulf and Oman Sea – has not been successful yet in harmonizing fishery measures in the area. The main shipping lines of the world's largest oil fields pass through the Persian Gulf's exit, the Strait of Hormuz, and thus, its ecology has been impacted by the pollution caused by multiple oil spills, to which, unfortunately, the effects of mining, a land reclamation project and largely unregulated fishing must be added (Roshan Moniri *et al.*, 2013). With the ever-increasing development of the oil industry in the region, oil pollution from offshore installations, oil tankers, tanker terminals, and petrochemical plants has become a major threat to the ecology of the Persian Gulf, but its effect on the fisheries cannot be assessed (Roshan Moniri *et al.*, 2013). Overfishing and over-capacity exist in the area, yet there is no arena to negotiate a balance between fishers and living marine resources. It seems that overfishing as a consequence of lack of proper management, together with environmental degradation, can explain the observed decline of fish stocks in the Persian Gulf region (Roshan Moniri *et al.*, 2013; Valinassab *et al.*, 2006). In 2001, a jellyfish, *Mnemiopsis leidyi*, originating from South America, affected marine resources of the Black Sea, and from there it spread to the Caspian Sea and was identified by Iranian scientist in early 1999. This species feeds on the larvae and eggs of Kilka and other fishes, which has had a negative effect on Kilka resources. To counteract the reduction in sturgeon resources in the Caspian Sea, a stock enhancement programmes was started in 1973, and since then millions of fingerlings have been released to the sea. In 2017, more than 43 million post-larval (>45 days) indigenous shrimp species were released in the northern side of the Persian Gulf and more than 308 million fingerlings of various fish species released to the southern Caspian Sea under rehabilitation programmes (IFO, 2018).

Marketing, Commercialization and Trade

In 1998, the Iranian Fisheries Organization created a new position in its organization for directing and improving fish marketing in Iran. Since then marketing has become a major priority in fisheries development. Most people in Iran live in central cities and have beef and chicken in their diet rather than fish or fisheries products. The type of food they usually cook and their culture has harmonized with red meat. Fish is of little interest, even having a negative image in some parts. Although, presently minimal in comparison with major global players, and representing only 2% of the total national exports of agricultural products, fish and fishery product exports from Iran are growing (Shaviklo, 2016). Iran Agricultural GDP in 2013 was 11% of total GDP, and fisheries were 4% of agriculture GDP (FAO, 2015). Although, there is a potential for fishing and aquaculture, the market is not ready for fish consumption and, culturally, fish is not acceptable in many populated areas, especially in the central cities. Therefore, changing the diet and eating habits of people in these areas requires long-term planning and significant investment. Direct export data from Iran reached 507 million US$ in 2017 (IFO, 2018), compared to the 50 million US$ shown by the mirror data. The United Arab Emirates are Iran's largest importer of fish and seafood products, with a peak value of US$ 29 million in 2013 accounting for 39% of total Iranian seafood exports. While the value of import by the United Arab Emirates for seafood from Iran has decreased in 2015 and 2016, the UAE import share has grown to 43% in 2016 and they still remain Iran's biggest importer. Tariff problems are expected to be the main reason for the decline of export values in general. It is likely that Iran cannot compete with lower tariff countries in Asia, which makes it important to reach out to other potential export partners. There have been some recent attempts to enter the Japanese and USA markets with shrimp, but export quantities are small. Only 8% of the seafood produced in Iran is exported. This small percentage is a consequence of reduced fish stocks of the various types of caviar-bearing sturgeon, which has led to a virtual ban on the sturgeon industry (Iran's main seafood export commodity). In order to protect of sturgeons stocks, fishing of these species have been banned from 2010 in Iran, and exports are only base on aquaculture products. Moreover, cultured fish, such as rainbow trout, are mainly produced for the domestic market due to its small size (700 - 800 g). According to Trade Map, International Trade Centre reported that crustaceans are, at the moment, the most profitable export species of the Iranian seafood sector. In 2016, 47% of the total seafood export volume was comprised of crustaceans, creating a value of 23 million US$. This is a reduction of US$ 7 million compared to 2015. Overall, the export values of Iranian seafood species have decreased in recent years, but with international sanction being lifted and surpassing diseases like the early mortality syndrome, Iran is keen on reviving its seafood industry (ITC, 2014).

Strategies Adopted to Harness Potential of Underutilized FMGR

As the population of Iran increases, the need for protein intake has also increased. In recent years, the exploitation of marine fish resources in Iran has increasingly been affected by the increase in illegal fishing efforts. It is estimated that about 11,167 fishing traditional boats and about 125 industrial vessels (IFO, 2018) are available; most of which are equipped by diver type demersal and midwater of fishing gears are exploiting the continental shelf and continental slope fish resources. Major landed catches are frozen or freshly consumed on the domestic market. Only species such as Large head hairtail, squid and cuttlefishes, rays, and shrimps are allowed to export. Some major economic species (Orange-spotted grouper, Black-spotted Croaker, Sharks, Silver pomfret, Forefinger threadfin, and Pearl oysters) have declined dramatically, and fisheries management efforts have not been effective to control the exploitation of these valuable fishes. On the other hand, the biomass of small and economically insignificant species has increased considerably. The majority of these small fishes were used to fishmeal product or dried for livestock and poultry industries. Also, a large amount of waste from fish canning factories is also used to produce fishmeal. The Strategy Plan for Sturgeons aimed at (1) genetic resources protection and extinction prevention, (2) reducing the fishing pressure on wild resources, (3) rehabilitation and regeneration of sturgeon resources (Pourkazemi, 2016). Iran's strategy is to track the value addition of low value and small fish through the production of conversion products such as protein, omega-3, medications, and more. In this regard, the Strategic Plan for Southern Fish States aimed at (1) reaching the world average per capita consumption (16 kg) or close to, (2) raising the income of fishermen and activists in the fisheries industry, (3) reaching to sustainable fish production and (4) making new job opportunities (Maramazi, 2016). The strategy and general policies of the programmes in the Persian Gulf and the Sea of Oman are as follows:

- Applying appropriate management to maintain the stability and enhancement of Southern fish stocks.
- Identifying and introducing new fish resources in offshore.
- Development of Southern fish aquaculture as a pivotal strategy.
- Increasing the productivity of marine products in order to increase the income of fishermen.
- Establishing constructive engagement with neighboring countries in order to develop and implement comprehensive and unit-wide management of shared fish resources.
- Development of fish conversion industries and services.

Major Focus Areas for Underutilized FMGR

Considering the completion of the exploitation capacity of most fish and marine fishes in Iranian waters, it seems that the exploitation of lanternfish stocks with 2.3 million MT of biomass and 400,000

MT per year of MSY is one of the objectives for Iranian fishery. The fishing ground of Myctophids (lanternfishes) is now located in the North-West of the Oman Sea (Valinassab *et al.*, 2007). The exploitation of deep-sea fishes (more than 400 m depth) is the new objective. Recently, first studies of exploration on deep-sea fishes in the Oman Sea area were started by Iranian Fisheries Science Research Organization. Squid stocks with 750,000 MT biomass from offshore areas in the Oman Sea and Arabian Sea (Chesalin *et al.*, 2002) is one of the underutilized fisheries potentials for Iranian fishery. Jellyfishes were recognized as a new potential of underutilized species from the Persian Gulf and Oman Sea (Dehghan Mediseh *et al*., 2017; Daryanabard & Dawson, 2008).

Infrastructure, Capacity Building and Financial Investment

The total number of fishermen in Iran was reported 141,917 people (131,330 people in the Persian Gulf and Oman Sea, and 10,587 people in the Caspian Sea (IFO, 2018). In recent years, there has been an increase in the number of fisherman cooperatives in Iran. The number of fisherman cooperatives in the Southern Seas fishery was 79 in 1997. This number increased to 169 in 2017. Those of the Caspian Sea was 204 in 1997 and reduced to 182 in 2017. Total fishing vessels were reported 11,292 fleets, as 799 fleets in the Caspian Sea (725 small boats and 74 Dhows) and 10,493 fleets in the Persian Gulf and Oman Sea (7233 small boats, 3135 Dhows, and 125 vessels) (IFO, 2018). Fisheries investment in Iran in 2000 was 71.2 million US$. In 2008, it raised to 446.8 million $ (6.3 times more), and recently in 2017, it was 153 million US$. The number of can factories in 1997 was only 47, in 2017 it exceeded to 134. The number of fish meal factories was 26 in 1997, it reached 47 in 2017. The number of frozen units in the fishery was 65 in 1997, it reached 128 in 2017. In 2017, the capacity of can factories was 717,000 tons/day, the capacity of fishmeal was 932 tons/day and the capacity of frozen units was 155 MT (IFO, 1998; IFO, 2018).

Case Studies/Success Stories for Improvement of Health and Livelihoods

Improving the sanitary conditions of Dhows was one of the most important projects implemented to improve the health conditions of the fishermen in Iran. Improving the condition of keeping fish in the store of Dhows was an effective help in selling fish and improving the quality of life of the fishermen. Health insurance for fishermen in Iran supported by the government has been well implemented and has been very effective in occupational safety and health promotion of the fishermen. Changing fishing methods from monofilament and gillnet and promoting hook and longline, development of fishing pier, and establishment of a health officer, in coastal areas were the effective measures to improve the livelihood of the fishermen.

Future Thrusts

With regard to the current stock exploitation and also the fishing infrastructure, it seems that fishing pressure will occur on large species, and fishing will, therefore, shift to less exploited species. Increasing the fish production, increasing per capita consumption, employment generation and warranty of beneficiaries' income can be predicted by fish products adding value through investing in the development of fish processing industries, processing of trash fishes, are the future thrusts of fish exploitation in Iran. Exploiting the lanternfishes, squids, and jellyfishes were planned and assessed by Iranian Fisheries Science Research Institute as a development programmes for fisheries. Marine aquaculture development programmes include cage culture, shrimp and fish culture are the right options for the protein supply of the community (Motalebi & Sharif Rohani, 2010).

Conclusions

Iran is a country with unique fishery capacities, surrounded by two bodies of waters, in the North (Caspian Sea) and the South (the Persian Gulf and Oman Sea), and has wide access to oceanic waters. The development trend of the marine fish resources exploitation indicates the good potential of fish resources in the Iranian waters. Significant investments have been made in exploiting of marine resources in Iran so that some commercial species have been fully exploited, as evidence of fishing pressure on large fish stocks. Hence, new options for fishery development are the less exploited fish resources include lanternfish stocks in the Oman Sea and the squid resources in Oman Sea and the Arabian Sea. Recently, some species as jellyfish, Babylon shellfish, Rays, and some other trash fishes have attracted foreign customers. Recently, deep-sea fish stocks in the Oman Sea are aimed by the Iranian Fisheries Science Research Institute for identification and feasibility of exploitation.

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COUNTRY STATUS REPORTS

SOUTH-EAST, EAST ASIA AND THE PACIFIC

Country Status Report: LAO PDR

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Introduction

The Lao PDR is a landlocked country located in the heart of South-East Asia. With a geographical area of 236,800 km^2, of which 87.7% (207,674 km) drains into the Mekong River, making up 26.1% of the Mekong Basin, and contributing about 35% of the Mekong River's discharge. Another 12.3% in the North-eastern area drains to the North of Viet Nam into rivers that flow to the East Sea. Almost all Lao territory is of enormous importance, both for fishery resources and for its rich aquatic biodiversity. Fisheries are an integral part of the lives of rural people, providing a major part of their animal protein and micro-nutrient intakes, as well as being an important source of secondary income for a large proportion of the population. People traditionally live beside rivers and streams and grow rice nearby, providing many opportunities to fish and collect other aquatic foods in both natural and constructed habitats. Wild capture fisheries continue to provide the major part of the production for Lao people, with aquaculture and stocking playing an increasing role in supplementing the wild catch.

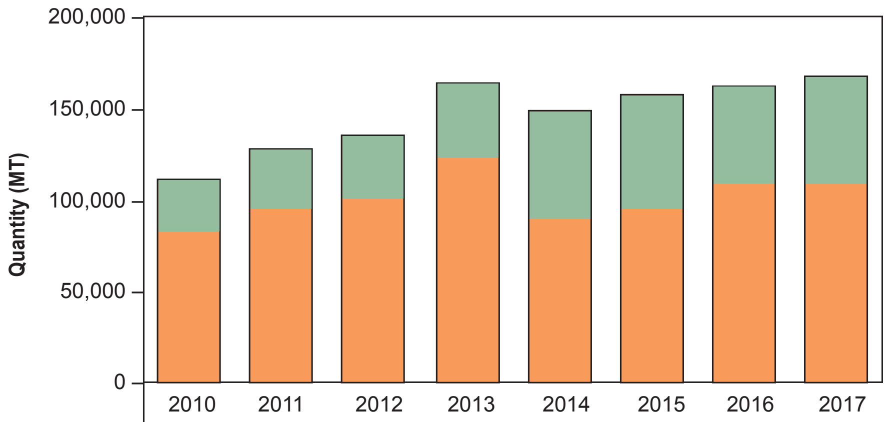
Importance of Fish and Marine Genetic Resources in Economy and Food Security

Most fishing is carried out as part of a diverse rural livelihood, ranked as the second or third most important activity after rice farming and animal husbandry, and contributing an average of about 20% to rural household income. Fishing as a full-time occupation is seasonal and limited only to locations near major rivers or reservoirs. The bulk of fish caught is consumed within the household, but surpluses may be sold, and this accounts for about a quarter of total catches. Catch price at first sale vary according to the species and size of the fish and it is not recorded regularly. The average price across the country is estimated to range from 15,000 to 20,000 Kip/kg and wild fish is in general priced higher for its taste than cultured fish species from 30,000 to 100,000 Kip/kg (US$ 2 = 15,000 Kip (2019). Wild fish still dominated the market, even though cultured fish production made an important contribution to total trade.

The people of Lao PDR, especially in the rural communities, rely heavily on aquatic resources as the most reliable sources of animal protein. The estimated fish consumption of inland fish is 24.5 kg/capita/year, while other aquatic animals account for about 4.1 kg/capita/year and marine products around 0.4 kg/capita/year, to make a total of 29 kg/capita/year of fish and aquatic products consumed (Hortle, 2007). During the rainy season, aquatic products are collected from all forms of water bodies and wetlands. Surplus aquatic products produced during the rainy season are preserved in a variety of ways according to cultural preference and prevailing local conditions such as fermenting (the most common process), pickling, drying, and smoking. Preserved fish products are generally more valuable than the fresh fish from which they are made. The preserved fish products are then utilized throughout the dry season, when food is relatively scarce. Fermented fish is also a significant staple in all villages, particular during periods in the year when catches are poor or peak agricultural labor requirements reduce the time available for fishing. While in dry season, there is a huge effort to collect the remaining animals trapped in shallow ponds created by receding waters.

a) Production and Consumption

Inland capture fisheries in Lao PDR utilize various water bodies such as the Mekong River and its tributaries, large hydropower reservoirs, natural ponds, lakes and small wetland, irrigation reservoirs, weirs, large areas of wet season rice fields, and seasonal Mekong flood plains. Moreover, even though slowly, aquaculture is growing in the country, which takes place in the central plains and highlands. Aquaculture provides fish during the dry season, allowing farmers to benefit from a good price for what is often a relatively low-quality product. The different types of aquaculture systems are rice-fish culture, pond culture, rain-fed and irrigated rice fields, and cage culture. The quantity of fisheries production of Lao PDR in 2010-2017 is shown in Figure 1.



	2010	2011	2012	2013	2014	2015	2016	2017
Inland capture	30,900	34,000	34,105	40,143	60,237	32,635	53,775	59,068
Aquaculture	82,100	95,600	101,895	124,085	90,355	95,965	109,835	109,793
TOTAL	113,000	129,600	136,000	164,228	150,592	158,600	163,610	168,861

Figure 1. *Fisheries production of Lao PDR in 2010-2017 by quantity (MT)*
(Source: SEAFDEC, 2017)

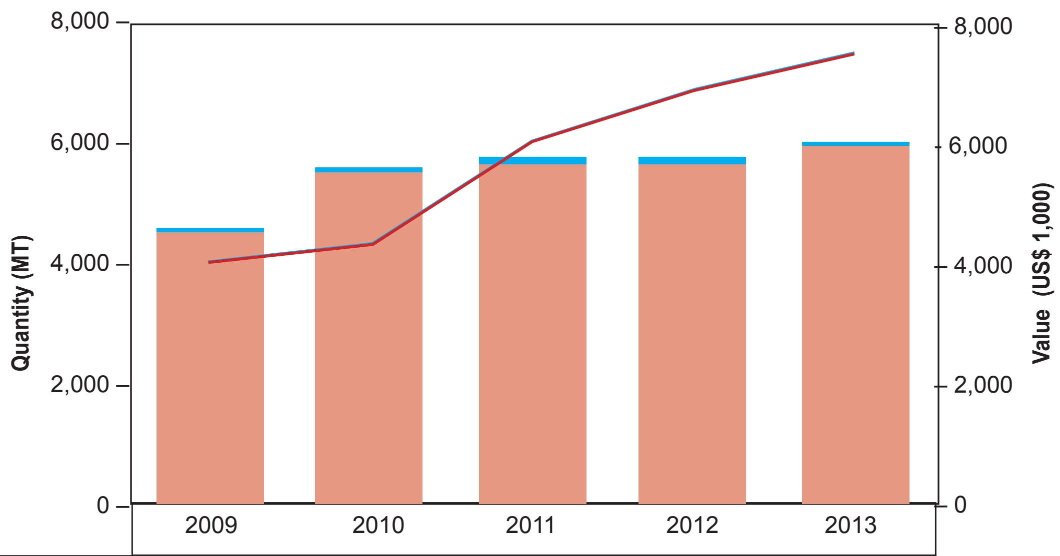
Fish and other aquatic animals (OAAs) are used to supplement a predominantly rice-based diet, so are important for the health and food security of the Lao people, especially in rural communities. From 2010 to 2015, there was a net increase in fish, meat and fruit products where fish consumption grew up to 28% (Table 1).

Table 1. Estimated per capita consumption of fish and OAAs in Lao PDR

	Inland			Marine products	Total aquatic	Other animals	Total animal consumption
	Fish	OAAs	Fish +OAAs				
FWAEs (kg/capita/year)	34.6	8.4	43.0	0.5	43.5	–	–
Actual consumption (kg/capita/year)	24.5	4.1	28.6	0.4	29.0	33.0	–
Protein consumption (g/capita/day)	15.8	1.8	17.6	0.2	17.9	18.69	62.1
Total animal protein consumption (%)	43.2	5	48.2	0.6	48.9	51.1	36.6
Note: fresh whole animal equivalent weights							

b) Imports and Exports of Fish

The information on the export and import of fishery products of Lao PDR from 2009 to 2013 are in Figure 2. The price of fish species varies during peak season (rainy season, August-November) and off-peak season (dry season, December-July) in Lao PDR (Figure 3). The considerable trade of fishery products takes place within the Mekong basin and its neighboring catchments.



	2009	2010	2011	2012	2013
Export (MT)	2	6	9	7	9
Import (MT)	4,591	5,561	5,747	5,731	5,995
Export (US$ 1,000)	7	12	17	33	28
Import (US$ 1,000)	4,120	4,449	6,126	6,952	7,554

Figure 2. *Quantity (MT) and value (US$ 1,000) of fishery products exported and imported by Lao PDR in 2009-2013 (Source: SEAFDEC, 2017)*

A lively trade takes place between Thailand and Lao PDR, with Lao traders sending high-value species over the river to Thailand, receiving in exchange seeds of tilapia and other species. Cultured fish from Thailand are also found in most markets along the Mekong River. In addition, the information on the imported fishery products from Thailand to Champasak Province, Lao PDR in 2014-2017 is shown in Figure 4 and Figure 5.

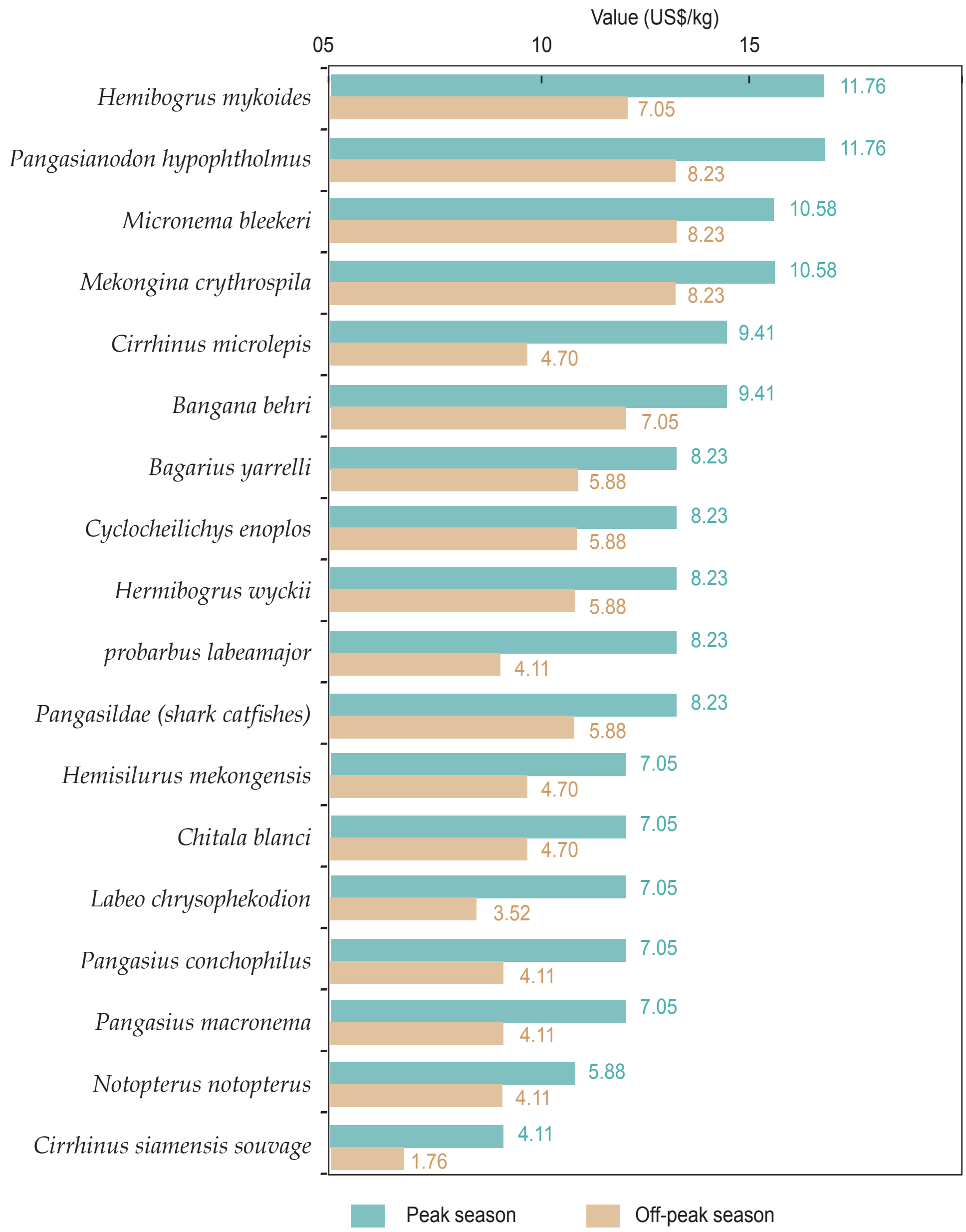
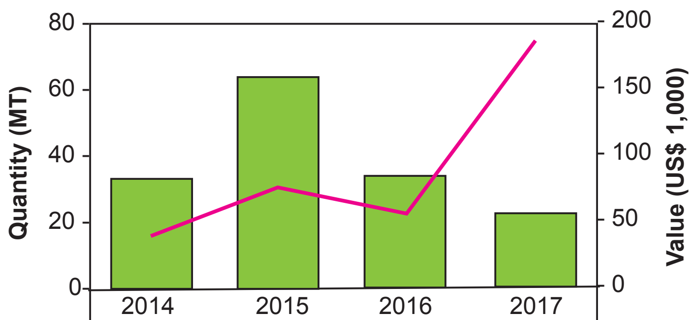
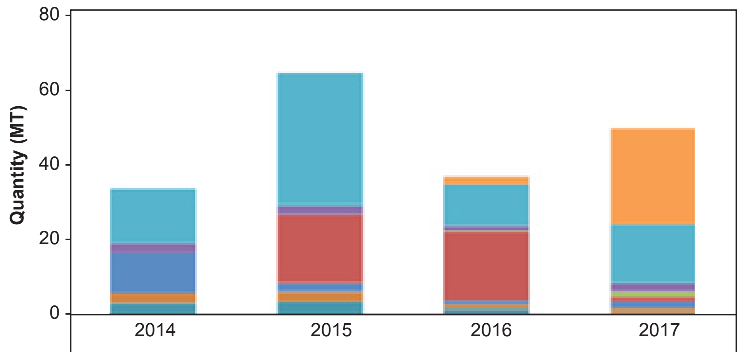


Figure 3. *Price (US$/kg) of fish species during the peak season and off-peak season in Lao PDR in 2017(Source: LFS-DAF, 2018)*



	2014	2015	2016	2017
Quantity (MT)	33.30	63.56	33.70	22.20
Value (US$ 1,000)	40.12	76.58	56.63	186.69

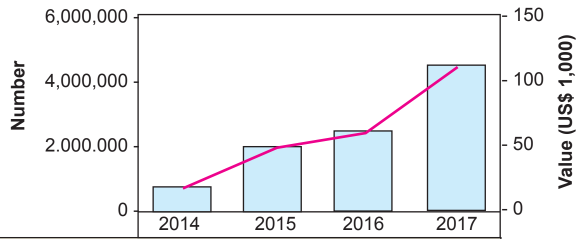
Figure 4. *Quantity (MT) and value (US$ 1,000) of fishery products imported from Thailand to Champasak Province, Lao PDR in 2014-2017 (Source: LFS-DAF, 2018)*



	2014	2015	2016	2017
Squid	–	–	1.90	25.00
Indian mackerel	14.00	34.76	11.00	15.20
Lobeo rohita	2.70	2.20	1.42	2.20
Octopus	–	–	0.10	1.50
Clarias gariepinus	–	17.80	18.00	1.40
Pangasianodan pypophthoimus	10.60	2.60	1.20	1.40
Cyprinus carpio	10.60	2.60	1.20	1.40
Barbonymus gonionotus	2.80	2.70	0.80	1.10
Shrimp	3.20	2.80	1.80	0.90
Carp	–	–	0.30	0.50
Dry squid	–	–	0.06	–
Hypophtholmichthys molitrix	–	–	0.30	–
	–	0.70	0.20	–

Figure 5. *Fishery products imported from Thailand to Lao PDR in 2014-2017 by quantity (MT) (Source: LFS-DAF, 2018)*

Furthermore, diverse species of fishes are cultured in Lao PDR including 18 indigenous and 10 exotic fish species. The fish species have been introduced to Lao PDR through various sources but most of the trades were not formally recorded. The number and value of fish fingerlings imported to Lao PDR including both indigenous and exotic species are shown in Figure 6 and Figure 7.



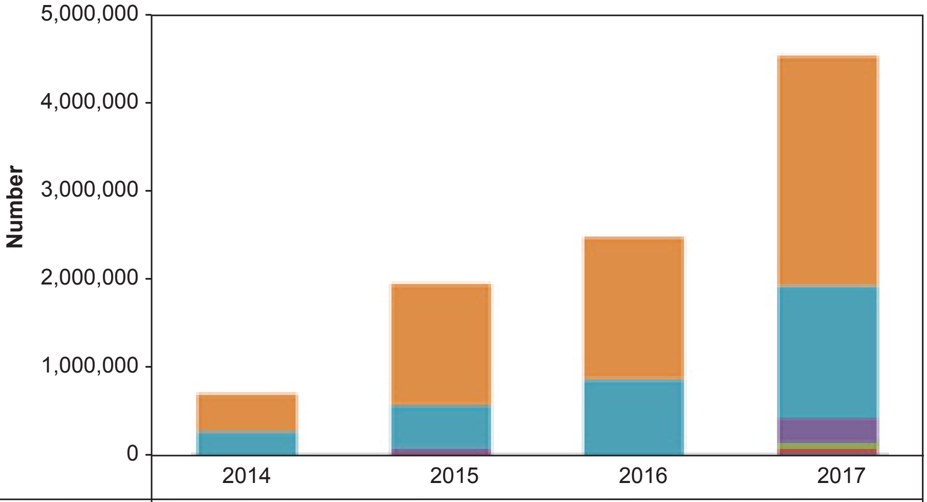
	2014	2015	2016	2017
Number	729,000	1,972,000	2,495,000	4,535,000
Value (US$ 1,000)	17.57	47.52	60.12	109.28

Figure 6. *Number and value (US$ 1,000) of fish fingerlings imported from Thailand to Champasak Province, Lao PDR in 2014-2017 (Source: LFS-DAF, 2018)*

At present, Lao PDR is using the Tariff Nomenclature 2012, which commodities are classified based on ASEAN Harmonized Tariff Nomenclature and Harmonized Coding System of World Customs Organization. In order to respond to the change of technology and new emerging products, it is necessary to update the nomenclature every five years. The values of imported fishery products using the HS codes are described in Table 2 and Figure 8.

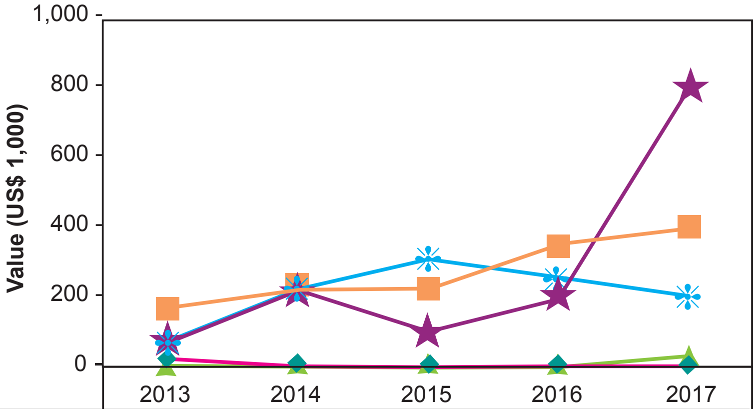
Table 2. Harmonized System (HS) codes of traded fishery products of Lao PDR (Source: LTP, 2018)

S.No.	HS code	Description
1	0303	Fresh fish and frozen
2	0304	Fish fillet, frozen, and any of fish processing
3	0305	Drying, pickling, smoking, and of fish processing
4	1604	Caviar and any kind of Caviar processing
5	1605	Frozen sea food and sea food processing



	2014	2015	2016	2017
Oreochromis niloticus	429,000	1,365,000	1,610,000	2,592,000
Clarias gariepinus	276,000	495,000	885,000	1,5000,000
Barbonymus gonionotus	16,000	55,000	–	271,000
Anabus testudines	–	–	–	62,000
Cyprinus carpio	–	37,000	–	60,000
Labeo rohita	8,000	9,000	–	50,000

Figure 7. *Species and number of fish fingerlings imported from Thailand to Champasak Province, Lao PDR in 2014-2017 (Source: LFS-DAF, 2018)*



	2013	2014	2015	2016	2017
0303	164.04	219.67	219.36	344.75	399.20
0304	3.63	–	–	–	20.06
0305	15.68	–	–	–	–
1604	64.82	216.69	97.25	196.44	801.20
1605	68.13	224.47	310.99	252.85	199.56

Figure 8. *Fishery products imported by Lao PDR using the Harmonized System codes from 2013 to 2017 by value (US$ 1,000) (Source: LTP, 2018)*

Status of Fish and Marine Genetic Resources

In Lao PDR, local communities are exploited fishes in rivers largely in their own area. Traditional systems for managing access and fishing effort are widespread and the fishery is an integral part of the livelihood of entire communities (Coates *et al.*, 2003). The resources from subsistence fishing provide at least 70% of the fish consumed by members of rural households each year, and local fisheries are considered vital to poor households.

The total fish production amounted to roughly 38,000 tonnes in which aquaculture contributed 12,000 tonnes (31.5% of the total production). In 2007, the DLF revised the structure of inland fisheries and fish production and estimated it was up to 143,847 tonnes, of which 89,097 tonnes came from capture fisheries and 54,750 tonnes from aquaculture (equal to 38% of total production) (MRC, 2010).

In summary, fisheries provide an essential livelihood for fishers and their families, mostly in rural areas. They generate income and employment for people involved in fishing activities, and more specifically, provides additional cash income for rural households as well as contributing substantially to their diets providing food security for the majority of the Lao people.

However, for more understanding and a better representation of the fisheries sector, there is a need for more reliable information on catches and on culture, especially regarding other aquatic animal productivity in wet-season rice-fields and small water body catches. A regular monitoring system should be established with more field-based monitoring; this would work better if it were accompanied by more in-depth research on the secondary value of fisheries, as well as the importance of different freshwater environments and various types of habitats. An inventory of potential water resources related to fisheries accompanied by in-depth assessments of fishery yield by various types of habitats would also be very useful.

Challenges and Opportunities

Inland capture fisheries and aquaculture in Lao PDR are based on water resources ecosystems, such as rivers and streams, hydropower and irrigation reservoirs, temporary or permanent diversion weirs, gates and dykes, small water bodies, flood plains and wet season rice-fields. In rural areas of Lao PDR, inland capture, mostly subsistence and semi-subsistence fisheries, is complex in nature and involves a wide variety of activities undertaken by people from a wide spectrum of socio-economic backgrounds (Ahmed *et al.,* 1999). This type of capture fishery is difficult to manage through control of exploitation, except in the areas where fishing activities are more centralized, such as in large reservoirs. As fish need a suitable habitat and water quality, and a certain type of hydrological regime which allows their migration from one habitat to another within a certain period of time each year, any activities or developments which cause habitat degradation, water pollution or that restrict migration may cause some impact on fisheries. These include urban developments, industrialization, deforestation, agricultural intensification, and dam construction. Other impacts on fisheries and aquatic biodiversity may arise from overfishing, illegal fishing and the introduction of exotic species.

Fortunately, the hydropower reservoir developments and large projects in Lao PDR have to be implemented through the Environmental Protection Law (02/99/NA), the Decree of the Environmental Protection Law (102/PM) and the Regulation on Environmental Assessment (1770/STEA). Uniform environmental assessment requirements and procedures should improve the integration of environmental conservation in all socio-economic development projects. For example, the Nam Theun 2 Project was required to comply with various management measures, including integrated catchment basin management, property and fisheries access rights, an extension programmes for stocking and harvesting techniques, private or public sector investments on hatcheries and stocking programmes, and the decentralization of fisheries management to ensure participation by fishers and primary stakeholders in implementing management measures.

A reassessment and monitoring of impacts also needs to be undertaken in areas where fisheries are being affected by pollution from activities such as slash and burn shifting cultivation, mining, agricultural intensification using pesticides, road construction, industrial waste water discharge and fish cage culture in rivers and reservoirs.

Marketing, Commercialization and Trade

The major constraint in fish trade in Lao PDR is limited access to market information especially on new markets, and this problem prevents producers from entering the market for products with higher value. Moreover, businesses in Lao PDR have no power over price because pricing is mainly regulated by non-Lao businesses. For processing businesses, the current phenomenon is copying of product designs and quality. The country is also facing issues that include weak regulatory enforcement and a largely "deals-based" approach, which reduces predictability and transparency. There are many illegal import and export transactions taking place in bordering countries.

Other obstacles that Lao PDR is facing include: (1) Lack of educated and skilled staff to develop income-generating activities and handle the collection, analysis, and dissemination of information on fish trade, (2) Shortage of capital and skilled labor to install new technology and equipment for production, (3) Lack of reliable and up-to-date information on export-import business opportunities, (4) The number of transportation companies within the country is limited and the cost is high for import and export transit services, (5) High import tariffs in many countries, particularly the EU and USA, which make Lao exports uncompetitive, (6) Small and medium enterprises lack experience in marketing and exporting and the quantity and quality of many products cannot meet demands of international market, (7) Exports transactions cannot directly be carried out, which most are done through third parties, and (8) Trade groups and associations are not well organized or extended across the country and lack of statistics on trade of fishery products.

Strategies Adopted to Harness Potential of Underutilized FMGR

The Department of Livestock and Fisheries has developed four major priority areas for fisheries as follow:

- Aquaculture and floodplain management
- Reservoir management
- Aquatic resources identification, assessment research and management
- Post-harvest fisheries technologies and regulation

Aquaculture and Flood Plain Management

This includes:

- Aquaculture development
- Wetland management and protection
- Brood stock development and seed production
- Technology development and dissemination
- Fish disease prevention and social impact related to fish disease

Reservoir Management

This includes:

- Pre impound assessment (EIA/SIA/GIA)
- Appropriate mitigation measures (bio-environmental and socio-economic)
- Participatory management (Co-management)

Living Aquatic Resources Research, Assessment and Management

These include:

- Inventory of indigenous living aquatic resources
- Habitat, migration, life cycle of important species
- Limnology of important species for the culture of indigenous species
- Environmental and social assessment
- Community awareness, empowerment and participatory management

Post-Harvest Technology and Regulations

These include:

- Improvement of traditional fish products
- Development of fish processing and marketing
- Development of post-harvest loss technologies
- Development of aquatic resources regulations and implementation
- Through community based or bottom-up approaches

Institutions for Management of Underutilized FMGR

For aquatic resources research and development coordination, collaboration and cooperation started for the DLF, with the establishment of the Living Aquatic Resources Research Centre (LARReC), which was inaugurated in 1999. The center opened with full operational support from the National Aquatic Research Institute/Danida project (1999-2005). This was followed by the establishment of the Namxuang Aquaculture Development Centre (inaugurated in 2002) through the Aquaculture Improvement and Extension Project (AQIP1 and AQIP2/JICA projects 2001-2019), which aimed to "enhance activities for aquaculture technology improvement and extension throughout the country". The adhesion of DLF and these two centers to the MRC, AIT, ACIAR, ICLARM (now WorldFish Center), and SEAFDEC, WWF and NACA as well as the assistance of Development Partners has broadened the inland fisheries' horizons of Lao PDR and allowed them to face new challenges. The results of collaborative assessment and research projects have highlighted the importance of subsistence fisheries management and the requirement for in-depth understanding of aquatic ecosystems and the socio-economic setting for further management interventions.

These projects include in particular those of the MRC Fisheries Programmes, such as the 'Management of Reservoir Fisheries' component (later re-named 'Management of River and Reservoir Fisheries' and 'Fisheries Management and Governance'), from 1995-2010; and the 'Assessment of Mekong Fisheries (later re-named 'Fisheries Ecology, Valuation and Mitigation' component) from 1997-2019. Other projects are the AIT/MRAG project on enhancement of small water bodies in southern provinces (2000-2004) and the ACIAR/ IDRC project on small-scale wetland indigenous fisheries management (SWIM 1999-2002).

Following the installation of the new regime in 1975, in 1977 the country received the first assistance through the Interim Mekong Committee to rehabilitate, with funds from the Government of the Netherlands, the NongTeng fish station, where Chinese and Indian carps were bred for the first time in Lao PDR (Gupta, 2000). From 1978-1988, the Interim Mekong Committee provided large-scale technical assistance to the building of a 30 ha fish farm at ThaNgone on the Nam Ngum River and its transformation into an Aquaculture Training Centre. Finally, the Mekong River Commission's Fisheries Programmes resumed its aquaculture development activities with the implementation of the 'Aquaculture of Indigenous Mekong Species' component from 2000-2019.

Future Thrusts

For further development of the fisheries sector of Lao PDR, there is a need for more reliable information, particularly on fish trade. The benefits of international fish trade such as gaining foreign currency and employment could be achieved through effective enforcement of the government and compliance of all stakeholders on laws and regulations in trading of fishery products. This way, the country could increase the production and improve the quality of fishery products, and eventually make the quantity and value of exported fishery products greater than imported products.

Conclusions

The development of aquatic resources should be recognized by the Government in its development planning, as it is a key component in improving food security for many rural people, as well as providing them with additional income and employment opportunities. Two inter-linked strategic frameworks of resource assessment and the management of capture fisheries should be developed, in concert with the promotion of the sustainability of aquaculture. Such research and development require well-balanced development between aquaculture, fisheries and aquatic environments and this, in turn, requires research and surveys of each sub-sector, technical development, training at all levels and the involvement of higher education.

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Country Status Report: MALAYSIA

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Ms Masazurah A Rahim has been working at Fisheries Research Institute since 2000 as a Research Officer. She is doing research on molecular biology specifically on population genetics and species identification for various aquatic organisms. She also involves in oyster (normal, polyploidy and hybrid) and blood cockle breeding programmes. She is looking forward to work on environmental DNA for monitoring purposes (harmful algae bloom), and checking on biodiversity of marine parks aquatic life (metabarcoding) in Malaysia.

Introduction

Malaysia is located between 2^o and 7^o North of the equator and longitudes 100^o and 119^o East. This South-East Asian sovereign nation covers an area of about 329,758 km^2, consisting of Peninsular Malaysia, and the states of Sabah and Sarawak as well as the Federal Territory of Labuan in the North-western coastal area of Borneo Island. Peninsular Malaysia comprises the states of Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Pulau Pinang, Perak, Perlis, Selangor and Terengganu, and the Federal Territories of Kuala Lumpur and Putrajaya. Pahang is the largest state in Peninsular Malaysia with an area of 35,965 km^2. The two regions (Peninsular Malaysia and the Borneo states) are separated by about 531.1 km of the South China Sea. Peninsular Malaysia, covering 131,598 km^2, has its frontiers with Thailand in the North and Singapore in the South, while Sabah with an area of 73,711 km^2 and Sarawak of about 124,449 km^2 border the territory of Indonesia's Kalimantan province. The fishery sector has been playing an important role as a major supplier of animal protein to the Malaysian population for decades. The total fishery production of the country amounted to 2,013,105 tonnes in 2015. Consist of two major components, namely, marine capture fisheries and aquaculture, the greatest bulk of the fish landings has always come from the capture fisheries (appox. 74%) of the total production with the rest coming from aquaculture. The production pattern has not changed much over the last couple of years with fish caught are getting smaller and with less diversity. Capture fisheries and aquaculture make vital contributions to Malaysia food security and provide important livelihood opportunities and income for many subsistence fishing and farming families.

The Convention on Biological Diversity defines genetic resources as genetic material of actual or potential value "as any material of plant, animal, microbial or other origin containing functional units of heredity". Genetic resources are the substance of agriculture and food production. The wealth of fish genetic resources provides the fisheries sector and aquaculture with great potential to further enhance its contributions to food security and to meeting the challenge of feeding a growing human population. Genetic resources are the foundation on improved strains and it is becoming increasingly important in view of their roles in improved aquaculture production and mitigating the threats to biodiversity and genetic resource conservation. Thus, they must be maintained as an investment for the future as it is part of biodiversity. Yet, despite estimates that by 2030 an additional 40 MT of fish per year will be required in order to meet global demand, the opportunities offered by fish genetic diversity remain largely unrealized and unexplored.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

Marine capture fisheries are managed and regulated by the Department of Fisheries (DOF) Malaysia under Fisheries Act 1985. Under this act, fishing without licence is an offence and can be prosecuted. The DOF had implemented in 1982 the four-zone marine protected areas (MPAs) denoted as A zone (0-5 nm), B zone (5-12 nm), C zone (12-30 nm) and D zone (beyond 30 nm). In 2014, a new zoning system was introduced to reduce the number of trawlers and their encroachment activities in the traditional fishing areas and to enhance the protection of coastal areas to protect juvenile fishes. The new zoning systems were applied only in some States such as Perak, Selangor, Penang, Perlis, and Kedah. On the contrary, other States retained the old system.

Figure 1 shows the different types fishing vessels in Malaysia. In 2016, 42% of total number of fishermen is artisanal using fishing vessels with outboard engine or no engine and there were 53,190 licensed fishing vessels. The main fishing gears used in marine capture fisheries were trawl and purse seine (Figure 2) which produce up to 70% of marine fish landings.

Aquaculture activities in Malaysia are implemented in both freshwater and marine. Over the last decade, aquaculture production in Malaysia is at a range of 400-500 thousand MT per year. The production of this product involves ponds systems, cages, rafts, ropes, and off-bottom culture. In 2015, a total of 520,000 MT of aquaculture products is produced with near-value RM 3.4 billion. This production involved 26,516 farmers and more than 36,000 hectares. This whole activity involves culturing of 55 species consisting of 45 species of fish, 5 species of crustaceans, 3 shellfish species

Figure 1. *Types of fishing vessels in Malaysia*

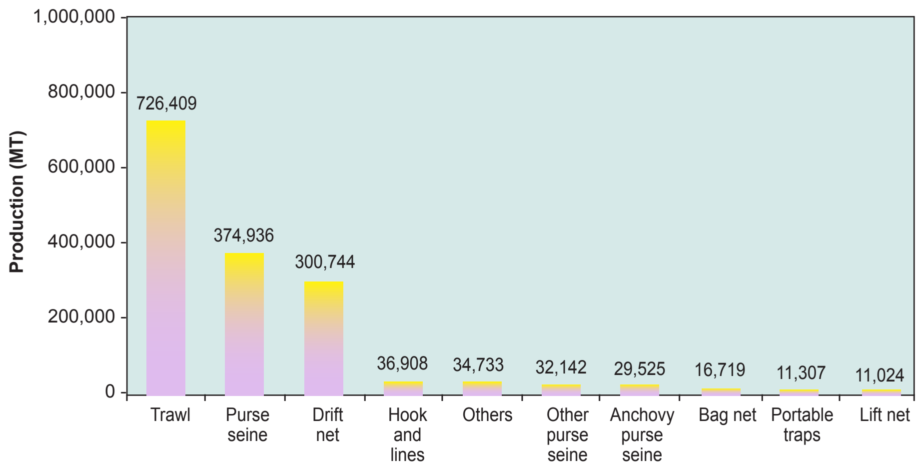

Figure 2. *Production of different types of fishing gears in marine capture fisheries in Malaysia in 2016*

and 2 species of seaweeds. Of the 45 species cultured for food, the inland fisheries sector rearing 23 fish species and 2 crustacean species. Of the 23 species the fish, 15 of whom are wildly sourced, 8 species of it are non-native species and two species of hybrid or from hybrid breed source or genetic improvement (non-natives). Two freshwater crustacean species still use wild mains and a non-native source.

For the marine aquaculture sector, 22 species of fish, 3 species of crustaceans and 3 species of shellfish were cultured. This sector is still adopting 15 species of wild cows for breeding in addition to 7 species domesticated breeds with genetic improvement features. While 2 breeds crustaceans or shrimp species are the parent from wild and from sources not native.

According to the Food and Agriculture Organisation (FAO), Malaysia is one of the top fish consuming countries in Asia (above 40 kg/capita/year), almost double the average in Thailand and China, although still below the levels in Japan and South Korea. The trend in fish consumption among Malaysians is increasing mainly due to population increases. Figure 3 shows that the trend in fish consumption among Malaysians is increasing which is mainly based on Malaysian population data from the national consensus and data on national fish consumption. This essentially means that in

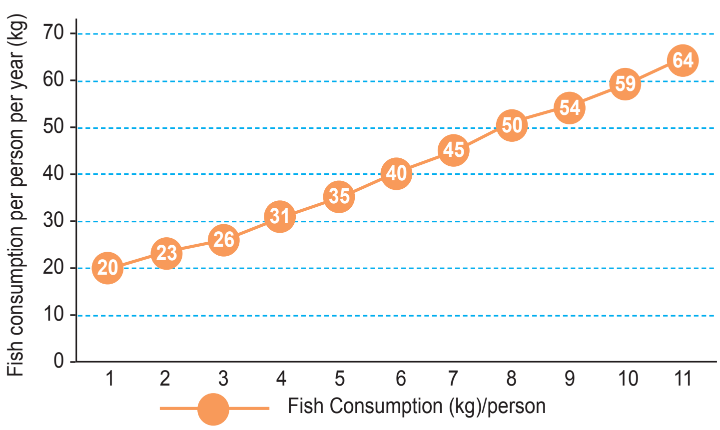

Figure 3. *Fish consumption of an average Malaysian from 1970 (20 kg) to 2015 (59 kg) has increased by about 195%*[1]

[1] *Inference is based on the accumulated data of the known & published population demand for fishery for year 2000 (45 kg/person/annum) and 2005 (50kg/person/annum) (New Straits Times. Study: Each Malaysian to To consume 55 kg fish per year by 2020. Published on 11th January 2012), with the population data from Department of Statistics in Malaysia throughout 1970 to 2010. Forecasted data for year 2015 and 2020 was based on the trendfrom the 1970-2010 range.*

2015 an average Malaysian consumed more fish (59 kg/year) compared to 20 kg in 1970; a dramatic increase in demand for fish over four decades that is compounded by rapid population growth.

b) Imports and Exports

Malaysia has always been a net importer of fish in term of volume and an exporter in monetary terms. Based on statistics from 2016, in value terms, the greatest portion of the imported fish came from China, with a share of 26.1%, followed by Indonesia (18.1%), Thailand (9.1%), Viet Nam (8.6%), Norway (4.9%) and India (4.0%). The rest of the imported fish came from Myanmar, Japan, Australia, Chile, Taiwan Province of China, Pakistan and a long list of other countries. In the same year, in value terms, Singapore was the main market for Malaysian exports of fish and fishery products with a share of 19.2%, followed by Vietnam (19.1%), Australia (9.9%), China (8.5%), Japan (8.4%), Thailand (6.1%) and others.

As noted above, although Malaysia is a net importer of fish, the self-sufficiency level is always on the high side (over 90%). Furthermore, with the export of high-value fish and shrimp species, the foreign exchange earnings acquired from such exports are generally more than sufficient to offset the expenditure for fish imports. The trend is likely to continue in the coming years. Production of high-value fish/shrimp species in the aquaculture sector is a major thrust of the National Agro Food Policy (NAFP). The policy is to develop a specific agro-food industry that focus on several key commodities or products and produces requiring meaningful increase in their value-added production targets in order to meet the domestic self-suffiency level and global demand. However, there is nothing to prevent those with the means to spend on luxurious seafood should they so desire. Also, in the rural areas many villagers probably get some of their protein requirement from catches from the river systems, irrigation canals, water impoundments and rice fields. Such catches generally are not reported and are therefore not included in the national production figures.

Status of Fish and Marine Genetic Resources

FMGR information refers broadly to genetic characterization (e.g. genetic sequences and other measures of genetic diversity at individual and group levels), breeding histories, performance data, and behavioural and life cycle characteristics. Categories of FMGR information include: DNA; genes; gametes; individual organisms; wild, farmed and research populations; species; forms that have been genetically altered by selective breeding; hybridization; chromosome manipulation and gene transfer; and methods for genetic characterization, FMGR conservation, and genetic improvement. In 2017, Department of Fisheries Malaysia has come out with *The State of The Aquatic Genetic Resources for Food and Agriculture in Malaysia*, which provide an overview on aquatic genetic resources in Malaysia that has the potential to contribute towards the improvement of the management of fish genetic resources.

a) Unique Underutilized Fish and Marine Genetic Resources

Seaweed

Malaysia is located in the Coral Triangle, a term which generally refers to a geographic area covering the waters adjacent to six countries (i.e., Indonesia, Malaysia, Papua New Guinea, the Philippines, the Solomon Islands and Timor-Leste) in South-East Asia and the Pacific (WWF undated). The tropical conditions in the coastal waters of Malaysia provide a favourable environment for the production and growth of diverse types of seaweed species. In Malaysia, the eastern coast of Sabah has a suitable environment for cultivating good value seaweed that includes the red seaweed *Kappaphycus alvarezii* and *Eucheuma spinosum*. The history of the seaweed aquaculture sector in Malaysia which dates back to 1978 when it was first introduced in Semporna, Sabah. Although the sector flourished over the years, the current commercial seaweed cultivation is still concentrated in Sabah. Seaweed aquaculture in Sabah has also proven to be successful in improving the livelihood of the coastal communities, which is in line with the government's efforts to eradicate poverty. Sabah is geographically situated below the monsoon and typhoon belt and, therefore, is known as "the land below the wind". Sabah is located on the Island of Borneo and is the only part of Malaysia where seaweed is grown commercially (Figure 4).

Figure 4. *Commercial seaweed cultivation in Malaysia*

Kaur and Ang (2009) claimed that, besides contributing to the country's revenue, seaweed aquaculture in Malaysia had also helped to improve the livelihood of fishing communities living in coastal areas. Sade *et al*. (2006) also claimed that seaweed cultivation alone had the potential to overcome the poverty of communities that were solely dependent on seaweed. In Malaysia, seaweed production was valued at RM44.6 million (about US$10.7 million) in 2017. Commercially, seaweed is the principle source of agar and carrageenan which are a major constituent of food products, cosmetics and pharmaceutical.

Jellyfish

All edible jellyfish belong to the order Rhizostomeae, in the Scyphomedusae. The bodies of these jellyfish are large and considerably tough and rigid, with a thick umbrella. At least 11 species in 5 families i.e. Cepheidae, Catostylidae, Lobonematidae, Rhizostomatidae and Stomolophidae, are known to be exploited worldwide. Because of their large size and difficulties in preservation for taxonomic study, taxonomic specialists have not yet had opportunities to study many specimens of edible jellyfish. Variations in morphological features, size and coloration are considerable, and the taxonomy remains somewhat confused.

The jellyfish catch is also a big part of the fishermen income when it is the season, for example, in Gerigat, Sarawak. These are processed in factories which occasionally employ women and children for washing, salting and conditioning the jellyfishes. Jellyfish is especially a valuable source of income; one fisherman can earn up to RM 250 per catch. It is a short season and it varies from one day to another but it is well appreciated by the fishermen.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Development

Seaweed

The present checklist of Malaysia seaweed stands at 459 taxa in 72 families; with 35 species in 12 families of Cyanophyta; 113 species in 16 families of Chlorophyta; 95 species in 8 families of Ochrophyta; and 216 species in 36 families of Rhodophyta. Only three species, *Kappaphycus alvarezii, Eucheuma denticulatum* and *Gracilaria manilaensis*, are being cultivated commercially.

Jellyfish

A preliminary taxonomic survey and molecular documentation of jellyfish species (Cnidaria: scyphozoa and cubozoa) have been done by a research team from Universiti Malaya.

c) Processing, Value Addition and Development

A small seaweed industry centred in Sabah, produces semi-refined carrageenan, which is mainly exported. Some of the biomass is brought over to Peninsular Malaysia, where seaweed products like desserts, health drinks, soaps and air-fresheners, are manufactured and sold. The locals serve it in various ways from stir fry to seaweed mac and cheese. It is also popular among the Chinese community as a cheaper alternative to bird's nest given its nutritional value.

The jellyfish is never sold fresh in the market as it spoils very fast. There is a process to preserve the jellyfish, so that it stays for a few weeks. The gonads and the mucus membranes of the jellyfish is removed and the flesh is treated with salt and alum. Salt reduces the water content of body tissues and keeps the products microbial stable, and alum aids in reducing pH, and acts as a disinfectant and hardening agent, giving and maintaining a firm texture by precipitating protein. Singularly use of salt or alum does not result in producing a product of satisfactory properties. The semi-dried products are marketed as a commodity. Judging from the shape of these commodities, the edible jellyfish harvest in South-East Asia is composed of more than 8 species. Dealers and merchants call the jellyfish at market simply by the following 8 types based on the colour, form, texture and size of the semi-dried products. It seems that with greater interest now in eating Japanese sushi and related food like salads, the supply of preserved jelly fish seems to be inadequate. Sarawak has for a long time been preserving jellyfish which is a traditional delicacy amongst the Melanaus and the Foochows.

Challenges and Opportunities

Seaweed

Farming of seaweed has expanded rapidly around the world as demand outstripped supply from natural resources. Research has led to the development of seaweed cultivation that now fulfils the world's market demand. In Malaysia, commercial production of seaweed is mostly in Sabah. With their excellent nutritional value and production potential, seaweed farming in Malaysia is seen as capable of meeting domestic and international demands. Hence, the government is emphasising on research and development of seaweed culture while promoting its commercial farming. There are several major issues and challenges in developing the seaweed industry in the country. This included the unavailability of good quality seedling, pollution in cultivation area, disease, shortage of raw material, lack of venture capital as well as research and development (R&D) programmes.

With proper development plans and strategies, it is envisaged that Malaysia may also emerge as a top producer of seaweed-based products with export potential, generating multiple benefits for the coastal communities. Although, the statistics of seaweed production show that the industry has grown significantly in the last three decades, there is still much to be done to further develop the seaweed aquaculture sector in Malaysia in terms of species diversity, human resource availability, and value-added activities. For example, only three seaweed species are currently cultivated commercially on a large scale. Furthermore, the country has only two seaweed processing plants with limited capability and inadequate raw materials. Despite these daunting challenges, Malaysia still has the potential to become an internationally-renowned producer of seaweed. There is a vast area of pristine waters in Sabah, which is conducive for seaweed cultivation. However, one of the major challenges highlighted was to intensify the aquaculture system through further refinement of technology. There is a need to explore new ways of cultivating seaweed, expand the seaweed variety for production, and discover new ways to utilise the products and to inculcate best practices in cultivating and utilising seaweed, while being mindful of conserving the environment.

Jellyfish

With the exception of local knowledge within fishing communities and processing plants, little detailed information is known on collection and processing methods, and the income of fishermen and the processing company, for this potentially commercially important fishery. A detailed description of the fishery from fishing methods to economics is important in assessing its importance to the local economy and how inter-annual variations in jellyfish catch may impact the fishery.

Strategies adopted to harness potential of underutilized FMGR

Being accorded as a high impact project in the country, governmental agencies and departments, especially the Economic Planning Unit (EPU) and the Ministry of International Trade and Industry (MITI), have to be equipped with detailed and comprehensive information on the seaweed industry to better plan strategies to develop the seaweed industry in Malaysia.

Major Focus areas for Uunderutilized FMGR

Seaweed

Efforts to boost the sector's growth should encompass:

- Capacity and capability building in R&D activity
- Application of modern biotechnology in high quality seedling production
- Exploration of new seaweed cultivation method
- Expanding seaweed variety for production
- Discovering more ways to utilize seaweed and its product
- Enhancing human resource at the technical and non-technical levels

Jellyfish

In spite of their importance as a fishery commodity, almost nothing is known about the biology and ecology of edible jellyfish in South-East Asia. Many commercial jellyfish species in the region have no scientific name. At first, therefore, taxonomic study should be carried out with many specimens from various fishing grounds for proper identification of the species involved.

Secondly, we emphasize the need for life history studies. The jellyfish fishery is characterized by considerable fluctuations in catch and the fishing season is restricted to a few months of each year. Unprecedented mass occurrences of rhizostomes sometimes disturb net fishing, while on other occasions they suddenly disappear from fishing grounds. In addition to local weather conditions, certain biological factors such as life history, growth and migrations must be involved in these phenomena. We consider that the number of polyps reproduced asexually and the number of ephyral discs liberated from the polyps are crucial factors that determine the population size of the 'harvested' medusa stage. Therefore, we particularly emphasize needs for future study on the life of the polyp stage for prediction of the fishery resources and fluctuations.

Infrastructure, Capacity Building and Financial Investment

The fisheries research incumbent on the Department of Fisheries is undertaken by Fisheries Research Institute Malaysia (FRI) headquartered in Penang. Its major objectives are:

- To provide scientific advice for the sustainable exploitation and management of fishery resources

- To conserve, rehabilitate and enhance aquatic resources
- To enhance fish production through the development of appropriate technologies and utilization of new species for aquaculture
- To develop new uses for living aquatic resources, upgrade quality and reduce post-harvest losses

The FRI has various branches located throughout the country, each specializing in specific fields of research:

- FRI Pulau Sayak, Kedah – Formerly The National Prawn Fry Production and Research Centre, focuses on hatchery technology for marine shrimp and finfishes
- FRI Gelami Lemi, Negeri Sembilan - specializes in freshwater fisheries and aquaculture
- FRI Gelang Patah, Johor - carries out research in brackishwater pond culture
- FRI Tanjong Demong, Terengganu - mostly involved in broodstock and hatchery development for marine finfishes
- FRI Bintawa, Sarawak - concentrates on fisheries and aquaculture in the state of Sarawak
- FRI Langkawi, Kedah – focuses on culturing activities of seaweeds and sea cucumbers
- FRI Kg Acheh, Perak – is a division to do research on capture fisheries

The Marine Fisheries Research Development and Management Department (MFRDMD/SEAFDEC) is a regional body aiming to be the centre of distinction in matters relating to resources and sustainable development of marine fishery resources in South-East Asia. MFRDMD is really not a branch of FRI in Penang, but a partner. It, nevertheless, collaborates closely with FRI in matters relating to fishery resources in the region. It is a regional organization, under the jurisdiction of the DoF.

Beside the various research branches of DoF mentioned above, the local universities, in particular Universiti Malaysia Terengganu (UMT) in Terengganu, Universiti Sains Malaysia (USM) in Penang, Universiti Malaya (UM), Kuala Lumpur, University of Malaysia Sarawak (UNIMAS), Universiti Putra Malaysia (UPM) in Selangor, Universiti Malaysia Sabah (UMS), Universiti Kebangsaan Malaysia (UKM) in Selangor, and Universiti Teknologi Malaysia (UTM) in Johor also actively conduct research on fisheries, namely, in resource assessment, fish biology, genetics, aquaculture, mangrove and coral ecology, habitat development and rehabilitation, pollution monitoring and assessment, disease control and prevention, toxicology, design of vessels and other subjects.

Future Thrusts

The development of the fisheries sector is continuing process to contribute to Malaysia's economy. However, the sector is facing new issues and challenges, resulted from changes in global economy and trade liberalization. The fisheries sector requires new strategies that address issues and challenges in order to achieve the objective of producing sufficient food for local consumption and high-value products for export markets.

The development of this sector has resulted in the increased of fishery productions. The production of many agro-food commodities has increased tremendously and as a result Malaysia reduced its importation of several fishery produces. The production of agro-food products will definitely improve the balance of trade in which Malaysia is always on deficit situation.

The NAFP set a direction that the production of agro-food commodities will grow around 4% a year in order to achieve a self-sufficiency level and enable to produce sufficient food for local consumption and generate income from export markets.

The seaweed industry can be enhanced by increasing the number of farms and farmers, strengthening local seaweed cooperatives and including them in decision-making, as well as by technological advances in the form of new and improved strains, more efficient seed supply and products.

To achieve a more stable and sustainable condition in the jellyfish fishery, the accumulation of scientific knowledge on edible jellyfishes is required, as well as establishing a monitoring system for physico-chemical oceanic conditions. To understand the factors controlling the stock size of jellyfish, studies on asexual reproduction, such as the strobilation ability in polyps in relation to environmental fluctuations, are essential.

Conclusions

Fishery remains an important sector in Malaysia. This sector still plays important role as food providers, create employments and generate earnings from export products. The development of the agricultural policies has enabled the fishery sector to grow sustainably and contributed to economic development in Malaysia. The agricultural policy set the direction for the agricultural sector, and as a result, this sector has been transformed from conventional and passive sector that focused on single commodity to a dynamic, diversified and modern sector.

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Country Status Report: PHILIPPINES

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Introduction

The Philippines (Republic of the Philippines) is an archipelagic country consisting of 7,146 islands. Bounded by the South China Sea to the West, the Philippine Sea to the East, and the Celebes Sea to the South, the country has a total estimated land area of 300,000 km^2, with a coastline length of 36, 289 km (BFAR, 2017; Figure 1).

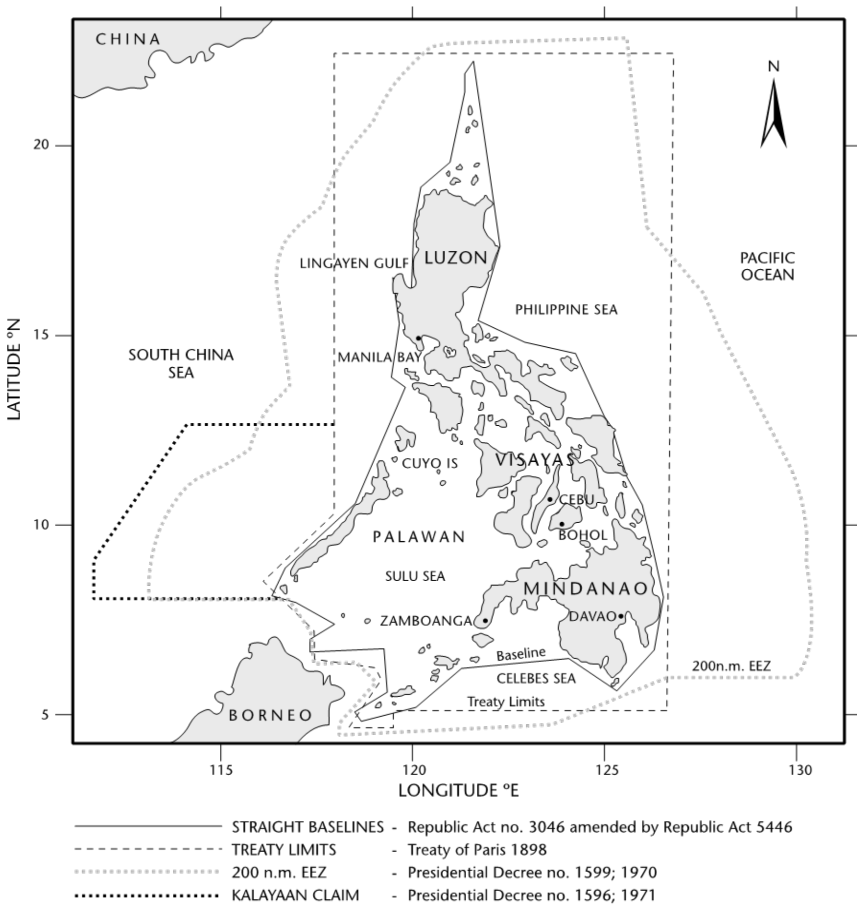

Figure 1. *Map of the Philippines showing marine justisdictional boundaries (Barut et al., 2003)*

The Philippines has a total estimated territorial marine area (including the Exclusive Economic Zone, EEZ) of 2,200,000 km^2, consisting of coastal areas (266,000 km^2) and oceanic areas (1,934,000 km^2) (BFAR 2017). Estimated continental shelf area (<200 m depth) is 184,600 km^2, and its coral reef area of 27,000 km^2 (BFAR 2017) is reckoned as the second largest in South-East Asia after Indonesia's 39,538 km^2 (ADB 2014). Situated at the apex of the Coral Triangle, the Philippine archipelago is reported to be the global epicentre of marine biodiversity (Roberts *et al*., 2002; Carpenter and Springer, 2005; Sanciangco *et al*., 2013).

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

The extent of marine habitats coupled with the biological diversity hosted within Philippine waters represent a wealth of goods as well as ecosystem services provided by marine resources. The country's marine ecosystems are estimated to contribute a conservative total monetary value (direct and indirect benefits) of USD 966.6 billion to the economy (Azanza *et al.,* 2017). In terms of fisheries production, the Philippines ranked 8th position globally among fish-producing countries, with a total production of 1.8 million MT of fish, crustaceans, molluscs and aquatic plants, constituting 2.1% of the total global production of 93.6 million MT. Aquaculture production in 2017 (1.57 million MT) contributed 3.0% share to the total global aquaculture production of 53.42 million MT, amounting to a total value of USD 427 million (FAO Statistics, accessed June 2019).

Marine fishery contribution to the country's Gross Domestic Product for 2017 (GDP) is estimated at 1.2%, translating to PhP 197.23 billion (USD 3.8 billion) of a total GDP of PhP 15,806 billion (USD 303 million). The industry provided employment to 1.6 million fishing operators nationwide, with 1.3 million fishers in the municipal sector, and commercial and aquaculture sectors accounting for 16,497 and 226,195 operators, respectively (BFAR, 2017).

The Philippines is a fish-eating nation. Fish and fish products are second only to rice in terms of contribution to daily food intake, accounting for 12.3% of the total food intake. Per capita food consumption of fish and fish products was highest at 137 g/day in 2003 (50 kg/yr), and declined to 101 g/day in 2017 (37 kg/yr), representing a slight decline to 11.9% of the total food intake (BFAR, 2017). Fish and its derivatives are the main source of dietary animal protein, estimated to contribute as much as 67% of the protein requirements of the Philippine population (Barut, 2003), which stood at 100 million in 2015 and is projected to reach 109 million by end of 2019 (Philippine Statistics Authority).

The Philippine fisheries sector is classified into capture fisheries and aquaculture. Capture fisheries are further subdivided into municipal, commercial, and inland fisheries. Under Republic Act (RA) 8550, known as the Philippine Fisheries Code of 1998 and amended by RA 10654, municipal fisheries are defined as traditional, artisanal or small-scale fishing operations that do not use fishing boats beyond 3 gross tons (GT). Commercial fisheries include all operations that use vessels over 3.1 GT, and are further classified into small-, medium-, and large-scale, depending on vessel sizes of 3.1-20 GT, 20.1-150 GT, and more than 150 GT, respectively. Commercial fishing vessels are also required to fish outside of municipal waters, areas beyond 15 km from the shoreline, and are required to secure commercial fishing vessel licenses from the Bureau of Fisheries and Aquatic Resources (BFAR).

In 2018, the total volume of fisheries production in the Philippines reached 6.48 million MT, valued at PhP 365 billion (USD 7 billion). Over a five-year period (2014-2018), cumulative fisheries production was estimated at 32.7 million MT, valued at PhP 1.6 trillion (USD 34 billion), with aquaculture production accounting for 69.4% (22.7 million MT) and capture production accounting for 15.5% and 15.1% for commercial and municipal fisheries (5.1 million MT and 4.9 million MT, respectively) (Table 1; Figure 2).

Table 1. Summary of fisheries production, by volume (metric tons) and value (USD x 1000)

Year	Metric Tons				Value USD x 1000			
	Commercial	Municipal	Aquaculture	TOTAL	Commercial	Municipal	Aquaculture	TOTAL
2002	1,042,193.00	857,294.00	2,654,612.51	4,554,099.51	778,062.04	682,936.33	1,380,050.38	2,841,048.75
2003	1,109,636.00	921,851.00	2,896,510.89	4,927,997.89	777,831.48	686,769.35	1,370,413.41	2,835,014.24
2004	1,128,382.38	938,745.71	3,417,083.00	5,484,211.09	863,379.80	735,122.97	1,591,151.32	3,189,654.09
2005	1,133,976.21	988,239.87	3,770,803.27	5,893,019.35	859,504.32	823,974.96	1,777,173.34	3,460,652.62
2006	1,080,667.70	1,074,134.37	4,164,283.44	6,319,085.51	952,076.88	1,057,642.64	2,172,074.94	4,181,794.46
2007	1,192,069.78	1,136,079.19	4,405,600.62	6,733,749.59	1,189,944.96	1,270,004.39	2,664,508.93	5,124,458.29
2008	1,226,204.88	1,151,308.73	4,790,769.45	7,168,283.06	1,435,684.16	1,451,686.50	3,693,895.38	6,581,266.04
2009	1,253,940.98	1,159,922.03	4,935,273.36	7,349,136.37	1,249,041.90	1,437,420.73	3,453,633.52	6,140,096.16
2010	1,242,101.76	1,184,137.15	5,071,233.76	7,497,472.67	1,343,487.36	1,559,976.82	3,667,230.88	6,570,695.05
2011	1,032,820.12	1,138,949.46	5,194,703.69	7,366,473.27	1,363,326.07	1,675,072.07	3,979,440.17	7,017,838.32
2012	1,042,317.88	1,083,426.55	5,061,493.81	7,187,238.24	1,568,909.14	1,690,065.12	4,371,213.76	7,630,188.02
2013	1,067,610.33	1,062,147.63	4,723,717.92	6,853,475.88	1,664,821.71	1,712,125.66	4,438,157.74	7,815,105.12
2014	1,107,220.80	1,029,394.45	4,653,526.68	6,790,141.93	1,504,313.83	1,634,661.26	4,249,494.66	7,388,469.75
2015	1,084,624.70	1,011,792.73	4,674,650.35	6,771,067.78	1,441,673.03	1,593,732.81	4,126,264.32	7,161,670.15
2016	1,016,948.05	976,941.19	4,380,272.65	6,374,161.89	1,252,479.93	1,513,438.09	3,859,644.21	6,625,562.23
2017	948,281.45	962,146.84	4,455,724.19	6,366,152.48	1,194,327.11	1,506,934.32	4,010,385.46	6,711,646.90
2018	946,437.62	941,870.86	4,591,760.11	6,480,068.59	1,173,940.18	1,632,150.21	4,226,066.23	7,032,156.61

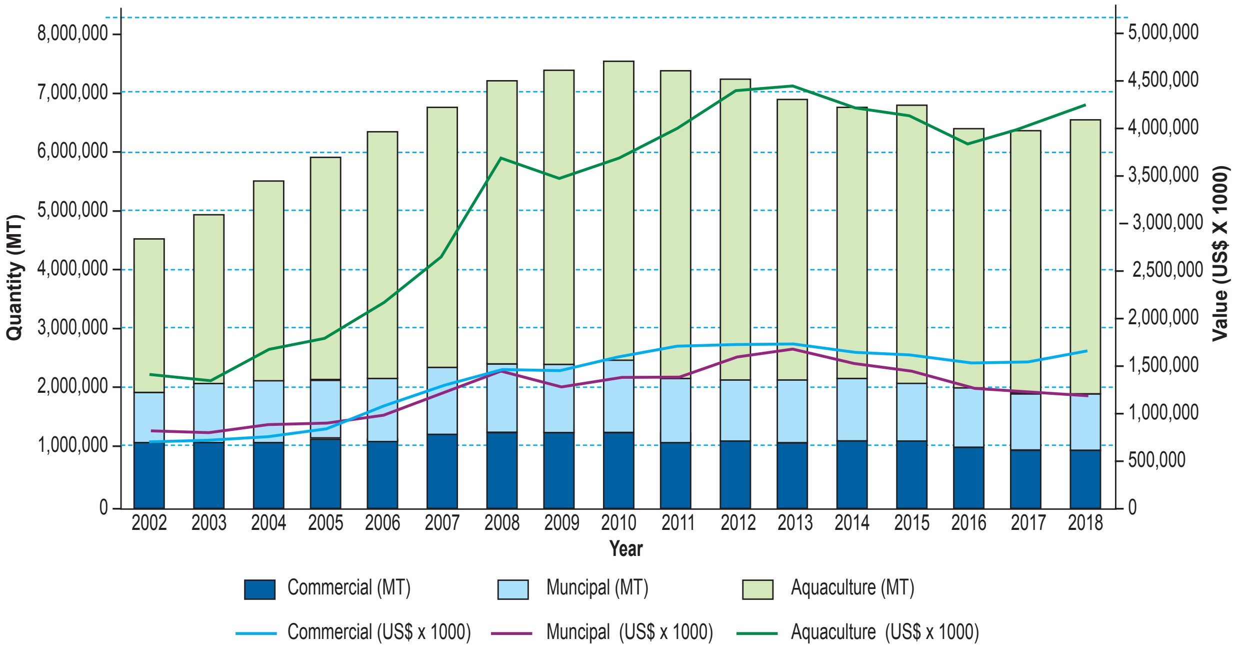

Figure 2. *Total Fisheries Production of the Philippines from 2002-2018, by volume (metric tons) and value (USD x 1000) for capture fisheries and aquaculture.*

The country's commercial fisheries contributed 946,437 MT to fisheries production in 2018. Roundscad, Indian sardines, and skipjack tuna each contributed 15-17% to total production, while frigate tuna, yellowfin tuna, big-eyed scad and fimbriated sardines each accounted for 4-7% of production. Municipal fisheries contributed 941,871 MT to fisheries production in 2018, with roundscad, frigate tune and Indian sardines each accounting for 7% of production, while other species such as skipjack, Indian mackerel, fimbriated sardines, yellowfin tuna and anchovies each accounting for 4-7% of production, with the remaining production accounted for by many other species.

The principal stocks exploited in the Philippines are small pelagics, tuna, other large pelagics, demersal fishes and invertebrates. Small pelagics such as round scad, sardines (Indian sardines, fimbriated sardines), mackerel and anchovies comprise an important segment of the fishery industry and are considered a main source of inexpensive animal protein for lower-income groups in the Philippines. Meanwhile, oceanic large pelagics such as tunas and tuna-like species, e.g. billfish, swordfish, sailfish, and marlin, are not fully exploited in the Philippine EEZ. While 21 species of tuna have been recorded in Philippine waters, only six species are caught in commercial quantity and only four species form the bulk of the tuna fishery and are listed in landed catch statistics: yellowfin tuna (*Thunnus albacares),* skipjack (*Katsuwonis pelamis*), eastern little tuna (*Euthynnus affinis)* and frigate tuna (*Auxis thazard*). Among the invertebrates, the key species contributing to the fishery are crabs with the blue swimming crab (*Portunus pelagicus*) accounting for 90% of the landed catch. Other key invertebrate species are cephalopods (squid) and *Acetes* shrimp.

Aquaculture production accounted for 70% of total fisheries production in 2018 (4.5 million MT), and over a five-year period from 2014-2018 with a cumulative volume of 22.7 million MT. Over a five-year period (2014-2018), only three species accounted for 95% of total aquaculture production: seaweeds contributed 65.4% (7.4 million MT), followed by milkfish and tilapia at 17.5% (1.97 million MT) and 11.7% (1.3 million MT), respectively. Other species accounted for the remaining 5% of production: Tiger prawn, grouper, siganids, spiny lobster, oysters and mussels. Aquaculture production steadily increased from 2002-2010 from 1.3 million MT to 2.5 million MT, followed by reduced production from 2010-2018 (average 2.31 million MT, range: 2.18-2.51 million MT).

While total volume of capture fisheries from Philippine waters increased from 1980 to 2010, this has been followed by a decline in production (Philippine Statistics Authority databases) despite continuously increasing fishing effort (Briones, 2007) and the increasing number of registered municipal and commercial fishers (BFAR Fisheries Profiles 1980-2012). This likely reflects the depleted and overexploited status of many Philippine fish and marine species due to over-fishing compounded by environmental degradation (Go *et al*., 2015, Stobutski *et al*., 2006) even as fisheries value has continued to increase over time. In addition to reduced catch, post-harvest losses further exacerbate the situation. While shortage of raw material for processing remains the major problem in the fisheries post-harvest industry, additional issues concern inconsistent quality of products, lack of appropriate safety standards for traditional products, and lack of appropriate infrastructure (e.g. cold-storage facilities) (Espejo-Hermes, 2004). An estimated 25-30% loss of the total catch is incurred due to improper handling (Kamari & Sayers, 1979; Camu, 1991). Other forms of loss are by-catch which are discarded at sea and pelagic species which are used for low-value products such as fishmeal instead of being sold as higher-value food fish.

Previous studies have already noted the unsustainability of most Philippine fisheries (Stobutski *et al*., 2006), reflected in declines in catch biomass, species diversity, and reported shifts in community structure (Silvestre *et al*., 2003; Stobutski *et al*., 2006; San Diego & Fisher, 2014), as well as the low incomes of many Filipino fishers. Philippine marine fisheries are currently characterised by: (1) depleted fishery resources; (2) degraded coastal environments and critical fisheries habitats; (3) unmet potential of aquaculture and commercial fishing grounds; (4) improper post-harvest practices and inefficient marketing resulting to physical losses and/or reduced value of catches ; (5) inequitable distribution of benefits from resource use; (6) inter- and intra-sectoral conflicts; (7) poverty among small-scale fishers; (8) inadequate systems and structures for fisheries management.

b) Imports and Exports

The Philippines is an exporter and importer of fish and fishery products. Foreign trade performance in 2017 registered a net surplus of USD 539 million, from a total export value of USD 1.095 billion and total import value of USD 556 million (Philippine Statistics Authority). Tuna was the top export commodity with a cumulative volume of 919 million MT from 2011-2017, valued at USD 2.88 billion (41% of export value in 2017). Other fish (fresh or preserved) were the second top export commodity by value at USD 2.2 billion. Seaweeds were the third top export commodity by value at USD 1.46 billion, followed by shrimps and prawns at USD 341 million, from 2011-2017 (21% and 4.9% of export value, respectively) (Table 2). The top 10 destinations for Philippine fisheries exports by value are the USA (16%), Japan (13.2%), Germany (9.61%), Hong Kong (7.88%), UK (7.02%), Spain (6.43%), China (5.37%), Taiwan (3.55%), Italy (3.26%), and Korea (2.05%), with other countries having a cumulative share of 25% of exports by value.

Table 2. Philippine fishery commodity exports, by quantity (MT) and value (USD) (Source: Philippine Statistics Authority)

Commodity	Quantity (MT x 1000)							TOTAL
	2011	2012	2013	2014	2015	2016	2017	
Fish, fresh or preserved	55,992	54,229	75,407	86,762	71,921	86,130	96,271	526,712
Seaweeds, carrageenan	46,613	34,061	55,750	42,445	39,490	40,012	35,602	293,975
Shrimps and Prawns	6,488	2,748	6,550	8,093	4,339	5,910	9,700	43,829
Tuna	76,884	56,708	162,848	118,465	97,267	102,064	305,461	919,687
Grand Total	185,977	147,747	300,555	255,765	213,017	234,116	447,035	1,784,212
Commodity	**Value (in USD x 1000)**							**TOTAL**
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
Fish, fresh or preserved	227,680	279,702	331,1	387,850	315,344	348,605	349,928	2,241,030
Seaweeds, carrageenan	210,814	184,750	219,149	263,257	207,722	199,805	174,982	1,460,478
Shrimps and Prawns	57,386	34,112	47,739	63,105	29,772	43,177	66,482	341,772
Tuna	292,411	411,335	660,258	446,654	293,338	277,521	504,211	2,885,729
Grand Total	788,292	909,899	1,259,067	1,160,866	846,177	869,107	1,095,603	6,929,010

Status of Fish and Marine Genetic Resources

a) Unique Underutilized Fish and Marine Genetic Resources: Sea cucumbers (Class Holothuroidea)

Sea cucumbers are soft-bodied marine echinoderms which have been harvested in the Indo-Pacific region for at least 400 years (Akamine, 2001). Sea cucumber fisheries in the tropics are multi-species, with an estimated 60 species having commercial value (Purcell *et al*., 2012, 2013). Traded in processed, dried form known as *trepang* or *beche-de-mer*, the value and demand for sea cucumbers continues to increase rapidly, driven by Asian markets where it is consumed as a luxury seafood commodity

(Ferdouse, 2004; Purcell, 2014). The relative ease with which sea cucumbers can be collected, coupled with slow population recovery rates due to their long generation time (Hamel, 2001), low recruitment and individual growth (Uthicke *et al.*, 2004) predispose natural populations to over-fishing and local extirpation. Recent assessments indicate global sea cucumber fisheries as characterized by pandemic over-fishing (Purcell *et al.*, 2010; Toral-Granda *et al.*, 2008), particularly in the Indo-Pacific region (Purcell *et al.*, 2013). In the Philippines, capture production of sea cucumbers declined from a peak of 3000–4000 MT from 1984 to 1992, to 600–800 MT from 1998 to 2006 (Choo, 2008).

b) Biodiversity Characterization, Evaluation, Conservation and Documentation

There have been limited studies on resource assessment of the sea cucumber fishery. An initial review of the fishery at national scales was first published in by Trinidad-Roa in 1987, which reported on the lack of baseline surveys to ascertain the extent of depletion, and the absence of inventory and monitoring of stocks in both exploited and unexploited areas. More recent efforts have resulted in published species inventories for selected regions, particularly in Palawan (Schoppe, 2000; Jontila *et al.*, 2014) and for selected biogeographic regions across the archipelago (Sea cucumber resource assessment project, Commission on Higher Education). Genetic assessment of natural populations of a widely-traded species, *Holothuria scabra*, has also been recently pioneered, and reported the delineation of genetic stocks consistent with marine biogeographic regions (Ravago-Gotanco & Kim, 2019).

c) Processing, Value Addition and Product Development

Sea cucumber resources in the Philipppines are utilized almost exclusively as export commodities, with minimal information on local consumption. Utilization of harvest is generally for (1) immediate domestic consumption; (2) trade to middlemen for export markets, either in wet or dried form. Processed items (dried form) are generally accumulated for bulk shipment to the export market. Value chain analysis reveals that post-processing quality, size and species are the largest determinants of market price. There is a preference for certain species which are traded at higher prices (*Holothuria fuscogilva* or *Holothuria scabra*), and dried product quality is graded into different classes (Class A, Class B, reject) with large price differences between classes. For instance, *H. scabra* Class A can getch up to PhP 7,000/kg while Class B is priced at PhP 1000/kg (Brown *et al.*, 2010). The greatest opportunity for value addition in *trepang* is the post-processing stage. However, fisher-produced *trepang* are generally of poor quality, as fishers use small-scale, rudimentary tools for primary processing which involves cleaning, gutting, and boiling the animals, and lack of mechanization in the drying process, employing only smoking and sun-drying methods. Generally, there is little investment in product development, i.e. improved drying and packing methods.

Aside from processing sea cucumbers into *trepang*, sea cucumbers are also known as good sources of bioactive molecules, and may harbor compounds and metabolites valuable for the pharmaceutical and nutraceutical industry. However, there is little research being conducted in the Philippines to assay and develop pharmaceutical products from sea cucumbers.

Challenges and Opportunities

Philippine fisheries have yet to be sustainably managed (Comprehensive National Fisheries Industry Development Plan 2006-2025). Management and conservation efforts are seriously warranted, and critical actions are needed to reverse fisheries decline. These include: (1) reduction and rationalisation of fishing effort; (2) protection rehabilitation and enhancement of coastal habitats; (3) improved utilization of harvests; (4) enhanced local stewardship and management of resources; (5) supplemental/alternative livelihoods for fishers; (6) capacity building and institutional strengthening (DA-BFAR, 2004). In 1998, the Philippine Fisheries Code (RA, 8550) was signed into law, which declares as a state policy that achieving food security is the main consideration in the development, management, and conservation of fisheries and aquatic resources. Since then, there have been several fisheries management measures put in place, which involve: (1) limited entry and effort reduction through licensing of municipal and commercial fishers; (2) gear, area, and temporal restrictions; and (3) reduction of environmental impacts.

While sustainable management of marine capture fisheries remains challenging, there are several options representing opportunities for supplementing fisheries production to meet food security goals, and enhanced utilization of fish and marine genetic resources. These are:

1. Expanded exploitation of oceanic areas outside the Philippine EEZ: While this option offers modest long-term opportunities for expanded exploitation, these require the bilateral negotiations with other nations and states;
2. Expansion of aquaculture production: The tropical climate conditions in the Philippines combined with relatively extensive coastal areas available for aquaculture represent great potential for improvement of aquaculture production. However, improvements in hatchery and culture technology will require investments in research, technology transfer and capacity building, and navigating complex combinations of human and institutional resources. To develop and maintain high aquaculture production, researches in all aspects of the value chain are needed, specifically in the following areas:
   - Brood stock quality and supply: Developing and maintaining high-quality broodstock through selection and breeding techniques requires investments in research, training, and infrastructure.
   - Disease control, including diagnostics and mitigation: This requires investments in developing technologies and tools for disease detection.
   - Development of more efficient production methods, from feeding to rearing requires investments in research and infrastructure.
3. Post-harvest and value-added product industry.
4. Expanding bioprospecting activities, including the entire research and development process from discovery of bioactive substances, to its development, commercialization and marketing as high-value products derived from marine genetic resources.

Strategies Adopted to Harness Potential of Underutilized FMGR

Much of the publicly-funded research adopted to harness the potential value of underutilized fish and marine genetic resources are focused on three major strategies. The first is aquaculture improvement, with investments in research towards genetic improvement of broodstock for desired production traits or resilience to disease, development of genetic and genomic resources to enable marker-assisted breeding and selection, and refinement of technologies and practices to support improved survival and growth. The second is improved post-harvest processing to increase the value of fish and marine genetic resources. The third approach focuses on improved bioprospecting, geared towards the discovery of potentially high-value products from marine genetic resources. These include screening for bioactive compounds with pharmacological and industrial use, or those with applications in the nutraceutical or cosmetics industries.

Major Focus Areas for Underutilized FMGR

This section provides examples from the Philippine experience, demonstrating integrative research on major focus areas for selected underutilized fish and marine genetic resources. Overall major focus areas include biodiversity conservation, sustainable management, genetic improvement for aquaculture species, and exploration of add-on value products (e.g. bioprospecting).

Sea cucumber research programmes: There are at least 60 sea cucumbers (Echinodermata: Holothuridae) which are commercially valued in the Philippines. These sea cucumbers can be considered as underutilized fishery and marine genetic resources. While the higher-value species such as *Holothuria* are considered overfished, most of the other species are generally overlooked for capture fisheries. Post-harvest processing for production of dried product (*beche-de-mer*) which commands higher prices as a luxury food and an export commodity is small-scale and does not produce consistent, high-quality product, and as such does not maximise the value of the resource. Thirdly, the species remains largely unexplored as a source of potential bioactive compounds which may represent new leads for pharmacological, industrial, and nutraceutical use. The Department of Science and Technology - Philippine Council on Aquatic Resources Research and Development (PCAARRD) has funded several research programmes aimed at improving utilization and management of sea cucumber fishery resources. Earlier studies conducted between 2011-2014 were focused on resource assessment of natural populations, by identifying species distributions and relative abundance in key areas throughout the Philippine archipelago through the Sea cucumber resource assessment programmes funded by the Commission on Higher Education (CHED). This study which involved various State Universities and Colleges and national government agencies (BFAR) established baselines for biodiversity assessment of sea cucumber fishery resources in key areas across the Philippines.

Complementary research on biodiversity assessment was conducted using molecular phylogenetic approaches for species identification (PCAARRD, Sea cucumber stock delineation project). The project also evaluated genetic diversity and delineated genetic stocks for one species, the sandfish, *Holothuria scabra,* which was a focal species on account of its high commercial value and trade of its dried derivatives, wide distribution across the Indo-Pacific, and availability of culture technology which made it amenable to aquaculture production. The second phase of the sea cucumber research programmes capitalized on advancements in molecular biology techniques and DNA/RNA sequencing technologies, and generated novel genomic resources in the form of RNA and DNA sequence profiles from different growth categories (fast- and slow-growth). The genomic data was used to examine the underlying molecular bases for differential growth in early juveniles for the sandfish (*H. scabra*). These genomic resources are intended to be eventually used to develop tools for marker-assisted selection for desired production traits such as growth rate, as well as develop genetic traceability systems for determining provenance, i.e. hatchery or region of origin. These tools include genetic linkage maps, and panels of single-nucleotide polymorphism (SNP) markers. The third phase will shift to bioprospecting, focusing on a new target sea cucumber species, *Stichopus* sp. (Family Stichopodidae). Stichopids are known to be a rich source of bioactive compounds which are anti-inflammatory, anti-proliferative (e.g. anti-cancer) (Ohtani *et al*., 1999; Kelly, 2005; Oh *et al*., 2017), and is a rich source of collagen for nutraceutical applications (Abedin *et al*., 2014).

Future Thrusts

Maximizing the utilization of fisheries and marine genetic resources requires careful consideration of key strategies for sustainable management of capture fisheries, development of aquaculture production, value-adding post-harvest technologies for processing, and discovery of additional products and alternative markets or income streams for these fisheries resources. While aquaculture production has the most potential to augment fisheries production in the medium term, it is imperative that the need for management of natural populations is not forgotten, and is anchored on conservation of underlying genetic diversity, such that the genetic resource remains intact for future efforts in genetic improvement (e.g. broodstock enhancement, selection and breeding initiatives). Environmentally-sound aquaculture and resource management are a key strategy for moving forward.

Conclusions

The high levels of biological diversity in the Philippine archipelago represent a wealth of goods, including those that have yet to be discovered, as well as ecosystem services provided by marine resources. However, these marine resources are threatened by human-mediated as well as natural environmental conditions. Capture fisheries production is already on the decline, and while interventions for rehabilitation, restoration and sustainable management of natural populations need time for the effects to be apparent, increasing aquaculture production may be a more feasible approach in the short to medium term, to meet food security goals for a growing Philippine population. Consequently, continued refinements to support enhanced aquaculture production are needed. These include broodstock enhancement, refinement of technologies for better growth and survival. Improved post-harvest processing is also warranted to increase the value of fish products and their derivatives, maximizing the potential value of fisheries and marine genetic resources requires intensive investments in research and development towards the discovery of new products or new ways to access marine genetic resources e.g. bioprospecting, biotechnology for product development. All these initiatives need to be integrated within a framework of biodiversity conservation, so that the fishery resources and marine genetic resources will be available to future generations.

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Country Status Report: TAIWAN

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Introduction

Today fish provided about 3.2 billion people with almost 20% of their average per capita intake of animal protein. Aquaculture and capture fisheries directly employ over 59 million people, and each sector provides about 50% of the world's aquatic food supply (FAO, 2018). Although, the wild harvest of fish, invertebrates (mainly mollusks and crustaceans) and aquatic plants (mainly seaweeds) have provided human populations with important sources of nutrition from ancient times, aquatic genetic resources have only recently begun to attract the attention internationally. Fishery genetics is defined as the application of genetic principles and methods for increasing aquaculture productivity by genetically modifying fish stocks and for the management of fish populations to obtain maximum sustainable yield without affecting the genetic diversity. Recently, the research of marine genetic resources (MGR) is fairly new but growing rapidly. Biological compounds taken from marine resources include those with potential medical benefits, like anti-cancer agents, and those with industrial value, like anti-freeze proteins. These biologically derived compounds can then be patented by those who isolate and test them, to be used for potential profit.

Taiwan is a small island, but it occupies a pivotal position as its proportion of species numbers and endemic organisms are high when compared to the world's average. Therefore, preservation of the the genetic materials of Taiwan's native species become most important.

Taiwan has been engaged since the early beginning in the use of molecular genetic techniques to assist genetic improvement in aquaculture, aiming at the production of superior broodstocks of fish for traits such as faster growth, resistance to diseases, and a better understanding of sex determination. Important work has been undertaken on genetic mapping, Quantitative Trait Loci (QTL) analyses and gene expression in aquaculture species.

Better management and conservation of important aquatic genetic resources towards sustainable aquaculture has been the focus in Taiwan in recent years. The Fisheries Research Institute (FRI), Council of Agriculture (COA) has launched a project to establish the National Aquatic Genetic Resources Center since 2001. It was planned to construct genetic resources facilities at four research centers of FRI. Selected aquatic organisms of genetic importance are conserved in indoor ponds.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

Taiwanese fish production was about 1,026.5 thousand tones (Table 1) in 2017, with aquaculture representing 27.6% of the total (FA, cited 2019 June 30). The total first sale value of fisheries and aquaculture production in 2017 was estimated at USD 2,906 million, of which USD 1,174 million was from aquaculture production. In per capita terms, food fish consumption reduced from 35.2 kg in 2013 to 24.6 kg (global average is 20.5 kg) in 2017, at an average rate of about 8.5% per year. In 2017, fish accounted for about 20.4% of animal protein consumed by the Taiwanese population. In comparison, preliminary estimate for the 2017 global per capita average is 20.5 kg. Fish accounted for about 17% of animal protein consumed by the global population.

The capture fisheries production of Taiwan was 743.4 thousand tonnes in 2017, a small decrease in comparison to the previous years. Fisheries in marine and inland waters provided 99.7 and 0.3% of the total in country, respectively. The aquaculture production of Taiwan was 283.1 thousand tonnes in 2017, an increase of 10.9% over the previous year and a decrease of 30.7% in comparison to the 2014. Aquaculture in marine and inland waters provided 9.5 and 90.5% of the country total, respectively. Aquaculture production in 2017 included 283.1 thousand tonnes of food fish and 0.84 thousand tonnes of aquatic plants. Farmed food fish production included 185.8 thousand tonnes of finfish, 80.1 thousand tonnes of molluscs, 16.4 thousand tonnes of crustaceans and 2.67 thousand tonnes of other aquatic animals such as turtles and frogs.

Table 1. Taiwanese fisheries and aquaculture production and consumption (1,000 tonnes/Year)

Category	2013	2014	2015	2016	2017
Production					
• Capture					
Inland	0.029	0.03	0.103	0.088	2.62
Marine	925.3	1068.4	985.6	748.5	740.8
Total capture	925.3	1068.4	985.7	748.6	743.4
• Aquaculture					
Inland	317.2	309.9	288.8	230.0	256.3
Marine	31.7	29.3	24.7	25.3	26.8
Total aquaculture	349.0	339.2	313.6	255.3	283.1
Total fisheries and aquaculture	1274.3	1407.6	1299.3	1003.9	1026.5
Consumption					
Human consumption	821.6	830.2	673.0	559.8	580.0
Non-food uses	1.98	1.99	5.67	4.82	3.84
Per capita consumption (kg/yr)	35.2	35.5	28.7	23.8	24.6

b) Imports and Exports

Total fish and fish products production in 2017 imported included 326.7 thousand tonnes of edible products with a value of 1,330.4 million USD (Table 2), and 155.2 thousand tonnes of non-edible products with a value of 241.4 million USD. The 707.2 thousand tonnes of total fish and fish products exported in 2017, included 700.1 thousand tonnes of edible products with a value of 1,766.4 million USD and 7.1 thousand tonnes of non-edible products with a value of 36.5 million USD.

Table 2. Quantities (1,000 tonnes/year) and values (USD 1,000,000) of Taiwanese imports and exports of fish and fish products in Taiwan

Category	2013	2014	2015	2016	2017
Import					
Edible					
Quantity	322.0	318.3	312.2	315.5	326.7
Value	912.5	1,040.0	1,083.4	1169.3	1,300.4
Non-edible					
Quantity	144.3	169.3	152.9	137.3	155.2
Value	269.9	310.2	316.2	275.2	241.4
TOTAL IMPORT (QUANTITY)	466.3	487.6	465.2	452.8	481.9
(VALUE)	1,182.4	1,350.2	1,399.6	1,444.5	1,541.8
Export					
Edible					
Quantity	665.7	780.8	787.2	671.8	700.1
Value	1,792.2	1,821.0	1,613.9	1,566.3	1766.9
Non-edible					
Quantity	17.9	13.7	8.2	7.2	7.1
Value	51.5	49.1	41.2	37.7	36.5
TOTAL EXPORT (QUANTITY)	683.5	794.5	795.4	678.9	707.2
(VALUE)	1,843.8	1,870.1	1,655.0	1604.1	1,803.4

Status of Fish and Marine Genetic Resources

a) Unique Underutilized Fish and Marine Genetic Resources

The fishes of Taiwan belong to 3,115 species in 1209 genera from 298 families, which include 13 species of hagfish (Class Myxini), 192 species of cartilaginous fishes (Class Chondrichthyes), and 2,992 species of ray-finned fishes (Class Actinopterygii) (TaiBIF, cited 30 June 2019). In total, eleven of the 13 hagfish species (85%), seven of the 192 cartilaginous fish species, and 95 of the 2,992 ray-finned fish species (3.2%) are endemic to Taiwan (Shao, 2019). A look into 220 species of freshwater fish, 36 species (16%) are endemic to the rivers of Taiwan.

The mollusks of Taiwan contain 4,308 species in 1,297 genera from 321 families, which include 926 species of bivalves (Class Bivalvia), 113 species of cephalopods (Class Cephalopoda), 3,214 species of gastropods (Class Gastropoda), 21 species of chitons (Class Polyplacophora), 33 species of scaphopods (Class Scaphopoda), and one species of solenogaster (Class Solenogastres). Totally 3,244 of 4,173 bivalves, gastropods, chitons and scaphopods (78%) live in marine, only 295 of 3,214 gastropod species (9.2%) are terrestrial. Of 295 species of terrestrial gastropods (land snail), 193 species (65%) are endemic to Taiwan (The Taiwan Malacofauna Database, cited June 30 2019). The decapod crustaceans (Order Decapoda) of Taiwan contain 1,635 species in 623 genera from 130 families. The euphausid crustaceans (Order Euphausiacea) contain 31 species in five genera from one family.

b) Germplasm Collection, Characterization, Evaluation, Conservation and Development

Selected aquatic organisms of genetic importance are conserved in the National Aquatic Genetic Resources Center, FRI since 2001. The 61 species of germplasm are collected at the three research centers of FRI, the Freshwater Aquaculture Research Center (FARC), Eastern Marine Biology Research Center (EMBRC), and Penghu Marine Biology Research Center (PMBRC). The other 101 species are under evaluation for germplasm collection (Table 3).

Challenges and Opportunities

Taiwan has been engaged in the study of genetic variation and stock structure of wild populations of fish species, aiming also at the identification of management units of commercial fish. It plays a leading role in deciphering the phylogenetic patterns and evolutionary history of marine species in the East Pacific, shedding light on possible connections between past climate variations, demographic histories, and present-day genetic variation in marine species (Chu *et al*., 2012; Hsiao *et al*., 2016; Chou *et al*., 2015). We have produced very successful work in the area of natural populations by applying molecular markers in studies of the genetic structure of marine species, with conclusions of direct relevance to practical applications such as fisheries management and conservation policies. There is a long list of species, such as black seabream (Hsu *et al*., 2011), flying fish (Chou e*t al*., 2015), yellowfin tuna (Wu *et al*., 2010; Aguila *et al*., 2015), dolphin fish (Ting, 2014) etc., whose genetic structure has been investigated by means of molecular genetic markers. The synthesis of the multi-species data is actually an important goal to better understand global patterns of biodiversity of marine species.

Marketing, Commercialization and Trade

Taiwan researchers are experienced in the use of molecular techniques for species and authentication of origin in marine organisms and their products. Shark fin is the most valuable part in a whole shark body, the custom of eating shark fin is very popular in East and South-East Asia, and it has been counted a traditional noble delicacy in China for centuries. We analyzed constitution of species in Taiwan market fins by using the molecular tool–DNA barcode (Liu *et al*., 2013; Chuang *et al*., 2016). We have developed a molecular technique for the identification of shark species, in order to aid traceability of commercially sold shark and ray fins which will be helpful for fishery management and species conservation.

Additionally, mislabeling of fish products not only impacts consumer finances, but can also be deleterious to public health. Fish products may be mislabeled for reasons including ambiguity of common fish names, challenging morphological identification, or willful intention to deceive. We reveal a high rate of mislabeling samples from Customs offices and Coastal Patrol Offices in Taiwan using DNA barcoding based on a partial segment of the mitochondrial cytochrome c oxidase subunit I gene (COI) (Chang *et al*., 2016). In order to reduce the mislabeling of imported fish products, the authorities should take some actions into consideration, such as institutionalizing molecular authentication of fish products, standardizing the usage of common fish names, and legislating for penalties. Finally, metabarcoding approaches have been used to study stomach contents, fish communities in a species-rich coastal sea and deep-sea communities (Shao *et al*., 2002; Ko *et al*., 2013; Chang *et al*., 2017; Shao & Lin, 2014).

Table 3. The germplasm collection of the National Aquatic Genetic Resources Center of Taiwan

Phylum	Class	Scientific name
Chordata	Actinopterygii	*Amphiprion clarkia*[1]
		Amphiprion ephippium[1]
		Amphiprion frenatus[1]
		Amphiprion ocellaris[1]
		Amphiprionocellaris var. [1]
		Amphiprion percula[1]
		Amphiprion perideraion[1]
		Amphiprion polymnus[1]
		Amphiprion sp. cf. *clarkia*[1]
		Amphiprion sp. cf. *clarkii*[1]
		Bidyanus bidyanus[3]
		Candidia barbata[3]
		Carassius auratus[3]
		Chrysiptera brownriggii[1]
		Chrysipteracyanea)[1]
		Chrysiptera glauca[1]
		Ctenopharyngodon idellus[3]
		Cyprinus carpio[3]
		Cyprinuscarpio carpio[3]
		Dascyllus trimaculatus[1]
		Epinephelus coioides[1]
		Epinephelus fuscoguttatus[1]
		Herichthys carpint[3]
		Hippocampus kuda[2]
		Macropodus opercularis[3]
		Micropterus salmoides[3]
		Neoglyphidodon melas[1]
		Neoglyphidodon oxyodon[1]
		Oreochromis aureus[3]
		Oreochromis hornorum[3]
		Oreochromis mossambicus[3]
		Oreochromis niloticus[3]
		Oreochromis niloticus[3]
		Oreochromis spilurus[2,3]
		Oreochromis sp.[3]
		Oryzias latipes[3]
		Paracanthurus hepatus[1]
		Parachromis managuensis[3]
		Piaractus brachypomus [3]
		Plectropomus leopardus[2]
		Pomacentrus moluccensis[1]
		Premnas biaculeatus[1]
		Premnas biaculeatus[1]
		Pseudorasbora parva[3]
		Puntius semifasciolatus[3]
		Puntius snyderi[3]
		Rhodeusocellatus ocellatus[3]
		Tilapia zillii[3]
		Zacco pachycephalus[3]

Phylum	Class	Scientific name
Arthropoda	Merostomata	*Tachypleus tridentatus*[2]
	Maxillopoda	*Apocyclops royi*[1]
	Malacostraca	*Cinetorhynchus hendersoni*[2]
	Malacostraca	*Hymenocera picta*[2]
	Hexanauplia	*Pseudodiaptomus annandalei*[1]
	Malacostraca	*Rhynchocinetes durbanensis*[2]
Mollusca	Gastropoda	*Babylonia areolata*[2]
Rotifera	Monogononta	*Brachionus plicatilis*[1]
Ochrophyta	Coscinodiscophyceae	*Chaetoceros muelleri*[1]
Chlorophyta	Chlorodendrales	*Tetraselmis chui*[1]
Chrysophycophyta	Eustigmatophyte	*Nannochloropsis oculata*[1]
	Prymnesiophyceae	*Isochrysis galbana*[1]

[1]Eastern Marine Biology Research Center (EMBRC)
[2]Penghu Marine Biology Research Center (PMBRC)
[3]Freshwater Aquaculture Research Center (FARC)

Strategies Adopted to Harness Potential of Underutilized FMGR

The first step is establishing the Barcode of Life Database (BOLD), which is promoted by the Consortium for the Barcode of Life (CBOL), International Barcode of Life (iBOL), and Global Bio-identification System (GBS). All the data can be accessed online at the Taiwan Wildlife Genetic Material Cryobank (http://cryobank.sinica.edu.tw). Many domestic and foreign research institutions have abided by the specimen management rules and obtained tissue samples, promoting academic exchanges and enhancing research qualities. This project will continue to expand the archiving of wild animals' genetic materials. There is a hope to build a DNA barcode system and permanently preserve all of Taiwan's wildlife genetic materials before some species disappear or become extinct. Moreover, it will continue to manage and maintain the cryobank and database website so that it can provide material for future research, education, conservation, restoration, and sustainable utilization, as well as meet the need of different aspects such as genetic diversity study, genetic resource usages, smuggling prevention, and alien invasive species control.

Major Focus Areas for Underutilized FMGR

Taiwan has been engaged since the early beginning in the use of molecular genetic techniques to assist genetic improvement in aquaculture, aiming at the production of superior broodstocks of fish for traits such as faster growth, resistance to diseases, and a better understanding of sex determination. Important work has been undertaken on genetic mapping, Quantitative Trait Loci (QTL) analyses and gene expression in aquaculture species.

Infrastructure, Capacity Building and Financial Investment

Better management and conservation of important aquatic genetic resources towards sustainable aquaculture has been the focus in Taiwan in recent years. The FRI has launched a project to establish the National Aquatic Genetic Resources Center since 2001. It was planned to construct genetic resources facilities at three research centers of FRI, namely, the Freshwater Aquaculture Research Center (FARC), Eastern Marine Biology Research Center (EMBRC), and Penghu Marine Biology Research Center (PMBRC). The facilities at FARC and PMBRC were completed in 2006. Selected aquatic organisms of genetic importance are conserved in indoor ponds.

Future Thrusts

Genetic resources could contribute greatly to our efforts to cope up with climate change, but in many cases the magnitude and speed of climate change will surpass our ability to identify, select, reproduce and use these resources in the field.

Sustainable fishery is key to reversing trends that lead to genetic resources loss, damaged ecosystems, and the overall deterioration of our natural resources.

Conclusions

The value of marine genetic resources will emerge in the few next years, and the database on marine genetic resources will also clarify their economic and financial values, as information on these aspects are being made available and compiled. A well-constructed, transparent and easy-to-access information basis will greatly facilitate the sustainable management of marine genetic resources in the future. The steady increase in the number of scientific publications and patents on marine genetic resources observed demonstrates that this area is of growing importance to both the scientific community and to those involved in bioprospecting.

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Country Status Report: FIJI

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Introduction

Fiji is situated in the center of the Pacific Ocean in the middle of the South Pole and the equator between the latitudes of 15 and 22 South and around the longitudes of 175 and 178 West. Fiji's Exclusive Economic Zone (EEZ) covers around 330 Islands of which approximately one-third are inhabited. It covers approximately 1.3 million km^2 of the South Pacific Ocean. Fiji's total land area consist of 18,333 km^2 of which there are two major Islands, Viti Levu which is 10,429 km^2 and Vanua Levu which is 5.556 km^2 (Figure 1). Other main islands are Taveuni (470 km^2), Kadavu (411 km^2), Gau (140 km^2) and Koro (104 km^2) (Berdach, 2005).

Majority of the land is owned by the Indigenous Fijians which accumulates to 83%, while 9% is state land and 8% is freehold land. From the Fiji land mass only 16% is suitable for agriculture which is found mainly on the coastal plains, river deltas, and valleys (Berdach, 2005). The eastern side of the island experiences heavy rainfall, while the western side is noticeably drier. The centre of the island is forested and includes the nation's highest peak Mount Tomanivi (otherwise Mount Victoria) rising to 1,324 meters. The capital is Suva and it is one of the two cities in Fiji. The other city is Lautoka and both are located on the island of Viti levu (Department of Environment, 1997).

Fiji's terrestrial and marine ecosystems contain significant levels of biodiversity and make up a key part of the Polynesia–Micronesia Hotspot. This biodiversity hotspot contains a wide range of ecosystems with 12 principal vegetation biomes and associations that include mangroves, coastal wetlands, tropical rainforests, cloud forests, savannas, open woodlands, and shrub lands. It also contains the unique and sensitive marine ecosystems being part of the Western Pacific which is recorded as having the highest marine biodiversity along with the most extensive coral reef system in the world. Assessments of global marine ecosystem diversity have identified a number of sites of global significance, with WWF's Global 200 list including Fiji among the five outstanding coral eco-regions in the hotspot. A number of ecosystems and habitats within these globally recognized marine areas have been identified as having national significance and have included in protected areas or part of the Fiji Locally Managed Marine Areas (FLMMA) network.

Fiji has undertaken considerable measure for environmental protection by adopting or promulgating number of laws, regulations and policies governing the protection and management of the ecosystems. However, despite this, there is continuous increase of pressure on remaining biodiverse systems

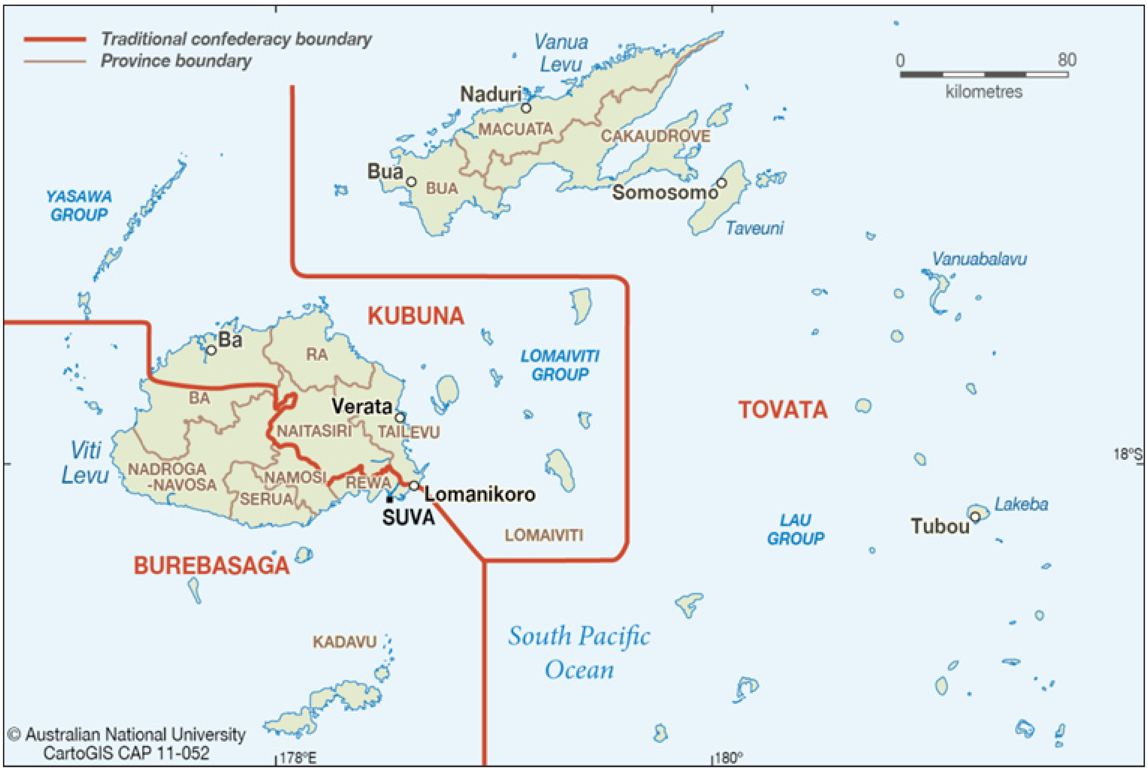

Figure 1. *The locality map of Fiji*

from socio-economic pressures that include population growth, urbanization, resource extraction and the lack of economic value placed on habitats, species and communities. There has been little focus on the value of genetic resources that are accommodated in Fiji's biodiverse areas and the means by which payment for ecosystem services could be used to stimulate conservation at the local level, while providing avenues for improved livelihoods. It is clear that there are gaps and work is needed for instituting relevant legislation, policy and institutional systems to assist with regulating the collection, storage, exchange, development and use of genetic resources to maximise opportunities for alternative livelihoods.

There is also a need to improve technological capacity at the national level. The barriers for maximizing benefits from genetic resources have been identified as (a) limited scientific research, technological and development capacity prevents national stakeholders from adding value to Fiji's genetic resources. There has been considerable aquaculture work in Fiji (marine, brackish water and freshwater) stretching over a long period and covering a large variety of species.

The earliest account of finfish species published by Henry W Fowler in the year 1959 in which it documented 560 species. According to the study, the list was brief and only covered a few species. The most recent scientific checklist was compiled by Seeto and Baldwin (2010) updating the previous reports. The authors recorded 2,304 fish species (2,031 confirmed including 275 doubtful records) from 200 families (192 confirmed including 8 doubtful families), however, not all fish species is listed as some of the fish can be classified to genus level only because it cannot be identified or possibly a new species (Seeto & Baldwin, 2010).

To sustain the natural finfish, the Fiji Government and donors have made a substantial investment in aquaculture. The current annual aquaculture production of the country is, however, quite small. Recent aquaculture efforts in Fiji have included tilapia, freshwater prawns, carps, saltwater shrimp, milkfish, seaweed, giant clams, trochus, pearl oysters, beche-de-mer, sponges, turtles, mud crab, and corals. The primary focus of the Fisheries Department in the last few years has been on pearl oysters, tilapia, shrimp, seaweed, and giant clams. Recent reports from the Fisheries Department show that in 2007 the following was produced: 143 tonnes of tilapia, 24 tonnes of giant freshwater prawn, 13 tonnes of giant tiger shrimp, and 67 tonnes of *Eucheuma* seaweed. About 50,000 black pearls were harvested and sold. The total value of the 2007 Fiji's aquaculture production has been estimated to be USD 1.7 million, of which about 38% was from pearls. About 90% of the 2007 pearl production came from one commercial farm off the island of Vanua Levu. Although, there were four commercial brackish water shrimp farms in Fiji in 2007, all 2007 production of these shrimp came from one operation on the island of Viti Levu. Most of the tilapia and seaweed production is from village-level operations.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

There has been considerable genetic resources work in Fiji (marine, brackish water, fresh water) stretching over a long period and covering a large variety of species. The Fiji Government and donors have made a substantial investment in aquaculture. The country's current annual aquaculture production is, however, quite small. Recent aquaculture efforts in Fiji have included tilapia, freshwater prawns, carps, saltwater shrimp, milkfish, seaweed, giant clams, trochus, pearl oysters, beche–de-mer, sponges, turtles, mud crab and corals. The primary focus of the Fisheries Department in the last few years has been on tilapia, shrimp, seaweed and pearl oysters. An SPC study used available documentation and interviews with Fisheries Department staff and producers of aquaculture products to determine Fiji's 2014 aquaculture production.

b) General Geographic and Economic Indicators

Table 1. Fisheries economic indicators

Total	**1, 18, 333 km^2**
Water area	21, 290, 000 km^2
Population (2007)	837 271
GDP of Fiji (2014)	USD 3 600 909 000
Fisheries contribution to GDP (2014)	USD 65 758 000
Fisheries contribution as a % of GDP (2014)	1.8

Table 2. Fisheries sector production (Gillett *et al.*, 2018)

	2014	
Production	Aquaculture	194
(Tonnes)	Capture	43,700
	Total	**43,894**
Employment	Aquaculture	N/A
(Thousands)	Capture	N/A
	Total	**N/A**
Value for trade	Fisheries exports	57,604
(1000 USD)	Fisheries imports	205,358
	Total	**296,962**

Table 3. Fisheries aquaculture breakdown production (Gillett, 2016)

Commodity	2014 production volume (kg) or pieces)	2014 production values (FJD)	2014 production values (USD)
Tilapia	150 500	526 750	266 035
Freshwater shrimp	11 462	183 392	92 622
Penaeid shrimp	5 617	140 425	70 922
Pearls	103.2	1 578 000	796 970
Pearl oyster spat	45 000 pieces	90 000	45 455
Seaweed	30 000	27 000	13 636
Mud crab	7 000	180 000	90 909
Total	204 682.2 kg plus 85 236 pieces	FJD 2 875 567	USD 1 452 307

Status of Fish and Marine Genetic Resources

a) Unique Underutilized Fish and Marine Genetic Resources

The modern era for aquaculture in the Pacific may have begun with a misstep when in the 1950s Mozambique tilapia from Africa was introduced for mosquito control and for aquaculture. With hindsight we now know that the Mozambique tilapia was the wrong species for cultivation and it never served this purpose. Its widespread invasion in the wild was touted by environmentalists as a red flag for aquaculture. At this time, before the widespread use of outboard motors, gillnets, etc. the state of fisheries could be considered relatively pristine. With plentiful fisheries resources, there seemed little rationale for aquaculture. Through the 1960s and 1970s, there was a string of failed aquaculture aid projects. Models introduced from overseas were often incompatible with the local socio-economic conditions. Governments were left with non-functional or monolithic facilities. By the 1980s, concern was building about the declining state of wild fisheries. Lacking the capacity and resources to prevent overfishing, authorities often turned to the promise of aquaculture and artificial restocking. These efforts gave a false sense of security and excessive fishing continued, probably putting stocks at more risk of serious depletion. The territories of French Polynesia and New Caledonia were successful after investment of significant resources into technology, financing and marketing, in creating industries for two commodities, blue shrimp and black pearl. After several decades the large-scale commercial enterprises were established and these French territories were regarded as world leaders in their fields (Ponia, 2010).

b) Germplasm Collection, Characterization, Evaluation, Conservation and Development

Common carp stocks from Hungary were shipped to the University of Agriculture Sciences, Bangalore, India in early June 2000. The strains, which are presently being maintained at the Fisheries Research Station, Hesaraghatta, have been used in the genetic improvement of common carp in Karnataka state, India. The first batch of 6th generation of improved GIFT germplasm was transferred to Malaysia from the GIFT Foundation International Inc., Muñoz, Phillipines in October 2000. The germplasm will be used in the breeding programmes that will be initiated by ICLARM in collaboration with the Malaysian Government. Similar batches of GIFT fish were also sent to Fiji, Thailand, India and Sri Lanka for use in their genetic improvement/aquaculture programmes (Mather *et al.*, 2000).

This species is currently being produced by the Ministry of Fisheries, Fiji. The local farmers depend on the Aquaculture Division to get supply of fingerlings to their development. GIFT tilapia seemed to be the best and it is popular among Fijian now days. It has been 19 years and the mind sets of the locals are starting to take heed of the message of driving the aquaculture sector. Fiji has its own breed of Tilapia but with this strain of GIFT tilapia it is more efficient and lucrative to farm. The relative growth performance of the GIFT strain Nile Tilapia (*Oreochromis niloticus)* was compared under integrated and non-integrated conditions with the best performing 'indigenous' Fijian tilapia strain, *O. niloticus* 'Chitralada' in Fiji.

Replicated trials in *hapas* over two generations (cool and warm seasons) showed that the growth performance of the GIFT strain was significantly better than Chitralada under both integrated and non-integrated culture conditions. Part of the significant difference in the mean final weights between the two strains resulted from the relatively 'late' maturation of GIFT compared to Chitralada, so that somatic growth was not reduced by energy being converted to reproduction. The data presented in the paper provide strong support for future fish breeding programmes to be based on GIFT strain so as to provide Fijian farmers with a better culture strain (Mather *et al.*, 2000).

c) Processing, Value Addition and Development

Value adding is not widely practiced however whole smoked Tilapia is sold occasionally and a small company in Suva smokes small quantities regularly. It is anticipated that demand for Tilapia consumption can grow as the supply of traditional marine seafood sources reduces and the cost of fish, poultry and pork increase over time. This will depend on willingness of farmers to invest in expanding farm size, fresh fish output and improving productivity. The investment particularly in Tilapia by ACIAR, SPC and local Fisheries and Aquaculture agencies over many years has helped develop a good base for subsistence development in both countries. This foresight can now be used as the springboard for a much-concerted effort to promote commercial farming and improve the availability of an alternative protein source for consumers.

Challenges and Opportunities

The Ministry of Fisheries is faced with difficulty in their extension programmes, owing to the increasing number of farms and limited resources to cover a wide range of operating farmers. Farmers expressed great concern about the availability of extension services, and felt there has been no improvement in extension services since their establishment. Those farmers who are not applying their training correctly will need reminders about best practice through regular extension visits (Teri *et al.*, 2007).

The inconsistency in supply of prawn and tilapia post-larvae was found to be a major constraint to development of the aquaculture industry. Farmers would understock ponds with whatever offer of post-larvae was made available to them. Post-larvae for *M. rosenbergii* and *O. niloticus* are produced at Naduruloulou Research Centre and provided free to farmers, and by the USP hatchery for commercial sale. Labor and equipment/facilities were two other observed constraints. Tilapia and prawn farmers generally lack equipment (vehicle, nets, holding tanks) for harvesting, and rely on the Ministry of Fisheries to harvest, transport and market their products. This stretches the limited resources of the Ministry of Fisheries to assist such a large number of farms, and it fosters a culture of dependency by farmers on government. Farmers in the highlands face difficulty in market access because of the distance involved, so their products are sold in the rural market at a lesser price. (Teri *et al.*, 2007). The competitive advantage of tilapia versus other fish products is selling it alive and thereby providing customers with a guarantee of freshness. The limited outlets and restricted volume of live fish sales have resulted in farmers (a) waiting a long time for a slot at Nausori Market, or (b) take small orders, and do partial harvests (these are tedious and time consuming) (Teri *et al.,* 2007).

The current 'central' method of control for stocking, harvesting and marketing has been successful in bringing the Fiji industry to its present point. It does have drawbacks however, whereby farmers do not have full control and accountability over their own fish farming business, such as the time of harvest, quality and quantity of fish sold, and oversight of the revenue less expenses. They also tend to take less care over pond preparation (e.g. eliminating fish predators) when fingerlings or post-larvae are given out for free. The strategy of government toward the freshwater aquaculture sector is through support in the form of free fingerling production and distribution, extension services, research, and market assistance. The relevance of this programmes, for example whether it is benefiting the farmers and whether its goals are being met, need to be regularly reviewed (Teri *et al*., 2007).

Opportunities

1. Understanding the markets and potential Tilapia products through consumer and customer research.
2. There seems little value in pursuing additional investment from the developers preferring that remaining funding is directed on the market that has the highest chance of success.
3. Further work for surimi and fish dips is set aside in favor of progressing towards a feasibility analysis of the commercial potential of the smoked variations.
4. The economics and growing fish over 600-700 g has not been done practically and it is recommended that a trial batch of fish is contracted and grown (using commercial feed) at a suitable location and then used for product development research purposes.
5. A plan is developed (IMR/SPC) to be used to justify the progressive development of permanent sales outlets in Suva and Nadi municipal markets to operate on Saturday market days while continuing to maintain the Nausori outlet.
6. Expansion of distribution to second tier markets such Sigatoka, Lautoka in the West and in Labasa to support farmers in Vanua Levu in the North.
7. That the concept is "workshopped" with prospective farmers and funding proposal led by the key stakeholders be developed. This proposal would require farmer contribution as well as provide resources for the development of the commercial cluster over a period.
8. A further recommendation is that lead demonstration farm(s) be developed under the cluster development strategy and these are used to proof farming techniques, education and promotion of the category to the wider community including other PIC.
9. That a rapid chain analysis of the fresh water prawn farms is conducted with a view to determine the issues constraining development, testing market acceptance with a view to integrate development issues with Tilapia farming.
10. That a review of the role of Naduruloulou Research Station is undertaken with a view to invigorating its national and regional role and ensuring management and operational outputs are lined up with the prawn and Tilapia fresh water strategies.
11. Future funding proposal includes establishing an industry development team (from stakeholder group) including a fulltime programmes development officer appointed to lead and drive the development of this industry.

Marketing, Commercialization and Trade

Current consumption of Tilapia in Fiji is limited as most farms do not have sufficient pond capacity and stock to regularly meet market demands. Eating quality is considered acceptable and the price of Tilapia presents excellent value comparatively to marine fish when sold fresh or live. For example, a buyer can purchase 1 kg (4-5 fish) for $10 in Fiji and can provide sufficient serves for a family meal. Most consumption of harvested fish is by farmers, their extended families, church and community groups and some is traded or sold from the farm or roadside stalls. In Fiji, there are limited to regular sales at one municipal market located at Nausori. Intervention by the Department of Fisheries is essential to promote farm sales and improve the economic prospects of farmers. To access the farmers market in Nausori, farmers are rostered on a weekly basis and assisted by fisheries officers to harvest and transport live fish in tanks to the market. A sales programmes is scheduled each Saturday morning, for purchasing seafood from the main market for 5 days. Live tank facilities are used by the farmer to sell fish direct to consumers. The nearby municipal market in Suva is not used to sell Tilapia and this limits the market development potential that can be created by exposing the product and farmers to a large urban population.

Marine prawns or shrimps are of high value, high demand short-term cash crop with a substantial local and overseas market potential. A number of local buyers have indicated that they would require individual sales of 5-6 tons per week, and a US buyer requires a minimum volume of 80 tons per month. Local shrimp consumption is currently around 900 MT (worth F$ 26.4 million), and less than 30% of this volume are supplied by the capture fisheries and 70% are imported from Australia and other producing countries. Local consumption continues to demonstrate a sustainable increase over the last 20 years. Apart from farming shrimps to replace imports, this commodity also has the potential to be exported to countries like USA, Japan and France. An American company is interested in purchasing 480 tons of shrimp annually from Fiji. Shrimps produced in Fiji are of the highest quality since it is produced in a disease-free environment. Unlike Asian countries where the coastal water is heavily loaded with pollutants, Fiji's coastal waters are clean and the massive oceanic currents that surrounds us, is an advantage (Bureau, 2009).

Strategies Adopted to Harness Potential of Underutilized FMGR

For aquaculture no formal objectives have been established but it is evident that increasing aquaculture production, especially by village level operations, has been the government's primary objective in the subsector. Various policy documents indicate that the increased production is intended to improve the nutritional status of rural populations, generate supplementary income, diversify activities, stem the flow of migration from rural to urban areas, and reduce inshore fishing pressure.

The Ministry has made efforts to have an inclusive and united society and involved the women, youths, elderly and the young of the communities in income-generating fisheries activities and benefits the disadvantaged people. These activities were carried out through the various aquaculture and coastal fisheries projects (Fisheries, 2018).

Major Focus Areas for Underutilized FMGR

Rapid growth is the main aim and providing of raising the level of the freshwater farming by increasing the involvement of local communities in making a drive to raise the number of farms in Fiji. The next plan is to further boost the mariculture sector in Fiji as previously stated that genetic improved products were merely focused on freshwater products. This has been the culture and Fiji is slowly transforming and processing the current information in order to make inform decisions. Key aspect is to make Fijians understand the benefits of genetically rearing underutilized resources to assist in the restocking of marine finfishes such as Groupers. Because groupers have recently declined in stocks and the Ministry of Fisheries is hoping to develop a grouper hatchery in Fisheries Research Station at Makogai Island.

Infrastructure, Capacity Building and Financial Investment

Supporting industries in Fiji are well established, compared with other Pacific nations. Existing feed industries, educational institutions (USP, Montfort Boys Town, SPC Community Education Training Centre) Government (Naduruloulou Research Centre), infrastructure, and support from multilateral partners, has made establishment of a freshwater aquaculture sector in Fiji possible and raised it to the level that it is today (Teri *et al*., 2007).

The Fijian Government has been providing assistance to farmers in terms of supplying the Post-larva's (PL's) and this includes spawning, nurture and delivery of prawns. The Ministry Fisheries is, therefore, requesting the Fiji Government to provide total funding support of F$17 million for two years to establish the number of farms or total land area capable of producing the volume of shrimp demanded locally. In the process, this commodity can be developed to be a successful and sustainable industry within the next two years. Taking the country's geography into consideration, only 16% or 2,933 square kilometers of Fiji's total land area of 18,333 square kilometers are suitable for agricultural activities. These areas are found mainly along the coastal plains, river deltas and valleys. However, the establishment of a prawn farm does not require high yielding lands, and therefore shall not compete for available land.

Future Thrusts

Fiji's aspirations in aquaculture are to:

- Encourage education and training to ensure that personnel at all levels are appropriately skilled; ensure that aquaculture is conducted in an ecologically sustainable manner.
- Including through controls on the introduction and movement of aquatic organisms.
- Make effective extension services available to the aquaculture industry.
- Develop aquaculture in rural areas as a long-term alternative to the limited inshore fisheries resources.
- Promote sustainable aquaculture development as a means of creating food security, income and employment, as well as increasing foreign exchange earnings.
- Carry out research and development, anticipating and meeting the needs of the aquaculture industry and the market.

Recently, the Fijian government opened a multi-species hatchery in Ra Province. The facility is to provide tilapia fry and post-larval shrimp for aquaculture operations. The aquaculture sub-sector is currently subject to controls under several laws. In late 2016, a comprehensive aquaculture bill was being considered by parliament.

Conclusions

In conclusion, the current status in Fiji regards genetically farmed products for consumption and as a potential source of income. Further research has to determine whether the aquaculture farmers will be able to supply the market demand and cater for the potential commercial processing industry. Genetically improved products will surely boost the sector in providing somewhat of a balance with aquaculture and wild capture. This sets the benchmark and the goal for the Fiji government for the next 10 years.

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Country Status Report: THAILAND

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Introduction

The Kingdom of Thailand, located in South-East Asia, covers an area of 513,120 km^2 between latitudes 5° 45´ and 20° 30´ N and longitudes 97° 30´ and 105° 45´ E. It is bounded by Myanmar on the North and West, Laos on the North-East, Cambodia and the Gulf of Thailand on the South-East, Malaysia on the South and the Andaman Sea and Myanmar on the South-West. The country is divided into 77 provinces. 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). The fisheries in Thailand are multi-gear and multi-species. Fishers use several gear types to capture several fish species. Catches from these types of gear comprise multi-species that can be grouped with numerous species into pelagic fish, demersal fish and invertebrate groups.

In Thai coastal waters, the fisheries can be categorized into commercial fisheries and artisanal fisheries. Under the Royal ordinance on Fisheries (No. 2) B.E. 2017 the definition of artisanal fisheries as "fishing operations in coastal seas in which a fishing vessel is used or in which a fishing gear is used without a fishing vessel, but in any case, does not include commercial fishing". The artisanal fisheries are mostly targeting for certain species and certain size range of fish, it comprises gillnet (fish gillnet, crab gill net, Indo-Pacific mackerel gill net, etc.), shrimp trammel net, trap (crab trap, squid trap, fish trap) and hook and line, etc. The fishing operations are mostly one night and landed their products at small fishing piers nearby their houses.

The commercial fisheries mean fishing operations using a fishing vessel of a size from ten gross tonnage or with an engine of a horse power as prescribed by the Minister, or using a fishing vessel with or utilizing fishing gears of the types, methods, the number of workers used, or natures of fishing as prescribed by the Minister. It shall also include using such fishing vessel to operate an aquatic animal processing, whether or not any fishing has also been conducted. The commercial fisheries are divided into trawler (otter board trawl, pair trawl and beam trawl), purse seines (luring purse seine, Thai purse seine, anchovy purse seine, purse seine with fish aggregating devices, etc.), squid falling net, anchovy falling net, king mackerel encircling gill net, short-necked clam dredges, etc.

Fishing fleet

Fishing vessels in Thailand are categorized into artisanal, four commercial categories based on size, power, and fishing gear. In 2018, there were about 36,380 fishing vessels operating in the marine waters of Thailand. The precise number of artisanal vessels is not known and the estimate is based on the number of registered artisanal vessels in a survey carried out in 2015. It is estimated that about 25,700 are currently active, which is 75% of all fishing vessels.

The fishing fleet is categorized into five categories of fishing vessels based on size (gross tonnage (GT), engine power (horse power (HP), and gear type (high efficiency and low efficiency gear):

1. Artisanal fishing vessels are fishing vessels with engine power less than 280 HP and vessel capacity < 10 GT (If the HP >280, the vessel is classified as a commercial vessel, regardless of GT).
2. Small commercial fishing vessels are fishing vessels between 10 – < 30 GT (any vessel using high efficiency gear is classified as a commercial vessel, regardless of size and power).
3. Medium commercial fishing vessels are fishing between 30-< 60 GT.
4. Large commercial vessels are fishing vessels 60-< 150 GT.
5. Extra-large commercial vessels are fishing vessels > 150 GT.

The high efficiency fishing gear are pair trawl, otter board trawl, beam trawl, purse seine, anchovy purse seine, anchovy falling net, anchovy lift net, and light luring vessel. The low efficiency fishing gear are squid falling net, pomfret lift net, gill net, sergestid shrimp push net, baby clam dredge, blood clam dredge, other shell dredge, fish trap, crab trap, squid trap, octopus trap, longline, red frog crab lift net, and handline.

Fishing Grounds

The Gulf of Thailand and the Andaman Sea are the major fishing grounds enjoyed by Thai fishing fleets since time immemorial. The Gulf of Thailand has been known as one of the richest fishing grounds in the world as its primary production is extremely high. The copiousness of tropical marine species typical to the Indo-Pacific region is made up by as many as 1,337 species belonging to 141 families. According to Priyanat (1996, cited after Mala and Pongpat, 2010) there were 618 species of food fishes, 350 species of ornamental fishes, and 379 species of trash fishes.

The important and productive fishing grounds of Thailand are located in two Exclusive Economic Zones: The Gulf of Thailand and the Andaman Sea (Figure 1). For fishery statistical purposes, these fishing grounds in the Gulf of Thailand are divided into 5 areas:

- ***Fishing Area 1:*** Eastern Gulf of Thailand consists of the seas off the provinces of Trad, Chantaburi and Rayong.
- ***Fishing Area 2:*** The Inner Gulf consists of the seas off the provinces of Chonburi, Chacheongsao, Samut Prakarn, Bangkok Metropolitan, Samut Sakorn, Samut Songkram, and Petchaburi.
- ***Fishing Area 3:*** Upper western Gulf of Thailand consists of the seas off the provinces of Prachuab Kirikhan, Chumphon, and Surat Thani.
- ***Fishing Area 4:*** Lower Western Gulf of Thailand consists of the seas off the provinces of Nakhon Si Thammarat, Songkhla, Pattani and Narathiwas.
- ***Fishing Area 5:*** Mid-Gulf of Thailand consists of the seas in the Mid-Gulf that extend southward to the international boundary line between Thailand-Kingdom of Cambodia and Thailand-Malaysia.

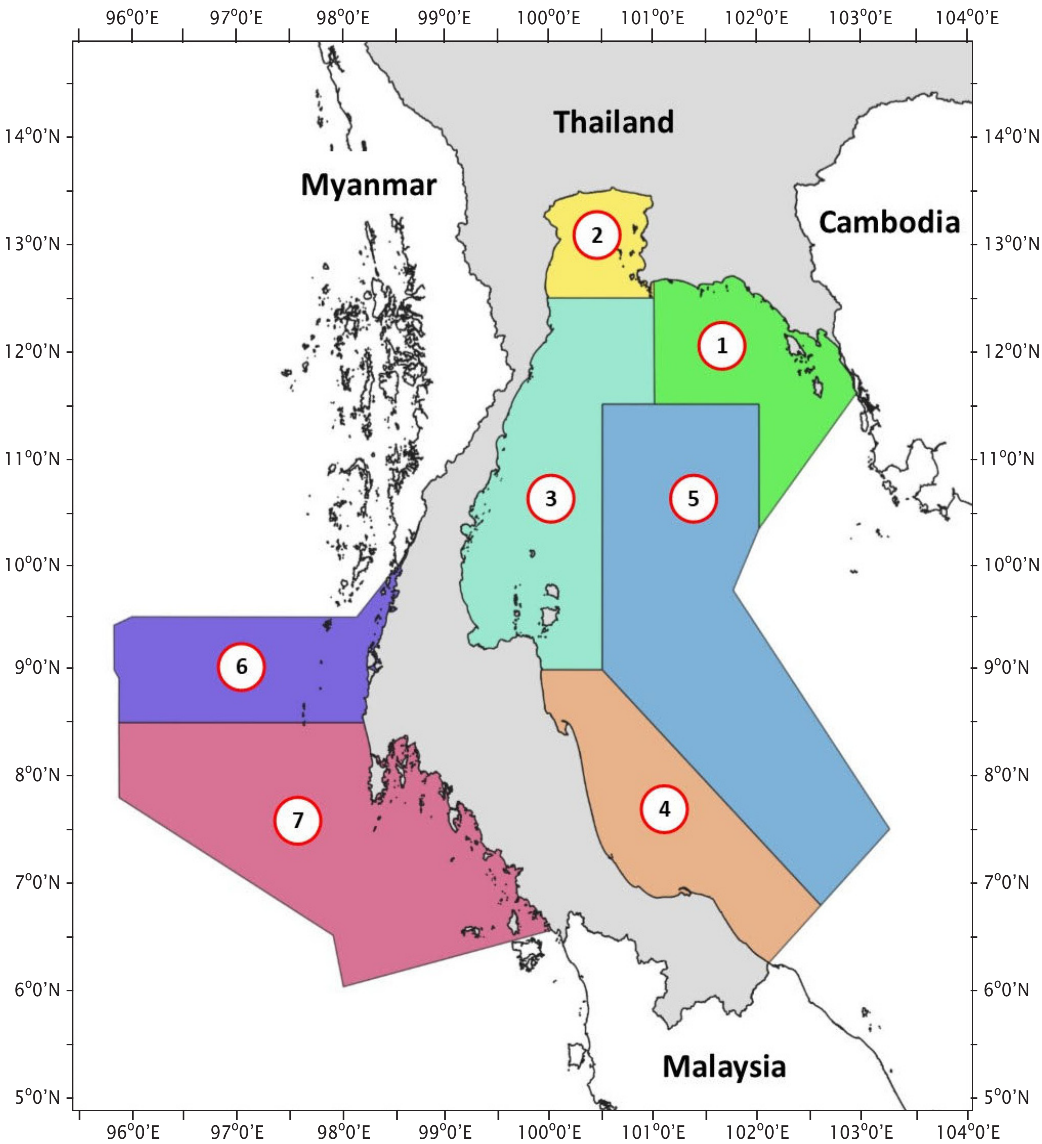

Figure 1. *Map showing fishing grounds in Thailand*

The Andaman fishing grounds can be divided into two major areas:

- ***Fishing Area 6:*** Upper Andaman Sea consists of the seas off the provinces of Ranong, Pang-nga, and Phuket.
- ***Fishing Area 7:*** Lower Andaman Sea consists of the seas off the provinces of Krabi, Trang, and Satun.

Importance of Fish and Marine Genetic Resources in Economy and Food Security

a) Production and Consumption

Marine fisheries are important both socially and economically for Thailand. Fish are very important to the food security and self-sufficiency of Thailand. Based on Thai Fishing Vessels Statistics in 2016, a total number of 40,688 fishing vessels caught 1.34 MT. This catch supports the livelihoods, incomes and employment for fishermen and people employed in supporting industries, mostly women (e.g. fish processing industry, ship building industry, canned and frozen fisheries product factories, fish meal factories). For rural Thailand, fish constitutes a generally affordable source of protein, contributing significantly to dietary health and food security, particularly the more than 2,500 villages of artisanal fishing communities along the coasts. The consumption rate per capita is 42 kg/year.

b) Imports and Exports

Thailand is also a major seafood producer and exporter. Most fishery products are exported in fresh chilled or frozen, steamed boiled salted dried or smoked, fish meal, fish sauce, aquatic animal live and others. The imported fishery products are in the same form. For example in 2016, commodity exports are 1.66 MT, valued at USD 7,128.94 million and commodity imports are 1.86 MT valued at USD 3,636.04 million (Table 1).

Table 1. Quantity and value of exports-imports by commodity (2016)

Types	Export		Import	
	Quantity (ton)	Value (million USD)	Quantity (ton)	Value (million USD)
Total	1,660,432	7,128.94	1,867,754	3,636.04
Aquatic animal live (including ornamental fish)	18,258	115.89	6,816	38.47
Fresh chilled or frozen	355,347	2,019.76	1,626,296	3,000.36
Steamed boiled dried or smoked	72,479	179.00	19,926	71.90
In airtight containers	321,840	1,460.97	19,841	64.12
Not in airtight containers	511,023	2,503.29	16,038	70.51
Prepared or preserved	92,288	418.55	32,980	144.66
Fish meal	147,649	191.88	68,129	87.51
Fish sauce	70,816	82.55	1,519	1.73
Oyster sauce	16,776	57.86	114	0.36
Fish oil	19,341	29.14	7,682	16.17
Seaweed & agar-agar	739	6.02	5,310	77.53
Others	33,876	64.03	63,103	62.72

Status of Fish and Marine Genetic Resources

a) Current Status of the Fishery Resources

The current status of the marine fisheries are cited in the Marine Fisheries Management Plan of Thailand (2020-2024). Standardized research vessel surveys have been carried out in both the Gulf of Thailand and the Andaman Sea since the 1960s. The CPUE declined dramatically during the 1960s at the time the fishery was developing rapidly and the CPUE is now only 7% and 17% of the original CPUE in the Gulf of Thailand and the Andaman Sea, respectively (Figure 2 & 3).

Stock assessments for demersal, anchovy and pelagic fish for 2017 have been carried out based on the analyses of the main fishing gear in Thailand marine waters (about 80% of the total catch). The maximum sustainable yield (MSY) estimate is 1.6 MT and the current catch is below the MSY in all these species groups in both the Gulf of Thailand and the Andaman except pelagic fish in the Andaman Sea. Also, because of recent reductions in fishing effort, the fishing effort is now below the fishing effort at MSY (FMSY), especially for anchovies (Table 2).

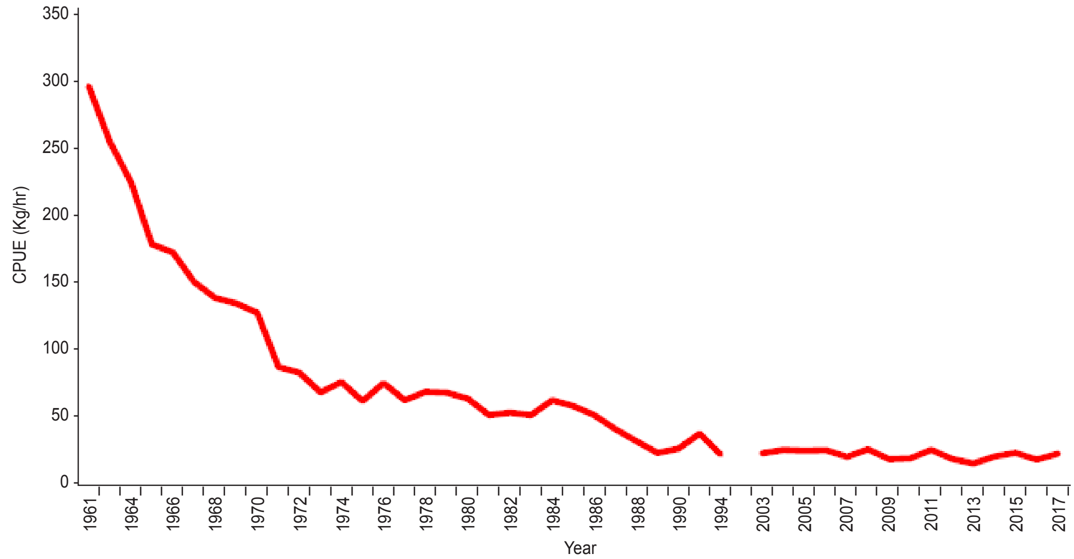

Figure 2. *CPUE (kg/hour) trends of demersal trawl surveys in the Gulf of Thailand, 1966-2017 (Sources: Marine Fisheries Management Plan of Thailand, 2020-2024)*

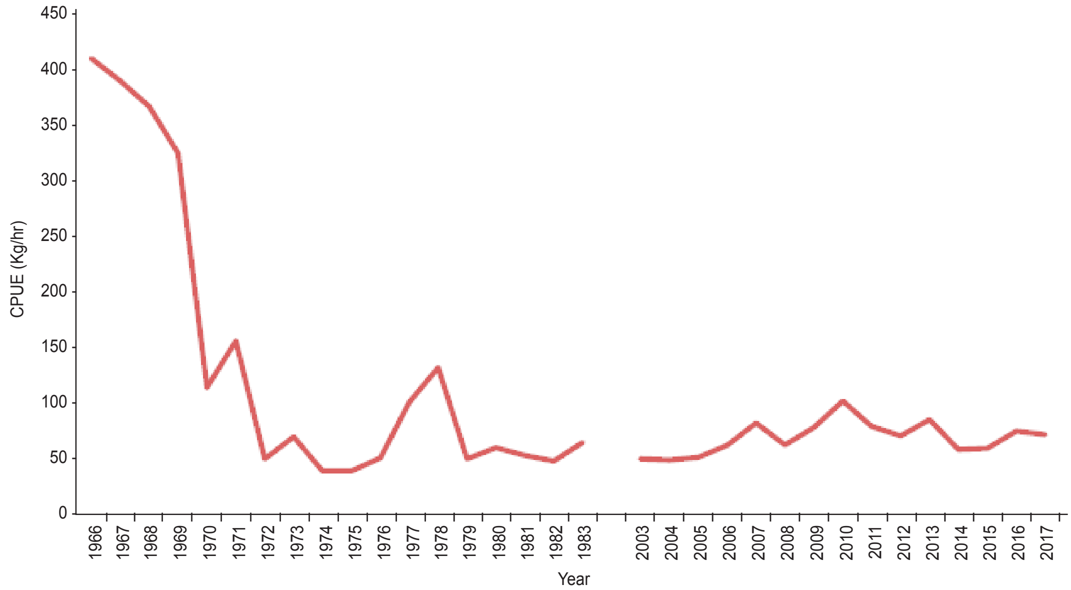

Figure 3. *CPUE (kg/hour) trends of demersal trawl surveys in 1960s-2017 (Sources: Marine Fisheries Management Plan of Thailand, 2020-2024)*

Table 2. Status of the fisheries resources in the Gulf of Thailand and Andaman Sea

	Demersal fish[1]	Anchovies	Pelagic fish
2015			
Gulf of Thailand	Overfishing[2]	Fished at MSY	Overfishing
Andaman Sea	Overfishing	Fished at MSY	Overfishing
2017			
Gulf of Thailand	Overfishing controlled Overfished[3]	Fished below MSY	Fished at MSY
Andaman Sea	Overfishing controlled Overfished	Fished below MSY	Fished at MSY

[1] *Demersal fish refers to all bottom-dwelling fish including crustaceans and molluscs.*

[2] *Overfishing is defined as excessive fishing that has produced a decline of the abundance of spawning fish and consequently low recruitment of young fish back into the population.*

[3] *Overfished is defined as a stock with an abundance below the sustainable level. A fish resource can remain overfished for a period of time after overfishing has been controlled.*

The results show that demersal and pelagic fish in Thai waters are currently fully utilized. Prior to 2015, overfishing had occurred in Thai waters resulting in overfished for demersal and pelagic species. Since 2015, fishing effort has been controlled and fisheries resources have been recovering. Recovery rate of pelagic fishes is generally greater than demersal fishes (Table 2). Therefore, the catches of pelagic fish in Thai waters are currently somewhat at MSY level. However, demersal fishes need more time to recover to MSY level.

For anchovy in Thai waters, the result of stock assessment suggested that the current fishing efforts are well below the required fishing efforts at MSY level which can be further increased for the catch. However, anchovy is one of the primary consumer in the marine food web and fed by several fishes. Therefore, ecosystem function of anchovy should be carefully considered if fishing efforts are to be increased. Fishing efforts have declined over the past three years in both the Gulf of Thailand and the Andaman Sea and the catch has also declined in all species groups, except for pelagic fish in the Andaman Sea (Table 3). Because the decline in efforts was greater than the change in catch, the CPUE has increased in all groups.

Table 3. Change in catch, fishing effort and CPUE for the main fishing gears from 2015 to 2017

	Catch 2015 (ton)	Catch 2017 (ton)	% change	Effort 2015	Effort 2017	% change	CPUE 2015	CPUE 2017	% change
Gulf of Thailand									
Demersal	503,276	462,512	-8.1	36.20 mh	22.29 mh	-38.4	13.9 kg/hr	20.8 kg/hr	49.6
Anchovies	183,216	108,212	-40.9	115,600 days	55,518 days	-52.0	1,585 kg/day	1,949 kg/day	23.0
Pelagic	245,986	199,507	-18.9	178,709 days	111,999 days	-37.3	1,376 kg/day	1,781 kg/day	29.4
Andaman Sea									
Demersal	177,684	140,130	-21.1	5.09 mh	3.55 mh	-30.3	34.9 kg/hr	39.5 kg/hr	13.2
Anchovies	33,903	13,570	-60.0	51,520 days	19,348 days	-62.4	658 kg/day	701 kg/day	6.6
Pelagic	99,039	121,400	22.6	64,925 days	45,094 days	-30.5	1,525 kg/day	2,692 kg/day	76.5

Fish catch

The total catch for the Thai fishing fleet was calculated from statistic data, fishing logbook and landing survey data (Table 4). The total catch in 2017 was 1.30 MT, down from 1.56 MT in 2014. The Gulf of Thailand catch was 71.9% of the total. The bulk of the catch in Thai waters comes from commercial vessels, 93.6% of the total catch in the Gulf of Thailand and 81.5% in the Andaman Sea. Overall, commercial vessels accounted for 90.1% of the total catch. There was no significant catch by Thai-flagged vessels outside Thai waters in 2017.

Table 4. Total catches (tonnes) in 2017 (DOF 2017)

Resources	Gulf of Thailand		Andaman Sea		Outside Thai waters
	Artisanal	Commercial	Artisanal	Commercial	
Demersal fish	36,688	464,070	8,917	147,137	–
Anchovies	1,966	115,491	236	15,802	–
Other pelagic fish	20,476	288,061	59,804	139,794	–
Subtotal	59,130	867,622	68,957	302,733	–
Total	926,752		371,690		–
	Artisanal		Commercial		–
Total	**128,087**		**1,170,355**		**5,411***
Grand total	**1,303,853**				

b) Unique Underutilized FMGR

In Thai waters, anchovy is underutilized fisheries resource. However, it is worth to conserve anchovy for maintaining integrity of marine ecosystem since it is primary consumer in the ecosystem. For transboundary species, the level of utilization is not clearly studied.

c) Processing, Value Addition and Product Development

There are several kinds processed fisheries products, i.e. fresh chilled or frozen, steamed, boiled, salted, dried, smoked, in airtight container, not in airtight container, and prepared or preserved (Table 5).

Table 5. Quantity of exports of fisheries products by commodity in 2016

Types	Quantity (ton)	Value (million USD)
Aquatic animal lLive (including ornamental fish)	18,258	115.89
Fresh chilled or frozen	355,347	2,019.76
Steamed boiled dried or smoked	72,479	179.00
In airtight containers	321,840	1,460.97
Not in airtight containers	511,023	2,503.29
Prepared or preserved	92,288	418.55
Fish meal	147,649	191.88
Fish sauce	70,816	82.55
Oyster sauce	16,776	57.86
Fish oil	19,341	29.14
Seaweed & agar-agar	739	6.02
Others	33,876	64.03

Challenges and Opportunities

Thai fishing fleets for all three groups of fisheries, i.e. demersal fish, pelagic fish, and anchovy are currently over-capacity. Fishing effort is controlled by limited number of fishing day. Fishing vessels operating high efficiency fishing gears is specified the number of fishing day in their fishing license

Table 6. Number of fishing day for commercial fishing license in 2018

Fishing gear	Annual fisheries 2016 - 2017		Annual fisheries 2018 – 2019	
	Gulf of Thailand	Andaman sea	Gulf of Thailand	Andaman sea
Otter board trawl	220	250	240	270
Beam trawl	220	250	240	270
Pair trawl	220	250	240	270
Purse seine	220	235	240	255
Anchovy falling/lift nets	235	205	255	225
Anchovy purse seine	235	205	255	225
Squid falling nets Fish trap Crab trap Squid trap Octopus trap Sergestid shrimp push net Short-necked clam dredges Ark shell dredges Other dredges Long line Handline and hook & lines Red frog crab lift net gill nets Pomfret lift net	N.S.	N.S.	N.S.	N.S.

N.S. - not specified

(Table 6). In addition, new fishing license for high efficiency fishing gears is not permitted in order to reduce the number of fishing vessel. The implementation of these measures results in reduction of capacity and allows increasing of number of fishing day. Therefore, to keep the fishing effort not exceed the fishing effort at MSY level is the main challenge to prevent overfishing.

Some species in Thai waters are transboundary species. The study of these species, e.g. migratory pattern, biology, and stock assessment needs cooperation among countries concerned. Therefore, their level of utilization is not clearly studied and there is an opportunity to increase their catch if the study shows that they are underutilized. The current 'central' method of control for stocking, harvesting and marketing has been successful in bringing the fishery industry to its present level. It does have drawbacks, however, whereby farmers do not have full control and accountability over their own fish farming business, such as the time of harvest, quality and quantity of fish sold, and oversight of the revenue less expenses. They also tend to take less care over pond preparation (e.g. eliminating fish predators) when fingerlings or post-larvae are given out for free. The strategy of government toward the freshwater aquaculture sector is through support in the form of free fingerling production and distribution, extension services, research, and market assistance. The relevance of this programmes, for example, whether it is benefiting the farmers and whether its goals are being achieved, need to be regularly reviewed.

Marketing, Commercialization and Trade

In 2016, total import of fisheries products was 1,867,754 tons valued USD 3,636.04 million. China, Myanmar, and Taiwan are top three exporting countries to Thailand. While total export was 1,660,432 tons valued USD 7,128.94 million. The top importing countries are Japan, United States, and China. The export value was significantly higher than import value. Most of imported fish is raw material for processing. The processed products are re-exported across the world (Table 7).

Table 7. Quantity and value of import and export by country in 2016

Country	Imports		Exports	
	Quantity (ton)	Value (million USD)	Quantity (ton)	Value (million USD)
Total	1,867,754	3,636.04	1,660,432	7,128.94
Australia	2,363	10.97	75,861	388.39
Belgium	12	0.16	1,651	7.29
Brunei	-	-	1,487	3.43
Cambodia	25,680	9.03	21,519	4.57
Canada	4,237	31.67	51,257	310.86
Chile	24,197	113.65	10,828	36.98
China	267,235	545.41	124,897	297.05
Denmark	1,695	7.99	1,904	9.36
Egypt	-	-	63,514	182.01
France	14,123	35.94	10,957	43.77
Germany	270	0.90	10,518	52.34
Hong Kong	173	0.70	29,572	129.50
India	77,329	209.23	5,168	12.27
Indonesia	55,434	151.57	10,748	16.52
Italy	49	0.78	34,317	198.60
Japan	87,501	174.58	231,758	1,419.18
Republic of Korea	98,524	219.43	27,698	171.32
Lao	-	-	12,429	18.92
Malaysia	79,348	61.21	87,905	104.61
Myanmar	253,709	130.29	30,615	44.21
Netherlands	2,984	3.73	14,792	64.05
New Zealand	8,723	31.65	9,111	42.77
Norway	29,277	166.30	3,922	17.39
Peru	17,630	27.83	10,191	42.80
Philippines	14,597	28.41	20,951	68.95
Russian Federation	7,358	38.66	24,375	39.17
Singapore	571	5.48	20,108	51.38
South Africa	231	1.11	21,933	64.01
Spain	24,448	45.93	5,663	23.76
Sweden	4	0.08	5,659	19.68
Switzerland	35	1.03	5,984	30.75
Taiwan	151,775	282.19	28,809	93.94
United Kingdom	1,809	5.72	24,182	152.24
United States	104,072	232.72	227,196	1,618.95
Viet Nam	147,761	342.68	77,143	272.65
Other countries	364,600	719.00	315,810	1,034.20

Strategies Adopted to Harness Potential of Underutilized FMGR

Since 2015, Marine Fisheries Management Plan (FMP) has been used as a framework for marine fisheries management. FMP recognizes the significant of managing the fisheries resources sustainably and details what actions and management measures are required. Fishing license issuance is based on reference point. Currently, maximum sustainable yield (MSY) is used as a reference point. Once MSY assessment is finalized, total allowable catch (TAC) will be determined and allocated to each single vessel. Catch and number of fishing day is specified in each fishing license. Therefore, all fisheries resources are assessed in order to obtain a reference point for fishing license issuance.

Major Focus Areas for Underutilized FMGR

The priority of harvesting underutilized FMGR is given to transboundary species which migrate in the Gulf of Thailand (South China Sea) or the Andaman Sea e.g. neritic tunas. Several studies on these species need to be conducted in order to discover migratory pattern, biology, stock status, etc. Then, utilization and management strategy can be taken place based on best scientific evidence.

Infrastructure, Capacity Building and Financial Investment

The Marine Fisheries Research and Development Division (MFRDD), Department of Fisheries, is responsible for fisheries data collection. There are six Research Centers under MFRDD, namely:

1. Eastern Gulf Fisheries Research and Development Center (Rayong)
2. Upper Gulf Fisheries Research and Development Center (Samut Prakan)
3. Central Gulf Fisheries Research and Development Center (Chumphon)
4. Southern Gulf Fisheries Research and Development Center (Songkhla)
5. Upper Andaman Sea Fisheries Research and Development Center (Phuket)
6. Southern Andaman Sea Fisheries Research and Development Center (Satun)

These centers collect the data from fishing ports based on monthly basis. Data is submitted to the Fisheries Resource Assessment Group, MFRDD to analyze and assess MSY. In addition, workshops related to data collection and analysis and MSY assessment are conducted every year. Total annual budget for these activities is around USD 172,000.

Future Thrusts

The Department of Fisheries conducts stock assessment in Thai waters every year in order to monitor fisheries resources status. DOF is working with the Southeast Asian Fisheries Development Center (SEAFDEC) and ASEAN countries to study some transboundary species. Furthermore, DOF has launched the Fisheries Improvement Project (FIP) for Longtail Tuna in the Gulf of Thailand, which is highly migratory species, including the study on distribution and stock assessment. The results will suggest the level of utilization of longtail tuna.

Conclusions

Fisheries resource in Thai waters is divided into three groups, i.e. demersal fish, pelagic fish, and anchovy. Recent stock assessment, in 2018, revealed that demersal fish and pelagic fish are fully utilized while anchovy is underutilized. However, the utilization of anchovy resource should consider their ecosystem function and effect of anchovy fisheries on the marine ecosystem.

Some species in Thai waters are transboundary species. Cooperative study in the region on their migratory pattern, biology, and stock status are needed prior to determine the utilization and management strategy.

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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		

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