Regional Expert Consultation on

Agricultural Biotechnology – Scoping Partnerships to Improve Livelihoods of Farmers in Asia and The Pacific

Bangkok, Thailand
May 29-31, 2018

Proceedings and Recommendations

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Back Cover : Elite germplasm of cocoa used for improving livelihoods of farmers (ACIAR, Australia)

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Foreword

The science of agricultural biotechnology has the potential to change the lives of smallholder farmers and can significantly help in achieving Sustainable Development Goals (SDGs). Technologies are available for increased production, long-term protection from disease, resource use efficiency for feed, energy and land especially in marginal agricultural zones with more efficient farming systems that are relevant to crops, fish and other aquaculture, microbes, agroecology, poultry, animals etc. However, the benefits of these technologies are not reaped in several developing and under-developed regions for various reasons including lack of awareness among public and policy makers. Often biotechnology is equated with Genetically Modified (GM) crops, more specifically Bt crops, to the disadvantage of this branch of science to serve the communities particularly smallholder farmers. In this context, APAARI organized a "Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnership to Improve Livelihoods of Farmers in Asia-Pacific" in Bangkok, Thailand from May 29-31, 2018.

One of the major driving forces to promote biotechnology in the Asia-Pacific Region is to study the scope of partnerships across the countries, organizations and different sectors of agriculture. The regional consultation is organized comprising six sessions that cover scoping global partnerships and investments; public private partnerships; country status reports; a World Café discussion that cover priorities of research, capacity building, public awareness, policy advocacy and possible partnerships; a panel discussion to highlight partnerships for innovative funding mechanisms and the plenary session to refine and consolidate the recommendations. I am extremely happy on the participation and deliberations of the regional expert consultation. Presentations, deliberations, interventions with whole hearted participation of global experts and their participation in World Café discussion and panel discussion led to major recommendations. I am happy to see the document on Proceedings and Recommendations, which comprehensively covers the presentation and key discussion points. I am also happy to place on record that a book on "Strategic Reports and Country Status Reports" is also being brought out, which will serve as reference for each country. Recognizing the sensitivities for each country, local leadership shall take advantage of this regional consultation to move forward to achieve SDGs by using technologies through partnerships and by developing required policy briefs.

Recommendations are equally applicable to all the member countries, organizations and partners. APAARI remains committed to contribute towards achieving SDGs and improve livelihoods of smallholder farmers of agriculture, aquaculture and animal sectors. APAARI will play the role of leadership, facilitation and promote knowledge economy in the region. It is, therefore, expected that all the members and international organizations shall play active role in realizing meaningful partnerships exploiting the biotechnology for the benefit of smallholder farmers.

In this context, I would like to place on record my appreciation for the APAARI team particularly Dr Rishi Tyagi for his leadership and untiring efforts. I am thankful to all the co-organizers, co-sponsors and technical partners for their technical, intellectual and financial contributions. I place on record my sincere thanks to all the participants of this regional expert consultation on agricultural biotechnology. I am also thankful to the team of editors in bringing out this publication.

I wish and hope that this publication will serve as reference to all stakeholders in planning at each country level for promotion of biotechnology for prosperity of the region through partnership and networking.

Ravi K. Khetarpal
Executive Secretary, APAARI

Acknowledgements

On behalf of Asia-Pacific Association of Agricultural Research Institutions (APAARI), Asia Pacific Consortium on Agricultural Biotechnology (APCoAB) and my own behalf, it is my great pleasure to acknowledge and profusely thank all the Co-Organizers - Council of Agriculture (COA), Taiwan, Department of Agriculture (DOA), Thailand, Australian Centre for International Agricultural Research (ACIAR), Australia; Co-Sponsors - CGIAR Research Program - Grain Legumes and Dryland Cereals (CRP-GLDC), International Crops Research Institute for the Semi Arid Tropics (ICRISAT) and Technical Support Partner Biotech Consortium India Limited (BCIL) and participants for their respective roles in the Expert Consultation on 'Agricultural Biotechnology - Scoping Partnerships to Improve Livelihood of Farmers in Asia and the Pacific'. Besides organizational support, strategic and technical input of individuals is equally important. Profound thanks are accorded to Dr Chung-Hsiu Hung, Director General, Department of International Affairs, COA, Taiwan, for delivering the inaugural address of the meeting and setting the tone of the deliberations. We are immensely grateful to Dr Yusuf Zafar, Chairman, APAARI, for his guidance, suggestions and encouragement during preparation and organization of the meeting. Thanks are due to Dr Andrew Alford, Research Program Manager, ACIAR, Australia, for his participation and representing Ms Mellissa Wood, General Manager Global Programs, ACIAR. Dr Rajeev K. Varshney, Research Program Director for Genetic Gains, ICRISAT, Hyderabad, India, is thanked for his support and networking not only for this meeting, but also for many other programs involving collaboration with APAARI and ICRISAT. Dr Siriporn Boonchoo, Deputy Director General, DOA, Thailand, is thanked for her presence and input in the meeting as well as the collaboration and support extended to APAARI in other major programmes. Dr Ravi Khetarpal, Executive Secretary, APAARI, was the key person responsible for smooth execution of this Expert Consultation. He provided valuable input in developing the concept note, technical program, financial guidance and networking, which are important for the success of the meeting. Sincere thanks are accorded for his overall leadership.

We place on record our gratitude to all Heads and their nominees from National Agricultural Research Systems (NARS) for their presence, sacrificing precious time for providing inputs in the consultation. Grateful thanks are extended to all the Co-Chairs for conducting the respective sessions efficiently and steering the discussions, which resulted in important and useful recommendations presented in this document. All the speakers and panellists of various technical sessions and panel discussion are thanked immensely for their excellent contributions, and participants/discussants for their insightful interventions. All the rapporteurs and facilitators of technical and plenary sessions, World Café and panel discussions are acknowledged for meticulously capturing the salient points that emerged from the presentations/discussion and also for drafting the recommendations.

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Rishi K. Tyagi
Coordinator, APCoAB
Co-Chair, Organizing Committee

The Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

http://www.apaari.org

The APAARI, with its headquarters in Bangkok, is a unique voluntary, membership-based, self-mandated, apolitical and multi-stakeholder regional organization in the Asia-Pacific region. It promotes and strengthens agriculture and agri-food research and innovation systems through partnerships and collaboration, capacity development and advocacy for sustainable agricultural development in the region. Since its establishment in 1990, APAARI has significantly contributed towards addressing agricultural research needs and enhancing food and nutritional security in the region. The close links, networks, partnerships and collaboration with stakeholders that APAARI has developed over the years, as well as its goodwill, authority and focus on results, make the Association an important actor in the region. The ultimate aim of APAARI is to help realising sustainable development goals in Asia and the Pacific.

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

http://www.apaari.org/web/our-projects/apcoab

The APCoAB, established in 2003 under the umbrella of APAARI, has 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. APCoAB's main objectives are to (i) serve as neutral forum for the key partners engaged in research, development, commercialization and education/learning of agricultural biotechnology as well as environmental safety in the Asia-Pacific region; (ii) Application of biotechnological tools for bioprospecting, conservation and sustainable use of bioresources; (iii) facilitate and promote the process of greater public awareness and understanding relating to important issues of IPRs, sui generis systems, biosafety, risk assessment, harmonization of regulatory procedures, and access and benefit sharing in order to address various concerns relating to adoption of agricultural biotechnology and sustainable use of bioresources; and (iv) facilitate human resource development for meaningful application of agricultural biotechnology and use of bioresources to enhance sustainable agricultural productivity, as well as product quality, for the welfare of both farmers and consumers.

Council of Agriculture (COA)

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

The COA, Taiwan, is the competent authority on agricultural, 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.

Australian Centre for International Agricultural Research (ACIAR)

http://aciar.gov.au

The ACIAR is a statutory authority within the Foreign Affairs and Trade portfolio operating under the ACIAR Act. ACIAR contributes to the objectives of advancing Australia's national interests, promoting economic growth and increasing sustainability through assisting and encouraging Australian scientists and institutions to use their skills to develop solutions to agricultural problems in developing countries. Its mandate is to plan, fund and manage projects across a broad range of agricultural and development areas. Approximately three quarters of the Centre's research budget is allocated to bilateral collaborative development-related research between Australia and developing countries. The remaining quarter of the research budget is allocated to multilateral development related research through contributions to international agricultural research centres. Besides, ACIAR provides training and development activities, including fellowships and support for training courses, as well as training provided within research projects, to help build capacity in research application and implementation in partner countries.

CGIAR Research Program - Grain Legumes and Dryland Cereals (CRP-GLDC)

http://gldc.cgiar.org/

The GLDC builds on the work done by three CGIAR Research Programs from 2012 to 2016: Grain Legumes, Dryland Cereals and Dryland Systems. It aims to increase the productivity, profitability, resilience and marketability of critical and nutritious grain legumes and cereals within the semi-arid and sub-humid dryland agroecologies of sub-Saharan Africa and South Asia. These agroecologies are where poverty, malnutrition, climate change and soil degradation are among the most acute globally.

Biotech Consortium India Limited

http://www.bcil.nic.in/

The BCIL established in 1990, is a public limited company, promoted by the Department of Biotechnology (DBT), Ministry of Science and Technology, Government of India and All India Financial Institutions for providing the necessary linkages among stakeholders and business support for facilitating accelerated commercialization of Biotechnology. BCIL was incorporated under the Indian Companies Act, 1956. The Board of Directors of BCIL consists of senior representatives of DBT, Council of Scientific and Industrial Research (CSIR), Indian Council of Agricultural Research (ICAR), leading all India financial institutions and the biotechnology industry. BCIL has been actively involved in technology transfer, project consultancy, fund syndication, information dissemination, manpower training and placement, related to biotechnology. It has assisted hundreds of clients including scientists, technologists, research institutions, universities, first entrepreneurs, corporate sector, national and international organizations, central government, various state governments, banks and financial institutions.

Department of Agriculture (DOA), Thailand

https://www.doa.gov.lk/index.php/en/

The DOA was established since October 1, 1972 under the Revolutionary Decree No. 216 dated September 29, 1972 by merging the former Department of Agriculture and the Rice Department. The union was aimed to facilitate coordination among the Departments and officers as well as to streamline its function to enable a more efficient implementation of its mandates. The 15 pioneering units of the Department of Agriculture comprised Office of the Secretary, Finance Division, Personnel Division, Planning Division, Rice Division, Field Crops Division, Horticulture Division, Sericulture Division, Rubber Division, Agricultural Engineering Division, Plant Pathology Division, Entomology and Zoology Division, and Agricultural Chemistry Division, A total of 95 research centres, stations and plant quarantine stations were then established throughout the country.

Acronyms and Abbreviations

AARINENA	Association of Agricultural Research Institutions in the Near East and North Africa
ABRC	Agricultural Biotechnology Research Centre
ACIAR	Australian Centre for International Agricultural Research
AFMA	Agriculture and Fisheries Modernization Act
AIT	Asian Institute of Technology
AMS	Agriculture Marketing Services
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APCC	Asia and Pacific Coconut Community
APCoAB	Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
APEC	Asia-Pacific Economic Cooperation
APHIS	Animal and Plant Health Inspection Service
APNAN	Asia Pacific Natural Agriculture Network
APR	Asia-Pacific Region
ARC	Agricultural Research Centre
AR4D	Agricultural Research for Development
ARDC	Agricultural Research and Development Centre
AREEO	Agricultural Research, Education and Extension Organization
ARS	Agricultural Research Services
ASEAN	Association of Southeast Asian Nations
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BASIC	Brazil, South Africa, India and China
BAU	Bangladesh Agricultural University
BCIL	Biotech Consortium India Limited
BIMSTEC	Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation
BLRI	Bangladesh Livestock Research Institute
BRAI	Biotechnology Regulatory Authority of India
BRICS	Brazil, Russia, India, China and South Africa
Bt	*Bacillus thuringiensis*
Cas	CRISPR associated gene
CABI	Centre for Agriculture and Bioscience International
CePaCT	Centre for Pacific Crops and Trees

CESAIN	Centre of Excellence on Sustainable Agricultural Intensification and Nutrition
CFR	Code of Federal Regulations
CGIAR	Consultative Group on International Agricultural Research
CIAT	International Center for Tropical Agriculture
CIMMYT	International Maize and Wheat Improvement Centre
CLA	CropLife Asia
COA	Council of Agriculture
CoE	Centre of Excellence
COGENT	Coconut Genetic Resources
CRISPR	Clustered, Regularly Interspaced, Short Palindromic Repeats
CRP-GLDC	CGIAR Research Program – Grain Legumes and Dryland Cereals
CSO	Civil Society Organization
DARE	Department of Agricultural Research and Education
DFAT	Department of Foreign Affairs and Trade
DNA	Deoxyribo Nulceic Acid
DOA	Department of Agriculture
EBN	Edible Bird's Nest
EM	Effective Microorganisms
EPA	Environmental Protection Agency
ERS	Economic Research Services
ET	Embryo Transfer
FAO	Food and Agriculture Organization of the United Nations
FAO RAP	Food and Agriculture Organization Regional Office for Asia and the Pacific
FDA	Food and Drug Administration
FMD	Foot and Mouth Disease
FNPP	FAO Netherlands Partnership Programme
FO	Farmers Organization
FtF	Feed the Future
GDP	Gross Domestic Products
GE	Genetically Engineered
GM	Genetically Modified
GMO	Genetically Modified Organism
GoI	Government of India
IAEA	International Atomic Energy Agency
IBC	Institutional Biosafety Committee
IBSA	India, Brazil, South Africa
ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dryland Areas
ICDF	International Cooperation for Development Fund
ICGEB	International Centre for Genetic Engineering and Biotechnology
ICRAF	International Council for Research in Agro-Forestry

ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDE	Innovation Driven Entrepreneurship
IFAD	International Fund for Agricultural Development
IISBR	Institute for Interdisciplinary Salivary Bioscience Research
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
IoT	Internet of Things
IP	Intellectual Property
IRIC	International Rice Informatics Consortium
IRRI	International Rice Research Institute
ISAAA	International Service for the Acquisition of Agri-biotech Applications
ISHS	International Society of Horticultural Science
ISTA	International Seed Testing Association
IUFRO	International Union of Forest Research Organizations
IWMI	International Water Management Institute
JICA	Japan International Cooperation Agency
JIRCAS	Japan International Research Center for Agricultural Sciences
LB	Livestock Biotechnology
LRD	Land Resources Division
MABC	Marker Assisted Backcrossing
MAGIC	Multi-parent Advanced Generation Inter-cross
MARDI	Malaysian Agricultural Research and Development Institute
MAS	Marker Assisted Selection
MDGs	Millennium Development Goals
MoAF	Ministry of Agriculture and Fisheries
MOALI	Ministry of Agriculture, Livestock and Irrigation
NACA	Network of Aquaculture Centres in Asia-Pacific
NAFRI	National Agriculture and Forestry Research Institute
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NBC	Nuclear Breeding Centre
NBIN	National Broodstock Improvement Network
NCBP	National Committee on Biosafety of the Philippines
NCSTPC	National Certification System for Plant Tissue Culture Plants
NFO	New Funding Opportunities
NGO	Non-Government Organization
NIFA	National Institute of Food and Agriculture
NPB	National Biotechnology Policy
NPBTs	New Plant Breeding Techniques

NPPOs	National Plant Protection Organizations
NSSC	National Soil Science Centre
OECD	Organization for Economic Cooperation and Development
PABP	Pingtung Agricultural Biotechnology Park
PARC	Pakistan Agricultural Research Council
PCAARRD	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PCR	Polymerase Chain Reaction
PFOs	Potential Funding Opportunities
PICTs	Pacific Island Countries and Territories
PNG	Papua New Guinea
PPA	Plant Protection Act
PPP	Public Private Partnership
QMS	Quality Management System
QTL	Quantitative Trait Loci
R&D	Research and Development
RIS	Research and Information System
S&T	Science and Technology
SAARC	South Asian Association for Regional Cooperation
SDC	Swiss Agency for Development and Cooperation
SDGs	Sustainable Development Goals
SE	South East
SEARCA-BIC	Southeast Asian Regional Center for Graduate Study and Research in Agriculture - Biotechnology Information Center
SLCARP	Sri Lanka Council for Agricultural Research Policy
SME	Small and Medium Enterprise
SOPs	Standard Operating Procedures
SPC	The Pacific Community
SSC	South-South Cooperation
STEA	Science Technology and Environment Agency
SW	South West
SWOT	Strength, Weakness, Opportunity and Threat
TALEN	Transcription Activator-like Effector Nuclease
TTO	Technology Transfer Organization
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
USA	United States of America
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
UUC	Under-Utilized Crop
VAAS	Vietnam Academy of Agricultural Sciences
ZFN	Zinc Finger Nucleases

Executive Summary

A '**Regional Expert Consultation on Agricultural Biotechnology - Scoping Partnerships to Improve Livelihoods of Farmers in Asia and The Pacific**' was held on May 29-31, 2018 at Rama Gardens Hotel, Bangkok, Thailand. The meeting was organized by the Asia-Pacific Association for Agricultural Research Institutes (APAARI) and Asia-Pacific Consortium for Agricultural Biotechnology and Bioresources (APCoAB), Bangkok, Thailand, with financial support from Council of Agriculture (COA), Taiwan, Australian Centre for International Agricultural Research (ACIAR), Australia and CGIAR Research Programme on Grain Legumes and Dryland Cereals (CRP-GLDC), Hyderabad, India. Other collaborators were the Department of Agriculture (DOA), Thailand and Biotech Consortium of India Limited (BCIL), Delhi, India.

The objectives of this Regional Expert Consultation were to provide a platform to develop networking and sustainable partnership between public-public, public-private and private-private sectors for knowledge sharing on experiences and best practices, to harness the potential of agricultural biotechnology for improving livelihoods of farmers in the Asia Pacific Region (APR) and scoping for funding and partnership at regional level. Accordingly, experts and participants were invited to deliberate to: (i) explore initiatives and mechanisms of sustainable partnership and networking for capacity and institutional building, developing regulatory framework, communication strategies, enabling policies for application of biotechnologies including bioprospecting of bioresources at regional level; (ii) share technical knowledge, experiences and learn lessons from public-public, public-private, and private-private partnership to accelerate the application of agricultural biotechnologies and establish the mechanisms to ensure continued exchange of information on experiences with agricultural biotechnologies; (iii) identify important areas of agricultural biotechnologies and scoping the new and innovative ways of making investments to improve the livelihoods of farmers in APR.

In all, 64 participants from 21 countries (Australia, Bangladesh, Bhutan, China, Fiji, India, Iran, Italy, Lao PDR, Malaysia, Myanmar, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Sri Lanka, Taiwan, Thailand, USA, Vietnam) participated in the meeting. The participants comprised senior officials, researchers from National Agricultural Research Systems (NARS), Consultative Group on International Agriculture Research (CGIAR) Centers, experts on biotechnology, representatives of research institutions, donors, private sector and NGOs.

The meeting was structured to include inaugural, technical (5) and plenary sessions, besides a World Café Discussion. The technical sessions comprised - (i) Partnership and Investment in Agricultural Biotechnology (8 speakers); (ii) Public-Private Partnership in Agricultural Biotechnology (9 speakers); (iii) Country Status Reports on Agricultural Biotechnology (14 countries); (iv) World Café Discussion (6 groups) (v) Panel Discussion on Partnerships and Innovative Funding Mechanisms for Priority Areas in agricultural biotechnology to achieve SDGs (9 Panellists).

The deliberations held during the meeting brought forth many important issues that need immediate attention, and participants gave several suggestions and recommendations. It was unanimously agreed that application of agricultural biotechnology has tremendous potential to contribute significantly towards achieving the sustainable development goals (SDGs) on ending hunger, poverty alleviation, good health and well-being, besides attaining sustainable production and consumption, climate change and sustainable use of ecosystems.

Salient recommendations that emerged for **Priority Research Areas** included development of climate resilient and/or stress tolerant crops, livestock and fish using conventional and high-tech biotechnological approaches such as gene editing technologies, genetic engineering, marker assisted breeding, phenomics and genomics for trait and gene discovery. Problems of new and emerging pests can be addressed by development of rapid, cost-effective diagnostics, information systems for early warning and pest-risk analysis. Enhancing productivity and use of under-utilized plants, less-utilized aquatic bioresources (algae, marine organisms); molecular characterization/MAS breeding, especially for under-utilized plants in the Pacific Countries and South-East Asia was also suggested. Development of protocols and commercialization of plant tissue culture for micropropagation, quality planting material, certification and conservation was emphasized. Innovations in areas of biofertilizer, biofuel, biopesticides and integrated pest management, bioprospecting, nutrigenomics and phytogenics was subscribed. Conservation and sustainable use of bioresources using biotechnological tools of tissue culture, cryopreservation and molecular biology was also recommended.

For **Capacity Development**, mapping of existing capacity (human resource, projects, technology, products etc.) is required for the APR, as a baseline for subsequent partnership and networking. Both technical and soft skills training (long- and short-term) are required using inter-disciplinary approach; however, given the diversity in the APR, regional learning routes as well region-specific capacity enhancement would be desirable. Capacities are also required to create robust impact pathways, prepare logical frameworks, measure indicators, from research to extension, policy, and impact on farmers. Functional capacity development is required to build awareness among policy makers, media and the public on benefits of biotechnologies, as also advocate for higher investment and resources in biotechnology by governments/international community. Integration of biotechnology and functional skill development in the curricula of higher education was also recommended.

In case of **Infrastructure Development and Investment**, tissue culture and other low-tech biotechnology infrastructure are needed for all countries; for high- tech biotechnology, demand-driven support for infrastructure development is required. Soft infrastructure (e.g. how to overcome patent issues, alignment of regulatory processes) is also required which can be adopted in partnership mode. Bionexus may be created wherein institutes/companies allow use of their facilities by any agency for sharing purposes, through collaborations. Technology business incubators which act as innovation centres can be developed, as exemplified by models in Taiwan, Iran and Thailand. Investment in research needs to be linked with national agriculture plan, which will require biotechnology plans and clear business models. Several mechanisms for investment in agri-biotechnology research, product development and marketing emerged, including PPP model. Promotion of biotechnology actions consistent with science-based key principles leading to trade promotion consistent with international obligations on trade challenges, was subscribed.

In the context of **Public Awareness**, various concepts and advantages of the products of low-tech and high-tech biotechnology need to be explained using all media platform in simple, non-technical and regional languages with authenticity and clarity so that all stakeholders (policymakers, politicians, farmers, journalists, students, religious scholars/clerks and general public) can effectively understand to avoid any mis-trust or mis-information. Biotechnologists should be vocal and interactive when there is criticism or negative message or mis-information spread in the media and masses, so that the position is clarified with scientific evidence-based information before harm is done to either producers or end users. Public awareness needs to be linked to consumer perspective, to enable informed choice to use or avoid any biotechnology product. APAARI and other organizations e.g. ISAAA can play an important role in public awareness by sharing of experiences, best practices and success stories across various communities, countries and regions.

For **Policy Advocacy** linking farmers and research, and bridging their gap need to be addressed on priority, to achieve the goals of zero hunger, poverty alleviation and climate change issues. Also, there is a need to separate smallholder farmers who need support, semi-entrepreneurs supplying to cities, and those that drive country GDP export. These three categories have different needs, and 'one policy fits all' cannot be applied. Enabling dynamic research policy to develop a biotech product is the most

important activity. Biotechnologies need to be perceived as a component of value chains and advocacy for improved investment is required. Instead of grouping countries based on geography in APR, categories may be defined based on status and specific issues related to agricultural biotechnology policies.

Finally, for **Possible Partnerships**, it was recommended to build partnerships and networking of groups and institutions to work on select key issues, deliverables and budget, by identifying areas of upstream and downstream research in agri-biotech for South-South Cooperation (SSC). Models of effective Public-Private Partnership (PPP) may be adopted, which benefit small and marginal farmers by providing good seeds/planting at affordable costs or take care of specific needs of consumers needs. Mechanisms for partnerships may include greater involvement of private sector and brokering of partnerships by agencies (e.g. APAARI, USAID, ICGEB) to facilitate sharing of experiences and lessons learnt on PPP, commercialization of biotechnology and innovations including licensing, IPR issues, royalties. Partnerships should be promoted to use latest technologies (high throughput sequencing/re-sequencing to identify candidate genes, marker detection, omics, CRISPR/cas9-mediated genome editing, microbiome and big data analytics) enhancing stakeholder capacities to further improve rice productivity and other dryland crops, and conservation of bioresources and sustainable use. FAO, in association with APAARI, may create a 'Knowledge Platform' on agricultural biotechnologies, promote PPP and SSC for agricultural biotechnologies and improve technology transfer.

Specific recommendations and action points for APAARI in collaboration with NARS partners, and other relevant organizations in the region that emerged included: (i) mapping the needs in agricultural biotechnology and expertise; (ii) development of focused capacity building modules directed to all levels of stakeholders including for policy makers; (iii) development of biotechnology policy briefs particularly for biotechnology beginners and for organic-oriented countries, in association with member countries; (iv) promote better understanding of regulatory architecture, study impact assessment to dispel negative effects of agri-biotech and bring out publications relevant to share experiences to promote SSC; (v) technical and professional assistance be extended to the member countries for follow-up meetings, based on request to promote agricultural biotechnology; (vi) facilitate workshop/meetings to promote partnerships/networks with private sector and related to international funding opportunities for promoting agricultural biotechnology in the region; (vii) facilitate studies on impact assessment of successful technologies and document the same to promote use of agricultural biotechnologies to contribute in achieving SDGs in the APR.

Background and Objectives

In addition to an increase in the proportion of the world's population that suffers from chronic hunger, the number of under-nourished people on the planet has also increased from 804 million in 2016 to 821 million in 2017 (SOFI, 2018). It is worth recording that Asia-Pacific Region (APR) as a whole not only met the Millennium Development Goals (MDGs) target of halving the proportion of people suffering from hunger, but also was the region with the largest reduction in the number of undernourished people in the world. Nevertheless, 12% of the region's population still remains hungry and there continues to be large disparities among sub-regions and countries in this regard (FAO, 2016). A world without hunger will be a challenging task by 2030 as committed under Sustainable Development Goals (SDGs), a resolution adopted by United Nations in 2015. However, this challenge is not impossible and can be met by appropriate and rational usage of available resources and science-led innovations and technology including the wide range of agricultural biotechnology. The Food and Agriculture Organization (FAO) of the United Nations organized an International Symposium on "The Role of Agricultural Biotechnologies in Sustainable Food Systems and Nutrition", on Feb. 15-17, 2016, at Rome. The Director General of FAO underlined a statement during his welcome address to the above symposium - "We must count on a broad portfolio of tools and approaches to eradicate hunger, fight every form of malnutrition and achieve sustainable agriculture in the context of climate change". He further added "We cannot lose sight of the fact that biotechnology, knowledge and innovation must be available, accessible and applicable to family farmers. Otherwise, they will have a limited impact" (FAO, 2016a,b). Thus, agricultural biotechnology will continue to play a significant role to achieve 'zero hunger' (SDG 2). To achieve any goal, strengthening partnerships at the global and regional level are equally important for sustainable development (SDG 17).

Biotechnological products and processes have been widely used in increasing agricultural production worldwide, especially in developed countries. The changes in socio-economic scenario have brought forth new demands for the transformation of the region's agriculture through new technologies and innovations. Besides, 18 million farmers are using Genetically Modified (GM) crops, which is a sub-set of about 90% small farmers, according to FAO definition (FAO, 2016a). Safety concerns of Genetically Modified Organisms (GMOs) have monopolized the debate world over. However, biotechnology is not to be considered as GMOs only, but is much more beyond GMOs. Agricultural biotechnology can be seen as a central component in necessary technological leap helping not only agricultural production but also overall economic growth, wherein technological exchange and partnership between countries play an important role. In the past, biotechnology has brought promising prospects of a worldwide growth in agriculture sector. As a field of great importance to the whole of society, which could change the pattern of future industry and economy, biotechnology has been drawing increasing attention from every country of the world, so is the case of Asia and the Pacific. Out of 570 million farms in 161 countries, 70% share of farms belong to APR with 84% farm size of <2 ha (Lowder et al., 2016). Many applications of agricultural biotechnology need to be adopted in APR to improve the livelihoods of smallholder farmers. Several solutions from low-tech (tissue culture, biofertilizers, biopesticides, fermentation, artificial insemination, etc.) to high-tech (DNA-based methodologies including genomics and gene editing) agricultural biotechnologies have a great promise to enhance the production and productivity to ensure the sustainable food and nutritional security in the region.

Biotechnology requires a large initial investment in what is traditionally referred to as basic research. An understanding of the basics of biological process is pre-requisite to use the tools of biotechnology. Therefore, basic research questions are often a necessary component of resolving agricultural problems using biotechnology. As technology and basic knowledge advance, a regulatory system to be able to adapt to assess and manage the risks due to new biotechnology products needs to be put in

place; this demands more research and developing new expertise and capacities. A committed research funding is required to address the risk analyses on the future biotechnology products. Generally, investments in agricultural biotechnology are foreseen from the national point of view to attain the food security measures at national level through contribution of generated innovations and technologies. At regional level also, to some extent, it is guided by domestic and foreign agricultural biotechnology community to generate and adopt new technologies for the farmers by making investments in areas of biotechnology. In the changed new era, be it low-tech or high-tech biotechnology, political, economic and business considerations (particularly return on investment) will also play an important role for taking the decisions for future investments. Asia-Pacific region has a few countries, which can make large investments over a long period, although many countries are resource poor in the region. Keeping the whole region in view, it is imperative to have partnerships and collaborations to move upward on the trajectory. It also includes the pooling of resources in order to not only generate and adopt the innovations created through biotechnology but to develop the research and training institutions in form of 'Centre of Excellence' to conduct research and develop the capacities in various areas of agricultural biotechnology. This will help to harness the maximum potential of benefits to the farming community through application of biotechnology in the different farming systems. In fact, both funding and institutions are the foundation for progress in biotechnology. These two factors nurture and shape the development of new knowledge, the training of scientists, and the implementation of technical innovations.

As tools of biotechnology are adapted to solve the problems of agriculture, new demands will be placed on the existing arrangement of research institutions. Similarly, biotechnology also will influence patterns of funding for research and training and may alter the established pathways between research discoveries and applications. The pace at which biotechnology is applied to agriculture depends on how rapidly the R&D system can incorporate these changes for harnessing the full potential of agricultural biotechnology for benefiting the farming communities.

Public-Private Partnership (PPP) is considered very vital and is being advocated all over the world for successful transformation to a new economy through use of innovations and technologies in farming sector. Foundations (ITAD, 2013 and McKnight Foundation, 2018) have played a significant role for supporting the innovative science programs in order to maximize their potential for having substantial influence of biotechnological tools in important areas of agriculture including bioprospecting of bioresources. Where public sector funding in agricultural biotechnology is essential, the role of private sector in investing in agricultural biotechnology is equally important. Generally, private sector invests in agriculture only if their investments are profitable; and that in turn requires investment in a wide range of public goods. The private sector's traditional emphasis on product development may not likely to change, even though there has been a dramatic increase since 1980 in private sector investment in high-risk basic research in agricultural biotechnology. Because public sector investment provides skilled manpower and the knowledge base for innovation, industry should act as an advocate for publicly supported training and research programs in agricultural biotechnology. Industry is also required to support biotechnology research through direct grants and contracts to organizations, cooperative agreements with laboratories at regional level, and education and communication strategies to inform the general public about the impacts of agricultural biotechnology.

In view of the above, it was considered appropriate to organize a Regional Expert Consultation to provide a platform to develop networking and sustainable partnership between public and private sector for knowledge sharing on experiences and best practices, and AR4D collaboration to harness the potential of agricultural biotechnology in the region and develop a roadmap for funding and partnership at regional level. Accordingly, experts and participants were invited to include researchers, representatives of various NARS organization (public sector) and private sector, CG centre, advanced research institutes, funding/ donor agencies, Civil Society Organization (CSO), Non-Government Organization (NGO) and Farmers' Organization (FO) for the Regional Consultation. Specific objectives of the Regional Expert Consultation were:

1. To provide a platform to explore initiatives and mechanisms of sustainable partnership and networking for capacity and institutional building, developing regulatory framework, communication strategies, enabling policies for application of biotechnologies including bioprospecting of bioresources at regional level;
2. To share technical knowledge, experiences and learn lessons from public-public, public-private, and private-private partnership to accelerate the application of agricultural biotechnologies and establish the mechanisms to ensure continued exchange of information on experiences with agricultural biotechnologies;
3. To identify important areas of agricultural biotechnologies and scoping the new and innovative ways of making investments to improve the livelihoods of farmers in Asia-Pacific region.

Opening Session

The **'Regional Expert Consultation on Agricultural Biotechnology-Scoping Partnerships to Improve livelihoods of Farmers in Asia and The Pacific'** began with a warm welcome extended to all the delegates by **Ravi Khetarpal**, Executive Secretary, APAARI, Bangkok, Thailand. While introducing the topic of the meeting, he also briefly gave an overview on the role and achievements of APAARI. He emphasized that the key words of deliberations during the meeting should be on scoping partnerships in biotechnology for benefit of farmers' livelihood. The three pillars of food security, biosecurity and trade facilitation require partnership. He said that gathering resources and PPP were important issues. It was hoped that the collective wisdom of the participants would result in high level policy brief. He placed on record his gratitude to all the sponsoring organizations and members of APAARI, for their help in organizing the consultation meeting.

Siriporn Boonchoo, Deputy Director General, Department of Agriculture (DOA), Thailand, said that biotechnology industry has been thriving in Thailand for several decades. She informed that biotechnology was being used in crop improvement to increase productivity, for pests and disease resistance, to meet emerging industrial demands and adaption to changing climatic conditions. In the case of livestock, genetic development is needed to generate more productive and faster-growing farm animals, higher yields of healthy offspring, etc. There is also interest in value-added bioindustry project that would turn economic crop into high volume product (bioenergy e.g. ethanol and biomass power), utilizing farm wastes as inputs for other industries. She informed that there are four main government agencies involved in the regulation of agricultural biotechnology. These are the (i) Department of Agriculture, Ministry of Agriculture & Cooperatives; (ii) National Centre of Genetic Engineering and Biotechnology, Ministry of Science and Technology; (iii) Ministry of Natural Resources and Environment, and (iv) Ministry of Public Health. In addition, the National Bureau of Agricultural Commodity and Food Standard under the Ministry of Agriculture and Cooperatives, help the Thai government in negotiating all sanitary and phytosanitary issues in international and national organizations such as food security, food safety, and Genetically Engineered (GE) products. She concluded by thanking APAARI and APAARI community for convening this timely expert consultation and expected the outcome to benefit the farmers in the APR.

Andrew Alford, Research Program Manager, Australian Centre for International Agricultural Research (ACIAR), Australia, at the outset apologized on behalf of Daniel Walker, Chief Scientist, ACIAR, who could not attend the meeting due to other commitments. He said that ACIAR has a long history of supporting APAARI as a knowledge forum bringing together NARS, international and regional institutes, higher educational institute representatives, and increasingly engaging the private sector, which was appreciated. He said ACIAR was pleased to support APAARI in programs such on S&T including agricultural research, APCoAB, as exemplified in this meeting. The role of APAARI is very fitting for thinking about biotechnology, which requires strong partnerships between research institutions and the governments; thinking about the complexities involved with high-tech biotechnologies, including GMOs. Also, the important linkage between public and private sector, which has strength of the intellectual property (IP) as well as markets. He said that this meeting would bring together technologies to impact the farmers in the APR, which is also the mandate of ACIAR.

Rajeev K. Varshney, Research Program Director, Genetic Gains & Director, Center of Excellence in Genomics and Systems Biology, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), India, in his opening remarks gave a brief overview about ICRISAT and the Consortium Research Project on Grain Legumes and Dryland Cereals (CRP-GLDC), both of which he was representing. He informed that both ICRISAT and CRP-GLDC strongly believed in partnership for agricultural biotechnology. ICRISAT,

a global CGIAR institute, which has its headquarter in Hyderabad, India has regional operations in seven countries. ICRISAT leads the global CGIAR program on CRP-GLDC. This second phase of CRP combines the lessons learned from three phase 1 CRPs: Dryland Cereals, Grain Legumes, and Dryland Systems. CRP-GLDC is a Research for Development investment of US$ 413 million over five years (2018-2022), of which USD 150 million have been amassed as yet. The goal is to increase productivity, profitability, resilience and marketability of critical and nutritious grain legumes and cereal crops in the semi-arid and sub-humid dryland ecologies of Sub-Saharan Africa and South Asia. These agro-ecologies are where poverty, malnutrition, climate change and soil degradation among the most acute problems, globally. CRP-GLDC works on nine crops, namely, cowpea, pigeonpea, chickpea, lentil, soybean, groundnut, sorghum, pearl millet and finger millet. CRP-GLDC has 13 priority countries in Africa and Asia. The expected outcomes of the CRP-GLDC include that by 2022 and 2030 adapted varieties would reach 1.7 million farm households, help 4.4 to 11.2 million people to exit poverty, and 12.7 to 24.8 million people will be able to meet daily nutrition needs from this investment. It is also expected that 50% of beneficiaries from this group would be women. CRP-GLDC is partnering with International Institute of Tropical Agriculture (IITA), International Centre for Agricultural Research in the Dry Areas (ICARDA) and the International Council for Research in Agro-Forestry (ICRAF) as Tier I partners and with International Livestock Research Institute (ILRI), International Water Management Institute (IWMI) and Bioversity International and as Tier II partners. In terms of partnership with other organizations, strong partnership exists with ICAR, India, APAARI, SAARC in Asia and similar fora in Africa. He concluded that the topic of this meeting was shared with ICRISAT, and it is expected to lead to not only regional but also global partnerships.

Trilochan Mohapatra, Secretary, Department of Agricultural Research & Education (DARE) & Director General, Indian Council of Agricultural Research (ICAR), India, while giving his remarks said that the topic chosen for this consultation was very timely. Challenges are many and these are common in APR and elsewhere in the globe. The changes due to climate and its impact are very much visible. In Asia particularly, population is growing at a very fast pace, and demands of population are diversified. The food needs have also changed during the last 20 years. The pressure on environment and ecology is also tremendous. The footprints that we leave because of agriculture in the environment are tremendous. We need to reduce water and carbon footprints and more carbon needs to be sequestered in the soil, so that soil productivity can be as good as it was 50 years ago. Given these challenges, we need to work together. Joining hands is far more relevant today because challenges are far more formidable. He cited an excellent example of partnership in biotechnology to tackle the issue of climate change and delivering a viable product. India produced a rice mega-variety by the name 'Swarna' more than 20 years ago. Rice in India is grown in 44 million ha and 'Swarna' occupies >5 million ha. However, it is susceptible to complete submergence. India also identified one flood tolerant line FR13A, which tolerates more than 15 days submergence. Both these lines were taken to International Rice Research Institute (IRRI), Philippines, where Indian scientists also worked. Through conventional breeding the gene on FR13A was mapped, and mobilized to 'Swarna'. After transfer the derived line was re-tested in multiple locations under complete submergence and released for commercial cultivation in India as 'Swarna Sub 1', which is also being cultivated in Bangladesh. The genetic gain derived out of this partnership has been actually harvested by different countries, in different varieties suitable to other countries in Asia and the Pacific. Partnership is very crucial to succeed in the area of biotechnology, including high and low end biotechnology, big data analytics is very crucial to achieve success. More investment, exchange of expertise, knowledge, sharing of information are crucial for success. New developments like GM crops (particularly in case of food crops) are not yet accepted by general public in this region. Alternatives or new technologies like gene editing (using CRISPR-Cas9) has emerged as a powerful way to meet the requirements. The expertise available in the APR or elsewhere can be utilized through partnership to harvest the benefit and power of the technology. He reposed confidence in the fact that another revolution could be brought out by using newer tools and techniques. When there is partnership, the investment requirement gets minimized. Also because of the exchange that happens, the bioresources can be tapped very effectively for discovering new genes. The information flow itself without mobilizing germplasm can be extremely useful. He said that he was sure that this forum provided by APAARI and APCoAB would go a long way to bring together partnership to provide solutions to long standing problems in the region.

Yusuf Zafar, Chairman, APAARI, Thailand, and Chairman, Pakistan Agricultural Research Council (PARC), Pakistan, welcomed and thanked all the participants on behalf of APAARI and its team. He informed that the genesis of this meeting was from the fact that since 1980s when biotechnology had become the buzzword in the globe, and considered as one of the growth engines for the socio-economic development of any nation, along with Information

and Communication Technology (ICT), technology that emerged in the preceding 20 years. Hence, biotechnology was considered as a panacea that would resolve many issues, which remained unsolved in the first green revolution or by conventional technologies. So all countries and regions, including APR, invested heavily in biotechnology, in their respective countries, using their own natural resources, as also through international partners. As funding was limited, major chunk was taken by biotechnologists. A reasonably good infrastructure and capacity was established in many countries like India, Bangladesh, Pakistan, etc. However, later on it was realized that unlike green revolution, agri-biotechnology poses several challenges. First was issues with IPR, and technology was not freely available. Second was the very extensive biosafety issues that require elaborate and expensive studies for several years, for the environment, organism, microbes, soil, human health etc. The international community tried to address this issue through the Cartagena Protocol on Biosafety, which was signed and ratified by many countries. Today in the international scenario, especially in APR, there are only eight countries who have released one or two GM crops or products in the environment. For example, Bt cotton in India and Pakistan, Bt brinjal in Bangladesh, Bt maize in Philippines. There are a few examples and we need to learn from these. Hence, the idea in the present meeting is that country representatives would present their work and this knowledge would be used to make it more effective and efficient so that earlier investment can be harnessed for socio-economic development. It is expected that out of this workshop, major countries who have already invested in this sector would facilitate in learning from each other (in terms of hurdles, way forward). He said that a joint session with the private sector was also possible, as the private sector is the major player, being the one that has made the progress so far on a global level. The International Centre of Genetic Engineering and biotechnology (ICGEB), a multi-lateral organization (>68 member countries), has the objective to make available access to technology to the third world. But so far, only capacity building has been done. The path whereby earlier and future investment can be better utilized for the socio-economic development. Technologies cannot be made for only discovery and publications *per se*, but policy makers and planners would always ask about 'impact on society'. Agribiotech is facing many challenges, and Yusuf Zafar called for a serious discussion in the present consultation to yield a good blueprint for developing the next meeting in 2019 involving all the major public and private sector players.

The inaugural address was delivered by **Chung-Hsiu Hung**, Director General, Department of International Affairs, Council of Agriculture (COA), Taiwan. While thanking the organizers for the opportunity, he elaborated on the importance of agricultural industry in the region and the current challenges faced. These challenges include food security, limited resources, rural-urban divide, preventing spread of diseases and pests, climate change, which make the situation more severe. As already projected, by 2050 world population is expected to reach 9.7 billion, which would require 70% more production than the present. The security of food supply would be at risk, if we continue to use traditional agriculture production and management methods. In addition, change in the environment and global warming could cause negative impact on the agriculture sector. Hence, the challenge is how to change the situation. APAARI has been playing a key role in strengthening agri-food research and innovation system in the APR; it provides not only cooperation amongst members on this emerging technology, but also the facilities and expertise required to provide innovative solutions to the stakeholders. We believe that investment in agricultural research and innovation is the key to sustainable future. Taiwan, like many other APAARI members, has been damaged by natural disasters such as typhoon, earthquakes, floods etc. In order to cope up with these severe challenges, the Taiwan government launched new agricultural innovation promotion program last year. This program has three major policy themes – (i) set up a new agricultural paradigm, (ii) enhance agricultural security system and (iii) modernize marketing capacity. The ultimate goal is to reverse the subsidy policy in the past, so that the existing resources could be utilized with increased efficiency. The COA, Taiwan, became member of APAARI in 1999 and the government has been supporting APCoAB for the past nine years, which has contributed significantly to agricultural biotechnology development. He said that his government was looking forward to cooperation with APAARI, and assured their full support for mutual benefit of APAARI members. He concluded by saying that the goal of the consultation meeting is to address all the key issues related to agri-biotechnology, and it is crucial for all to share viewpoints to come up with practical solutions and action plan.

After the inaugural address, two recent publications of APAARI were released on the occasion by Chair of the Session, **Chung-Hsiu Hung**. These comprised the 'Proceedings and Recommendations' and the 'Thematic, Strategic Papers and Country Status Reports' of 'Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific' organized by APAARI from Nov. 13-15, 2017 (Tyagi *et al*., 2018 and 2018a). This was followed by a formal vote of thanks, proposed by **Rishi K. Tyagi**, Coordinator, APCoAB, APAARI, Thailand.

Technical Session I

Partnership and Investment in Agricultural Biotechnology

Co-Chairs	**Chung-Hsiu Hung**, COA, Taiwan and **Trilochan Mohapatra**, ICAR, India
Rapporteurs	**K.S. Varaprasad**, Ex-ICAR, India and **Martina Spisiakova**, APAARI, Thailand

The first session consisted of eight presentations, including one through skype, on a wide range of topics related to partnership and investment in agricultural biotechnology.

Andrew Alford (ACIAR, Australia), made a presentation on "*ACIAR for Promoting Partnership and Investment in Agri-biotechnology in Asia-Pacific*". He elaborated on how ACIAR engages in partnership and investment in biotechnology, informing that ACIAR has 36 partner countries in Pacific, South East Asia, South Asia and African countries, with a budget of 120 million AUD. As a partnership broker, ACIAR comissions international partnerships and research collaborations that are not only productive and long-term, but also responsive to partner country priorities by building trust and being transparent, leading to a better understanding of partners that benefits all parties. To face the challenges of increasing food production, malnutrition and climate change, transformational changes are needed in food production systems, agricultural value chains and post-harvest loss and wastage. Research, therefore, needs to embrace a wide range of 'blue sky' and on-farm adaptation options and value chains. ACIAR recognises appropriate use of biotechnologies (including genetic engineering) as tools for improved global food security and reducing the environmental footprint. Accordingly, ACIAR has established a biotechnology policy (ACIAR, 2014) that addresses requests of partner countries, develops agreements to collaborate based on priority areas, seeks approvals of policymakers, regulatory authorities and research partners, and ensures biosafety, regulatory and enforcement systems for the use of GMOs in keeping with laws and regulations in Australia and the partner countries. Andrew provided examples of successful international partnerships mediated by ACIAR that involved biotechnological interventions. These included cotton (public institutions and multinational seed companies), grouper aquaculture (Vietnam, Philippines and Australia), international mungbean improvement network (Myanmar, India, Bangladesh, Australia and World Vegetable Centre, Taiwan) and cocoa improvement (Indonesia and South Pacific). Andrew concluded by emphasising that for ACIAR, rather than viewing biotechnology as a 'silver bullet', research projects and partnerships need to be anchored in projects/programs that deliver impact for smallholders and communities.

Rhodora R. Aldemita (ISAAA, Philippines) spoke on "*Current Status and Long-term Investments in Agricultural Biotechnology for Sustainable Development in Asia-Pacific*". She presented an overview on the data on global area under crop varieties developed through biotechnology, highlighting the significant positive socio-economic and environmental impacts of the global adoption of biotechnology in agriculture. Global hectarage of biotech crops has increased ~110-fold from 1.7 million ha in 1996 to 185.1 million ha in 2016 – this makes biotech crops the fastest adopted crop technology in recent times. These biotech crops have been grown in 26 countries (19 developing and 7 industrial), with developing nations having 54% area (99.6 million ha) compared to 46% (85.5 million ha) for industrial countries. From 1996-2016, biotech crops provided $186.1 billion in economic gains to some 17 million farmers. In 2016, USA led biotech crop planting (72.9 million ha), followed by Brazil (49.1 million ha), Argentina (23.8 million ha), Canada (11.6 million ha) and India (10.8 million ha). The four major biotech crops: soybean, maize, cotton and canola, in decreasing

area, were the most adopted crops with 78% of soybean, 64% of cotton, 26% of maize and 24% of canola being biotech in 2016. Biotech crops planted in the 8 countries of Asia and the Pacific ranged from fiber (cotton), feed (maize and canola) and food (maize and eggplant).

Sachin Chaturvedi (RIS, India), gave a presentation over Skype on "*Agricultural Biotechnology for South-South Cooperation*". He began with the issue of redefining the term "South" *vs* "North" in the present economic growth of nations. Foreign aid from the North is not automatically the best instrument for redistribution of income; rather route to success is through control of primary natural resources as well for unconditional and efficient aid delivery. He said that South is no more a mute spectator - China and Korea are spending more on R&D than most of the developed countries in terms of per cent of GDP. In agricultural R&D at least 10 countries in the South are working on CRISPR/Genome Editing. The public sector R&D in agriculture is still strong in many countries including Brazil, South Africa, China and India and some of these countries are engaged in cooperation with countries in Africa. The issue is more of building synergies that would propel SSC in agri-biotech than capacity *per se*. He opined that a strategy is needed to evaluate the technological strength in South in agri-biotech and identify how SSC can be developed in agri-biotech. Ideas like Technology Bank, Patent Pooling and Clearing Houses for SSC in agri-biotech can be explored. Promotion of joint research in frontier areas in non-GM technologies such as CRISPR, Marker Assisted Selection (MAS), gene editing, whole genome sequence mapping of important crops was required. He subscribed to the use of open innovation (open source, data and hardware) to promote SSC in agri-biotechnology, as exemplified by FAO's "Agrisource", a free online platform for climate-smart agriculture. Governance of technology calls for cooperation in responding to rapidly advancing technologies in biosciences. Governing CRISPR is becoming a challenge. Instead of looking at North, Southern nations can develop a framework that can be more suitable to them and that provides flexibility. The North took the lead in GM regulation through Organization for Economic Cooperation and Development (OECD) and despite differences they built up the scientific basis for regulation. South should do it for post-GM and genomics based agri-biotech through SSC by forming working groups and inter-agency collaboration, to develop regulation and governance that is more suited to South. To begin with at least in regional grouping or in groupings like India, Brazil, South Africa (IBSA) or Brazil, South Africa, India and China (BASIC), the scope for SSC should be discussed. RIS research shows that in bio-pharma, SSC worked well as countries had a good understanding of their capacities and roles. In agri-biotech, a similar approach can be adopted by identifying immediate or relevant needs in applications and services, e.g. joint development of genome edited crops for enhancing food security. He suggested that it would be beneficial to identify the scope for SSC in agri-biotech, do a SWOT analysis of current SSC in agriculture and select two or three key issues/ themes to work with a time frame, deliverables and budget. This may be done by developing synergies and combining available technological prowess in different disciplines, identifying areas for upstream and downstream research and building a network of groups and institutions that would work on the identified themes/issues.

Amgalan Ariunbold (FAO-RAP, Thailand), made her presentation on "*FAO's Role in Agricultural Biotechnology*". She gave an overview on the organizational set up and objectives of FAO, with special reference to its role in promoting agricultural biotechnology. FAO considers agri-biotechnology as an essential option in providing solutions to existing food challenges. These biotechnologies range from low-tech approaches involving biofertilizers, artificial insemination in livestock, polyploidy in farmed fish; 'medium-tech' involving PCR tools or DNA marker-assisted selection in crops, livestock, forestry or aquaculture, embryo transfer in livestock, tissue culture in crops and trees; and 'high-tech' involving gene editing, genome sequencing, genetic engineering, and cloning of livestock. As FAO is a big network of 194 members present in over 130 countries, it has been promoting biotechnology by providing a neutral forum to discuss policy and technical issues, providing legal and technical advice, developing capacities and providing access to high quality, balanced and science-based information. The term "agricultural biotechnologies", therefore, covers a broad range of technologies used in food and agriculture. Recently FAO carried out a study entitled 'The State of Application, Capacities and the Enabling Environment for Agricultural Biotechnologies in the Asia-Pacific Region (2017), in 43 APR countries. The results demonstrated that although agricultural biotechnologies are well-entrenched and expanding in the APR, significant differences (from very low, low, medium, high to very high use) existed among countries in their application in all four agricultural sectors - crops, livestock, fisheries

and forestry. Gaps in capacity, technology adoption, human resources and policy measures emerged as the key concerns. A knowledge platform on agri-biotechnologies needs to be created to address this, as also promoting public-private partnership and South-South Cooperation and technology transfer in the Pacific needs to be improved.

David E. Johnson (IRRI, Philippines) gave a presentation on "*Role of Biotechnology in Improving Productivity for Rice Producers in Asia from IRRI's Perspective*". He elaborated the constraints in rice production (e.g. salinity, submergence and drought) and the challenge of raising productivity in the unfavorable rice environments for which biotechnological interventions were being extensively applied. About 116 million tons of additional rice is needed by 2035 to feed the growing population (5 million tons every year). It is only possible to produce this amount with additional partnerships. He informed how rice genetic resources were targets for improvement for traits like nutrition, stress tolerance, yield and pest resistance. The IRRI bioinformatics team has three main activity areas- (1) Big Data-driven activities for analysis and solutions development (i.e. sequence and genotype databases, computational methods, software), (2) Scientific collaborations with genetic/physiology/ breeder teams for allele mining and candidate gene discoveries, and (3) Coordination of the International Rice Informatics Consortium (IRIC). He highlighted SNP-Seek as their high-impact output, a web application developed by IRRI team that enables visualization and allele mining of genome variants discovered from ~5,000 combined rice entries from the 3k Rice Genomics and High Density Rice Arrays (HDRA) projects. IRRI breeders and geneticists routinely use SNP-Seek to discover rice entries (in the diversity collection) with allele variants for their QTLs/genes of interest, and also discover new genome variants that may be associated to target phenotypes/traits of interest. Another thrust is creation of novel genetic resource using MAGIC lines as reference population in rice array and for trait discovery. Another important area is development of Fe- and Zn-fortified rice by co-expressing bean ferritin and rice nicotianamine synthase in rice var. IR64 under field conditions. Gene discovery for abiotic stress tolerance (drought and salinity) is also being undertaken in partnership mode. New areas of biotech research at IRRI include high throughput sequencing, marker detection and Omics, CRISPR/Cas9-mediated genome editing, environmental biotechnology (pest/ pathogen life-cycle and population analysis) and Big Data bioinformatics and Omics based models for candidate genes.

Rajeev Varshney (ICRISAT, India), presented his talk on "*Advances in Genomics Research and Molecular Breeding in Dryland Crops through Partnership for Achieving Food and Nutritional Security*". Dryland crops are essential for food and nutritional security. ICRISAT has a strong record of developing and delivering demand-driven innovations to smallholder farmers in the dryland areas of India for over 43 years, and in future, there is need for integrated farm research to support sustainable intensification for Indian dryland agriculture. He opined that several important traits such as yield under drought, heat stress, biotic stresses and nutritional traits can be addressed through genomics approaches. As many genome sequences are already available, re-sequencing, genome-wide association analysis and functional genomics approaches can identify candidate genes. He emphasized the integration of genomics with germplasm management, phenotyping and breeding was equally important. Since this is a challenging exercise, ICRISAT established the Center of Excellence in Genomics that recently added the 'Systems Biology' element to its title. In the last decade, ICRISAT has led international sequencing consortium to sequence genomes of pigeonpea, chickpea and pearl millet, besides co-leading genome sequencing in groundnut, mungbean, sesame and adzuki bean. This has resulted in development of several molecular breeding products. He said that molecular breeding can help enhancing yield/crop productivity to enhance crop production/per capita consumption and for this strong partnership is essential for developing high quality products in less time and less resources.

Russell Nicely (US Embassy, Thailand) made a presentation on "*Agricultural Biotechnology in 21st Century – USDA's Perspective*". He gave an overview of the U.S. agencies and government partners that work on biotechnology issues, including regulatory agencies [Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and USDA's Animal and Plant Health Inspection Service (APHIS)]. The Foreign Agricultural Service (FAS), a sister agency of APHIS, is the primary trade agency of USDA (in 2016, U.S. Agricultural exports were valued at USD 134 billion). Other agencies that have an interest in agricultural biotechnology are the Agricultural Research Service (ARS) and National Institute of Food and Agriculture (NIFA), Agriculture Marketing Services (AMS), Economic Research Services (ERS), United States Agency for

International Development (USAID) etc. The USDA supports the safe and appropriate use of science and technology, including biotechnology, to help meet agricultural challenges and consumer needs. The main role is to assure that plant and plant products derived from biotechnology techniques are safe to be grown and used in the USA and once these plant and plant products enter commerce, USDA supports bringing these and other products to the world marketplace. This is to ensure environmental safety, human and animal health safety; promote innovation while addressing protection goals, and cost of regulation should be justified. The USDA regulates plants and products developed through genetic engineering (foreign DNA inserted through *Agrobacterium* or gene guns, as was the case for most commercially available GE crops in the past). However, plants/products, which have been developed through New Plant Breeding Techniques (NPBTs) and innovations such as genome editing, CRISPR-Cas9, TALEN, Zinc Finger Nucleases (ZFN), etc. under the Plant Protection Act (PPA regulations for GE organisms that are or have the potential to be plant pests are codified at 7 CFR part 340. On March 28, 2018, US Secretary of Agriculture announced a clarification on the USDA's regulatory policy for new innovations in plant breeding. It did not change the existing regulation, rather, it clarified how existing USDA policy under 7 CFR Part 340 ("Am I Regulated") applied to plant breeding innovations such as genome editing (deletions, single base pair substitutions, insertions from compatible plant relatives, complete null segregants) as long as the modified plants are developed without the use of a plant pest as the donor or vector agent and the plant species is not itself a plant pest (Plant Protection Act definition of plant pest excludes all plants except parasitic plants such as dodder, witchweed, etc.). Examples of plants made with these new technologies especially gene editing excluded from regulation are: (i) Soybean with higher oleic acid (May 2015) - TALEN deletion to *fatty acid desaturase 2* (*fad2*) gene; (ii) Non-browning white button mushroom (April 2016) - used CRISPR-Cas to generate small deletions between 1 and 14 base pairs long, resulting in knock out of one of six polyphenol oxidase genes (that's an enzyme that causes browning), reducing the enzyme's activity by 30%; (iii) Waxy corn (DuPont Pioneer – April 2016) - CRISPR-Cas used to create a deletion in the *waxy* gene, causing its inactivation. While normal corn kernels contain 75% amylopectin and 25% amylose, waxy corn kernels contain over 97% amylopectin, essentially eliminating amylose from the kernel. As amylopectin is more soluble than amylose, making starch from waxy corn a better choice for paper adhesives and food thickeners; (iv) CRISPR to create soybean with drought and salt tolerance (Oct 2017) - climate change adaptation.

Cherdsak Virapat (NACA, Thailand) spoke on "*National Broodstock Improvement Network (NBIN)*". The Network of Aquaculture Centres in Asia-Pacific (NACA) is an inter-governmental organization that promotes rural development through sustainable aquaculture and aquatic resources management. It is formulated into a network and partnership to assist member governments (19 at present) to implement action programmes, to share knowledge, technologies and responsibilities among institutions in the APR for improving the livelihoods of rural people, reduce poverty and increase food security and for solving many common problems that the countries of the region face in modernizing and expanding aquaculture. Together the network produces >90% global aquaculture production and about 50% of global food fish supplies. Cherdsak informed that although biotechnology has been applied in few cases, examples include use of HPLC to inspect shrimp products for antibiotic residues of local shrimp farms in Thailand meant for export to USA and Japan; PCR screening of broodstock, shrimp larvae and monitoring for acute hepatopancreatic necrosis disease for shrimp hatcheries and grow out farms. However, there exists a larger number of missing biotechnologies in aquaculture that allows aquaculture to adapt biologically to new and diverse farming systems, environments and consumer groups. Conspicuously missing biotechnology in aquaculture includes techniques for exchanging germplasm without risking disease, techniques for easily and cheaply identifying aquaculture "breeds" and their genetic quality and origin, techniques in lieu of pedigree for inbreeding control breed associations modeled on those for cattle, swine, dogs, horses, ornamental fish, pigeons etc. Thus, NACA has proposed NBIN, which is a strategy consisting of partially interconnected but independently evolving broodstocks. The NBIN aquaculture genetic exchange network strategy is complementary to, but very different from, a traditional "Nuclear Breeding Centre" strategy that has a single, centralized breeding program and one or very few separate gene pools. The NBIN aquaculture genetic exchange network is a network of aquaculture gene pools, not a network of institutions, meant for exchanging genetic material (germplasm including broodstock, eggs, sperm and perhaps nuclei) as well as information about gene pools.

Key Discussion Points

(Discussants: Ravi Khetarpal, S.K. Shukla, Zongwen Zhang, Siriporn Boonchoo, B.S. Dhillon and Yemi Akinbamijo)

Although, many advances have been made on GM crops, the gap between farmers and research remains high. Linking farmers and research, and bridging this gap need to be addressed on priority.

Similarly, learning and advancement that biotechnology science brought to Asian development, has not been the same in Africa. For more than 30 years, agricultural biotechnologies have been discussed in Africa with little progress. What is required are institutional measures, larger network of academic institutions, as well as entrepreneurs to come forward. Discussions are currently taking place on how BRICS can help Africa absorb new technologies through education and research.

The fruits of agricultural biotechnology should be targeted towards the needs of smallholder farmers.

Much progress has been made in agricultural biotechnology in APR, but this progress as well as national government support, varies from country to country. For example, India has a plethora of biotechnology products and Government of India is recognizing about 150 biotech companies with established biotechnology plants. But in other countries, such as Bhutan, these companies are not available. A knowledge platform needs to be established that could facilitate establishment of a regional network (laboratories in different regions) and a quality management system. It is also important not just addressing technologies *per se*, but also related policies. Guidelines are needed to improve the understanding of agri-biotechnologies and address the needs of different countries that work together to promote technology use among farmers and other end users. Partnership is required to produce guidelines for policy makers to enhance regional efforts.

It was opined that conservation of aquatic genetic resources is a difficult task that cannot be done alone by any nation. The roles of inter-governmental agencies like NACA and WorldFish were discussed. NACA has a number of country offices, including in India, Iran, Thailand and Philippines, that are available to provide country support. Similarly, NASI is a network for aquaculture in central Europe based in Hungary. Genetic resources programmes are part these agencies, which have networking amongst them.

The right approach for APAARI on SSC in agri-biotechnologies was discussed at length. Most agri-biotechnologies are being promoted by agencies in the North. APAARI is playing an important role in promoting this topic in APR. APAARI needs to focus on three important areas: (i) promote better understanding on regulatory architecture; (ii) facilitate impact assessment (not just on GM alone) through an inter-disciplinary approach and by bringing APR and Africa together in this exercise; and (iii) share experiences by looking at how significant issues are being addressed.

The role of FAO in PPP and SSC in agricultural biotechnology was discussed in the background that it needs to be neutral. A South Asia knowledge platform is being established, which requires public-private organizations to work together, including regional fora.

The working mode of ICRISAT with multiple partners was appreciated as it gives a clear message about good partnership management. Similarly, other stakeholders need to keenly assess the kind of partners needed for different areas (such as extension and research), as per individual requirements. Partnerships can only be built when you tell the partner about the value of proposed partnership. If we talk about value chains, lack of partnership creates the breaking of the value chain.

Many countries in APR are challenged by different country policies. APAARI should be playing an important role in preparing a policy brief with recommendations and approach sub-regional institutions, such as Asia-Pacific Economic Cooperation (APEC), Association of Southeast Asian Nations (ASEAN), for endorsement to mainstream biotechnology policy.

Bangladesh and India used to work together on the development of Bt brinjal. However, Bangladesh has gone forward in cultivation, while India has not. The issue seems to be a matter of public perception and policy-making choices rather than research issue. More pragmatic approach is, therefore, required in terms of moving forward on GM crops in India. One important dimension is building public confidence in biotech crops, especially through effective communication, especially mass media.

Technical Session II

Public-Private Partnership in Agricultural Biotechnology

Co-Chairs	**Yusuf Zafar**, APAARI, Thailand and **Siriporn Boonchoo**, DOA, Thailand
Rapporteurs	**Anuradha Agrawal**, NBPGR, India and **Martina Spisiakova**, APAARI, Thailand

A total of nine presentations by experts from Taiwan, Bangladesh, Philippines, Fiji, Italy, USA, Singapore, Malaysia, and China were made during this session.

Su-San Chang (PABP, COA, Taiwan), made a presentation on "*Agricultural Biotechnology Park in Public-Private Partnership*". She enumerated the progress made at Pingtung Agricultural Biotechnology Park (PABP), the incubation base of Taiwan agri-enterprises and agricultural cluster. The objective of PABP is to foster technology-intensive, high value-added, environment-friendly industry, to propel export of agricultural products and bring together academia and agro-enterprises. PABP integrates over 30 colleges/research institutes (over 300 experts) to offer tailor-made academia-industry cooperation projects. This PPP offers adequate consultancy and assistance for agri-enterprises in accordance with their needs at different stages. It promotes sustainability and building up agricultural circular economy by integrating the local industrial chain, encouraging smart production, precision agriculture, adopting biomedical technology to increase added value and competitiveness and linking nearby academia to establish an agri-biotech industry in Taiwan.

Md. Rafiqul Islam Mondal (BARI, Bangladesh), gave a presentation on "*Success of Bt Brinjal in Bangladesh*". Brinjal is a very important source of nutrition and income for poor people. Through, the Agricultural Biotechnological Support Project-II programme (BARI-Cornell University, 2005-13), biotechnology access, research support, higher training and study visit for Bangladeshi scientists were provided in the areas of tissue culture, embryo management, micropropagation and somaclonal variation. In 2005, it introduced hybridization of nine Bangladesh brinjal cultivars with Bt brinjal candidate variety at Mahyco and F_1 seeds were collected and back crossing programe was initiated at Mahyco, India (150-250% increase in yield); 4 varieties were released in October 2013. Consequently, the number of Bt brinjal growing farmers increased from 20 in 2014 to 7,500 in 2018 as they understood that Bt brinjal is profitable due to no infestation of shoot and fruit borer insect, thereby, decreased use of insecticides, and reduced the cost of production. Importantly, farmers could keep their own seeds for next season because they are not hybrids. The success story of Bt brinjal in Bangladesh was also depicted through a short video film. Rafiqul said that from the experience of Bt brinjal in Bangladesh, it can be suggested that the biotechnological tools can be successfully utilized in solving many biotic and abiotic problems of crop production. International development partners should come forward to support this type of research initiatives in the developing countries.

Reynaldo V. Ebora (PCAARRD, Philippines), spoke on "*Success of GM Maize in Philippines*". This includes research, extension, capacity development, and sustained communication initiatives through outreach and media engagement. MON 810, the first GM Maize approved (efficacy testing in 1997; Limited confined field testing in 1999; multi-location testing in 2001; large scale propagation for food or feed in 2002 by Bureau of Plant Industry). In March 2016, an area of 656,084 ha were under this variety. The use of GM maize has a statistically significant net-income increasing effect of PhP 4,300/ha. This was the first approval in Asia of a GM crop for food and feed and high adoption rates of GM maize resulted in benefits at the farm and macro level. Reynaldo opined that there is a need for capacity building for agencies currently involved in the evaluation of GM crop applications. A need for policy formulation fora

to cover new requirements under Joint Department Circular 1-2016 (JDC 1) *vis-á-vis* Bt brinjal along with awareness building for stakeholders about JDC 1. He also said there is a need for farmers' and traders' voices to be heard in national discourse, for sustained scientific outreach to legislative and judicial branches of the government and for discussions on gene editing/new breeding techniques.

Jan Helsen (SPC, Fiji), gave a presentation on "*Investing in Agricultural Biotechnologies - Striving for an Effective Broad Stakeholder Alliance in the Pacific*". He informed that the Secretariat of Pacific Community (SPC) was the principal scientific and technical organization supporting development in the Pacific Region with the objectives of sustainable economic development for empowered and resilient communities to ensure that they live long and healthy lives. This was being achieved by applying an integrated approach through sustainable agriculture, sustainable forests, value chains and genetic resources. The Land Resources Division (LRD) is one of the SPC's 10 Programs that provides scientific advice and services for land, agriculture and forestry development issues, utilizing latest innovations and applications. LRD's key stakeholders are regional government departments that deal with land, agriculture, forestry, biosecurity and trade facilitation; smallholder farmers and farming communities; and the donor community. The Centre for Pacific Crops and Trees (CePact) is a globally recognized SPC Centre of Excellence that aims to assist Pacific Island Countries and Territories (PICTs) to conserve the region's genetic resources, and to provide access to the diversity, when they need it. Presently, CepACT requires funding for core genebank operations, core collective needs, collection, outreach and partnerships to develop Quality Management System (QMS) and Standard Operation Procedures (SOPs). Activities that make an immediate and critical contribution to the global system of conservation and use (capacity building, partnership projects, impact assessment and communication of impact) were required, as exemplified with ACIAR and Coconut Genetic Resources for Enhanced Livelihoods (COGENT) in New Caledonia and French Polynesia. There is need to develop an effective Pacific Seed System (Pacific Seeds for Life) with the availability of and access to quality and quantity of healthy and Climate Smart Crops. Jan spelt out the strategic partnerships to facilitate achieving SPC's goal. He said that LRD should be part of and steering an umbrella alliance (SPC-FAO) and ACIAR could partner to strengthen LRDs operational/management capacities. University of South Pacific, Samoa and National Agricultural Research Institute-Papua New Guinea (NARI-PNG) could provide SSC for learning and impact. Partnerships for deepening research for purpose capacity could be with Landcare, Agresearch, CGIAR and APAARI and for existing Communities of Practice, COGENT, Darwin Initiative, ACIAR, Department of Foreign Affairs and Trade (DFAT) and Crop Trust were good options. SPC would greatly benefit in research for development alliance with FAO, The Asian and Pacific Coconut Community (APCC), International Fund for Agricultural Development (IFAD) and APAARI. Thus, SPC could be incubator for diversified partnerships (ACIAR, APAARI, APCC, Commonwealth Agricultural Beureaux International (CABI), CGIAR, FAO, International Atomic Energy Agency (IAEA), DFAT, Crop Trust etc.) to provide integrated solutions for integrated deliverables.

Martina Viviani (ICGEB, Italy), gave a talk on "*Leveraging Funds for Basic Research in Agricultural Biotechnology: ICGEB's Experience*". She informed that International Centre for Genetic Engineering and Biotechnology (ICGEB) is an intergovernmental organization, developed under a special project of UNIDO, as a Centre of Excellence for research, training and technology transfer to industry in the field of biotechnology to promote sustainable global development. With 64 Member States and more than 20 signatory countries, the ICGEB forms an interactive network of internationally recognized scientists and state-of-the-art laboratories located in Trieste (Italy), New Delhi (India) and Cape Town (South Africa). These research centres are the instruments of action with cutting edge scientific research, advanced education, financial support to meetings, courses, and workshops at the international level. Genetic engineering of plants, development of eco-friendly biofertilizers, and other agricultural biotechnologies, together with molecular studies on the resistance of plants to biotic and abiotic stresses, are among the main research topics, which are undertaken by staff, and pre- and post-doctoral researchers. Every year, calls for advanced education are announced by ICGEB. Competitive research grants for scientists in member countries (one call per year), including early career return grants are also sought. Advanced education supported by long- and short-term fellowships for PhD students/post-docs and competitive research grants for scientists in Member Countries, including Early Career Return Grants, are offered. ICGEB also facilitates organization of meetings, courses and workshops at the international level. There is also provision of technology transfer to industry (e.g. production of biotherapeutics and diagnostics) and biosafety knowledge dissemination, including

technical assistance and capacity enhancement in the regulation of biotechnology and its products. She concluded by stating that the collaboration with the ICGEB may be an asset for its Member States, which can have access to advanced research techniques, enhance human capital, funds projects aligned to the specific needs of the country and connect scientists from its Members in a truly international network of researchers. The quality of a proposal is essential to succeed in the fund-raising challenge, for which training early career scientists in grant-writing and a properly established fund-raising office are important. To secure returns, it is crucial to have measures in place to protect and to transfer know-how and IP.

Tracy Powell (USAID, USA), made a presentation on "*Feed the Future Grant and Partnership Programs in Biotechnology for Agricultural Development".* She gave an overview on what is agricultural biotechnology and how does it fit into the context of the U.S. government's investments in global food security. 'Feed the Future (FtF)' is the effort to sustainably reduce global hunger, malnutrition and poverty through agriculture-led economic growth, strengthened resilience among people and systems, and a well-nourished population. She elaborated the current investments of US Government in agricultural biotechnology, including key examples like Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CESAIN). It helps coordinate ongoing USAID-funded agriculture projects, amplifies and disseminates research results, builds capacity of faculty and students, and partners with private sector to develop agri-business entrepreneurs and experts. She provided briefly, guidance on where to find information about new funding opportunities, upcoming areas of interest. She said that the role of NARS and opportunities for partnership would vary with the crop; handover to private sector may occur at early or late stage of development process (or not at all) who may be able to subsidize public-sector actions in key areas through various models. She provided an overview about New Funding Opportunities (NFO) and Potential Funding Opportunities (PFO) of the FtF available for grants (https://www.grants.gov/) or for contracts (https://www.fbo.gov/). She also informed about Seeding Labs, a membership-based company in Boston, USA, which helps talented scientists in developing countries conduct life-changing research by ensuring that they have access to the right resources including equipment, training and colleagues worldwide (https://seedinglabs.org/).

Sianghee Tan (CLA, Singapore), spoke on "*Challenges in Globalization of Agricultural Biotechnology – Private Sector's Perspective*". He eloquently presented the dilemma of the plant science industry, with traditional farmers using low-tech methods of cultivation on one hand and informed educated consumers on the other end. He elaborated the areas in which CropLife Asia (CLA) may have collaborative activities with APAARI, comprising communications, capacity building, policy formulation supportive of plant breeding innovations and knowledge awareness or information dissemination (expert consultations/meetings/conferences; trainings/workshops; database; and publications). He said that CLA was keen to extend support to APCoAB on co-organizing a technical seminar on Plant Breeding Innovations and by having capacity building on biotech research stewardship *via* 'Excellence through Stewardship'. He also outlined plans on partnering with APAARI to achieve the phytosanitary harmonization in the region to facilitate seed movement, strengthen networks with the National Plant Protection Organizations (NPPOs) in setting up targets for the international movement of seeds and harmonization of policy measures in the APR.

Kamarudin Md Isa (Department of Veterinary Services, Malaysia), presented a talk on "*Investments in Livestock Biotechnology and Scoping Partnership*". He presented an overview of livestock industry situation and practices in Malaysia. Livestock Biotechnology (LB) initiatives were identified in there major sectors - poultry, ruminant and Edible Bird's Nest (EBN) production. He identified LB areas for further development and application, expected to improve farmers' income in a sustainable livestock environment. Collaboration of international agencies with local agencies or companies is expected to increase the number of biotechnological products and enhances efficiency of livestock production in Malaysia and APR. Accordingly, he proposed possible collaborators and partnership in the areas of research, product development and utilization.

Zongwen Zhang (Bioversity International, China) made a presentation on "*Building-up the Partnership for Using Biotechnological Tools for Sustainable Utilization of Bioresources – Role of Bioversity International*". He elaborated the importance of bioresources and the causes for their loss. He said that biotechnology is a powerful tool that can play an important role in conservation and sustainable use of bioresources, particularly plant genetic resources. Bioversity is an international research organization on agricultural biodiversity, a member

of CGIAR, mandated to deliver scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security. Bioversity has played effective role in use of biotechnology in genetic resources management, particularly in developing technologies and tools for *in vitro* conservation, genotypic characterization, and establishment of global platform for banana genetic resources. It has also contributed in capacity building in biotechnology, including using molecular tools. It is suggested to develop stronger partnerships with national programmes for effective management of bioresources for sustainable development.

Key Discussion Points

(Discussants: Yusuf Zafar, Ravi Khetarpal, B.S. Dhillon, Su-San Chang, Tracy Powell, Siriporn Boochoo and Wen-Chin Yang)

The PPP model of PABP, Taiwan was discussed in detail in terms of pros and cons. The infrastructure was established by the government (USD 400 million) while its revenue comes from small and medium size enterprises, as well as bigger companies renting the Park with the total area of 233 ha. Private companies need to be involved for scaling up and commercialization to develop the industry. The government provides the enabling environment and efficient administration services and collecting the fees (rent, amenities and management fee). This money goes to the operational fund that is used for maintenance of the park. The Park is run by Taiwan central government and directly supervised by the Council of Agriculture (COA) which is the competent authority on the agricultural, forestry, fishery, animal husbandry and food affairs in Taiwan. Although, the exact figures of revenue were not available, and small as yet, the Park represents a cluster that is bringing the transformation in the agriculture sector and value to sustainable development.

The issue of whether PPP benefits small and marginal farmers, and the best model to provide good seeds/planting material to farmers was debated. The example of Known-You Seed Co. Ltd., Taiwan, was discussed, which has been a business model for success, producing the best seeds that are also affordable. Such experiences need to be publicized in the government or high level policy makers. However, based on India's experience of Bt cotton, it was opined that distinctions need to be made between foreign and domestic companies. About 80% of farmers in India are smallholder farmers and the price of Bt cotton is very high for most of them. Much more profit goes to seed companies than to farmers. There is a need to separate smallholder farmers who need support, semi-entrepreneurs supplying to cities, and those that drive country GDP export. These three categories have different needs, and 'one policy fits all', cannot be applied.

There was consensus that the media had an important role in generating opinion and acceptance about agri-products developed using cutting edge biotechnologies. For instance, GM insect-resistant Bt cotton was introduced commercially in Burkina Faso in 2008, to replace the bollworm susceptible indigenous but good quality (high fibre length) varieties. However, after the first few years of commercialization of Bt cotton, some undesirable characteristics of the fibre, particularly its length, were noted: the Bt cotton had produced shorter fibre lengths and lower cotton fibre efficiency than conventional cotton. As a result, cotton companies from Burkina Faso began to lose international markets because of the poorer lint quality. Media stepped in and they pulled the product. In 2015, some seven years after Bt cotton was first cultivated commercially in Burkina Faso, a decision was made to return to conventional cotton and that no GM cotton would be grown in the 2016/17 growing season. For Burkina Faso's cotton growers, GM ended up as a trade-off between quantity and quality.

The PPP model is important for not only growers but also consumers. For instance, a Japanese company (Kitoku Shinryo) has invested in producing reduced-protein rice (lowered to 8% of original) using vegetable lactic acid bacteria fermentation technology. People suffering from renal failure and other kidney disorders need to limit their daily protein intake, and the protein content of staple foods such as rice can be a major concern for those with a protein-restricted diet. This reduced-protein rice can replace ordinary rice in a low-protein diet, has superior taste, with a natural flavour and firm texture.

It was generally agreed that a single agri-biotech policy was not possible, but would depend on commodity, market and technology available. Licensing tools, how to structure licensing needs to be looked into. Restrictions can also be introduced in commercialization.

Technical Session III

Country Status Reports on Agricultural Biotechnology

Co-Chairs	**M. Roff Bin Mohd Noor**, MARDI, Malaysia and **Rajeev Varshney**, ICRISAT, India
Rapporteurs	**K.S. Varaprasad**, Ex-ICAR, India and **Geraldine Nemrod**, APAARI, Thailand

A total of 14 country reports were presented from South and West Asia (Bangladesh, Bhutan, India, Iran, Sri Lanka and Pakistan), South-East Asia (Lao PDR, Malaysia, Philippines, Taiwan, Thailand and Vietnam), and The Pacific (PNG and Samoa). Nepal report could not be presented due to absence of the speaker. Detailed country reports have been published as a separate document. However, a brief summary of each country report is presented in following sections.

South and West Asia

Bangladesh country report was presented by **Md Harunur Rashid** (BARC, Bangladesh). The programme on plant biotechnology in Bangladesh was initiated in late 1970s in the Department of Botany, Dhaka University with tissue culture of jute, and within a span of 10-12 years, tissue culture research laboratories were established throughout the country. Bangladesh Livestock Research Institute (BLRI) and Bangladesh Agricultural University (BAU) have already initiated modern biotechnology programmes. The techniques of genetic engineering are yet to start in the country for the improvement of plant, animal, and industrial microorganisms and also to combat environmental pollution problems etc. The total investment in agricultural biotechnology in the country is USD 0.07 million, while that in agricultural research *per se* is USD 88.29 million. Policies related to biotechnology are Biosafety Policy (2012), Bangladesh Biosafety Rules (2012) and Monitoring and Enforcement Manual for GMO. Some 8 NARS institutes are involved in biotechnology research (with > 60 scientists and 20 scientific staff), but with high variability in lab facilities among the research institutes. BARI released 4 brinjal varieties and research is in progress in golden rice and late blight resistant potato. Nevertheless, varying level of infrastructure and lab facilities for different organizations are yet required. Existing partnerships are well established with many international organizations in the crop sector. For fisheries partnership with any reputed Universities and Research Institutes around the world is welcome. In case of livestock, partnership can be sought with ILRI, and reputed Universities/ Institutes in the world. Bangladesh vision for agri-biotech includes improvement/optimization of tissue culture methods for better quality crops, disease-free seed, production of plantlets within short period of time; breeding of important crops such as rice, wheat, pulses, oil seeds through MAS; biotic and abiotic stress resistant transgenic plants; molecular characterization and preservation of microorganisms for maintaining genetic stability of plants; genome sequencing of important crops and forest plants for specific use; introduction, evaluation and testing of transgenic crops.

Bhutan country report was presented by **Wangda Dukpa** (DOA, Bhutan). The value of agriculture GDP in USD 107.97 million. The total investment in agriculture research is USD 75.44 million. Neither any specific policy nor investment is allocated for agricultural biotechnology research. The national strategies for R&D in various areas of agricultural biotechnology especially for agriculture (crop) sector include tissue culture, biofertilizers, biopesticides and Effective Microorganism (EM) technology. The Agricultural Research and Development Centre (ARDC), Yusipang, coordinates research on biofertilizers and biopesticides in collaboration with other ARDCs, National Plant Protection Centre

and National Soil Service Centre for establishment of biofertilizer manufacturing plants. The NSSC coordinates promotion of EM technology in collaboration with School Agriculture Program, ARDCs and Asia Pacific Natural Agriculture Network (APNAN). The National Seed Centre started tissue culture activity in 1984 under the national seed program, for fruit crops (banana, potato, kiwi, avocado and apple) ornamental plants, orchids and potato for their rapid multiplication and to produce disease-free planting materials. Future outlook on a short-term basis includes making available bioinputs in adequate quantity, creating awareness on organic agriculture for both producers and consumers, putting in place the necessary measures for incentivizing organic agriculture production and also incentivizing the private sector to start producing organic inputs in-country and strengthening capacity (technical and infrastructure) on tissue culture and EM. For medium- and long-term outlook, capacitating extension systems to respond to organic agriculture needs, bioinputs testing laboratory facilities, strengthen the laboratory and human resources capacity for bioprospecting program, and collaborative activity on bioprospecting between ARDCs under Department of Agriculture and Nuclear Breeding Centre (NBC), are some of the priorities.

India country report was presented by **Trilochan Mohapatra** (ICAR, India). India is an agriculture-based country with more than 18% of the total GDP arising from agriculture. Approximately USD 1,000 million is allocated for agricultural research, of which about 15.5% is for agricultural biotechnology research. The Government of India (GoI), announced the First National Biotechnology Development Strategy in September 2007 and in 2015, DBT, GoI announced "The National Biotechnology Development Strategy-2015-2020". Its sectorial priorities include human resource, building knowledge environment, research opportunities (human genome research, vaccines, infectious and chronic disease biology, stem cells and regenerative medicine, basic research, translational research, human developmental and disease biology-maternal and child health, bioengineering and biodesign), agriculture, animal health and productivity, medicinal and aromatic plants, food fortification and biofortification, bioprospecting, value-added biomass and products, marine biotechnology and biodiversity, environmental management, Clean bioenergy, nurturing entrepreneurship-IP landscaping, technology transfer, incubators, entrepreneurship, Small and Medium Enterprise (SME) support systems, biotechnology and society, and biotechnology cooperation. Major activities undertaken so far include (i) launch of four major missions in healthcare, food and nutrition, clean energy and education; (ii) creation of technology development and translation network across India with global partnership, including 5 new clusters, 40 biotech incubators, 150 Technology Transfer Organisations (TTOs), and 20 bio-connect centres; (iii) strategic and focused investment in building the human capital by setting up a Life Sciences and Biotechnology Education Council. Priority areas in agriculture biotechnology undertaken by different institutes of ICAR include transgenics, genomics and applied genomics for the development of varieties/breeds and related fundamental research. Since late 1980s, India established its policy and regulatory system for agri-biotech development, the first set being enactment of the Environment Protection Act of 1986 to ensure safety from the use of GMOs and products thereof. The policies have been quite effective to develop products related to agricultural biotechnology, their evaluation and release for commercial use. This only led to the development and release of Bt cotton. Policies for agriculture itself have to deal with a multitude of new and emerging issues, and decision making is further complicated by influential legal binding instruments negotiated globally, nationally and bi-nationally. Coordination between ministries and local governments is a key to success of developing and implementing policies. The proposed establishment of Biotechnology Regulatory Authority of India (BRAI) as an independent regulatory body will help in taking decisions for release of GMOs for commercial use, however, this is highly influenced by the law makers in the Parliament, Non-Government Organizations (NGOs) and media. BRAI can help in taking decisions on critical issues like Bt brinjal and taking efforts and investments to logical ends. The short-term plan for agricultural biotechnology is expected to bring all the GMOs available, to a logical end, bring a more transparent regulatory system and deploy the available gene(s) using MAS/MABC and release them for the benefit of resource poor farmers (Bt cotton being a successful example). For the medium- and long-term plan, there is need for significant funding, collaboration and focussed research to understand the mechanisms and gene function, their identification and cloning, and further use.

Iran country report was presented by **Fariborz Ehteshami** (AREEO, Iran). Iran considers modern biotechnology important to its social and economic development and thus issues relating to modern biotechnology are included in policies, plans and research activities. The total investment in agricultural

research is USD 0.42 billion, while that of agricultural biotechnology is about 50% i.e. USD 0.2 billion. Iran has experienced remarkable advances in the R&D of agricultural biotechnology during the last few decades. The Agricultural Research, Education and Extension Organization (AREEO) is an important national and regional player in agricultural science, technology and development, including biotechnology. The Ministry of Health of Iran declared GM rice as safe; work is in progress for the release of several domestically produced transgenic crop plants namely, insect-resistant and fungal disease-tolerant cotton plants (stacked genes), insect-resistant sugar beet, insect-resistant alfalfa, insect-resistant potato, herbicide-tolerant canola and rice. Attempts were also made to improve crop tolerance against abiotic stresses, mainly drought and salinity. Iran has not only produced GM crop plants, but is also producing transgenic animals (goats produced through genetic engineering for pharmaceuticals in their milk). Iran has set targets for biotechnology development, including becoming the regional leader in biotechnology and increasing its share of the global biotechnology market to 3% by 2025 from its present estimated share of around 0.62%. Iran has partnership with FAO, JAICA, APAARI, CGIAR (ICARDA, CIMMYT, IRRI, ICRISAT), International Society for Horticultural Science (ISHS), International Seed Testing Association (ISTA), Institute for Interdisciplinary Salivary Bioscience Research (IISBR), OECD and International Union of Forest Research Organizations (IUFRO). Scoping of new partnerships is desirable with WorldFish, International Centre for Tropical Agriculture (CIAT), International Water Management Institute (IWMI), The Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) and ILRI.

Sri Lanka country report was presented by **Frank Niranjan** (SLCARP, Sri Lanka). Sri Lankan agricultural sector broadly consists of six sub-sectors including non-plantation crops (rice, vegetable crops, fruit crops, and other field crops), plantation crops (tea, rubber, coconut, sugarcane, export agricultural crops, palmyrah and cashew), forestry, floriculture, livestock and poultry, fisheries and aquaculture. Total investment in agricultural research is about USD 8.27 million, and that in agricultural biotechnology research is USD 0.25 million. Several policy thrust areas have been identified by the National Policy on Biotechnology (NSF & NSTC, 2009). These include establishment of (i) an apex body National Biotechnology Council, (ii) innovative sustainable funding mechanism, (iii) an environment conducive to innovation, product development and commercialization and (iv) legislative reforms and compliances. Sri Lanka's national research priorities on agricultural biotechnology (2017-2021) has six thrust areas, namely, (i) germplasm conservation and characterization, (ii) genetic improvement, (iii) tissue culture and mass propagation; (iv) detection and identification of pathogens and pests, (v) biotechnological industrial application and (vi) genetic engineering. The major challenges in growth of biotechnology sector in Sri Lanka comprise lack of (a) adequate investment (equipments, chemicals, and facilities), (b) trained researchers and support staff, (c) central facilities for sequencing and genotyping, multidisciplinary approach, and weak PPP. There is urgent need to increase awareness about the importance of biotechnology and promote biotechnology-related industries and entrepreneurship and establishment of biotechnology parks to represent all six sectors in agriculture. Also urgent attention is needed for Sri Lanka to link with regional networks to increase the access to advanced biotechnological tools.

Nepal country report could not be presented due to absence of the speaker. However, it was submitted by **B.N. Mahto** (NARC, Nepal). Total investment on agricultural research is about USD 23.75 million and on agricultural biotechnology research is about USD 0.48 million. Nepal has identified six sectors for agricultural biotechnology i.e. (i) agriculture and food sector, (ii) animal science sector, (iii) animal health care sector, (iv) Industry sector, (v) environment and biodiversity sector, and (vi) human resources development sector. Under these sectors, priorities for low-tech and high-tech biotechnology have been identified. Applied agricultural biotechnology is the major focus areas of Nepal Agricultural Research Centre (NARC). Micropropagation and DNA technologies are the major subject of interest to develop profitable agriculture in Nepal. Some of specific focuses are on virus indexing on potato, large cardamom, banana, MAS on major cereals, vegetables and fruit species, genetic diversity assessment and DNA fingerprinting of indigenous crops, livestock, fishes, microorganisms and insects; banking of DNA and tissue, screening of germplasm against biotic and abiotic stresses; disease diagnosis; laboratory strengthening and manpower development. The National Policy on Biotechnology needs to be reviewed in consultation with other relevant ministries for updating, harmonization and standardization of the policy in line with the fast development in this field. Biotechnology has been considered to overcome the consequences of abiotic and biotic stresses, basically developing climate resilient varieties. Biotechnology can play significant role in food and nutrition security through increased agricultural

production, nutrition-dense production and diversified production by adopting new biotechnological tools. For this, there is need for the development of human resources and infrastructure. The country too needs to keep biotechnological research on the priority. Strong linkages and collaboration with national and international institutions are equally important for proper use of biotechnology in agricultural research and development. Bilateral and multilateral collaboration of the local R&D organizations with advanced laboratories of the world needs to be encouraged to gain access to cutting-edge research in this emerging field and for training, expert service and facility development in areas of national interest.

Pakistan country report was presented by **Muhammad Kamal Sheikh** (PARC, Pakistan). The country has made significant progress in development and usage of biotechnology, as Pakistan has grown GM cotton on 2.9 million ha, 7th in global ranking. Total investment in agricultural biotechnology research is USD 3.85 million, about half of USD 7.69 million budget allocated for agricultural research. Pakistan started working on modern biotechnology in the mid-1980s. Currently, there are more than 50 biotech centres/institutes in the country. However, only a few of them have appropriate physical facilities and well-trained manpower to develop GM crops. Pakistan Agricultural Research Council (PARC) is the apex agricultural R&D body in the country. Thirty-one Bt cotton varieties and three GM events have been approved for commercial cultivation, so far. A number of GM events in other crops are waiting for their commercial release. Most of the activities are focused on cotton among the major crops of Pakistan. Biotic (virus/bacterial/insect) and abiotic (salt, drought, cold) resistant genes have already been incorporated in some crop plants. Concerted and coordinated efforts based on biotechnology are being undertaken for improvement in the livestock sector as well. Almost 95% of the vaccines for large animals are produced locally in public sector institutes and only Foot and Mouth Disease (FMD) vaccine is currently imported. However, the coverage of these vaccines is fairly low. The FMD of cattle is causing heavy losses every year. Domestic poultry is also not fully vaccinated, however, all commercial poultry farms are 100 per cent vaccinated against the viral diseases. Fast track mechanism of regulatory processes for biotech crops on Brazil Model, enactment of Plant Breeder Rights Law, indigenous research and development on new generation technologies, adoption of adaptive research, formulation of national biotechnology policy, exploration of new technologies such as nano-biotechnology, innovative pest control strategies, embryo transfer, *in vitro* fertilization, sexing, cloning, and transgenesis, development of PPPs based on biotechnology interventions and development of National Genomic Database are suggested as future working areas on biotechnology in Pakistan.

Co-Chairs	**Gerry Jayawardena**, SLCARP, Sri Lanka and **B.S. Dhillon**, PAU, India
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **M. Kamal Sheikh**, PARC, Pakistan

South-East Asia

Lao PDR country report was presented by **Chay Bouphanousay** (NAFRI, Lao PDR). Agriculture is one of the most important economic sectors of Lao PDR and has played an important role in rehabilitating and stabilizing the national economy. Under the country's 8th National Social-Economic Development Plan (2016-2020), it is expected that agriculture sector grows at an average of 6.3%, accounting for 35.75% of the GDP by 2020. Presently, agricultural research investment is to the tune of USD 14.4 million, and allocation towards biotechnological research is USD 3.42 million. Some budget allocation for biotechnology research was done from the international projects. For example, in 2007, FAO with the support from the FAO Netherlands Partnership Programme (FNPP) and in collaboration with NAFRI carried out plant breeding and associated biotechnological survey in the country. Results of the survey indicated the urgent need for development of a national strategy for short- and medium-term human capacity building; increased allocation of resources for PGR utilization and increased international support to enhance the local breeding programmes by using modern biotechnological tools. Lao PDR initiated two biotechnology laboratories on tissue culture located at Agriculture Research Centre (ARC) and the Sciences Technology and Environment Agency (STEA) established in 1998 and 1999, respectively. These laboratories focus on tissue culture to produce

planting material of banana, potato, and some flowering plants. Collaboration between Lao PDR and IRRI started in 1987 and intensified, when the Swiss Agency for Development and Cooperation (SDC) supported the Lao PDR-IRRI Research and Training Project from 1990 to 2007. The project sought to improve and strengthen the country's rice research capacity and included research support, development, and training. IRRI's work in Lao PDR is currently supported by the International Fund for Agricultural Development, the Bill & Melinda Gates Foundation, ACIAR, and the Government of Japan. Further funding mechanisms need to be worked out based on the assessment study. Government of Lao PDR has expressed through different policy documents that conservation and utilization of genetic diversity is highly important to improve food security, alleviate poverty, and promote rural development. As current capacity (human and infrastructure) in biotechnology is very limited, there is urgent need for collaboration (e.g. APAARI, RDA of Korea) to address the gap.

Malaysia country report was presented by **M. Roff Bin Mohd Noor** (MARDI, Malaysia). He said that Malaysia, being a world leader in the production of several industrial crops, like oil palm, rubber, cocoa, pepper and tropical timber, coupled with its rich biodiversity and strong ICT infrastructure, is driving forward in its goal of biotechnology to improve the nation's food security and economic growth. The total investment in agricultural research was USD 37.38 million and that in agricultural biotechnology was USD 0.81 million. The key research areas for agriculture are agricultural genomics, tissue culture technology, livestock farming, animal health and nutrition, biopesticides and biofertilizers, extraction of metabolites and nutritionally enhanced agriculture products. The opportunities of biotechnology expanding in Malaysia are vast as it has conducive environment for biotechnology investors due to political stability coupled with its excellent infrastructure. The richly endowed diverse flora and fauna can potentially be developed into various value-added natural products. Malaysia also has its own policy with regard to biotechnology, namely, the National Biotechnology Policy, 2005 and also the Biosafety Act (2007). Malaysia has strong government support in terms of grants, incentives and establishing infrastructures and research institutions, which houses modern facilities and state-of-the-art equipment for biotechnology research. A comprehensive funding structure and financial incentives to the tune of RM 2 billion have been allocated under the Ninth Malaysia Plan for R&D and commercialization, strategic technology acquisition, business and entrepreneurship development as well as building of the requisite infrastructure. Thus, biotechnology in Malaysia offers a great opportunity in supporting and consolidating sustainable development in the sectors of agriculture, environment.

Philippines country report was presented by **Reynaldo V. Ebora** (PCAARRD, Philippines). He informed that Philippines started its biotechnology programmes in 1979 with the establishment of the National Institute of Molecular Biology and Biotechnology (BIOTECH) at the University of the Philippines, Los Banos (UPLB). Total investment in agricultural research is USD 335.93 million whereas investment in agricultural biotechnology is USD 4.96 million. The Philippines is the first ASEAN country to initiate a biotechnology regulatory system, which established the National Committee on Biosafety of the Philippines (NCBP) in 1990. The country's biosafety regulatory system follows strict scientific standards and has become a model for member-countries of the ASEAN seeking to become producers of agricultural biotechnology crops. The types of research undertaken in the Philippines from 1980 to 1999 were mainly related to conventional biotechnology. With the onset of Agriculture and Fisheries Modernization Act (AFMA) in 1997, modern biotechnology has been recognized as a major strategy to increase agricultural productivity. Priority areas for R&D in crop biotechnology are germplasm evaluation, conservation, utilization and management; varietal selection and improvement; and production of good quality planting materials. In livestock, it is on breed development and genetic improvement for meat, dairy, and draft; reproductive biotechniques, nutrition, feeds and feeding system. For aquaculture, disease diagnosis, conservation, utilization and management and improvement of broodstock are the priority areas. Biotechnology techniques are also used in biodiversity-related studies and conservation efforts. The country has strong PPP for biotechnology activities and a number of awareness campaigns have been conducted with ISAAA and Southeast Asian Regional Center for Graduate Study and Research in Agriculture – Biotechnology Information Center (SEARCA BIC) on the commercialization of biotechnologies. Collaborations with agencies outside of the country are also being continuously explored, in terms of program funding and use of technologies. The country is very open to pursue further collaborations with more traditional and non-traditional partners.

Taiwan country report was presented by **Ruey-long Chen** (COA, Taiwan). The island of Taiwan is a natural gateway to East Asia as it is strategically located in the middle of the chain of islands with a variety of land types, from the ocean to the mountains, and endowed with rich biodiversity. Even though, only one-quarter of the land is arable, the subtropical climate permits multi-cropping of rice and growing of fruits and vegetables all year round. Since 1999, application of biotechnology to agriculture has become a very critical issue to sustain the growth and development of the country. Currently, the investment in agricultural biotechnology research is USD 24.92 million, out of the total investment in agricultural research amounting to USD 143.59 million. In Taiwan agricultural biotechnology, which includes plant tissue culture, applied microbiology, and applied molecular biology, have been included in the key areas of research funded by the government. The Council of Agriculture (COA) is the competent authority on agriculture, forestry, fishery, animal husbandry and food affairs in Taiwan. Biotechnology and Pharmaceutical Industries Promotion Office, Ministry of Economic Affairs, acts as single contact window for domestic and international biomedical-related industries acting as one-stop window; promoting industrial investment and integration, assisting biotechnology, pharmaceutical, medical device industry development and upgrade. Taiwan's agricultural industry, with its high level of agricultural expertise resulting from a century of accumulated research and technical advances, is advancing toward a technology-intensive model characterized by academic-public-private collaboration with the support from Ministry of Foreign Affairs. Some of the government-backed successful technology developments include development of world's only fluorescent pink lionhead fish, cloned goats, banana-based pig vaccine, muscle building fish feed, new breed of *Oncidium* orchid, biogas power generation using animal effluent, tissue culture based orchid production, Cavendish banana with resistance to Fusarium wilt, biopesticides, transgenic rice, broccoli, potato, tomato, eucalyptus and papaya (resistant to *Papaya ring spot virus*). Chen advocated for more public communication and education, as also increased international cooperation in research or business aspects related to biotechnology products.

Thailand country report was presented by **Piyarat Thammakijawat** (DOA, Thailand). He informed that agriculture in Thailand is highly competitive, diversified and specialized, and its exports are very successful internationally. The total investment in agricultural biotechnology in the country is USD 10.28 million, while that in agricultural research *per se* is USD 541.8 million. The Government of Thailand has been aggressively promoting growth and fostering developments in biotechnology, in an effort to transform Thailand into the Center of Excellence for Biotechnology in Asia. Factors such as limited availability of agricultural land, water shortages, the low-yielding crops, and pest problems are being addressed by researchers to develop innovative agricultural technologies through extensive R&D activities. Thailand's biotechnology development will improve significantly if capital and financing mechanisms, along with limited IP management, standard system and regulations are improved. The country's emphasis is on application of core technologies, e.g. genomics, bioinformatics, plant and animal breeding by means of molecular markers to accelerate development in the priority areas of agriculture/food, medical care and environment protection, new knowledge creation for the development of higher value-added products, as well as for knowledge-based policy and strategic planning. In addition to being consistent with the national agenda and government policy directions, the national goals for biotechnology development are also derived from consideration to other dimensions. As per current national policies on agricultural biotechnology, neither any GE crops have been approved for cultivation or field trial nor does the country engage in the development or production of GE animals.

Vietnam country report was presented by **Pham Van Toan** (VAAS, Vietnam). He said that the Vietnamese agricultural sector identified biotechnology as a key strategic spearhead to deal with the problems of developing sustainable agriculture to ensure national food security and contribute to the world's food security. Currently, the investment in agricultural biotechnology research is USD 6.43 million out of the total investment in agricultural research amounting to USD 60.07 million. Biotechnology in Vietnam's agricultural sector has achieved significant success, which includes the application of gene technology in selecting varieties that have high yield and good quality and are resistant to diseases; technology in propagation of promising varieties in both crop and animal sectors; creating biological products such as biofertilizers and biopesticides, biomaterials in treating aquaculture environment etc. Recently (April 2017), a master plan for the bioindustry development up to 2030 was approved by the government, which aims to concentrate the resources on investment for

developing the bioindustries, renewing mechanisms and policies, taking advantage of international cooperation and support for creating favourable conditions for enterprises to invest in production of biotechnology products in the fields of agriculture, industry, medicine and environmental protection. The bioindustry enterprises in the agricultural sector will focus on production of plant varieties, animals and aquatic breeds, production of organic fertilizers, biofertilizer, biopesticide, bioinsecticides, bio-preparation used in environmental treatment, animal feeds, vaccines, biomedical to control animal and aquatic diseases and the biological products for food, feed preservation and processing as well as bioproducts for control of residues or prohibited substances in food and feed.

Co-Chairs	**Pham Van Toan**, VAAS, Vietnam and **K.S. Varaprasad**, Ex-ICAR, India
Rapporteurs	**Wangda Dukpa**, DOA, Bhutan and **Geraldine Nemrod**, APAARI, Thailand

The Pacific

Papua New Guinea report was presented by **Birte Komlong** (NARI, PNG). She informed that agriculture in PNG has a huge untapped potential for application of biotechnology, which needs to be explored through a multi-pronged strategy involving modern and improved agricultural technologies. PNG is a nation, rich in genetic resources. These resources provide unique opportunity not only for improving productivity but also for creating more desired diversity and using these for alternative purposes. However, without the application of some aspects of biotechnology, it is not possible to explore this opportunity and such potentially available benefits cannot be derived. Total investment in agricultural biotechnology research is about USD 0.06 million and that in agricultural research is USD 12.95 million. The NARI supports crop improvement initiatives at all stages, from laboratory research to field trials to commercialization and the delivery of technology. Importance of biotechnology policy is emphasized in order to enhance food and nutritional security by compiling the status of agricultural biotechnology highlighting PNG's specific needs. At present any funding that has been provided towards the development of policies in biotechnology has come from donors or external funding bodies. Departments in the PNG government are chronically under-funded and do not have the required level of technical expertise to progress with relevant policies on biotechnology and biosafety. Hence, there is no interest by the private sector to engage in discussions, dialogue or to engage in PPPs in the area of policy development in biotechnology and biosafety, as yet. PNG is yet to develop a significant capacity for developing and using agricultural biotechnology innovations and tools. Capacity development is required at all levels including the national policy level, the mainstreaming of agricultural biotechnology in secondary school and higher education curricula, the development of institutional strategies and mobilizing funding to support relevant research interventions. The country can be benefitted from increased collaborations and networking in this area with other countries in the APR.

Samoa report was presented by **Tolo Iosefa** (MoAF, Samoa). He mentioned that the Samoan islands nation is blessed with large area of arable lands suitable for agricultural development, but less fortunate as it has no known minerals or oil deposit. During the past 20 years, conventional participatory plant breeding approach, which involved the development of complementary regional and national breeding programmes, was adopted. The main objective was to provide Samoan taro growers the option of growing new improved taro varieties resistant to taro leaf blight disease through population breeding and mass recurrent selection. The country relies on exports for foreign exchange where fish and agriculture if combined, contributes more than 50% of the total export annually. Agricultural biotechnology in Samoa is almost non-existence and its utilization is very low. Tissue culture is the only agricultural biotechnology tool employed by the Ministry of Agriculture and Fisheries (MoAF) Crops Division for *in vitro* conservation and mass propagation of disease-free planting materials of selected commercial crops. There is no policy directly related or in place to support agricultural biotechnology in Samoa but there are regulations, ordinance, or biosafety legislation put in place by the MoAF to regulate highly toxic pesticides, chemicals and even GM products to prevent them from being introduced into the country. Agricultural research in Samoa is long way to go and APAARI is a platform to facilitate and coordinate short-term visit to several

national and organizations in Agricultural Research in Asia for short-term training and consultation on skill development, knowledge management, exchange and communication linking biotechnology in areas of agronomy, post-harvest, tissue culture and pest/ disease management.

Key Discussion Points

(Discussants: Tracy Powell, Yusuf Zafar, Ravi Khetarpal, B.S. Dhillon, Martina Viviani, Rishi K. Tyagi)

- It was opined that biotechnology research (especially recombinant DNA technology) has high potential, but normally does not pay immediately, rather gives results in the long-term. For example in India, investments have been increasing in biotechnology, but the returns are not commensurate, as yet. The reasons are that regulatory processes need to be addressed and also public perception is currently not in favour. Changing public perception will take time. Such limitations are to be addressed to get the benefits to the country. It may not accrue the benefit immediately but doesn't mean investment in research should be stopped, which would amount to going backwards.
- A strong consensus was developed on the need to develop partnerships for biotechnological research and application, and help each other in the process. Platforms, such as the present meeting, should be used effectively for greater enhancement in public perception. Faster progress with regards to release for GM crops in countries where public perceptions are against will take longer period.
- APAARI affirmed a strong commitment to work for Pacific region, in collaboration with organizations like ACIAR, IFAD, COA Taiwan etc. APAARI may plan to open a small sub-regional office in the Pacific to work efficiently in future.
- To promote and upscale tissue culture programme in the Pacific region, establishment and promotion of entrepreneurship in the countries was suggested, in view of developing local market although crop priority differs between countries. However, in view of the facts that PNG, Samoa and Fiji have rich genetic resources, India extended partnership in capacity building for *in vitro* conservation and cryopreservation. This can be done by providing on-site help to these areas, as well inviting the participants for training programs in India. ICRISAT also extended the offer in capacity building for both low-tech and high-tech biotechnology, and invited partnership proposals.
- The issue of *ad hoc* and short-term projects and sustainability of the activities after the project in the Pacific region was discussed. To this end, APAARI expressed their commitment in helping the Pacific region for medium-term projects, which could be extended and/or upgraded for long-term projects. However, countries from the Pacific region were requested to identify their requirements and extend their support in preparing the proposal.
- It is essential to increase international collaborations through training courses and research projects in agricultural biotechnology. As a result, new PhD, MSc, and short-term training programmes for scientists should be initiated; and training programmes for supporting staff at laboratories should also be arranged for capacity development. Infrastructure development also needs to be undertaken.

Technical Session IV

World Café Discussion on 'Priority Research Areas, Capacity and Infrastructure Development, Public Awareness and Policy Advocacy, and Possible Partnership'

The 'World Café Discussion' also known as 'Knowledge Café', is a structured conversational process for knowledge sharing in which groups of people discuss a topic at several tables, with individuals switching tables periodically and getting introduced to the previous discussion at their new table by a "table host". The discussion was held on five thematic areas, namely, (i) Priority Research Areas, (ii) Capacity and Infrastructure Development, (iii) Public Awareness (iv) Policy Advocacy and (v) Possible Partnerships. The discussion was coordinated by following:

Moderator: **Rishi Tyagi**, APAARI, Thailand			
	Theme	**Host**	**Facilitator**
i.	Priority Research Areas	**Anuradha Agrawal**, NBPGR, India	**Geraldine Nemrod**, APAARI, Thailand
ii.	Capacity and Infrastructure Development	**Martina Spisiakova**, APAARI, Thailand	**Celilu Bitong**, APAARI, Thailand
iii.	Public Awareness	**M. Kamal Sheikh**, PARC, Pakistan	**Fai Collins**, APAARI, Thailand
iv.	Policy Advocacy	**K.S. Varaprasad**, Ex-ICAR, India	**Tarathip Sanboonkrong**, APAARI, Thailand
v.	Possible Partnership	**Birte Komolong**, NARI, PNG	**V.K. Sah**, APAARI, Thailand

All the participants contributed in the discussions at various tables. The important discussion and recommendations that emerged were summarized in the Technical Session IV B, and are given briefly hereunder.

Co-Chairs	**Reynaldo V. Ebora**, PCAARRD, Philippines and **Jan Helsen**, SPC, Suva
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **Fai Collins**, APAARI, Thailand

1. Priority Research Areas

Using low-tech biotechnology, research needs to be prioritized for:

- Development of climate resilient crops, livestock and fish
- Development of rapid, cost-effective diagnostics for new and emerging pests
- Biotic and abiotic stress tolerant crops and livestock
- Cost-effective, farmer and eco-friendly technologies i.e. biofertilizers, biopesticides, biofuels and IPM, that give high returns to farmers
- Enhancing productivity and use of under-utilized plants, less-utilized aquatic bioresources (algae, marine organisms); molecular characterization/ MAS for breeding, especially for Under-Utilized Crops (UUC) (Pacific and South East Asian countries).
- Products and diagnostics for enhanced human health (non-communicable diseases, biomedical research)
- Plant tissue culture for micropropagation (including reduction in production cost), quality planting material, certification and conservation (South East Asia and Pacific countries)
- Bioprospecting (especially microbes), nutrigenomics and phytogenics (herbal plants)

Using high-tech biotechnology, research needs to be prioritized for:

- Gene editing technologies (e.g. CRISPR-Cas) to overcome constraints of GE crops (SE and SW Asia). GMOs for addressing abiotic and biotic stress, only where conventional or marker assisted breeding fails
- Phenomics and genomics for trait and gene discovery (SE and SW Asia)
- Responsive and rapid research for addressing emerging problems of pests (based on Big Data Analytics)
- Molecular characterization/MAS for breeding, especially for UUC (Pacific Countries and SE Asia)
- Overcoming antibiotic resistance in animals
- 'Precision Agriculture' (ICT/sensors) and 'Circular Agriculture', high value added processing to produce zero waste

2. Capacity and Infrastructure Development

It was agreed that technical, functional, institutional and individual capacity building was required since new technologies are rapidly evolving in the area of biotechnology. Further, different stakeholders as well as countries have different capacities and there is need for upgrading from low to high-tech biotechnology capacities. Capacity building is required for technical and soft skills training (long- and short-term) using inter-disciplinary approach (ICT, agri-machinery). There is also need for capacity development mapping e.g. manpower, kinds of projects, technology focus etc. Infrastructure development (laboratories) demand driven support is also required. Regional learning routes (e.g. Pacific learning from India on tissue culture) as well region specific capacity enhancement needs include: (i) Microbial formulation (biofertilizers and biopesticides), tissue culture, and gene editing technologies in South and West Asia; (ii) Germplasm management, micropropagation, molecular breeding and technology gene editing technologies in South East Asia; (iii) Tissue culture, DNA fingerprinting and gene editing technologies in the Pacific.

Functional capacity development is required to build awareness among policy makers, media and the public on benefits of biotechnologies (e.g. development of policy briefs, advocacy, communication), as also advocate for higher investment and resources in biotechnology by governments/international community. Capacities are also required to create robust impact pathways, prepare logical frameworks, measure indicators, from research to extension, policy, and impact on farmers. Integration of biotechnology and functional skill development (capacity to innovate, entrepreneurship, risk-taking, IP) in the curricula of higher education is another important domain for capacity development. Other areas include development of biosafety regulatory frameworks and Big Data Analytics (biometry, genomics).

Issues of infrastructure requirement are applicable across all the countries, although within regions, there are differences in terms of requirement and level of use of biotechnologies, hence, there is a need for compartmentalization. At least tissue culture and other low-tech infrastructure are needed for all countries. Soft infrastructure (e.g. how to overcome patent issues) is also required. New approaches for these can be adopted through partnership. Bionexus may be created wherein institutes/companies may allow use of their facilities by any agency for sharing purposes, through collaborations. The purpose of infrastructure, whether research or commercialization, should be linked with well-defined indicators for investment to measure outcome and impact. Investment in research needs to be linked with national agriculture plan, which will require biotechnology plans and clear business models. Technology business incubators, which act as innovation centres can be developed, which are facilities for many to use; one factor considered is sustainability with support from government. In Iran, private companies use facilities provided by the government, then buy their own facilities and operate independently. For spin-off companies there is no need to buy equipment, they can use services already available. Countries that are successful with effective facilities (e.g. sequencing) need to be identified and shared across institutions.

Organizations like APAARI can contribute significantly in the area of capacity and infrastructure development, by acting as a broker institution to facilitate upscaling. They can identify the range of infrastructure available in different countries and provide such information and link to potential users, along with procedures to access these. They can lobby for increased resources with national governments or international community, by liasioning with policy makers directly or through member institutions. APAARI may also provide guidelines for development of regional biotech centres, support national or regional training programmes, creation of international genome bank etc.

3. Public Awareness

There was general consensus that effective and well-designed efforts are needed for creating public awareness highlighting the advantages of biotechnology. This requires a more targeted and well-articulated communication for all stakeholders of society including policymakers, politicians, farmers, journalists, students, religious scholars/clerks and general public. The communication should be simple and easily perceptible, using all the tools, media and channels. There is need for credible and authentic information, as well as source of information to make it more reliable and useful for all. During technical workshops, seminars and conferences, there is need to invite policymakers to further improve their understanding of basic science and the various domains of biotechnology. Greater education is also necessary for better understanding of biotechnology, which should start from elementary level.

Various concepts and products of biotechnology must be explained with clarity so that general public can effectively understand what these actually are, e.g. tissue culture, GMOs, bioproducts, biopesticides, biofertilizers. Technical and scientific language should be minimized to make information easily understandable by various groups. Biotechnologists should be more vocal and interactive when there is criticism or negative message or mis-information spread in the media and masses, so that the position is clarified before it gets too late and harm is done to either producers or end users. It is equally important that biotechnologists give only science and evidence-based information, not opinions, and let the public decide what is bad or good for them. Social media should be carefully and selectively used to provide the right information. False or negative information needs to be monitored on these networks, e.g. making myths and wrong portrayal of biotechnology innovations. In fact, some information policies should be designed to check such wrong information. Guidelines should be prepared ahead of any awareness interventions, so that anyone preparing a campaign for awareness should follow these even without having an expert to help them do so. Public awareness should also be linked to consumer perspective so that they can make choices to use or not to use any biotechnology product. APAARI and other organizations can play important role in sharing of experiences, best practices and success stories across various communities, regions and countries.

4. Policy Advocacy

Policy advocacy is a complex issue that involves peace, prosperity, productivity, priority, programme, projects, public perception, perseverance, pro-poor etc. Enabling research policy to develop a biotech product is the most important activity in policy advocacy, and needs to be dynamic, subject to reform and review. Biotechnologies need to be perceived as a component of value chains and advocacy for improved investment is required. A great degree of variation exists on the policy and capacity between the countries *vis-á-vis* biotechnology. It was suggested that APAARI may help in developing broad science-based guidelines on biotechnology based on status and specific issues relevant to each country, in association with national partners. Further, instead of grouping countries based on geography, categories may be developed based on status and specific issues related to biotechnology policies. Policy advocacy needs are diverse for each category. Following categories were proposed:

Category	Countries	Current Level of policy on biotechnology	Suggested actions
A	PNG, Samoa	No policy or beginners	Policy bank is developed with documents on existing policies of different countries, by the SPC.
B	Bhutan and Nepal	Not interested in recombinant DNA	Policy advocacy may focus on pro-organic agriculture by use of conventional biotechnology tools that include use of molecular maker technology in crops, livestock, fisheries and forestry. Policy for export and import of GM products required.
C	Vietnam	Recombinant DNA acceptable for feed alone	Policy advocacy to promote recombinant DNA technology for developing food products and for export and import of GM products required.

Category	Countries	Current Level of policy on biotechnology	Suggested actions
D	India and Pakistan	Recombinant DNA acceptable for non-food	Policy advocacy to promote recombinant DNA technology for developing food products may be developed. Initiate policy advocacy for acceptability and promotion of gene editing as high investments are in place. Policy for export and import of GM products required.
E	Bangladesh and Iran	Recombinant DNA acceptable for all crops with or without GM food label	Issue based policy advocacy may be developed. In case of Bangladesh policy advocacy to further promote Bt brinjal. In case of Iran policy advocacy for labelling GM products may be considered.

Policy to conduct research for knowledge generation should be introduced wherever needed. It is necessary to initiate policy advocacy for those countries who are investing heavily on gene editing technologies (CRISPR-cas) without waiting for the product development. Science-based policy protection to prevent rapid changes with politics is needed.

APAARI may help in taking a position with reference to information linked to DNA, its sequence and seed for exchange. Current guidelines are counter-productive for science development in the context of Access and Benefit Sharing. APAARI may have dialogue with states in India to promote policy advocacy as agriculture is a state subject. Develop information for communication to general public that will change the perception and contribute to policy advocacy.

5. Possible Partnership

The ideas for mechanisms of how partnerships may be formed were as follows:

- More involvement of private sector required and brokering of partnerships. Exchange of experiences and lessons learnt on PPP and commercialization of biotechnology and innovations including licensing, IPR issues, royalties.
- Exploring synergies and complementarities, e.g. some countries focus on genetic improvement in certain crops, while other countries or institutions focus on agronomy or post-harvest issues.
- Conferences, workshops, ICT platforms, expert consultation and discussion.
- Partnership to develop and facilitate tailor-made training courses depending on country-based needs assessment.
- Mapping of expertise available in the network as well as regional and international organisations (e.g. CG centres)

The specific domain and regions of possible partnerships were identified as follows:

- Micropropagation in South Asia, South East and Pacific region; establishment of a consortium/platform for micropropagation especially for skill development (managers, operators, etc.), entrepreneurship development, establishing stock cultures, and having a quality management system in place.
- Link up for advocacy for agricultural research.
- Harmonization of production standards, quality controls, certification for vaccines and biopesticides.
- Better cross-disciplinary exchange and communication (linking biotechnologists with agronomists etc.).
- Application of biotechnology for Conservation and use of biodiversity.
- Technology transfer cycle.

Some suggestions on role of APAARI for fostering partnerships were as follows:

- APAARI as a partnership broker to bring actors together on skill development, research infrastructure and equipment exchange (match those who need with those who can provide). Broker partnerships for funding instruments available (partnership agreement, need assessment, plan to meet, stakeholder assessment).
- Conduct need assessment in each sub-region on requirements of capacities for low- and/or high-tech biotechnologies.
- To facilitate, consolidate, and monitor effective partnership in research, capacity building and exchange of technology, including the funding opportunities.
- To link up with regional consortia/platforms e.g. ASEAN, ASEAN Ministerial Meeting on Agriculture and Forestry, Asia Pacific Economic Cooperation (APEC).
- Enhancing communication on biotechnology within APAARI network by collaborating with ISAAA, increase frequency of APAARI newsletter to have more timely alerts about news and developments in the region.

Technical Session V

Panel Discussion of Partnership and Innovative Funding Mechanism for Priority Areas in Agricultural Biotechnology to achieve SDGs

Co-Chairs	**Trilochan Mohapatra**, ICAR, India and **Su-San Chang**, PABP, Taiwan
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **K.S. Varaprasad**, Ex-ICAR, India

To achieve the 2030 agenda set for SDGs, new innovative approaches are required that are socially inclusive and environmentally benign. Accordingly, this session focussed on shaping partnership and innovative funding mechanism for priority areas in agricultural biotechnology to increase agricultural productivity and address the SDGs to achieve food security and improved nutrition, promote sustainable agriculture and end hunger. Eight panellists, who were experts in specific areas, shared their views on the subject, as briefly summarized below:

Cherdsak Virapat (NACA, Thailand), said that he represented 19 governments in the APR with respect to aquaculture. The APR has some 400 million people suffering from malnutrition, and some 18 million fish farmers. He urged that very clear targets and roadmap to achieve SDGs be developed. At least four SDGs had direct bearing with his responsibilities related to promotion of sustainable aquaculture, These comprise (i) SDG #2 on 'Zero Hunger' which aims to end hunger, achieve food security and improved nutrition, and promote sustainable agriculture; (ii) SDG #13 on 'Climate Action' that seeks urgent action to combat climate change and its impacts by regulating emissions and promoting developments in renewable energy; (iii) SDG #14 on 'Life Below Water' to conserve and sustainably use the oceans, seas and marine resources for sustainable development and (iv) SDG #17 on 'Partnerships for the Goals' for strengthening the means of implementation and revitalizing the global partnership for sustainable development. These SDGs target production, ecosystem, adaptive capacity and funding related to issues of aquatic animal health, climate smart aquaculture, genetic biodiversity, certification and food safety. He reiterated his call (made during his previous presentation) regarding prioritization of missing biotechnology for smallholder farmers. He said that climate smart aquaculture for smallholder farmers would not only be financially beneficial but also promote conservation of aquatic species. Further, Cherdsak acknowledged the grouping of countries in five categories (from very low, low, medium, high and very high) with respect to adoption of biotechnology, as presented by the speaker from FAO. He urged that such classification be used for discussion in the present meeting, to determine where to focus in different sectors of agriculture (plants, animal, aquatic, microbes etc.). Such information needs to be made available by FAO, and should be used to determine what kind of needs we can further strengthen. Cherdsak pointed out that during 2010-15, funding aid to agricultural research increased by 15%; but in aquaculture, it declined by 30% and on climate related projects by 70%. Hence, there is an urgent need to speed up and find more funds to do the work with clear targets and roadmap. Cherdsak observed that some people in the meeting had recommended that infrastructure and capacity building should be done. He suggested that mechanisms need to be set up for establishing minimum requirements of technology, since for some of the countries, infrastructure development for advanced agricultural biotechnology was still not easy. He advocated to set up some kind of financial mechanism (e.g. a trust fund) from countries and donors, where the richer partners add more money. Such a fund would ensure that minimum requirement of technology be available to everyone.

Roland Schafleitner (WorldVeg Centre, Taiwan), said that he was excited to see development of agricultural biotechnology, its adoption and policy implementation in the region, which varied with agriculture and development profile of countries in the APR. He observed that there is a broad range

of needs and opportunities in the region that need to be addressed by research, which requires funding support. The challenges everywhere were the same, namely, funds, capacity and infrastructure. Hence, there was need for new partnership and innovative funding for biotechnology. He suggested that the first way to look at innovative funding infrastructure is through a 'value chain approach' to solve complete problem, which requires partnership along the value chain to reach farmers. The second approach could be through establishment of 'endowment fund' from people with a lot of money, who are willing to support biodiversity related projects. Such a fund can also be used to conserve, characterize and use genetic resources, conservation through for biotechnological tools. The third way to leverage funding could be through private firms (especially for vegetables), who would fund for getting the technology and/or germplasm. This PPP model may require some compromise; e.g. private sector has access for 1-2 years and later goes into public domain and becomes global public good. For all investments, there is need to consider business cases whereby calculation of return of investment on progress in specific field is made. Roland provided the example from WorldVeg in Taiwan. The Taiwan government financed a new phenotyping facility, which created capacity and knowledge for understanding the in-depth data on plant phenotypes to support the biotechnology, genotyping and molecular breeding research. The facility is a training platform, and creates capacity and knowledge. It paves the path for new biotechnology development.

Tracy Powell (USAID, USA), also echoed the sentiment of being impressed with the sheer diversity in countries and partners and range of R&D efforts made in agriculture and biotechnology in the APR. The types of experimentations being undertaken and lessons learnt, PPP and policies were also eye opening. She appreciated the initiatives of some governments for supporting start-ups and spin-off companies that led to helping the farmers. Both innovative work from those who have access to resources and technology and also those who struggle for even minimum capacity, were appreciated. This diversity indicates that the APR has a lot of opportunities for learning and partnership. What is required is the need to identify what are the priorities and how agencies like APAARI can facilitate this. She observed that a lot of interest was shown during the meeting for partnership with private sector, but it was unclear how APAARI would help in that; whether through international companies, local businesses, commercialization of public sector efforts, access to private sector IP, securing finance, working with corporate funds etc. She proposed USAID can help in mobilizing of resources and facilitate in development of different financing models. As a donor, USAID is keen to support APAARI to facilitate better awareness to knowledge and access to many opportunities of food security, and science and technology in which APAARI is already engaged in.

Tin Htut (MOALI, Myanmar), said that he could see the effective role of APAARI in the APR, if done right. Low-tech biotechnology was introduced in Myanmar (tissue culture and somatic hybridization), but they do not know hardening. Thus, he wanted to talk on partnership and innovation. Myanmar needs 4Ps – peace, prosperity, productivity and profitability. The 4Ps need priority, which in turn governs policy. The Myanmar Agricultural Development Policy was developed with the help of several donors. He cited the example of successful partnership between Myanmar and Thailand (Kasetsart University) funded through Generation Challenge Program. An aromatic rice could be developed through MAS. What is required is political commitment, professionals and also PPP. Innovative business arrangements are also required. Scientists should be good at marketing also, besides doing good science. He appreciated the outcome of the Myanmar and ICAR cooperation. He urged that global and regional platforms such as the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC), ASEAN APEC, USAID, Asian Development Bank (ADB) etc. need to be tapped for generating partnerships and funding, and APAARI could facilitate in development of both high-tech and low-tech biotechnology projects. He concluded by saying that Myanmar needs scaling-up, integrate diversifying, intensify and main streaming with respect to agricultural biotechnology.

Anil Kumar Anal (AIT, Thailand), informed about the functioning of Asian Institute of Technology (AIT), which is primarily focused on higher education in S&T and social sciences. He flagged the issue of knowledge gap with respect to GM technology, and challenges which have not changed in the last two decades, especially in the APR. He urged that there is a need for inter-linking between stakeholders and some platform should be created to fill this gap. With respect to technical aspects, soil and water contamination is alarming and issue of biosafety equally important. Food value chain production also needs more focus, post-harvest loss needs to be controlled. There are many biotech products, that can be used for solving many problems - how to

preserve food, reduce post-harvest loss, prevent diseases etc. He said that food safety issues are very important and chemicals (e.g. anti-microbials) used in aquaculture and livestock leads to microbial resistance and superbugs, which is projected to be a major health hazard by the year 2050. Thus, development of a healthy food value chains with appropriate technological interventions is warranted. Recent studies at AIT in salads (lettuce) from different regions have revealed that it is contaminated with food pathogens like *Salmonella* and *Escherichia coli*, which have come through contaminated with soil, water, etc. Thus, biotechnology needs to address these issue of safe food production.

Wen-Chin Yang (ABRC, Taiwan), said that like some previous speakers, he also would focus on partnership and innovative funding mechanism and research strategy. Each country has its own policy on regulation of agricultural biotechnology (GM, biosafety, food safety etc.). In terms of research, it is important to identify the research areas on crops, livestock and aquaculture, current research partners. With respect to infrastructure, it is always money consuming. Hence, cooperation and sharing are needed for the sake of economy. Funding mechanisms are very crucial for success of research, infrastructure development and capacity building. He said that he learnt during this meeting that public funding donors at national and international level e.g. ICGEB, USAID, ACIAR, Taiwan Government have set up International Cooperation and Development Fund (ICDF). He stressed on the importance of funds from the private sector, saying that if research projects are competitive and profitable, more money can be solicited from private sector. In this context, identifying the potential profitable research area and creation of a value chain, creating a positive cycle for future revenue is very important. He acknowledged the fact that creating revenue for agricultural research is difficult. He observed that country status reports, as provided in the present meeting, are very useful for mutual understanding and exchange of ideas. These can be used for creating mutual biotechnology exchange partnership. He proposed an important exchange strategy, for example by creating hubs to exchange the information about agricultural biotechnology, knowledge, expertise and research partners, where APAARI can play a role. Strategy for partnership in international regulation, identification of the priority area for agricultural biotechnology cooperation, public information, policy, capacity are required. He informed that ABRC was working on both basic and translational research in four major areas - integrative stress biology (for climate change), herbal medicine research, molecular vaccine technology and enzyme biotechnology. Wen-Chin's own area of expertise was animal science and he proposed partnership with plant experts in the program related to herbal medicine research (botanical drugs for human health) where development of high end value products was the final target. Such approach helps in attracting private sector support and funding. He elaborated on the infrastructure and technical capacity of ABRC offered cooperation in areas like tissue culture, transformation, genetic engineering, biofertilizers, biopesticides, bioinformatics, bioprospecting, bioproduct for animal and human health. ABRC also has a good program in PhD and visiting scholar scheme for education and research.

Karisdete Teeranitayatarn (IDE, Thailand), informed that IDE is an innovation driven enterprise in Thailand. He said that IDE is a model company that uses partnership and funding mechanism for its success. IDE research since past 15 years is related to food safety, security and sustainability. Its labs in the Thailand Science Park are connected with the AIT, which has the ecosystem of ~4,000 researchers from around the world, who work on effects of overuse of chemical pesticides used in agriculture. IDE collaborates in research with the Thailand University and International University, supported by funding from the Thailand government. The company has novel products like a patented vaccine (sample of product was shared with all the participants in the meeting), which induces natural immunity in the plants to protect itself from worms and insects. This product is being sold in many countries like China, Malaysia and Singapore. In China, it was found superior in tackling the problem of citrus greening disease, as compared to chemical pesticides. Similarly, it has been found useful in rice, pineapple, strawberry, tomato, potato and onion, melon, apple, papaya, banana. It is also being used to decrease the chemicals in the animal feed in Thailand as corn is being imported from around the world. IDE has also produced vaccine for animals and fish to increase their immunity, as their feed is contaminated with several antibiotics. There is global awareness to procure organic meat, milk, egg and crops, which are free from antibiotics and other chemicals. IDE's product is an immune booster to induce animal immunity that naturally increases milk, fat and muscle. In addition to government funding, IDE is getting support from venture capital and the company expects to move to the stock market in the next two years.

Shiv Kant Shukla (BCIL, India), said that Indian biotechnology sector is globally visible and being tracked by investors for the various opportunities. It is ranked 12th globally with 2% contribution. In APR, India has third position after China and Japan. This reflects the role of India in contribution to biotechnology as such. He informed about Biotechnology Consortium India Limited (BCIL) and its structure. With respect to 17 SDGs with 169 targets, low-tech biotechnology such as plant tissue culture, biofertilizers and biopesticide have immediate priority and should be promoted as they have great potential and zero controversy. These technologies are universally acceptable to all countries in the APR. Only thing required is replication of success stories in areas where it has not reached as yet. But at the same time the power of high-tech is also not to be underestimated. For achieving SDGs, there is need to provide high quality planting materials to the farmers at low prices. For this plant tissue culture and Quality Management Systems (QMS) need to be replicated in different crops and regions. Further, QMS is also required in the areas of biofertilizers and biopesticides. He shared the success story of National Certification System for Tissue Culture Plants (NCSTCP) in India. It is a QMS (not a regulatory mechanism) to give support to new/mature companies to meet the quality parameter requirements, thereby, reducing the loss due to contamination or mortality. Plants are, thus, produced at very economical rates. Currently, some 78 companies are registered under the NCSTCP, having good market visibility. Farmers have tryst while using quality planting material. BCIL can contribute both low- and high-technology partnership. He proposed that a consortium called 'Asia-Pacific Consortium on Micropropagation (APCoM) may be considered on the lines of APCoAB, under the APAARI umbrella with BCIL for technology transfer, skill development, quality planting material, certification, creating new facility, etc.

Key Discussion Points

- It was suggested that agencies like Japan International Research Center for Agricultural Sciences (JIRCAS), ADB, FAO should be in a panel as these organizations offer assistance in activities related to agricultural biotechnology.
- Effective PPP or even public-public partnership is required and agencies like USAID to facilitate the SMEs in the field of agri-biotechnology. APAARI has an agenda to facilitating the youth and women, and this requires greater discussion.
- The models from Taiwan, Thailand, Iran where initially government supports entrepreneurs and spin off companies, and also the model of BCIL, where government collaborated with a consortium of companies. An expert consultation may be organized to discuss such varied models to suit individual countries in the APR. APAARI may consider scaling up such an idea.
- Bioversity International is operative through partnerships with NARS and international organizations. Hence, it would like to further contribute in the area of agri-biotechnology in the areas of bananas, under-utilized crops, training etc. to contribute towards the regional development to enhance farmers' income and contribute towards issues of climate changes.
- India has many strengths and can offer supporting capacity building in the region. The ICAR would be happy to contribute in capacity building process, as it has 73 agricultural universities and 98 agricultural research institutions. It also has experience in upscaling and outscaling low-tech technologies for smallholder farmers. ICAR and BCIL can offer solutions and consultation services in micropropagation, marker assisted breeding, genomics and Big Data Analytics.
- Developing effective partnership with donors (e.g. USAID) is also need of the hour. APAARI may facilitate in linking these and that would be an effective outcome of the consultation meeting.

Plenary Session

Co-Chairs	**Su-San Chang**, COA, Taiwan, **Siriporn Boonchoo**, DOA, Thailand, **Birte Komolong**, NARI, PNG, **Ravi Khetarpal**, APAARI, Thailand
Rapporteurs	**Rishi K. Tyagi**, APAARI, Thailand and **Geraldine Nemrod**, APAARI, Thailand

The plenary session summarized the deliberations held during the two and half day consultation meeting. The rapporteurs from the respective technical sessions presented the major recommendations from each session (Technical Sessions I and V by **K.S. Varaprasad**, Technical Session II by **Anuradha Agrawal** and Technical Session III by **Wangda Dukpa**, and Technical Session IV by **Martina Spisiakova**). The deliberations brought forth many important issues that need immediate attention, and participants gave several suggestions and recommendations. It was unanimously agreed that application of agricultural biotechnology would address SDGs on ending hunger, poverty alleviation, good health and well-being, besides attaining sustainable production and consumption, climate change and sustainable use of ecosystems. The meeting would be useful to develop future collaborative programs and novel funding mechanisms, between countries and participating organizations. Special remarks were made by the organizers, which are summarized as below:

Su-San Chang thanked all the participants on behalf of COA, one of the Co-organizers of the event, for their valuable comments and expert recommendations. She attributed the success of the meeting to the active participation of all, and more importantly the recommendations, which would help to draw up further action plan which will lead to agricultural biotechnology helping farmers to improve livelihoods and contributing towards achieving the SDGs in the APR. She also expressed her appreciation to all the Chairpersons and Rapporteurs for efficient conduct of the sessions during the meeting. She extended special thanks to the APAARI Secretariat for all the arrangements and good job, specially the leadership of Ravi Khetarpal and Rishi Tyagi. She expressed her sincere gratitude to the host country Thailand, for their arrangements, hospitality and long-term support to APAARI activities. On behalf of COA, Taiwan and other relevant agencies, she assured continued active contribution and participation of COA in APAARI activities. She hoped that through the platform of this meeting, partnership would be strengthened with other institutions, private sector and countries in APR, to help in achieving the SDGs.

Siriporn Boonchoo congratulated APAARI on behalf of DOA, Thailand, for successfully concluding this important consultation meeting. She said that it was very satisfying to note the dynamic discussion and deliberation during the two and half days meeting. The carefully designed technical sessions and World Café helped to contribute to substantiative recommendations on how APAARI would play a leading role in moving forward with respect to creation of knowledge hubs in research, development and innovation. The DOA, being a long-time partner of APAARI, will continue its full support particularly for MoU between DOA and APAARI.

Birte Komolong, on behalf of Chairman, APAARI, thanked APAARI for organizing the consultation meeting. She also expressed that it was an event to bring together diverse partners in the APR, to listen and learn about current work and activities related to agricultural biotechnology, which would bring great advances in the goals of poverty alleviation and food security. She said we should remember whom we are working for as the final beneficiaries in the APR - the smallholder farmers. The APAARI

secretariat has a big job ahead to address the recommendations emerging from various sessions. The World Café also brought out a long list that need to be relooked to remove redundancy. Further work is also required to extract the essence of where priority projects can be developed. Partnership groups may be formed for capacity building, policy advocacy, capacity development for policy etc. Finally, it boils down to finding the best short-term solutions and understanding the role of APAARI. Member countries also need to come forward to contribute to achieve the purpose.

Ravi Khetarpal said that the meeting went beyond an expert consultation, as there was so much brainstorming, which has brought forth many things to learn and actions to undertake. While profusely thanking all participants, he again reiterated the role and ideology of APAARI. The organization's four keywords were that it is (i) membership based, (ii) multi-partner, (iii) not for profit and (iv) apolitical. The ultimate objective is to support smallholder farmers. Based on the summary of each session, he observed that a lot of home work had been given to APAARI including its members, and expectations have been raised from APAARI. However, two important activities emerged as most important for the way forward - (i) facilitation for holding follow up meetings, developing policy briefs, capacity building and (ii) knowledge management. Considering the human and financial resource limitation of APAARI, he proposed that APAARI would like to remain in its domain of these two aspects i.e. facilitation and knowledge management. As an output of this consultation, follow-up actions needed are (i) to bring out a fine-tuned recommendation; (ii) prepare a task force for the important areas like research policy, public awareness, capacity building, infrastructure etc.; and (iii) sharing the recommendations with the partners with a request to have national expert consultation at the country level (NARS). The last activity would help in getting the inputs for mapping the issues at APR level. He requested all the members to hold national consultations or meetings with key players in agriculture biotechnology, to obtain a clear picture on need assessment. He said that amongst the many recommendations that emerged specifically for APAARI, the key point was upscaling of partnership with, e.g. with ASEAN, BIMSTEC, APEC, and so on. He appreciated the generous support from Dr T. Mohapatra, DG, ICAR, regarding ways in which ICAR can come forward in this area, and APAARI would work towards formalization of the procedures to do so. He observed that enough emphasis was not given on education during the expert consultation. He informed that APAARI was currently in the process of getting into higher education in agriculture sector, in collaboration with UNESCO. Based on this meeting, he proposed to include teaching of agricultural biotechnology in a holistic manner by inclusion of value chain, social biotechnology, economics, entrepreneurship, besides the research aspects. He further informed about the subsequent workshops planned by APAARI, which include : (i) animal resources, likely to be hosted by MARDI, Malaysia; (ii) soil and plant health in climate change for achieving SDGs, with DOA in Thailand; (iv) fish resources in Sri Lanka; (v) in Taiwan on a topic yet to be finalized by COA; (vi) vegetable production and processing in Iran; (vii) post-harvest losses and management, in Malaysia with MARDI; (viii) how to improve farmers' income with India. Opportunities for diversification in the region by APAARI had been amply highlighted. However, challenges are resource mobilization to implement and achieve the recommendations at APAARI end, and how to carry forward the recommendations from this meeting. He concluded by saying that APAARI works for APR with collective wisdom and collective knowledge for all its members.

Other Co-Organizers, namely, **CRP-GLDC** and **BCIL** assured full cooperation with APAARI in its endeavours.

Rishi K. Tyagi proposed a vote of thanks to all the dignitaries, experts, participants, Co-organizers, sponsors and staff of APAARI secretariat.

Major Recommendations

Priority Research Areas

- Development of climate resilient and/or stress tolerant crops, livestock and fish using conventional and high-tech biotechnological approaches such as gene editing technologies, genetic engineering, marker assisted breeding, phenomics and genomics for trait and gene discovery.
- Responsive research for addressing problems of new and emerging pests by development of rapid, cost-effective diagnostics, information systems for early warning and pest-risk analysis.
- Enhancing productivity and use of under-utilized plants, less-utilized aquatic bioresources (algae, marine organisms), molecular characterization/ MAS breeding, especially for UUP in the Pacific Countries and SE Asia.
- Development of protocol and commercialization of plant tissue culture for micropropagation (including reduction in production cost), quality planting material, certification and conservation.
- Innovations in areas of biofertilizer, biofuel, biopesticides and IPM, bioprospecting (especially microbes), nutrigenomics and phytogenics (herbal plants).
- Conservation and sustainable use of bioresources using biotechnological tools of tissue culture, cryopreservation and molecular biology.

Capacity Development

- Mapping of existing capacity for agricultural biotechnology in terms of human resource, projects, technology, products etc. is required for the APR, as various stakeholders and countries have different capacities. This would become the baseline for subsequent partnership and networking.
- Both technical and soft skills training (long- and short-term) are required using inter-disciplinary approach, however, given the diversity in the APR, regional learning routes (e.g. Pacific learning from India on tissue culture) as well region-specific capacity enhancement would be desirable. For example (i) Microbial formulation (biofertilizers and biopesticides), tissue culture, and gene editing technologies in South and West Asia; (ii) Germplasm management, micropropagation, molecular breeding and gene editing technologies in South East Asia; (iii) Tissue culture, DNA fingerprinting and gene editing technologies in the Pacific. Other areas include development of biosafety regulatory frameworks and Big Data Analytics.
- Capacities are also required to create robust impact pathways, prepare logical frameworks, measure indicators, from research to extension, policy, and impact on farmers' livelihoods.
- Functional capacity development is required to build awareness among policy makers, media and the public on benefits of biotechnologies (e.g. development of policy briefs, advocacy, communication), as also advocate for higher investment and resources in biotechnology by governments/international community.
- Integration of biotechnology and functional skill development (capacity to innovate, entrepreneurship, risk-taking, IPR) in the curricula of higher education is required.

Infrastructure Development and Investment

- At least tissue culture and other low-tech biotechnology infrastructure are needed for all countries; for high-tech biotechnology, demand-driven support for infrastructure development is required.
- Soft infrastructure (e.g. how to overcome patent issues, alignment of regulatory processes) is also required which can be adopted in partnership mode.
- Bionexus may be created wherein institutes/companies allow use of their facilities by any agency for sharing purposes, through collaborations. Technology business incubators which act as innovation centres can be developed, which are facilities for many to use, as exemplified by models in Taiwan, Iran and Thailand.
- Investment in research needs to be linked with national agriculture plan, which will require biotechnology plans and clear business models. Several mechanisms for investment in agri-biotechnology research, product development and marketing emerged, including PPP model (e.g. PABP, Taiwan).
- Promote biotechnology actions consistent with science-based key principles leading to trade promotion in harmony with international obligations on trade challenges.

Public Awareness

- Various concepts and advantages of the products of low-tech and high-tech biotechnology must be explained using all media platform in simple, non-technical and regional languages with authenticity and clarity so that all stakeholders (policymakers, politicians, farmers, journalists, students, religious scholars/clerks and general public) can effectively understand.
- Biotechnologists should be vocal and interactive when there is criticism or negative message or mis-information spread in the media and masses, so that the position is clarified with scientific evidence-based information before harm is done to either producers or end users.
- Public awareness should be linked to consumer perspective, to enable informed choice to use or avoid any biotechnology product.
- APAARI and other organizations e.g. ISAAA can play an important role in public awareness by sharing of experiences, best practices and success stories across various communities, regions and countries.

Policy Advocacy

- The gap between farmers (especially smallholders) and research and products of agricultural biotechnology remains still high. Linking farmers and research, and bridging this gap need to be addressed on priority, to achieve the goals of zero hunger, poverty alleviation and climate change issues. Also, there is a need to separate smallholder farmers who need support, semi-entrepreneurs supplying to cities, and those that drive country GDP export. These three categories have different needs, and 'one policy fits all' cannot be applied.
- Enabling dynamic research policy to develop a biotech product is the most important activity in policy advocacy; policy advocacy initiatives need to be taken for those countries who are investing heavily on gene editing technologies (e.g. CRISPR-cas), without waiting for the product development.
- Biotechnologies need to be perceived as a component of value chains and advocacy for improved investment is required.
- Instead of grouping countries based on geography in APR, categories may be developed based on status and specific issues related to agricultural biotechnology policies.

Possible Partnerships

- To develop synergies in the region, there is need to build partnerships and networking of groups and institutions to work on select key issues, with a defined time frame, deliverables and budget, by identifying areas of upstream and downstream research in agri-biotech for South-South cooperation.
- Models of effective PPP (e.g. Known-You Seed Co. Ltd., Taiwan and Kitoku Shinryo, Japan) may be adopted, which benefit small and marginal farmers by providing good seeds/planting at affordable costs or take care of specific consumers' needs.
- Mechanisms for partnerships may include greater involvement of private sector and brokering of partnerships by agencies (e.g. APAARI, USAID, ICGEB) to facilitate sharing of experiences and lessons learnt on PPP, commercialization of biotechnology and innovations including licensing, IPR issues, royalties.
- NACA and APAARI may collaborate for the benefit of their member countries to exploit biotechnology in aquaculture through the concept of National Broodstock Improvement Network (NBIN) – a strategy consisting of partially interconnected but independently evolving broodstocks. The NBIN aquaculture genetic exchange strategy is a network of aquaculture gene pools (not a network of institutions), meant for exchanging genetic material as well as information about gene pools.
- Partnerships should be promoted to use latest technologies (high throughput sequencing/re-sequencing to identify candidate genes, marker detection, omics, CRISPR/cas9- mediated genome editing, microbiome and Big Data analytics) enhancing stakeholder capacities to further improve rice productivity and other dryland crops, and conservation of bioresources and sustainable use.
- FAO, in association with APAARI, may create a 'Knowledge Platform' on agricultural biotechnologies, promote PPP and SSC for agricultural biotechnologies and improve technology transfer.

Action Points for APAARI

APAARI, under its APCoAB programme, needs to take up certain actions for knowledge management and facilitation to promote agricultural biotechnology in discussion and partnership with the NARS and related organizations. Necessary funding for mandated activities should be explored and projects may be developed for capacity building, public awareness and policy advocacy with the help of consultants.

- Mapping the needs in agricultural biotechnology and expertise available in the region as well as in world to promote agricultural biotechnology.
- In collaboration with other organizations, focused capacity building modules may be developed directed to all levels of stakeholders including policy makers. Develop biotechnology policy briefs particularly for biotechnology beginners (PNG and Samoa) and for organic oriented countries (Nepal and Bhutan) in association with member countries.
- To promote better understanding of regulatory architecture, study impact assessment to dispel negative effects of agri-biotech and bring out publications relevant to share experiences to promote South-South Cooperation.
- Technical and professional assistance be extended to the member countries for follow up meetings, based on request to promote agricultural biotechnology.
- Facilitate workshops/meetings to promote partnerships/networks with private sector and related to international funding opportunities for promoting agricultural biotechnology in the region.
- Facilitate studies on impact assessment of successful technologies and document the same to promote use of agricultural biotechnologies to contribute in achieving SDGs in the APR.

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Appendix I

Inaugural Address by Dr Chung-Hsiu Hung, Chief Guest and Director General, International Affairs Department, Council of Agriculture, Taipei, Taiwan

In October 2017, Dr Chung-Hsiu Hung took office as the Director-General of International Affairs Department, Council of Agriculture (COA), R.O.C. Prior to this, he had held several important positions, including Director-General of the Farmers' Service Department, COA, and the Director of the Planning Division, Agriculture and Food Agency, COA, etc.

Dr Hung got his Ph.D. in Applied Economics Department from National Chung Hsing University, Taiwan, R.O.C. He has been an adjunct Assistant Professor in the Business Assistant Department of National Open University for 20 years, serving as an adviser to doctoral and master's students and teaching Economics and Finance. Dr Hung has published over 90 papers in domestic and foreign seminars and journals.

Dr Yusuf Zafar, Chairman of the APAARI; Dr Ravi Khetarpal, Executive Secretary of the APAARI; Dr Rishi Tyagi, Coordinator, APCoAB, Distinguished Guests; and Ladies and Gentlemen!

It is a great pleasure for me to be with you here today at the opening ceremony of the "Regional Expert Consultation on Agricultural Biotechnology – Scoping Partnership to Improve – Livelihoods of Farmers in Asia Pacific". I would like to extend my sincere appreciation to Dr Ravi and his capable staff of APAARI for organizing this important event and wonderful arrangement and hospitality. I am confident that the concerted efforts will ensure great success for this event.

The agricultural industry is one of the oldest industries. Now-a-days, the agricultural sector is facing a number of challenges including: achieving food security, limited resources, rural-urban gap and maintaining livestock health through preventing the spread of disease. Especially, the climate change makes the situation more complicate and severe.

As we are aware, by 2050, the world population is expected to reach 9.7 billion and will require 70% more protein than is currently available. With 2 billion more mouths to feed, security of food supply will be at risk if we continue to use traditional agricultural methods. Currently, we are living beyond ecological means and over-using our natural resources by more than 50%, this over use means the Earth needs 1.6 years to regenerate our annual consumption. In addition, changes in the environment and global warming could cause negative impact on agriculture sector. These challenges are making agriculture a hot topic, as it is one of the key industries where changes must be implemented in order to create a sustainable future for the next generations.

As the world is recognizing the importance of agricultural biotechnology, our gathering today has reaffirmed APAARI's determination to collectively meet the challenges and to jointly improve the livelihood of farmers in the Asia Pacific region. We also believe only boosting the partnership between the public and private sectors will provide innovative models to cope with severe challenges in the near future.

APAARI has been playing a key role in strengthening Agri-food Research and Innovation Systems in Asia-Pacific region. APAARI not only provides cooperation between members on these emerging technologies but also supplies stakeholders with the facilities and

expertise required to improve innovative agri-tech solutions. We believe that investment in agriculture research is the key to unlocking a sustainable future. Traditional agricultural methods are simply not sustainable enough for us to achieve food security for a rapidly growing population, lower our carbon footprint, and maintain the health of our livestock. Biotechnology, novel materials, Big Data and the Internet of Things (IoT) can be used to address the challenges presented.

Taiwan, like many other APAARI members, has been constantly challenged by natural disasters, including typhoons, floods, and droughts. On top of this, Taiwan is also undergoing unprecedented economic and social changes brought about by globalization, regional economic integration, an emerging M-shaped society, an aging population, and a rising income discrepancy between the rich and the poor.

To cope with these severe challenges, my government has launched a "New Agriculture Innovation Promotion Program" since 2017, which will be ended in 2020. This program has three major policy themes - a new agriculture paradigm, enhanced agricultural security and modernized marketing capacity, which is based on the policy blueprint of President Tsai and the principle of innovation, employment, distribution and sustainability. The ultimate goal is to reverse the conservative subsidy policy in the past so that existing resources could be reallocated to strengthen interdisciplinary communication and integration, expedite industry structural transformation, create favorable environment for young talents to return and work in agriculture, in the hope of raising agro-business added value and forging a revolutionary new agriculture. The overall objective will include increasing food self-sufficiency ratio by 40%, expanding agricultural output to NT$219 billion (US$7.3 Billion), creating employment opportunities for over 370,000 people, and exporting agricultural product to overseas emerging markets with annual growth rate of 57%.

Council of Agriculture has become the member of APAARI family since 1999. My government has been supporting the Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB) Program of APAARI for 3 consecutive terms of 9 years, and this year will be the second year of the third term.

The program has made significant contributions to agricultural technology development in the Asian-Pacific areas with fruitful outcomes. My government is looking forward to continuous cooperation with APAARI to implement the term of 2017-2020 and will continue our funding to the program to benefit the members of APAARI and the entire Asia-Pacific region.

Finally, I would like to emphasize that the goal of this expert consultation meeting is to address all key issues related to agri-biotechnology. It is crucial for all of us to frankly share and discuss our views in order to come up with practical solutions, policy recommendations, and action plans. I am confident that, with the collective wisdom and professional expertise of all in attendance here, we will achieve the goal of this event. Your participation in this meeting will definitely contribute toward the common goal of improving livelihoods of farmers in the Asia-Pacific region.

In closing, I look forward to a very productive meeting and wish all attendees from abroad a pleasant and rewarding stay.

Thank you very much!

Appendix 2
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Appendix 3
Technical Programme

May 29, 2018

08:00-09:00	**Registration**	
09:00-10:30	**Opening Session**	
09:00-09:05	**Welcome Address**	**Ravi Khetarpal**, APAARI, Thailand
09:05-09:10	Remarks	**Siriporn Boonchoo**, DOA, Thailand
09:10-09:15	Remarks	**Andrew Alford**, ACIAR, Australia
09:15-09:20	Remarks	**Rajeev K. Varshney**, ICRISAT, India
09:20-09:28	Remarks	**Trilochan Mohapatra**, ICAR, India
09:28-09:35	Remarks	**Yusuf Zafar**, APAARI, Thailand
09:35-09:55	Inaugural Address	**Chung-Hsiu Hung**, COA,Taiwan
09:55-10:00	Vote of Thanks	**Rishi K. Tyagi**, APAARI, Thailand
10:00-10:30	***Tea/Coffee Break and Group Photograph***	

Technical Session I
Partnership and Investment in Agricultural Biotechnology

Co-Chairs	**Chung-Hsiu Hung**, COA, Taiwan and **Trilochan Mohapatra**, ICAR, India
Rapporteurs	**K.S. Varaprasad**, Ex-ICAR, India and **Martina Spisiakova**, APAARI, Thailand

10:30-10:50	ACIAR for Promoting Partnership and Investment in Agri-biotechnology in Asia-Pacific	**Andrew Alford**, ACIAR, Australia
10:50-11:10	Current Status and Long-term Investments in Agricultural Biotechnology for Sustainable Development in Asia-Pacific	**Rhodora Aldemita**, ISAAA, Philippines
11:10-11:30	Agricultural Biotechnology for South-South Cooperation	**Sachin Chaturvedi**, RIS, India (Skype presentation)
11:30-11:50	FAO's Role in Agricultural Biotechnology	**Amgalan Ariunbold**, FAO-RAP, Thailand
11:50-12:05	**Discussion**	
12:05-13:05	***Lunch (Greenery Café, Ground Floor)***	
13:05-13:25	Role of Biotechnology in Improving Productivity for Rice Producers in Asia from IRRI's Perspective	**David Johnson**, IRRI, Philippines
13:25-13:45	Advances in Genomics Research and Molecular Breeding in Dryland Crops through Partnership for Achieving Food and Nutritional Security	**Rajeev K. Varshney**, ICRISAT, India

13:45-14:05	Agricultural Biotechnology in 21st Century – USDA's Perspective	**Russell Nicely**, US Embassy, Thailand
14:05-14:25	National Broodstock Improvement Network (NBIN)	**Cherdsak Virapat**, NACA, Thailand
14:25-14:40	**Discussion**	
14:40-15:00	***Tea/Coffee Break***	

Technical Session II
Public-Private Partnership in Agricultural Biotechnology

Co-Chairs	**Yusuf Zafar**, APAARI, Thailand and **Siriporn Boonchoo**, DOA, Thailand
Rapporteurs	**Anuradha Agrawal**, NBPGR, India and **Martina Spisiakova**, APAARI, Thailand

15:00-15:15	Agricultural Biotechnology Park in Public-Private Partnership	**Su-San Chang**, PABP, Taiwan
15:15-15:30	Success of *Bt* Brinjal in Bangladesh	**Rafiqul Islam**, Ex BARC, Bangladesh
15:30-15:45	Success of GM Maize in Philippines	**Reynaldo V. Ebora**, PCAARRD, Philippines
15:45-16:00	Investing in Agricultural Biotechnologies in the Pacific: Striving for an Effective Broad Stakeholder Alliance	**Jan Helsen**, SPC, Suva
16:00-16:15	**Discussion**	
16:15-16:30	Leveraging Funds for Basic Research in Agricultural Biotechnology: the ICGEB Experience	**Martina Viviani**, ICGEB, Italy
16:30-16:45	Opportunities for Funding: Grant and Partnership Programs in Biotechnology for Agricultural Development	**Tracy Powell**, USAID, USA
16:45-17:00	Challenges in Globalization of Agricultural Biotechnology – Private Sector's Perspective	**Siang Hee Tan**, CropLife Asia, Singapore
17:00-17:15	Investments in Livestock Biotechnology and Scoping Partnership	**Md. Kamarudin Isa**, Malaysia
17:15-17:30	Building-up the Partnership for Using Biotechnological Tools for Sustainable Conservation and Utilization of Bioresources – Role of Bioversity International	**Zongwen Zhang**, Bioversity International, China
17:30-17:45	**Discussion**	
18:15-20:30	***Social Dinner (Greenery Café, Ground Floor)***	

May 30, 2018

Technical Session III
Country Status Reports on Agricultural Biotechnology

Co-Chairs	**M. Roff Bin Mohd Noor**, MARDI, Malaysia and **Rajeev Varshney**, ICRISAT, India
Rapporteurs	**K.S. Varaprasad**, Ex-ICAR, India and **Geraldine Nemrod**, APAARI, Thailand

	South and West Asia	
09:00-09:15	Bangladesh	**Md Harunur Rashid**, BARC, Bangladesh
09:15-09:30	Bhutan	**Wangda Dukpa**, DOA, Bhutan
09:30-09:45	India	**Trilochan Mohapatra**, ICAR, India
09:45-10:00	Iran	**Fariborz Ehteshami**, AREEO, Iran
10:00-10:15	Sri Lanka	**Frank Niranjan**, SLCARP, Sri Lanka
10:15-10:30	Nepal	**B.N. Mahto**, NARC, Nepal
10:30-10:45	Pakistan	**M. Kamal Sheikh**, PARC, Pakistan
10:45-11:00	**Discussion**	
11:00-11:15	***Tea/Coffee Break***	

Technical Session III
Country Status Reports on Agricultural Biotechnology (contd.)

Co-Chairs	**Gerry Jayawardena**, SLCARP, Sri Lanka and **B.S. Dhillon**, PAU, India
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **M. Kamal Sheikh**, Pakistan

	South-East Asia	
11:15-11:30	Lao PDR	**Chay Bouphanousay**, NAFRI, Lao PDR
11:30-11:45	Malaysia	**M. Roff Bin Mohd Noor**, MARDI, Malaysia
11:45-12:00	Philippines	**Reynaldo V. Ebora**, PCAARRD, Philippines
12:00-13:00	***Lunch (Greenery Café, Ground Floor)***	
13:00-13:15	Taiwan	**Ruey-long**, Chen, Taiwan
13:15-13:30	Thailand	**Danai Narkprasert**, Thailand
13:30-13:45	Vietnam	**Pham Van Toan**, VAAS, Vietnam
13:45-14:15	**Discussion**	
14:15-14:45	***Tea/Coffee Break***	

Technical Session III
Country Status Reports on Agricultural Biotechnology (contd.)

Co-Chairs	**Pham Van Toan**, VAAS, Vietnam and **K.S. Varaprasad**, Ex ICAR, India
Rapporteurs	**Wangda Dukpa**, DOA, Bhutan and **Geraldine Nemrod**, APAARI, Thailand

	The Pacific	
14:45-15:00	Papua New Guinea	**Birte Komlong**, NARI, PNG
15:00-15:15	Samoa	**Tolo Iosefa**, MOAF, Samoa
15:15-15:30	**Discussion**	

Technical Session IV A: World Café Discussion
(a) Priority Research Areas; (b) Capacity and Infrastructure Development; (c) Public Awareness; (d) Policy Advocacy; (e) Possible Partnership

Moderator	**Rishi K. Tyagi**, APAARI, Thailand	
15:30-17:30 (about 20 min. for a group of 7-8 participants on each table)	**Host/Facilitator:**	
	Table 1. Research	**Anuradha Agrawal**, NBPGR, India and **Geraldine Nemrod**, APAARI, Thailand
	Table 2. Capacity Building	**Martina Spisiakova**, APAARI, Thailand and **Celilu Bitong**, APAARI, Thailand
	Table 3. Infrastructure Development	**Frank Niranjan**, SLCARP, Sri Lanka and **Norah Omot**, APAARI, Thailand
	Table 4. Public Awareness	**M. Kamal Sheikh**, PARC, Pakistan and **Fai Collins**, APAARI, Thailand
	Table 5. Policy Advocacy	**K.S. Varaprasad**, Ex-ICAR, India and **Tarathip Sanboonkrong**, APAARI, Thailand
	Table 6. Possible Partnerships	**Birte Komolong**, NARI, PNG and **V.K. Sah**, APAARI, Thailand
	Compilation of Recommendations: (by all Hosts/Facilitators of each table; and finally to be handed over to Anuradha Agrawal and Martina Spisiakova)	

May 31, 2018

Technical Session IV B
Recommendations of World Café Discussion

Co-Chairs	**Reynaldo V. Ebora**, PCAARRD, Philippines and **Jan Helsen**, SPC, Suva	
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **Fai Collins**, APAARI, Thailand	
9:00-9:15	Compilation and Presentation of Recommendations	**Anuradha Agrawal**, NBPGR, India **Martina Spisiakova**, APAARI, Thailand
9:15-9:30	**Discussion**	

Technical Session V
Panel Discussion on Partnership and Innovative Funding Mechanism for Priority Areas in Agricultural Biotechnology to achieve SDGs

Co-Chairs	**Trilochan Mohapatra**, ICAR, India and **Su-San Chang**, PABP, Taiwan
Rapporteurs	**Frank Niranjan**, SLCARP, Sri Lanka and **K.S. Varaprasad**, Ex ICAR, India
09.30-10:50	Perception of Panellists (8 min each)
	Cherdsak Virapat, NACA, Thailand
	Roland Schafleitner, WorldVeg Centre, Taiwan
	Tracy Powell, USAID, USA
	Tin Htut, MOALI, Myanmar
	Anil Kumar Anal, AIT, Thailand
	Wen-Chin Yang, ABRC, Taiwan
	Karsidete Teeranitayatarn, IED, Thailand
	Shiv Kant Shukla, BCIL, India
10:50-11:00	**Discussion**
11:00-11:20	***Tea/Coffee Break***

Plenary Session

Co-Chairs	**Su-San Chang**, COA, Taiwan, **Siriporn Boonchoo**, DOA, Thailand, **Birte Komolong**, NARI, PNG, **Ravi Khetarpal**, APAARI, Thailand	
Rapporteurs	**Rishi K. Tyagi**, APAARI, Thailand and **Geraldine Nemrod**, APAARI, Thailand	
11.20-12:00	Presentation of Recommendations of Technical Sessions/ World Café Discussion	Technical Sessions I: **K.S. Varaprasad** Technical Session II: **Anuradha Agrawa**l Technical Session III: **Wangda Dukpa** *Technical Sessions IV: **Anuradha Agrawal** and **Martina Spisiakova** Technical Sessions V: **K.S. Varaprasad**
12:00-12:05	Brief Remarks by the Co-Organizers	**Su-San Chang**, PATB, Taiwan (on behalf of COA) **Siriporn Boonchoo**, Thailand (on behalf of DOA)
12:05-12:30	Remarks by the Co-Chairs	**Birte Komolong**, NARI, PNG **Su-San Chang**, COA, Taiwan **Ravi Khetarpal**, APAARI, Thailand
12:30-12:35	Vote of Thanks	**Rishi Tyagi**, APAARI, Thailand
12.35-13.35	***Lunch (Greenery Café, Ground Floor)***	

**Presented during Technical Session IV B*

Appendix 4
Organizing Committee

Dr Yusuf Zafar, APAARI, Thailand	Chairman
Dr Ravi Khetarpal, APAARI, Thailand	Co-Chairman
Dr Rishi Tyagi, APAARI, Thailand	Co-Chairman
Dr Norah Omot, APAARI, Thailand	Member
Mr Fai Collins, APAARI, Thailand	Member
Mr V.K. Sah, APAARI, Thailand	Member
Ms Thansita Tanaphatrujira, APAARI, Thailand	Member
Ms Celilu Bitong, APAARI, Thailand	Member
Ms Tarathip Sanboonkrong, APAARI, Thailand	Member
Ms Geraldine Nemrod, APAARI, Thailand	Member
Ms Lorene Siegwart, APAARI, Thailand	Member

Appendix 5
Photo Gallery

Participants of Expert Consultation

Registration by participants

APAARI officials receiving guests

Dignitaries during Inaugural Session

Releasing of APAARI publications

Inaugural Session

Yusuf Zafar, APAARI

Chung-Hsiu Hung, COA

T. Mohapatra, ICAR

Rajeev Varshney, ICRISAT

Andrew Alford, ACIAR

Siriporn Boonchoo, DOA

Felicitation of Dignitaries by Executive Secretary, APAARI

Chung-Hsiu Hung, COA

Yusuf Zafar, APAARI

T Mohapatra, ICAR

Siriporn Boonchoo, DOA

Andrew Alford, ACIAR

Rajeev Varshney, ICRISAT

Participants Corner






World Café Discussion





Cultural Corner for Relaxation and Dinner




Plenary Session and Good Bye!

Dignitaries in Plenary session

Anuradha Agrawal, ICAR, presenting recommendations

Martina Spisiakova, APAARI, presenting recommendations

K.S. Varaprasad, Ex ICAR, presenting recommendations

Ravi Khetarpal concluding the Plenary Session

Rishi Tyagi proposing Vote of Thanks

Signing of MoU between APAARI and FARA - Regional Collaboration

Signing of MoU between APAARI and FARA

Exchanging of MoU between APAARI and FARA

Thumps up APAARI team!

Dedicated and happy APAARI team

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