



World Vegetable Center



Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific

Taichung, Taiwan; 1-3 November 2016



Proceedings and Recommendations

Organizers

Asia-Pacific Association of Agricultural Research Institutions (APAARI)
Council of Agriculture (COA)
Australian Centre for International Agricultural Research (ACIAR)
World Vegetable Center (AVRDC)
Asian Farmers Association for Sustainable Rural Development (AFA)



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PROCEEDINGS AND RECOMMENDATIONS

Editors

Bhag Mal, Shyam Sunder Singh and Raghunath Ghodake

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Council of Agriculture (COA)

Australian Centre for International Agricultural Research (ACIAR)

World Vegetable Center (AVRDC)

Asian Farmers Association for Sustainable Rural Development (AFA)

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The Organizers

The Asia-Pacific Association of Agricultural Research Institutions (APAARI)

The Asia-Pacific Association of Agricultural Research Institutions (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. For more details, please visit: <http://www.apaari.org>

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AVRDC – The World Vegetable Center, an international non-profit research and development institute, is committed to alleviating poverty and malnutrition in the developing world through the increased production and consumption of nutritious and health promoting vegetables. From its founding mandate in 1971 to support vegetable research and development in tropical Asia, AVRDC – The World Vegetable Center has expanded its focus to serve more continents, more countries, and more people. Today, Center researchers lead and participate in projects throughout Asia, Africa, Central America, and Oceania. We have 300 staff engaged in this spread of activities, and seek to partner with governments, nongovernmental organizations, universities, research institutes, and the private sector to promote prosperity for the poor and health for all. For more details, please visit the website: <http://www.avrdc.org>

Asian Farmers Association for Sustainable Rural Development (AFA)

The Asian Farmers Association for Sustainable Rural Development (AFA) is a regional alliance of national federations and organizations of small scale women and men farmers and producers. It was established in 2002 after a series of farmer exchange visits organized by its strategic NGO partner, AsiaDHRRA (Asia Partnership for the Development of Human Resources in Rural Asia). In these five farmer exchange visits, conducted over three years, farmers saw the great need to come, share, learn and act together towards their common desire for a better quality of life for themselves, their families, and their farming communities. AFA invites national farmers' organizations as members and works with NGOs in facilitating the formation of national farmers' organizations and in continuously building their capacities. It convenes a General Assembly every two years and an Executive Committee meeting every semester. For more information, please visit the website: <http://www.asianfarmers.org>

Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific

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Contents

Foreword	ix
Acknowledgements	xi
Acronyms and Abbreviations	xiii
Introduction	1
Objectives	3
Inaugural Session	4
Technical Sessions	6
Technical Session I. Models and Case Studies of Agri-food Innovations	6
Working Groups	
Working Group 1: Micronutrient deficiency in human populations	7
Working Group 2: Dairy production and food safety	8
Working Group 3: Pesticide residues	8
Technical Session II. Partnership for Agri-food Innovations	9
Working Groups	
Working Group 1: Institutional partnership in generating innovations	10
Working Group 2: Add value partnerships in innovations	10
Technical Session III. Capacity Development in Agri-food Innovations	11
Working Groups	
Working Group 1: Capacity development for agri-food innovations	11
Working Group 2: Socioeconomic dimensions of agri-food innovations	13
Technical Session IV. Technology Based Agri-food Innovations	13
Working Groups	
Working Group 1: Strategies to innovate in agri-food systems	14
Working Group 2: Technology for agri-food innovations	15
Technical Session V. Knowledge Management on Agri-food Innovations	16
Technical Session VI. Policy Oriented Agri-food Innovations	19
Working Groups	
Working Group 1: Agri-food innovation policies	19
Working Group 2: Financing agri-food innovations	20
Final Plenary and Concluding Session	21
Key Recommendations	25

Extended Summaries of Presentations

Framework for Exploring Different Models of Innovation and Partnership – <i>Andy Hall</i>	33
Analysis of ACIAR Project Case Studies – <i>Miriam McCormack, Andrew Alford Julien de Meyer and Mellissa Wood</i>	40
Designing Environmental Research for Impact – <i>C.A. Campbell, E.C. Lefroy, S. Caddy-Retalic, N. Bax, P.J. Doherty, M.M. Douglas, D. Johnson, H.P. Possingham, A. Specht, D. Tarte and J. West</i>	47
Facilitating Multistakeholder Partnerships to Support Farmer Innovation in Food and Agriculture - Lessons from PROLINNOVA Nepal – <i>Dharma Raj Dangol, Suman Shekhar Manandhar, Basanta Rana Bhat, Bharat Bhandari and Chesha Wettasinha</i>	66
Strengthening Capacities in Innovation Partnerships – <i>Myra Wopereis and Richard Hawkins</i>	70
Household Garden Interventions for Food and Nutrition Security – <i>Pepijn Schreinemachers and Gregory C. Luther</i>	72
Carrageenan as Plant Food Supplement Boosts Rice Productivity – <i>Jocelyn E. Eusebio</i>	76
Selective Breeding in <i>Kankrej</i> Native Breed of Cattle – <i>Suresh Acharya, Ashok A. Patel and Bharat S. Rathod</i>	83
Cadalmin™ Green Mussel Extract (Cadalmin™ GMe) for Use Against Joint Pain and Arthritis – <i>Kajal Chakraborty</i>	87
Facilitating and Monitoring Agricultural Innovation Systems: An Online/Blended Course for Employing Multi-Stakeholder or Innovation Platforms as a Vehicle for Agricultural Innovation and Development – <i>Iddo Dror and Steve Staal</i>	92
Innovations on Marketing of Wax Apple through ICT – <i>Hsieh-Liang Tsai, George C. Lin and Wen-Chi Huang</i>	100
NAVARA-The Wellness Rice from India – <i>Narayanan Unny Potteth</i>	106
Transition of Taiwan's Agricultural R&D Strategies from Efficiency-Driven to Innovation-Driven – <i>Hung-Hsi Lee</i>	110
A Successful Rural Innovation Policy: The Sixth Industry Initiative in Japan – <i>Osamu Koyama</i>	115

Annexures

Annexure I. Welcome Address	121
Annexure II. Introductory Remarks	123
Annexure III. Inaugural Address	126
Annexure IV. Perspective Outcomes	127
Annexure V. Technical Programme	129
Annexure VI. List of Participants	134

Foreword

The Asia-Pacific region is home to 60 per cent of the world population. At present, it has 4.7 billion people and 40 per cent of it is in the rural areas facing problems of poverty, food insecurity, hunger and malnutrition. Despite concerted efforts of the National Agricultural Research Institutions (NARIs) and National Agricultural Research Organizations (NAROs), the CGIAR Institutions, GFAR, FAO and other organizations to help increase food production and productivity, there are still enormous problems of access and distribution of food, alleviating poverty and sustainable use of natural resources in the Asia-Pacific Region (APR). Many resource-poor and smallholder producers and rural communities have yet to benefit from improved technologies and agricultural innovations.

There are a large number of agri-food innovations developed by researchers, policy makers, the private sector, financing institutions, self-help groups, CSOs and others. However, not all such innovations are successful and socioeconomically viable. A number of farmer-led innovations developed with the use of indigenous technology and blended with modern technology is proving to be successful. For realizing the full potential of successful agri-food innovations, it is important to have insights into the key issues that can influence the benefits to the smallholders. Considerable attention needs to be given to the best practices and lessons learned through case studies to illustrate the successes and failures. There is also a need to critically assess various types and kinds of agri-food innovations for their strengths, weaknesses, mechanisms and constraints. This will enable identifying the successful innovations for their potential scaling up and out to bring an impact at scale for the benefit of smallholder producers, rural communities and overall sustainable agricultural development. Also, crucial is to consider the enabling environment such as information communication technologies (ICTs), capacity development, policies, institutional framework, and markets as important determinants to bring about effective scaling up and scaling out.

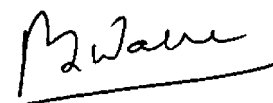
In view of the above considerations, the Asia-Pacific Association of Agricultural Research Institutions (APAARI) in partnership with the Council of Agriculture (COA), Taiwan; Australian Centre for International Agricultural Research (ACIAR), Australia, the World Vegetable Center (AVRDC), Taiwan; and the Asian Farmers Association (AFA), the Philippines organized an “Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific” on 1-3 November 2016 at Taichung, Taiwan. The overall purpose was to have in-depth deliberations/discussions and to develop a road map for scaling up and out the potential and successful agri-food innovations in the region.

The Consultation was organized in six technical sessions: i) models and case studies of agri-food innovations, ii) partnership for agri-food innovations, iii) capacity development in agri-food innovations, iv) technology based agri-food innovations, v) knowledge management on agri-food innovations and vi) policy oriented agri-food innovations. There were in-depth discussions which helped bringing out some major recommendations on the agri-food innovations for the benefit of smallholder producers, rural communities and overall sustainable agricultural

development. The recommendations include: i) there is need for strong cooperation amongst the organizations/ nations to facilitate the sharing and adaptation of tested policies, systems, institutional arrangements and bridging the required knowledge gap; ii) there is an urgent need for developing a road map and platform for innovative partnerships in the Asia-Pacific region; iii) capacity development for innovation should be based on a long-term strategy covering three interconnected dimensions - individual innovation capacity, organizational innovation capacity, and the creation of an enabling environment; iv) an innovation strategy needs to be apt and well-articulated in terms of providing the basis to beat the competition and create new space; v) concerted efforts are required in managing the knowledge on innovations in production process, postharvest handling, product processing, reduction of greenhouse gas emissions, climate change, and innovations in marketing, institutional development, capacity building, etc.; and vi) there is greater need for policy interventions in support of agri-food innovations and removal of all barriers in implementing policy, especially in path-breaking innovations such as health, diet, functional food supplements, organic farming, malnutrition, low-cost technology, IPR and biodiversity.

This publication summarizes the proceedings of the Expert Consultation and provides key recommendations. We highly appreciate the valuable contributions of the co-organizers and participants in making this event a big success. We also thank the editors - Dr Bhag Mal, Senior Consultant and Dr Shyam Sunder Singh, Consultant, for their intensive involvement in compilation, editing and bringing out this publication.

It is expected that the recommendations of this expert consultation will draw attention of policy-makers, administrators, researchers, industry leaders, farmers and other stakeholders in implementing them to promote scaling- up and scaling- out successful agri-food innovations to enhance productivity, efficiency and sustainability of agri-food systems in Asia and Pacific.



Raghunath Ghodake

Chairman, Organizing Committee and
Executive Secretary, APAARI

Acknowledgements

The sixty per cent of the world population (about 4.7 billion) lives in the Asia-Pacific region. Out of this, nearly 1.88 billion people live in rural areas under extreme poverty. The best possible pathway for reducing poverty of these people lies in adoption of the best practices and innovations in food security and agriculture. Keeping this in view, the “Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific” was organized by APAARI and its partners. The purpose was to catalyze policy/decision makers and sensitize stakeholders in agri-food research and innovations and to help promote scaling-up and scaling-out of successful agri-food innovations to enhance productivity, efficiency and sustainability of agri-food systems and to contribute to accomplishing the Sustainable Development Goals in Asia and the Pacific. The fruitful discussions among the experts in the field of agri-food innovations, policy makers and farmer representatives needed to develop a road map for scaling-up and out of the potential and successful agri-food innovations in the region.

We are grateful to the Co-organizers—the Asia-Pacific Association of Agricultural Research Institutions (APAARI), Council of Agriculture (COA), Taiwan; Australian Centre for International Agricultural Research (ACIAR), Australia; The World Vegetable Center (AVRDC), Taiwan and Asian Farmers’ Association (AFA), for Sustainable Rural Development, the Philippines for their support in successfully organizing the Expert Consultation. Sincere thanks are due to the Taiwan Agricultural Research Institute (TARI) and the COA, Taiwan for full support and cooperation in organizing the Expert Consultation including logistic arrangements. We also express thanks to TARI and AVRDC for arranging the field trip to the World Vegetable Center and Taiwan Orchid Plantation (TOP) sites.

We take this opportunity to extend our sincere thanks and deep sense of gratitude to Mr Chin-cheng Huang, Hon’ble Deputy Minister, COA, Taiwan and dignitaries in the Inaugural Session and all the Co-Chairs, Moderators, Panelists, Speakers, Conveners, Rapporteurs and Session Coordinators of the Technical Sessions and the Final Plenary Session. We sincerely thank all the participants of the Expert Consultation for their immense contributions through various sessions, presentations, and discussions which helped coming out with a series of recommendations as presented in this publication.

The scientific and professional staff of TARI, and staff of APAARI Secretariat deserve our sincere thanks and appreciation for their concerted and untiring efforts and invaluable contributions in making the consultation a great success.

Editors

Acronyms and Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ACE	Antarctic Climate and Ecosystems Cooperative Research Centre
ACEAS	Australian Centre for Environmental Analysis and Synthesis
AFA	Asian Farmers Association for Sustainable Rural Development
AIS	Agricultural Innovation System
AIMS	Australian Institute of Marine Science
AITDP	Agricultural Industry Technology Development Programme
APAARI	Asia-Pacific Association of Agricultural Research Institutions
AR	Apudthama Rangers
ANU	Australian National University
APR	Asia-Pacific Region
ATRI	Agricultural Technology Research Institute
AVRDC	The World Vegetable Center
AWC	Australian Wildlife Conservancy
BARC	Bangladesh Agricultural Research Council
BCYDC	Balkanu Cape York Development Corporation
BPH	Brown Plant Hopper
CABI	Centre for Agriculture and Bioscience International
CARP	Council for Agricultural Research Policy
CDAIS	Capacity Development for Agricultural Innovation Systems
CDU	Charles Darwin University
CERF	Commonwealth Environmental Research Facilities
CFF	Crops for the Future
CGIAR	Consultative Group on International Agricultural Research
CII	Confederation of Indian Industry
CIMMYT	International Maize and Wheat Improvement Center
CMFRI	Central Marine Fisheries Research Institute
COA	Council of Agriculture
COX	Cyclooxygenase
CPFS	Carrageenan as Plant Food Supplement
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSKHPKV	CSK Himachal Pradesh Krishi Vishvavidyalaya
CSO	Civil Society Organization
CSU	Charles Sturt University, Djelk: Djelk Rangers (Bawinanga Aboriginal Corporation)
DALY	Disability Adjusted Life Years
DFID	Department for International Development
DOA	Department of Agriculture

DOST	Department of Science and Technology
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FEAST	Feed Assessment Tool
FNCA	Forum for Nuclear Cooperation in Asia
FO	Farmer Organization
GA	Geoscience Australia
GAC	Girringun Aboriginal Corporation
GAP	Good Agricultural Practice
GBRMPA	Great Barrier Reef Marine Park Authority
GFAR	Global Forum on Agricultural Research
GHG	Green House Gas
GI	Geographical Indications
GISA	Go Incubation Board for Startup and Acceleration Firms
GLH	Green Leaf Hopper
GMO	Genetically Modified Organism
GU	Griffith University
HTML	Hyper Text Multiple Language
IACP	Industry-Academia Cooperation Programme
IAEA	International Atomic Energy Agency
IARC	International Agricultural Research Center
IAUA	Indian Agricultural Universities Association
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICRA	International Centre for Development Oriented Research in Agriculture
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information Communication Technology
IDRC	International Development Research Centre
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INR	Indian Rupees
IoT	Internet of Things
IP	Innovation Platform
IPM	Integrated Pest Management
IPR	Intellectual Property Rights
IRD	Intelligent Robotic Devices
IU	International Units
JCU	James Cook University
JIRCAS	Japan International Research Center for Agriculture Sciences
JPY	Japanese Yen
KIT	Royal Tropical Institute

KM	Knowledge Management
LCP	Link Control Protocol
LD	Lethal Dose
LISF	Local Innovation Support Fund
LLR	Lama Lama Rangers
LMS	Learning Management System
LOX	Lipoxygenase
MAF	Ministry of Agriculture and Fisheries
MAFF	Ministry of Agriculture, Forestry and Fisheries
MARDI	Malaysian Agricultural Research and Development Institute
MSC	Most Significant Change
MU	Macquarie University
MVic	Museum of Victoria
NABARD	National Bank for Agriculture and Rural Development
NAILSMA	Northern Australian Indigenous Land and Sea Management Alliance
NAP	Neo Agriculture Policy
NARC	Nepal Agricultural Research Council
NARI	National Agricultural Research Institute
NARO	National Agricultural Research Organization
NCPC	National Crop Protection Center
NCRIS	National Collaborative Research Infrastructure Strategy
NEF	Navara Eco Farm
NERP	National Environmental Research Programme
NGO	Non-Governmental Organization
NIF	National Innovation Facilitators
NOAEL	No-Observed Adverse-Effect Level
NRM	Natural Resource Management
NSAID	Non-Steroidal Anti-Inflammatory Drugs
NSWEOH	New South Wales Office of Environment and Heritage
NTLRM	Northern Territory Department of Land Resource Management
OECD	Organization of Economic Cooperation and Development
PABP	Pingtung Agricultural Biotechnology Park
PCAARRD	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PFS	Plant Food Supplement
PGP	Plant Growth Promoter
PID	Participatory Innovation Development
PNG	Papua New Guinea
PNRI	Philippine Nuclear Research Institute
PPP	Public Private Partnerships
PPVFRA	Protection of Plant Variety and Farmers Right Act
PRA	Participatory Rural Appraisal

PROLINNOVA	Promoting Local Innovations
PUFA	Polyunsaturated Fatty Acids
PV	Parks Victoria
R4D	Research for Development
RAF	Regional Aquafeed Forum
RAPA	Rainforest Peoples Aboriginal Alliance
RF	Rheumatoid Factor
RFO	Regional Field Offices
RMIT	Royal Melbourne Institute of Technology
RRA	Rapid Rural Appraisal
S&T	Science and Technology
SAC	SAARC Agriculture Centre
SDAU	Sardarkrushinagar Dantiwada Agricultural University
SDG	Sustainable Development Goals
SME	Small and Medium Entrepreneur
SPS	Sanitary and Photosanitary
TAP	Traceable Agricultural Product
TARI	Taiwan Agricultural Research Institute
TATM	Taiwan Agriculture Techno Mart
TERN	Terrestrial Ecosystem Research Network
TNAU	Tamil Nadu Agricultural University
TOP	Taiwan Orchid Plantation
TSRA	Torres Strait Regional Authority
TT	Technology Transfer
TWADA	Taiwan Wax Apple Development Association
UAS	University of Agricultural Sciences
UMelb	University of Melbourne
UNITECH	University of Technology
UPLB	University of the Philippines Los Banos
UQ	University of Queensland
USB	Universal Serial Bus
USD	United States Dollar
USyd	University of Sydney
UTAS	University of Tasmania
UTS	University of Technology Sydney
UWA	University of Western Australia
VAAS	Vietnam Academy of Agricultural Sciences
VCSGUUHF	V.C.S.G. Uttarakhand University of Horticulture and Forestry
VDEPI	Victorian Department of Environment and Primary Industries
WGAG	Wunambal–Gaambera Aboriginal Corporation
WorldVeg	World Vegetable Center
WLML	Warrdeken Land Management Limited
WTMA	Wet Tropics Management Authority.

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Taichung, Taiwan; 1-3 November 2016

Introduction

The Asia-Pacific region is the home for 60 per cent of the world population. At present, it has 4.7 billion people and 40 per cent of it is concentrated in the rural areas facing problems of poverty, food insecurity, hunger and malnutrition. Despite concerted efforts of the National Agricultural Research Systems (NARIs) and National Agricultural Research Organizations (NAROs), the Consultative Group on International Agricultural Research (CGIAR) Institutions, Global Forum on Agricultural Research (GFAR), Food and Agriculture Organization of the United Nations (FAO) and other organizations to increase food production and productivity, there are still enormous problems of access and distribution of food, alleviating poverty and sustainable use of natural resources in the Asia-Pacific Region (APR). Many resource-poor and smallholder producers and rural communities have yet to benefit from improved technologies and agricultural innovations.

Innovation system stresses on application of knowledge by different actors to the production of goods and services that are new to them irrespective of whether they are new to their competitors, their countries or the world. The learning and innovation are closely linked with inclusive and sustainable development which is now considered extremely important for making smallholder farming efficient and viable. The agricultural innovations can be of diverse types, namely, technological, institutional, organizational, policy oriented, mixed and integrated systems, partnerships, networking, markets, value chains, financing and investment, capacity development, national and regional integration. The innovation system's approach allows understanding the context including the policy environment as well as the actors, their competencies, habits, attitudes, practices, linkages, needs, gaps, etc. The innovation is a continuous process and needed for social and economic development. The smallholder producers in different agroecological environments need context-specific innovations and hence appropriate strategies need to be developed to meet their needs through such innovations. Therefore, the smallholder farmers must be part of analysis of the options, the decision-making as well as the implementation.

In Asia-Pacific region, there are a number of best practices in agri-food innovations, especially targeting smallholder producers. These innovations need to be documented, characterized and facilitated for upscaling and outscaling for the benefit and wellbeing of smallholder producers in the entire food value chain.

- Upscaling of innovations will include participation of different actors and organizations along the value chains, from primary production to value addition, waste minimization, marketing and consumption, for enhancing benefits to much wider beneficiaries.

- Outscaling of innovation refers to use and application of innovations in similar or different environments for wider participation and benefits across space.

Features of best practice in agri-food innovation may include:

- Innovation which is based on and developed around a central concept/ idea and principles of intervention/ change, could be technical, policy, institutional, partnership, etc. in agri-food development.
- Willing participation of relevant actors, partners and organizations in various processes and stages of agri-food innovations, leading to economic, social and environmental benefits and overall sustainability.
- Pragmatic, effective and self-adjusting arrangement of participation, actions and interactions towards positive and sustainable development for the benefit of all partners involved.
- Innovation that has positive benefits to women, youth and the marginalized and disadvantaged groups of the society.
- Innovation that has proven potential to be upscaled and outscaled to bring impact at scale for wider benefits.
- There are a large number of agri-food innovations developed by researchers, policy makers, private sector, financing institutions, self-help groups, non-governmental organizations (NGOs) and others. However, not all such innovations are successful and socioeconomically viable. A number of farmer-led innovations developed with the use of indigenous technology blended with modern technology are proving to be successful. For realizing the full potential of successful agri-food innovations, it is important to have insights into the key issues/areas that can influence the benefits to the smallholder producers. Considerable attention needs to be given to the best practices and lessons learned using case studies to illustrate the successes and failures. There is also a need to critically assess various types and kinds of agri-food innovations for their strengths, weaknesses, mechanisms and constraints. This will enable identifying the successful innovations for their potential upscaling and outscaling to bring an impact at scale for the benefit of smallholder producers, rural communities and overall sustainable agricultural development. Also, crucial is to consider the enabling environment such as information communication technologies (ICTs), capacity development, policies, institutional framework, and markets as important determinants to bring about effective up-scaling and out-scaling.

The innovation process must be inclusive; take on board, farmers' circumstances and adopt a longer term perspective. New capacities for research, science, innovation and business need to be developed and nurtured. The knowledge infrastructure to support the domestication of the innovation systems approach, strengthened policy coherence, strategic visioning, increased investments in research and innovation are also needed.

In view of the above considerations, the Asia-Pacific Association of Agricultural Research Institutions (APAARI) jointly with the Council of Agriculture (COA), Taiwan; Australian Centre

for International Agricultural Research (ACIAR), the World Vegetable Center (WorldVeg), Taiwan; and the Asian Farmers Association (AFA), the Philippines jointly organized an Expert Consultation on Best Practices in Successful Agri-food Innovations in Asia and the Pacific on 1-3 November 2016, to have pertinent deliberations/discussions and to develop a road map for upscaling and outscaling of the potential and successful agri-food innovations to enhance productivity, efficiency and sustainability of agri-food systems and to contribute to accomplishing the Sustainable Development Goals in Asia and the Pacific. The Expert Consultation was attended by 87 participants including researchers, policy makers, innovative farmers and representatives of various organizations including NARIs, NAROs higher education institutions, the private sector, civil society organizations (CSOs- NGOs, FOs), women and youth representatives, CGIAR Centres, and International Agricultural Research Centers (IARCs).

The purpose of the consultation was to catalyze policy/decision makers and sensitize stakeholders in agri-food research and innovations and to embrace successful agri-food innovations for upscaling and outscaling in Asia and the Pacific. The consultation was organized into 6 technical sessions: i) models and case studies of agri-food innovations with 3 working group sessions each on a) micronutrient deficiency in human populations, b) dairy production and food safety, and c) pesticides residues; ii) partnership for agri-food innovations with 2 working group sessions on a) institutional partnership in generating innovations and b) add value partnership in innovations; iii) capacity development in agri-food innovations with 2 working group sessions on a) capacity development for agri-food innovations and b) socioeconomic dimensions of agri-food innovations; iv) technology based agri-food innovations with 2 working group sessions on a) strategies to innovate in agri-food systems and b) technology for agri-food innovations; v) knowledge management on agri-food innovations with panel discussion; and vi) policy oriented agri-food innovations with 2 working group sessions on a) agri-food innovation policies and b) financing agri-food innovations. The in-depth discussions were held in all the sessions and the outcomes of the discussions were presented in the plenary session by the session coordinators.

Objectives

The specific objectives of the expert consultation were as follows:

- To document and discuss best practices in agri-food innovations for validating, refining and disseminating for wider adoption.
- To assess the strengths, weaknesses, mechanisms, constraints, and likely impact of successful agri-food innovations.
- To identify the gaps in enabling environment in areas such as technologies, policies, institutional arrangement, and knowledge infrastructure for improving access, applicability and effective use of successful agri-food innovations.
- To assess the need for necessary policy intervention, advocacy and capacity development for upscaling and outscaling of potentially successful agri-food innovations for the larger and wider impact at scale for the benefit of resource poor smallholder producers and rural communities, more specifically of women and youth.

Inaugural Session

Welcome: *Marco C.S. Wopereis*, Director General, The World Vegetable Center (AVRDC), Taiwan

Introductory Remarks: *Waraporn Prompoj*, DDG, Department of Agriculture, Thailand

Inaugural Address: *Chin-cheng Huang*, Hon'ble Deputy Minister, COA, ROC, Taiwan

Perspective Outcomes: *Raghunath Ghodake*, Executive Secretary, APAARI, Thailand

The Expert Consultation on Best Practices in Agri-food Innovations In Asia and the Pacific commenced with a welcome address by **Marco Wopereis**, Director General, World Vegetable Center, Taiwan. He highlighted the problems of smallholder farmers including women facing poverty, hunger and malnutrition, climate change and degradation of natural resources in the Asia and Pacific region and the younger generation shifting to urban areas in search of jobs as the agriculture in not having profitable employment. He hoped that the Expert Consultation will show the way for economic growth in the region as the World Bank has already predicted the contribution of modern agriculture technologies and organizational structures in enhancing economic growth.

He mentioned that he has advised the government of Karnataka state in India to adopt modern agricultural and processing practices such as protected cultivation of vegetables for economic growth and employment opportunities to younger generation. He also mentioned that he has suggested the Government of Karnataka state in India to adopt all four thematic areas of APAARI's new 2017-2022 Strategic Plan - management and use of natural resources, manage risks and uncertainties in the agri-food system, inclusive development and integration of value chains, targeting smallholder farmers and need to think about public policies in order to increase vegetable production in the state where vegetable farmers are facing challenges of fluctuation of market prices, access to water and labor scarcity.

Wopereis hoped that expert consultation will take stock of best practices in agri-food innovations in Asia and the Pacific and show the way out for upscaling and outscaling of such innovations to enhance profitability in agricultural sector and entrepreneurship vis-à-vis improving economic condition of smallholder farmers in the region.

Waraporn Prompoj, Deputy Director General, Department of Agriculture, Thailand in introductory remarks on behalf of Suwit Chakiattiyos, Chairman, APAARI Executive Committee and Director General, Department of Agriculture, Thailand presented the scenario of the Asia-Pacific region. He highlighted that this region is the home for sixty per cent (4.7 billion) of the world population with forty percent of it are concentrated in the rural areas facing problems of poverty, food insecurity, hunger and malnutrition. In order to feed 9 billion people by 2050, there is need for advancement of economic development and reduction of pressure on the environment.

He emphasized that appropriate strategies to be developed as the context-specific innovations are needed in different agro-ecological environments for smallholder farmers since agricultural innovations are of diverse types. There is urgent need to document the successful agri-food innovations developed by all stakeholders including farmers after critical assessment and their

upscaling and outscaling in order to benefit smallholder producers, rural communities and overall sustainable agricultural development.

Prompoj stressed that there are tremendous opportunities, to develop information communication technologies (ICTs), new capacities, knowledge infrastructure, policy coherence, strategic visioning, increased investments in research and innovation as well as to catalyze policy/decision makers and sensitize stakeholders in agri-food research and innovations. This will lead to enhancement of production and alleviating hunger and malnutrition in the Asia and the Pacific.

He concluded that we have a good opportunity during the next three days to review and discuss major issues and develop a road map on strategies, options and priorities for upscaling and outscaling of successful agri-food innovations in the Asia and the Pacific. He suggested that APAARI will incorporate the outcomes and recommendations emerging from the Expert Consultation into its plans and activities.

Chin-cheng Huang, Deputy Minister, Council of Agriculture, ROC, Taiwan, in his inaugural address mentioned that the global population may reach 10.5 billion in 2050, with the doubled food demand. He showed a concern that the Taiwan is now facing many challenges impacting agricultural growth such as climate change, shortage and aging of agricultural labor and food safety, despite continuing growth in agricultural sector. He informed that by adoption of improved technologies like a food traceability system, intelligent robotic (IR) devices, the internet of things (IoT), information communication technologies (ICTs) and big data analysis, has impact on productivity, value addition and communication between stakeholder resulting in economic growth of the country.

He concluded his remarks by the statement that identification of best practices in agri-food innovations by the experts from Asia-Pacific countries and cooperation amongst all stakeholders will promote enhancement in productivity, efficiency and sustainability in this region.

Raghunath Ghodake, Chairman, Organizing Committee and Executive Secretary, APAARI in his remarks mentioned that the organizers of this consultation accepted the concept of agri-food innovations as the process whereby actors and partners (individuals or organizations) bring existing or new products, methods processes, technology, and forms of organization into social and economic use to increase effectiveness, competitiveness, resilience, sustainability, thereby contributing to food and nutritional security, economic development and sustainable natural resource management. He stressed upon the partnership mode which is instrumental in bring great impact economic growth.

Ghodake emphasized on understanding the concept of innovation which is a highly complex process and needs in depth discussion and analysis in turn to understand the practices. However, there is a need for identification of successful agri-food innovations by consultation for creating impact at larger scale. He hoped that the designed perspective on outcomes by APAARI would act as guiding principles on focusing key issues of agri-food innovations and suggest pathways to develop successful agri-food innovations and their upscaling and outscaling for the benefit of smallholder farmers including women in the Asia and the Pacific.

Technical Sessions

Technical Session I. Models and Case Studies of Agri-food Innovations

Co-Chairs: *Sharif Haron*, Director General, MARDI, Malaysia

Huu-sheng Lur, Distinguished Professor, National Taiwan University, Taiwan

Rapporteur: *Ramakrishna Akkinapally*, Deputy Director General, NARI, Papua New Guinea

Working Group Conveners:

Group 1: *Andy Hall*, Group Leader, AGCP, CSIRO, Australia

Group 2: *Andrew Alford*, Research Programme Manager, ACIAR, Australia

Group 3: *Andrew Campbell*, Chief Executive Officer, ACIAR, Australia

Session Coordinator: *Andrew Campbell*, Chief Executive Officer, ACIAR, Australia

In the lead paper on ‘Framework for exploring different models of innovation and partnership’, **Andy Hall (CSIRO)** mentioned that in order to improve agricultural innovation, the broad prescription is that research and technology needs to be better coupled with market and policy changes that allow ideas and solutions to be deployed. Australian and international agriculture sector players, however, continue to grapple with questions on how to implement this prescription. In particular on how to arrive at a mode of innovation that matches the ambition of transforming the performance and sustainability of the sector, both now and in the challenging years ahead.

He presented a framework to better understand the relationship between different innovation configurations (partnerships, networks, and practices) and impact. It assumes that while configurations are contextually specific, broad patterns of practices and partnership associated with innovation and impact would emerge. These patterns could then form the basis of a framework to better explain how the impact takes place, and point to tools and practices that increase the likelihood of innovation and impact.

He highlighted that the study approach was to undertake theory informed process analysis of the manner in which innovation and impact processes unfold over time. The key analytical perspective used was that of innovation systems, an empirically based concept underpinned by systems and evolutionary economics theories that explain the innovation process as a networked and socially embedded phenomenon, driven by evolutionary learning and systemic change. The innovation systems concept has emerged as a powerful tool for revealing the processes and capabilities associated with innovation. This framing was used to explore a series of case studies using secondary sources, backed up with interviews where possible.

Andy Hall indicated three modes of innovation which include: i) incremental innovation and system optimization - deliver incremental improvement of existing products and services or incremental improvement of value chain efficiencies that deliver marginal social, economic and environmental impact within specific production systems and value chains, ii) radical innovation and sub-system transformation – characterized by technological and / or market “step jumps” or discontinuities that open up new economic, social and environmental impact opportunities in a specific sub-sector or market sector and opens up new opportunities for incremental

innovation, and iii) transformative innovation and system transformation - deep systems changes underpinned by broad-based consensus that significantly advance the economic, social and environmental frontiers of the agricultural sector as a whole, and that open up opportunities for new waves of radical and incremental innovation.

Andrew Alford (ACIAR) analyzed four case studies from ACIAR work based on the innovation framework established in the preceding paper by Andy Hall. These case studies included: i) pearl industry development in the western Pacific (Tonga, Fiji, PNG), ii) development of cocoa and chocolate industry in Indonesia, Papua New Guinea (PNG), Solomon Islands, Vanuatu, Fiji and Samoa, iii) feed improvement for mariculture in Vietnam and Australia, and iv) beef cattle production in Eastern Indonesia.

These case studies project variables demonstrated incremental or radical innovation based on Hall's framework. The importance of partnerships in ACIAR projects that enables innovation to take place was highlighted. The application of the framework required reviewing the project in terms of:

- What initiated the project (Initiator)
- Critical features of project partners
- Role of research
- Operational alliances
- Strategic alignment of stakeholders at sector or national level
- Solution, product or system innovation
- Scope of impacts

He informed that the ACIAR projects demonstrated incremental innovation with (mariculture feed improvements, beef production in Eastern Indonesia) and radical innovation modes (pearl industry in the Pacific, Chocolate 'Bean to Bar'). The importance of enabling elements for innovation to occur include: partnerships - their scope and quality; alignment of stakeholder objectives; shared accountability; project champions; and project flexibility and adaptability and time to build trust amongst partners.

Working Group 1: Micronutrient deficiency in human populations

Convener: *Andy Hall*

The region including Asia and the Pacific is home to almost 62 per cent of the world's undernourished. Besides the calorie consumption deficit, the problem of under-nutrition is manifested in high rates of stunting in children below five years of age, while various micronutrient deficiencies prevail among people of all ages. This is despite existing regional research success stories regarding the development of innovative solution to address micronutrient deficiencies. Examples include submergence-tolerant rice and techniques to induce off-season flowering of mango, and possible future examples including 'high zinc' (plus iron) rice in Bangladesh and India; 'high zinc' (plus iron) wheat in India and Pakistan and 'high iron' pearl millet in India, as well as the region's golden rice. However, a few of these technologies have reached adoption at scale.

Working Group 2: Dairy production and food safety

Convener: *Andrew Alford*

The Asia-Pacific region plays an increasingly important role in the dairy industry, their strategies are also changing. Some countries in the region have embarked on a strategy to reduce its reliance on the export of whole milk powder to China for example. Some countries are now placing greater focus on skimmed milk powder and butter, and have expanded their market horizons.

Working Group 3: Pesticide residues

Convener: *Andrew Campbell*

An effective food safety management and reducing the risk of hazards from pesticide residues require not only adequate skills but also systems and institutions to develop policies based on sound research, regulate, enforce and monitor, i.e. governance. South-South Cooperation has the potential to facilitate the sharing and adaptation of tested policies, systems, institutional arrangements and bridge the required knowledge gap.

Key highlights:

- In order to improve agricultural innovation, there is need to link together research and technology with market and policy changes so that allows ideas and solutions to be deployed.
- To address the needs and sustainability of the sector, a framework is required to understand the relationship between different innovation configurations (partnerships, networks, and practices) and impact. This will lead to emergence of various patterns of practices and partnership associated with innovation and impact.
- The first framework needs to be developed to deliver incremental improvement of value chain efficiencies that deliver marginal social, economic and environmental impact with in specific production systems and value chains.
- The second framework on radical innovation and sub-system transformation needs to be established in order to have significant positive technological and market oriented change which can open up new opportunities for incremental innovation.
- Another framework on transformative innovation and system transformation that open up opportunities for new waves of radical and incremental innovation.
- There is strong need to strengthen partnerships; accountability, flexibility and adaptability; and building trust amongst partners for innovation to occur.
- Micronutrient deficiencies are most common among people of all ages and therefore there is an urgent need to focus on developing innovative solutions to address these deficiencies.
- There is need to have strong systems and innovations to develop policies based on sound research, regulation, enforcement and monitoring, i.e. governance.

Technical Session II. Partnership for Agri-food Innovations

Co-Chairs: *J.D.H. Wijewardena*, Director/Secretary, CARP, Sri Lanka
Mathew Prasad, Vice Chancellor, VCSGUUHF, India

Rapporteur: *Yashpal Singh Saharawat*, Country Manager, ICARDA, Afghanistan

Working Group Conveners:

Group 1: *Suhas P. Wani*, Research Programme Director, ICRISAT, India

Group 2: *Rudrappa Giraddi*, Dean (Agriculture) UAS, Dharwad, India

Session Coordinator: *J.L. Karihaloo*, Senior Consultant, APAARI, India

Andrew Campbell (ACIAR) made a presentation on ‘Designing collaborative multi-institutional research for impact’. Successful multi-institutional trans-disciplinary research is necessarily a joint enterprise between funding agencies, researchers and the end users of research. Andrew Campbell elaborated his study conducted in five provinces of Australia, which included more than five hundred researchers from different fields including climate, energy, water and irrigation, and food science. He emphasized that global emissions of green house gases (GHG) from energy, transportation and other sectors are reducing, whereas, emissions from agriculture are increasing. The studies showed that share of agriculture on global emission had reached up to 70 per cent. Therefore, the challenge to current agriculture is how to assure growth, how to adapt to climate change, how to increase water productivity, energy productivity and food productivity? These are complex issues which require trans-disciplinary research involving researchers, managers, planners, policy makers and end-users. He also emphasized that success in trans-disciplinary science demands leadership, scientific competence, shared goals and strategic planning, continuity, flexibility in action, adaptability and proficient programme management. Knowledge is the intermediary process that involves information generation and its sharing through better linkage and match making through focused and strategic collaboration. He further opined that presently scientist-policy interface lacks trust and to build the trust, durable relationships and synergy among researchers, professional institutes and political leadership are needed.

Suman Manandhar (PROLONNOVA) made a presentation on ‘Facilitating multi-taskholder partnership to support farmer innovation in food and agriculture: Lessons from PROLONNOVA, Nepal’ and informed that PROLINNOVA (Promoting Local Innovations) is a community of practice in ecologically oriented agriculture and natural resource management involving partners in Africa, Asia and Latin America. This Global Partnership Programme embraces both state and non-state organizations and promotes recognition of local innovations by women and men farmers as an entry point to farmer-led participatory innovation development. The PROLINNOVA business model stresses that any innovation should be technologically and economically feasible, gender balanced, easily disseminable, environment friendly, and socially acceptable. PROLINNOVA Nepal was established in 2004 as a multi-stakeholder partnership organization to promote farmer innovation and participatory innovation development. It was the first country platform within the international network to organize National Farmer Innovation Fair. Its partners have conducted large capacity development programmes within agricultural research and development organizations and pioneered Local Innovation Support Fund as a means of funding farmers’ research.

Working Group 1: Institutional partnership in generating innovations

Convener: *Suhas Wani*

Key highlights:

- Partnership is a co-evolving process based on shared vision and depends on what kind of change/innovation is required i.e. incremental, transformational, etc.
- Transdisciplinary and multi-stakeholders partnerships for innovations are needed between funding partner, technical/ implementing partner, policy partner, and end users.
- There must be institutionalization of partnerships for greater impact.
- Partnerships should be transparent, flexible and based upon mutual trust and not expect too much from each other in shorter terms.
- Holistic, heterogeneous and cohesive partnerships which include all actors of value chain.
- Due diligence should be taken into account before making partnership.
- Partners should be complimentary and supplementary with positive mindset of top management and tangible outputs.
- For public-private partnership to become successful, barrier breaking actors or facilitation mechanisms are needed.
- The partners should be clear whether partnership is for social cause or financial cause.
- There was a general agreement that innovations and partnerships are often accidental and not planned.

Working Group 2: Add value partnerships in innovations

Convener: *Rudrappa Giraddi*

Key highlights:

- The complexity of agricultural production and consumption system necessitates creation of partnerships among diverse stakeholders that add value to food production-consumption chains through combined and synergistic efforts.
- One successful add value agri-food innovation that can serve as example is UAS, Dharwad, India; McGill University Canada; International Development Research Centre (IDRC) Delhi, farmer and local NGOs partnership leading to increased cultivation of millets, processing, value addition, and marketing of millets based food products. This partnership is resulting in availability of nutritious food, enhanced income of farmers, local industries and other stakeholders.
- Protected vegetable cultivation in hilly regions involving participation of university-polyhouse industry – farmers has resulted in increased income to farmers.

- Researchable issues like food processing without loss of nutrients, packaging and shipping (cold/non-cold chain), and development of small machinery for farm gate food processing should be addressed.
- Development of incubation centres to promote and upscale local agri-food innovations in public-private partnership mode.
- Encourage adoption of good agricultural practices, sanitary and phytosanitary protocols and product labelling.
- Availability of market intelligence to strategize production and marketing.
- Ensure fair distribution of profits among all actors in the value chain.
- Participation of cooperative societies and NGOs in technology dissemination.

Technical Session III. Capacity Development in Agri-food Innovations

Co-Chairs: *Reynaldo V. Eborá*, Acting Executive Director, PCAARRD, Philippines
Ashok Kumar Sarial, Vice Chancellor, CSKHPKV, India

Rapporteur: *Kabir Uddin Ahmed*, Principal Scientific Officer, BAARC, Bangladesh

Working Group Conveners:

Group 1: *Myra Wopereis-Pura*, Global Project Coordinator, CDAIS, France

Group 2: *Esther Penunia*, Secretary General, AFA, Philippines

Session Coordinator: *Syed Ghazanfar Abbas*, Consultant, APAARI, Thailand

Myra Wopereis-Pura (ICRA) made a presentation on ‘Capacity development for agricultural innovation systems’ and discussed strengthening of capacity through individual, organizational and institutional levels and focusing on both technical and functional capacities. In summary, it was revealed that in order to achieve lasting positive changes, collective actions and investments by all the partners are urgently needed.

Pepijn Schreinemachers (World Vegetable Center) while making his presentation on ‘Household garden interventions for food and nutrition security’ described that the micronutrient malnutrition is the main problem in rural communities and it is increasing over the years in almost all over the world. The presentation dealt with the importance of household garden interventions in addressing the issue of malnutrition by ensuring the year-round supply of a diverse range of fruits and vegetables from a household-managed garden. Sharing of partner institutions experience especially protected vegetable cultivation in India and defining household garden size for rural and urban communities were emphasized on queries by participants. It was emphasized that that without adequate investment by the governments and collaboration among APAARI partners, it is difficult to eradicate micronutrient malnutrition especially in developing countries.

Working Group 1: Capacity development for agri-food innovations

Convener: *Myra Wopereis-Pura*

Key highlights:

- Capacity building is an important aspect with regard to solving the complex problems (climate change, etc.) which need the collaboration of many agencies and actors. The capacity in agri-food innovations area will need to be built individually to work collectively.
- Technical capacities are usually well developed, but functional capacities (partnering skills, dealing with complexity, etc.) are mainly missing. This leads to missed opportunities because people's vision of both challenges and opportunities is too narrow to navigate how to transform innovation process that can actually be made to happen.
- Target groups need to be identified for training based on their background knowledge and skill in continuous manner with advancement in technology. Building confidence on gaining training should be aimed so as to empower them to be competitive and independent entrepreneurs in agri-business.
- The essential element of capacity development is the capacity development plans based around needs assessment or diagnostic exercises to understand priority needs. This should focus on individual, organizational and systems capacity needs.
- In the individual capacity prioritization, it is important to target the correct groups of actors. It was suggested that there may be a hierarchy of training needs with farmers needing attention first. Of course, support to farmers will be effective if other parts of the innovation system are also strengthened.
- A large part of the capacity building need concerns the need for stronger collaboration across organizations. Strengthening collaboration is going to need the brokering of new relationships. However, underpinning this needs to be significant attitudinal change, particularly helping shift from a competitive to a collaborative outlook. This builds connections and social capital that can be used in subsequent collaborations.
- There are already existing bodies of capability in existence. Efforts are needed to develop platforms that bring together these different bodies of capability.
- Partnerships between organizations are often going to need financial support to make them an operational relationship. This suggests that investment is always going to be needed to strengthen enhanced patterns of collaboration.
- Efforts to build the capacity of agri-food innovation systems are going on, accompanied by some way of judging the health of particular innovation systems. Innovation systems in different countries are going to operate differently due to historical patterns of institutional development and the differing contexts of key challenges. However, ways will need to be found to assess whether innovation system capacity is improving and is fit for the purpose for particular set of contextual issues it is dealing with. This will be important in evidencing the value proposition of capacity building of this sort.
- This new form of capacity building for innovation, with its emphasis on institutional change as well as skill development requires strong political will to drive it and to legitimize it. APAARI could play a critical role in documenting and sharing experiences in mobilizing political will across the Asia-Pacific region.

Working Group 2: Socioeconomic dimensions of agri-food innovations

Convener: *Esther Penunia*

Key highlights:

- Product innovation should be more specific, targeting consumer specifics. e.g. personalized fruit sizes depending on family sizes.
- Build capacities to scope and analyze changing socioeconomic dimensions, capacity to provide these learnings to inform the innovative platforms in countries. APAARI can work with organizations such as the International Food Policy Research Institute (IFPRI) to look at developing capacities.
- Consider the risks, provide farmers an element of control. Risks can also be the impetus for innovations.
- Build partnerships in innovative platforms, broadening the scope of partnerships (to include youth, NGOs, farmer's organizations, correctional institutions, and women). Such collaboration should have participatory nature.
- Need capital costs for farmers so they can accept innovation.
- Consider time required for innovations.
- Steps should be taken to provide safety nets as well as economic returns for farmers when they are taking a new innovation.

Technical Session IV. Technology Based Agri-food Innovations

Co-Chairs: *Yama Raj Pandey*, Executive Director, NARC, Nepal
N.K. Krishna Kumar, Regional Representative for South and Central Asia, Bioversity International, India

Rapporteur: *Srinivasan Ramasamy*, Entomologist, The World Vegetable Center, Taiwan

Working Group Conveners:

Group 1: *Bui Quang Dang*, Director, VAAS, Vietnam

Group 2: *Abdul Halim*, Professor & Head, UNITECH, Papua New Guinea

Session Coordinator: *Shyam Sunder Singh*, Consultant, APAARI, India

Reynaldo Eborá (PCAARRD) made presentation on 'Carrageenan technology for rice in the Philippines' on behalf of his colleague Jocelyn Eusebio. Carrageenan is an indigestible polysaccharide extracted from red edible sea weed species (*Eucheuma cottonii* and *E. spinosum*). The extract is degraded by radiation to develop bioactive agents (oligo-carrageenan). carrageenan as plant food supplement (CPFS) makes the rice stem stronger and thus resist lodging. It increases the resistance to rice tungro virus and bacterial leaf blight in multi-location trials. It is applied as foliar spray at 12-14 days after transplanting and thereafter three applications at 15 days interval. It is also compatible with farmers' fertilizer application practices. Overall, it significantly increases the yield. Besides, it reduces the application of chemical pesticides and fertilizers. The actual mechanism is still under elucidation. Hence, this technology has a high potential for scaling- up. Almost 2,000 hectares of rice farms have been sprayed with CPFS in Regions 2 and 3 in the northern Philippines.

The economic value of carrageenan application against using commercial fertilizers and pesticides is that instead of using 9 bags of fertilizers, farmers use only 3 bags when they apply carrageenan. Hence, they save the expenses of 6 bags of fertilizers. The cost of carrageenan is only 10 per cent of the cost of chemical fertilizers. Carrageenan is sulfonated polysaccharides and it has carcinogenic properties and hence, it is prohibited from using in food products, while it is commonly used in products like tooth-paste and other pharmaceutical products. In addition, the quantity used is much less, and hence it is considered safer. The product itself is not radioactive; it is just exposed to radiation (just like sterilization). However, more research will be carried out in the future to confirm its biosafety.

Suresh Kumar Acharya (SDAU) presented an overview on ‘Herd improvement in Kankrej native breed of cattle’. Sardarkrushinagar Dantiwada Agricultural University (SDAU) is conserving and improving the native breeds of North Gujarat, as part of the genetic improvement programme. *Kankrej* cattle breed is highly adapted to adverse climatic conditions such as high temperatures and inordinate water scarcity. This breed requires less quantity of fodder compared to other breeds, and thus coping well with low fodder productivity which is characteristic of dry and hot weather. Thus, its milk production is much better during harsh summer, when the milk production of other breeds is drastically reduced. In the last four decades, its productivity increased from 977 litres/lactation to 3,150 litres/lactation (mainly because of an increase in lactation period by 81 days) through arduous selection programme. Calving interval has gone down from 472 days to 390 days. SDAU scaled-up only in forty villages entailing 10,000 breedable females. The fat in milk is 6-7 per cent which is very high. In order to check inbreeding and genetic drift, the best proven bull is assigned to nucleus herd only after pedigree tree of each breedable female is checked for six generations and the other proven bulls are assigned to best breedable females in associated herds.

Kajal Chakraborty (ICAR) made a presentation on ‘CadalmiTM green mussel extract (CadalmiTM GMe) for use against pain and arthritis’. CadalmiTM GMe contains 100 per cent natural marine bioactive anti-inflammatory ingredients derived from Asian green mussel, *Perna viridis* (family Mytilidae). The active ingredients inhibit arachidonate oxygenation by COX-2/5-LOX pathways, and thus decreasing pro-inflammatory prostaglandin / leukotriene synthesis and down regulating the inflammatory sequence. Thus, CadalmiTM GMe is a potent, but relatively slow-acting anti-inflammatory agent. The product is also proved to be safe, and an effective alternative to synthetic non-steroidal anti-inflammatory drugs (NSAIDs). It has high shelf-life. This technology was developed in 2012 and commercialization is being done by private companies in India, namely, Celestial Biolabs, Hyderabad, India; Accelerated Freeze Drying Company Ltd., Cochin, India.

Working Group 1: Strategies to innovate in agri-food systems

Convener: *Bui Quang Dang*

Key highlights:

- Incubation centres may be good option to get involved into before innovation as well as after innovation for scaling-up purpose.
- Business development model needs to be prepared for the innovations to be handed over to people if we intend to invite private sectors in upscaling the innovations.

- Investment in agriculture innovation is vital for growth and improvement in the productivity, profitability, competitiveness and sustainability.
- The nutrition as well as food security needs to be seen from different perspectives. As the urban population is growing gradually day by day, the quality aspects as well as the volume (quantity) of agri-products will be in greater demand.
- The women farmers who are not fully employed can be engaged in roof top gardening and take care of agricultural waste like plastics, etc.
- There should be marriage between IT and agriculture. There is urgent need to fully utilize the IT into production as well as marketing.
- The farmers are getting lesser portion of the benefits in the supply chain resulting in ineffective supply chain performance. As land area is shrinking it is needed to promote integrated approach of plantation like boundary plantations, etc. hence cost : benefit analysis should be made for the innovations before it is disseminated.
- As a long-term strategy to improve economic security at the farm greater thrust needs to be given for reducing production costs, increasing the value of farm products, and diversifying income streams.
- Diversification of crop and livestock enterprises represents an important component of many modern sustainable agricultural systems. However, there has been growing attention to efforts of some farmers to diversify their income by developing alternative agriculturally related enterprises and marketing strategies

Working Group 2: Technology for agri-food innovations

Convener: *Abdul Halim*

Key highlights:

- Role of technology development is the key in agriculture and farmers' economic condition which should improve through such innovations.
- Crops which require more water like paddy and sugarcane should be replaced by other less-water requiring crops.
- There is urgent need to minimize post-harvest and storage losses.
- There should be robust biosafety and quarantine policies in order to prevent large scale loss of biological integrity, focusing both on ecology and human health. The plant protection specialists have a major role to play not only in promoting and facilitating export and import in the interest of their respective nations but also in protecting the environment from the onslaughts of invasive alien pests and unforeseen ill-effects of the introduction and trading in genetically modified organisms (GMOs).
- The innovations should be made as simple as possible so that farmers can adopt it easily without any complications. For example, vegetables produced in poly tunnels / plastic tunnels is simple technology where farmer can earn more money.

- Agricultural extension is about sharing scientific findings and know-how with farmers and helping them capture a greater share of the value chain. Farmer-to-farmer extension is the best and cheapest means of dissemination of the innovation.
- Emphasis should be not only the promotion of crops but also on fisheries and animal husbandry.
- Cage culture in marines need to be best utilized as the cultivable land is shrinking.
- There is a need of strong database before any inference can be drawn from the innovations.
- The new technology or innovation should be context, location and season specific. Blind dissemination of any untested innovations should be avoided and discouraged.
- Agrobiodiversity (including crops, forestry, weeds, rivers, animals) should be promoted by supporting the various research agendas that have already been developed by organizations and groups aiming to increase the effective use of biodiversity for food and agriculture.
- Since high density planting system of cotton in India is simple technology which cost about Indian rupees (INR) 600-700 with the additional production of almost 50 per cent. Innovations should not be encouraged at the cost of ecology and environment.

Technical Session V. Knowledge Management on Agri-food Innovations

Co-Chairs: *Narendra Singh Rathore*, Deputy Director General, ICAR, India
Andy Hall, CSIRO, Australia

Rapporteur: *Tayan Raj Gurung*, Senior Programme Specialist, SAC, Bangladesh

Moderator: *Andy Hall*, CSIRO, Australia

Panelists: *Ravi Khetarpal*, Regional Advisor, CABI, India
Kevin Tiessen, Senior Programme Specialist, IDRC, India
R.P. Singh, Executive Secretary, IAUA, India
Steve Staal, Programme Leader ILRI, Kenya
Hsieh-Liang Tsai, TWADA, Taiwan
P. Narayana Unny, Navara Eco Farm, India

Session Coordinator: *Chwen-Ming Yang*, Researcher & Director, TARI, Taiwan

Hung-Hsi Lee (COA) made a presentation on ‘Understanding, facilitating, and monitoring agricultural innovation systems’ and stressed the importance of using blended learning approach (online e-learning plus face-to-face discussion) with instructional design to develop and facilitate agricultural innovation systems. Blended learning is a formal education approach in which a participant learns at least in part through delivery of content and instruction *via* digital and online media. This is combined with some element of participant control over time, place, path, or pace. By using a combination of digital instruction and one-on-one face time, participants can work on their own with new concepts. Instructional design is the systematic process by which instructional materials are designed, developed, and delivered. Instructional designers apply systematic approaches to helping learners acquire and retain new skills, knowledge and attitudes.

Hsieh-Liang Tsai (TWADA) made a presentation on ‘Innovations on marketing of wax apple through ICT’ and mentioned that wax apple is a tropical fruit grown mainly by small farmers in southern Taiwan and it has emerged from a common garden fruit tree to become flagship items for export market. He highlighted the experience of innovative wax apple marketing practices through application of ICT in Taiwan.

P. Narayanan Unny (Navara Eco Farm) heading a smallholder integrated Certified Organic Farm-Navara Eco Farm (NEF) made presentation on ‘Best practices in agri-food innovations in Navara rice in India’ covering farmers’ initiative of conserving and popularizing organic cultivation of Navara rice by Navara Eco Farm in India. The almost extinct Navara rice variety was conserved at NEF. Specialty rice like Navara (a nutritional and medicinal type of rice used in India’s indigenous system of medicine, "Ayurveda", for treating arthritis, paralysis, polio, psoriasis), Palakkadan Matta (a red rice variety) and other agricultural products were cultivated organically from 2003 onwards at NEF. Navara’s various forms such as the grain, bran, powder, and root are used in the treatment of different ailments in "Ayurveda".

The Panel Discussion addressed the following three issues/questions:

- Knowledge dissemination - What can be most effective and responsive channels for dissemination of information and knowledge in the context of agri-food innovations?
- Knowledge development (capacity building) - How do we develop capacity in use of knowledge for successful agri-food innovations by targeting various stakeholders and others that are necessary in the process of ‘knowledge for innovative development’?
- Knowledge investment - How to advocate and encourage increased investment in knowledge sharing, knowledge creation, sharing of data, information, which may require high-level public and private institutional support?

Knowledge management (KM) has been acknowledged as the process of creating, sharing, using and managing the knowledge and information of an organization, institution, agency, company, etc. It is also about collection, customization, and dissemination of innovative knowledge and information to try to convert personal knowledge into organizational knowledge and corporate information. The experts attending the Technical Session V have identified a number of technical and non-technical topic areas for agri-food innovations. Most importantly, all experts agreed that KM will be useless without turning innovation and knowledge into practical application. The topic areas within the scope of knowledge management on agri-food innovations may include the following:

- Technical innovations in production process, postharvest handling, product processing, reduction of greenhouse gas emissions, climate change, etc.
- Non-technical innovations in marketing, institutional development, capacity building, etc.

The context of knowledge management will change dramatically based on disciplinary and objectives of an organization. According to the above mentioned topic areas, knowledge, information and innovations to be recognized and managed including: i) production process, ii) product classification and grading, iii) quality certification and standards, iv) nutrition facts

and information, v) traceability (tracking system for information produced during production processes), vi) marketing, and vii) logistic support (management of network, website and others). For an integrated logistic support, it is suggested to bring together the collection, analysis, integration, management, and repacking of knowledge and information and to make it accessible to an applicant.

The experts raised quite a few questions rather than answers during the session as well as the panel discussion.

Key highlights:

- Knowledge management (KM) has been acknowledged as the process of creating, sharing, using and managing the knowledge and information of an organization, institution, agency, company, etc.
- Knowledge management is also about collection, customization, and dissemination of innovative knowledge and information to try to convert personal knowledge into organizational knowledge and corporate information.
- It is extremely important to know about the most effective and responsive channels for dissemination of information and knowledge in the context of agri-food innovations.
- There is an urgent need to understand the mechanism to develop capacity in use of knowledge for successful agri-food innovations by targeting various stakeholders and others that are necessary in the process of 'knowledge for innovative development'.
- Knowledge investment is an important area to be addressed on priority. For this, there is a need to advocate and encourage increased investment in knowledge sharing, knowledge creation, sharing of data, information, which may require high-level public and private institutional support.
- Knowledge investment is useless without turning innovation and knowledge into practical application. The topic areas within the scope of knowledge management on agri-food innovations must be well understood.
- Knowledge management on agri-food innovations consisting of technical innovations in production process, postharvest handling, product processing, and reduction of greenhouse gas emissions, climate change, etc. must be given due attention.
- Knowledge management on agri-food innovations consisting of non-technical innovations in marketing, Institutional development, capacity building, etc. should be adequately addressed.
- Best practices in agri-food innovations are conditioned by environments, in terms of location, climate and policy, and resources, such as technology, partnership, capacity, financial support and knowledge management.
- Based on the interactions of the aforesaid factors and through the use of dynamic and real-time integrated knowledge/information systems, specific decisions with actionable knowledge and best practices can be determined and be timely applied

to agri-food production processes. To make it feasible and applicable, investments in promoting agri-food innovations and knowledge management are strongly encouraged with the development of the principles of knowledge management to be the next step.

Technical Session VI. Policy Oriented Agri-food Innovations

Co-Chairs: *Simon Hearn*, Agricultural Consultant, Australia
Kumaraswamy Ramasamy, Vice Chancellor, TNAU, India

Rapporteur: *Palate Matalavea*, Principal Crops Research, Officer MAF, Samoa

Working Group Conveners:

Group 1: *Suresh Acharya*, Director of Research & Dean PG, SDAU, India

Group 2: *Max Herriman*, CFF, Malaysia

Session Coordinator: *Greg Luther*, Technology Dissemination Specialist, The World Vegetable Center, Taiwan

Hung-Hsi Lee (COA) made a presentation on ‘Transition of Taiwan’s Agricultural R&D Strategies from efficiency-driven to innovation-driven’ and mentioned that there are many challenges due to population growth, climate change and liberalization in agricultural trade around the world. In Taiwan, there are many research institutes and superior agricultural technologies to solve the problems of the agriculture industry. Over the last fifteen years, the Council of Agriculture (COA) has not only undertaken innovation in agricultural technology, but also executed more innovations for technology management, by establishing industry clusters, strengthening agribusiness assistance, enhancing agro-tech marketing, assisting finance in the capital markets, training human resources and integrating industrialization platforms. Lee further mentioned that Taiwan has made a smooth transition from efficiency-driven to innovation-driven for agricultural science and technology (S&T). The success of these agricultural innovation approaches is helping to support Taiwan to develop its bioeconomy and intelligent agriculture in the next ten years. Taiwan is targeting to achieve these values of “Neo-agriculture Policy” for innovation in economic growth, jobs for people, and distribution for a stable society.

Osamu Koyama (JIRCAS) made a presentation on ‘A successful rural innovation policy: the sixth industry initiative in Japan’ and informed that the rural innovation policy was implemented in Japan in the year 2011. The policy tries to revitalize rural community and to increase rural income by encouraging collective actions of multi-sectoral stakeholders who plan to produce new types of agricultural products and services, as well as to develop new market channels. He highlighted that the initiative has been adopted by a large number of groups throughout the country and has successfully stimulated rural economy by raising the income of those groups.

Working Group 1: Agri-food innovation policies

Convener: *Suresh Acharya*

Key highlights:

- The key areas of policy interventions identified were: conservation of natural resources, promoting value-added functional food products for health, quality control and sanitary and phytosanitary (SPS) issues.
- It was felt that there is a need for a policy to shift from production-oriented agriculture to value-added or product oriented agriculture.
- Traditional pesticide/fertilizer based farming may be considered in lieu of agro-chemical based pest control/IPM, for which policy intervention is needed.
- APAARI may play a major role to initiate and exchange the innovative ideas between different countries in the Asia-Pacific region.
- Sharing of database between public and private organizations was considered as crucial in policy intervention for upscaling and outscaling the technologies in a public-private partnership (PPP) mode. It was felt that there should be customised policy interventions for larger and small-scale farmers / urban and rural centric farming.
- Since the predominant farmers in the Asia-Pacific region are marginal / small, the development of technologies for small scale farmers should be given high importance.
- Low-cost regulatory and traceability policy, storage, irradiation technology, value addition in agriculture and prioritization of innovation development also need consideration for appropriate policy intervention.
- The possible barriers that hamstring policy development for agri-food innovations were identified as availability of finance, mandates of the individual institutions, and knowledge of the consumers with regard to the agri-food innovations. There are innumerable examples where differential policies of governments to implement the technologies of agri-food innovations have resulted in biased pragmatic results.

Working Group 2: Financing agri-food innovations

Convener: *Max Herriman*

Key highlights:

- Finance is obviously very important and innovation cannot just rely on the public sector, and hence the private sector which is better placed, needs to be involved.
- Organizations involved should not always produce public goods.
- Need to consider intellectual property rights (IPR), whether to protect the product or make it public.
- If careful protection is implemented, this can facilitate development and uptake of the innovation, in some cases.
- Need to keep in mind beneficiaries that do not have the capacity to pay, therefore less privileged should not be neglected.

- Consider making an investment with a return on investment expected from the organization who received it; however the risk here is skewing R&D to outputs that are profitable and may reduce innovations for those who cannot afford to pay.
- Consider having a levy on transactions, for example, on imports and exports, and the funds should be invested into agricultural R&D.
- Recognize those organizations which raise awareness of regional bodies and governments for investing in innovation in areas from where their food is sourced. The best example is Singapore, which imports a large share of their food.

Final Plenary and Concluding Session

Co-Chairs: *Marco C.S. Wopereis*, Director General, World Vegetable Center, Taiwan
Vincent Lin, Chief, Trade Administration Section, COA, Taiwan

The key highlights and recommendations emerged from the discussions in various sessions, working groups and panel discussion were presented by the respective Session Coordinators: Session I: Andrew Campbell, Chief Executive Officer, ACIAR, Australia; Session II: J.L. Karihaloo, Senior Consultant, APAARI; Session III: Syed Ghazanfar Abbas, Consultant, APAARI; Session IV: Shyam Sunder Singh, Consultant, APAARI; Session V: Chwen-Ming Yang, Researcher & Director, TARI, Taiwan; and Session VI: Greg Luther, Technology Dissemination Specialist, World Vegetable Center, Taiwan.

Marco C.S. Wopereis, Director General, World Vegetable Center, Taiwan in his chairperson's remarks concluded that the expert consultation allowed to take stock of best practices in agri-food innovations in Asia and the Pacific and discuss how such innovations can be upscaled and outscaled. All the four programmes of the new APAARI strategy (knowledge management, partnerships and networking, capacity building and advocacy) will need to play a crucial role.

The consultation distinguished between incremental innovation, radical innovation and transformational innovation (Andy Hall's framework). Convincing examples of these different types of innovation processes were presented. Given the challenges that are ahead of us (adding 2 billion people by 2050, climate change, agriculture still very much fossil fuel based, water scarcity, malnutrition – double burden, aging farming population...) we need to aim for transformational change and transformational innovation processes. Such innovation processes must take into account today's complex policy and institutional environment for agriculture and the more pluralistic set of actors engaged in action and decision-making.

The Capacity Development for Agricultural Innovation Systems (CDAIS) framework may be used to analyse gaps in capacities to innovate among actors. CDAIS distinguishes technological capacities and functional capacities in three dimensions: individual, organizational and institutional. Functional capacities are often lacking in innovation (e.g. capacity to connect people, capacity to navigate complexity, capacity to negotiate). This means that major opportunities are missed.

Developing capacity across the food and agriculture system to innovate is critical for countries to take advantage of new opportunities and face challenges. Incentives and resources are

needed for the creation of networks and linkages that enable different actors in the innovation system (farmers, researchers, advisory service providers, value chain participants, etc.) to share knowledge and work towards common objectives. He stressed on promoting innovation and best practice by facilitating exchange of innovation, experiences and best practices among stakeholders and regions, and monitoring, evaluation and learning systems to track progress and to change track when needed.

Transdisciplinary and multi-stakeholder partnerships, generosity and flexibility, transparency and openness are needed for innovation to flourish, with farmers playing a central role. The challenge for research organizations is to think beyond development of new knowledge directed 'only' to tackle certain problems and opportunities. Managers of research organizations must see the 'big picture' and reach out to other partners to allow transformational innovation to occur, whilst still focusing on certain key research strengths within their organizations. Research organizations must build capacity for transformational innovation or link with partners who can help connect between disciplines, institutions and work with policy makers. This aspect is often forgotten and not budgeted. But, someone will need to pay for building social capital.

There is an urgent need for increased public and private sector investment in agricultural research and development, extension and advisory services. A thorough understanding of the information systems and social relationships/influences through which innovations are implemented is needed to achieve sustainable gains in performance that are shared in a fair and equitable manner.

Wopereis recommended that APAARI members reflect on building a knowledge base on agri-food systems development, working with Andy Hall's framework and the CDAIS framework and adding suitable metrics. Such a database could e.g. provide for different 'cases studies' information on:

- Partnerships and their roles
- Vision and ambitions and how progress is monitored
- Capacity development needs and how these are tackled
- Knowledge management issues and how these are tackled
- Innovations that are making a difference
- Jobs created for youth
- Connections with policy makers and how this triggers change
- Key facilitators and champions 'making it happen'

Such a database should ideally provide information on the 'health' of an agri-food system and allow comparisons between systems and over time.

Vincent Lin, Chief, Trade Administration Section, COA, Taiwan, highlighted that the innovation in agriculture is a precondition for meeting the challenge of feeding the world's growing population in the face of a changing climate and degrading natural resources. It is fundamental

to achieving the sustainable development goals of ending poverty and hunger, achieving food security, improving nutrition and promoting sustainable agriculture. In order to do so, there is urgent need to strengthen the capacity of individuals and organizations, create an enabling environment and, crucially, reinforced or make more effective agricultural innovation systems. Lin emphasized on building a multistakeholder partnership, and partnership leaders continue to improve and refine their approach over time. In addition, sustainable agricultural practices often have high start-up costs and long payoff periods and farmers may need appropriate incentives to provide important environmental services. Effective local institutions, including farmers' organizations, combined with social protection programmes, can help overcome these barriers. He mentioned that agribusinesses use information technology (IT) systems to varying degrees, information is in fact a crucial source for competitive advantages: delays in its adoption risk being highly costly but, at the same time, its efficient use serves as a strategic resource to the chain. Therefore, there is an urgent need for use of information technology at various levels in agri-food value chain. He stressed on innovative financing for development as innovative financing mechanisms rely on new partnerships between a wide range of stakeholders: countries of diverse levels of development, local authorities and private sectors. Private sector partners can include: global and domestic food companies, input supply and agro-processing companies, financial institutions, SMEs and producer associations, civil society (NGOs, FOs) and third-party contractors. The public-private-producer partnerships explicitly involve producers as a key component of the arrangement through the creation of smallholder-inclusive value chains. In the agricultural sector, combined investments can increase the profitability of smallholder-inclusive initiatives by agribusiness. They can also improve the way that agricultural markets work for small-scale farmers and rural communities and create sustained agricultural growth.

Raghunath Ghodake, Executive Secretary, APAARI, in his concluding remarks, highlighted that the topic of the consultation is rather complex and difficult to deal with. It is not only that the main subject of the agri-food innovation is a highly complex area but there are very many closely intervening aspects such as knowledge management, partnership, sustainability, externalities which also bring in interactive and add-on complexities. Therefore, it has been a challenging subject to deal with and to come up with clear recommendations and/or way forward on various issues, aspects and dimensions that were targeted for deliberations.

The organizers were aware of these complexities and therefore tried to simplify the understanding of the concept of innovation as akin to a house under permanent construction. The house undergoes constant modifications and renovation in response to changing internal and external environments such as increase in household size, changing weather, etc. The purpose is not only to improve the welfare of household members but also not to cause an adverse effects on others outside of the household. Therefore, this becomes atypical phenomenon that is only applicable to this house under the current context and situation. This phenomenon cannot be generalized for other households and other environments. Similar is the logic applicable to agri-food innovations. The agri-food innovations are location, time and environment specific and cannot be generalized and applied to other situations. So any straight-forward and jacketed recommendations and guidance cannot be made applicable to such other situations.

However, the guiding principles as ideal basis for innovation can be frame-worked and used to understand, describe and determine innovations under different contexts and environments. This Expert Consultation has certainly attempted to underscore and provide the basis for such guiding principles that can be used to appreciate the ideal systems and components of innovations.

That allows us deriving guiding principles (in terms of strengths and weaknesses) from the best practices, case studies, experiences of experts in agri-food innovations and see if we could suggest pathways to go for developing successful agri-food systems. We wanted to see such guiding principles, emerging by focusing on key aspects/ formations of agri-food innovations. These are specified as partnership (institutional and add value), skills and capacities, socioeconomic scenarios, strategies to innovate, technologies for innovations, knowledge management, policies and investments.

In fact, the consultation opened up can of worms and as expected we came up with more complex issues and understanding even within those broad key aspects. As a way forward, the following key strategies can be considered for implementation as an on-going effort in progressing on the development of agri-food innovations in Asia and the Pacific.

- Many insights have been obtained from this consultation though all are not explicitly understandable and cannot be used in practice. This will require systematic assessment and synthesis of the outcomes of the consultation and these need to be objectively documented and presented through formal proceedings and recommendations.
- We need to consider and recognize that this consultation is the first ever direct attempt to address this new and crucial area of innovation, especially in the context of agri-food innovations in Asia and the Pacific. Obviously, we encountered a number of expected and unexpected difficulties, right from conceptual/theoretical basis to actual practices. Therefore, further systematic steps are needed in focusing on individual aspects and distilling these for fuller understanding of complexities involved.
- Although right from the conceptualization of this consultation, the organizers have been emphasizing on the broad spectrum of innovations, including policies, partnerships, value chains, organizational changes, and technological innovations, etc. However, as it turned out, the major focus remained on agri-technologies and agricultural research as the centre piece in agri-food innovations. Therefore, the major efforts are needed to try and separately focus on diverse dimensions and types of innovations.
- Efforts are also required to segregate individual aspects involved in agri-food innovation and analyzing various components and complexities of these for fuller understanding of their contribution and synergies arising of such innovation.
- Certainly one area of paramount importance is the systematic documentation of how innovations in agri-food systems are developed, being practiced and being further innovated. These efforts will provide invaluable basis not only to advance our understanding of innovations but also to promote systematic advancement in innovations.

- A series of more focused consultations on specific aspects/subject matters of agri-food innovations would be essential to help deducing much realistic guiding principles that can be more closely applied in developing location specific/contextual innovations.
- We would certainly look forward to continue our collaboration and partnership in the above areas.

In conclusion, on behalf of the organizers, he thanked very sincerely the Hon'ble Chin-Cheng Huang, Deputy Minister, for his inaugural address and thanked all the participants for their participation and performing various roles and responsibilities in successful conduct of the consultation. He also extended grateful thanks to the Council of Agriculture to be the lead host for this consultation.

Ray Chang, Director, Taiwan Agricultural Research Institute (TARI), Taiwan extended vote of thanks to the Chief Guest Chin-cheng Huang Hon'ble Deputy Minister, Council of Agriculture (COA), Taiwan and other dignitaries in the Inaugural Session, and to the Chairs, Co-Chairs, Moderators, Panelists, Convenors, Session Coordinators, Rapporteurs and participants of the Expert Consultation. He expressed profound thanks to Raghunath Ghodake, Bhag Mal and APAARI Secretariat staff both from Bangkok and New Delhi. Ray Chang also expressed sincere thanks to his colleagues from TARI, J.J. Chen, Director General, S.J. Fang, Director, Y.S. Hsieh and the efficient team members from Technical Service Division. He expressed gratefulness to the Council of Agriculture for funding and fully supporting all the logistic arrangements, and extended special thanks to Tracy Shu-hwa Tarn and Siao-huei Jiang, for their tireless efforts for arranging invitations and visa required for entering into Taiwan.

As for the field trip, Dr Ray Chang expressed profuse thanks to the World Vegetable Center (AVRDC) for hosting the tour and arranging the lunch and the participants were very impressed after visiting the demonstration garden and genebank. He also extended sincere thanks to the Local Facilitation Committee members led by S.J. Fang, which played an important role and without their dedicated efforts and, commitment, the success of Expert Consultation would not have been possible. He also thanked all the people who were actively involved in making various arrangements for successful conduct of the Expert Consultation.

Finally, he expressed the hope that the participants had a pleasant stay in Taiwan, and wished them a safe journey back home

Key Recommendations

I. Models and Case Studies of Agri-food Innovations

- Partnerships and alliances with new actors are essential in contributing to innovative solutions to achieve scaling-out targets. Groups or organizations including the private sector that are key allies for technologies would be important in order to provide valuable insights and capacity (e.g. biofortified crops, pesticides) to help inform about government policies to achieve appropriate environment for scaling- up and scaling-out of innovations.
- There is a greater need for establishing innovation platforms in order to share knowledge between the various actors including industry, policy makers and researchers.

- The development of good agricultural practices which comes under the incremental innovation should be expedited in order to effectively address pesticide residue and food safety concerns.
- Further, the pesticide residues or biofortification issues particularly afford themselves to more radical or transformative innovation systems with new markets potentially established. For example, pesticide residues can limit international trade opportunities.
- There is a need for strong cooperation amongst the organizations/ nations to facilitate the sharing and adaptation of tested policies, systems, institutional arrangements and bridge the knowledge gap.

II. Partnership for Agri-food Innovations

- Concerted efforts are needed to develop public-private partnership to catalyze private investment in innovation and scaling- up of innovations in agriculture and agri-food value chain.
- There should be documentation of successful and innovative partnerships between funding agencies, researchers and the end users of research. Special efforts need to be made to develop database on agri-food market chains and post-harvest losses.
- There is a need for developing a road map and platform for innovative partnerships in Asia and the Pacific region.
- Incubation centres should be developed to promote and scale- up local agri-food innovations in public-private partnership mode.
- There is a strong need for participation of cooperatives, and NGOs in technology dissemination. It should be ensured to have market intelligence to strategize production and marketing.
- There is urgent need to create incubation centers and also establishing linkages amongst incubation centers with adequate infrastructure and availability of sectoral experts for scaling- up of agri-food innovations.

III. Capacity Development in Agri-food Innovations

- For solving complex problems of agri-food innovations, the technical and functional capacities play a major role. Therefore, there is an urgent need to find capable people who can work with systems. The capacity in agri-food innovations area will need to be built individually to work collectively.
- Capacity development for innovation should be based on a long-term strategy covering three interconnected dimensions: individual innovation capacity, organizational innovation capacity, and the creation of an enabling environment.
- For successful capacity development, plans should be prepared focusing on capacity needs of organizations, individuals (farmers-first) and systems for stronger collaboration to help broker the new relationships.

- There is a greater need for broad-based capacity building for innovation in the agricultural sector which will be able to transform itself into an attractive place for the youth in the future.
- Greater thrusts need to be given on developing training activities for building collaboration that brings together diverse actors, partners and groups.
- There is a need for political support in capacity building for innovation with the emphasis on institutional change and skills development.
- New concepts and institutional innovations are needed to ensure cohesion of rural areas and prevent economic and social marginalization, foster diversification of economic activities.
- It is important to describe with great precision which specific innovation initiatives should be pursued, and where to invest and compete. Also, to develop capacity in measuring the impacts of different efforts and interventions to promote innovation capacity.
- A wide range of innovative agricultural finance and risk management products and mechanisms is already in use in transition economies, therefore there is urgent need for applying these risk management products to safeguard the interests of farmers as well as enhance their capacity and economy.
- Greater thrust needs to be given for strengthening local institutions and the capacity to maintain and use biodiversity for food and agriculture at local levels through mechanisms such as farmer field schools, participatory crop and livestock improvement and locally-identified adaptation strategies.
- Concerted efforts are needed to train farmers in agricultural extension in order to disseminate technological innovations in agri-food at faster and cheaper rate.

IV. Technology Based Agri-food Innovations

- There should be an emphasis on developing agri-food innovations which should be contextual in nature, location- specific and season- specific.
- There is a need for ICT led agriculture as it has scope to bring wide-ranging benefits to farming sector. Innovation is driven by technological advances, and also through novel ways of organizing farmers and connecting them to technologies.
- Women farmers account for a significant share of the agricultural workforce and have the potential of making important contributions to increasing food production and improving natural resources management needs to be given due support at all levels including gender equality, financial and social security.
- Concerted efforts need to be made for development of new technologies to help improve the productivity of the farming systems while decreasing their impact on the environment and also to minimize post-harvest and storage losses which will add income to farmers and in value chain.
- In order to have technological innovations, there is a greater need for the collection, documentation, maintenance, and application of information related to all processes in the supply chain.

- There is greater need for conservation and profiling of indigenous breeds which is a treasure to improve the biodiversity of animals.
- There is a great need to get the products certified through an authorized body (e.g., Association of Certified Medical Professionals).
- There is also a need to address researchable issues like food processing without loss of nutrients, packaging and shipping (cold/non-cold chain), and development of small machinery for farm gate food processing.

V. Knowledge Management on Agri-food Innovations

- Concerted efforts are required for collection, customization, and dissemination of knowledge and information in order to convert personal knowledge into organizational knowledge and corporate information. Hence, greater thrust needs to be given on investment in a wide range of intangible assets such as data, software, patents, design, new organizational processes and specific skills.
- Focused attention is needed at the system level such as networks and linkages among different actors in the innovation system which can facilitate the exchange of information and knowledge and foster collaboration towards common goals.
- For achieving success in dissemination of information, there is need for credible messages in national and simplified language. Face-to-face meetings, including demonstrations, have been proven to work well.
- In transferring knowledge to different stakeholders, technical agri-food associations and extension agencies should be used to inform their members or other interested stakeholders. Use of mediators such as associations or consultants should also be encouraged.
- For identifying target audience and its motivation for exploring new ideas, it is essential to learn about the needs, problems, working environment and then establish strong and trusted relationship among the stakeholders.
- Concerted efforts are required in managing the knowledge on technical innovations in production process, post-harvest handling, product processing, reduction of greenhouse gas emissions, climate change, and also on non-technical innovations in marketing, institutional development, capacity building, etc.
- There is a need for innovations for technology management, by establishing industry clusters, strengthening agribusiness assistance, enhancing agro-tech marketing, assisting finance in the capital markets, training human resources and integrating industrialization platforms.
- Efforts are needed for organizing a series of workshops including senior research managers supported by expert sessions on enhancing skills for partnering and engagement, project logic and theory of change, monitoring evaluation and learning tools, the theory and practice of multi-stakeholder processes, innovation platforms etc.,
- Special efforts need to be made on undertaking a cluster of experimental innovation projects supported by innovation mentors / coaches, who help identify innovation

and market opportunities and partners (particularly in the private sector), broker partnerships, support adaptive management and learning by doing. Such projects can then be used as the focus for reflective learning and understanding the nature of effective innovation process in a particular national setting.

- The leaders and staff of farmer organizations usually need help to identify the capabilities they lack. Even when the needs have been identified, it is difficult to build the capabilities, especially in organizations formed by marginalized groups, which need economic, managerial, and technical support. Therefore, there is a need for external consultants and innovation brokers to identify these gaps and design capacity building programmes for farmer organizations.
- There is an urgent need for investment in knowledge-based capital as it is a key to future productivity growth and living standards. There is also need to encourage investment in change, including enhanced skills and knowledge transfer, use of shared data and widespread adoption of best practices. However, greater investment is needed at the individual level, in human capital and education to support participants in the innovation system – family farms, service providers, traders and processors, researchers, policy-makers, etc. – in developing their capacity to innovate. Special attention to youth and women is important.

VI. Policy Oriented Agri-food Innovations

- There is an urgent need for policy on agricultural transformation to revitalize rural community and to increase rural income by encouraging collective actions of multi-sectoral stakeholders
- by which individual farms shift from diversified, subsistence-oriented production towards more specialized production (product or market) oriented agriculture.
- There is a greater need for policy intervention in agri-food innovation and removal of all barriers in implementing policy in path-breaking innovations such as health, diet, functional food supplements, organic farming, malnutrition, low-cost technology, IPR, and biodiversity.
- Policymakers should encourage investment in agriculture research and development in order to raise productivity, improve quality of agricultural products, and lead to better post-harvest practices, which ultimately will increase smallholder incomes and promote rural entrepreneurship for small agribusinesses.
- The poor and less privileged that do not have capacity to pay, should be fairly treated. There should be equal opportunities for all segments of the society.
- Special efforts need to be made on facilitating cooperation, networking activities and partnerships among different innovation actors/partners working in the same field – universities, research and technological centers, SMEs and large firms – to achieve synergies and technology transfers.
- Concerted efforts are needed to develop indicators and tools to evaluate the performance of the agricultural agri-food innovation systems, taking longer term effects into account.

- APAARI should play a major role in sharing knowledge of agri-food innovations across the countries in the Asia-pacific region.
- There is need to share database between public and private organizations for scaling-up and scaling-out the technologies and innovations, keeping in view the interest of smallholder producers.
- An innovation strategy needs to be truly inspiring and ambitious in terms of providing the basis to break away from the competition, beat the competition, and create new spaces.
- Sustained political support for investments in agricultural education and training is needed to develop a system of core institutions.

**Extended Summaries
of
Presentations**

Framework for Exploring Different Models of Innovation and Partnership

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Keywords: Innovation, partnership, system transformation, characteristics, investment, tools.

1. Context

To improve agricultural innovation, the broad prescription is that research and technology needs to be better coupled with market and policy changes that allow ideas and solutions to be deployed. However, the question remains: how to arrive at a mode of innovation that matches the ambition of transforming the performance and sustainability of the sector, both now and in the challenging years ahead?

2. Unpacking Agricultural Innovation

2.1. Innovation systems

Considerable empirically backed work has been done on understanding how agricultural innovation takes place and the role of research within that process. Notable has been the work done on elaborating the idea of agricultural innovation system.

An innovation system can be defined as “a system that brings together actors from the public, private and civil sector to bring new products, processes and organizational forms into economic and social use, together with institutions and policies that affect actor’s interaction and how knowledge is used and exchanged” (World Bank, 2006).

Innovation in this framing is understood as a process rather than a technological artifact or output *per se*. An innovation system is heuristic to understand (diagnose), plan and invest in the organizational and policy conditions and capacities involved in sustaining the process of innovation.

Key observations that underpin this idea:

- The critical feature of innovation is not novelty in the sense of invention, but novelty in the sense of putting ideas into use in new ways for economic and social gain.
- Innovation can involve technological change, business model change and policy change and is usually a combination of these.

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- Innovation emerges from dense networks of interaction and this often involves a two way interface between knowledge creation and knowledge use by farmers or companies. Partnerships are a core modus operandi.
- Innovation is a multi scale phenomena with, for example, technological changes at the farmer level being co-dependent on accompanying changes, markets and policy regimes.
- Innovation is rarely a linear predictable process of ideas-application-impact. Instead, it involves complex pathways and chains of events with innovation trajectories unfolding in unpredictable ways often over long time frames.
- The roles of the public and private sectors are neither mutually exclusive nor fixed. Instead the role of players evolves during the innovation process, with configuration of players adapting to the contingencies of opportunities and challenges being addressed.

2.2. Unpacking partnerships

Partnerships are now a common place practice for research organizations, businesses and companies alike. How partnerships are used in different ways for different dimensions of the innovation process. Figure 1 illustrates some of the common partnerships encountered. The

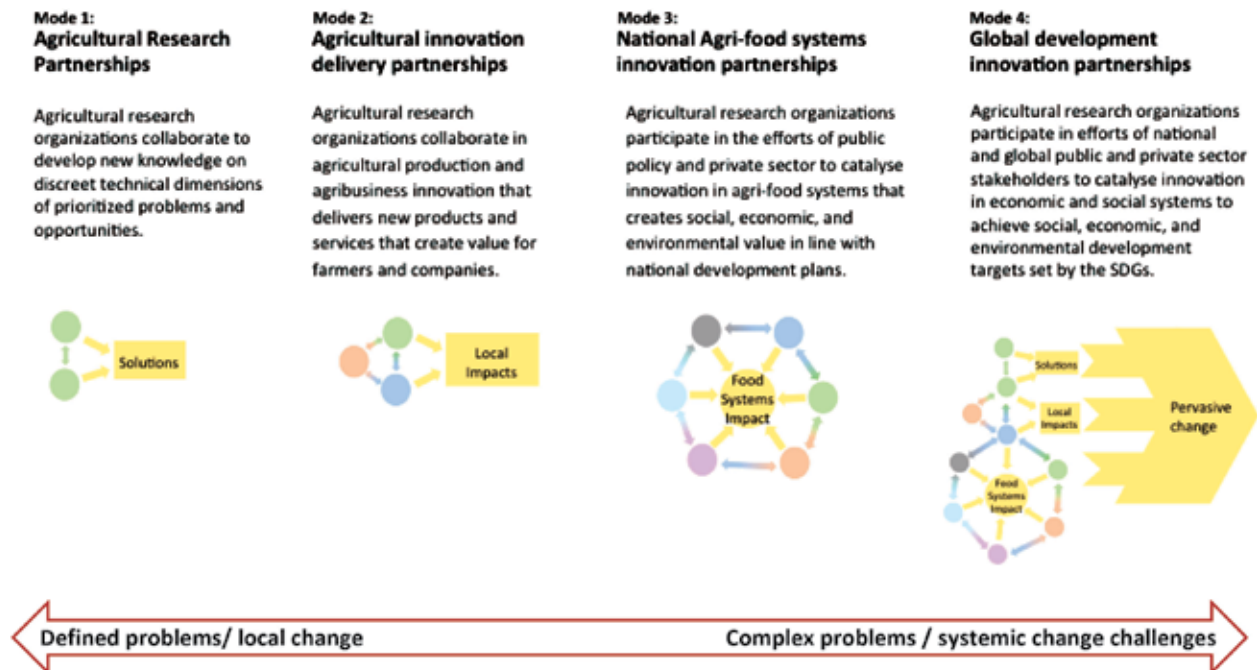


Figure 1. Modes of innovation and partnership practice

(Source: ISPC, 2016)

key message is that innovation usually requires partnership between dissimilar partners and for innovation to have pervasive impacts at scale this often requires complex architecture of partnership that span local to national scale and beyond.

2.3. Unpacking innovation systems-Modes of innovation and patterns of partnerships

One of the challenges of working with innovation systems and indeed some of the misunderstandings around the topic is that it seems to suggest that there is a generalizable blue print for how to organize innovation. Casual observation suggests that this cannot be the case. There is also the problem of why some innovations spread and have pervasive impacts while other remains only locally important.

Recent thinking has started to unpack these questions by exploring how innovation takes place in three very different innovation and impact scenarios (i) incremental innovation and system optimization; (ii) radical innovation and sub-system transformation; and (iii) transformational innovation and systems transformation (see Figure 2 and descriptions below).

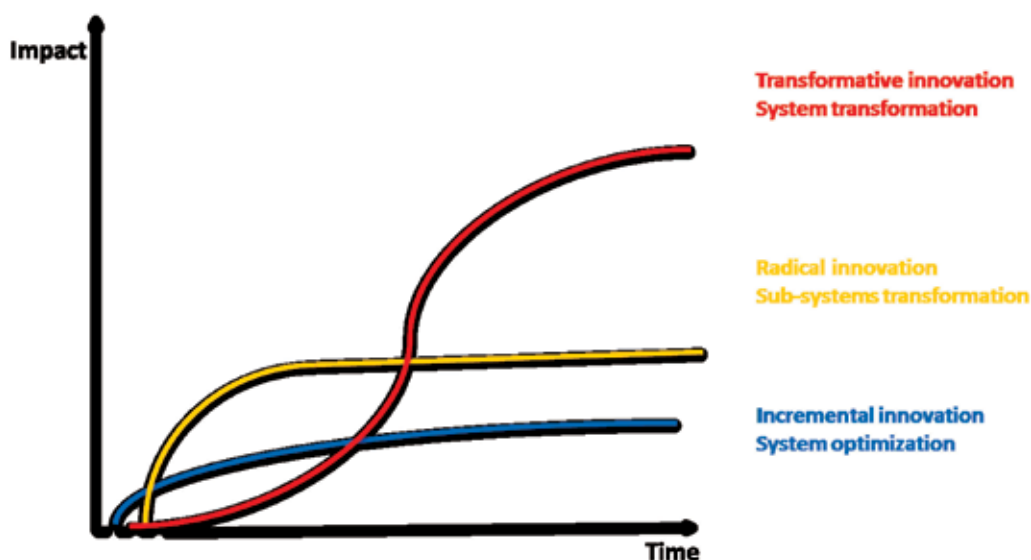


Figure 2. Modes of innovation and impact

2.3.1. Incremental innovation and system optimization

Examples: Improved agronomy, pest management, animal husbandry techniques, agro-processing. Product or process solutions within existing systems.

Process: These deliver valuable local improvements to livelihoods of smallholders and profits for value chain actors. Demand-led research and collaborative action by local stakeholders is critical in defining and developing solutions. The scale of impact, however, is often restricted by the absence of policy, institutional and market systems changes and investments needed to spread and sustain these innovations.

Key characteristics: Incremental improvement of existing products and services or incremental improvement of value chain efficiencies that deliver marginal social, economic and environmental impact with in specific production systems and value chains.

2.3.2. Radical innovation and sub-system transformation

Examples: development of specific animal disease treatment or eradication programs, introduction of crop or livestock insurance. Product, service or system solutions for whole sub-sector

Process: Mission focused research and other interventions has provides radical innovations to generic subsector challenges, followed by incremental innovations to improve effectiveness. Demonstrate a degree of sub-systems transformation. Such cases open up new economic and other value add opportunities, new incremental innovation opportunities in the production and market systems system and opportunities for the delivery of a wider range of products and services through the delivery systems established.

Key characteristics: Technological and / or market “step jumps” or discontinuities that open up new economic, social and environmental impact opportunities in a specific sub-sector or market sector and opens up new opportunities for incremental innovation

2.3.3. Transformative innovation and system transformation

Example: sector wide transitions to sustainable agriculture; sector wide transitions driven by agricultural big data. Systems solutions that create conditions for new product and process solutions.

Process: These are far-reaching, deep types of innovations with pervasive implications for the entire agricultural sector. These cases are not demand driven *per se*, but emerge from a broad-based consensus on the need to pursue new directions or take advantage of new platform technologies and often involve the integration of social and technological change. In some cases combination of policy-push and technical and institutional responses and innovation can extended the frontiers of both profitability and the sustainability of the sector. The high level stakeholder and political alignment and the organizational arrangements put in place to advance this transformation can also been used to address other sustainability, social and economic challenges.

Key characteristics: Deep systems changes underpinned by broad-based consensus that significantly advance the economic, social and environmental frontiers of the agricultural sector as a whole, and that open up opportunities for new waves of radical and incremental innovation.

2.3.4. Discussion

- All the three modes of innovation discussed have a value in progressing equitable and sustainable economic growth, albeit with different scales of impact. These modes, however, also highlight the way clusters of policies, practices, and stakeholder interests can lock agricultural into incremental innovation and system optimization at a time when step changes are needed. It, therefore, also presents a framework for allocating scare public and private sector resources in ways that open up new opportunities for innovation and impact.
- One symptom of this is that public (but also industry body) investments have given primacy to addressing the immediate needs of farmers. At one level, this client orientation is laudable. An over emphasis on demand-led, bottom-up processes and short-term impacts at the farm scale, however, can skewed the allocation of public resources towards this local optimization route. Innovation must always end with impact at local level, but local impact is not necessarily going to drive the transformative changes that all countries are seeking.
- System optimization allows poor farmers to improve their livelihood marginally but it rarely leads to a transit out of poverty. In the developed world, it sees, for

example, vulnerability to competition, profits eroded, a sunset industry, out migration, skewed age distribution in family farming.

- The appropriate mix of public and private sector investments needed for transformation require an agreement on what are the critical challenges ahead and this in turn requires a strategic partnership between public, civil and private sectors at a political level. The global agreement of Sustainable Development Goals (SDGs), perhaps sets the framework for such processes. In reality for many countries these goals have been eclipsed by more immediate and local priorities and political imperatives where national economic growth trumps more altruistic global ambitions.

Tables 1 and 2 present a framework for navigating and progressing across the modes of innovation articulated by this paper.

Table 1. Typologies of innovation modes

	Incremental innovation	Radical innovation	Transformational innovation	Paradigm innovation
Focus	Systems optimization	Sub-system transformation	System transformation	Systems replacement
Key features	Continuous improvement of existing products and services in current production systems and value chains	Technological and/or market “step jumps” or discontinuities that enable the creation of new products or service but restricted to a sub-sector or existing market segment	Deep systems changes that significantly affect the agricultural sector as a whole enabling the creation of new classes of products and services	Paradigm changes that potentially affect all sectors of the economy
Impact Scope	Incrementally improves social, economic and environmental impact with in system limits	Significantly expands economic, social and environmental impact in a specific sub-sector or existing market segment	Unlocks new economic, social and environmental impact possibilities across the agricultural sector.	Reframed global limits to growth
Trajectory	Creates understanding of technological and system’s limits that need to be addressed.	Creates opportunities for next wave of incremental innovation in agricultural sub-sectors or market segments	Creates opportunities for next wave of radical and incremental innovation in the agricultural sector	Creates opportunities for transformative, radical and incremental innovation in all economic sectors
Defining processes and practices	Demand-led priorities setting and user-led co-creation of solutions informed by research coupled with participatory processes and governance	Alignment of business and policy incentives and agendas allows commercialization of technological breakthroughs addressing defined problems and opportunities	Public, private and civil society’s alignment around new directions to tackle critical societal issues involving uncertainty and complexity	Global uncertainty. The search for unimagined futures

Contd...

Table 1 (contd...)

	Incremental innovation	Radical innovation	Transformational innovation	Paradigm innovation
Policy framing	Science and technology	Sub-sector innovation policy	National systems of innovation	
Case study examples	Fodder in Indonesia, AR4D innovation platform projects	NOVAC, IBLI, FMD control	WUE, (Australian Big Data)	Digital revolution advanced materials
Time frames/phasing	Continuous	Discontinuous events	Periodic tipping points	Epochs with shortening cycles.

Source: Hall *et al* 2016

Table 2. Practice and policy considerations in different innovation modes

	Incremental innovation	Radical innovation	Transformational innovation	Paradigm innovation
Realm of application	Continuous upgrading and improvement of existing production and value addition processes	Defined sub-sector challenges where game changing technological breakthroughs and other advances exist or are likely	Complex, contested concerns at the sector or societal level	Creating new futures
Public investment rational	Market failure	Market and systems failure	Systems failure and uncertainty	Uncertainty
Tensions to be managed	Over investment in immediate improvements jeopardizes long term opportunities	Reinforces position of incumbent market players at the expense of emergent players with strong innovation potential	Conflicts between emerging and incumbent stakeholders in reaching consensus and implementing joined-up action	The future is unknown and unknowable
Limiting factors	Local vested interests	Effective public private sector partnerships social license	Lack of consensus at societal level clarify on public and private sector roles and investments	Investment for societal good
Characteristics of tools and approaches	Need to bridge scales Needs a stronger political economy perspective Need to support experimentation in both the technology sense and the impact effectiveness sense Need to help navigate the transition between local optimization and transformation, including tools for integrated diagnostic analysis of systems to be transformed Need to help with alignment of stakeholder agendas and consensus building			Need to assist in building imagined futures
Innovation capacity metrics	Rural innovation capacity	Ability of players to respond to sub-sector challenges and opportunities	Agricultural innovation systems health	

Source: Hall *et al* 2016

3. What Does This All Mean for Agricultural Research Organizations?

- 3.1.** There will be an expanded number of roles agricultural research organization will need to play, implying both new tools but also new capabilities, including: (i) brokering alignment; (ii) science informed foresight;(iii) science discovery to populate the sector with transformational enabling technology; (iv) managing the iteration between technological opportunities and market and social application on the big challenges that alignment coalesces around; (v) research into, and brokering of, new policy and institutional frameworks that enable more effective innovation processes.
- 3.2.** Research organizations will need to undertake new forms of experimentation. For example, pilot mechanisms to provide facilitative support to subsectors that are seeking to transform. This is different from the current focus on incubating innovation at the firm and technology scale. The new focus is on incubating systems innovation that helps transform subsectors and even sector. It is ambitious but needed.
- 3.3.** There is still an on-going need to continuously learn about the effectiveness of nuts and bolts practices and strategies. The caveat being that these should also be used to highlight under performing organizational strategies and structures, routines and practices that are prone to lock-in and system optimization only.

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Analysis of ACIAR Project Case Studies

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Keywords: Innovation, resilience, partnering, dissemination, hatcheries, value-chain, nutritional models, optimization and transformation.

1. Background

Innovation was first defined in an economic context by Schumpeter (1939) as the introduction of a new production method, new inputs into a production system, a new good or a new attribute of an existing good, or a new organizational structure. For Schumpeter: Innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation (Schumpeter, 1939). In 2005, the OECD and Eurostat (2005) defined innovation as “the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations”. The World Bank (2010) refines the definition further: “Innovation means technologies or practices that are new to a given society. They are not necessarily new in absolute terms. These technologies or practices are being diffused in that economy or society. This point is important: what is not disseminated and used is not an innovation.” For the World Bank, there is a social benefit dimension: “Innovation, which is often about finding new solutions to existing problems, should ultimately benefit many people, including the poorest.” Finally, the FAO in 2012, defined innovation in an agricultural context: “Agricultural innovation is the process whereby individuals or organizations bring existing or new products, processes and forms of organization into social and economic use to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability thereby contributing to achieve food and nutrition security, economic development and sustainable natural resource management” (FAO, 2012).

2. Agriculture Innovation for ACIAR

The Australian Centre for International Agricultural Research (ACIAR) mission is to achieve more productive and sustainable agricultural systems for the benefit of developing countries and Australia, through international agricultural research partnerships. As Australia’s specialist agricultural research-for-development (R4D) agency, ACIAR brokers research collaborations between Australian institutions and researchers from developing countries across Asia, the Pacific and East Africa to build healthier, more equitable and more prosperous societies. ACIAR

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contributes to agricultural innovation in Australia and in the region through funding and managing research projects as partnerships between developing countries scientists and Australian and international research centres; facilitating the communication and dissemination of the research findings of these projects; and supporting the international agricultural research centres of the CGIAR. For ACIAR, innovation is a creative and adaptive process rather than a punctual event, it incorporates learning and R4D elements and is geared toward solving problems. Innovation from ACIAR's perspective should include both economic and social impacts.

3. Strength and Weaknesses and Successful Upscaling of Agri-food Innovations

The essential features of the ACIAR case studies in agri-food innovations are given in Table 1.

3.1. Case Study 1 - Pearl industry development in the western Pacific (Tonga, Fiji, PNG)

Pearl farming is the Pacific region's most valuable aquaculture activity, presenting beneficial opportunities at every step of the pearl-industry supply chain: from the collection of oyster spat (juvenile oysters) to the production of half-pearls and pearl shell used to make jewellery and other artefact souvenirs.

ACIAR has commissioned a series of projects to address constraints along the value chain from spat production to marketing. The strengths of this case study are multi-faceted. It aligns well with public policy; in Tonga the Government set aside a special marine management area which supports spat and oyster production. The partnerships created within this project are unique; ACIAR and collaborators worked with oyster producers, women's groups, a large, local retailer, local and Australian researchers and has cultivated links with the tourism industry. Research played an important role across the series of projects and was long-term. The series of ACIAR investments targeted improved hatchery efficiency, increased production, improved nursery culture procedures, increased availability of oysters to farmers, built capacity for spat collection, diversified production into half pearls and facilitated the importation of algae feed in a tube. This last activity, initiated by the project team, is revolutionizing the breeding of oysters as hatcheries no longer require a specialist algae grower to provide feed to juveniles; a very expensive and difficult undertaking.

This portfolio of projects focused at first on the optimization of the production system but eventually led to a sub-system transformation with the identification of a business opportunity for jewellery design and production. This activity has increased the opportunity for income and employment for the Ba Women's Forum, whose members are increasingly independent, confident, enthusiastic and business-savvy. The groups is producing two jewellery ranges that have obtained a "Fijian made" country of origin accreditation and are sold through the Tappoo department store to target a niche market of customers demanding a high quality, local product.

3.2. Case Study 2 - Development of cocoa and chocolate industry in Indonesia, Papua New Guinea (PNG), Solomon Islands, Vanuatu, Fiji and Samoa

Chocolate is a USD 80 billion-a-year (AUD 102 billion) global industry which is forecast to grow as much as 30 per cent by 2020 (Stringer, 2015). A substantial share of this growth

Table 1. The essential features of the ACIAR case studies in agri-food innovations

Cases	Initiator	Critical features	Role of research	Operational alliances	Strategic alignment of stakeholders at sector or national level	Solution, product or system innovation	Scope of impact
Pearl industry development in the western Pacific	Projects commissioned to develop research informed production and value chain solutions to improve poor smallholder livelihoods	Multi-country research teams and a coalition of policy, industry, research and private sector seeking solutions to deliver sustainability with profitability	Development and evaluation of technology and marketing options	Mainly research and local farming, value chain and development stakeholders, alliances include women's groups and retailers	Links to private sector (retail and cruise liners) and local and national policy agencies	System optimization and sub-System innovation to deliver product and service innovation	Currently limited to project domain but potential for sub-sector wide impact (Made in Fiji Jewelry)
Development of cocoa and chocolate industry in Indonesia, Papua New Guinea (PNG), Solomon Islands, Vanuatu, Fiji and Samoa	Projects commissioned to address known agronomic issues and private sector needs to stimulate investments	Multi-country research team develops an innovation platform including private sector, producers and consumers (Salon du chocolat in Paris)	Development and evaluation of technology and research convenes stakeholders to develop and test client oriented solutions	Developing alliance of researchers, producers and small and medium enterprises in Australia and the US first for piloting and proof of concept, then productivity and quality improvement and finally to look into financial services	Link with Australia's growing engagement in the high-end market for single-origin chocolate. National policies for economic growth and trade	System optimization in Australia with use of trellising. sub-system innovation with "Bean to Bar" approach	Wider impact in the industry with growers in Australia using innovative production system and private sector company developing links with producers outside of the project scope

Contd...

Table 1 (contd...)

Cases	Initiator	Critical features	Role of research	Operational alliances	Strategic alignment of stakeholders at sector or national level	Solution, product or system innovation	Scope of impact
Feed improvement for mariculture in Vietnam and Australia	Commissioned research project to improve all aspects of feed formulation, manufacture and use in fish farming in both countries	Multi-country team develops a multi-stakeholder technology transfer mechanism, knowledge discovery for Vietnam and capacity development in Australia	Development and evaluation of nutritional technology for barramundi, cobia, grouper, mud crabs and lobster	Annual Regional Aquafeed Forums (RAFs) which bring together feed manufacturers, fish farmers, researchers and policy makers in Vietnam. Continuation of the RAFs will ensure the impacts of the project will continue in the future	Strong alignment with public investment in aquaculture sector development in Vietnam	System optimization where nutritional models were developed to account for growth prediction and utilisation of nutrients for finfish, mud crab and spiny lobster	RAF have facilitated the integration of the various sectors of an industry with exports worth approximately US\$5 billion annually
Integrated village management system to improve cattle productivity in Eastern Indonesia	Research commissioned to solve livestock productivity constraints in nutrition and fertility	Community and farmer organizational development (Kadang) and extensions methodology promotes technology and practices	Development and evaluation of technology, pilot testing and capacity development	Australian and Indonesian (National and local) researchers, public extension system and farmers groups. This project led to the development of the Large Ruminant Consortium in Indonesia	Strong alignment with public investment in livestock development in Indonesia and economic growth focus of the Australian Aid program	System optimization using existing feed techniques as well as new community based livestock systems	Impact is wider than project area in the island of Lombok

is at the premium end of the market, which includes “single-origin” and boutique chocolate products. Most of the cocoa beans consumed globally are produced by millions of smallholder family farmers in the world’s tropical and subtropical zones (Markham R. Pers. Com.). However, the majority of these beans are sold into the bulk market where profit margins for producers are low. In the Pacific islands, where cocoa trees have been cultivated since the 19th century, harvest of this potentially high-value commodity in past has been relatively haphazard. ACIAR has commissioned projects to improve productivity of cocoa production in the region, but has also investigated opportunities for Pacific island producers to meet the high- quality standards required to enter the premium markets that offer higher returns to the crop.

Pacific producers have begun partnering with premium chocolate makers in Australia to produce some unique “single-origin” products. At first, this portfolio of projects focused on optimizing the production system in the orchards. This led to incremental innovations such as the use of trellising in Australian orchards. However, the partnerships have evolved to develop an innovation platform where chocolate makers have had the opportunity to develop a “bean to bar” model of marketing in conjunction with farmers. Chocolate makers initially judged the beans produced by the smallholders to be too smoky, too mouldy, too astringent, improperly fermented and improperly dried. This redirected the research effort towards locally appropriate methods for drying and fermentation.

In the last 4 years, the value-chain partnership has developed in ways that benefit research outcomes, enhance private-sector opportunities and improve cocoa smallholder livelihoods. The innovation platform created has provided opportunities for engagement between researchers and the private sector at multiple levels and at all project stages—concept, planning, execution, monitoring, evaluation and knowledge transfer.

Today the chocolate companies are committed value-chain partners, whose role extends beyond assessing bean quality, they provide training in chocolate tasting for lead farmers, and engage in visits to the cocoa plots, meetings with the communities, discussions around options for improving drying and fermenting processes, and recommendation for appropriate equipment for researchers to test. Finally, this agriculture innovation system is moving beyond production and processing, as the chocolate makers are now suggesting alternatives for group financing and organizational structures to overcome cash flow limitations based on their own experiences with other growers around the globe.

3.3. Case study 3 - Feed improvement for mariculture in Vietnam and Australia

This project series has brought together researchers, feed millers and fish producers in Vietnam and Australia in a partnership to improve all aspects of feed formulation, manufacture and use in aquaculture systems in both countries. The project improved the capacity for nutritional research in Vietnam and consolidated nutritional research capacity in Australian counterparts. Nutritional models were developed to account for growth prediction and utilisation of nutrients. Finfish (barramundi, grouper and cobia), mud crab and spiny lobster were the key species studied. The project built on efforts related to diet development and replacement of fish meal and fish oils from three previous ACIAR projects.

The strength of this case study is as well in its partnership development, as the project initiated the Regional Aquafeed Forums (RAFs), which is an annual meeting of feed manufacturers, fish farmers, researchers and policy makers in Vietnam,. The RAFs have directly facilitated the

integration of the various sectors of the aquaculture industry in Vietnam, helping it to become a mature and economically important industry (aquaculture exports from Vietnam are worth approximately USD 5 billion annually) (ACIAR, 2015)

One of the key elements of the success of innovation in this project is the enabling environment that exists in Vietnam. The economic shift towards liberalization and an entrepreneurial culture, combined with high competition and low protection of the industry has formed a strong foundation for a system receptive to innovation.

3.4. Case study 4 - Beef cattle production in eastern Indonesia

Smallholder farmers in eastern Indonesia have been major suppliers of beef cattle to the local markets, as well as to the large-scale market in Java for decades. However, the growth in the demand for beef, both in Indonesia and the wider region, has outstripped the local capacity to supply. ACIAR commissioned a series of projects after identifying two important elements for innovation in Java: a strong market demand for the product and a demonstrated willingness by farmers to use their cattle to generate income. The research partnership brokered by ACIAR aimed to develop strategies to deal with the shortage of Bali cattle to supply the Java markets and increase the live weight of the cattle sold into the market.

The strength of this case study is again in the partnerships it has developed, although no private sector was present, the project brought together researchers from Australia and Indonesia as well as extension services and producers from Indonesia. The researchers worked with villagers to introduce a simple management system aimed at increasing pregnancy rates in lactating cows, reducing calf mortality, reducing the bull cost per calf, and increasing average post-weaning growth rates and survival. These strategies minimized production costs, increased turn off rates, reduce average turn-off age and increase net financial returns to producers.

4. Conclusion

Patterns of innovation and impact observed in the case studies: The case studies presented illustrate two very broad patterns of innovation each with distinctive configurations namely, incremental innovation and system optimization and radical innovation and sub-system transformation (Hall *et al.*, 2016).

4.1. Incremental innovation and system optimization

The mariculture and the beef cattle projects (Case study 3 & 4) illustrate the way research can help develop incremental improvements in existing farming systems and individual value chains. It delivers valuable improvements to livelihoods of smallholders and profits for value chain actors. Demand-led research and collaborative action by local stakeholders is critical in defining and developing solutions. The scale of impact is restricted to the existing system which these industries operate in.

4.2. Radical innovation and sub-system transformation

The pearl and the cocoa case studies (1 & 2) illustrate the way new types of products and

services have created step-wise improvements in specific sub-sectors. In the case of the pearl case study, a new sub-system with focus on locally made jewellery was created, this provided new research questions and the development of solutions that could be adopted by the Ba Women's forum and deliver social and economic benefits that would not have been possible otherwise. In the case of the cocoa case study, the adoption of a "Bean to Bar" approach by chocolate manufacturers created a new challenge that could not be addressed by simply improving production of the bean, but required a research focus on post-harvest issues as well. This increased the growing "single origin" sub-sector within the Australian chocolate industry that in turn increased the potential scale of impact.

The key common factor leading to innovation across the four case studies, is the partnerships that were formed through the R4D activities. These partnerships were brokered by ACIAR and were highly context specific. There was no pattern for reaching each type of innovation, but the working relationships formed, combined with the enabling environment allowed for change to take place. This change is required in order for innovation to occur and continue to the benefit of those involved. ACIAR will continue to broker partnerships that suit the context of the working environment with a view to see further innovation and subsequent impact.

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Designing Environmental Research for Impact

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1. Introduction

Human society faces a number of ‘grand challenges’, several of which arise from the relationship between people and the environment. These include climate change adaptation and mitigation, food security, energy and water security, habitat loss and species extinctions, pollution, and the spread of weeds, pests and diseases.

These and other ‘wicked problems’ (Brown *et al.*, 2010) are characterised by technical complexity and often uncertainty, large scales in space and time, a mix of social, economic and biophysical drivers, abundant but disparate and heterogeneous data, and contested issues among diverse stakeholders. The nature of such contest is itself important: it may be rooted in conflict over values and norms, and/or uncertainty in the data. Notwithstanding complexity, uncertainty, risk and conflict, on such issues there is nevertheless typically a need for governments, industries and communities to make a choice, reflected in decisions and actions. Such choices are often negotiated, often messy rather than clear-cut, and for most environmental issues the choice to do nothing (whether made actively or by default) also has environmental consequences.

A key response to such environmental challenges is to invest in applied research, which the Australian Bureau of Statistics (1998) defines as ‘*work undertaken primarily to acquire new*

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knowledge with a specific application in view'. The nature of these challenges is such that they can rarely be comprehended satisfactorily within a single scientific discipline, or indeed by science alone. There is a significant literature on the conceptual challenges associated with multi-, inter and transdisciplinary research (Fry, 2001; Klein, 2008; Gibbons *et al.*, 2008; Bammer, 2013), and on the imperative for new ways of organising research — e.g. 'Mode 2' research and 'Post-normal science' (Funtowicz and Ravetz, 1993). Less has been published about the practice of working with end users to design and organise multi-institutional environmental research to tackle large scale, long-term environmental problems, based on analyses of current and past experience (Campbell and Schofield, 2007; Tress *et al.*, 2005a, 2005b).

Australia has invested significantly over the last twenty years in organising applied research collaborations at national scale, including the Cooperative Research Centres programme (Allens, 2012), Rural Research and Development Corporations (Productivity Commission, 2011), and Centres of Excellence funded by the Australian Research Council and the National Climate Change Adaptation Research Facility (NCCARF, 2014).

This paper briefly reviews what we mean by transdisciplinary research, then discusses the findings of a participative, 'structured reflection' involving researchers, funders and end users of successive national environmental research initiatives in Australia, adapting an analytical framework developed by Roux *et al.* (2010).

2. Transdisciplinary Research

Roux *et al.* (2010) propose a "framework for participative reflection on the accomplishment of transdisciplinary research programs". They distinguish between post-normal science (Funtowicz and Ravetz, 1993; Francis and Goodman, 2010), sustainability science (Clark and Dickson, 2003; Burns and Weaver, 2008), and interdisciplinary studies (Newell, 2001; Repko, 2008), while noting 'considerable overlaps of purpose' between these approaches and the key point that all purport to complement, rather than replace traditional disciplinary research. Transdisciplinary studies incorporate elements of all these approaches in applying insights and tools from different disciplines, explicitly embracing complexity and uncertainty, acknowledging multi-stakeholder perceptions and values, in addressing problems that are 'user inspired and context driven' (Roux *et al.*, 2010). A key feature of transdisciplinary research thus defined is the engagement of non-scientist stakeholders – in particular the end users of research – in the research enterprise (Roux *et al.*, 2010):

"A key characteristic of transdisciplinary research is that the domains of science, management, planning, policy and practice are interactively involved in issue framing, knowledge production and knowledge application."

Accordingly, Roux *et al.* (2010) suggest that there are three key groups of stakeholders in transdisciplinary research: researchers, end users of research, and funders of research. While all three groups may have shared broad goals to acquire new knowledge with a specific application in view they are likely to have different perspectives on those goals and how to achieve them, and to define success in different ways. Roux *et al.* (2010) propose a framework that sets out different accountabilities for the three 'functional domains' of funders, researchers and end users, as in table 1 below.

Table 1. A framework to guide co-reflection on progress in transdisciplinary research programmes that incorporates the accountabilities of funders, researchers and end users (after Roux *et al.*, 2010).

Functional domain	Accountability indicators
Funders of research	Strategic planning and leadership Continuity and scientific competency Discourse between funders, providers and users to ensure effective programme goals and model Flexibility to adjust programme model and goals to meet research provider and user needs Adaptive learning
Providers of research	Professionalism Knowledge sharing Relevance to end-user needs Capacity building Research excellence
Users of research	Capacity for adoption Adaptive decision-making and policy revision Continuity of personnel Co-location of personnel Capacity to build upon emerging research

More detail explaining each of these accountabilities is set out in Roux *et al.* (2010) who caution that these are not proposed as definitive or comprehensive, but to serve as a departure point from which this framework could be modified in the context of a specific research initiative.

3. Australia's National Environmental Research Programmes

The Roux *et al.* (2010) framework was seen to be ideally suited for use as an analytical lens to distil lessons for the design and management of collaborative, multi-institutional applied environmental research from the experience of national environmental research programmes sponsored by the Australian government.

The key process in the application of the Roux *et al.* (2010) framework was a 'structured reflection' workshop such as the one involving the authors of this paper in April 2014. The workshop participants between them had well over one hundred person years of experience in leading and/or funding multi-institutional, transdisciplinary research programmes, with total investment exceeding AUD 500 m. The workshop was further informed by an on-line survey of 500 participants with experience in the programmes. Each respondent was asked to self-identify as a researcher, research funder or end-user/stakeholder. A response rate of around 9 per cent was obtained, of whom 57 per cent claimed to be researchers, 11 per cent research funders, and 32 per cent were end-users and/or stakeholders. Several respondents identified with more than one role.

The two research programmes analysed in depth at the workshop were the Commonwealth Environmental Research Facilities (CERF) programme, which was initiated by the Australian

government environment ministry in 2006, and subsequently evolved into the National Environmental Research Program (NERP) from 2010. The AUD 160 m CERF programme was evaluated by Urbis (2010). The AUD 154 m NERP programme is described by DEWHA (2010) and was evaluated by Spencer *et al.* (2014). Both programmes were designed to meet the perceived knowledge needs of the environment portfolio, and to tackle issues that were not being adequately addressed by research investments through other government programmes.

The CERF programme commenced with a national call for research proposals against a programme prospectus. Well over one hundred proposals were evaluated on merit by an independent, expert reference group that recommended a suite of investments to the Minister for the Environment, including individual research projects, 'hubs' (clusters of research projects focused on particular problems/themes/ecosystems) and fellowships. The NERP programme drew on the experience and the evaluation of the CERF programme (Urbis, 2010) in having a competitive national Expression of Interest process against broad research priorities, but then focusing its investment primarily around five research hubs, all of which evolved out of successful antecedents in the CERF programme (Appendix A).

As of March 2014, almost 560 researchers from 53 organizations and many more end users had participated in NERP projects, many of whom were also involved in the preceding CERF programme. Unfortunately, there was not a seamless transition from CERF to NERP, but rather a significant hiatus in funding during which some researchers who had been funded through CERF moved on to other roles. In the transition from CERF to NERP, the federal environment department sharpened its focus to concentrate on biodiversity conservation and management, and framed itself more explicitly as the key client and end-user of the outputs of the programme. The NERP programme was thus expected to inform policy development and programme implementation within the federal environment department first and foremost. However, the programme was supported by an equivalent level of co-investment from other research users and partners, including other departments, governments (at state and local levels), industries and communities, who also expected useful outputs from the research relevant to their interests.

The ability of the five NERP hubs (Appendix A) to respond to the needs and interests of their research users meant that they evolved subtly different structures and *modus operandi*. Three had a strong and extensive geographic focus: the Tropical Ecosystems hub focused on the Great Barrier Reef, its rainforest hinterland and the Torres Strait; the Marine Biodiversity Hub focused on Australia's marine territory; and the Northern Australian Biodiversity hub focused on Northern Australian aquatic and terrestrial systems. These foci largely determined their research users and stakeholder groups, and resulted in a combination of bottom up self-organization around specific research issues and top down coordination to resource and deliver large, complex research programmes. The Environmental Decisions hub worked in partnership with a wide range of research users in the public and private sectors across the country, identifying discrete research topics through focused workshops after which small teams worked with end users on projects of varying duration from several months to several years. The Landscapes and Policy hub identified several regions as case studies, with biophysical and social researchers working in interdependent teams on questions defined by the management agencies in each region.

Aligned with a general trend over the past twenty years for increased participation across all sectors in environmental management (Holley, 2010), the environment department outlined five key design parameters for strengthening links between researchers and policy makers (Box 1).

The five current NERP hubs now constitute a considerable body of experience and expertise in multi-institutional, transdisciplinary research collaborations focused on contemporary challenges in environmental science, policy and management. All NERP hub directors, plus senior representatives of funders and end users, participated in the ACEAS workshop.

Lessons emerging from each of the hubs and the insights of their directors are elaborated further below. While the NERP hubs were all selected against the same national prospectus and funded by the same government agency against the same overall objectives, guidelines and accountability measures, it is notable that each developed in quite different ways. All now have distinct and markedly different identities and *modus operandi*, yet the recent evaluation found each to be effective against both hub and programme level objectives. This suggests

Box 1. Design parameters for the NERP programme to improve linkages between research and policy. Excerpt from DIISRTE (2012)

NERP builds on the Commonwealth's experience in implementing and evaluating the previous Commonwealth Environment Research Facilities programme, and includes increased focus on mechanisms to ensure improved delivery to the end-users of funded research, particularly in government for evidence-based policy. In support of this objective, the programme reflects best practice principles for strengthening the links and alignment between research and the needs of policy makers:

- *involving policy makers in the framing of research questions* : NERP programme guidelines and research priorities are based upon consultation across the department, with a selection panel involving both researchers and departmental representatives then working through a two-stage process to allow for the further refinement of proposals.
- *specific focus on knowledge brokering and translation* : programme guidelines require that 10% of the funding for each hub must be devoted to communication and knowledge brokering activities – the programme also acknowledges that effective translation requires integration – across research disciplines and of new and existing knowledge.
- *facilitating access to research* : in addition to other communication efforts, all NERP-funded research outputs must be made freely and publicly available to allow their use by a broader range of decision-makers.
- *enhancing mutual understanding* : the programme also supports enhanced two-way engagement through mechanisms such as the identification of departmental end-users and contact officers for each hub, short-term secondments for researchers into the department and the 'pairing' of researchers and policy staff.
- *innovation in evaluation* : the NERP monitoring and evaluation strategy requires regular reporting on the usefulness of research in policy, with a mix of quantitative and qualitative measures employed.

Common challenges of linking research and policy remain, such as differing timelines and time pressures, and particularly the reward structures within which research and policy staff work, which often do not explicitly value the types of activity outlined above.

that there is no single ‘magic bullet’ formula for designing a successful collaborative applied environmental research programme. Rather, programme design, management structure and research practice should respond to the specific ecosystem/issue, mix of stakeholders and end users and the nature of their knowledge needs, cognizant of the history of research investment in that context.

Acknowledging the importance of context in shaping local responses, we nevertheless contend that principles of good applied environmental research practice emerge across all hubs. The following section attempts to elucidate these using the framework proposed by Roux *et al.* (2010), focusing on the five NERP hubs that originated in the CERF programme, summarised in Appendix A.

4. The Relative Accountabilities of Researchers, Funders and End Users in Transdisciplinary Research Programmes

In using the Roux *et al.* (2010) accountabilities as a lens through which to reflect on the experiences and achievements of the five hubs, we involved a mix of researchers, funders and end users, both in the survey and the workshop. As suggested by Roux *et al.*, 2010 we also monitored the utility of the framework during this reflection, and identified potential improvements.

Roux *et al.* (2010) cluster the accountabilities according to the functional domain (funders, researchers, end users) primarily responsible for their realisation. This implies that there could be shared accountabilities across domains, but this is not the impression conveyed (Appendix A). We contend that multi-institutional, transdisciplinary research is a shared enterprise across funders, researchers and end users. All three domains have important roles to play, and most of these are shared responsibilities. The ultimate performance measure for such research is the generation of useful and relevant new knowledge that is applied by end users, resulting in a net environmental benefit that exceeds the cost of the research. It is very difficult for this to be realised, and it is not genuinely transdisciplinary research if any of the three domains is disengaged or discharges their responsibilities poorly.

Reflecting the conceptual framework of a shared enterprise, at the workshop we assigned a simple 3, 2 or 1 score to the degree of responsibility a given domain has for a given accountability (with 3 being most important), and we also modified the Roux *et al.* (2010) accountabilities slightly to better fit the NERP context, splitting some, combining others and deleting ‘co-location’. The consensus view of the researchers, funders and end users involved in the April 2014 workshop produced a modified version of the Roux *et al.* (2010) framework.

These weighted accountabilities are illustrated in figure 1, enabling a visual comparison across the three domains.

The accountabilities seen as important for all three groups were leadership, engagement and discourse. All participants in collaborative transdisciplinary research need to demonstrate leadership and to remain engaged and actively communicating throughout the research process. Successful leadership and engagement require that each domain is able to understand and

**(a) funders****(b) researchers****(c) end users**

Figure 1. Weighted accountabilities of (a) funders, (b) researchers and (c) end users in transdisciplinary research programmes

explain its own needs and potentials in ways that can be related to the needs and/or potentials of other domains.

The leaders of NERP-funded research hubs felt that it is important that funding agencies maintain sufficient continuity in staffing to be intelligent purchasers, able to ‘take the long view’ and undertake high quality strategic planning and adaptive management at a research programme level – responding to changing circumstances and priorities as necessary, but no more than necessary. Research funders need competent project management systems, extending to management of data, information and the knowledge ‘legacy’ from concluding research programmes. They need sufficient scientific capacity to be able to evaluate research proposals and to compare the track records of competing research providers, but not to the extent of second-guessing researchers once programmes and projects are contracted.

Researchers' accountabilities emphasise scientific competence, relevance, willingness to engage in two-way knowledge sharing and to respond to the needs of end users, competent project management and underpinning the quality of their research through publishing in strong journals, in addition to communication designed to be meaningful for end users.

The accountabilities for research end users underscore their willingness to engage in the research process to the extent necessary to maximize the chances of research outputs being fit for purpose, meeting research user knowledge needs and able to be implemented in their real world in industry, government or the community. This requires end users to have sufficient organizational research capacity and scientific competence to be able to engage effectively with researchers in problem definition and/or co-design of the research, which in turn requires continuity in personnel engaged in the research process.

The ultimate performance measure for such research investments is the extent to which programme outputs are adopted, and the resulting environmental benefit. The capacity to interrogate, adapt and utilise research outputs, and their ability to engage in adaptive learning and decision-making as new knowledge emerges, are crucial accountabilities for end users.

5. Discussion

The experience of the NERP hubs confirms that in successful transdisciplinary research programmes, research end users are not passive recipients of knowledge products arising from a linear process conceived by researchers and/or funders and implemented by researchers. Rather, it is essential that they work collaboratively with funders and researchers to define the problem and scope knowledge needs, work out approaches to tackle that problem, and then interact with researchers during the active inquiry phase of the programme so that researchers develop as deep an understanding as possible of the end users' context, why their research is important, and how their results will be used. Some problems will require more effort from the end user in defining questions, than from researchers in responding to them.

The shared experiences spanning the implementation of both the CERF and NERP models suggests that all participants' understanding of knowledge gaps evolves as collaborative applied research programmes unfold, which is why accountabilities such as engagement and discourse are important and continuity is critical for all three groups.

A design feature of the CERF programme that was seen as very successful and consequently built into the NERP programme (Box 1), was the requirement that each hub invest at least 10 per cent of its budget in knowledge brokering and communication activities. Knowledge brokers are professional intermediaries (people or organizations) who facilitate knowledge exchange and sharing between researchers and practitioners. Knowledge brokering emerged in the public health sector (CHSRF, 2003) and is now applied in diverse ways in multiple sectors (Bielak *et al.*, 2008; Michaels, 2009). Some NERP hubs have knowledge brokers embedded with end users, others with researchers, but all have explicit and significant investments in people and processes designed to ensure that end users are engaged in the research, and that research outputs are tailored to meet the needs of end users. While transaction costs may be high, the CERF and NERP experience is that direct, face-to-face interaction between researchers and end users is the most effective.

Knowledge brokering is situated along a spectrum of knowledge processes from conventional, linear dissemination of information (science communication) on the left hand side, through intermediary and brokering strategies in the middle, to co-production of knowledge, social learning and more systemic innovation (Fig. 2). A characteristic of knowledge brokering is that knowledge is provided at the time and in the form required by the end user rather than those most convenient to the researcher.

In some contexts, these knowledge intermediary processes may begin where the research stops, to improve uptake of research results and amplify research impact. In other contexts however – for example the complex, multi-dimensional and multi-stakeholder problems being addressed by the CERF and NERP hubs – brokering processes between the producers and users of knowledge (who may overlap to a significant degree) are seen to greatly enhance programme efficacy, particularly if undertaken before research is initiated, to refine research

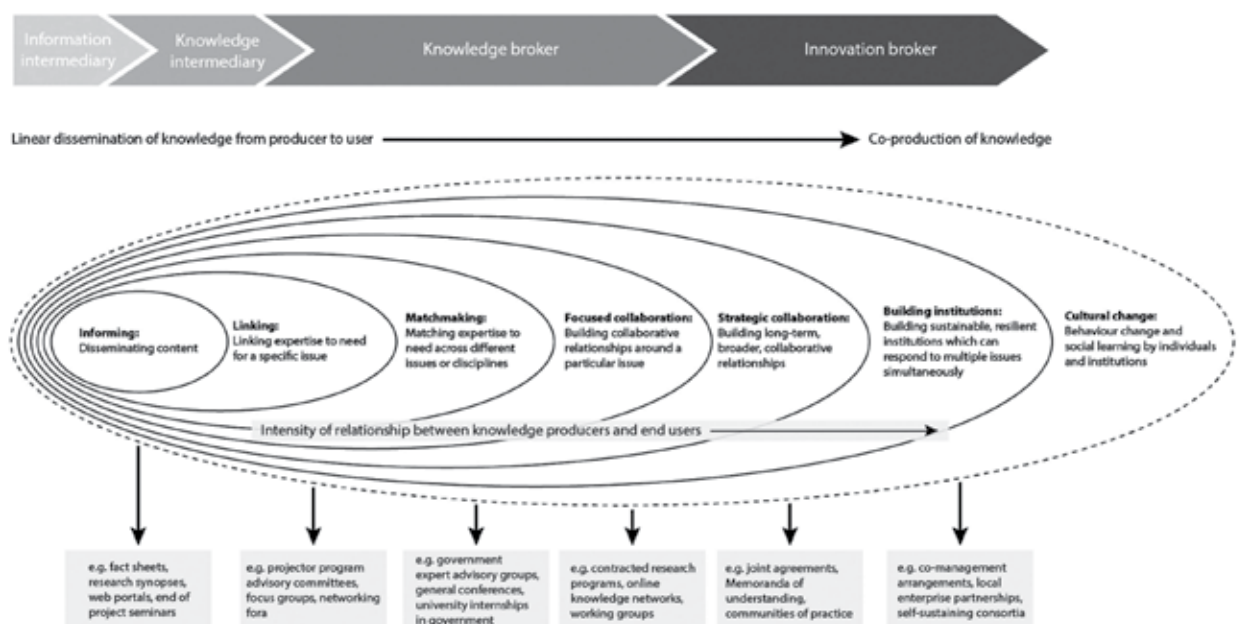


Figure 2. Knowledge roles and functions from information dissemination to social learning. After Michaels (2009)

questions, influence methodologies, determine an appropriate form of delivery, and ensure that intended end-users have a degree of ownership of research outputs. In the context of the Australian environment, this is particularly relevant to respectful engagement with Indigenous Traditional Owners of Country. In such contexts, scientific inquiry may not be the only or even the most appropriate mode of knowledge production. Local, tacit, experiential and other forms of knowledge can emerge through various types of inquiry.

Of course useful research outcomes can and do occur without knowledge brokering, but they involve a greater element of chance which can and should be avoided, especially in times of constrained research funding and greater emphasis on accountability. It is doubtful that an organization or research programme can jump to sophisticated knowledge intermediary processes (the right hand side of Fig. 2) without being competent at the basics of science communication: the ability to pick up research highlights early and present them well; good web interface and search capabilities; effective media and event strategies; and the ability to synthesize research outputs in attractive ways targeted to the knowledge needs of intended audiences. This requires dedicated resources, recognised in the CERF–NERP requirement to allocate at least 10 per cent of budget to communication and knowledge brokering processes.

In designing transdisciplinary, multi-institutional environmental research programmes for impact, we need to understand the knowledge system we are seeking to influence. This means more than researchers' understanding their market, which is weakest with the Indigenous sector. Our key point, exemplified by the experience of the CERF and NERP hubs, is that such research is a shared enterprise between researchers, funders and end users, built on a platform of shared goals and social capital across these three functional domains.

Figure 1 illustrates that continuity is an important attribute for all three groups. With sufficient continuity of personnel across the collaboration, elements of social capital such as trust and reciprocity become increasingly valuable as collaborations evolve and mature. Extended interaction over a number of years bridges the cultural differences between the different worlds of researchers and end users, it helps researchers to understand the needs of end users, it makes it easier for end users to challenge researchers and to interrogate research findings more freely, and it gives funders more confidence to invest in possibly riskier, less well-defined or more adaptive projects in a spirit of co-learning. The latter is facilitated when the funding body is also an end user, as the Australian Department of the Environment was with respect to the CERF and NERP programmes.

It is now all too common in Australia for research programmes to be funded for four years or less, which makes it difficult to sustain continuity of personnel and to build social capital (familiarity, respect, trust, reciprocity) between funders, researchers and end users. So the fact that five CERF hubs were successful in a national competitive funding round and hence became NERP hubs was very important in the evolution – and we would argue the success – of this overall investment.

The scale and complexity of 'wicked' environmental problems require both a transdisciplinary approach and sustained effort. Within the Tropical Ecosystems' NERP Hub, several research projects required at least ten years of sustained work to be useful, for example: (i) problems that

require temporal data to track the response of an ecosystem after a management intervention such as rezoning or an extreme weather event; and (ii) complex problems such as coastal water quality that have been attacked in bite-size (i.e. fundable) portions.

However it is important to note that continuity of funding for five hubs from CERF to NERP was by no means deliberate or guaranteed. In fact there was a funding gap between CERF and NERP, during which many CERF-funded researchers on short-term contracts moved on to other roles, thus undermining staff continuity and hub cohesion in the transition to NERP. Both the CERF and NERP programmes began with competitive funding processes, subject to normal Commonwealth procurement rules around contestability and competitive neutrality (DoF, 2014). Under such rules, against a background of three-year electoral cycles and budget processes, designing and sustaining long-term transdisciplinary research investments are inherently difficult. Two CERF hubs that were seen by the Department as being highly relevant and effective (focused on taxonomy and marine mammals), were not funded under NERP, due to revised government priorities for the programme and alternative funding sources.

The reviews of the CERF (Urbis, 2010) and NERP (Spencer *et al.*, 2014) programmes revealed that the hubs' flexibility and responsiveness to identify research topics in detail with their research users enabled them to address environmental issues in their specific contexts, at the appropriate scales and with objectives relevant to research users. Importantly, funding contracts with most of the NERP hubs were signed before all research projects were designed and specified in detail. Whether deliberate or not, the flexibility allowed to these NERP hubs in terms of refining research methods and detailed research programmes and projects in response to end user needs, turned out to be one of the strengths of the programme. Stakeholders and research users had a meaningful opportunity to influence the research direction and allocation of funds once the hubs became real and people were seriously engaged, rather than 'joining in' to established research projects after they had already been designed and funds already committed. As well as improving the relevance and impact of research outputs for users, in the opinion of the manager of the CERF and NERP programmes within the Department of the Environment, this ability to be flexible and responsive '*contributed to a positive cultural change to problem solving between researchers and the Environment Portfolio*'.

Where research programmes were specified in detail and contracted as such from the outset, subsequent lack of flexibility became a problem as it constrained meaningful consultation with end users, which was especially problematic for Indigenous interests.

Political scientist Brian Head (2008) argues that in modern pluralist democracies, the response to any given policy problem is ultimately informed by the interplay between three distinctly different types of knowledge and evidence, as illustrated in figure 3.

In this formulation, scientific research is one 'lens' through which Ministers and their advisers seek to understand an issue, weighed up against political judgement and the organizational knowledge, corporate memory and professional practices of relevant agencies. Each lens has a distinctive epistemology – in effect polarized by its own context and experience. Evidence that may seem compelling viewed through one lens may be virtually invisible, unconvincing

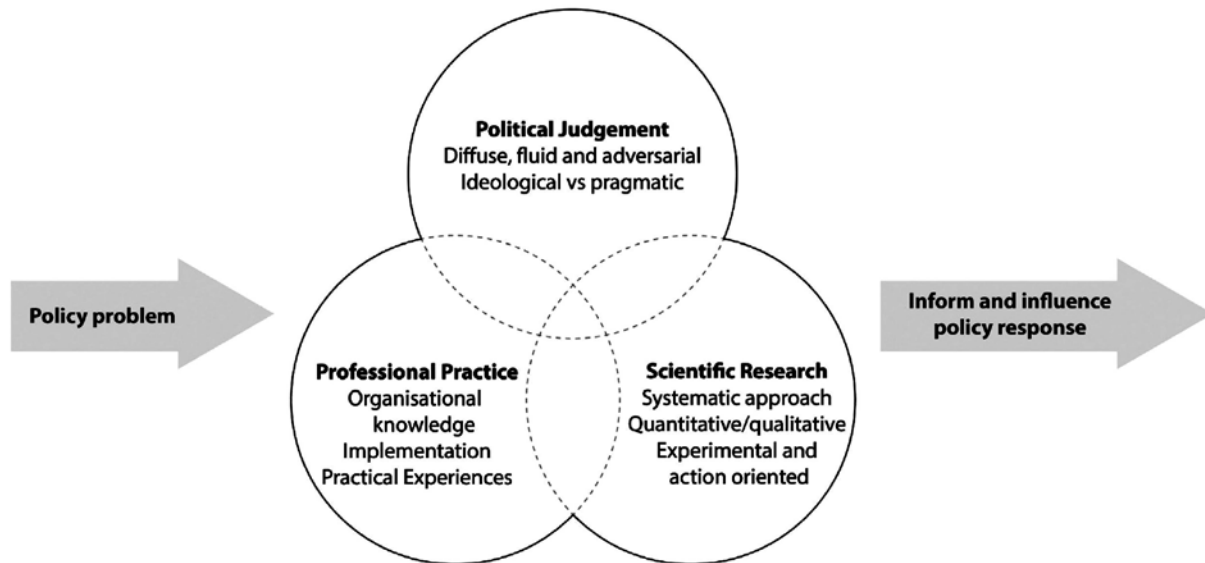


Figure 3. Knowledge roles and functions from information dissemination to social learning.
After Michaels (2009)

or rejected through another. For example, research and independent inquiries might produce evidence that pricing instruments (e.g. carbon pricing) are economically efficient means of achieving a desired policy outcome (e.g. reductions in net greenhouse gas emissions), but such evidence may be ignored, contested or rejected through an ideological political lens if election commitments have explicitly and vociferously ruled out pricing carbon.

However if researchers, funders and end users are working closely together in a joint enterprise with shared goals and a high level of social capital, and if programme design pays close attention to the accountabilities in figure 1, then over time the overall programme is more likely to be seen as useful and hence influential through all three lenses. Ministers and their officers seek feedback from clients and end users in making political judgements, and active engagement of civil servants with research programmes is likely to accelerate osmosis from research findings into organizational knowledge. A well designed and managed transdisciplinary research programme is more likely to position itself in the ‘sweet spot’ in the centre of Head’s Venn diagram than more conventional approaches wherein scientists carry out research in isolation, then publish their findings in academic journals, then lament the lack of uptake in policy. An anonymous reviewer of this paper put it well: “engagement, dialogue, planning etc. all help to shift the polarities so that everyone can see the sweet spot.”

The Australian science ministry examined the use of science in policy development in the Australian public service (DIISRTE, 2012) and concluded that the five key challenges to the use of science in policy development in the Australian public service are ‘timeliness, cultural differences, relationships, timeframes and access to data and information’. A senior environmental policy maker at the workshop noted that the CERF–NERP programmes “have been significant in building strong relationships between environment portfolio staff and researchers. But maintaining enduring relationships, particularly in the face of churn and changing priorities, remains a challenge.”

As noted at the bottom of Box 1, and consistent with DIISRTE (2012), reward systems for researchers and policy makers differ markedly. The timeframes within which policy decisions need to be made are usually much shorter than a typical research project. Consistent with the doctrine of New Public Management (Hood, 1991), the Australian public sector is characterised by ‘churn’ or frequent turnover of personnel, a suspicion of deep subject matter expertise, preference for generic process skills and a default tendency to assume that any services can simply be purchased through competitive tendering processes. Consequently it is difficult and rare for staff inside government agencies to build sufficient domain expertise and/or researcher contacts to be able to understand, articulate or interrogate research needs, or to wish to be involved in iterative development of research programmes through negotiation with researchers and end users.

In our experience, these factors are prevalent across the modern public sector in Australia at all levels of government. They work against effective transdisciplinary research to inform policy.

Paradoxically, they also make investment in such research more essential.

We found the framework developed by Roux *et al.* (2010) to be a useful starting point for framing a structured reflection among experienced research leaders to elicit lessons learned from the collective experience of five national research hubs over eight years.

There is a high level of consensus among the leaders of multiinstitutional, transdisciplinary environmental research programmes in Australia that the chances of such research influencing and improving policy are maximized when research investments are designed such that funders, end users and researchers have shared goals, sufficient continuity of personnel to build trust and sustain dialogue throughout the research process from issue scoping to application of findings, and sufficient flexibility to be able to adjust and respond to new knowledge, changing circumstances and priorities. These design criteria are important for all three functional domains of researchers, end users and funders. Other accountabilities proposed by Roux *et al.* (2010) were also important for one or two functional domains as outlined in figure 1.

As this paper was being finalized, the Australian government was evaluating proposals for research hubs against six national environmental research priorities, for a new six-year \$125 m National Environmental Science Programme (NESP) from 2015. In a two-stage process, the detail of hub research plans is to be worked out through negotiation between the Department of the Environment and successful proponents in consultation with end users, with the Department acting as both a funder and end user. Hopefully that process will be characterised by shared goals, dialogue, trust, continuity and flexibility across researchers, funders and end users, extending from the planning phase over the six years of the Programme. It is encouraging that many of the lessons from CERF and NERP distilled in this paper appear to have informed the design of the NESP.

The diverse operating models of research hubs in the CERF and NERP prove that there is no single magic formula for the design and governance of multi-institutional, transdisciplinary environmental research programmes. In spite of this, there are important design criteria that

all players – researchers, funders and end users – need to keep in clear focus as research investments are planned and implemented in order to realise an environmental benefit that exceeds the cost of the research.

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Appendix A. Research hubs of the National Environmental Research Program (NERP) and their antecedent hubs of the Commonwealth Environmental Research Facilities (CERF) programme

Hub	Research focus	Scientific disciplines	# research providers*	# researchers		Funding		Total
				CERF 2007-11	NERP 2011-14	CERF 2007-2011	NERP 2011-14	
NERP environmental decisions hub (CERF applied environmental decision analysis)	Understanding major biodiversity drivers to maintain ecosystems and maximize their resilience against human impacts	<ul style="list-style-type: none"> Climate science Ecology Economics Public policy 	9 Core partners: <ul style="list-style-type: none"> ANU CSIRO NSW OEH PV RMIT UMelb UQ UWA VDEPI 	108	118	CERF: AUD 7.81 m Co-contributions: AUD 9.9 m Total: AUD 27.71 m	NERP: AUD 11 m Co-contributions: AUD 6.4 m Total: AUD 17.4 m	Australian government: AUD 18.81 m Co-contributions: AUD 16.3 m Total: AUD 35.11 m
NERP landscape and policy hub (CERF landscape logic)	Retrospective evaluation of the impact of public environmental funding. Regional scale assessment of biodiversity including social and institutional drivers and functional attributes.	<ul style="list-style-type: none"> Geography Climate science Ecology Economics Hydrology Public policy Social science 	7 <ul style="list-style-type: none"> ACE ANU CSIRO CSU GU MU UTAS 	58	37	CERF: AUD 8.75 m Co-contributions: AUD 12.32 m Total: AUD 21.07 m	NERP: AUD 6 m Co-contributions: AUD 9.2 m Total: AUD 15.2 m	Australian government: AUD 14.75 m Co-contributions: AUD 21.52 m Total: AUD 36.27 m

Contd...

Appendix A (contd...)

Hub	Research focus	Scientific disciplines	# research providers*	# researchers		Funding		
				CERF 2007-11	NERP 2011-14	CERF 2007-2011	NERP 2011-14	Total 2007-14
NERP marine biodiversity hub (CERF marine biodiversity hub)	Provision of biodiversity and baseline data to underpin marine decision making, particularly in reference to marine bioregional planning, protected areas and natural resource management	<ul style="list-style-type: none"> • Earth science • Fisheries • Marine biology • Oceanography • Public policy • Remote sensing 	7	45	102	CERF: AUD 6.6 m Co-contributions: AUD 12.64 Total: AUD 19.24	NERP: AUD 11 m Co-contributions: AUD 18.6 m Total: AUD 29.6 m	Australian government: AUD 17.6 m Co-contributions: AUD 31.24 m Total: AUD 48.84 m
NERP Northern Australia hub (CERF tropical rivers and coastal knowledge)	Improvement of biodiversity outcomes in northern Australian terrestrial, freshwater and estuarine systems. Combining biodiversity monitoring and reporting with adaptive planning and community based natural resource management to improve biodiversity outcomes and Indigenous livelihoods	<ul style="list-style-type: none"> • Agricultural science • Ecology • Limnology • Marine biology • Natural resource management • Planning • Public policy • Traditional knowledge 	16	113	59	CERF: AUD 8.8 m Co-contributions: AUD 11 m Total: AUD 19.8 m	NERP: AUD 14.7 m Co-contributions: AUD 15.8 m Total: AUD 30.5 m	Australian government: AUD 23.5 m Co-contributions: AUD 26.8 m Total: AUD 50.3 m

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Appendix A (contd...)

Hub	Research focus	Scientific disciplines	# research providers*	# researchers		Funding		
				CERF 2007-11	NERP 2011-14	CERF 2007-2011	NERP 2011-14	Total 2007-14
NERP tropical ecosystems hub (CERF marine and tropical sciences research facility)	Improvement of scientific understanding and environmental decision making in far north Queensland with particular reference to the Great Barrier Reef, rainforests of the Wet Tropics and Torres Strait	<ul style="list-style-type: none"> Climate change Ecology Fisheries Limnology Marine biology Natural resource management Public policy Traditional knowledge 	13 <ul style="list-style-type: none"> AIMS ANU AR CSIRO GAC GBRMIPA GU JCU LLR RAPA TSRA UQ WTMA 	267	242	CERF: AUD 37.2 m Co-contributions: AUD 45 m Total: AUD 82.2 m	NERP: AUD 28.5 m Co-contributions: AUD 33.4 m Total: AUD 61.9 m	Australian government: AUD 65.7 m Co-contributions: AUD 78.4 m Total: AUD 144.1 m
Australian government						AUD 69.16 m	AUD 71.2 m	AUD 140.36 m
Partners						AUD 90.86 m	AUD 83.4 m	AUD 174.26 m
Total			52	591	558	AUD 160.02 m	AUD 154.6 m	AUD 314.62 m

*ACE: Antarctic Climate and Ecosystems Cooperative Research Centre, AIMS: Australian Institute of Marine Science, ANU: Australian National University, AR: Apudthama Rangers, AWC: Australian Wildlife Conservancy, BCYDC: Balkanu Cape York Development Corporation, CDU: Charles Darwin University, CSIRO: Commonwealth Scientific and Industrial Research Organisation, CSU: Charles Sturt University, Djelk: Djelk Rangers (Bawinanga Aboriginal Corporation), JCU: James Cook University, GA: Geoscience Australia, GAC: Girringun Aboriginal Corporation, GBRMPA: Great Barrier Reef Marine Park Authority, GU: Griffith University, LLR: Lama Lama Rangers, MU: Macquarie University, MVic: Museum of Victoria, NAILSMA: Northern Australian Indigenous Land and Sea Management Alliance, NSWOEI: New South Wales Office of Environment and Heritage, NTLRM: Northern Territory Department of Land Resource Management, PV: Parks Victoria, RAPA: Rainforest Peoples Aboriginal Alliance, RMIT: Royal Melbourne Institute of Technology, TSRA: Torres Strait Regional Authority, UMelb: University of Melbourne, UQ: University of Queensland, USyd: University of Sydney, UTAS: University of Tasmania, UTS: University of Technology Sydney, UWA: University of Western Australia, VDEPI: Victorian Department of Environment and Primary Industries, WaLML: Warrdeken Land Management Limited, WGAG: Wunambal-Gaambera Aboriginal Corporation, WTMA: Wet Tropics Management Authority.

Facilitating Multistakeholder Partnerships to Support Farmer Innovation in Food and Agriculture - Lessons from PROLINNOVA Nepal

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Keywords: PROLINNOVA, global partnership, participatory innovation, multi-stakeholder, platform, inclusiveness, empowerment, collaboration, local innovation support, capacity building, academic curricula, publications, commitment and livelihood.

1. Background to PROLINNOVA

Promoting Local Innovation (PROLINNOVA) in ecologically oriented agriculture and natural resource management, is a community of practice involving partners in several countries in Africa, Asia and Latin America. Initiated by civil society organizations (CSOs), this Global Partnership Programme under the umbrella of the Global Forum on Agricultural Research (GFAR) embraces both state and non-state organizations. It promotes recognition of local innovation (LI) by women and men farmers as an entry point to farmer-led participatory innovation development (PID) which is a process whereby farmers take the lead in experimentation to improve their innovations supported by external service providers such as extensionists, scientists, processors, input providers and others. The ultimate aim is to integrate this approach into institutions of agricultural research, extension and education.

2. PROLINNOVA Nepal

PROLINNOVA Nepal was established in 2004 as a multistakeholder partnership to promote farmer innovation and participatory innovation development (PID). PROLINNOVA Nepal has partners from non-governmental organizations (such as Local Initiatives for Biodiversity, Research and Development, Ecological Services Centre, TUKI Sunkoshi), governmental organizations (such as the Department of Agriculture and its district offices, academia (Tribhuvan University), international non-governmental organizations (such as Practical Action and CARE), and farmer innovators, each with its own capacities and strengths.

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2.1. Essential features of PROLINNOVA

- Multi-stakeholder partnership led by CSOs
- Common vision of a world where men and women farmers play decisive roles for in agricultural research and development for sustainable livelihoods
- Driven by a set of shared values and principles that include integration, inclusiveness, empowerment, collaboration, shared learning, good governance, ownership and being open source
- Platform for learning, sharing and advocacy, where experiences, lessons, successes and failures of partners are shared openly and transparently in order to grow and become stronger. Moreover, such shared learning and analysis allows for evidence-based policy dialogue.
- Accountability throughout the network through the PROLINNOVA Oversight Group at international level and National Steering Committees at country level
- International partners workshop is an annual gathering of partners from all country platforms (CPs) and international support team who come together for reflection on previous year and strategising and planning for coming year.
- All partners including farmer innovators are equal partners in the process of participatory innovation development.

2.2. Good practices of PROLINNOVA Nepal

PROLINNOVA Nepal was the first country platform within the international network to organise a National Farmer Innovation Fair that brought together more than 60 women and men farmer innovators to Kathmandu for a three day public event which attracted many ARD stakeholders, students and the general public. The event that was declared open by the then Minister of Agriculture & Cooperatives, provided an excellent opportunity for farmer innovators to directly interact with agricultural research and development (ARD) policymakers and stakeholders. Live telecasting of the event gave wide publicity to farmer innovators and celebrated their creativity. The experiences and lessons from this event have been used to organise similar farmer innovation fairs in other countries and regions in the world.

PROLINNOVA Nepal partners have done a great deal of capacity building within agricultural research and development organizations. Having built up a core team of trainers in PID, PROLINNOVA Nepal has built the capacity of many front-line staff of agricultural and rural development programmes and organizations to identify and document farmer innovations and facilitate processes of farmer-led joint research. They have also strengthened the capacity of many farming communities to improve their own innovations by engaging in joint research that is led and controlled by them.

PROLINNOVA Nepal was also the pioneer of Local Innovation Support Fund (LISF) as a means of funding farmers' research. This idea was picked up by the international network and expanded into LISF pilots in several countries and the recommendations provided to policy makers on how farmers' research could be supported and managed at community level through LISFs.

PROLINNOVA partners in education have taken some bold steps for integrating the LI/PID approach into academic curricula. The Institute for Agricultural and Animal Sciences (IAAS) of the Tribhuvan University developed courses on LI/PID at B.Sc. and M.Sc. level. Several students of the institute did their research on aspects of LI/PID and worked together with farmer innovators. Farmer innovators were invited to share their experiences with students and staff through seminars. PROLINNOVA partners have started to work with primary and secondary schools and post-secondary colleges, trying to get children and youth interested in pursuing futures in sustainable farming. Farmer innovators are used as resource persons in such programmes. As many youth are disenchanted with farming and migrating out of rural areas, it is crucial to capture their interest and stimulate them to choose for farming as a livelihood that could support them, their families and their communities.

PROLINNOVA Nepal has brought out several publications to disseminate its experiences and to promote its approach. These include three catalogues of local innovation, a set of guidelines to document local innovation, several videos in local innovation and participatory innovation development.

2.3. Added value of PROLINNOVA

In just over a decade, PROLINNOVA has made considerable strides towards its mission of stimulating a culture of mutual learning and synergy among diverse stakeholder groups to actively support and promote local innovation processes in agriculture and natural resource management (NRM).

- Multistakeholder partnerships have been established and continued, from 3 CPs in 2003 to 21 CPs in 2016.
- Innovative methods have been incubated and developed such as PID, LISFs, FIFs, farmer-led development, etc.
- Capacities of a large number of development practitioners and farmers have been enhanced.
- PID has been used in new areas such as HIV-aids affected communities, adaptation to climate change, farmer-led research networks, etc.
- PID has increased recognition of the contribution of farmer innovators to food and nutrition security.
- Integrated aspects of the PROLINNOVA approach into mainstream institutions of agricultural research, extension and education
- Enormous personal commitment of many individuals in the network who invest a lot of their own time in continuing the work

2.4. Challenges faced by PROLINNOVA

As an international network, PROLINNOVA continued to face challenges, which it deals with as it moves along. Some of the key challenges are:

- Finding donors who are more interested in and willing to learn together with PROLINNOVA partners in a process-oriented approach

- ARD stakeholders who are too impatient to deal with an approach to sustainable agricultural development that seemingly takes longer to show development outcomes
- Time required to build evidence that can be used to influence policy makers
- No core funds to support at least some of the networking activities that are now done by individuals who invest a lot of their own time
- Finding creative ways of engaging PROLINNOVA staff even when they leave organizations

3. Conclusion

PROLINNOVA Nepal continues to be a vibrant network of multi-faceted partners who are committed to seeing women and men farmers in Nepal and plays active and decisive roles in agricultural research and development for sustainable livelihoods.

Strengthening Capacities in Innovation Partnerships

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Keywords: Innovation, scaling out, capacity development, functional capacities, innovation partnerships, strength, weaknesses, collective actions and investments.

1. Background

Innovation linked to rural and urban markets is key to drive sustainable growth and poverty reduction. This can be promoted using an agricultural innovation system (AIS) approach which requires capacities to innovate that are often limited in the public and private organizations in the agriculture sector. These capacities tend to be weak due to systemic challenges within organizations and their environment, limiting the development as well as the spread or scaling out of innovations. In many cases, organizational models of research and development, management practices, incentives and individual capacities of staff still reflect and reproduce a vision of development based on disciplinary boundaries and the prominence of technical innovation.

Capacity Development for Agricultural Innovation Systems (CDAIS) is a project financed by the European Union and jointly implemented by Agrinatura and FAO, which aims to address these capacities both at the global level and in the 8 pilot counties.

2. Capacities to Innovate and the Process of Capacity Strengthening

Capacities reside at individual, organizational and institutional levels. A recent review of capacities to innovate identified that the key “capacity to adapt and respond in order realize the potential of innovation”, could be broken down into 4 key “functional capacities”: the capacity to navigate complexity, the capacity to collaborate, the capacity to reflect and learn, and the capacity to engage in political and strategic processes³. Without these functional capacities, technical capacities alone are likely to have limited impact.

Strengthening these capacities requires a process of capacity development that engages key actors within an innovation partnership. The CDAIS project uses a process of mobilizing actors,

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³The Common Framework on Capacity Development for Agricultural Innovation Systems (conceptual background, guidance note, and synthesis) is available (at <http://www.cabi.org/Uploads/CABI/about-us/4.8.5-other-business-policies-and-strategies/tap-conceptual-background.pdf>; <http://www.cabi.org/Uploads/CABI/about-us/4.8.5-other-business-policies-and-strategies/tap-guidance-note.pdf>, and <http://www.cabi.org/Uploads/CABI/about-us/4.8.5-other-business-policies-and-strategies/tap-synthesis-document.pdf>

visioning to develop shared objectives, conducting participatory capacity needs assessments, joint action planning, followed by joint implementation, and reflection and learning in a series of learning cycles.

Key drivers of this process in the CDAIS Project are national innovation facilitators (NIF). A team of facilitators provide support to selected innovation partnerships, and conduct in-depth participatory capacity needs assessments. This process leads into the identification of needs and capacities within specific innovation partnerships, which will then result into a more relevant and sustainable capacity action plans. Findings from each innovation partnership will be consolidated and analyzed to identify required support actions by organizations with national mandates at national level to achieve economies of scale. The organizations will in turn be supported to build their capacities to innovate. This approach builds on the concept that building capacity for innovation is an experiential and social learning process. It can only take place through an iterative process of action, reflection, consolidation of lessons learned, and re-planning, by the different actors involved. This is a very different process than conventional training.

The process is designed to result in changes in performance or behavior at individual, organizational and institutional levels. These changes can be tangible or intangible. Therefore, a reliable framework is being developed to monitor changes at these different dimensions and levels, with indicators that reflect the functional capacities described.

3. Strengths and Weaknesses

3.1. Strength

The process engages directly with the actors. Specific capacity needs to achieve the objectives of the innovation partnerships are jointly identified. This may concern changing certain behavior, investments and performance of individuals, organizations and institutions. Capacity development interventions are designed with the core concepts of collective learning and adaptation in mind to cater to numerous opportunities and challenges within partnerships or networks. This process enhances interactions, trusts and synergies among actors enabling joint actions (including investments and policies) to avail of opportunities at all levels.

3.2. Weakness

The process takes substantial time and resources because identification of needs and interventions are iterative and inclusive. Engaging key actors with different or conflicting interests will require facilitation. Facilitation is a key element in the process going beyond the conventional task of communication and information sharing. It requires ability to foster synergy among actors and resources to enable collective planning and decision making. Investing in strengthening capacities to facilitate is critical before initiating activities.

4. Conclusion

Capacities to innovate are best strengthened by targeting all three dimensions (individual, organizational and institutional) of actors and focusing on both technical and functional capacities. This requires collective actions and investments by relevant actors to achieve concrete and lasting positive change.

Household Garden Interventions for Food and Nutrition Security

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Keywords: Developing countries, disability adjusted life years (DALYs), home based food production, impact evaluation, nutrition security.

1. Background

For poor people, home garden produce can make a critical contribution to the household diet and provide several other benefits, particularly for women. However, the productivity of most existing home gardens is low because of poor soil quality, limited water availability, low quality seed, crop pests and diseases, poor crop management and the destruction of crops by livestock.

The experience of the World Vegetable Center and other organizations shows that capacity building and targeted support can address many of these production constraints, and when combined with parallel interventions in nutrition and health, can sustainably improve the nutritional status of people vulnerable to micronutrient malnutrition.

The potential of home gardens to address micronutrient under nutrition in developing countries has been recognized in a rapidly growing body of literature (*e.g.* Iannotti *et al.*, 2009; Galhena *et al.*, 2013; Olney *et al.*, 2013; Ruel and Alderman, 2013; Weinberger, 2013; DFID, 2014). Recent research by the World Vegetable Center provides evidence that household garden interventions increase vegetable consumption and production (Schreinemachers *et al.*, 2015), contribute to women's empowerment (Patalagsa *et al.*, 2015), and are cost-effective to lessenvitamin A, iron and zinc deficiencies in people's diets (Schreinemachers *et al.* 2016).

2. Essential Components of Household Garden Interventions

The household garden intervention targets people vulnerable to micronutrient undernutrition, especially women of child-bearing age and households with children under 5 years old. The intervention design is documented in World Vegetable Center (2016). The Center's household garden intervention has three synergistic components (Figure 1):

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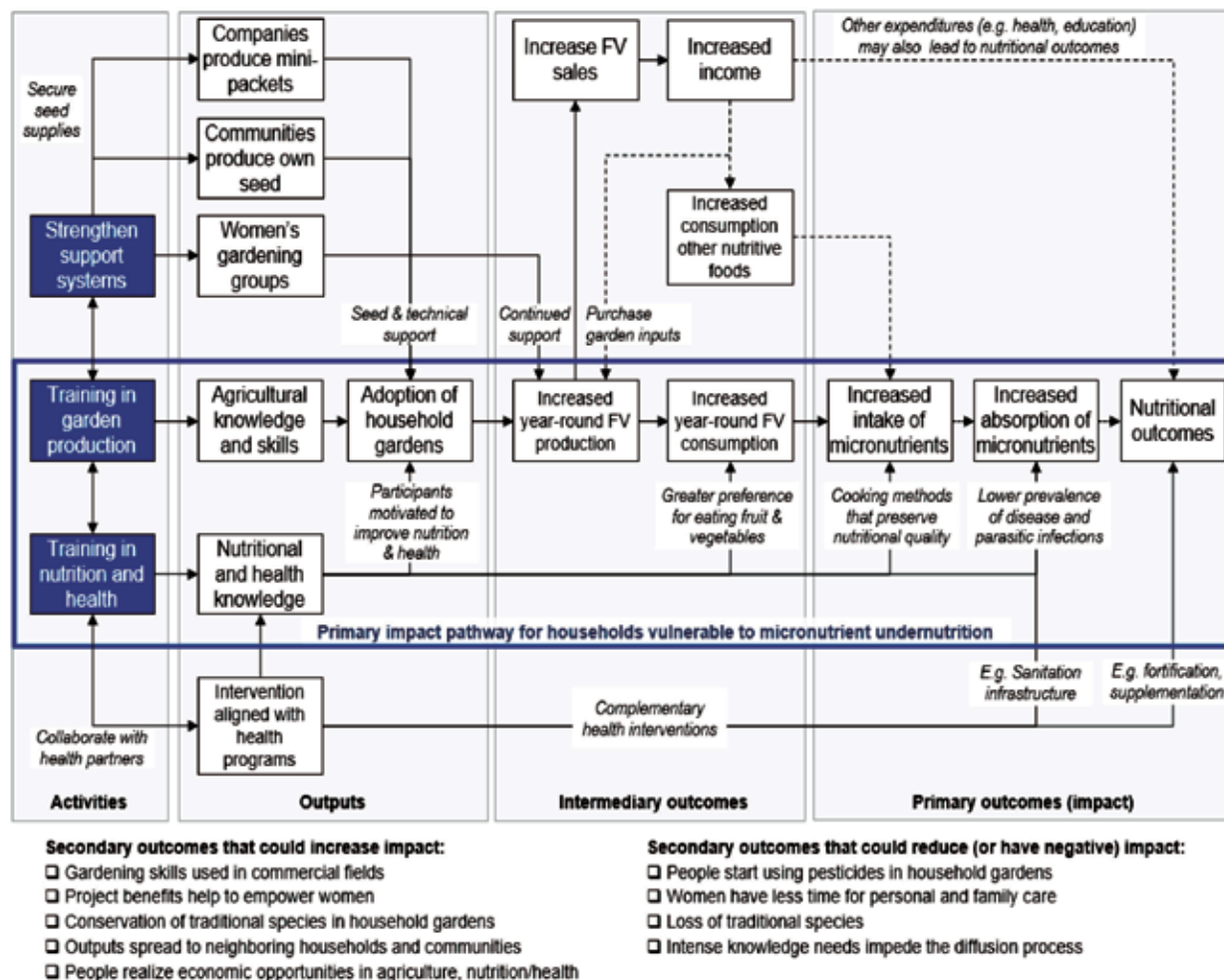


Figure 1. Theory of change of the World Vegetable Center household garden intervention

Note: FV = fruits and vegetables

2.1. Garden production

(i) a diverse range of nutrient-dense fruit and vegetable species, combining traditional and improved varieties, suited to prevailing environmental conditions; (ii) garden management based on good agricultural practices to overcome production constraints.

2.2. Nutrition and health

(i) increased knowledge about the importance of fruit and vegetables for nutrition and health and knowledge about good food practices that enhance the preservation, uptake and utilization of micronutrients; (ii) awareness raising about the importance of clean water, sanitation and hygiene for health and alignment of the household garden intervention with existing programmes in this area.

2.3. Support systems

(i) supply of high quality seed by commercial seed suppliers or community-based seed systems;

(ii) support from the community through involvement of community leaders and community-based groups such as women's groups, or their establishment where they are absent.

3. Strengths of Household Garden Interventions

Malnutrition is a complex problem that requires comprehensive interventions combining better access to food, nutrition practices and healthy environments. Household garden interventions are ideally suited to deliver this. They help people to help themselves by enabling them to produce greater quantities of a diverse range of fruit and vegetables (and the vitamins and minerals contained therein) while simultaneously raising people's awareness about the importance of good nutrition and a healthy environment. By influencing people's abilities and choices to produce and consume food rich in vitamins and minerals, household garden interventions address some of the root causes of malnutrition.

The benefits of household garden interventions go beyond micronutrients as they contribute to dietary diversification (an important welfare indicator in its own right), increased resilience against external shocks, women's empowerment, and other social and economic functions. For Bangladesh, Schreinemachers *et al.* (2016) calculated the annualized cost per household to be USD 23.2 (including women's time spent). Comparing this to the benefits in terms of healthy life years saved (DALYs) from micronutrient under nutrition, they showed that the intervention is cost-effective according to World Health Organization (WHO) standards. In comparison, biofortification of staple crops, micronutrient supplementation, and food fortification might be more cost-effective to address micronutrient deficiencies as these are less costly to scale, but do not provide the same wide range of nutritional, social and economic benefits as household garden interventions. Home garden interventions should therefore be seen as complementary to these interventions for addressing the root causes of malnutrition.

4. Potential for Successful Scaling

Helen Keller International reached over 1 million households in Bangladesh with home garden interventions, which shows that the intervention has potential for scaling-out (Iannotti *et al.*, 2009). With regard to scaling-up, it is important to recognize that, in spite of the enormous contributions of home gardens to food and nutrition security, they receive little to no attention in agricultural research, agricultural extension, and policy. The normative view of modern agriculture is one that is market-oriented, large-scale, and technology-intensive; household gardening seems to be exactly the opposite. It is therefore important for research, extension and policy to better recognize the importance of home gardens to food and nutrition security and the potential of household garden interventions. Due to the knowledge-intensive nature of household gardening, successful scaling will most likely require adequate investment in quality educational activities to enable effective implementation.

5. Conclusion

Household garden interventions, combining capacity development in gardening and nutrition with support systems, address some of the root causes of malnutrition in developing countries.

Evidence is accumulating for their positive impact on food and nutrition security. There is a need to recognize their potential in research, extension and policy.

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Carrageenan as Plant Food Supplement Boosts Rice Productivity

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Keywords: Carrageenan, resistance, interventions, seaweed, food supplement, oligomers, bio-efficiency, polysaccharides, heavy metals, bio-stimulants, elicitors, tungro virus, up-scaling, capacity building.

1. Introduction

Rice is the staple food crop of the population of the Philippines. In 2013, it covers a physical land area of 4.75 million hectares, about 45 per cent of the country's total agricultural land area. Of the 4.75 million hectares devoted to rice farming, about 3.24 million hectares were irrigated, while 1.51 million hectares were rainfed.

Current rice farming practices incorporate fertilizer, insecticide, and fungicide treatments into farm management programmes to be able to increase yield of rice. It is a known fact that misuse of these chemicals has some adverse effects on health and the environment. Thus, efforts are being done to address these concerns by innovative approaches in terms of modification of production inputs like the use of good varieties, proper nutrition and appropriate water management which are the three critical factors to produce better yields, and can promote sustainable agriculture.

Recently, one of the science-based interventions used in rice production is the application of plant food supplement sourced from seaweeds known as Kappa (κ -) carrageenans. They are hydrophilic polymers that comprise the main structural polysaccharides of numerous species of seaweed *Eucheuma*. They are composed of D-galactose units linked alternately with $\alpha(1,3)$ -D-galactose-4-sulfated and $\beta(1-4)$ -3,6-anhydro-D-galactose. Upon irradiation, polysaccharides e.g. carrageenans can be degraded to form shorter fragments in the form of oligosaccharides. These low molecular weight fragments exhibit a wide variety of biological activities including plant growth promoter (PGP) effects.

The Philippines being the largest producer of industrial carrageenan has global sales estimated at USD640 million. China is the main exporter to global markets in the US and Europe. The most commonly used sources are *E. cottonii* (*Kappaphycus alvarezii*, *K. striatum*) and *E.*

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spinosum (*Eucheuma denticulatum*), which together provide about three-quarters of the world production. After harvest, the seaweed is dried, baled, and sent to the carrageenan manufacturer. The raw weed is first sorted and crude contaminants are removed by hand. The product is called semi-refined carrageenan, Philippines natural grade or in the U.S., it simply falls under the common carrageenan specification.

Indonesia currently leads the production of carrageenan which is produced by a specific type of seaweed, *Eucheuma species*. The Philippines still produces carrageenan and processes it to refined carrageenan. However it also imports the *Eucheuma* seaweed from Indonesia. It then extracts the raw carrageenan and processed it to refined carrageenan for both domestic use and for export.

2. Carrageenan as Plant Food Supplement (CPFS)

2.1. What is carrageenan?

It is an indigestible polysaccharide (a carbohydrate) extracted from red edible seaweed species. Carrageenan is widely used for its gelling, thickening and stabilizing properties in the food industry and as a binder in toothpaste and shampoo. Results of studies conducted by the Philippine Nuclear Research Institute of the Department of Science and Technology (DOST-PNRI) showed that carrageenan-derived polysaccharide enhances rice growth (as foliar organic fertilizer) when degraded through a “very small dose” of gamma radiation (Abad, 2015). Acting as plant food supplement, carrageenan develops substances that can improve the overall health, growth and development of plants. The agricultural benefits of carrageenan are achieved from its building blocks: the long-chain carrageenan polymer that can be broken down into shorter chain fragments known as oligomers (“oligo” for few). These oligomers are easily absorbed by the plant to help their growth and development and also improve their resistance to diseases.

2.2. Carrageenan dosage requirement

The refined carrageenan is the raw material being irradiated to produce the plant food supplement (PFS). The quantity of refined carrageenan is available locally. Initial studies showed that refined carrageenan is a better source of PFS than raw or semi-refined carrageenan. A minimum dose of 30 kGy has been found to produce the most effective PFS. A bio-efficacy test was conducted (Magsino, 2015) which established the optimum application of PFS to be 9L/ha equivalent to 0.1 kilo carrageenan /ha. Optimum radiation doses to obtain an average Mw of 2-10 kDa were determined for use as PFS. Both k-carrageenan and seaweed carrageenan solution gave oligomers of this size range at 20-30 kGy (kilogray), a radiation-absorbed dose measurement.

Radiation degraded polysaccharides can induce various kinds of bioactivities such as growth promotion of plants, suppression of heavy metal stress on plants, anti microbiological and anti viral activities (Kume, 2000). Earlier studies on radiation processing of polysaccharides as plant growth promoter show that alginate, chitosan or carrageenan are more effective as PGP compared to the non-irradiated form. Under the auspices of International Atomic Energy

Agency (IAEA) and the Forum for Nuclear Cooperation in Asia (FNCA), a regional cooperative project on “Radiation Processing of Natural Polymers” have demonstrated the usefulness of radiation degraded polysaccharides as growth promoter and protector of crops (IAEA & FNCA Meetings). A lot of studies have been carried out in Member States, including the Philippines, to investigate the plant growth promotion and plant protection effect of radiation processed polysaccharides in a variety of crops under different environmental conditions. The radiation processes polysaccharides have clearly shown that even at very low concentrations are very effective for its organic fertilizing values.

3. Bio-efficacy Evaluation

3.1. Project development

The development of carrageenan as plant food supplement started in May, 2013 with the initiation of Department of Science and Technology-Philippines Nuclear Research Institute (DOST-PNRI) project on “Plant Bio-stimulants and Elicitors from Natural Polymers” being funded by the Department of Science and Technology - Philippines Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD). The project which has a duration of three (3) years aim to develop and test plant bio-stimulants (with growth promoting mechanism) and inducers of disease resistance from radiation-modified carrageenan on peanut, mungbean, and rice which could benefit the farmers in general (PCAARRD, 2015). In this project, the DOST-PNRI provides the supply of irradiated carrageenan while the University of the Philippines, Los Banos - National Crop Protection Center (UPLB-NCPC) supervises actual treatments and application in the field. Researchers from UPLB-NCPC were able to establish the efficacy of radiation-modified carrageenan as plant food supplement and as inducers of disease resistance in rice through different treatments and timing of application at UPLB Central Experiment Station. The efficacy of radiation-modified carrageenan as inducer of resistance against pests and diseases of rice under greenhouse and field conditions.

3.2. Experimental trials

Field testing of the CPFS reduced bacterial blight severity in rice regardless of concentration (50, 100 and 150 ppm). No tungro virus infection has been observed in the project areas despite the presence of green leafhoppers and infected rice fields nearby. At present, the efficacy of the product as inducers of resistance in rice insect pests such as green leaf hopper (GLH), brown plant hopper (BPH), rice stem borer, climate change pests (cutworm and armyworm) and its influence on the population density of beneficial arthropods are being subjected into a multi-location demonstration trials at farmers’ field in multi-location trials for dry and wet cropping seasons.

3.2.1. Multilocation trials

In June 2015, DOST-PCAARRD provided fund support to further demonstrate and evaluate the efficacy of carrageenan in four different field trial sites in Lucena, Iloilo City; Pulilan, Bulacan; Muñoz, Nueva Ecija; and Victoria, Laguna under the “Multi-location Field Trials of Radiation-

modified Carrageenan as Plant Growth Promoter” project. This activity demonstrated the best and refined treatments of radiation-modified carrageenan application on plant resistance to insect pests and diseases and further assessed the effects of organic plant growth promoters versus inorganic fertilizers in rice under selected field conditions. Multi-location trials were conducted at a one-hectare farmer’s field in four locations for one wet and one dry cropping season following the established spray application protocol (Fig. 1).

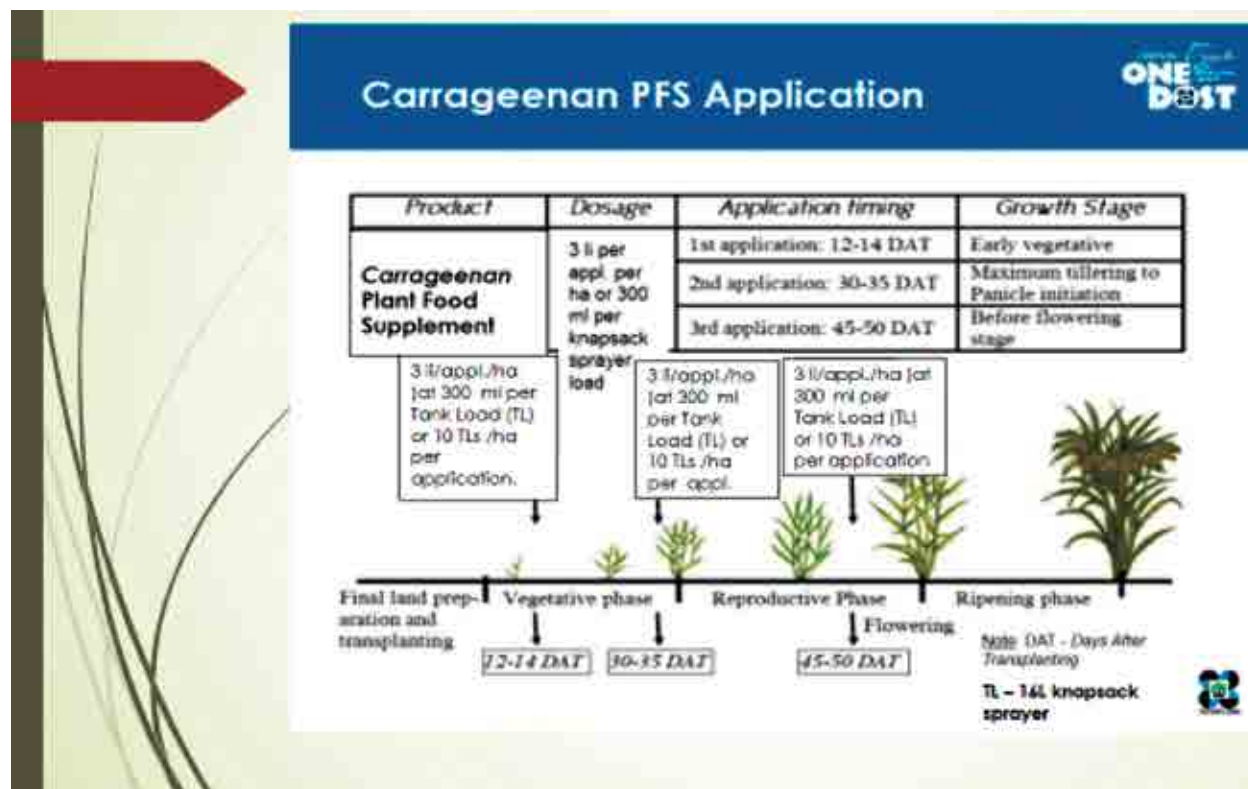


Figure 1. Schedule of spray application on rice of carrageenan plant food supplement

In Pulilan, Bulacan field trial, researchers from UPLB-NCPC found out that the addition of 20 milliliters per liter of carrageenan to 3-6 bags of fertilizer per hectare led to an increased grain weight of 450 and 455 grams, respectively, as compared to the 275 grams of grain weight produced through traditional farming practices. The decrease in the amount of fertilizer needed when using carrageenan PFS could lead to bigger savings for rice farmers. Results in multi-location trial sites was able to confirm increase in rice yield by more than 35 per cent through the application of carrageenan PFS. However, in Pulilan, Bulacan, results of experiment showed a 65 per cent increase (Magsino, 2016). Similar results in terms of increasing trend in yields were observed in other testing sites with increased in yields using half of the recommended fertilizer granular plus carrageenan. Moreover, observations were made on the reaction to diseases and insect pests that most farms with CPFS were free from infestation and with abundant presence of natural enemies.

3.2.2. Upscaling of CPFS

The breakthrough in carrageenan PFS during the multi-location trials resulted in development of

a pilot testing programme for rice farmers in Regions 1, 2, 3, 4a, 6, 9, and 11, cultivating some 37,000 hectares of rice lands all over these regions starting from January, 2016 for two cropping seasons. Under this DOST and UPLB-NCPC “Field Verification Testing of Carrageenan PFS for Enhanced Growth and Induced Pest and Disease Resistance” project, large scale demonstration and adoption of the usefulness of carrageenan plant food supplement on rice growth and yield under different (location specific) environmental field conditions will be evaluated. The Department of Agriculture (DA) through their Regional Field Offices (RFO) shall identify the areas and potential farmer-cooperator. The DOST through their Regional Offices will enable the supply and delivery of carrageenan PFS through the DOST-PNRI, initiate production of IEC materials and training farmers on the technology and farming practices. Both DA and DOST agrees on the collection of data/feedback on the results of carrageenan demonstration. Depending on agreed arrangement, both offices will help to facilitate the free distribution of CPFS in the field. The project already distributed free carrageenan PFS in Regions 2 and 3 for actual usage in farmers field in time for the January cropping season. Almost 2,000 hectares have been sprayed with CPFS in two regions and majority of the farmers enjoyed the benefits of the effect of the product. In Region 2, four provinces are being used as hubs for distribution of the product through the Local Government Units. The rest of the regions will start during the November-December 2016 cropping season. The project will benefit some 30,000 farmers in the targeted regions. The carrageenan distribution programme in Region 2 is as follows (Fig. 2).

3.3.3. Capacity building

Several successful activities were conducted in the town of Pulilan, Bulacan during the 2016 dry season rice cropping (January to May) highlighting the launching of the carrageenan plant food supplement (CPFS) through technology forum, survey/interviews with farmer-beneficiaries

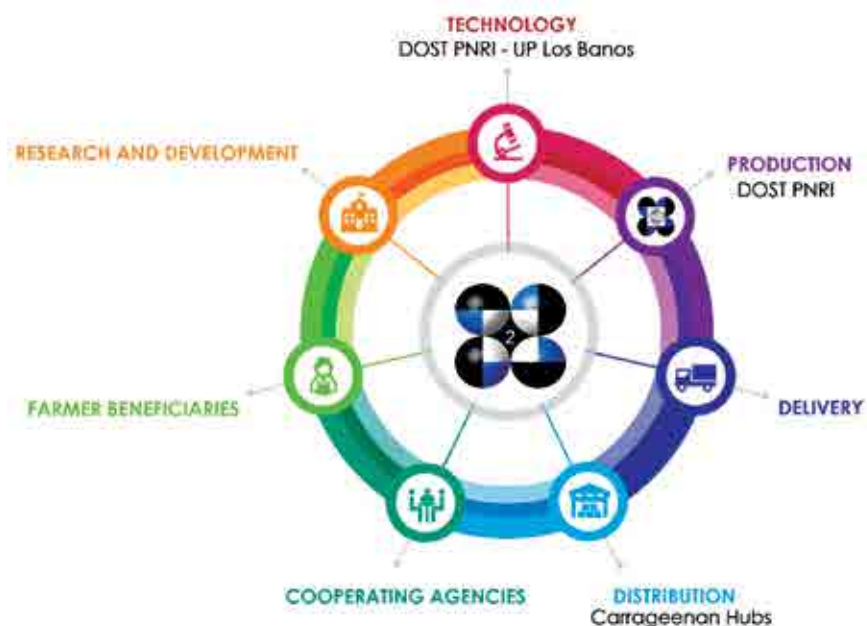


Figure 2. Flowchart for the action plan on the application of CPFS in selected areas of Cagayan Valley (Region 2)

and training on the rice production and application of CPFS, Harvest festival and distribution of information materials on CPFS were also done. Pulilan, Bulacan is one of the fortunate first beneficiaries of the CPFS technology from the Department of Science and Technology (DOST) which increases the grain yield. In January 18, 2016, each of the approximately 1,200 farmers in sixteen barangays were provided with 9.6 liters of CPGP for free and tested on their farms. DOST Region 3 initiated data gathering among Pulilan farmers. Similar activities were conducted in Region 2 and there are currently 15 techno-demo farms in 1,137 hectares of rice farms. Through surveys and interviews, positive results were obtained, specifically, the comparison of crop yield during the summer of 2015 and 2016.

4. Conclusion

CPFS offers an array of benefits because it provides an increase in yields, makes the rice stem stronger thus, improves rice resistance to lodging, it is compatible with farmers' practice on fertilizer application thus, giving higher grain yield potential, it promotes resistance to rice tungro virus and bacterial leaf blight. Moreover, it has no harmful effects on natural enemies or beneficial insects and arthropods and thus environment-friendly.

CPFS does not only improve the rice yield, but provide savings to the farmers by reducing the commercial fertilizers and pesticides applications. It is further recommended that monitoring of the efficiency of the product be pursued. The product must be registered with authorized authority to effect the adoption in commercial scale.

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Selective Breeding in *Kankrej* Native Breed of Cattle

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Keywords: Native cattle breed, *Kankrej*, selective breeding, proven bulls, semen processing.

North Gujarat, India, has semi-arid growing conditions marked by very warm summers (around 47°C) and very low rainfall (around 600 mm). The rainfall is received only during July and August and is abysmally capricious in quantum and space. The harsh and warm summers not only lead to reduction in milk production but the conception rate of cows is also affected. The water in the aquifer is very deep, and often requires lot of energy to haul the water out. Consequent upon low availability of water, fodder availability is also constrained. The *Kankrej* breed originated in *Kankrej* taluka of Banaskantha district of Gujarat, India; though now it is distributed over North Gujarat and *Kachchh*, western Rajasthan, Madhya Pradesh, Haryana state of India and other countries like USA, Brazil, Jamaica, Japan and Mauritius, where they have been exported during 18th century and thereafter. It is a dual purpose breed (milk production less than 1,000 litres/lactation); often valued for its alacrity and faster gait. Consequently, the breed primarily had been used more for draft purposes rather than for milk. The value of the breed can be gauged from the fact that it has been taken to different countries like Brazil, USA, Japan, Mauritius, etc. primarily for drafting purpose due to alacrity of bulls in general and faster gait in particular. Considering the hostile milieu that this breed has dwelled, Mr North Cot, the then Governor of Bombay, India, did special endeavours to start North Cot Farm in Gujarat, India, in 1902 to sustain this breed from climatic vagaries. This breed has special characteristics to adapt to hostile warm climatic conditions. Unlike other native and exotic breeds, its milk production and conception rate do not plummet during very warm summers of North Gujarat. By nature, it eats around 20 kg forage compared to 30 kg per day of other cattle breeds. Thus, this breed has special adaptation traits to the impacts of imminent climate change. Needless to underscore, forage production requires huge water and saving one-third fodder carries lot much meaning in terms of water and land required to produce it.

Sardarkrushinagar Dantiwada Agricultural University (SDAU), Sardarkrushinagar, Gujarat, India used a timeworn practice for genetic improvement to conserve and improve the native breeds of North Gujarat that is treasure trove of biodiversity of both plants and animals. The selective breeding done in *Kankrej*, a native breed of cattle is a textbook classic. *Kankrej* cattle breed is specially adapted to harsh climatic conditions of North Gujarat characterized by high

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temperatures and inordinate water scarcity. The conspicuous maintenance and adaptation of *Kankrej* is reflected in its sustained milk production during harsh summer as compared to other breeds in which case it is drastically reduced (Figure 1). Whereas, *Kankrej* breed sustained its milk productivity from 8.73 litres/day in January to 7.35 litres/day in June; the reduction in other breeds was very drastic from 6.55 litres/day in January to 2.94 litres/day in June. This indicated that unlike other breeds of cattle, the impact of heat on production of milk in *Kankrej* cattle is negligible. Its average production in 1978 was 977 litres/lactation. After 37 years of arduous selection, the average production of *Kankrej* herd maintained by SDAU has touched 3,250 litres/lactation (Figure 2), with maximum milk production of 6,198 litres/lactation. There are cows bought from SDAU by the farmers under farmers' field that yield around 7,800 litres/lactation, indicating further scopes for increasing milk production with better management. The other characteristics of the breed have been improved as per international standards are given in table 1 below:

Table 1. Characteristics of *Kankrej* breed

Trait	Status in	
	1978	2016
Average milk yield l / Lactation	977	3250
Lactation period (Days)	220	301
Age at first calving (Days)	1522	1198
Wet average (l)	5.02	9.20
Wet average in summer (l)	3.80	9.80
Herd average (l)	1.57	5.75
Calving interval (Days)	472	390
Service period (Days)	155	110

This improvement has been done both by culling the females and selection of bulls proven for milk production. The semen of these proven bulls for milk production is collected, processed and stored as frozen semen doses for artificial insemination. The semen doses are also preserved on long-term basis for maintenance of the breed in case of any calamity.

There are 6.5 million indigenous descript breed cattle in Western India. The milk production of these cattle is pathetic lesser than 1,000 litres/lactation. Considering that there are enormous scopes for herd improvement and thereby milk production of the region, the SDAU established a High Tech Semen Processing Laboratory wherein proven pedigree bulls of *Kankrej* breed are maintained in sets of eight bulls. These bulls produce around 3,000 doses of semen per month. The SDAU has also developed wholesome long-term semen storing facilities in which more than 100,000 doses of semen of proven bulls are stored with all the technical details prescribed on the dose. It needs no underscoring that genes for milk production reside in bulls that ultimately manifest itself as G+E+GxE in cows. The milk production in different proven bulls at LRS varied from 2,500 to 6,198 litres/ lactation. SDAU achievements in herd improvement are so complacent and satiating that selective breeding has now been scaled up covering 10,000 *Kankrej* cows in 50 villages.

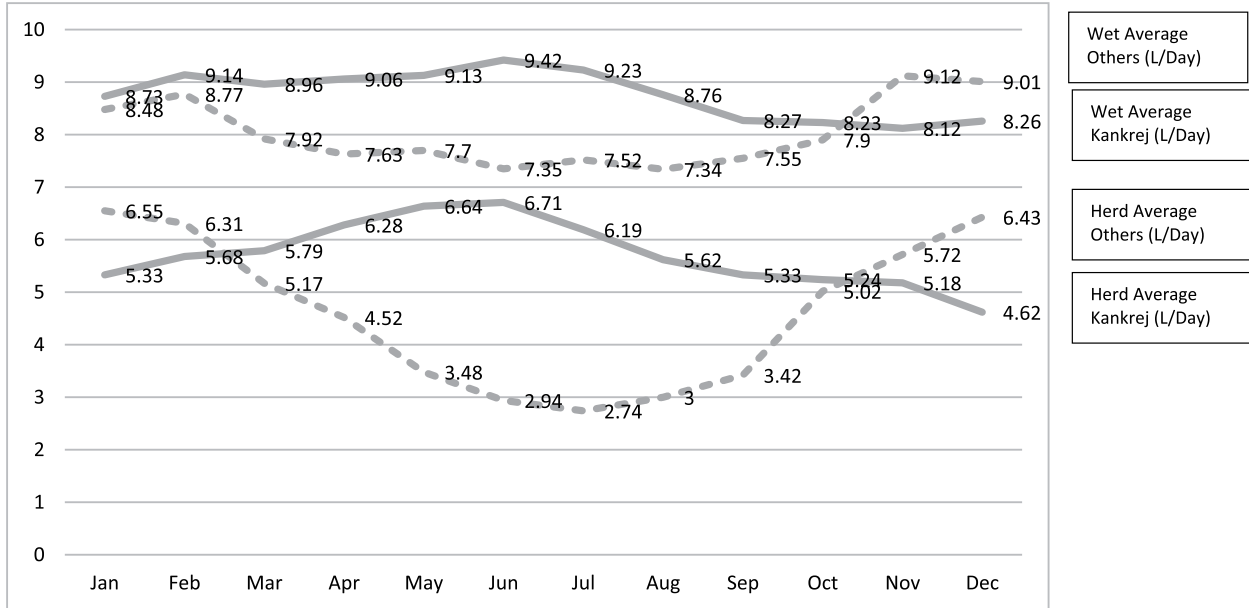


Figure 1. Comparative milk production of *Kankrej* cattle during different months of the year depicting the least impact of harsh temperatures (March to September)

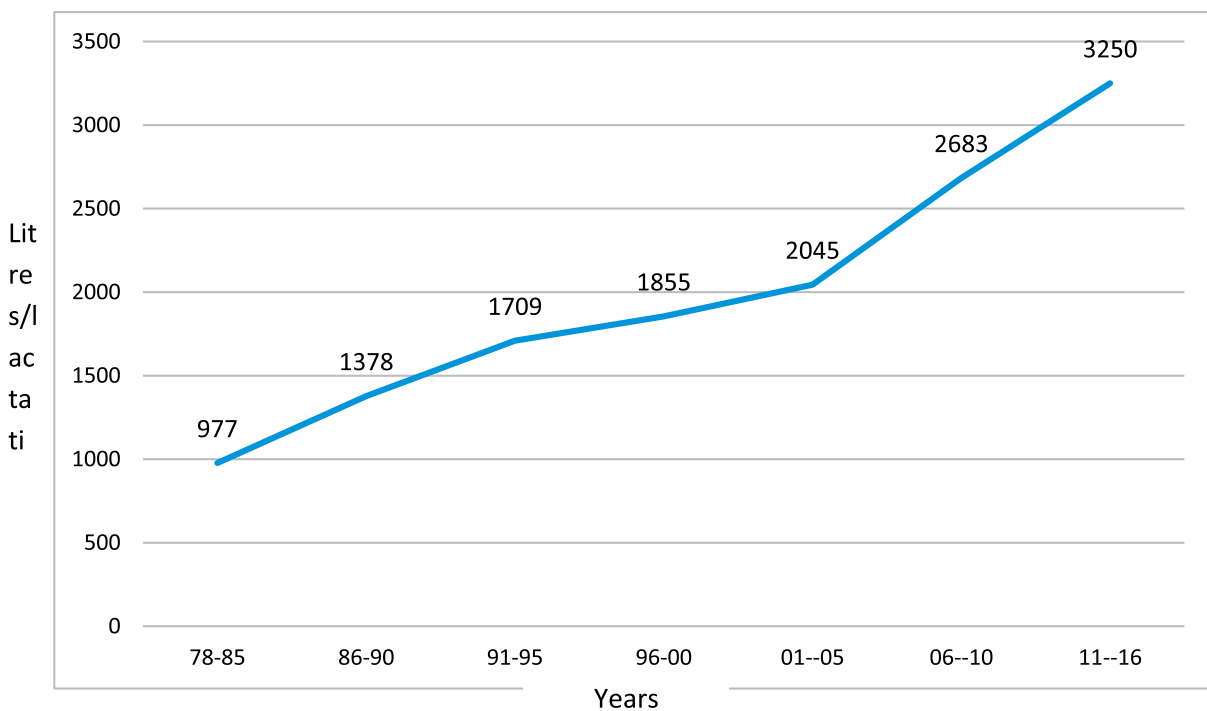


Figure 2. Progressive involvement in milk production (l/lactation) over the years in *Kankrej* breed of cattle in Gujarat, India

The North Gujarat is known for its dairies and dairy's products. *Banas* and *Amul* brands have become the global brands. Today district Banaskantha alone processes over 4.8 million litres milk/day. The SDAU fully appreciates that excessive exploitation of animals for high milk yield may peter out the body reservoirs of nutrients and fluid that are continuously

secreted in the milk. The consequential negative balance of energy may debilitate both efficiency and potential of animal besides inflicting long term reproductive complications. The practice of challenge feeding comprises increasing 500 gram concentrate per day additively in regular ration to high milk yielding animals till the production evince zenith. When the yield per day pinnacles to the maximum, the ration is formulated calculating that maximum production.

Cadalmin™ Green Mussel Extract (Cadalmin™ GMe) for Use Against Joint Pain and Arthritis

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Keywords: Cadalmin™ Green mussel extract, arthritis, *Perna viridis*, anti-inflammatory, nutraceutical.

1. Introduction

There has been a growing interest in functional foods (or nutraceuticals) in recent years, and the functional foods, enriched with natural ingredients have been proved to provide beneficial action for human health. Marine derived bioactive components and the functional food ingredients demonstrated to possess health benefits, such as anticancer or anti-inflammatory activity (Chakraborty *et al.*, 2014a). The Asian green mussel, *Perna viridis*, is a bivalve mollusc (Family: Mytilidae), native of the Arabian Gulf and throughout the Indo-Pacific and Asia-Pacific (Chakraborty *et al.*, 2016). It forms a significant fishery and contributes nearly 50 percent to the total bivalve production of the area (Chakraborty *et al.*, 2014b). Recently, after the importance of *P. viridis* as a potential health food had been realized (Chakraborty *et al.*, 2016), studies on its biochemical composition began to receive considerable attention. Traditionally, indigenous people, notably in Western Mexico and throughout the South Pacific, use green mussel supplements as a remedy for arthritis. The commercially available products, namely freeze-dried extract (Seatone) and CO₂ extracted oil (Lyprinol), obtained from New Zealand green-lipped mussel *Perna canaliculus* were reported to inhibit inflammation in the treatment of rheumatoid arthritis and osteoarthritis (McPhee *et al.* 2007). *P. canaliculus* is restricted to the temperate waters around New Zealand, whereas *P. viridis* occurs widely in tropical waters throughout the coastal Arabian sea and Asia-Pacific regions of Asia (Spencer, 2002), although there have been meager efforts to develop an effective nutraceutical supplement for use against arthritis and inflammatory diseases from the latter. Notably, non-steroidal anti-inflammatory drugs (NSAIDs), such as aspirin, ibuprofen, etc, are popularly used for managing arthritic pain and inflammation. However, the side effects of these drugs are often deleterious, which include gastrointestinal ulcers, cardiovascular diseases, and reported toxic effects on the vital organs in the body. The present work is envisaged to isolate the anti-inflammatory components of the Asian green mussel (*P. viridis*) and to develop an anti-inflammatory concentrate named Cadalmin™ Green Mussel extract (Cadalmin™ GMe) (Fig. 1) for use as nutraceutical and/or functional food, which can offer solutions to the drawbacks of the adverse effects of synthetic painkillers (Chakraborty *et al.*, 2012).

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Figure 1. Cadalmin™ Green Mussel extract (Cadalmin™ GMe) for use against joint pain and arthritis

2. Experimental

2.1. Isolation of anti-inflammatory components of *P. viridis*, and preparation of Cadalmin™ GMe: The detailed processing of raw material, isolation of anti-inflammatory components, method(s) used to assure stability under storage conditions, and chemical analysis demonstrating the composition of the material have been described elsewhere (Chakraborty *et al.* 2012). The bioactive components bearing (→4)-2, 4 di-(N-acetyl-β-D-mannosamine) - (4-N-acetyl *p*-phenoxy) bearing oligosaccharide along with substituted 2-[(2-(acetyloxy)-3-[(E)-9-octadecenyloxy] propoxyhy droxyphosphoryl)oxy analogue, glycolipoprotein and C₂₀₋₂₂ *n*-3 polyunsaturated fatty acids (C₂₀₋₂₂ PUFA-ETester) isolated from *P. viridis* were added at a particular proportion (Chakraborty *et al.* 2012) to yield Cadalmin™ GMe.

Anti-inflammatory assays and safety evaluation: Anti-inflammatory properties of Cadalmin™ GMe were evaluated by cyclooxygenase (COX-1 and COX-2), 5-lipoxygenase (5-LOX) inhibition (Chakraborty *et al.* 2014a) and *in vivo* carrageenan-induced mice paw edema experiment (Chakraborty *et al.* 2014b). As a part of the safety evaluation, acute oral toxicity followed by 90-day oral toxicity studies was performed to establish the no-observed adverse-effect level (NOAEL) (Chakraborty *et al.* 2014b).

3. Results and Discussion

3.1. Anti-inflammatory activities of Cadalmin™ GMe

Cadalmin™ GMe (1 mg/ml) showed inhibiting properties against pro-inflammatory COX-2 (50%) and 5-LOX enzymes (47%), and the activities were found to be comparable with standard NSAIDs. Time dependent anti-inflammatory properties in mice with carrageenan-induced foot paw edema were investigated and the effect of Cadalmin™ GMe was compared with standard drug, aspirin. Cadalmin™ GMe showed considerable inhibition on swelling in carrageenan-induced mice paw edema test as compared to aspirin (80.27 and 78.37%, respectively) after sixth hour, illustrating that the nutraceutical is potent but relatively slow-acting anti-inflammatory agent (Fig. 2).

3.2. Preclinical evaluation

The mean lethal dose (LD₅₀) of Cadalmin™ GMe was found to be greater than 4000 mg/kg body weight of the mammalian subjects that indicate the safety of the product unlike

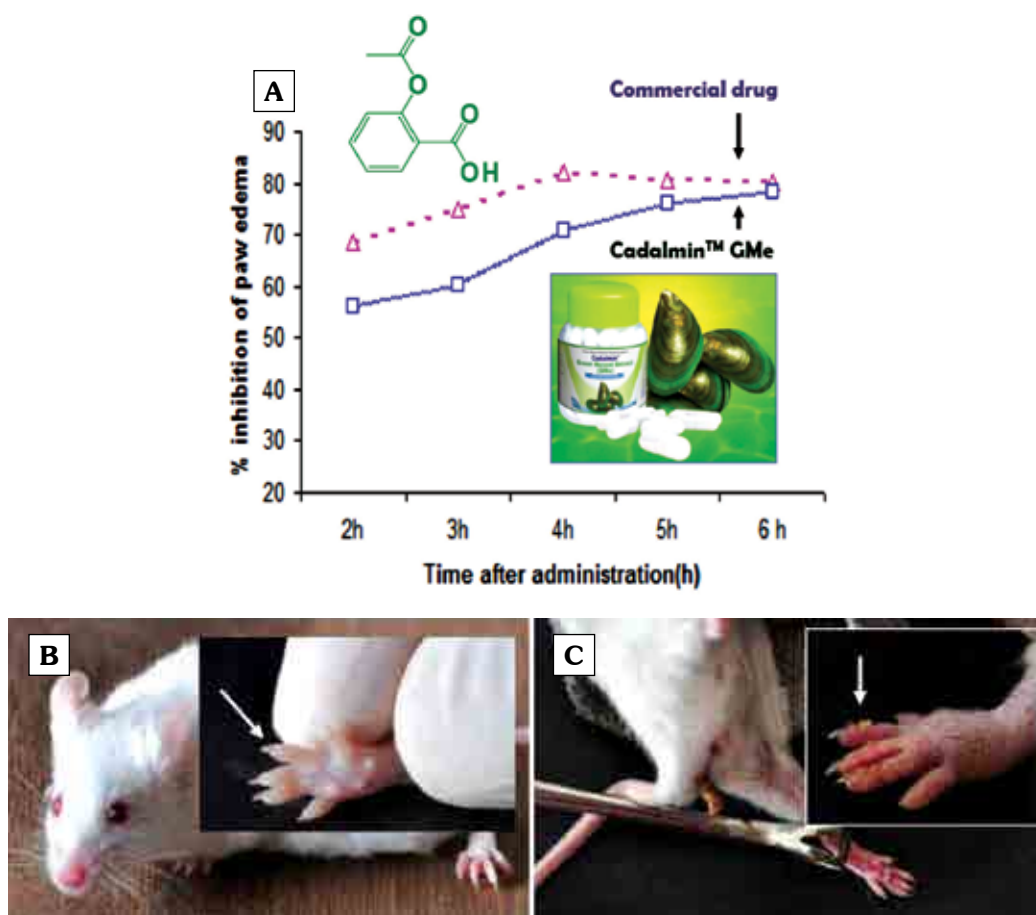


Figure 2. (A) *In vivo* anti-inflammatory activity (inhibition of paw edema) by Cadalmin™ GMe treated mice, (B) Carrageenan-induced hind mice paw edema in BALB/C mice. The arrow indicates the swelling of dorsal surface of the paw, (C) Reductions in mice paw edema in treated mice, The reduction in paw swelling is indicated by an arrow.

the painkillers available in the market. No toxicity related significant changes were noted in renal/hepatic function, hematological indices, and serum biochemical parameters between the control and treated groups. Histopathological alterations were not observed in the vital organs of rats (Fig. 3). Subchronic NOAEL for the formulation in rats is greater than 2,000 mg/kg. This study demonstrated that the green mussel formulation is safe to consume without any adverse effects in the body.

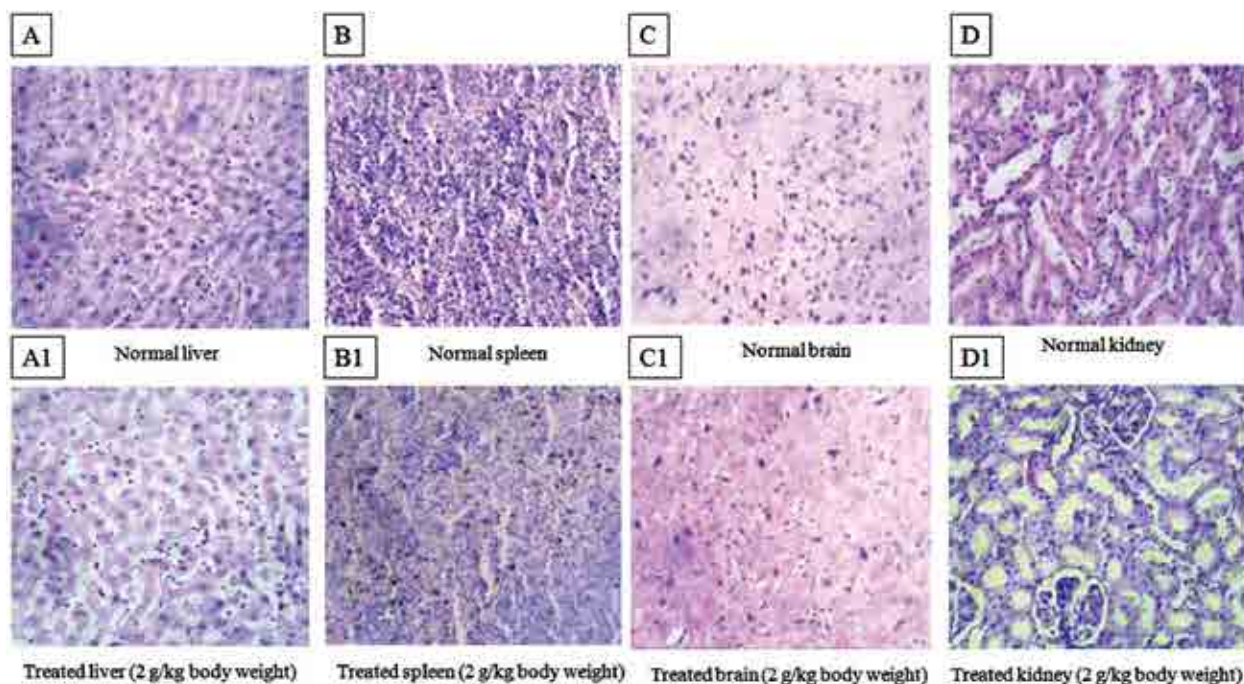


Figure 3. Photomicrograph of histopathological sections of the rat liver and spleen on day 90 of subchronic toxicity test. (A) Normal liver, (A1) liver sections after 90 days of treatment with 2.0g/kg of Cadalmin™ GMe showing apparently normal morphology of hepatocytes, (B) spleen section from control, and (B1) experimental rats showing normal lymphoid follicles, (C) normal brain sections, (C1) treated brain sections showing normal glial cells, (D) kidney section from control, (D1) kidney sections from experimental rats after 90 days of treatment with Cadalmin™ GMe showing normal glomeruli

3.3. Status of commercialization

Cadalmin™ GMe has been commercialized during 2012 with Amalgam Group of Companies (Fig. 4). This is the first nutraceutical produced by an institute of Indian Council of Agricultural Research (ICAR). This product is commercially produced and marketed by Accelerated Freeze Drying Company Pvt. Ltd. under their brand name “Musseltone®”.

4. Conclusion

Till date no medications are available to combat arthritic pain. The available options available are knee replacement or painkillers, which have multiple adverse effects on human health. Cadalmin™ GAe is a solution to these problems. This product was distributed to more than 1,000 patients suffering with chronic joint pain and arthritis, and more than 98 per cent of the respondents were satisfied with about 70-85 per cent relief in joint pain. The diagnostically useful autoantibody termed as Rheumatoid Factors (RFs) significantly reduced from more than 300



Figure 4. Cadalmin™ GME developed by ICAR-Central Marine Fisheries Research Institute has been commercialized on 5th October 2012 with Amalgam Group of Food Companies.

IU/ml to less than 20-35 IU/ml within a period of three months of consuming the product. The commercialization of Cadalmin™ GME is significant to the mariculture industry and fishermen as this will enhance the demand to produce green mussels.

5. Acknowledgements

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Facilitating and Monitoring Agricultural Innovation Systems: An Online/Blended Course for Employing Multi-Stakeholder or Innovation Platforms as a Vehicle for Agricultural Innovation and Development

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Keywords: Facilitating and monitoring, sustainable transformations, partnerships, development, training programs, Neurotrophic Factor, blended learning, instructional design, learning management systems, skills, subject matter experts, leveraging, ILRI's learning portal, course and portal.

1. Background

There is an increasing recognition that the solution to many agricultural problems lies not in simple technology transfer but in the collective intelligence and effort of multiple stakeholders including, among others, farmers, traders, researchers, financial organizations, and policy makers. Various names have been given to these partnerships and the approach of working together to find innovative solutions. Examples include learning alliances, multi-stakeholder and self- help groups, social learning and social differentiation approaches, and innovation platforms (IPs).

IPs are increasingly seen as a promising vehicle for agricultural innovation and development. In the field of agricultural research for development, such platforms are an important element of a commitment to more intentional, structured and long-term engagement among sector stakeholders. Consequently, IPs is widely viewed as a promising vehicle for increasing the impact of agricultural research and development. Significant learning has occurred about what leads such partnerships to generate innovative, cost- effective and sustainable transformations. This learning can be found in formats ranging from academic articles, to videos, to learning materials used in a rich variety of online and face-to-face training programs. In this paper, we present a few examples of how this has been applied by the International Livestock Research Institute (ILRI) and its partners in recent years, with a particular focus on leveraging learning approaches and technologies.

2. Best Practices in Agri-food Innovations

2.1. Leveraging learning theories and learning technologies for agricultural innovation

2.1.1. Instructional design & blended learning

The benefits of using games and leveraging learning technologies and adult learning theories

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are well documented. There are examples showing that play improves memory and trigger the secretion of Brain-Derived Neurotrophic Factor (a substance essential for the growth of brain cells), as well as evidence that play promotes creative problem solving and increases engagement. Similarly, blended instruction is reportedly more effective than purely face-to-face or purely online classes, and mobile learning is showing very promising initial results in applications in CGIAR's context.

Blended learning is a formal education approach in which a participant learns at least in part through delivery of content and instruction via digital and online media. This is combined with some element of participant control over time, place, path, or pace. By using a combination of digital instruction and one-on-one face time, participants can work on their own with new concepts. This frees instructors up to circulate and support individual participants who may need individualized attention, and help all participants reach their full potential as opposed to the lowest common denominator – as they would in a traditional classroom. Such blended courses are powered by 'Learning Management Systems' (LMS), which offer much functionality for learners and learning administrators, such as:

- Allows instructors to grant or restrict access to lessons in the LMS during a classroom training session, sequence modules, and give scores for attendance and participation.
- Integration of social learning –can require that users post to discussion forums in order to proceed with a course, then notifies them of responses.
- Branding and sub-portals –with options to share or separate content for different audiences and set different preferences for each.
- Ability to scale with the growth of CGIAR programmes – allows for more advanced course design including multicourse sequences, awarding credits for classes etc.
- A unique approach to assessments – includes support for conducting and analyzing pre-assessment and post assessment tests and assigning weightage to different assessments.
- Advanced reporting features – including generation of HTML5 graphs and dashboards.

Instructional design is the systematic process by which instructional materials are designed, developed, and delivered. Instructional designers apply systematic approaches to helping learners acquire and retain new skills, knowledge and attitudes. As a field, instructional design is historically and traditionally rooted in cognitive and behavioral psychology, though recently Constructivism (learning theory) has influenced thinking in the field.

Instructional designers are learning experts. They focus on learners and determine how information can best be structured in light of learners' existing skills, knowledge and learning preferences, as well as the organization's infrastructure to support learning. To be effective, they need to work side by side with "Subject Matter Experts" (e.g. a researcher: with an expertise in a particular topic). Key skills that an instructional designer brings to such a 'co-creation' process include:

- Identify key target audience characteristics
- Quickly learn and organize subject matter

- Remain impartial in selecting information that meets both audience and organizational needs
- Restructure information to clearly and quickly teach it
- Design an evaluation to measure whether the audience has learned the material

The partnership between a subject matter expert and an instructional designer is where the ‘magic’ really happens. Both bring their expertise to the table: the SMEs, their content knowledge; instructional designers, their learning and technical experience.

2.1.2. Learning technologies

Alongside the development of the learning materials, it is important to have an online platform where they could be made accessible. ILRI first approaches this area by setting about identifying a learning management system (LMS)³ where the learning materials and other courses could be run. The minimum requirements were that the ILRI LMS would be able to track learner progress through modules including results on exercises and quizzes, be compatible with a blended learning approach, be able to scale up to more complex course designs while keeping costs to a minimum, and, most important, be deliverable in classrooms with poor or no Internet connections.

Reviews⁴ of a wide range of LMS products did not reveal a suitable solution. While some products came close to satisfying requirements, vendors were unwilling to customizing their products to meet ILRI’s requirements. In the end, ILRI partnered with Sonata Learning, who, in addition to developing the learning materials, developed an LMS to ILRI specifications under a favourable licensing arrangement for ILRI and its partners.

The Sonata LMS features include:

- Simple, clean, intuitive user interface;
- “Blended first” approach to delivery - allows instructors to grant or restrict access to lessons in the LMS during a classroom training session and give scores for attendance and participation.
- Integration of social learning –can require that users post to discussion forums in order to proceed with a course, then notifies them of responses.
- Branding and sub-portals –with options to share or separate content for different audiences and set different preferences for each.
- Ability to scale with the growth of ILRI programmes – allows for more advanced course design including multicourse sequences, awarding credits for classes, etc.
- A unique approach to grading – includes support for conducting and analyzing pre-assessment and post assessment tests and assigning weightings to different assessments.

³An LMS is a specialist web portal where learners can find learning content including text, videos, audio files, assessments and discussion forums. It also allows course administrators to track when and how learners use these resources including recording grades where appropriate.

⁴For a more detailed overview, see <https://cgspace.cgiar.org/handle/10568/65951>

- Reporting features –including generation of HTML5 graphs and dashboards.
- To deliver training in low-bandwidth environments, Sonata Learning also developed a stand-alone offline player module with the following features.
- Runs on a USB drive without the need to install any software on the learner’s hard drive.
- Plays any type of content in its own self-contained browser, avoiding any complications that might arise with the computer’s default browser (Internet Explorer, Chrome or Firefox, etc.).
- Saves learner assessment and progress data to the USB drive from which it can be copied to a central computer.
- Provides a programme to automatically install the player to multiple USB drives making it fast and easy to prepare for training workshops.

Of course, online modules also have the advantage of including quizzes and with ILRI’s learning portal, administrators can check how participants perform on quizzes and even which wrong answers they selected. However, when there are high stakes, such as the possibility of being barred from attending a workshop if one fails the quiz, our experience, sadly, is that cheating will occur. Faced with this, ILRI opted to set up online proctoring to maintain testing integrity in the online space.

In normal university settings, a proctor is a supervisor or monitor who invigilates exams. With eLearning, an *online* proctor is a service that ensures that online test takers are not cheating. This is done by humans, using the technology on the test-takers’ laptops (camera, microphone etc.) and using specialized software that allows proctors to see the test-takers’ screen and the room where they are sitting the test.

In 2016, ILRI’s capacity development unit used the services of ProctorU to test the extent to which partner organizations in the mNutrition project have mastered online content before committing its trainers to running in-country workshops. As these partners are located in Mozambique, Rwanda, Uganda, Zambia and Kenya, online proctoring, at a cost of between USD17-25 per test, is a much more cost-effective option than flying in trainers to personally invigilate the exam. Once all local content provider representatives have been certified as having mastered the knowledge objectives of the course, trainers are free to work with them on applying this knowledge to the work they will actually do, thus ensuring a higher quality product for the client.

2.1.3. Blended course on IPs

The intersection of work on IPs, instructional design and learning technologies culminated in a blended course on “Understanding, Facilitating and Monitoring Agricultural Innovation Platforms”. The purpose of this course, originally run as a face to face workshop in 2014, and gradually developed into a fully-fledged online and blended learning course, is to harvest this learning into a cost-effective and time-efficient training programme that can be used by organizations interested in using the partnership approach to confront complex agricultural problems.

In this course, we use the label ‘Innovation Platform’ for the partnership approach described above. However, the course is equally directed to those engaged in, or intending to engage in, multi-stakeholder processes, self-help groups, social learning approaches and learning alliances. There is significant common ground between these approaches and it is this common ground that this course addresses.

The target audience for this course is often busy people with multiple demands on their time. They may face constraints of time, distance and cost that make lengthy face-to-face training workshops an unattractive option. They can be expected to come to the course with a common interest in learning how to set up, facilitate and sustain innovation platforms. However, their backgrounds will be dissimilar. Some will have had a high level of exposure to participatory practices, some will already be involved in innovation platforms and be currently confronted with issues of power dynamics or the need to learn from sound monitoring and evaluation practices, and some will be facing a completely new and daunting challenge. The course design recognizes this range of needs by:

- Providing content knowledge in a self-paced online modality which allows learners to learn at their own pace – to dive deeply into lesson content if desired, or to skip familiar sections. A content mastery test provided at the beginning and end of each module will allow learners to self-assess their prior knowledge so that a judgment call can be made on whether the module can be skipped in favour of spending more time on more advanced modules.
- Making this content available both through ILRI’s online learning management system (LMS) and on ILRI’s purpose-built offline LMS for learning environments where bandwidth access is unreliable or intermittent.
- Including activities to be conducted in face-to-face mode to provide an opportunity for learners to discuss their experiences and challenges in the light of the content knowledge covered in the online course component and their own diverse and complementary backgrounds. This modularized design for face-to-face training/workshops will enable course organizers to choose between conducting longer standalone workshops, piggy-backing onto other events, or conducting smaller, more frequent workshops where resources are available.

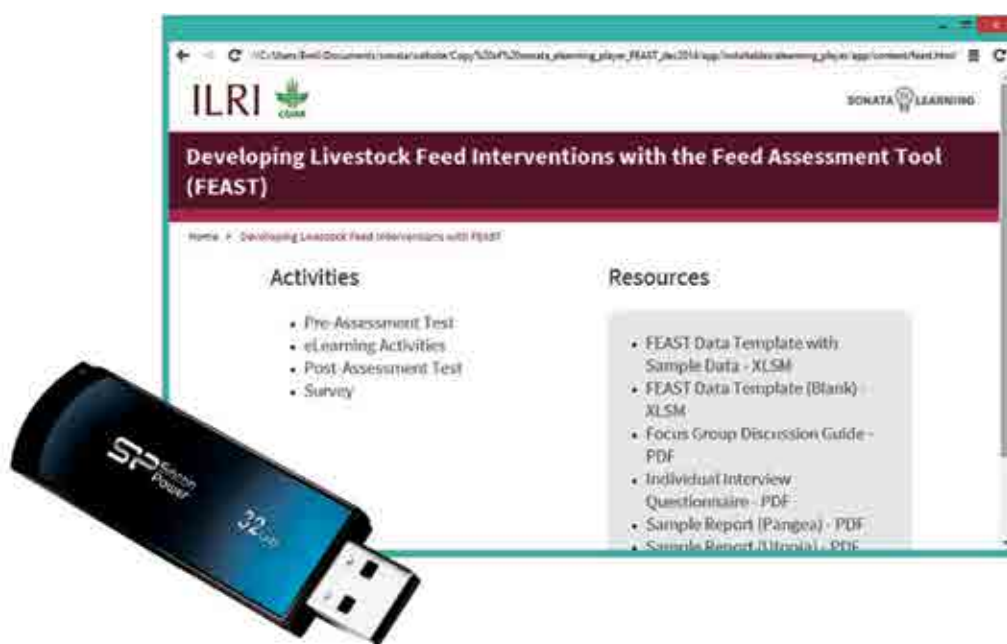
The course design draws on the instructional design services of ILRI’s Capacity Development Unit and the knowledge and experience of subject matter experts (SMEs) from ILRI, IITA, FARA, KIT and Wageningen University to sequence content and learning experiences so that learners can rapidly acquire and retain the skills and knowledge needed to effectively facilitate innovation platforms.

The course design is based on a constructivist approach which recognizes that learning occurs as the result of interacting with the content and with other learners⁵. The self-paced online learning modules include frequent quiz questions to provide feedback to the learner on their progress and a rich variety of interactive learning assignments.

⁵<http://www.learning-theories.com/constructivism.html>



Learning initiative



Developing livestock feed interventions

Related workshop modules are based on highly interactive group exercises that challenge learners to apply the skills and knowledge gained through the online program. Many of the exercises are based on case studies of existing innovation platforms recently published under the title “Innovation platforms for agricultural development: Evaluating the mature innovation platforms landscape” (Dror *et al.*, 2016). A course pre- and post-test with subsequent analysis of effect size and significance tests provides insights on course effectiveness. Individual learner statistics such as time spent on task, results on inline quizzes, and participation in group exercises such as chats and discussion forums can be generated through the ILRI LMS. Upon completion of the course participants will be able to:

- Define what is meant by a complex agricultural problem
- Identify prerequisites to finding innovative solutions
- Identify the basic differences between agricultural innovation systems and technology transfer approaches
- Recognize situations in which TT approaches are appropriate and those where an AIS approach is needed
- Choose participatory methods appropriate for stages of the IP life cycle
- Distinguish between RRA and PRA
- Describe an Innovation Platform and similar participatory partnership arrangements
- Decide on the optimal composition of an Innovation Platform based on a stakeholder analysis
- Describe the process of setting up an Innovation Platform
- Use a visioning tool to establish a common goal for an IP
- Decide the appropriate course of action to be followed by an Innovation Broker confronted with common IP scenarios
- Plan a IP meeting to analyze problems and identify opportunities for innovation using a participatory tool of own choice
- Assess the impact of own personal style in facilitation, communication, leadership and dealing with conflicts
- Use appropriate participatory methods to respond to common IP scenarios
- Plan the use of monitoring tools including MSC stories to develop a learning history of an IP
- Demonstrate the use of a range of communications tools
- Suggest strategies for sustainability of an IP faced with different scenarios
- Plan organizational structures and rules of engagement for an IP
- Design an M&E framework for an IP

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Innovations on Marketing of Wax Apple through ICT

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Keywords: Marketing channel, organization, quality assurance, Taiwan, wax apple.

1. Wax Apple Industry in Taiwan

Wax apple is grown mainly in the Southern part of Taiwan. The total planted area was 3,849 hectares with production of 65,775 metric tons in 2015 (COA, 2016). The production region is concentrated in Southern Taiwan in Pingtung (73.4%) and Kaohsiung area (11%) (Fig. 1).

The characteristics and history of the wax apple product development is already well documented elsewhere (e.g. Council of Agriculture 2016a). The major production season was known to be during the summer months and was used mainly as a garden fruit tree. The fruit was small and not very tasty. Due to the dedicate nature of the fruit, it was not popular for the

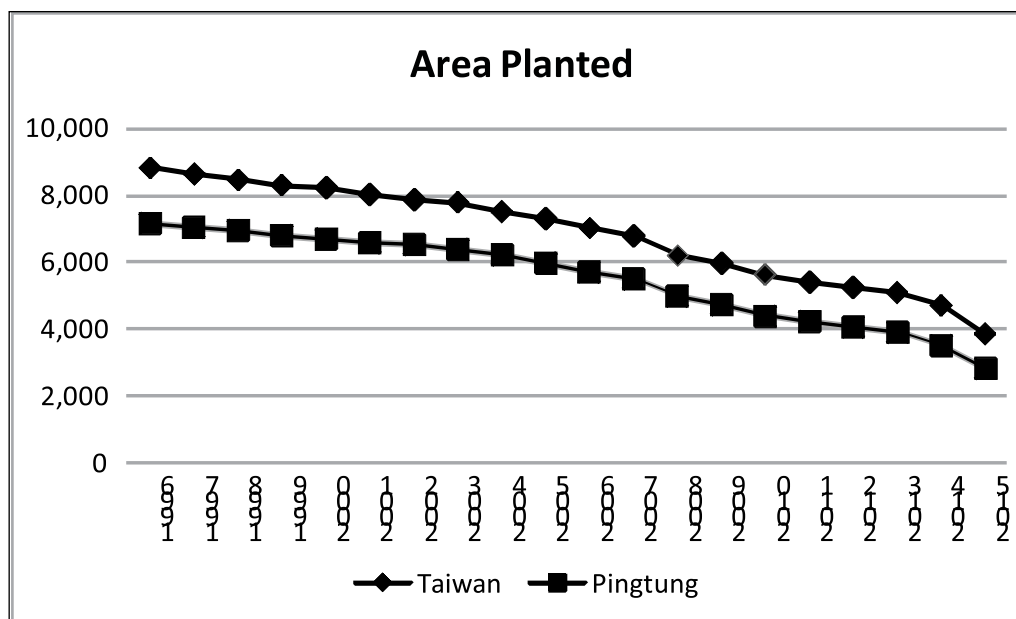


Figure 1. Wax Apple Area Planted in Pingtung in Reference to Taiwan

(Source: Council of Agriculture, 2016c)

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market channel operators; it has to mature on the tree, it is highly perishable, and it had to be handle with care throughout the marketing channel.

Over the years, technical innovations in production and post harvest handling, development of proper packaging method, institutional development through farming organizations (production and marketing groups, farmers associations and Taiwan Wax Apple Industry Development Association (TWADA), availability of the cold chain and other marketing mechanism made the wax apple an exciting new business. Much of such achievement was made possible through the extension services provided by the Kaohsiung District Agricultural Research and Extension Station, Council of Agriculture as well as the extension services of the National Pingtung University of Science and Technology.

Now the main production season has shifted to winter and spring (November to April) become the winter/spring fruits have more attractive features such red colour and sweetness, and different varieties and production areas are also identified. The members of the board of TWADA also actively render technical services to new locations in Taiwan. Now we have producers from as far north as Yilan County in Northeast Taiwan and as high in elevation as Meishan Township in Chiayi County which is more than 1,000 meter above sea level. Wax Apple is now produced and exported year round.

With regard to the topic of application of ICT in wax apple marketing, we have to be very appreciative of the government effort to make the technology becoming friendlier for farmers over the years.

2. Objectives

The objective of the paper is to share the successful implementation of various ICT in the marketing of wax apple in Taiwan, but the similar technology has been widely adapted in Taiwan.

3. Essential features of the innovation

The most likely question farmers would pose is the issue of “how” to market their product. It is now recognized among the wax apple farmers that they need to know that marketing activity is an integral part of the production management activities. Therefore, it is important to point out that the farmers use ICT from the production stage. We would like to discuss the dimensions of the application from the following perspectives:

3.1. Quality assurance (quality control)

3.1.1. Production management

For the most new comers into the wax apple business, the most challenging issue is production management. Once farmers pass through the challenges, then we can talk about quality assurances. Shown in Figure 2 is the flow chart before and after we adapt ICT. The flow chart on the left hand side is posted in the team meeting place for we use throughout the production process. But the current production management app that we can install on the smart phone is much helpful.



Figure 2. Production management for wax apple before and after using ICT

(Source: Nanjo Fruit Production and Marketing Group No. 1; Tsai, HL)

3.1.2. Product selection standards

There is already a well received quality standard for wax apple and widely adapted by wax apple growers based on colour and size. Figure 3 shows the wax apple standard. The standard was developed over the years though participation of producers and the extension specialists from the district agricultural research and extension groups. The figure 3(b) is a

QUALITY STANDARD

Color (Red)	Size (per 600 g count)				
	3-4 (brand)	4-5 (XL)	5-6 (L)	6-7 (M)	7-8 (S)
AAA (Darkest)					
AA					
A					
BBB					
BB					
B (Lightest)					

Note: A:br>10 *B
6:br>8 *B
Source: Lee, S.T., 2003 Training Manual (available from the Council of Agriculture Knowledge management Portal, in Chinese)

(a) Quality standard description



(b) Quality standard on the poster

Figure 3. Product grading standard for wax apple

Source: (a) translated from the training material for farmers by ST Lee (2003) from the knowledge management portal of the Council of Agriculture (COA, 2016c). (b) The poster was prepared by the Taiwan Wax Apple Industry Development Association, now located in Nanjo Production and Marketing Group No. 1.

visualized version which serves the guide for product grading at the sorting site at the Nanjo Fruit Production and Marketing Group No. 1. The Taiwan Wax Apple Industry Development Association (TWADA) prepared the bulletin poster, as it is more comprehensive than the information from the training manual of the source in figure 3(a).

3.2. Quality certification and customer communication options

The Nanjo Fruit Production and Marketing Group No. 1 is one of the current 6,084 registered production and market groups, and one of the 208 fruit group that produces wax apple (as of Oct, 2016, COA 2016b). The team leader ST Tsai, was the founding member of the TWADA, a former chairman of the board and a current senior board member of TWADA.

For the domestic market, we need to be identifiable. The group registered its brand name very early on with the suggestion from the extension specialist, to be identifiable from those other growers. The brand name has been further polished through continuous efforts. In the past, the group won national recognition as one of the top 100 and top 10 teams of the year. The group member also won best farmers award several times. However, we also find it important to have new comers from other production region that the product could form critical mass for its export market. Winner of such recognition is a good marketing tool once we started doing e-marketing. We also took part in major product safety measures such GAP (good agricultural practice for vegetable and fruits, mainly for chemical residues), certified traceable agricultural product (TAP, a third party accreditation system for tracing and tracking agricultural products), Ecocert (EUREP G.A.P. and the new agricultural traceability mechanism using QR-code (Figure 4). With this new system, even though the batch of the products is unknown, unlike the TAP system, but it is easy for the customer to identify the producer and is less costly for the producers.



Figure 4. The Production Traceability Information Interface Showing Tasi. HL

(Source: <http://qrc.afa.gov.tw/blog/1401000003>)

3.3. Marketing management and logistic support

The standard serves a guide not only for grading, but also for targeting different markets. The differentiated products targets alternative markets such as export, jobber (wholesaler), hypermarket and supermarket, convenience store (fresh-cut) and home delivery (phone or e-order from consumers).

The jobber and delivery truck would come to the product assembly lots for collecting the products for different market. The most expensive one is for the home deliver. The products gathered from the orchard are separated based on the standards for each market. The cold chain delivery system is now in place for timely delivery of product. We used the flow chart for marketing management (Figure 5a), with the above mentioned product grade chart (Figure 3), but now we have a platform to manage our stock and its flow with the new product management system (Figure 5b).



Figure 5. Marketing management tools

(Source: Poster from Nanjo Production and Marketing Group No. 1)

Strength

Compared to other fruit trees, production management for wax apple has a tougher entry barrier compared with other orchard. We have well established commodity group to support the activities of its members. Moreover, the product quality guarantee mechanism as well as traceability system now is all link to the new APP that it is easier to make the product information transparent to the consumers.

Weakness

The main weakness is on the general characteristics of farming. Even with good physical

infrastructure such as road, cold storage, and the logic system and the soft skills of using ICT to enhance the production and marketing activities, the nature is still challenge us all the time. This year we had problem with the very cold weather that hurt the production for the first quarter, and now the flooding associated with the typhoon made us lost all the potential harvest for the season. We need to serious consider putting more protective devices to protect the trees.

Opportunities for Upscaling and Outscaling

The smart phone APP is now earlier to use and it will become the fundamental tools for farmers. We believe that it is now already very popular among farmers in Taiwan. It is so common that we do not usually think that it is an innovation. However, to be able to use it successfully, a strong support from the government is needed to develop such APP to be used on farms in Taiwan. It is unlikely that it would be affordable to individual farmers or even organized farmers group to develop their own.

4. Conclusion

The wax apple in Taiwan is grown by small farmers. The infrastructural and institutional support in Taiwan is the key. We have good support for assistance in technical support. For wax apple growers, the Kaohsiung District Agricultural Research and Extension Station, Council of Agriculture is the home base to find the technical support. To develop the industry, the extension specialist at the station helped the formation of the Taiwan Wax apple Industry Development Association through the grass root leaders training.

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NAVARA-The Wellness Rice from India

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Keywords: Navara Eco Farm, wellness rice, ayurveda, shastikas, black glumed, Navarakizhi, Navaratheppu, Panchakarma, value added products, organic farming, ICT, conservation, geographical indication and integrated farming.

1. Background

Navara Eco Farm (NEF) is a smallholder integrated Certified Organic farm with a total holding of 18 acres, growing specialty rice varieties, vegetables, fruits, medicinal trees and plants, spices, coconuts. NEF is a traditional and centennial farm (125 years old) located in Palakkad, Kerala, India.

Farming in India and especially in the state of Kerala, was a losing proposition from 1970's and more so from 1991 when the country's economy took the liberalization path. Farmers in Kerala were selling their land or leaving fallow the farm land and looking for other occupations. It was at this time the author (P. Narayanan Unny), third generation farmer of this family farm, took over the management of the farm in 1995. The decision to wind up the successfully running computer business and to take up the management of the farm was a conscious one. A long term plan was made focusing on the strength of the farm - which was primarily based on rice cultivation and innovation therein.

During that time, Unny realized that some of the rare varieties of traditional rice were getting extinct. One of the variety which he took interest is the Navara rice. The almost extinct NAVARA Rice variety was conserved at NEF. Specialty rice like NAVARA (a nutritional and medicinal type of rice used in India's indigenous system of medicine, "Ayurveda", for treating arthritis, paralysis, polio, psoriasis), Palakkadan Matta (a red rice variety) and other agricultural products were cultivated organically from 2003 onwards at NEF.

2. About Navara Rice and its Properties

Navara – a medicinal type of rice is famed for its use in the ancient Indian system of medicine, Ayurveda. (Ayurveda relies on herbs and massages and is increasingly gaining repute across the world as a complimentary system of medicine).

According to ancient Ayurvedic texts, Ashtanga Samgraha of Vagbhata (7th century AD), and Susruta Samhita (400 – 200 BC), *Navara* is known as one of "Shastikas" – which is a variety of rice that matures in 60 days (typically, rice takes upwards of 90 days to mature). Shastikas are sweet in taste and are said to aid digestion.

¹Progressive Farmer

Navara's various forms such as the grain, bran, powder, and root are used in the treatment of different ailments in Ayurveda. It is of two varieties – black glumed and golden yellow glumed (this refers to the colour of the outer covering or husk).

Navarakizhi and Navaratheppu are two major treatments in the Panchakarma method of treatment within Ayurveda for conditions such as arthritis, paralysis and neurological disorders. In Navarakizhi (or “Pindasweda” as it is referred to in Sanskrit) Navara rice is boiled in kurunthottikashayam (a decoction of sida root and milk). It is then enclosed in cloth pouches (kizhis) and is used for massaging. In Navaratheppu, a paste of boiled Navara rice of light warmth is applied on the body. Here again the rice is boiled in kurunthotti kashayam.

Various forms of Navara have distinctive and unique therapeutic uses in Ayurveda. Navara rice is used as health food for babies. Navara rice powder cooked with brown sugar and milk is found to be a nourishing food for babies.

3. Best Practices and Innovations

3.1. Efforts to conserve Navara rice variety

Kerala, India, has a rich tradition in rice farming. However, over the past 50 years, many traditional varieties have either become extinct or are not grown on a significant scale. This is largely due to shifts in crop cultivation patterns towards high yielding varieties. This pattern has adversely impacted Navara. It is estimated that Navara cultivation has declined from approximately 2,000 acres to less than 50 acres.

The key driving force behind this project was pure line selection of Navara and conserve this unique rice variety. Available Navara seeds were mixture of multiple varieties of rice and purifying the seed was a major issue. The methodology here was to sort manually the available seeds from all over Kerala and bring about the pure seed needed for Navara cultivation. This was a major process and took many years to yield good results.

3.2. Organic farming of Navara

NEF pioneered certified organic cultivation of Navara and Palakkadan Matta rice varieties in India. By adopting this method, the farm made sure that the ecology and environment was protected, biodiversity maintained and that the consumers could get healthy products without chemical fertilizers or pesticide residues.

Intellectual property right / geographical indications (GI): Simultaneously, NEF pioneered in empowering farmers by forming clusters and registering Navara and Palakkadan Matta rice varieties as geographical indications (GI), which is a community right. Navara and Palakkadan Matta were the first agricultural products in India to be registered as GI under a farmer-led initiative.

3.3. Value added products

After a few years of marketing Navara rice, NEF arrived at a conclusion that consumers are attracted more if value added products are made available to them. After conserving the unique traditional rice variety NAVARA, cultivating organically and registering as GI, NEF addressed the last mile connectivity of “Market Linkage”, by value adding as food products like UNF

Navara Rice, UNF Navara Rice Flakes, UNF Navara Rice powder and by branding, packaging and marketing these products.

3.4. Biodiversity

NEF is an integrated farm cultivating specialty rice, coconuts, mangos, jack fruits, papaya, medicinal trees and plants, spices, vegetables organically, thus conserving biodiversity.

3.5. Web based awareness creation

ICT and internet were used as a tool for reaching out to consumers online by providing facility to know and buy Navara products through the website *www.navara.in*

3.6. Working with Government and NGOs

Navara Eco Farm has been working closely with different ministries and organizations like Ministry of Agriculture, Govt. of India; ICAR; PPVFRA; Govt.of Kerala; CII and NABARD to create awareness and conduct scientific studies for the last 14 years. Results of some of the studies and details of awareness programmes conducted are provided in the website *www.navara.in*

4. Strength of Best Practices in Navara

By the year 1998 the area under Navara cultivation came down drastically and pure seed of Navara was not available. It was at this time in 1998 that Navara Eco Farm started the revival of this unique agricultural treasure of India. Now, Navara Eco Farm could expand area of cultivation to 24 acres of Organic, GI Registered Navara.

4.1. Organic farming

NEF as the pioneer in organic farming in Kerala, India. The certification process started in 2003 and the entire farm was certified organic in 2006 for annual and perennial crops. NEF is a leading player in the organic agriculture movement in Kerala and NEF products represented Kerala in BioFach 2015.

4.2. Geographical indication (GI)

By registering Navara as GI, the producer is assured of better price and consumer is assured of authentic product.

4.3. Value addition

By value adding products as Navara rice, Navara rice flakes, Navara rice powder, farmers have better value realization and authentic ready to eat products to the consumer.

4.4. Integrated farming

By adopting integrated farming method and organic cultivation, NEF conserved bio-diversity, nature, ecology, environment which in turn has potential for carbon credits.

4.5. Reduced water usage

By adopting this method, NEF has found that instead of irrigating once a week, the farm needs to be irrigated once in 10 days, thus saving water upto 25-30 per cent.

4.6. Market access

Facilitating easy access to products for consumer by online sales through website *www.navara.in*

5. Weakness

Lack of infrastructure facilities and funding are the major challenges. These two factors are affecting upscaling and outscaling of Navara cultivation.

6. Potential of Best Practices

The best practices followed by NEF for Navara cultivation has a very good potential for scalability and marketability as health, nutritional and wellness food.

7. Conclusion

We at NEF feel that we have done a wonderful job in taking up a farmer led initiative of conserving and making popular the Navara variety of rice.

Upscaling and outscaling of ethnic, health and nutritional food like Navara is the need of the hour. For this to happen governments, financial institutions, NGOs, and media should take initiative for whole hearted support to the farming community.

7.1. Challenges of upscaling

Navara Eco Farm has now the experience and expertise to upscale and outscale the innovative organic Navara cultivation. However, the organic Navara adoption has unique challenges that require concerted and sustained efforts by different stakeholder communities. Some challenges are:

- 7.1.1.** Sensitizing stakeholders such as Ayurveda/pharma companies regarding advantages of using Organic Navara.
- 7.1.2.** Issue of other rice varieties being sold as Navara and Non-Organic Navara being sold as Organic Navara.
- 7.1.3.** Need for promoting Organic Navara as wellness rice among international community.
- 7.1.4.** Promoting GI registered, Organic Navara internationally.

With consistent and concerted efforts of stakeholder agencies, the Organic Navara cultivation can be upscaled gradually by creating an informed user community in India and other countries in Asia and the Pacific.

Transition of Taiwan's Agricultural R&D Strategies from Efficiency-Driven to Innovation-Driven

Hung-Hsi Lee¹

Department of Science and Technology, Council of Agriculture (COA), Taiwan

Keywords: Agro-tech marketing, bioeconomy, natural catastrophes, bioenergy, academia sinica, agribusiness, commercialization, investment, agricultural intellectual property rights committee, commercial products, competitiveness, agro-tech exhibitions and biotechnology park.

1. Introduction

The entire world has been impacted by population growth, climate change and liberalization in agricultural trade. Governments and major international organizations have deep concerns about issues such as ensuring food security, improving nutrition, alleviating poverty in rural areas, promoting economic development and sustainable utilization of natural resources.

Over a 10-year time horizon, Global Risk Report (2016) showed 29 global risks, categorized as societal, technological, economic, environmental, or geopolitical and rated each one according to its perceived likelihood of occurring and its impact if it does. There are 4 risks of top 10 risks are related to agriculture, such as failure in climate-change mitigation and adaptation, water crisis, extreme weather events and natural catastrophes. By 2050, the world's population will reach 9.1 billion, and global demand for food, feed and fiber is expected to grow by 70 per cent, with crops increasingly being used for bioenergy and other industrial purposes. The global working population is decreasing and aging and small-scale farmers are inefficient.

Fortunately, Taiwan has had some superior agricultural technologies over the past 100 years. According to the number of published Taiwanese scientific papers, the country currently ranks 16th in the world. In Taiwan, a total of 1,198 papers per one million people have been published, indicating a higher academic ratio than other Asian countries like South Korea, Japan and China. The relative influence of agricultural science is above the world average, reaching 40 per cent.

2. Cornerstone of Agricultural Innovations

Like many developed or developing countries, Taiwan established its research capacity mainly built upon the public sector. National universities and the well-known Academia Sinica have undertaken most of the basic research. Sixteen affiliated research institutes of COA, comprising

¹Deputy Director General, COA

9 research institutes and 7 district agricultural research and extension stations, are responsible for applied research. The R&D results of these research institutes could be potentially directly applied to farming or developing new products for farmers, agribusinesses, associations and cooperatives. Thus, the agricultural research and extension framework of Taiwan are firmly functioning.

In the past, the R&D results developed in the public sector have been regarded as public property and were free and gratuitously licensed for farmers and the industry. However, if some technologies could not be utilized directly by the farmers, they were then manufactured by agribusinesses and then sold to the farmers, still at no charge to the farmers. In order to accelerate the commercialization of agricultural technologies, COA has encouraged agribusinesses and farmers to utilize their R&D results for their own enterprise.

3. Agricultural Innovation Approaches & Performances

COA has implemented 8 agricultural innovation approaches in the last 15 years (Figure 1), and each one is described in detail in the following subsections.

3.1. Building R&D capacity

Since 1999, COA has offered two kinds of programmes for commercialization. They are the Industry-Academia Cooperation Program (IACP) and the Agricultural Industry Technology Development Program (AITDP) for integrating public and private sector resources. The former aims at accelerating the commercialization of public R&D results, while the latter aims at subsidizing the commercialization of agribusinesses' R&D, with the intellectual property rights (IPR) belonging to the agribusinesses. There have been 1,382 projects of IACP from 2001-2015. These agribusinesses invested a total of NT\$220 million in 1,382 projects. On average, an investment of NT\$1 by COA brought about NT\$1.64 in value of output. Fifty-one agribusinesses participated in AITDP from COA. These agribusinesses invested a total of NT\$240 million to develop R&D projects. On average, an investment of NT\$1 by COA brought about NT\$4.92 in value of output.

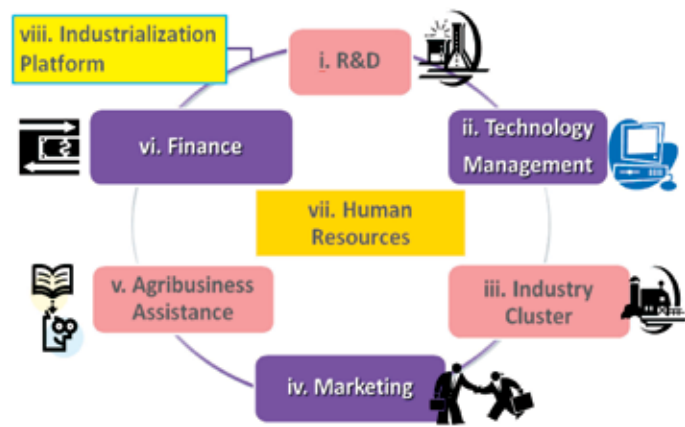


Figure 1. Agricultural innovation approaches in Taiwan

3.2. Building technology management

In the late 1990s, when Taiwan faced the global trend of the knowledge-based economy, the government promulgated the 'Fundamental Science and Technology Act' in 1999. From then on, even in the field of agriculture, COA has helped improve and strengthen technology management, protection and technology transfer of public R&D results. COA set up the Agricultural Intellectual Property Rights Committee in 2001 to make decisions or to deal with a particular subject about IPR registration and technology transfer. According to

COA statistics, an average of income from R&D results totaled NT\$81 million from 2011 to 2015 and highest income totaled NT\$100 million in 2014. There are 370 R&D results have been completed commercialization and the output value of these products totaled NT\$980 million.

3.3. Establishing industry clusters

Since 2002, COA has promoted its affiliated research institutes to set-up innovation incubation centres. In 2005, Livestock Research Institute set up the first innovation incubation centre in COA, followed by Agriculture Research Institute and Fisheries Research Institute in 2009, Agricultural Technology Research Institute (ATRI) in 2014, and Forestry Research Institute in 2015. Those five incubation centres offer space and excellent facilities to start-up companies. Prior to June 2016, those five incubation centres have assisted 105 companies.

There are currently two prominent biotechnology parks in Taiwan. One is the Pingtung Agricultural Biotechnology Park (PABP) located in Pingtung County, which has six major industry clusters. The other is Taiwan Orchid Plantation (TOP) located in Tainan City. There are 102 resident companies in PABP that have invested about NT\$9.39 billion. There are 75 resident companies in TOP that have invested about NT\$12.02 billion.

3.4. Strengthening agribusiness assistance

COA has developed an assistance programme for management improvement from 2009 to 2016 for improving the capacity of agribusinesses. Experts were invited to offer consultation and assistance to help these agribusinesses. The programme has improved the business management capacity of 173 businesses and assisted in 27 centre-satellite system cases. COA held the Grand Awards of Innovation in Scientific and Technological Agribusiness for agribusinesses that have made outstanding achievements in both technology innovation and application. The Agricultural Business Good Idea Contest was set up to encourage and demonstrate agricultural innovation ideas of student teams in search of investors.

3.5. Enhancing agri-tech marketing

Agro-tech exhibitions are a vital channel for the industry. Each year, three important technology exhibitions are held for agricultural technology: Taipei International Invention and TechnoMart, Bio Taiwan Conferences & Exhibition, and BIO International Convention held in the U.S. The Techno Mart specifically serves as a platform for licensing public R&D results. The other two exhibitions serve as platforms for businesses to promote and market their products. COA established the Taiwan Agriculture Techno Mart (TATM) website and is the first agricultural technology-licensing platform in Taiwan. TATM aims at matching agribusiness technology needs and providing two-way communication exchanges for COA's research institutes and registered agribusinesses.

3.6. Assisting finance in capital markets

Financial support is an important assistance for agribusinesses. To assist them, COA developed 4 kinds of financial support programs. First, loans for biotechnology park and innovative

agribusinesses have an interest rate 1.5 percent and the credit limit is NT\$80 million. There were 391 cases are approved and NT\$1.99 billion in total. Second, a reduction of expenditures for research treats expenditures for corporate research as investments and 3 cases are approved. Third and fourth, assessment opinions of listed company at capital market and go incubation board for startup and acceleration firms (GISA) are offered to the Taiwan Stock Exchange and the Taipei Exchange by COA. One company is approved at over-the-counter market and 4 companies at GISA.

3.7. Training human resources

To encourage more talents to work in agriculture, COA offered 3 talent-training programmes for agribusinesses, including Technology Management Programme, Agribusiness Management Programme and International Marketing Programme, which combine related resources from universities, governments and industries. Five hundred trainees have completed the Technology Management Programme, 256 trainees have completed the Agribusiness Management Programme, and 249 trainees have completed the International Marketing Programme.

3.8. Integrating industrialization platforms

Taiwan's agricultural sector needed new thinking on how to raise competitiveness. In 2014, COA decided to develop a strong driving force in agro-technology, new value chains and advance market-oriented agro-industries, and thus established ATRI. The missions of ATRI are: (i) to take research results produced by agricultural research institutions and find industrial applications for these results, thereby enhancing their economic value; (ii) to assist businesses to take over agro-technology R&D results and turn them into commercial products on an industrial scale; (iii) to use its technical and professional skills to support and assist government agencies.

4. Future Prospects

Bioeconomy and intelligent agriculture are the big trends for the future of agriculture. Taiwan government has approved two programmes for bioeconomy and intelligent agriculture and will implement from 2017.

Taiwan is one of the few countries with a strong base of industrial technology, information technology, biotechnology and agricultural technology, and has the capability to smoothly integrate these technologies for the development of its bioeconomy. The agricultural bioeconomy programme has 4 key target fields as priority items, including new plant and animal species and seedlings, agricultural genomics applications, animal and plant health, and materials regenerating applications. There are 6 integrated measures to accelerate the industrialization of these fields.

Through intelligent production and digital service, intelligent agriculture programmes should be able to enhance the overall efficiency of agricultural production and marketing by integration of monitor and intelligent devices, internet of things and big data computing. COA will build an active all-round agricultural consumption/service platform to meet the needs of agricultural stakeholders.

5. Conclusion

Over the last 15 years, COA has encouraged 8 approaches in agricultural innovation and Taiwan has made a smooth transition from efficiency-driven to innovation-driven in agricultural S&T. The success of these agricultural innovation approaches is supporting Taiwan to develop a viable bioeconomy and intelligent agriculture for the next 10 years. COA now has planned “Neo-Agriculture Policy” to strengthen the domestic industry’s agricultural competitiveness with new technology and new products, to transform the value-added system with new business and services, and to confirm to a more demand-oriented market (Figure 2). We emphasize

“food source safety, sustainable production, technology value added, food security intelligent application, energy creating/saving, and international marketing and sharing”, not only to enhance innovation and competitiveness, but also to increase the local industry’s popularity and internationalization. Taiwan will certainly achieve the values of Neo-Agriculture Policy in terms of innovation for economic growth, jobs for people, and distribution for a stable society with the support of agricultural S&T.



Figure 2. Neo-agriculture policy of Taiwan

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A Successful Rural Innovation Policy: The Sixth Industry Initiative in Japan

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Keywords: Agricultural policy, innovation, multi-sector, sixth-industry, value addition.

1. Background

Revitalization of rural economies and communities has become one of the prioritized policy targets in Japan as its national agricultural income has gradually decreased and its agricultural labour force has been aging rapidly. Japan's food self-sufficiency rate is 39 per cent on calorie supply basis and 64 per cent on product value basis. In 2011, a new legislation, the so called "Sixth Industry Act" was enacted in order to promote the full-fledged utilization of local resources and the collaboration among farmers, processors and distributors, as well as to enhance local production and local consumption. The "sixth industry" signifies the functional integration of primary, secondary and tertiary industries i.e., the multiplication of these three industrial sectors.

This initiative is also called "AFFr-innovation" in English texts. It is an abbreviation of invented terms Agri-innovation, Forest-innovation and Fishery-innovation. The concept and definition are exactly the same as "sixth industry", and it means adding value to agriculture, forestry and fishery products in innovative ways by making new combinations and creating value chains. For several decades till now, there have appeared various similar concepts, including the basic idea of the sixth industry itself, with respect to the development of rural areas in Japan for several decades. However, this initiative can be distinguished from the others as it has been strongly supported by national-level policy instruments based on the above legislation. The Japanese government aims to trigger rural innovation and to alter its stagnant agriculture, forestry and fisheries into growing industries.

2. Features of the Initiative

The Sixth Industry Act defines the conditions needed to be recognized and approved as an "incorporated/integrated project", hereinafter referred to as "project". Farmers and farmer-centered groups submit project proposals which incorporate multi-sectoral collaborations. The proposals should contain one of the following innovative features. Firstly, the projects must develop new goods or services which indispensably use agricultural (including forestry and fisheries) materials. Secondly, they must introduce new sales methods or improve the existing

¹Vice President, JIRCAS

sales methods. Or, thirdly, they must improve production systems for materials in order to fulfil the above two conditions.

The Ministry of Agriculture, Forestry and Fisheries (MAFF), Govt. of Japan together with local governments, provides various kinds of supports according to the progress status of the project. Even before the start of the project, in other words at incubation stage, farmers or farmer-centered groups can receive general support, such as advisory assistance and training. “The sixth industry support project” subsidized by the government provides the professional advisors, called “planners”, and organizes events for business information exchange and trainings. Once the proposal is approved, the project is supposed to receive stronger supports such as subsidies and loans for machines and facilities. If the project moves to the next stage where it expands the activity towards regional, national or even international scale and creates a joint enterprise

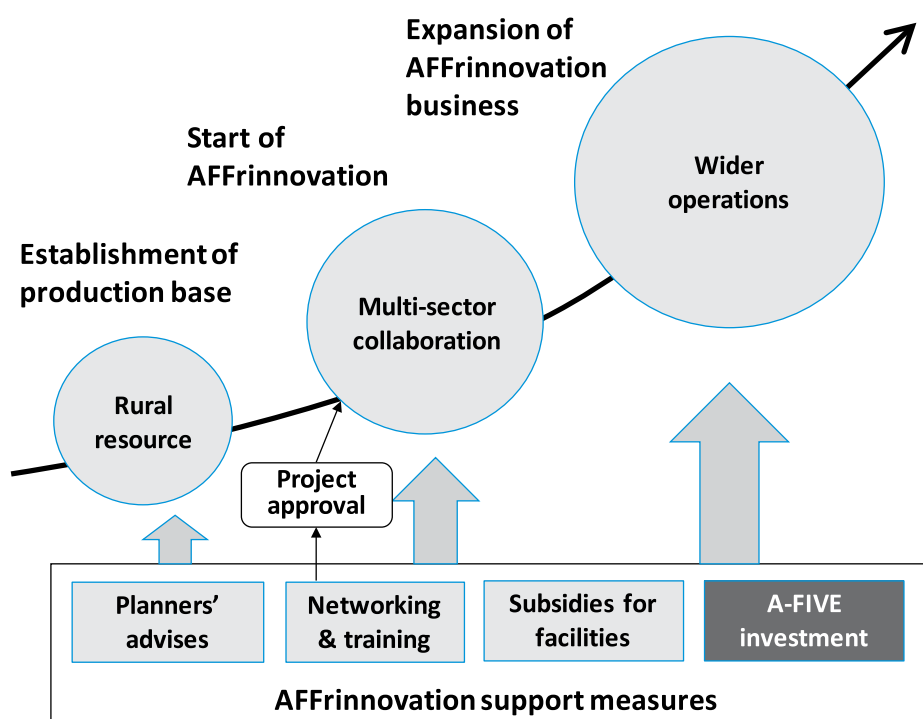


Figure 1. AFRinnovation support measures according to the progress status

Note: A-FIVE is the abbreviation for “Agriculture, forestry and fisheries Fund Corporation for Innovation, Value-chain and Expansion, Japan.”

with collaborators, it is eligible to accept investment from a specially established governmental funding company, i.e. “Agriculture, forestry and fisheries Fund corporation for Innovation, Value-chain and Expansion Japan (A-FIVE)” (Fig. 1).

3. Current Situation

A total of 2,171 projects were approved in five years up to 31 August, 2016. Most of the projects deal with agricultural and livestock products (1,914) and 31.5 per cent of the projects are targeting the processing and sale of vegetable-based products (Fig. 2). Nearly 70

per cent of the projects process the products by themselves and sell them directly to consumers. The average project-related sales generated over a project period increased by 17 per cent (after one year), 33 per cent (after two years), 38 per cent (after three years) and 41 per cent (after four years) (MAFF2016). To date, there are 965 registered planners who are actively giving advices on these projects. The most requested issues for the planners are the planning of new products and the development of sales channels. The total amount of investment for the AFFr-innovation enterprises from A-FIVE and its sub-funds reaches 7.5 billion Japanese Yen (JPY) in September 2016. Success stories are shared in various events and through the internet, and new products and services from the projects are advertised widely (Fig. 3).

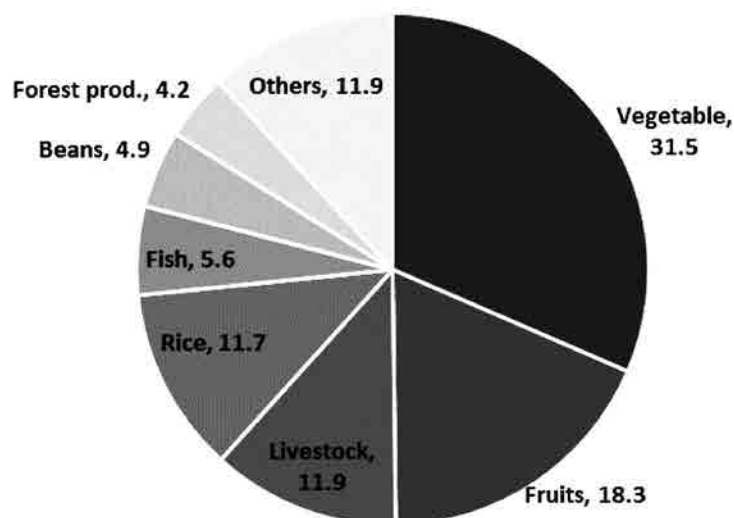


Figure 2. Percentage of target products of approved projects (MAFF 2016)

Note: 1. "Others" includes wheat, barley, tea, buckwheat, flowers, and native animals.
2. The total number of approved projects is 2,171 (as of August 2016).

4. Technological improvement

Technological development required for the projects is also supported by national and local researchers. A considerable number of the planners are technical advisors who give advises on production and processing technologies. In order to support this initiative, the agriculture forestry and fisheries research council included AFFr-innovation as one of the 21 key research and development targets requiring prompt solutions in the Basic Plan for Agriculture, Forestry and Fisheries Research (MAFF 2015). In the plan, the national research system is planned to develop high-value added processed food products in collaboration with local food businesses. Also they plan to identify functions of the components of local agricultural products such as rice, cereals, soybeans and vegetables and to develop and propagate local varieties such as traditional vegetables that could contribute to the Sixth Industry Initiative.

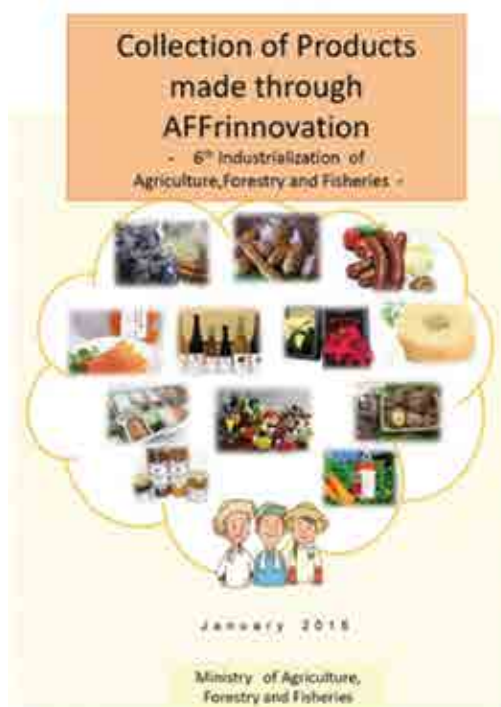


Figure 3. Booklet introducing more than 300 innovative products (MAFF 2016)

5. Conclusion

This policy framework promotes multi-sectoral collaborations among various rural stakeholders and connects diversified players, ideas and resources. It also generates new employment in rural areas and provides the basis for producer-led value chain or agribusinesses. The sales from the sixth industry activities, including those which are not registered, have been increasing in Japan. The value of direct sale of agricultural processed products by rural entities increased to c.a. 2 trillion JPY in the fiscal year 2014 and the number of employees involved in those businesses was 0.4 million, according to a MAFF survey (MAFF 2016). Although this trend can be explained partly by the enhancement of IT environment, it can be concluded that the initiative had a ripple effect and that it is successfully up-scaling. It has potential to expand further the demand frontier for local agricultural resources and to promote high value agriculture.

However, if individual cases are investigated in detail, there would probably be many managerial and technical problems to be solved. In some cases, the approved project plans have not yet implemented, or product sales are decreasing year by year in other cases. In order to up-scale this initiative to the level which would enable more effective revitalization of rural areas, further strategic efforts such as wider networking and regional branding are thought to be needed. Many of the projects are still based rather on individual efforts. Innovation comes from new combinations of institutional, managerial and technological components. Thus, activities done through the sixth industry initiative in Japan can be called as the efforts to generate innovations, if not called as innovation generated.

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Annexures

Welcome Address

Dr Marco C.S. Wopereis

Director General, The World Vegetable Center (AVRDC), Taiwan

Your Excellency, Mr Chin-Cheng, Deputy Minister, Council of Agriculture, Taiwan; Dr Waraporn Prompoj, Deputy Director General, Department of Agriculture, Thailand; Dr Raghunath Ghodake, Executive Secretary APAARI, distinguished participants, ladies and gentlemen.

On behalf of the organizing institutions: APAARI; Council of Agriculture (COA), Taiwan; Australian Centre for International Agricultural Research (ACIAR), Australia; Asian Farmers Association (AFA), Philippines and the World Vegetable Center (AVRDC), Taiwan. I would like to welcome you to this 'Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific.

The Asia and Pacific Region is home to 60 per cent of the world's population, 40 per cent of which is living in rural areas facing persistent problems of poverty, hunger and malnutrition, climate change and degradation of natural resources. Many of the poorest people in this huge region are still smallholder producers and many of them are women. Convincing young people to work in agriculture is proving to be difficult, leading to an exodus to urban areas, leaving an aging farming population behind.

Meanwhile there are huge opportunities to make a decent living out of the agri-food sector. The World Bank has shown that economic growth originating from agriculture is 2-4 times more effective at reducing poverty than growth originating from other sectors. In many cases, productivity of the agri-food sector per unit of land, water or labor is far below what would be possible with improved technology, management or organizational arrangements. Examples of how that can be done in a sustainable manner often exist elsewhere. It is, therefore, totally appropriate that we focus our efforts over the next three days on taking stock of best practices in agri-food innovations. We need to ask ourselves what we can learn from these successes that can be applied elsewhere to make a lasting and positive difference for producers and consumers of agri-food products in the Asia and Pacific Region.

Ladies and Gentlemen, the Minister of Agriculture of Karnataka State in India told me last week that vegetable farmers in his state are faced with three major challenges: fluctuation of market prices, access to water (the state is facing enormous drought problems) and labour scarcity - because young people are not interested in finding employment in agriculture. The Minister asked us to source novel expertise 'from outside India' to modernize the vegetable sector in his state. He said that only by modernizing farming and processing practices it will be possible to attract young people to the agri-food sector in Karnataka State.

Moving forward with vegetables in Karnataka State requires thinking about supply, demand and quality of vegetable products, combining technological, organizational and institutional innovation. In fact, it requires working in all four thematic areas of APAARI's new 2017-2022 Strategic Plan:

- There is a need to work on management and use of natural resources (Thematic area 1): in Karnataka, we must work on increasing water use efficiency, for example through introduction of drip-irrigation techniques.
- There is a need to manage risks and uncertainties in the agri-food system, (Thematic area 2): in Karnataka, we need to tackle the issue of price fluctuations, perhaps through diversification – growing a larger variety of vegetables, working on improved quality of vegetable products or stimulating off-season production.
- There is a need to work on inclusive development and integration of value chains, targeting smallholder farmers (Thematic area 3): in Karnataka, we must reflect on how we can link vegetable farmers to retailers catering to the Bangalore market, creating a win-win situation for all along the value chain.
- And last but not the least, there is a need to think about public policies (Thematic area 4): can we provide subsidies to Karnataka farmers to enable them to invest in shade net houses and drip irrigation?

He mentioned that he has suggested the Government of Karnataka state in India to adopt all four thematic areas of APAARI's new 2017-2022 Strategic Plan in order to increase vegetable production in the state where vegetable farmers are facing challenges of fluctuation of market prices, access to water and labor scarcity.

Ladies and Gentlemen, the key to solving the region's challenges and seizing the opportunities lies in development of modern, competitive and sustainable agri-food systems. There are enormous opportunities to network and learn from each other. If you came by train from Taipei to Taichung you just needed to look out of the window to realize that Karnataka state can learn a lot from Taiwan in terms of protected cultivation of vegetables.

Over the next three days, we will take stock of best practices in agri-food innovations in Asia and the Pacific and discuss how such innovations can be upscaled and outscaled. Without doubt, this will require all of us present here to truly engage in the four programmes of the new APAARI strategy: knowledge management, partnerships and networking, capacity building and advocacy. Some of us may focus on a particular thematic area or convene a research network on for example management of pests and diseases in particular cropping systems. Pests and diseases do not recognize borders and concern all of us. Others may contribute to a growing knowledge base on agri-food systems development stimulating youth employment – something we are all concerned about as well.

Whatever we do, it is crucial to consider farmers not as beneficiaries but as real partners and invest in them through their organizations. I am happy to note that the Asian Farmer Association is co-organizer of this event. I still remember the words of AFA's representative during the recently held Food Security Forum organized by the Asian Development Bank (ADB) in Manila, Philippines: No farmer, no food, no future!

Ladies and Gentlemen, I look forward to the debates over the next three days and sincerely hope that we will be able to formulate concrete recommendations on the way forward, thereby contributing to operationalizing the APAARI strategy.

Thank you

Introductory Remarks

Dr Waraporn Prompoj

Deputy Director General, Department of Agriculture, Thailand on behalf of
Dr Suwit Chakiattiyos, Chairman, APAARI Executive Committee and Director General,
Department of Agriculture, Thailand

Honored guests, ladies and gentlemen

On behalf of APAARI and the Department of Agriculture (DOA), Thailand, I would like to warmly welcome you all to the Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific. It is certainly an honour and great pleasure for me to give introductory remarks in the Inaugural Session of this Expert Consultation.

First and the foremost, I would like to congratulate APAARI for bringing together and provide a platform to high level officials and leaders of research and development institutions from the Asia-Pacific region. This has been possible because of the highest level of support and cooperation extended by the co-organizers - Council of Agriculture (COA), Taiwan, Australian Centre for International Agricultural Research (ACIAR), the World Vegetable Center and the Asian Farmers Association (AFA) and also all of you who could join us today.

I express my sincere appreciation for your participation which is an indication of your dedication and commitment to address the important area of agri-food innovations that will not only help fight hunger of the vast population today but also for the wellbeing of future generations. This Consultation certainly signifies our common concern and recognition of the vital role of agri-food innovation and their invaluable contribution to economic growth and sustainable development in the region.

As you are aware, the Asia-Pacific region is the home for 60 per cent of the world population. At present, it has 4.7 billion people and 41 per cent of it is concentrated in the rural areas facing problems of poverty, food insecurity, hunger and malnutrition. We all agree that one of the paramount questions the world will be facing over the next three and half decades is how to feed more than 9 billion people by 2050. This needs to be done in a manner that advances economic development and at the same time reduces pressure on the environment. A great balancing act is needed to simultaneously close the gap between the amount of food available today and what is required in 2050.

The agricultural innovations can be of diverse types, namely, technological, institutional, organizational, policy oriented, mixed and integrated systems, partnerships, networking, markets, value chains, financing and investment, capacity development, and national and regional integration. The innovation system approach allows to understand the policy environment as well as the actors, their competencies, habits, attitudes, practices, linkages, needs, gaps,

etc. The smallholder producers in different agro-ecological environments need context-specific innovations and hence appropriate strategies need to be developed to meet their needs through such innovations. Therefore, the smallholder farmers must be part of analysis of the options, the decision-making as well as the implementation.

In the Asia-Pacific region, there are a large number of agri-food innovations developed by researchers, policy makers, private sector, financing institutions, self-help groups, NGOs and others. These innovations need to be documented, characterized and facilitated for upscaling and outscaling for the benefit and wellbeing of smallholder producers in the entire food value chain. A number of farmer-led innovations developed with the use of indigenous technology and blended with modern technology are proving to be successful. Considerable attention needs to be given to the best practices and lessons learned using case studies to illustrate the successes and failures.

There is also a need to critically assess various types of agri-food innovations for their strengths, weaknesses, mechanisms and constraints. This will enable identifying the successful innovations for their potential upscaling and outscaling to bring an impact at scale for the benefit of smallholder producers, rural communities and overall sustainable agricultural development. Also, crucial is to consider the enabling environment such as information communication technologies (ICTs), capacity development, policies, institutional framework, and markets as important determinants to bring about effective upscaling and outscaling.

The innovation process must be inclusive; take on board, farmers' circumstances and adopt a longer term perspective. New capacities for research, science, innovation and business need to be developed and nurtured. The knowledge infrastructure to support the domestication of the innovation systems approach, strengthened policy coherence, strategic visioning, increased investments in research and innovation are also needed.

The goal of the Expert Consultation is to promote, upscale and outscale successful agri-food innovations to enhance productivity, efficiency and sustainability of agri-food systems and to contribute to accomplishing the Sustainable Development Goals (SDGs) as well as to catalyze policy/decision makers and sensitize stakeholders in agri-food research and innovations. The major objectives are to: i) document and discuss best practices in agri-food innovations, ii) assess the strengths, weaknesses, mechanisms, constraints, and likely impact iii) identify gaps in enabling environment, and iv) assess the need for necessary policy intervention, advocacy and capacity development for upscaling and outscaling agri-food innovations.

Ladies and Gentlemen, much more efforts and innovations will be urgently needed in order to sustainably increase agricultural production, improve the global supply chain, decrease food losses and waste, and ensure that all who are suffering from hunger and malnutrition have access to safe and nutritious food. Therefore, boosting agricultural production to the levels needed to feed the increased world population will require sharply increased and improved investment in agricultural research, new technologies, innovations and development.

We do hope that as a result of in-depth discussions, a clear road map on strategies, options and priorities will be developed for upscaling and outscaling of successful agri-food innovations in the Asia and the Pacific. The task in front of us is enormous. But, I am confident, we will rise

to the challenge with the help of all of you here today, as policy makers, investors, scientists, economists, farmers, men and women and other stakeholders.

APAARI being an organization that promotes the development of agricultural research and innovations in Asia and the Pacific will incorporate the outcomes and recommendations emerging from this Consultation into its operational/implementation plans and activities.

I would like to wish all of us a productive and fruitful consultation.

Thank you very much

Inaugural Address

Mr Chin-cheng Huang

Deputy Minister, Council of Agriculture (COA), ROC, Taiwan

Dr Wopereis, Director General of the World Vegetable Center; Dr Prompoj, Deputy Director General representing Chairman, APAARI; Dr Ghodake, Executive Secretary, APAARI; Distinguished Guests; Ladies and Gentlemen.

It is a great pleasure for me to be with you here today at the opening ceremony of the “Expert Consultation on Best Practices in Agri-food Innovations in Asia and the Pacific” on behalf of Mr Chi-hung Tsao, Minister of the Council of Agriculture. I am very pleased that the Taiwan Agricultural Research Institute (TARI) of the Council of Agriculture (COA) has the honor to coorganize this conference with the APAARI and the World Vegetable Center (formerly, AVRDC). I am confident that the concerted efforts will ensure great success for this event. Meanwhile, I would like to take this opportunity to extend a cordial welcome to those who have traveled from India, Bangladesh, Thailand, the Philippines, Malaysia, Samoa, Cambodia, Nepal, Pakistan, Vietnam, Indonesia, Sri Lanka, Papua New Guinea, Iran, Afghanistan, Bhutan, Australia, France and Japan to attend this meaningful conference.

It is estimated that the global population may reach 10.5 billion in 2050, with the food demand doubled. Despite continuing growth in its agricultural output, Taiwan, a net food-importing country, is now facing such challenges as climate change, agricultural labor aging and shortages, and food safety. All of these challenges have a considerable impact on agriculture productivity. However, Taiwan has accumulated successful experience in developing innovative programmes for its small-scale agricultural production like a food traceability system, intelligent robotic devices (IRD), the Internet of Things (IoT), Information Communication Technologies (ICTs) and Big Data analysis. The adoption of these technologies has improved our agricultural productivity, promoted value-adding and established a new pattern of producers and consumers.

The purpose of this conference is to gather experts from Asia-Pacific countries and organizations to share their experiences and seek further cooperation among nations, governments, academia, research institutions and private sectors. The best and successful practices in agriculture innovations will be identified and discussed, in order to promote productivity, efficiency and sustainability of agri-food systems in the Asia-Pacific region. I believe that, with your contributions and inputs, this Expert Consultation will come up with many fruitful outcomes and valuable suggestions for us to tackle the tasks ahead of us.

Finally, I would like to thank you again for your meticulous preparations for this conference. I also wish to extend my sincere thanks for the gracious presence of all assembled here. I wish the conference great success.

Thank you

Perspective Outcomes

Dr Raghunath Ghodake

Executive Secretary, APAARI, Bangkok, Thailand

Mr Chin-Cheng Huang, Hon'ble Deputy Minister, Council of Agriculture, Taiwan; Dr Marco Woparis, Director General of the World Vegetable Center, Taiwan; Dr Waraporn Prompoj, Deputy Director General, Department of Agriculture, Thailand; Prof. Andrew Campbell, CEO of Australian Centre for International Agricultural Research, Australia; Ms Esther Penunia, General Secretary of Asia-Farmers Association, the Philippines, distinguished participants, ladies and gentlemen.

The organizers of this Expert Consultation have accepted the concept of agri-food innovations as the process whereby actors and partners (individuals or organizations) bring existing or new products, methods processes, technology, and forms of organization into social and economic use to increase effectiveness, competitiveness, resilience, sustainability, thereby contributing to food and nutritional security, economic development and sustainable natural resource management.

The basic premise being that by working together in partnership and collective mode, all stakeholders – including farmers, traders, governments and civil society - can produce overall impact greater than the sum of its parts. Also, the consideration is that science, research, technology and inventions are necessary for development but innovations can bring in sufficiency condition for development.

However, agri-food innovation may mean different things to different people and may be different under different situations. It is a complex concept both in terms of theory and practice. Innovations are practiced but often without necessary theoretical basis. Often practices are used to design theory and models in turn to understand the practices. Therefore, at the moment, the concept remains a highly complex process to deal with and needs further understanding.

While organizing this expert consultation, we were challenged as to what should be our expectations on the outcomes from the consultation. We were concerned as to whether we shall be able to identify successful agri-food innovations that can be used as recipes and recommend these for upscaling and outscaling to create impact at scale. We were held back from it because of the lack of understanding of the theoretical basis and sense of reasoning / rationalization behind such an attempt.

Therefore, we developed our perspective on outcomes, what we call Perspective Outcomes from this Consultation. The aim is to look at guiding principles (in terms of strengths and weaknesses) from the best practices, case studies, experiences of experts in agri-food innovations and see if we can suggest pathways to go for developing successful agri-food systems.

We would like to see such guiding principles, emerging by focusing of key aspects/ formations of agri-food innovations. These are specified as partnership (institutional and add value), skills and capacities, socioeconomic scenarios, strategies to innovate, technologies for innovations, knowledge management, policies and investments.

We, therefore, look forward to such guiding principles that will allow us to create pathways to develop successful agri-food innovation that then can be considered for upscaling and outscaling. That is how sessions, working groups and panel discussion are organized. We hope that proves the best approach given the current dilemma and ambiguities.

On behalf of the organizers, I thank very sincerely the Hon'ble Deputy Minister, Mr Chin-Cheng Huang, Deputy Minister, for his inaugural address and thank all those dignitaries on dais and all the participants of the Expert Consultation.

Thank you all

Technical Programme

1 November, 2016

08:00 – 08:25 Registration

08:25 – 08:50 Opening Session

08:25 – 08:30	Welcome	Marco Wopereis (Director General, World Vegetable Center)
08:30 – 08:35	Introductory Remarks	Waraporn Prompoj (DDG, DOA)
08:35 – 08:45	Inaugural Address	Chin-Cheng Huang (Hon'ble Deputy Minister, COA, Taiwan)
08:45 – 08:50	Perspective Outcomes	Raghunath Ghodake (Chairman, Organizing Committee and Executive Secretary, APAARI)
08:50 – 09:00	<i>Group Photograph</i>	

09:00 – 11:15 Technical Session I: Models and Case Studies of Agri-food Innovations

	<i>Co-Chairs</i> : Sharif Haron, MARDI, Malaysia Huu-sheng Lur, COA, Taiwan	
	<i>Rapporteur</i> : Ramakrishna Akkinapally, NARI, Papua New Guinea	
09:00 – 09:25	Framework for exploring different models of innovation and partnership	Andy Hall, CSIRO, Australia – <i>Lead Paper</i>
09:25 – 09:45	Analysis of ACIAR project case studies	Andrew Alford, ACIAR, Australia
09:45 – 10:00	Discussion	
10:00 – 11:00	Working Groups	
	Group 1 : Micronutrient deficiency in human populations (<i>Convener</i> : Andy Hall, CSIRO, Australia)	
	Group 2 : Dairy production and food safety (<i>Convener</i> : Andrew Alford, ACIAR, Australia)	
	Group 3 : Pesticide residues (<i>Convener</i> : Andrew Campbell, ACIAR, Australia)	
11:00 -11:15	Presentation of Working Group Reports (<i>Session Coordinator</i> : Andrew Campbell/ Andrew Alford, ACIAR, Australia)	
11:15 – 11:30	<i>Tea/Coffee Break</i>	

11:30- 14:45 Technical Session II: Partnership for Agri-food Innovations

	<i>Co-Chairs</i> : Hemantha Wijewardena, CARP, Sri Lanka Mathew Prasad, VC, UHF, India
	<i>Rapporteur</i> : Y.S. Saharawat, ICARDA, Afghanistan

11:30 – 11:55	Designing environmental research for impact	Andrew Campbell, ACIAR, Australia – <i>Lead Paper</i>
11:55 – 12:15	Facilitating multi-stakeholder partnership to support farmer innovation in food and agriculture – Lessons from PROLINNOVA, Nepal	Suman Manadhar, PROLINNOVA, Nepal
12:15 – 12:30	Discussion	
12:30 – 13:30	<i>Lunch Break</i>	
13:30 – 14:30	Working Groups	
	Group 1 : Institutional partnership in generating innovations (<i>Convener</i> : Suhas P. Wani, ICRISAT, India)	
	Group 2 : Add value partnership in innovations (<i>Convener</i> : Rudrappa Giraddi, UAS, Dharwad, India)	
14:30 – 14:45	Presentation of Working Group Reports (<i>Session Coordinator</i> : Jawahir Karihaloo, APAARI)	
14:45 – 15:00	<i>Tea/Coffee Break</i>	
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15:00 – 17:30	Technical Session III: Capacity Development in Agri-food Innovations (Concurrent Session)	
	<i>Co-Chairs</i> : Yusuf Zafar, PARC, Pakistan Ashok Sarial, CSK HPKV, Palampur, India	
	<i>Rapporteur</i> : Shivappa Mantur, UAS, Dharwad	
15:00 – 15:25	Capacity development for agricultural innovation systems	Myra Wopereis-Pura, CDAIS, ICRA, France – <i>Lead Paper</i>
15:25 – 15:45	Household garden interventions for food and nutrition security	Pepijn Schreinemachers, World Vegetable Center, Taiwan
15:45 – 16:00	Discussion	
16:00 – 17:00	Working Groups	
	Group 1 : Capacity development for agri-food innovations (<i>Convener</i> : Myra Wopereis-Pura, CDAIS)	
	Group 2 : Socioeconomic dimensions of agri-food innovations (<i>Convener</i> : Esther Penunia, AFA, Philippines)	
17:00 – 17:15	Presentation of Working Group Reports (<i>Session Coordinator</i> : Ghazanfar Abbas, APAARI)	
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15:00 – 17:30	Technical Session IV: Technology Based Agri-food Innovations (Concurrent Session)	
	<i>Co-Chairs</i> : Yama Raj Pandey, NARC, Nepal N.K. Krishna Kumar, Bioversity International, India	
	<i>Rapporteur</i> : Srinivasan Ramasamy, World Vegetable Center	
15:00 – 15:20	Carrageenan technology for rice in the Philippines	Reynaldo Ebor, PCAARRD, Philippines
15:20 – 15:40	Selective breeding in Kankrej native breed of cattle	Suresh Acharya, SDAU, India

15:40 – 16:00	Cadalmin™ green mussel extract (Cadalmin™ GMe) for use against pain and arthritis	Kajal Chakraborty, ICAR – CMFRI, Cochin, India
16:00 – 16:15	Discussion	
16:15 – 17:15	Working Groups	
	Group 1 : Strategies to innovate in agri-food systems (Convener : Bui Dang, VAAS, Vietnam)	
	Group 2 : Technology for agri-food innovations (Convener : Abdul Halim, UNITECH, Papua New Guinea)	
17:15 - 17:30	Presentation of Working Group Reports (Session Coordinator : Shyam Sunder Singh, APAARI)	
17:30 – 18:30	Poster Session	

2 November, 2016

08:00 – 10:00	National Hotel to World Vegetable Center	
10:00 – 10:40	Welcome and Briefing on the World Vegetable Center	Marco Wopereis, Director General
10:40 – 11:10	Group 1 : Visit Demonstration Garden (Convener : Yi-Chin Wu & Mandy Lin)	
	Group 2 : Visit to Genebank (Convener : Yung-Kuang Huang)	
11:10 – 11:45	Group 1 : Visit to Genebank (Convener : Yung-kuang Huang)	
	Group 2 : Visit Demonstration Garden (Convener : Yi-Chin Wu & Mandy Lin)	
11:45 – 13:00	Lunch - Sylvia Hsu	
13:00 – 13:45	Departure for Taiwan Orchid Plantation (TOP)	
13:45 – 14:30	Group 1 : Visit to Star Orchids - The Cultivation of Phalaenopsis Orchids in an All-Computer-Controlled Ecology Greenhouse	
	Group 2 : Visit to Tai-Ling Biotech - The Production, Preservation, and Transportation of Phalaenopsis Cut Flowers	
14:35 – 15:20	Group 1 : Visit to Tai-Ling Biotech - The Production, Preservation, and Transportation of Phalaenopsis Cut Flowers	
	Group 2 : Visit to Star Orchids - The Cultivation of Phalaenopsis Orchids in an All-Computer-Controlled Ecology Greenhouse	
15:30 – 16:00	Visit to Taiwan Orchid Growers Association- Briefing on the Development of Taiwan Orchid Industry and the Introduction of TOP	
16:00 – 18:00	TOP to National Hotel	

3 November, 2016**08:00 – 10:20 Technical Session V: Knowledge Management on Agri-food Innovations (Concurrent Session)**

	<i>Co-Chairs</i> : Narendra Rathore, ICAR, India Andy Hall, CSIRO, Australia	
	<i>Rapporteur</i> : Tayan Gurung, SAC, Bangladesh	
08:00 – 08:25	On-line innovation system tools	Steve Staal, ILRI, Kenya – <i>Lead Paper</i>
08:25 – 08:45	Innovations on marketing of wax apple through ICT	Hsieh-Liang Tsai, TWADA, Taiwan
08:45– 09:05	Best practices in agri-food innovations in Navara rice in India	Potteh Unny, Navara Eco Farm, India
09:05 – 09:20	Discussion	
09:20 – 10:20	Panel Discussions	
	<i>Moderator</i> : Andy Hall, CSIRO, Australia (<i>Session Coordinator</i> : Chwen-Ming Yang, TARI, Taiwan)	

08:00 – 10:35 Technical Session VI: Policy Oriented Agri-food Innovations (Concurrent Session)








	<i>Co-Chairs</i> : Simon Hearn, Canberra, Australia Mathew Prasad, VC. UHF, India	
	<i>Rapporteur</i> : Palate Matalavea, MAF, Samoa	
08:00 – 08:25	National experience on agri-food innovations in Taiwan	Hung-Hsi Lee, COA, Taiwan – <i>Lead Paper</i>
08:25– 08:45	A successful rural innovation policy: The sixth industry initiative in Japan	Osamu Koyama, JIRCAS, Japan
08:45 – 09:10	Discussion	
09:10 – 10:10	Working Groups	
	Group 1 : Agri-food innovation policies (<i>Convener</i> : Suresh Acharya, SDAU, India)	
	Group 2 : Financing agri-food innovations (<i>Convener</i> : Max Herriman, CFF, Malaysia)	
10:10 – 10:25	Presentation of Working Group Reports (<i>Session Coordinator</i> : Greg Luther, World Vegetable Center)	
10:25 – 10:40	<i>Tea/Coffee Break</i>	

11:30 – 12:30 Final Plenary and Concluding Session

	<i>Co-Chairs</i> : Marco Wopereis, World Vegetable Center Vincent Lin, COA, Taiwan	
15:00 – 15: 25	Presentation of Session Reports: Chairpersons' Remarks:	Session Coordinators Marco Wopereis Vincent Lin

	Concluding Remarks:	Raghunath Ghodake, APAARI
	Vote of Thanks:	Ray Chang, TARI
12:30 – 13:30	<i>Lunch Break</i>	
13:30 – 18:30	14th APAARI General Assembly Meeting (Only for APAARI members or their nominees)	
18:30 – 20:30	Farewell Dinner hosted by APAARI	






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